AN ARCHAEOLOGICAL INVESTIGATION OF THE MT. HICKS OBSIDIAN SOURCE, MINERAL COUNTY, NEVADA

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AN ARCHAEOLOGICAL INVESTIGATION OF THE MT. HICKS OBSIDIAN SOURCE, MINERAL COUNTY, NEVADA

A Thesis

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Abstract

of

AN ARCHAEOLOGICAL INVESTIGATION OF THE MT. HICKS OBSIDIAN SOURCE, MINERAL COUNTY, NEVADA

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Previous studies of obsidian sources in the western Great Basin have identified a similar pattern of use through time, though varying somewhat in scope, methodology, and conclusions. A distributional or "non-site" archaeological survey strategy was adopted to investigate the Mt. Hicks obsidian source. Spatial associations of artifacts were recorded and samples collected for analysis. In addition to techno-morphological assessment, select obsidian artifacts were subjected to obsidian hydration analysis.

Results of these analyses indicate that the Mt. Hicks production curve broadly resembles that of other western Great Basin obsidian sources, but when examined in detail all differ from one another in significant ways. Results also suggest that some explanations presented to explain the shape of production curves seem inadequate, and that general trends in flaked stone use through time meet theoretical expectations.

_______________________, Committee Chair
Mark E. Basgall, Ph.D.

____
Date

DEDICATION

This work is dedicated to the memory of Anita Marie Martinez. My love, I have kept all the promises I made to you, but one. And that in time. *Nostrum prosapia est an Ferrum Orbis*.

ACKNOWLEDGMENTS

My name is on the front, but this thesis wouldn't have been completed without the help and support of a host of people. First, I'd like to thank Mark Basgall, Michael Delacorte, and David Zeanah. More than just my committee, they were good friends during the most painful time in my life. Thanks to Jack Scott for his patience and allowing me to conduct research at the Humboldt-Toiyabe National Forest.

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Back home at the ARC my thanks go out to Emilie Zelazo for the artifact photos. The charts and maps would have looked like crayon drawings if not for Bridget Wall. Carl Hansen assembled and formatted the document. He deserves my heart-felt thanks, and gets it, too!

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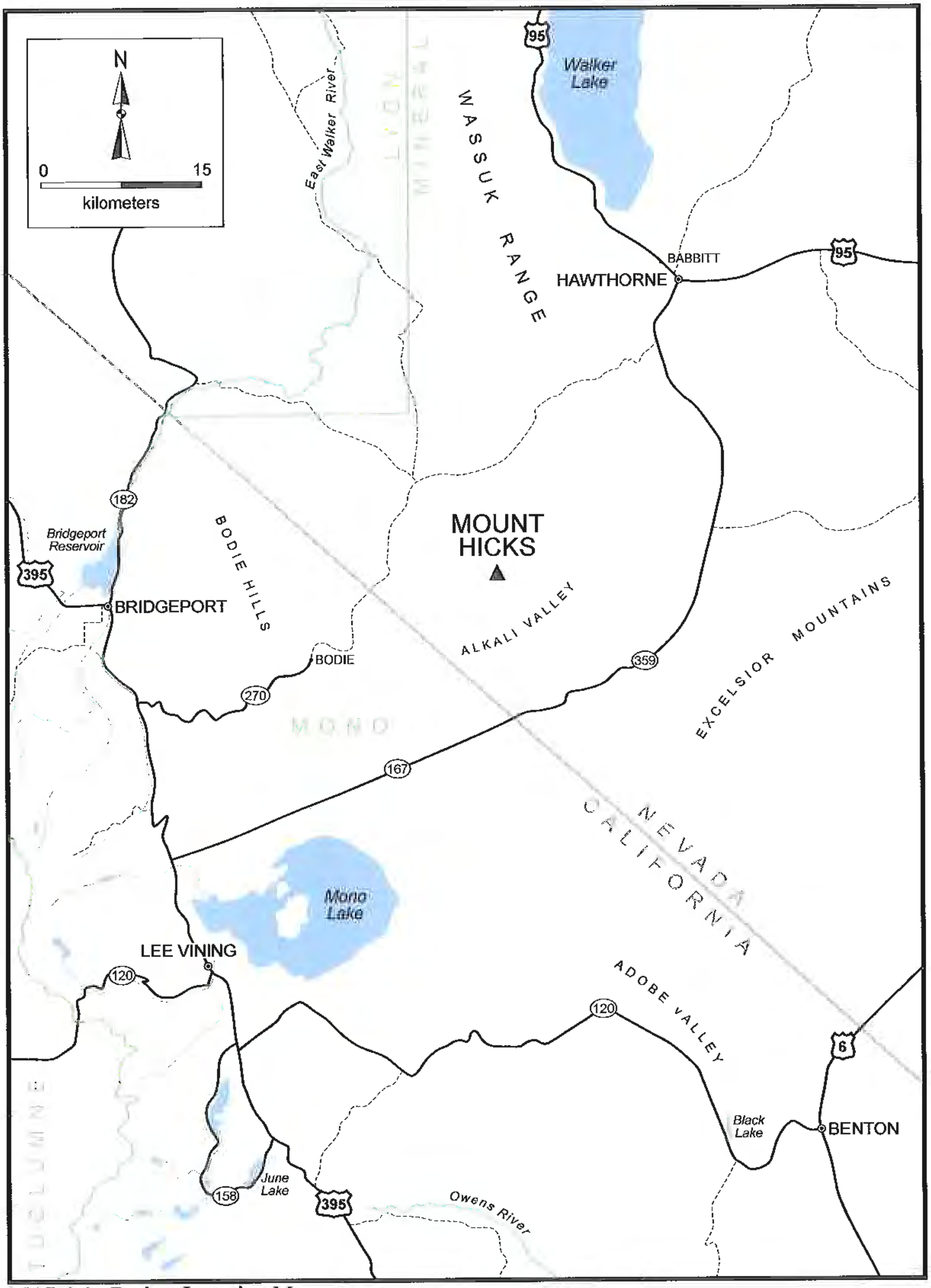
Chapter 1

INTRODUCTION

This thesis uses a distributional approach to study the surface of the Mt. Hicks obsidian source area (Map 1.1), located in the northeast corner of the Mono Lake Basin some 20 miles east of the Bodie Hills obsidian quarry. The primary aim of the study is to develop a production history for the quarry, but secondarily to assess how well current archaeological organization of technology theory can explain obsidian exploitation patterns and existing explanations for the shape of production curves at previously studied obsidian quarries in the western Great Basin. This necessitates a sampling strategy that cuts across environmental zones, varying distances from primary obsidian outcrops, and includes both quarrying and non-quarrying contexts.

Previously studied obsidian quarries in the western Great Basin include the Bodie Hills (Singer and Ericson 1977), Casa Diablo (Bouey and Basgall 1984; Hall 1983), Coso (Gilreath and Hildebrandt 1997), and Truman/Queen source areas (Ramos 2000). Production histories at these quarries generally reveal limited stone-working activity prior to 5500 BP, increases in exploitation until 1275 BP, and then sharp declines in subsequent quarrying activity. Inasmuch as the various studies employed different methods, data, and theoretical approaches, such parallels are probably robust.

Singer and Ericson (1977) conducted a very limited study of the Bodie Hills obsidian quarry. Citing a lack of habitation sites as support, they concluded that production at that source was a result of flintknapping specialists producing bifaces



MAP 1.1. Project Location Map

exclusively for trade. They argued that a subsequent decline in production is a result of breakdown in trans-Sierran trade networks. Singer and Ericson's study can be commended for outlining the now-familiar production curve, however, their explanation for the spike in productivity during the Newberry period being a result of trade-related biface production is not compelling. They claim that biface production debris is far too numerous in the area to account only for local use. In fact, while bifaces are very effective and efficient tools for the transport of raw material, their actual manufacture is very wasteful. It is likely that some of these tools were manufactured for exchange, as there are early historic accounts of such activity, but a local population emphasizing that production focus could easily create tremendous quantities of debitage. Further, it is unlikely that local groups would not exploit a major obsidian source to their own benefit; the contention, therefore, that biface production was done exclusively for trade is probably spurious.

Hall (1983) proposed that late Holocene volcanic activity and associated environmental stresses were responsible for disruption of trans-Sierran movement of Casa Diablo obsidian. He argued that such stress would leave only remnant populations in the area to conduct trade across the Sierra Nevada. This might have influenced production and exchange of Casa Diablo obsidian, at least on a short-term basis, but would not explain the similar production curve for Coso and other, more distant obsidian sources in the western Great Basin that were not subject to recent volcanic events (Gilreath and Hildebrandt 1997). Bouey and Basgall (1984), by contrast, see the Great Basin and California as articulating economically, at least in terms of obsidian production and demand, rather than as two independent areas. They suggest that it is increasing social complexity, which affected demand for obsidian, that influenced the production curve for Casa Diablo obsidian. In their model, changes in population density and mobility patterns among eastern Sierran groups resulted in increased territoriality, limiting access to the source from western Sierran groups who had previously supplied central California. With eastern Sierra groups either unwilling or unable to meet outside demands for obsidian, this in effect made North Coast Range sources "cheaper" and more readily available than before; one result was that production on the east side declined. The conclusions reached by this economic perspective seem logical, but the study largely ignored local factors such as subsistence strategies that may have affected production as well as other resources that may have continued to be traded.

Gilreath and Hildebrandt (1997) have a similar explanation for the shape of the obsidian production curve at the Coso Volcanic Field. They conclude that increasing territoriality in the Coso area limited or precluded direct access to obsidian resources by non-local groups. They add that changes in subsistence-settlement patterns as well as shifting technologies (i.e., adoption of the bow and arrow) were all contributing factors to the decreased activity at Coso. Exactly how these factors affect quarry production, however, is never fully articulated and treated in a cursory manner. At Coso, non-lithic resources are sparse and were exploited only late in time. Surrounding areas, by contrast, have abundant resources but were not examined as part of the quarry study. Assessing how subsistence-settlement changes affect exploitation of lithic resources is difficult if the only sites assessed are predominantly quarry workshops.

The most recent quarry investigated is the Truman/Queen obsidian source (Ramos 2000). Truman/Queen obsidian is found in extremely low quantities west of the Sierra Nevada, but has virtually the same production curve as other western Great Basin sources. This led Ramos to reject the idea that regional changes in trans-Sierran exchange are responsible, at least significantly, for trends in quarry use. He likewise finds that mobility as a primary conditioner of lithic technology provides an insufficient explanation, arguing that groups exploiting the source at different times pursued alternate mobility strategies. The primary determinant for technology, he argues, is related to the potential of specific tool forms to improve subsistence return rates by reducing resource handling time. Ramos makes a case for bifaces being specialized tools for butchering artiodactyls, rather than more generalized implement/cores employed by groups with high residential mobility; thus, with the decline of the importance of large game hunting to subsistence, there was little reason to produce bifaces. As biface manufacture produces copious amounts of waste, with the decline of that tool form, so fell the production curve during the Late Archaic. Ramos' conclusions seem sound insofar as there is no reason why a group would continue to produce and transport large numbers of a tool or core form if they were unlikely to be used. The specifics leading to this conclusion, however, are open to debate. Using regional archaeological data Ramos attempts to show parallel declines in artiodactyl bone recovery and biface production in Haiwee period and later sites compared to earlier periods. Much of his argument hinges on groups with differing mobility patterns exploiting the Truman/Queen obsidian source, an area that is very rich in food resources, especially pinyon. It seems unlikely that groups exploiting this area would have had subsistence-settlement strategies different than those inhabiting other resource-rich areas of the western Great Basin. More so than other explanations, however, Ramos' argument seems very testable. A logical outcome of his conclusions is that despite the presence of essentially limitless amounts of available raw material at a quarry, biface technology should be as prevalent as at any other site in the region, given that hunting was taking place in the area and that bifaces are specialized butchering tools. As the Mt. Hicks area certainly supported artiodactyls, biface to flake tool ratios similar to other parts of the region would support the argument.

Previous studies in the western Great Basin have demonstrated similar production histories for major obsidian quarries. Production histories at these quarries generally reveal limited activity prior to 5500 BP, increases in obsidian production until around 1275 BP, and then sharp declines in subsequent production. As discussed, explanations as to why the production histories appear as they do have included social interaction, technological change, and changing subsistence strategies, but for the most part these studies were unsystematic and done in a piece-meal fashion. While answering all of these broad questions is beyond the scope of the present work, the fact that this study was performed in an integrated manner – examining quarry and non-quarry areas simultaneously with the same methodology– should provide insight into whether any one, or a combination, of factors could best explain apparent similarities in quarry production.

The archaeological distribution of Mt. Hicks obsidian differs from other eastern Californian sources. Coso obsidian, for example, travels west and southwest from its source area, Casa Diablo moves mainly to the west, and Bodie Hills again is primarily distributed to the west. The amount of Mt. Hicks glass, in contrast, drops dramatically, or disappears altogether, to the west and south but appears in greater quantities to the north and east. In short, Coso, Casa Diablo, and Bodie Hills glass are transported into California, while Mt. Hicks glass is transported primarily into the Great Basin.

It is significant that the major obsidian quarries already studied in some detail were important sources of volcanic glass for cismontane California. This has led many archaeologist to focus on shifts in social interaction, particularly the development of trans-Sierran exchange systems and the consequent emergence of territorial control over local resources by host populations, to account for the increases and decreases seen in quarry production. As the Mt. Hicks quarry area appears to have supplied a very different population and clearly played only a minor role in whatever trans-Sierran exchange practices were occurring at different times in the past, it provides an opportunity to study the role that subsistence strategies and technological change may have played in influencing obsidian exploitation. If the major factor influence on production histories at other sources is increased territoriality, then the curve at Mt. Hicks should be divergent; should the production curves look similar, it seems likely that other factors that commonly influence all the sources – such as technological changes to accommodate shifting subsistence-settlement patterns – could be of greater influence on obsidian production curves than territoriality.

In fact, similar technological trends are found across the western Great Basin through time. Mt. Hicks is well suited to testing whether these technological trends, as influenced by shifting mobility and subsistence activities, are the dominant factor shaping obsidian production histories. The area is itself ecologically diverse, making it attractive for more than lithic resources, and therefore likely to have had a full array of economic and habitation activities occurring at the locale. Prehistoric economic activities, of course, were driven by a host of factors, lithic procurement being no exception.

Following this introductory chapter, Chapter Two provides background on the natural environment, regional ethnographic information, and archaeological cultural chronology. The theoretical and conceptual foundation of the thesis is discussed in Chapter Three. Chapter Four describes the distributional field methodology as well as the analytical procedures conducted both on recovered artifacts and those left in the field. Chapter Five presents diachronic results of the thesis including survey and lithic analysis. Chapter Six presents the results of obsidian studies and organizes data by time period. Chapter Seven presents the conclusions of the thesis. Data appendices follow.

Chapter 2

PROJECT CONTEXT

No archaeological study occurs in a vacuum, the context of the work influences both results and interpretation. This chapter provides a brief section on the geology, background for the biotic communities, an integral component of the thesis, a discussion of the past and present climate, archaeological and ethnographic context of the western Great Basin, and a discussion of the implications the context has on the study.

PHYSIOGRAPHY AND GEOLOGY

Mt. Hicks is located in the western Great Basin, generally defined as a series of internally draining basins and north-south trending mountain ranges. The study area is located approximately 50 kilometers northeast of Tioga Pass in the Sierra Nevada. Located in the northeastern corner of the Mono Lake Basin, Mt. Hicks lies within modern boundaries of the Toiyabe National Forest; the research universe itself comprises 40 km^2 and includes Mt. Hicks as well as part of Alkali Valley bordering it on the east. Elevations in surrounding valleys range between 4000 and 6800 feet, though the floor of Alkali Valley is just over 7000 feet in elevation; Mt. Hicks itself rises to 9414 feet. Several springs, ponds, and a small marsh area are found within 10 km of the summit of Mt. Hicks, a spring 8 km north, another 5 km west/northwest, ponds 3.5 km north, another 8.5 km north/northeast, and the marsh 6 km to the west/southwest. These are all easily accessed from any centrally located camp site, with relatively easy travel costs as, with a few exceptions, slopes along the mountain are not as severe as in other nearby mountain ranges.

Part of the Aurora-Bodie volcanic field, Mt. Hicks is a mafic, volcanic vent which last erupted one to six million years ago (Wood and Kienle 1990), and is associated with the Walker Lane fault system which has been active for the last 15 million years (USDA 1991). The area has been volcanically active as long as the fault system, with andesite, dacite, breccias, and ashflow tuffs dated between 8-15 million years ago, underlying younger cinder cones and flows, and covering 80 km^2 (Wood and Kienle 1990). No less than nine other volcanoes lie within 10 km of Mt. Hicks, the closest being Spring Peak (silicic volcanic vent, 1-6 million years old) just 2.5 km to the south, Aurora Peak (mafic volcanic vent, 1-6 million years old) 4 km to the west, Aurora Crater (mafic volcanic vent, last erupted only 250 thousand years ago) 6 km to the northwest, Mud Springs Volcano (mafic volcanic vent, last erupted likely in the late Pliestocene) 10 km to the northeast, as well as five other unnamed vents (Higgins 1985).

Approximately 25 km south/southwest of Mt. Hicks is Mono Lake, which is itself adjacent to the Sierra Nevada mountains in eastern California. This saline lake would have provided a variety of subsistence resources for prehistoric peoples to exploit within its various wetland habitats (Brady 2007); perhaps the most well known ethnographic example is the harvesting of brine fly larvae/pupae (*Ephydra [Hydropyrus] hians*). The Excelsior Mountains lie 21 km to the east/southeast. This area has essentially the same biotic communities as Mt. Hicks, but in addition has an extensive marsh (Teels Marsh) to the south, which again would have provided an extensive array of economic resources.

Elevational differences in the latter area, however, are more pronounced, which would have made access to resources in varying biotic communities far more difficult and time consuming. North of Mt. Hicks, and a bit further afield, is Walker Lake, some 48 km distant. Fed by the Walker River, this area, too, would have provided a abundant resources including several species of fish. Separating Mt. Hicks from Walker Lake, however, is the Wassuk Mountain range which has steep mountains with several rising over 10,000 feet in elevation. East of Mt. Hicks can be found the Garfield Hills, Whiskey Flat, Soda Spring Valley, and the Pilot Mountains. As their names suggest, they have much lower elevations and generally lack productive pinyon-juniper zones; those stands that are present are very restricted in size. Prehistoric peoples traveling from the east would have found it relatively easy to approach Mt. Hicks from Whiskey Flat through the relatively low Anchorite Hills making it the first area they would have encountered with a variety of biotic communities and their accompanying resources.

ENVIRONMENTAL CONTEXT

Given one of the goals of the present research, how technological organization interacted with varying environments, that context is obviously important. The research universe was chosen so that several micro-environments would be represented, with areal constraints imposed by what was believed could be covered by a crew of five individuals over a 10-day work schedule. For purposes of the study, the study area was divided into four readily identifiable micro-environments, though there is certainly variation within each zone. Each environmental zone is defined primarily by vegetation, but they also conform closely with changes in elevation, soil, and climate. Over the years several excellent descriptions have been written (Bettinger 1982b; Billings 1951; Delacorte 1990; Grayson 1993; Hall 1991; Ryser 1985; Smith 2000) detailing the environmental zones and fauna located in the research universe, what follows being a distillation of those as well as personal observation.

Lower Desert Scrub Zone

Lower elevations in the study area, from the valley floor at 7000 feet to roughly 7500 feet, are characterized by a sagebrush/grass vegetation community and encompasses some 6.63 km^2 of the study area. The dominant soil is a coarse, non-acidic sandy loam derived from alluvium of mixed rock sources and volcanic ash. Currently, this area is heavily used for cattle grazing, which has impacted the environment greatly and reduced several native species of plants; large, mechanically excavated watering holes are not uncommon on the valley floor.

The vegetation of this zone consists primarily of low perennial shrubs. These include shadscale (*Atriplex confertiflia*), salt bush (*Atriplex* sp.), greasewood (*Sarcobatus vermiculatus*), Nevada ephedra (*Ephedra nevadensis*), rabbit brush (*Chrysothamus nauseosus*), bud sage (*Artemisia spinescens*), spiny hopsage (*Grayia spinosa*), cottonthorn (*Tetradymia axillaris*), and indigo bush (*Psorothamnus fremontii*). Herbs in this community include chia (*Salvia columbariae*), galleta (*Hilaria jamesii*), blazing star (*Mentzelia* sp.), primrose (*Oenothera* sp.), and glyptopleura (*Glyptopleura marginata*). Some species of cactus (genus *Opuntia*) are also present, though in low numbers.

Important vegetal resources exploited by ethnographic peoples in this environment include ricegrass (*Oryzopsis hymenoides*), Great Basin wild rye (*Elymus cinerus*), giant wild rye (*Elymus triticoides*), needlegrass (*Stipa speciosa*), squirreltail (*Sitanion hystrix*), and wheatgrass (*Agropyron trachycaulum*).

Several species of mammals were also available in this zone (as well as other environmental zones), including large ungulates, rodents, and some carnivores. Artiodactyls inhabiting or visiting this zone include pronghorn antelope (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), and bighorn sheep (*Ovis canadensis nelsoni*),which were available throughout much of the year. In the past, however, the abundance and distribution of these species may have been far different (cf. Grayson 1982).

Various species of lagomorphs and rodents inhabiting this zone include cottontail rabbit (*Syvilagus nuttallii*), black-tailed jackrabbit (*Lepus californicus*), antelope ground squirrel (*Ammospermophilus*), pocket gopher (*Thomomys* sp.), pocket mice (*Perognathus* sp.), kangaroo rats (*Dipodomys* sp.), deer mice (*Peromyscus* sp.), and woodrats (*Neotoma* sp.). Distribution of these species varies through this and other environmental zones, with cottontail rabbits, deer mice, and antelope ground squirrels preferring areas of dense vegetation to hide from predators, other species such as kangaroo rats and pocket mice favoring areas with loose, sandy soil.

Carnivores found in this and other zones include coyote (*Canis latrans*), skunk (*Mephitis mephitis*), gray fox (*Urocyon cinereoargenteus*), mountain lion (*Felis* *concolor*), and bobcat (*Lynx rufus*). Other species of mammals may also have at one time inhabited this zone, but have since become locally extinct (Grayson 1982).

Reptiles found in this zone include zebra-tailed lizard (*Callisaurus draconoides*), sagebrush lizard (*Sceloporus graciosus*), coachwhip snake (*Masticophis flagellum*), gopher snake (*Pituophis melanoleucus*), and western rattlesnake (*Crotalus viridis*). Amphibians are rare in the area, but desert toad (*Bufo punctatus*) occur in localized wetland settings.

A large number of species and subspecies of birds, both perennial and migratory, can be found in the Great Basin. Some that would have used this zone for resources or for nesting include red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), sage grouse (*Centrocercus urophasianus*), California quail (*Callipepla californica*), greater roadrunner (*Geococcyx californianus*), and common poorwill (*Phalaenoptilus nuttallii*). Sage grouse males congregate in large numbers just prior to breeding, which would have made them an excellent target for prehistoric predators, including humans. Sage grouse, California quail, greater roadrunner, and common poorwill all nest on the ground.

Pinyon-Juniper Zone

Superimposed over the sagebrush community at elevations between 7300 and 8000 feet is a pinyon-juniper woodland, which comprises approximately 7.38 km^2 of the study area. The dominant soil is a fine, sandy loam, derived from volcanic rocks, including basalt, and eolian volcanic ash (USDA 1991).

The understory of the woodland is not much different than the dominant species found in the lower desert scrub zone, with big sagebrush, ephedra, bitterbrush, rabbit brush, and broom sagebrush (*Artemisia nova*) being the most important shrubs. Among the herbs that are present are wild rye, ricegrass, squirreltail, bluegrass (*Poa* sp.), junegrass (*Koeleria macrantha*), sego lily (*Calochortus bruneaunis*), and phlox (*Phlox stansbury*). The most important species are Utah juniper (*Juniperus osteosperma*) and, of course, single-leaf pinyon pine (*Pinus monophylla*).

The arrival of pinyon trees in this part of the Great Basin, as well as the history of pine nut exploitation, deserves special consideration in the description of resources found in the vicinity of Mt. Hicks as they would have provided a significant reason for prehistoric groups to visit the area, at least in some time periods. Pinyon nuts were an important resource over much of the Great Basin, as the pine nut of the single-leaf pine tree was a rich source of high quality proteins, fats, and carbohydrates (Lanner 1981). It has been suggested that pinyon trees were very late arrivals to the project area, possibly colonizing only within the last 1400 years. If this is true, then pinyon could not have been an important resource for groups exploiting the Mt. Hicks area until very late in time. This is highly doubtful, however, as there is strong archaeological evidence for their exploitation for the past several thousand years. Grayson (1993: 216-219) gives an excellent summary of this evidence taken from radiocarbon dates of pack-rat middens containing residue of pine needles and pine nuts. The earliest date comes from southeastern Nevada (Meadow Valley Wash) at 6590 BP. Earlier dated strata contained no evidence of pinyon. A little further north there is a date of 6250 BP, and the further north one goes the younger the dates become, suggesting a migration of pinyon from the Mojave Desert region. This is not entirely clear-cut, however, as a very early date, over 7000 BP, has also been obtained that suggests pinyon may have migrated from the north (Grayson 1993). Pinyon trees thrive in warmer weather, and during the middle Holocene temperatures increased from 7-9 degrees F. Grayson also notes that biologists believe that pinyon trees could spread through the highlands of the Great Basin at a rate of 8-12 miles per century, meaning it would take thousands of years to colonize the entire region. If this is so, then it may not have been until late in time that pinyon trees made a foothold in the area of Mt. Hicks, and even later until they became abundant. It is important to note at this juncture that nearly all these data have been gathered from the central Great Basin, not the west.

There is evidence that pinyon may have been present in the western Great Basin as long or longer. In the White Mountains, *Pinus monophylla* has been directly dated to 8790 BP (Jennings and Elliot-Fisk 1992). Studies of woodrat nests have found evidence of pinyon in middens dated to 4980 BP at the nearby Dry Lakes Plateau in the Bodie Hills (Halford 1998: 80). Lanner and Van Devender (1998) note that while pinyon has been found in the Mojave Desert as early as 19,500 BP, poised for a migration north and awaiting only a warming trend, they propose an alternative hypothesis– the so-called Tehachapi route. They propose that pinyon trees migrated either from the southern spur of the Sierra Nevada or possibly even across the range itself. Analysis of pine needles show that western Great Basin samples (from near Mono Lake) are more similar to those found along the aforementioned "Tehachapi route" than those found in the Mojave

Desert. While this might be expected if California pines are descended from Great Basin stock, they cites an earlier study that shows pine trees were present on the western slope of the Sierra Nevada for tens of thousands of years. Cole (1983: 128) studied the late Pleistocene vegetation of Kings Canyon on the western slope of the Sierra Nevada, where in pack rat middens he found pine needles dating to 35,000 BP and suggesting that *P. monophylla* was first present in California on the western slopes and not introduced late in time. Lanner and Van Devender (1998) also note that pine needles have been found in tar pits in the San Joaquin valley, further suggesting they may once have been prevalent throughout the state. If this is so, then pinyon could have taken mere centuries, rather than thousands of years, to spread to the Mt. Hicks area. Furthermore, it would have become an exploitable resource far earlier in the west than in the central Basin, perhaps making the area more attractive to prehistoric peoples.

The specifics of pine nut exploitation lie outside the scope of the study, for the most part, but its importance is not. It is widely believed that initial the means of exploiting this resource was "brown-cone" procurement, a low-cost strategy that entailed waiting until the cones are mature, brown, and brittle. The cones are struck from the tree with simple poles and then struck with a stick to loosen the interior nuts; fallen cones are taken as well (Bettinger and Baumhoff 1983, citing an early ethnographic account). Bettinger and Baumhoff note that shortcomings of this strategy include a limited harvesting time and competition with rodents and birds. In contrast, "green-cone" procurement, which entails harvesting cones while they are still on the trees, is much higher in cost. This strategy, emerging late in time, was used when the cones are mature but still green, covered in pitch, and tightly closed. Hooked poles were used to either shake cones from the limbs or bring them into reach of the collector. Other equipment used included mats, bags, and baskets. Cones were then roasted or left to sun-dry, then pounded with a mano and metate and finally winnowed (Steward 1933: 242). Steward (1933) notes that an individual could harvest up to 40 bushels during the fall. Excess foodstuffs were then cached for later use, especially for the winter season when Paiute peoples would often go up into mountain villages. Using this strategy, competition with rodents and birds is nearly eliminated and harvest times are greatly increased, resulting in higher overall takes of foodstuff, but greater costs make yields lower per unit time (Bettinger and Baumhoff 1983: 832). Both these strategies are performed in the same season, at the same localities, and target the same resources, but Bettinger and Baumhoff (1983) show that they result in different durations, technology, and return rates.

Bettinger and Baumhoff originated the concepts of "green cone" versus "brown cone" as a response to critiques by Simms (1983). In an earlier article Bettinger and Baumhoff (1982) used tenets of optimal foraging theory to explain how Numic speaking peoples could out-compete Prenumic groups over the same landscape by using differing exploitation strategies, the Numic using higher cost collection strategies but having larger overall takes of resources, while the Prenumic used a much lower cost foraging strategy with lower productivity by comparison. Simms (1983) argues that greater technological efficiency aimed at a particular resource is not indicative of that resource's dietary importance. Further, adding experimental observations of his own on pickleweed, he asserts that twined seed beaters (which again occur late in the archaeological record) were not more efficient than simply using a stick to extract seed, and in fact were less efficient. Bettinger and Baumhoff countered with the relatively straightforward example of pine nut exploitation, also noting that Simms' data could simply be wrong due to inexperience with the technology, but more importantly that conditions may have been such that, under the correct circumstances, it simply was more efficient. The most telling argument against Simms, ironically, is the simplest; it is highly unlikely that groups would have invested such great effort on a technology that gave little or no improvement in harvesting such an important resource. This strategy was likely employed very late in time, during the Marana period when there is a general intensification of land-use practices. Pinyon would have been abundant in the Mt. Hicks area from the very beginning of intensive exploitation. This has several serious implications for regional archaeology: first, because green cone exploitation is much more visible in the archaeological record than brown cone procurement, i.e., evidence for this strategy should be apparent during the survey with discovery of at least some milling equipment, caching facilities, and seasonal camps); secondly, it will directly affect how long groups were staying in the area (and thus potentially exploiting obsidian resources) as well as how early in time these prolonged stays began in the region; and finally, it will effect the distribution of artifacts and features within the various environmental zones.

Smaller mammals found in this zone include black-tailed jackrabbit, cottontail rabbit, antelope ground squirrel, pocket gopher, pocket mice, kangaroo rats, harvest mice, deer mice, and woodrats. Carnivores include mountain lion, bobcat, coyote, gray fox, badger, and weasel. Reptiles found in this environmental zone include Great Basin collared lizard (*Crotaphytus bicinctores*), zebra-tailed lizard, desert horned lizard (*Phrynosoma platyrhinos*), sagebrush lizard, racer snake (*Coluber constrictor*), gopher snake, and western rattlesnake.

Some of the species of avifauna that can be found in this zone include American kestrel (though they prefer open hunting grounds), blue grouse (*Dendragapus obscurus*), California quail, mourning dove (*Zenaida macroura*), greater roadrunner, and common poorwill. Blue grouse, California quail, and common poorwill make their nests primarily on the ground, under cover of bushes and downed branches. The nesting habits of mourning doves are more flexible, but generally also on the ground or in low-lying branches of trees or bushes. This would have made hunting these avifauna easier than birds nesting high in trees or cliff sides, and made their eggs more accessible as well.

Upper Desert Scrub Zone

Representing 6.63 km^2 of the study area, the upper desert scrub vegetation community begins at about 8000 feet and continues to the top of the mountain. Soils for the most part consist of gravelly, sandy loams with parent materials of andesite and related rocks as well as eolian volcanic ash. Vegetation tends to be more dense in this zone than at lower elevations (USDA 1991).

Again, vegetation is not much different from that found at lower elevations. Important shrubs again include big sagebrush, ephedra, and bitterbrush, but snowberry (*Symphoricus longiforus*) and wax currant (*Ribes cereum*) are now also present. Herbs are dominated by wildrye, squirreltail, needlegrass, sego lily, buckwheat, as well as mimulus (*Mimulus* sp.), lupine (*Lupinus* sp.), and milk-vetch (*Astragalus* sp.).

Mammals found in this environment are primarily lagomorphs, rodents, and predators. Some of the more important species found here are black-tailed jackrabbit, cottontail rabbit, pocket gophers, deer mice, and, possibly at one time, voles (Grayson 1982). Mountain lion, coyote, bobcat, badger, and weasel are among the predators found in this zone. During the summer months, deer, sheep, and antelope would have been present. Reptiles that can be found in this zone include the desert horned lizard, western fence lizard (*Sceloporus occidentalis*), sagebrush lizard, gopher snake, and western rattlesnake.

Birds found at these higher elevations include the turkey vulture (*Cathartes aura*) which can be found hunting at all elevations, northern harrier (*Circus cyanus*), though rarely, American kestrel, California quail, and mountain quail (*Oreortyx pictus*). Like most quails, the California and mountain quail reside in groups called coveys for most of the year, except during mating season when they break into pairs, and they both nest on the ground.

Lacustrine Zone

Adjacent to Mt. Hicks on the east is Alkali Valley, which has a small seasonal lake. This zone takes up 3.13 km^2 of the study area. Soils in this zone are primarily loamy sands of mixed alluvium. Parent materials are granite, andesite, and volcanic ash and are very alkaline. Silty clay loams are also present. Sand dunes are common and are moderately alkaline. Plant resources in this environmental zone would have been the first available during the spring, when stored resources from winter would be running low.

Not surprisingly, this zone is the most divergent in terms of vegetation. Greasewood (*Sarcobatus vermiculatus*) is a dominant species in this zone due to the alkaline nature of the soil. Other important species include rabbitbrush, shadscale, spiny hopsage, and big sagebrush. Among herbs, saltgrass (*Distichlis spicata*), alkali arrow-grass (*Triglochin debilis*), scratchgrass ((*Muhlenbergia asperfolia*), Nevada blue-eyed grass, as well as indian ricegrass (*Oryzopsis hymenoides*) are present. Other plant resources available in this environmental zone include tomcat clover (*Tifolium tridentum*), cow clover (*Trifolium invlucratum*), tiger lily (*Lilium parvum*), and cattail (*Typha latifolia*).

Several species of mammals would have been available in this zone. Ungulates using this zone would have included mountain sheep, deer, and antelope. Small game found here include cottontail rabbit, black-tailed jackrabbit, ground squirrel, pocket gophers, pocket mice, kangaroo mice, kangaroo rats, deer mice, and woodrats. Though this zone is relatively small, the distribution of these animals would have varied, as each prefers different terrain providing either habitation areas or protection from predators. Those predators include coyote, skunk, gray fox, badger, weasel, bobcat, and mountain lion. Standing water was not always present. During times when it was, the number and diversity of fauna would have been much greater than when the lake was dry.

A diverse array of avifauna, both resident and migratory, occupy this zone, though none can be great in numbers given its limited extent. Migratory waterfowl species

Table 2.1. Some animal and plant taxa found in the Mt. Hicks area, by environmental zone.

Lower Desert	Pinyon-Juniper	Upper Desert	Lacustrine
Flora	Flora	Flora	Flora
Oryzopsis hymenoides	*Oryzopsis hymenoides*	*Elymus cinerus*	*Sarcobatus vermiculatus*
Elymus cinerus	*Elymus triticoides*	*Sitanion hystrix*	*Chrysothamus nauseosus*
Elymus triticoides	*Sitanion hystrix*	*Stipa speciosa*	*Artiplex confertiflia*
Stipa speciosa	*Ephedra nevadensis*	*Calochortus bruneaunis*	*Grayia spinosa*
Sitanion hystrix	*Chrysothamus nauseosus*	*Atriplex* sp.	*Distichlis spicata*
Agropyron trachycaulum	*Artemisia tridentata*	*Ephedra nevadensis*	*Triglochin debilis*
Atriplex conifertiflia	*Artemisia nova*	*Symphoricus longiforus*	*Muhlenbergia asperfolia*
Atriplex sp.	*Poa* sp.	*Ribes cereum*	*Oryzopsis hymenoides*
Sarcobatus vermiculatus	*Koeleria macrantha*	*Mimulus* sp.	*Tifolium tridentum*
Ephedra nevadensis	*Calochortus bruneaunis*	*Lupinus* sp.	*Trifolium invlucratum*
Chrysothamus nauseosus	*Phlox stansbury*	*Astragalus* sp.	*Lilium parvum*
Artemesia spinescens	*Juniperus osteosperma*	Fauna	*Typha latifolia*
Grayia spinosa	*Pins monophylla*	*Syvilagus nuttalli*	Fauna
Tetradymia axillaris	Fauna	*Lepus californicus*	*Syvilagus nuttallii*
Psorothamnus fremontii	*Odocoileus hemionus*	*Thomomys* sp.	*Lepus californicus*
Salvia columbariae	*Lepus californicus*	*Peromyscus* sp.	*Ammospermophilus*
Hilaria jamesii	*Syvilagus nuttalli*	*Felis concolor*	*Thomomys* sp.
Menzelia sp.	*Ammospermophilus*	*Lynx rufus*	*Perognathus* sp.
Oenothera sp.	*Thomomys* sp.	*Canis latrans*	*Dipodymys* sp.
Glyptopleura marginata	*Perognathus* sp.	*Taxidea taxus*	*Peromyscus* sp.
Opuntia	*Dipodymys* sp.	*Mustela franata*	*Neotoma* sp.
Fauna	*Peromyscus* sp.	*Odocoileus hemionus*	*Canis latrans*
Syvilagus nuttallii	*Neotoma* sp.	*Antilocapra americana*	*Mephitis mephitis*
Lepus californicus	*Canis latrans*	*Ovis Canadensis nelsoni*	*Urocyon cenereoargentueus*
Ammospermophilus	*Lynx rufus*	Reptiles	*Felis concolor*
Thomomys sp.	*Urocyon cinereoargenteus*	*Phyrynosoma platyrhinos*	*Lynx rufus*
Perognathus sp.	*Felis concolor*	*Sceloporus graciosus*	*Taxidea taxus*
Dipodomys sp.	Reptiles	*Pituophis melanoleucus*	*Mustela franata*
Peromyscus sp.	*Callisaurus draconoides*	*Crotalus viridis*	Avifauna
Neotoma sp.	*Sceloporus graciosus*	*Sceloporus occidentalis*	*Fulica americana*
Canis latrans	*Pituophis melanoleucus*	Avifauna	*Charadrius vociferus*
Mephitis mephitis	*Crotalus viridis*	*Falco sparverius*	*Capella gallinago*
Urocyon cenereoargenteus	*Crotaphytus bicinctores*	*Cathartes aura*	*Actius macularia*
Felis concolor	*Phyrynosoma platyrhinos*	*Circus cyanus*	*Recurvirostra americana*
Lynx rufus	*Coluber constrictor*	*Callipepla californicus*	*Himantopus mexicanus*
Reptiles	Avifauna	*Oreortyx pictus*	*Steganopus tricolor*
Callisaurus draconoides	*Falco sparverius*		*Ardea herodius*
Sceloporus flagellum	*Callipepla californicus*		*Podiceps nigricollis*
Pituophis melanoleucus	*Geococcyx californianus*		*Phalacrocorax auritus*
Crotalus viridis	*Phalaenoptilus nuttalli*		*Laras delawarensis*
Avifauna	*Dendragapus obscurus*		*Branta canadensis*
Buteo jamaicensis	*Zenaida macroura*		*Anas* sp.
Falco sparverius			*Aytha* sp.
Centrocercus urophasianus			*Bucephala albeola*
Callipepla californicus			*Oxyura jamaicensis*
Geococcyx californianus			*Mergus meranser*
Phalaenoptilus nuttallii			

include Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), gadwall (*Anas stepera*), pintail (*Anas acuta*), green-tailed teal (*Anas crecca*), blue-winged teal (*Anas discors*), cinnamon teal (*Anas cyanoptera*), American widgeon (*Anas americana*), northern shoveler (*Anas clypeata*), redhead (*Aythya americana*), canvasback (*Aythya valisineria*), lesser scaup (*Aytha affinis*), bufflehead (*Bucephala albeola*), ruddy duck (*Oxyura jamaicensis*), and common merganser (*Mergus meranser*). Most of these species migrate in the spring and fall, residing during the winter. The number of waterfowl present at any one time would depend heavily on the amount of water present.

Migratory shorebirds are also present, for the most part only during the spring and fall migrations. These species include killdeer (*Charadrius vociferus*), common snipe (*Capella gallinago*), spotted sandpiper (*Actitis macularia*), American avocet (*Recurvirostra americana*), black-necked stilt (*Himantopus mexicanus*), Wilson's phalarope (*Steganopus tricolor*), great blue heron (*Ardea herodias*), eared grebe (*Podiceps nigricollis*), double-crested cormorant (*Phalacrocorax auritus*), and ring-billed gull (*Laras delawarensis*).

Discussion of Environmental Zones

The four broadly defined environmental zones as defined above would have varied in their importance to prehistoric peoples. Changing adaptive patterns and strategies would have determined how each zone was exploited. The upper desert scrub contains vegetal and faunal resources that were important in all time periods to at least some extent, but these same resources can be found at lower elevations and were thus cheaper to exploit elsewhere. The major draw of this zone is the number of large ungulates that could be found here. If, in fact, pre-Archaic peoples emphasized hunting in their subsistence strategy, this zone may have been most valuable during that era. Hunting, of course, would have been engaged in throughout prehistory, but with early peoples moving through the landscape quickly, and little reason for later peoples to stay for extended periods, the archaeology can be expected to be sparse and somewhat diffuse with the exception of specialized hunting camps.

The pinyon-juniper zone is an altogether different matter. Given that pinyon was likely present throughout a large portion of the Holocene, likely from 5000 BP, this may have been an important magnet resource for much of that time. The low cost of brown-cone procurement would have made this zone attractive for exploitation early in time. The pinyon-juniper woodland would have increased in importance later in time when land-use intensified and there was a shift to a green-cone strategy.

The lower desert scrub zone does not have the appeal of the other zones, *i.e.,* the presence of large numbers ungulates for hunting, a readily and easily harvested nut crop, or extensive spring grasses and large numbers of migrating birds. It does have the benefit of being low in elevation and having abundant, though lower-ranked vegetal resources. Smaller game is present and resources would have been exploited from late spring through the early fall, long enough to fill the void between spring exploitation of the lacustrine zone and fall use of the pinyon-juniper woodland. This zone would have been the least attractive to regional populations until quite late in time, when the lower-ranked resources in this zone would have become increasingly valued.

The lacustrine zone is another which would have been a major draw throughout time. The bounty of spring grasses would have provided important, if not vital, resources following winter seasons. Likewise, the presence of water attracted larger mammals that would have been hunted by prehistoric peoples, not to mention the water itself. Avifauna, especially during migrations, would have been an especially important and abundant resource. The presence of habitation sites among the sand dunes adjacent to the lake attest to this, though they are probably a late prehistoric phenomenon; it will be left to the hydration analysis to determine when these deposits were occupied. Regardless, this zone likely rivals the pinyon-juniper in importance through prehistory.

PRESENT AND PAST CLIMATE

Climate in eastern California and western Nevada is affected by several factors. During the summer months, nearly all air entering the region derives from over the Pacific Ocean, across California, and over the Sierra Nevada mountain range, arriving primarily as clear, dry air (Powell and Klieforth 1991). Little precipitation falls in the region from this weather pattern, due to the strong influence of the rain shadow effect of the Sierras. Occasionally, a flow of moist, maritime, tropical air from the Gulf of Mexico or the Gulf of California will become dominant, but usually only for very short periods of time. When this does occur, however, it accounts for much of the precipitation in the area, and makes thunderstorms possible. Precipitation is greatest during the winter months, when air flow is dominated by fronts from the Gulf of Alaska, lower latitudes, and very occasionally from northerly areas such as Canada and the Rocky Mountains. At

Mt. Hicks, as other mountainous areas, precipitation varies with elevation. The valley floor averages only 20.0 cm of rainfall per year, gradually increasing to 35.6 cm at the highest elevations (USDA 1991).

Temperature also varies with elevation, warmer weather increasing as elevation decreases, but can also have dramatic shifts from day to night. Temperature averages 9.4°C in the valley bottom, cooling to an average of 6.7°C at the highest elevations.

The temperature and precipitation data (Table 6.2) were taken from a soil survey conducted during the early 1990s (USDA 1991) and reflect two or three years of collected data. Though they fit well with regional data, a closer look at longer-term data gathered from various Nevada weather stations is warranted and sets Mt. Hicks in a wider context. As shown in Table 2.2, temperature declines and precipitation increases to the west (Bridgeport seems to be an exception, but yearly snowfall there is much higher). Mt. Hicks is closest in both of these measures to Bodie. Hawthorne, further east, is much higher in temperature and lower in precipitation. In fact, this trend of decreasing precipitation from west to east can be found throughout the region: Mono, (CA) at 35.6 cm; Benton, (CA) at 19.1 cm; Schurz, (NV) at 12.2 cm; Mina, (NV) at 11.4 cm; and

Table 2.2. Nevada weather station data from areas surrounding Mt. Hicks.

Station	Low Avg. Temperature	High Avg. Temperature	Total Average Yearly Precipitation*
Bridgeport, CA	4.5°C (Jan.)	28.5°C (July)	22.9 cm
Bodie, CA	-14.6°C (Jan.)	24.9°C (July)	32.8 cm
Hawthorne, NV	-4.6°C (Jan.)	35.7°C (July)	11.4 cm

*Does not include snowfall.

Tonopah, (NV) at 12.4 cm. Taken as a rough indicator for environmental productivity in an area, again Mt. Hicks is among the first areas of relatively high resource availability for peoples coming in from the east.

Prior to the establishment of this modern pattern in the early Holocene there were large lakes in the area, such as Lake Lahontan, and modern channels would have had perennial water flow, and likely more robust spring flows. Mifflin and Wheat (1979) hypothesize that only a relatively small change in annual average temperature (2.7°C increase), and a shift in rainfall patterns from predominately winter precipitation to the modern more even distribution, was necessary to dessicate Lahontan Lake, along with smaller lakes such as Alkali Lake.

Decades of research in the western Great Basin incorporating various paleoenvironmental data including studies on packrat middens, tree rings, lacustrine sediments, and pollen profiles (Elston 1982; Mehringer 1986; Kohler and Anderson 1995; Stine 1990) indicate a fluctuating environment since the end of the Pleistocene. The first half of the early Holocene (10,500-8500 BP) is characterized by relatively cool-moist conditions, followed (8500-6000 BP) with a warm-dry climate, and then by a series of shorter time spans of alternating cooler and warmer periods extending into the late Holocene; cool-moist from 6000-5300 BP, warm-dry from 5300–3400 BP, cool-moist from 3400-2200 BP, warm-dry and warm-moist from 2200-1700 BP, cool from 1700-1100 BP, cool-moist from 1100-950 BP, arid from 950-750 BP, and cool from 750-200 BP.

Closer to Mt. Hicks, pinyon was present in rat middens since at least 4980 BP, perhaps earlier (Halford 1998: 94), during a warm-dry period. Data from the Dry Lakes Plateau, Bodie Hills indicate that flora has been remarkably stable for much of the Holocene, reaching modern distribution about 2000 BP (Jennings and Elliot-Fisk 1993; Halford 1998:92). Research by Mifflin and Wheat (1979) support this view, but hypothesize that cooler temperatures and greater precipitation would have shifted biotic communities down as much as 2000 feet in elevation, meaning it is possible that the pinyon-juniper zone may have extended down to, or near, the bottom of Alkali Valley twice during the last 5000 years.

Unfortunately, no direct research has been conducted on the levels of Alkali Lake during the Holocene. It is likely that the lake became at least seasonally desiccated during the terminal Pleistocene along with most lakes in the region. Data on nearby Mono Lake, Lake Tahoe, and on the Dry Lakes Plateau, however, can provide proxy information on possible lake stands or at least relative productivity for the past several thousand years.

Stine (1987) in his study of Mono Lake shows several fluctuations over the last 3850 years. From 3850 BP to 1850 BP he shows a gradual decline from a high of 1981 m to a low of 1941 m. Over the remaining time up until the present there are no less than 11 fluctuations, most occurring in the last 1000 years and varying from lows of 1941 m to highs of 1968 m. Alkali Lake was likely still only a seasonal lake during this interval, but the six high stands at 3550 BP, 1300 BP, 800 BP, 650 BP, 500 BP, and 350 BP may have been times of exceptional productivity.

Earlier data are available for Lake Tahoe (Lindstrom 1990), where there were low lake levels at 6300 BP of 1893 m, followed by a gradual rise to 1897 m by 5600 BP, a drop to 1895 m at 5400 BP with an almost immediate rise to 1897 m, a drop to 1896m at 5200 B.P., and finally a rise and leveling off from 5150-4900 BP at 1897 m. These data are a bit further afield and are based on submerged tree trunks, and the author admits the possibility that fluctuating lake stands may be due to tectonic activity.

Much closer and more relevant to the current research are data from the Dry Lakes Plateau in the Bodie Hills (Halford 1998), which has lower elevations, including its two dry lakes (the aptly named West Lake and East Lake), identical to Alkali Lake and located only 12.9 km to the west. Based on woodrat midden macrofossils, Halford infers the climate and hydrology of the Plateau for the last 5360 years. He shows alternating periods of warm-moist with warmer-less moist/cooler-less moist/more moist conditions. His interpretation is that the lakes were seasonally flooded, with seasonal productivity varying from mid-late summer through the early fall (Halford 1998:82 [Table 2.3]).

Table 2.3 shows that Halford's (1998) reconstruction of the paleoenvironments on the Dry Lakes Plateau conforms fairly closely to regional data. Likewise, his periods of high effective precipitation correspond with Stine's research showing high stands at Mono Lake. It is reasonable to assume that the climate at Mt. Hicks was similar to that on the Dry Lakes Plateau; productivity would have been particularly high during the middle Holocene, when pinyon would have first appeared, and again during the middle late-Holocene around 3120 BP, perhaps prompting longer stays by groups in the area during these times.

Table 2.3. Paleoenvironment of the Dry Lakes Plateau Based on Woodrat Midden Macrofossils and Great Basin Regional Climate (Based on Halford 1998:82).

Years B.P.	Inferred Climate of the DLP	Inferred Hydrology of DLP	Great Basin Regional Climate
Present	Warm and Moist, High Effective Precipitation	Lakes Seasonally Flooded-Productive through Early Fall	Warm and Moist
540 B.P.	Moderately Warm and Moist, Effective Precipitation Moderately High	Lakes Seasonally Flooded-Productive through Mid-Late Summer	Transition from Medieval Warm Period to Little Ice Age
3120 B.P.	Warm and Moist, High Effective Precipitation	Lakes Seasonally Flooded-Productive through Early Fall	Cool and Moist Neoglacial Period
4060 B.P.	Transition from Warm less Moist to Cool more Moist, Effective Precipitation Moderate	Lakes Seasonally Flooded-Productive through Mid-Late Summer	Transition to Neoglacial Period
4980 B.P.	Warm and Moderately Dry, Moderate to High Effective Precipitation	Lakes Seasonally Flooded-Productive through Mid-Late Summer	Warm and Moist
5260 B.P.	Warm and Moist, High Effective Precipitation	Lakes Seasonally Flooded-Productive through Early Fall	Warm and Moist

ARCHAEOLOGICAL AND ETHNOGRAPHIC CONTEXT

Western Shoshoni and Northern Paiute Ethnography

Ethnography can provide insight into why the archaeological record appears as it does. Thomas (1973) tested Steward's (1938) model of subsistence and settlement patterns in the Great Basin, including areas to which Mt. Hicks glass was transported, and finds that he is essentially correct that there was no appreciable change over time(Thomas 1973), at least for the Reese River Valley. Steward's work is not without some criticism (Fowler 1982; Thomas 1983), nor was he an archaeologist or examining archaeological data, nevertheless his monograph at the very least provides context for the late archaeological record. As the Reese River Project shows, however, the patterns he describes may have been in place deep into the Late Archaic. The following paragraphs give only a very brief outline of the ethnography of the Western Shoshoni, whose area is where Mt. Hicks obsidian is found most often and abundantly, and the Northern Paiute, which most often used the glass of previously studied quarries as well as Mt. Hicks to some extent; the section draw heavily on Steward (1933, 1938) and Fowler's (1982) synopsis of ethnography in the Great Basin.

Steward describes the Western Shoshoni as living in small family groups, each working as essentially an independent economic unit. Their subsistence pattern consisted of foraging for a broad range of plant resources, supplemented by hunting and sometimes fishing. This pattern was implemented within a roughly 20 mile radius of winter villages. Annual rounds were usually very regular, but variation in spatial and temporal resource availability could change areas that were exploited. After harvesting season, families would return to their winter villages where they remained until the following spring and began the pattern over again. Steward noted that this cycle could be altered in areas where resources were more abundant, such as at Reese River Valley and Ruby Valley.

Winter villages were located most often in the mouth of canyons, pinyon-juniper zones, or in broad valleys near fishing streams. How cohesive each "village" actually was depended greatly on how much food could be gathered and stored within a convenient distance from each individual camp. This could result in camps being scattered anywhere from a few hundred yards apart up to a mile or more, or the clumping of 15 to 20 camps to form a true village; some camps were isolated. The composition of individuals in each camp could vary highly from year to year. It was this, as well as the highly variable nature of the annual rounds, that led Steward to believe that ownership of resource areas and the development of territorial rights were largely precluded. This also prohibited social and political cohesion as well as the formation of corporate land-holding bands. He also believed this pattern was likely generally true of the entire Great Basin with the exception of Owens Valley.

A very different picture is shown for Northern Paiute groups, and the Owens Valley in particular. There, Steward describes permanent villages and actual composite land-owning bands as being common. Villages were usually located on lower margins of alluvial fans from streams issuing from the mountains, with some villages containing up to 200 individuals. As for all groups in the Great Basin, a wide variety of food resources were used. Due to the environmental structure of the valley, however, most of these resources could be reached within a days walk of the village. Population groups in Owens Valley also irrigated root crops and seed plots, which may have helped maintain population stability. The only population movements necessary were to exploit pine nut resources (and occasionally acorn), when the village would travel up to the pinyon-juniper zone and disperse onto family owned plots, with some choosing to remain for the winter and live on cached food.

Early Holocene (12000? - 8000 B.P.) – Lake Mohave

Relatively little is known about the terminal-Pleistocene/early-Holocene, Lake Mohave Phase (Table 2.4) in the western Great Basin. Sites are few and generally consist of sparse flaked stone scatters that give little indication of their age unless subjected to obsidian hydration (Basgall *et al.* 2003).

Table 2.4. Chronological phases of the western Great Basin.

Phase	Years B.P.	Diagnostic Artifacts	Adaptive Strategy
Mohave	12000?-8000	Great Basin Stemmed	Pre-Archaic
Little Lake	8000-4000	Little Lake series, Pinto, Gypsum Triple T, Gatecliff series	Early Archaic
Newberry	4000-1350	Elko series, Humboldt	Middle Archaic
Haiwee	1350-650	Rose Spring, Eastgate	Late Archaic
Marana	650-Contact	Cottonwood, Desert series, Brownware pottery	Late Archaic

Diverse obsidian source profiles suggest that mobility was far ranging if somewhat irregular (Basgall 1988, 1993; Delacorte 1999; Delacorte *et al.* 1995), though this does not appear to be consistent throughout the Great Basin (Willig and Aikens 1988). Groups are thought to be small, having great mobility in terms of frequency of moves and distance traveled, and exploiting a wide variety of resources (Basgall 1988, 1989; Basgall and McGuire 1988; Beck and Jones 1990; Milliken and Hildrebrandt 1997). That said, hunting appears to have been a primary focus for these early groups based on assemblages of mainly flaked stone artifacts and a dearth of milling equipment; these patterns suggest that seed resources, at least, were not important (Basgall 1988, 1993; Davis 1964; Hall 1990).

Technologically, a number of fluted and non-fluted concave-base points, often edge-ground, morphologically similar to points found in the Great Plains and the Southwest, have been reported and are indicators of this time period (Basgall 1987, 1989; Davis 1964; Hall 1990). Obsidian hydration dating indicates that they date in excess of 9000 BP. (Basgall 1988). Also diagnostic of this interval are the Great Basin Stemmed series of points, consisting of "Silver Lake" points which are short-stemmed and wellshouldered, and "Lake Mohave" points which are long-stemmed and weakly-shouldered (Basgall and McGuirre 1988; Davis 1964; Gilreath and Hildebrandt 1990; Hall 1990; Harrington 1957; Jackson 1985). These points frequently co-occur with a range of highly formalized flake tools such as scrapers, gravers, and, less frequently, crescents.

Middle Holocene (8000 - 4000 BP) – Pinto

There are relatively few sites dating to the middle Holocene in the area. Some of the more notable exceptions to this are the Stahl site (Harrington 1957; Meighan 1981) and several sites investigated during the Alabama Gates project (Delacorte et al. 1995; Delacorte 1999). Trends in mobility and resource intensification, which continue through the rest of the record, begin here. Recently it has been argued that the culture-history of this interval is in need of drastic revision (Basgall et al. 2003), characterized by more varied time-sensitive artifacts than first recognized which have been mis-identified or forced into existing classifications. Also, the age ranges of some points forms are dramatically different than originally thought; a more thorough discussion of these marker artifacts follows the outline of mobility and subsistence.

Mobility is still thought to be high, as material source profiles still show varied locations, with high intra-site variability (Delacorte 1999), which has been interpreted as indicating a non-regimented, loosely structured settlement. Further, in the Mojave Desert, sites dating from this time tend to occur as large accumulations in limited locations, which has been interpreted as reoccupation or regular visitation to more productive environments (Basgall 2000).

While hunting is still important, a more varied array of environmental zones was exploited, with plant and broad-spectrum resources in general becoming more important, and the practice of food storage also appearing (Basgall 1989; Bettinger 1982b; Elston 1986). At least late during this interval, pinyon exploitation evidently began (Basgall et al. 2003; Bettinger 1982b; Elston 1986), as well as the use of wetland resources (Basgall and McGuirre 1988; Basgall et al. 2003; Delacorte 1998; Zeanah and Leigh 2002) including fish, waterfowl, and amphibians. These changes were probably not triggered by demographic growth, as the scarcity of sites suggest population densities were still relatively low, but rather by changing environmental conditions. It is during this interval when lakes and marshes were becoming desiccated, and when pinyon may have first appeared in the western Great Basin; with fewer "good" areas to exploit, prehistoric peoples would have needed to visit environments that were still highly productive more often than previously and expand their diet breadth.

Technologically, tool kits seem to have smaller and less specialized tools, but still look to be curated and apparently designed for transport (Bettinger 1982b; Delacorte et al. 1995; Delacorte 1999; Elston 1986). Tools are more diversified, however, and include a variety of projectile points, formed and simple flake tools, cobble tools, as well as well-worn and formal handstones and millingslabs. Overall, these tool kits are more diverse in comparison to later periods.

As mentioned earlier, time-sensitive artifacts, specifically projectile points, are much different than originally thought both in terms of time range and variety of morphological types. Two bifurcate stemmed projectile points types with very different temporal ranges appear to be present (Basgall and Hall 2000). Robust forms (Pinto series) seem to dominant in the southern portion of the western Basin and seem to be quite early (8000-4000 BP), while more gracile forms (Little Lake or Gatecliff split-stem series) are more prevalent in the north and east and date later in time (5000-3000 BP). Adding to this complexity are the more recently identified Fish Slough Side-notched variant (Basgall and Giambastiani 1995; Basgall et al. 1995) and the "thick Elko" projectile point (Gilreath and Hildebrandt 1997). These last two points have often remained unidentified and confused with other morphological types, resulting in sites being erroneously assigned to the wrong time period.

In the more central part of the Great Basin, large, wide, concave-base points called Triple T points are diagnostic of the early part of this phase, while Gypsum points have been subsumed within the Gatecliff series, and are associated with the latter part of the phase. Large numbers of Gatecliff series points in Reese River and Monitor valleys have led some researchers to believe this indicates an increase in population and greater use of upland areas, possibly including pinyon nut exploitation (Thomas 1983). Considering the changing environment and subsistence patterns of this time, it seems more likely that here as well groups were targeting the few remaining high productivity areas repeatedly.

Late Holocene (4000 - 1350 BP) – Newberry

This time period is much better understood than previous ones. This is likely due to the larger "footprint" that biface technology leaves as well as it being younger in age and therefore simply more visible. There do appear, however, to be a much greater number of sites dating to this time, implying that populations were growing.

Source variability of obsidian is high during this period, and toolstone material from distant sources is abundant, indicating that mobility patterns were wide-ranging; an increase in the consistency in volcanic glass type, moreover, also suggests that movement was very regularized (Basgall et al. 2003; Basgall 1989; Basgall and McGuire 1988; Delacorte 1999; Delacorte et al. 1995). This is not always consistent, however, as it is common for flaked stone tools in sites near obsidian sources to be dominated by that source (Basgall et al. 2003). More than just moving in regularized seasonal rounds from camp to camp, as was likely the pattern previously, settlement patterns indicate that groups exploited surrounding landscapes with specialized logistical forays (Basgall 1989; Delacorte 1990, 1999; Delacorte et al. 1995).

Hunting remains an important aspect of subsistence, but continuing the trend that started in the middle Holocene food resources are increasingly diversified and new micro-environmental zones are also utilized (Elston 1986). Wetland resources became very important during this period, with the remains of fish, waterfowl, and wetland plant taxa becoming most common of any interval (Basgall et al. 2003; Basgall and McGuire 1988; Delacorte 1999; Zeanah and Leigh 2002). It is also during this time that pinyon nuts become a regularly exploited, though probably not staple, resource (Basgall et al. 2003). This overall intensification of resource procurement is also evidenced by high altitude winter encampments, large midden accumulations, and well-built house structures (Basgall et al. 2003).

It is during this period that the use of biface technology reaches its zenith (Gilreath and Hildebrandt 1997; Ramos 2000; Singer and Ericson 1977), as well as an increase in the variety of highly formalized and curated tools (Basgall et al. 2003). The greater reliance on biface technology in combination with regularized, long distance travel, likely spurs activity along the Sierran front; obsidian sources including the Bodie Hills, Pine Grove Hills, and Mt. Hicks exploited to a greater extent (Elston 1986). There is also an increase in the number and diversity of ground stone artifacts (Basgall 1988, 1989; Basgall and McGuire 1988; Delacorte 1997, 1999). Elko series dart points are diagnostic of this time period throughout the western and central Great Basin (Bettinger and Taylor 1974; Thomas 1981), first appearing perhaps as early as 4000 BP and staying in the record as late as 1350 BP (Basgall 2002). Other points are also somewhat indicative of this time, but vary somewhat in their introduction and persistence. Humboldt Basal-notched variants are believed to be diagnostic of this time period, but persist slightly into the Haiwee era (Basgall et al. 2003; Basgall and McGuire 1988; Delacorte 1999); likewise, Humboldt Concave-base are also considered markers but appear prior to 3200 BP.

Late Holocene (1350 - 650 BP) – Haiwee

Long-term trends initiated earlier continue to develop during the Haiwee period. The pace and magnitude of changes, however, are especially large in regard to mobility, intensification of resource use, settlement, and technology (Basgall 1988, 1989; Basgall and Giambastiani 1995; Basgall and McGuire 1988; Bettinger 1989, 1991; Bettinger and Baumhoff 1982, 1983; Delacorte 1997, 1999).

Source profiles on lithic materials indicate that mobility during this time period is greatly reduced (Basgall 1989; Jurich 2003). Moreover, analysis of debitage and flaked tools showed a disjunct between the two during earlier time periods, leading some researchers to conclude that the raw material was collected while in the course of residential moves, while during this interval the profiles of debitage and formal tools are more closely matched. This has been interpreted to mean that more regularized exchange and interaction had taken root (Basgall 1989). If so, this could imply that movement was even more restricted than the source profiles might indicate.

As mentioned earlier, subsistence/settlement patterns continue to intensify. Residential locations in pinyon-juniper woodland appear; it has been noted that this would not have been an economical strategy unless pinyon had become an important resource for groups to utilize over the lean winters, necessitating greater efforts in procurement, processing, and storage (Basgall et al. 2003; Bettinger 1977). More "marginal" areas, such as the Volcanic Tablelands, also begin to be exploited more heavily for their abundant, but costly, seed resources (Basgall and Giambastiani 1995).

There are several arguments regarding why these major changes in regional land-use and subsistence occurred including population increase, environmental change, technology and innovation, sociopolitical/economic factors, or combinations of these (Basgall and Giambastiani 1995; Basgall and McGuire 1988; Bettinger 1990, 1991; Delacorte 1999; Delacorte et al. 1995). An important factor in all of this, which is still up for debate, is the pace at which these changes took place (Basgall et al. 2003). Factors such as population growth and sociopolitical/economic change imply that subsistence-settlement patterns may have evolved gradually, while technology and climate change lend themselves to arguments of rapid change. It is not difficult, however, to imagine a feedback relationship, where an important technological change leads to growth in population which in turn spurs other changes.

Technologically, there is a much less reliance on biface technology (Gilreath and Hildebrandt 1997; Ramos 2000; Singer and Ericson 1977) and increasing use of less formalized flaked stone tools (Delacorte and McGuire 1993; Jurich 2003). Milling technology incorporates larger numbers of items that are less formalized but still heavily used. The technological change possibly having the greatest impact was the introduction of the bow and arrow at ca. 1300 BP. Bettinger (1999) and Delacorte (1999) argue that it is this technology that makes it possible for groups to switch from making the basic economic unit the band (several families traveling and working together) to the individual household. The bow and arrow, being a more efficient hunting technology, reduces the foraging returns of individual hunters who are no longer reliant on the group. This in turn makes it now economically feasible for households to privatize both resources and tools (Delacorte 1999). The two projectile point types that are diagnostic of this time period are the Eastgate point and the Rose Spring point.

Late Holocene (650 - Contact) – Marana

It is during this phase that prehistoric groups in the western Great Basin may have adopted the subsistence-settlement strategy that was described by Steward (1933, 1938), and assessed archaeologically by Thomas (1973). Later research (Basgall et al. 2003; Basgall and Delacorte 2003; Zeanah and Leigh 2002) would seem to confirm this, but the home range and district system described by Steward in Owens Valley may be a purely historical phenomenon with little in the way of archaeological evidence to document it earlier in time.

Mobility appears curtailed during this era, obsidian source profiles showing a dominance of local glasses (Basgall 1989; Basgall and Delacorte 2003; Basgall et al. 2003; Zeanah and Leigh 2002), though there are slightly higher frequencies of eastern, Nevada-derived glasses in Owens Valley. Small, diffuse sites even in the supposedly densely populated Owens Valley indicate occupations were of household size, settlements generally located on valley floors.

Resource extraction again intensifies during this phase and more low-ranked resources, such as freshwater mussel, enter the diet (Basgall and Giambastiani 1995). Use of riparian resources seem complex. In some areas, these resources seem to become less important late in time, though some researchers (Basgall et al. 2003) attribute this to scheduling conflicts with the intensification of seed resources; and the fact that only one or the other could be readily exploited at a time. In areas near wetlands, however, research has shown that a wide variety of available resources such as small fish, wetland plants, waterfowl, and freshwater mussel were all exploited (Delacorte 1999). At other sites, by contrast, some only 2 km away from wetlands, no resources from these habitats were found whatsoever (Zeanah and Leigh 2002). This is likely due to constraints on mobility caused, again, by scheduling conflicts (Basgall et al. 2003).

It is during this phase that use of flaked stone implements apparently plummets (Gilreath and Hildebrandt 1997; Singer and Ericson 1977; Ramos 2000). There is an increased reliance on simple flake tools, suggesting that tasks which in the past were accomplished with bifaces and formed flake tools were now performed with these more expedient implements. Perhaps more importantly, the form of the bifaces that are found may be different than previous phases, with middle-stage bifaces perhaps becoming more dominant and later stage specimens reduced in importance (Jurich 2003). Pottery is also introduced during this phase, possibly indicating a strategy to increase return rates of some resources by increasing cooking efficiency (Pierce 2004). Projectile points diagnostic to this time period are small, triangular arrow points, the Cottonwood and Desert Side-notched forms. These forms tend to be smaller than earlier arrow points and darts, and thus could be fashioned from much smaller masses of material.

IMPLICATIONS FOR THE RESEARCH

The interactions of environment with subsistence-settlement patterns and flaked stone technology would have guided how obsidian was exploited by aboriginal groups in a variety of ways; in the amount of material that was used, where and under what circumstances exploitation was taking place, as well as the form of flaked stone artifacts.

During the earliest part of the archaeological record, the Lake Mohave period, there is expected to be little evidence in comparison to later occupation in the Mt. Hicks area. Populations were presumably very low and groups did not stay in any one location for very long, opting for frequent moves to areas with the highest return rates for hunting and gathering, though plant use seems low. Mt. Hicks, however, would have been a very productive area in for high-return resources so there is almost certainly to be some evidence of early groups. Given the apparent emphasis on hunting, artifacts from this earliest phase will likely be found in the higher elevations of the research area. Another area could include the ancient shoreline of Alkali Lake for readily accessible spring plant resources or animals visiting the lake for water.

The ensuing Pinto Period is more complicated to predict. Many of the patterns seen in the early-Holocene are still expected, but changing environmental conditions forced changes in habitation and mobility strategies. Given that Mt. Hicks was still probably productive relative to other resources areas, groups active during this interval would have likely visited the area repeatedly. Population densities, while probably not high enough by themselves to trigger the changes seen during this time, were still likely higher than during the previous Lake Mohave period. These two factors make it highly probable that there will be more archaeological remains found in larger accumulations dating from this period that the previous. These artifacts will again likely be found in the higher elevations and in greater numbers along the shrinking shoreline of Alkali Lake as wetland resources became more important. The exploitation of lower ranked resources, including the possible use of pinyon very late during this phase, makes it likely that at least some artifacts will be found in every environmental zone, albeit in lower numbers.

Several factors operating during the Newberry phase likely result in the most obsidian use across all environmental zones and archaeological phases. Mobility is more regularized but still high in terms of distance traveled, the spectrum of exploited food resources continues to expand, population continues to increase, and most importantly, the use of biface technology reaches its zenith. Many of these factors are, of course, interconnected. The Mt. Hicks area would have been highly productive during much of this interval with high effective precipitation. The higher elevations, as during all phases, would have been attractive due to hunting of large ungulates, but now the pinyon-juniper zone would have increased in importance. The lower desert scrub zone also would have seen greater use for exploitation of seed resources, and lacustrine resources were highly utilized during this period. Factor in the abundant amounts and easy access to obsidian in all environmental zones and it seems clear that this phase will be well represented, especially with regards to biface technology.

Even though regional subsistence-settlement patterns change drastically during the ensuing Haiwee period, it must be assumed that use of the Mt. Hicks area was still high. Resources, specifically pinyon, which likely become important during this period, would have been abundant in the area. Some of the largest outcrops of obsidian cobbles on Mt. Hicks are found in the pinyon-juniper zone, so it would have been particularly easy to access obsidian during the course of other subsistence related activities during this time. Reliance on heavily curated flaked stone artifacts does begin to decline during this era, and previous research at other western Great Basin obsidian quarries shows the beginnings of significantly lower levels of obsidian use during this period, leading to the conclusion that this will likely be the case at Mt. Hicks as well; however, Gilreath and Hildebrandt (1997) in their study of the Coso Volcanic Field note that use of Coso glass away from the quarry is actually highest during the beginning of this phase and then drops off afterwards. Subsistence resources at the Coso Volcanic Field are meager at best, so there is little reason to visit beyond obsidian. Mt. Hicks is quite different environmentally, so it is possible that high use may continue on well into this phase.

All previous quarry studies show drastic reductions in the use of flaked stone artifacts during the Marana era, though quarry exploitation still continued at a more curtailed rate. Mt. Hicks likely mirrors this pattern. Once again, the rich environment was a strong draw for late prehistoric groups, and even with greatly curtailed mobility, access to obsidian resources would have been extremely easy. The important issue revolves around whether there was still a strong need for lithic resources during this time. Ethnographically, groups exploiting Mt. Hicks were still using traditional technologies and exploiting wild resources well into the historic period, and may have been more mobile than contemporaneous groups. This leaves open the possibility that the production curve at Mt. Hicks may develop differently than previously studied quarries. Production levels will likely show at least some decline; there is no longer a need for as much stone to produce projectile points, hunting was declining in importance and mobility patterns were more curtailed.

Chapter 3

THEORETICAL BACKGROUND AND EXPECTATIONS

It is only within the last thirty years or so that archaeologists have systematically looked at quarry locales. Ericson (1984) notes that before this, and for some time after, quarries were seen as material records that were non-diagnostic, undatable, redundant, and often voluminous – making them very unattractive to most researchers – notwithstanding Gramly's (1984) observation that they seem to be the logical place to begin study of stone-tool using cultures. Singer and Ericson's (1977) study of the Bodie Hills obsidian source was an early attempt to answer difficult research questions that pertained not only to flaked stone tool production, but to larger regional issues as well. As noted in Chapter One, there have been several major studies of obsidian quarries since that time in the western Great Basin. There have also been many other works relevant to the thesis outside this area, some specifically focused on quarries and others on raw material acquisition in general (e.g., Andrefsky 1994; Bamforth 1990, 1991; Brantingham and Olsen 2000; Gramly 1980; Rickliss and Cox 1993; Roth and Dibble 1998). Far from simply describing artifacts found at quarries, all of these works had larger concerns regarding flaked stone technology and raw material acquisition. This is not surprising given that an emerging body of theory on technological organization, much of it emphasizing flaked stone technology in particular, was beginning to appear at roughly the same time that Singer and Ericson were publishing their research.

Beginning with the pioneering ethnoarchaeological studies of Binford (1979), archaeologists began to look at technological strategies as problem solving systems that respond to the interaction between humans and the environment (Bleed 1986; Kelly 1988; Parry and Kelly 1987; Nelson 1991; Shott 1986). Most of these works have, at least indirectly, an evolutionary perspective; that human beings will, consciously or not, try to optimize their behavior in terms of time and energy as well as reducing risk (Kelly 1995; Smith and Winterhalder 1992, various authors). Most of the body of work addresses several issues regarding tool design, efficiency, and maintenance, but much also looks at the relationship between group mobility and its technological strategies.

There is, obviously, a close relationship with theory regarding tool design and technological organization, and studies focusing on the acquisition of the raw material needed to make those tools. The aforementioned works by Andrefsky (1994), Bamforth (1990, 1991), Brantingham and Olsen (2000), Gramly (1980), Rickliss and Cox (1993), and Roth and Dibble (1998) address many of the issues examined in the literature on technological organization, mostly keying in on the subject of mobility and technological strategy. Many considerations of raw material acquisition are based on research done in varying landscapes, some with abundant raw material of high quality, others with low quality tool stone, or with low amounts of lithic material; other factors included non-lithic resources present in the area, and varying degrees of mobility of the groups exploiting the sources of raw material. Their results, to various degrees, often contradict what theory says should be present.

Nevertheless, both of these approaches are important in understanding the nature of lithic exploitation at Mt. Hicks. Theories of technological organization will provide a systematic framework for viewing and interpreting analysis of flaked stone artifacts encountered and collected during the current work. Previous archaeological views of artifacts simply regarded them as a means of identifying different cultures (*sensu* Bordes 1968), or if more in-depth analyses were performed, they were seldom aimed at explaining questions of human behavior. The goals of this thesis are to understand why prehistoric groups exploited obsidian in the Mt. Hicks area as they did through time and in varying ecological contexts, their needs changing along with their subsistence-settlement patterns. The theory of technological organization provides the tools with which to begin that inquiry. Previous work, in the western Great Basin and much further afield, also provides insight on how other researchers approached similar problems and how their results did or did not support conceptual expectations.

This chapter will continue first with an overview of technological organization theory. Embedded in this discussion are expectations for the archaeology of Mt. Hicks and findings of other researchers on appropriate issues. The chapter concludes with an overview of the distributional approach to archaeology that this thesis has adopted as the framework for research. This approach to archaeological research, very coarsely described as the sampling of landscapes, is particularly appropriate to the current research in that it minimizes some of the very serious issues regarding study of extensive quarry areas; the problems with researching expansive areas with literally millions of artifacts and potentially very large, but redundant artifact collections.

TECHNOLOGICAL ORGANIZATION

Binford (1979, 1980) first examined the concept of technological organization from the perspective of settlement systems. He was concerned with how hunter-gatherers exploited different kinds of environments, especially in terms of mobility patterns, and how groups organized their tools depending on activities they expected to engage in or might occur in unforseen situations. Many of his ideas were generated through his ethnoarchaeological studies of Nunamiut Eskimos in north-central Alaska and comparisons with the !Kung, G/wi, and other modern hunter-gatherers.

Looking first at his description of subsistence-settlement systems, Binford (1980) identifies two different kinds of hunter-gatherers, foragers and collectors, which actually represent two ends of a strategic continuum. Foragers are described as "mapping on" to the landscape to exploit resources. They generally do not store food resources, but rather gather foods daily on an encounter basis and return gathered food stuffs to their residential bases every afternoon or evening. The residential bases themselves are moved when an area has been depleted of easily exploited resources. Forager moves, generally seasonal in nature, can be expected whether resources are patchy or occur within more homogenous areas such as tropical rain forests. Binford (1980) notes that there can be considerable variability in the size of groups using this kind economic strategy, as well as the number and extent of residential moves. In homogenous areas, the number of moves may be relatively large and the distance relatively short. If resources, however, are sparse and dispersed, the size of the group may be reduced, scattered across the landscape, with each exploiting an extensive foraging radius. Likewise, occupational duration may vary considerably.

The archaeological implications for this model are that foragers will leave two different kinds of sites, residential bases and locations. Locations where resources are extracted have a very low archaeological "visibility" since foragers do not store food resources in large amounts, such sites are only in use for a few hours at a time and accumulate minimal debris. Residential bases are more substantial, but can also be very ephemeral depending on the length of occupation. Binford does note that forager residential bases can become very large where groups reoccupy the same location to exploit important resources that are "patchy" and constrained by time and/or place. Tool assemblages at residential bases will typically be more diverse than those at locations. Finally, Binford (1980) points out that as various factors come into play that restrict mobility, it is expected that there will be an increase in the degree of logistically oriented resource extraction, a strategy more characteristic of what Binford refers to a collector system.

As described in Chapter 2, previous research in the region strongly suggests that the earliest groups exploiting the Mt. Hicks area, during the Lake Mohave and Pinto periods, likely employed a forager strategy. Populations were presumably small and there do not seem to be other factors that would curtail mobility. The implications for the archaeological record would include ephemeral resource extraction sites, most perhaps hard to identify, and more substantial residential sites containing a wider array of tool types.

Binford (1980) describes a collector strategy as one in which groups collect resources through specially organized task groups that target specific resources. These groups will leave the residential base and establish field camps or stations from which resource procurement activities are planned and implemented. Resources may be field processed to aid in transport to the residential base. Another important aspect of a collector strategy is that groups will store resources for at least part of the year. Logistically oriented strategies are designed to solve the problem of incongruent distributions of resources or conditions otherwise constraining mobility. Put more simply, they provide a means of dealing with situations in which an key resources are not located near other equally important resources. While Binford does not explicitly say so, it is implied that collector groups are generally larger than forager groups.

The archaeological implications of this are a greater variety of site types. While collector groups will produce residential base camps and locations, as do foragers, in addition they will have field camps, stations, and caches; field camps are places where the specialized task group maintains itself while away from the residential base, while stations are information gathering sites for the task group. Inasmuch as specialized task groups are essentially small groups gathering resources for larger groups, they will produce bulk resources that need to be transported to the larger group. This will require a temporary storage phase, either a general location or one constructed specifically for a target resource, and thus caches. The number of different location types will increase depending on how many resources are targeted.

In the western Great Basin, archaeological data seem to indicate that groups shifted to a collector strategy at the start of the Newberry phase. An increase in the variety of resources that were exploited and, especially, the appearance of caches point to this shift in mobility strategy. The reasons behind this shift are not readily apparent. Looking at the environmental data, there is no dramatic change in climate that would alter the distribution of exploited resources. While it is during this time that pinyon is likely to have become available in large amounts, the record suggests it was not yet a significant resource or staple, used only sporadically. Perhaps the most likely explanation for the shift is population growth. As stated previously, the number of sites attributed to this time greatly increase, and one of the constraints on mobility that could push groups into a more logistical strategy is an increase in the number of groups/individuals exploiting an area. It is worth noting that while foragers generally have more frequent residential moves than collector groups, Bamforth (1990) points out that this is not necessarily always true. It is an important characteristic of Newberry period population that while they may lie closer to collectors on the subsistence-settlement continuum, they are still extremely mobile in that their residential moves are of relatively great magnitude.

In an earlier paper, Binford (1979) refined key concepts of technological organization, examining how cultures organize technologies in relation to their settlement system. This is a fundamental shift in how artifacts were viewed by archaeologists, who for the most part saw artifacts and artifact assemblages as cultural markers. The focus had been on the presence/absence of artifact types, their relative abundances or their functional connotations. Binford now proposed that artifacts could be used to gauge how prehistoric groups used and adapted to the landscape.

During his work with the Nunamiut Eskimos, Binford came to the conclusion that subsistence activities are goal oriented, and "are made with definite expectations as to the nature of future conditions" (Binford 1979: 261). In response to planned activities, as well as possible contingency activities, groups chose what tools were most appropriate to anticipated or possible tasks. Binford identifies three different classes of tools that are employed to meet these demands; *site furniture* – artifacts that generally have low use and are left at sites in anticipation of future use, *situational gear* – artifacts that are made in response to an unforseen situation and are made from whatever materials and tools are available, and *personal gear* – tools carried by an individual, chosen for anticipated activities as well as possible mishaps; these tools also tend to be highly curated (see below).

Binford was studying a highly mobile hunter-gatherer group that he later described as being collectors, thus his observations and conclusions are best applied to similar groups in the prehistoric record. In the western Great Basin, groups active during the Newberry period most closely resemble this model of highly mobile collectors. It is during this phase and later that site furniture should be present in the archaeological record. Situational gear would not be particularly indicative of any given time period as it is a response to unforseen circumstances and uses whatever materials may be available. The concept with the greatest implications for the archaeology at Mt. Hicks is that of personal gear, more specifically the idea of curation. As defined by Binford, a curated technology is one in which tools receive heavy maintenance, reuse, and are often recycled. These tools among the Nunamiut, were usually discarded within residential bases to insure that tools taken into the field were in good condition. Given the characteristics of curated tools, they are distinguishable from tools that are not heavily curated by the greater amount of modification they have received.

More recently, curated technologies have been most often associated with small, residentially and logistically mobile groups (Bousman 1993; Elston 1992; Kelly 1988; Kelly and Todd 1988; Kuhn 1992, 1994; Parry and Kelly 1987; Shott 1996). Beyond what Binford wrote, there have been more refinements to the concept, considering the preparation of tools and raw material in advance of their actual use, which may involve the advanced manufacture, transport, caching, and reshaping of tools. Aspects of tool design are also important (Bamforth 1986; Bleed 1986; Kelly 1988; Shott 1986, 1996). Design of curated tools is seen as a trade-off between reliability, versatility, and maintainability. This technological strategy would be very useful for highly mobile groups – anticipating a prolonged interval before lithic resources would be available, or not knowing when lithic resources would again be encountered – as it would minimize their risk of being caught without the means to manufacture tools (Bousman 1993; Elston 1992; Kelly 1988; Kuhn 1992, 1994; Parry and Kelly 1987; Shott 1996).

Biface manufacture is often associated with curated technologies, especially in the western Great Basin, due to various characteristics of that artifact type, which include a long use life, functional efficiency, and versatility (Kelly 1988; Kuhn 1994; Morrow 1996). Bifaces are not, of course, the only option for a prehistoric curated technology.

Kuhn (1994) argues that carrying bifaces is less efficient than carrying a larger number of smaller tools, a conclusion strongly critiqued by Morrow (1996), and Delacorte (1999) argues that in Owens Valley a prepared core/flake technology was important during the early/middle Holocene, when mobility seems to be high. Likewise, Binford (1979) describes a prepared core technology used by the Nunamiut in his studies.

Nevertheless, decades of previous archaeological work in the western Great Basin has shown that biface technology was important during, at least, the Newberry period if not earlier in time, gradually declining in importance through the Marana era. The mere presence or absence of a single tool type, however, will not mark an entire subsistence-settlement strategy; it is likely that bifaces were used in all time periods to varying degrees. Of importance here is how tool-kits changed through time to meet the needs of groups in the region. Groups active during the early and middle Holocene, who were likely highly mobile foragers, may have used a prepared core/flake technology as Delacorte (1999) argues for in the Owens Valley. Certainly during the Newberry period there was either a new emphasis on biface technology or at least an increase in the overall number of bifaces produced. In either case, one of the outstanding characteristics of the Newberry era relates to long distance travel to regularly visited locales. The qualities of bifaces mentioned above would have been ideal for groups moving long distances, who would have had to maximize the use of whatever material they were carrying. Producing bifaces is very wasteful of raw material, but this would not have been constraining inasmuch as there are several sources of high quality obsidian in the region, and even less so for groups in the Mt. Hicks area which had abundant material to exploit very close at hand.

In contrast to a curated strategy, an expedient strategy is characterized by minimal technological effort where time and place for tool use is highly predictable (Nelson 1991). Costs for employing an expedient technology are thought to be low, as the acquisition of raw materials and manufacture of tools is embedded in other tasks; this can also be true, however, for a curated strategy (Binford 1979). This strategy is often associated with groups that are less mobile or sedentary (Parry and Kelly 1987), as they would be near known sources of lithic raw materials, have access to them through trade and exchange, or have access to previously cached raw materials.

According to Parry and Kelly (1987), and perhaps evidenced by Jackson (1988), a group using an expedient technology would likely take either entire cobbles of raw material, minimally worked cobbles, or previously manufactured flakes, rather than produce new tools or tool blanks. While the need to carry personal tools would never disappear (Binford 1979; Kuhn 1992), groups having less risk of being caught without lithic raw materials would begin to maximize time for other activities, rather than minimize risk (Parry and Kelly 1987). This would be accomplished by investing less time in producing readily transportable tools, and investing more time in subsistence related activities, facilities, or specialized cached tools (Bousman 1993).

As reviewed in Chapter 2, post-Newberry times saw a decline in both the absolute and relative numbers of bifaces accompanied by a comparative increase in the importance of simple flake tools; it also appears that mobility during the Haiwee and, especially, the

Marana was greatly curtailed compared to earlier in the record. While this consistent with what should happen when groups become less mobile, it does not explain why production curves at previously studied western Great Basin obsidian sources appear as they do. The expectation of theory is that technologies will shift to expedient strategies with decreasing mobility, not that the use of lithic resources themselves will decline. Indirectly, this shift in technology does account for at least some of the downward trend in obsidian quarry production late in the archaeological record; biface production is more wasteful of raw material than simple flakes driven from a core, and therefore leaves a much larger imprint at the quarry itself, especially if groups begin taking unmodified or minimally worked cobbles and previously produced flakes (Parry and Kelly 1987).

As the discussion of organization of technology above notes, tools are made to solve problems, and prehistoric groups likely encountered different contingencies depending on the environments they were exploiting. Various environmental zones can be expected to have tool assemblages reflecting which tools were most important in those contexts. As shown in Chapter 2, Mt. Hicks has a typical western Great Basin environmental setting, with vegetation zones and their accompanying resources changing with elevation. All four major environmental zones found in the region are present in the research universe, and each should produce a somewhat divergent tool assemblage. The design and use of these tools in turn would have been influenced by their mobility patterns and the presence of abundant raw material. The mere presence or absence of a particular tool type, however, will not tell us much about a group's subsistence and mobility patterns. Examining the relative abundance of tools types within a specific environmental zone as well as differences in their morphology, both across environments and over time, should provide insight into how prehistoric groups exploited the area in the past.

Binford (1979) also introduced the concept of "embedded strategy", the idea that hunter-gatherers often exploited lithic resources in the context of other activities. He argued that very rarely, and only if things had gone wrong, would groups leave camp for the sole purpose of obtaining lithic raw material. In an embedded strategy there is essentially no "cost" in obtaining raw material. The example he gives to illustrate his point is that of a group of men who go out fishing. The fishing is not going very well, so a smaller group breaks off, travels to a quarry just a few miles away, reduce the material until it can be easily transported, then return to the fishing group and continue to work the stone. Binford's arguments are based on the expectation that suitable lithic sources occur near the areas where groups perform subsistence activities. While it is easy to find situations where this would not be the case, at Mt. Hicks the concept proves especially useful.

There was unlikely ever a time when Mt. Hicks was not attractive to prehistoric groups, each environmental zone providing resources that would have drawn people there at one season or another. It is also, of course, a source of a high quality and abundant lithic raw material. Given the abundant resources in the area, it is possible that embedded procurement has been the strategy predominantly employed. The implications for the archaeology are several. The first is that cobbles were likely only reduced enough to make them readily transportable, as Binford describes in his example. At primary acquisition areas this would leave residues containing a relatively high proportion of cortical and interior flakes, with likely lower amounts of flakes that are further along the reduction spectrum, such as biface thinning flakes; the inverse would be true in areas where raw material was being transported. Late in time, if groups are becoming less mobile, they could become nearly “invisible” in the archaeological record at primary acquisition sites and elsewhere to some extent as well. This is because, as Parry and Kelly (1987) predict, groups would have only minimally worked cobbles or simply picked up flakes that had been made in the past. The extremely large number of flakes that can be found in the Mt. Hicks area would have made this strategy particularly easy to engage in. Technological changes, specifically the adoption of the bow and arrow, would contribute to this as well since small flakes could be used to make perfectly serviceable points. Also, if later bifaces were less “finished” than earlier ones, this would result in even less waste production and a lighter archaeological imprint.

There is a danger of these models oversimplifying the technological strategies employed by prehistoric peoples. As Bamforth (1990, 1991) points out, a host of factors influenced the actual technology used, including raw material availability and social practices; discard patterns (Bamforth and Becker 2000) also influence artifact distribution across the landscape. Further, it is possible and even likely that a single group would have used multiple strategies depending on circumstances (Bamforth 1990). Identification of specific tool classes during the survey portion of the research, the analysis of collected tools and debitage, and obsidian hydration studies should make it clear when and in what environmental zone specific tool classes were most often used.

Furthermore, these analyses of tools will hopefully show if and how specific tool classes changed through time in response to differing needs.

CRITIQUE OF THEORY, QUARRY/ACQUISITION STUDIES, AND MT. HICKS

While organization of technology theory has altered the way archaeologists view artifacts, shifting from a cultural historical and functional perspective to a more integrated, systematic, and interpretive model, it has not gone without some criticism. Interestingly, much of the criticism stems from researchers who approach the subject from the prospective of material acquisition and/or quarry studies.

Andrefsky (1994) takes issue with the idea that lithic technology can be *predictably* linked to prehistoric settlement patterns. He argues that raw material quality and availability are factors just as important, if not more so, than group mobility. He posits that mobile prehistoric populations would not necessarily produce formal (curated) tools if they had good quality raw material readily available. Likewise, sedentary people would not use a wasteful expedient technology if raw material was not abundant. He also states that ethnographic evidence would suggest that availability is the primary factor influencing the design of flaked stone tools, with some groups traveling very great distances to acquire high quality lithic material.

Several other critics mirror this line of thinking. Bamforth (1990, 1991) agrees that such universals as mobility and seasonal constraints do effect lithic tool-kits, but notes that too many times there is a focus on single factors, not considering simultaneous and important influences such as local environment. Using research conducted at twenty-three sites, including two quarries, in the Mojave Desert, Bamforth argues that the same basic lithic strategy was suitable for a wide variety of activities through time, despite great changes in group mobility and settlement patterns. He writes that given similar group sizes and needs there is no reason this should be so. He also admonishes researchers that there is a difference between kinds of mobility and degree of mobility, noting that foragers do not necessarily move residentially more often than collectors.

It should be noted here, however, that Bamforth (1990, 1991) writes that at the two quarry sites there were changes in the rates they were exploited, the degree of reduction carried out at one of the quarries over time, as well as changes in emphasis through time at the kind of tools that were produced. He also acknowledges that flaked stone material is more thoroughly worked at quarries by groups with higher mobility in order to reduce the risk of transporting poor quality or unusable material. In effect, he disproves his own conclusion about a single lithic strategy being sufficient for various activities, but he did show that a variety of factors, including mobility, are important.

Like Andrefsky and Bamforth, Brantingham and Olsen (2000) in their study of a late Pleistocene assemblage from Tsagaan Agui cave in Mongolia, and Rickliss and Cox (1993) in their work on the central gulf coast of Texas also emphasize a multiplicity of factors influencing lithic technology. Brantingham and Olsen began from the perspective that raw material quality strongly influences whether a tool-kit will include formal (curated) or informal (expedient) tools. Later period archaeological assemblages in the area are informal and made from poor quality raw material. At Tsagaan Agui, however, the early assemblage was highly formalized, but still made from poor quality material.

This convinced them that no one factor can account for what technological strategy will be adopted. Rickliss and Cox (1993) note that depending on distance from lithic sources, as well as subsistence activities, lithic strategies changed in a very dynamic system that adapted itself to meet subsistence needs.

Other researchers have varied criticisms. Nelson (1991) argues that the curation versus expedient dichotomy is too simple, and would add a third strategy– opportunistic– which is subsumed in the expedient category and is essentially identical to Binford's situational gear. As the name implies, however, this is no strategy at all in the sense that opportunistic behavior could occur under any unforeseen circumstance and is not planned behavior. Bousman (1993) complains that there is no one accepted definition for "curated", noting six different uses of the term in the archaeological literature. He also argues that the notion of curated and expedient tools are far too simplistic (as is Binford's "forager-collector" continuum), and would construct complicated flow charts to track artifact use lives. Abbot et al. (1993) argue that organization of technology (or any other theoretical orientation) simply has no explanatory component to it. They would explain changes in lithic technological strategies, and everything else, in terms of selection. They argue that change from a biface to a core/flake technology is due to selective agents.

Some of these critiques are more applicable to the present research than others, but most illustrate the point that the various factors influencing a groups lithic strategy can make predicting what the archaeology should look like complex. Previous studies at quarries, however, may give some insight into how at least portions of the archaeological record may, or may not, appear at Mt. Hicks.

Gramly (1980) in his study of the Mt. Jasper rhyolite quarry found a large number of finished tools made of "exotic" material. He noted that other quarries in the region did not have nearly as many finished tools made from distant material sources. He concluded that prehistoric groups exploiting the quarry stopped during long seasonal trips, dumping their old tools in favor of newly crafted ones. This quarry model is almost sure not to hold for Mt. Hicks, which was likely a destination for seasonal movement and not a quick stop in between to reload on lithic material.

Roth and Dibble (1998) studied a quarry, Combe-capelle Bas, in southern France, dating to the Middle Paleolithic. They describe the source as being rich in high quality flint. The site itself is located in the valley of the Couze River, an area which is rich in both high quality sources of flint and in Paleolithic remains. Based on a full range of artifact types but a general lack of typological differences between them, they concluded that procurement was embedded in other resource gathering activities. This would seem to be a good model for what to expect at Mt. Hicks, at least in a limited sense. Quarry areas at Mt. Hicks will likely be similar to the French situation, having several different tool types present, but all in very early states of manufacture before discard at the source. Unfortunately, Roth and Dibble did not include a comparison with non-quarry areas, so there is no direct evidence to show how these two very different kinds of areas could differ.

Several quarry investigations have been performed at the Marine Corps Air Ground Combat Training Center at Twentynine Palms, California (Giambastiani and Basgall 1999; Basgall et al. 2005; Bethard et al. 2005). This area, located in the southern

Mojave Desert, has several sources of rhyolite and micro-cryptocrystalline lithic raw material, including quarry areas in the Wood Canyon, Quackenbush, and Gays Pass training ranges. These series of studies highlight two aspects of quarry production that are of interest; the first is the effect of raw material quality on core form and debitage technological profiles. Giambastiani and Basgall (1999), doing research in the Wood Canyon quarry area, concluded that core form was tied into the initial form of cobbles, with those that were tabular in initial shape tending to be shaped into bifacial cores more often than those that were not, with the latter more often shaped into unidirectional or multi-directional cores. In comparison to the Wood Canyon quarries, the Quackenbush and Gays Pass quarries had much higher percentages of cortical flakes (Basgall et al. 2005; Bethard et al. 2005). Again, researchers attribute this to the shape of cobbles that are being reduced; cobbles at Quackenbush and Gays Pass are far more irregular in shape than at Wood Canyon, though generally having good quality flaking characteristics once the cortical exterior is removed. The second aspect of these studies is that none of the quarries themselves have much, if any, archaeological evidence indicating residential activity, and all are located in contexts that are poor in food resources; although Wood Canyon is adjacent to much more productive areas, Quackenbush and Gays Pass are some distance from such habitats. Neither area showed very much evidence of "exotic" lithic resources, and most flaked stone tools showing evidence of use were made of local material. This has led researchers to argue for direct procurement of tool stone for these quarries. If lithic acquisition was embedded in other resource activities, it would be reasonable to expect, as at Mt. Jasper, that there would be discarded tools made of extralocal material. The investigation of the Quackenbush area also included residential/non-quarry sites that were located some distance from the actual quarries. An interesting dichotomy in the debitage technological profiles of the two areas was observed. Quarry areas showed very high percentages of cortical debris, while the residential sites had dramatically lower proportions of cortical flakes and far higher relative amounts of debitage further along in the reduction spectrum.

The Mojave Desert is far different than the western Great Basin, and it is highly unlikely that obsidian at Mt. Hicks was directly procured on a regular basis. The research at Quackenbush has one very important similarity with efforts at Mt. Hicks that no other quarry study shares; the investigation of both quarry and residential/non-quarry areas. Like at Quackenbush, a dichotomy between quarry and non-quarry areas should be evidenced by differing debitage technological profiles, with quarry areas having higher relative amounts of cortical debris, correspondingly higher percentages of non-cortical flakes, and more refined tool forms. As the quality of raw material at Mt. Hicks is very high, cortical flakes should be more common at quarry areas but probably not overwhelmingly dominant.

Evaluating Hypotheses of Western Great Basin Obsidian Production

As discussed in the first chapter, there have been several hypotheses proposed to explain the drop in obsidian production during the Haiwee and Marana periods, including restricted access to raw material due to increasing territoriality (Gilreath and Hildebrandt 1997), social and economic forces such as "cheaper" sources of obsidian (Bouey and

Basgall 1984), and the notion that a substantial decrease in artiodactyl hunting resulted in a proportional drop in biface production because bifaces were actually *specialized* artiodactyl butchering tools (Ramos 2000). The Mt. Hick area is well suited to examine these hypotheses. As noted in Chapter 1, while Mt. Hicks glass does enter California, it is rarely found in large quantities across the Sierra Nevada range; it is far more common to the east and presumably served central Nevada populations.

The ramifications for this are twofold: first, any disruption in acquisition, whether through decreased trade or more constrained direct access, probably minimally affected production at Mt. Hicks; second, the ethnographic record suggests that groups who likely exploited Mt. Hicks obsidian were more mobile and had little concept of territoriality. If so, a curated, biface-oriented technology may have stayed in place for a longer period of time than it did for groups exploiting other obsidian quarries in the western Great Basin. It is possible that the production curve at Mt. Hicks may play out differently than other quarries in the region, perhaps with little drop off in production until late in the archaeological record. This assumes, however, that the ethnographic pattern of less mobile and more territorial groups in the far western Great Basin extends at least into the Marana period and is not restricted to the historic record (Basgall et al. 2003; Basgall and Delacorte2003; Zeanah and Leigh 2002).

The actual examination of these hypotheses comes from comparing actual results of the thesis study and expectations derived from the models. For purposes of the thesis, Gilreath and Hildebrandt's territorial, and Bouey and Basgall's social and economic arguments can be lumped together, as both models result in less glass being exported across the Sierra Nevada. If either of these hypotheses has validity then the production curve for Mt. Hicks should play out differently since so little of Mt. Hicks obsidian is transported across the range. It could actually be expected that the production curve would look much different; it is an unstated but implied presumption of these hypotheses that the spike in production during the Newberry period is due either to direct access by, or trade with, western Sierran groups, otherwise there would not be such a steep drop when their relationships disintegrate. The production curve therefore should look "flatter," with a less dramatic increase during Newberry times and less drastic drop during the Marana era. Should the production curves prove similar, then it is probable that neither accounts for why production curves appear as they do.

For Ramos' hypothesis that bifaces are actually specialized artiodactyl butchering tools there are three criteria that must be met. The first is that the production curves appear similar; he argues for trends that are pan-Basin in scope and have little or nothing to do with trans-Sierran exchange, therefore the same factors should be affecting all quarries. If the production curve at Mt. Hicks differs from those seen at other western Great Basin quarries then Ramos' hypothesis is likely not valid, at least for the more central part of the Great Basin, since that would give support that territoriality and/or economic factors have a large influence on production histories. The second expectation is that biface to simple flake tool ratios should be high in areas where hunting took place; Ramos argues for bifaces as specialized tools, therefore bifaces should constitute a higher percentage of the assemblage where hunting is a focus of activities. Also, because they are specialized tools, it should not matter how much lithic material is present; in fact, since there is no reason to conserve lithic material in rich source areas, it is reasonable to assume that there may be even greater proportions of bifaces in areas that were used primarily for hunting and have abundant raw material present. The upper desert scrub zone at Mt Hicks is well suited to test this proposition. There would have been little reason for prehistoric groups to visit the upper desert scrub zone other than for hunting artiodactyls; while it does have some plant resources as well as obsidian outcrops, these same resources and many more can be found at more accessible elevations. If bifaces are indeed specialized artiodactyl butchering tools, then this zone should have a higher proportion of that tool class than any other zone in the research universe; if it does not there would be no support for the hypothesis. The third and last criterion may be the most significant; since bifaces, again, are argued to be specialized tools and used for the same purposes over time, their morphological characteristics should remain constant. Delacorte (1997, 1999) argues that the morphology of tools within the same tool class will likely change through time because of changing uses of those same tool types. Biface analysis to be conducted for the thesis includes such measures as weight and basic dimensions, as well as stage of reduction – a measure of how much, and what kind, of work has been done on a biface. If bifaces were used for the same purpose, these measures should be similar across time and between environmental zones.

A Non-Site/Distributional Approach

Traditionally, archaeologists have used sites as basic units of inquiry, sites being seen as "spatially discrete, bounded entities that are the remains of past human behavior as evidenced by the presence of artifacts and/or archaeological features" (Dunnell 1992). There has been debate, however, on the continued usefulness of this concept in archaeology (Dunnell 1992; Ebert 1992), with critics of the site concept calling into question the validity of "sites" as discrete occupational episodes, noting the problems of post-depositional influences. Most so-called sites are actually accumulations of numerous behaviors that are unrelated in time, thus negating any idea of true association between nearby artifacts, and complicating efforts to identify bounded units of analyses. Site-based approaches also tend to focus on larger, more substantial artifact concentrations and features.

There are various names which critics of site-based approaches have labeled themselves, including off-site (Foley 1981), non-site (Dunnell and Dancy 1983; Thomas 1975), and distributional (Ebert 1992) archaeology. While particular methods differ, they are all similar in that they view the archaeological record as continuously distributed across the landscape and consider the artifact or feature, not the site, to be the basic unit of analysis. Other characteristics of these studies include the sampling of different environments or micro-environments (Raven and Elston 1989) rather than the sampling of sites, as well as the tendency to be surface investigations only with little or no subsurface sampling.

Thomas (1973) first used a deliberate non-site approach in the western Great Basin during the Reese River Ecological Project. The goal of his research, already reviewed, was to test Steward's (1938) model of Shoshonean subsistence patterns. Thomas found that the extant body of archaeological work done to that point in time was insufficient to test this model, most projects involving the excavation of caves containing cultural remains in good stratigraphic context, but lacking information from different environmental contexts or a variety of site types. To get a non-biased, or random, sample of the archaeology, Thomas turned to a non-site approach that involved a survey that sampled the landscape rather than known sites. This allowed him to associate the artifacts encountered with each ecological zone to that context. Since Thomas' ground-breaking work there have been several studies that focus on the interplay of environment and cultural adaptation (Basgall and Giambastiani 1995; Bettinger 1982b; Halford 1998; Madsen and O'Connell 1982, various authors; Raven and Elston 1989) in the Great Basin; many works have entailed random and/or stratified sampling strategies (Delacorte 1990; Ebert 1992; Raven and Elston 1989).

Despite the drawbacks mentioned earlier, there is no doubt of the advantages gained in a site-based approach that involves excavation, including retrieval of dietary information, larger artifact assemblages, and possibly greater chronological controls. Site-based approaches do tend to overlook activities that occurred away from residential areas, and thus data generated will be different from non-site research. Non-site approaches do have their own biases and gaps in data retrieval. The most serious of these is the general lack of chronological control. The particular nature of obsidian quarry areas, however, play well to the strengths of non-site archaeology, especially for the current research, and therefore a non-site, or distributional, approach was adopted for the project.

Several of the critiques leveled at site-based archaeology are magnified in quarry locales; sites are at best difficult to identify due to numerous episodes of use that span thousands of years, many of which overlap one another. Further, one of the advantages of site-based approaches, larger artifact assemblages, is here turned into a negative, with artifact scatters that may extend for kilometers. Using a site-based approach at an extensive quarry such as Mt. Hicks would be nearly impossible, with issues of scale soon becoming overwhelming. Adopting a non-site approach, however, eliminates several of these problems. Since it is the landscape that is being sampled, there is no need to define the boundaries of a site, which would be a daunting, time-consuming task in and of itself, as well as resulting in a much more manageable artifact assemblage. The identification of sites, or site types, is not necessarily abandoned, but one of the major focuses of the research is to see how technological strategies changed through time. This will be accomplished through the identification and analysis of specific tool types, their changing morphology, and distributional patterns. Finally, the most serious drawback of non-site archaeology, chronological control, is less of an issue here because obsidian can be subjected to hydration analysis. The problem is not completely skirted, however, due to the presence of non-obsidian artifacts and features which cannot be directly dated.

Chapter 4

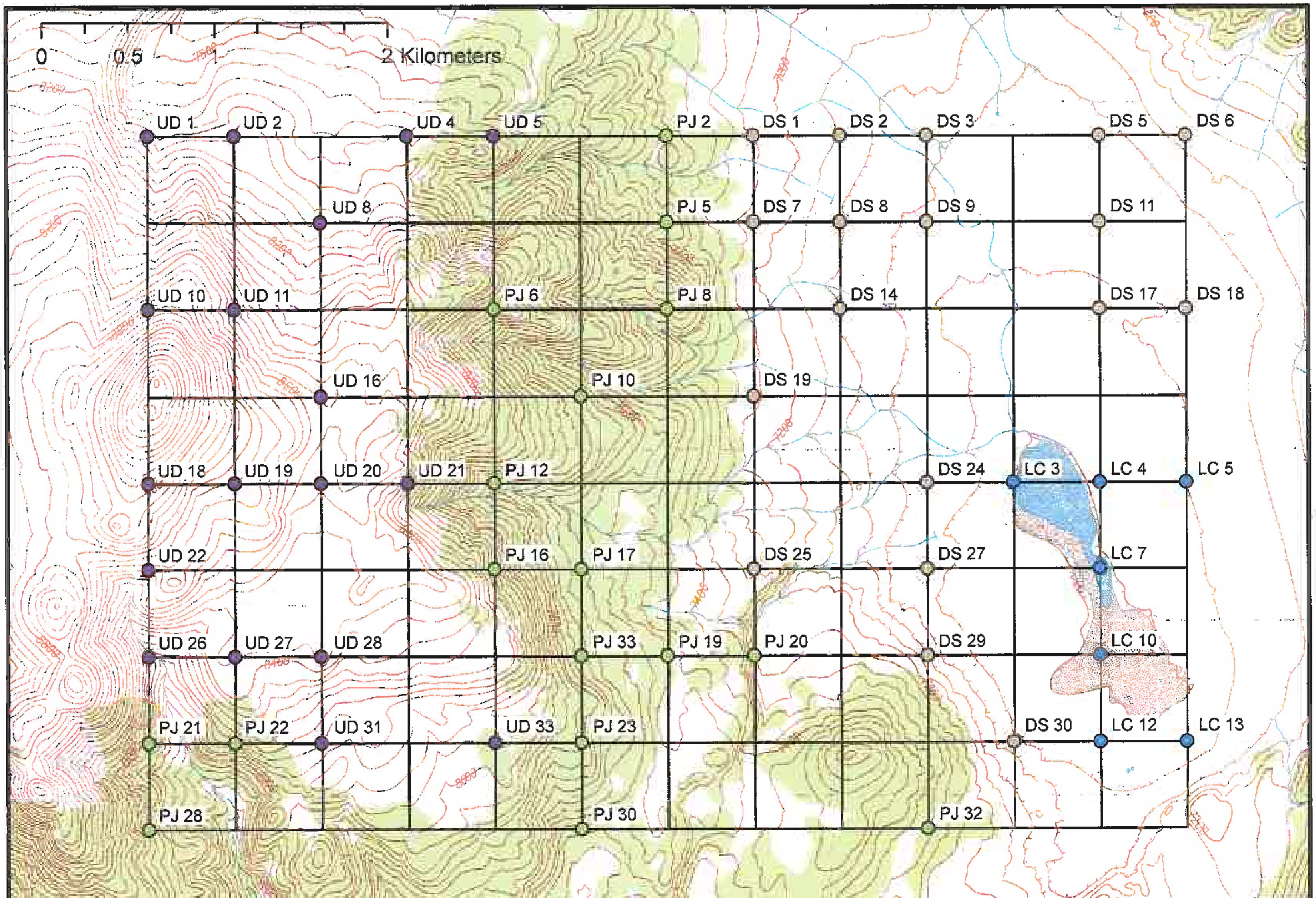
FIELD METHODS AND ANALYTICAL PROCEDURES

FIELD DISTRIBUTIONAL METHODS

The field methods employed for the study were designed to generate a random sample of artifacts unbiased by a more subjective site-based approach that requires definition of what constitutes a "site." To accomplish this a distributional approach was developed for the field work.

An Observation Unit (OU), measuring 45 x 45 meters and divided into nine 15 x 15 meter cells, was placed every 500 meters within the 24 km^2 research universe that encompasses four environmental zones (Map 4.1). Using UTM lines as a reference, this produced a four by six kilometer grid containing 117 potential units. Each potential unit was given a unique identifier, beginning either with UD (upper desert scrub), PJ (Pinyon-Juniper), DS (lower desert scrub), or LC (lacustrine). Units were ascribed to each of the environmental zones on the basis of vegetation and elevation depicted on the Mt. Hicks USGS quadrangle map. Fifty percent of the OU's within each environmental zone were chosen randomly for survey, yielding a total of 60 units: seven in the lacustrine zone, 17 in the lower desert scrub, 18 in the pinyon-juniper belt, and 18 in the upper desert scrub. The southwest corner of each OU was located and recorded in the field using a Global Positioning Unit.

Each OU was systematically surveyed by a field crew walking transects spaced at one meter intervals and all archaeological artifacts and features pin-flagged. When



MAP 4.1. Mount Hicks Research Universe.

survey was completed, each unit was sketch mapped and photographed. The central, N15/E15, cell of each OU was designated as a Data Collection Unit (DCU) and all flaked stone tools collected from the DCU's. Owing to the large amount of debitage in some OU's, a Debitage Collection Sub-Unit (DCS) was placed within each DCU. The default size for each DCS was one meter square, placed in the densest concentration of flakes within the DCU. If fewer than ten flakes were found within the DCS, it was progressively expanded by a whole meter (i.e. 2 x 2 meters, 3 x 3 meters, etc.) until a minimum of ten flakes was recovered or a maximum DCU size of15 x 15 meters was reached. There were several instances when no archaeological remains were recovered within the DCU and other cases where tools were present in adjacent cells. When this occurred, either the DCU and DCS were moved to a more productive cell or a second DCU was established. A second unit was also established if the majority of tools were outside the N15/E15 cell. This was done to ensure that an adequate sample of tools was obtained for hydration and other analytical purposes. This resulted in the collection of roughly half of the tools encountered during the survey (see Chapter Five). Upon return from the field, all collected artifacts were washed, catalogued, analyzed, and stored at the Archaeological Research Center, California State University, Sacramento. An abbreviated analysis program was performed in-field on all artifacts that were not collected (see below).

ANALYTICAL PROCEDURES

Analytical procedures began in the field with the initial characterization of artifacts on the basis of morphology, material, and artifact class, i.e., flaked stone (bifaces, projectile points, cores, simple flake tools, formed flake tools, and debitage) or ground stone (handstones, millingslabs, or miscellaneous ground stone). Basic metrical data were obtained for all artifacts in either the field or laboratory. This included their maximum length, thickness, and width with incomplete measurements on broken artifacts indicated by a "-" for ease of tracking and separate calculations if necessary. Also recorded for all artifacts were material, condition, and weight (collected artifacts only). Specific temporal or regional types (e.g., projectile point series types) were also noted where appropriate.

More detailed technological analysis is needed to understand how tool categories may have changed through time and space in response to shifting technological needs. Procedures adopted for this detailed analysis generally follow regional protocols (e.g., Basgall and McGuire 1988; Basgall and Giambastiani 1995, etc.), though a more abbreviated program was employed for some in-field analysis.

Projectile Points

Projectile points are bifacially flaked artifacts retaining diagnostic hafting elements, such as shaped basal ends, notches, or tangs. Projectile points were assigned to temporal/morphological types based on metrical data (Thomas 1981) and other morphological traits attributed to types common to the region. Additional analysis included evidence of use-wear, resharpening, and absence/presence of impact fractures. All projectile points, both within and outside OU's, were collected given their temporal significance.

Bifaces

These are artifacts with continuous flake scars along opposite sides of the same margin that lack hafting elements. Some bifaces are, no doubt, projectile point fragments and when this appears to be the case it is noted in the comment section of the catalogue. Another problematical issue with bifaces is that they tend to overlap with the category of bifacially worked cores. This, however, is not as severe a problem as it first appears, in that bifacial cores tend to be thick in cross-section and have often discontinuous bifacial margins. In contrast, bifacial tools have a much higher width-to-thickness ratio, making separation of these tool classes very reliable, though not infallible. Some researchers (e.g., Ramos 2000), however, collapse bifaces and bifacial cores into a single category in an effort to eliminate any subjective bias. While this is certainly a laudable goal, it may cause more confusion by obscuring data related to artifact classes that are appreciably different in morphology and functional intent.

A five stage techno-morphological reduction was employed to characterize bifaces and to gauge the level of reduction/flake removal for each of the artifacts along the blank-preform-finished artifact continuum. *Stage 1* bifaces are percussion flaked forms with relatively thick cross-sections, limited planar symmetry, and irregular, sinuous margins. *Stage 2* bifaces are thinner in cross-section, have greater symmetry, and more regular margins, but are still exclusively percussion flaked. *Stage 3* bifaces are also produced by percussion flaking, but the work is more extensive with flake removals extending across the mid-line of the tool, greater planar symmetry, and more regular, even margins. *Stage 4* bifaces are completely or nearly symmetrical, have uniform margins and cross-sections, and show, most importantly, at least some pressure flaking. *Stage 5* bifaces are finished tools (i.e., undiagnostic projectile point fragments or knives) that have extensive pressure retouch on opposing surfaces along the entire margin, and flake scars that are very closely spaced.

Other observations made on bifaces include the original tool form (flake or bifacial blank), end shape (rectangular, convex pointed, convex rounded, straight, triangular, irregular, unworked), general size (arrow point, dart size, knife/blade size), spine-plane angle, and the presence of use-wear (e.g., micro-chipping, edge flaking, edge ground, step-fracturing). In-field analysis was restricted to reduction stage defined variously as early (*Stage 1* and *Stage 2*), middle (*Stage 3*), and late (*Stage 4* and *Stage 5*), type of use-wear, and end shape when appropriate.

Formed Flake Tools

Formed flake tools are thought to be restricted primarily to early archaeological contexts. As the name suggests, they are often fashioned on large percussion flakes, with intrusive flake scars that modify the overall morphology of the original piece. As such, it is the extent of modification and generally uniform edges that distinguishes this tool category from simple flake tools. Additional analyses on formed flake tools include flake type, overall shape (amorphous, domed), number of worked edges, edge angle, use-wear, modified surface (dorsal, ventral), edge shape (concave, convex, straight), and continuity of wear (jagged/irregular or even). In-field analysis was restricted to number of worked edges, overall shape, and use-wear.

Simple Flake Tools

In contrast to formed flake tools, this category is defined by a lack of intentional modification or significant edge preparation. In fact, margins on this artifact class generally maintain their original shape. The largest of these tools, found in or near quarrying areas, are probably large flake blanks with edge modification/platform preparation performed but then discarded before further reduction was performed. Analysis of this tool category included flake type, number of edges, edge shape, edge angle, use-wear, and surface where use-wear occurs. In-field analysis was restricted to number of modified edges and type of use-wear.

Cores

Cores were defined as masses of stone from which two or more flakes were removed on the same striking platform or a total of five flakes removed from multiple platforms. Analysis included original core form (tabular cobble, angular cobble, globular cobble, flake core, and interior chunk), the number of platforms, platform configuration (unidirectional, bidirectional, multidirectional, or bifacial), platform type (interior or cortical), maximum flake scar length, and overall core type or configuration (unidirectional, bidirectional, multidirectional, and bifacial). Given the length of time required to analyze cores, field analysis of uncollected specimens was limited to core type.

Debitage

By far the most ubiquitous artifact found in the research universe, debitage consists of all unmodified flaking debris resulting from the manufacture, use, and maintenance of stone tools. Obsidian was the overwhelming material type present, although some cryptocrystalline material was encountered but not collected because it fell outside of the OU's. All debitage was counted and weighed by OU and all of it subjected to detailed technological analysis.

Debitage was first sorted into five size categories based on the smallest diameter circle that would encompass the flake in plane-view: <1.0 cm, 1.0-2.0 cm, 2.0-3.0 cm, 3.0-5.0 cm, and >5.0 cm. Individual pieces of debitage were then assigned to four broad technological reduction categories that were further segregated into more detailed flake types. The first of these is decortication debris, which includes *primary decortication* (flakes having 70% or more of their dorsal surface covered in cortex), *secondary decortication* (pieces having less than 70% cortex or cortical platform only), and *cortical shatter* (angular pieces that have any cortex) that collectively reflect the early stages of flaked stone reduction work. The second debitage category is interior percussion flakes that include *simple interior* (straight flakes that have only one dorsal arris), *complex interior* (straight flakes that have more than one dorsal arris), and *linear interior* (straight flakes that are twice as long as they are wide), flakes indicating the more advanced reduction of toolstone masses. The third category is biface thinning debris, which can be produced from the manufacture of both biface tools and reduction of bifacial cores. It includes *early biface thinning* (flakes that tend to be curved in longitudinal section and have platforms that are at obtuse angles, or tilted back, from the long axis of the flake and have one or two dorsal arrises), and *late biface thinning* (as above, but with three or more dorsal arrises). The last category is pressure flakes associated with tool finishing or resharpening that includes *edge preparation* (small flakes that retain remnants of tool or core margins with complex dorsal surfaces), *linear pressure flakes* (small flakes with greater length than width), and *rounded pressure flakes* (small flakes with round or amorphous outlines), and *indeterminate pressure flakes* (small, usually broken flakes that cannot reliably be classified). Many flakes were also classified into various undiagnostic types. These include *angular percussion* (cuboidal pieces of shatter that may have occurred at any point in the reduction trajectory), *percussion fragments* (sections of percussion flakes lacking a platform or other diagnostic features), and *indeterminate percussion* (whole percussion flakes that cannot be typed due to weathering or other hindrance). No flakes were analyzed in the field.

OBSIDIAN STUDIES

The primary objective of the thesis required that a number of artifacts undergo obsidian hydration analysis. The western Great Basin has long made use of this approach (see Chapter 6), with the present analysis carried out at the California State University, Sacramento, hydration laboratory.

The numerous flakes and contexts sampled during the survey presents challenging issues for selecting the specimens to undergo hydration analysis. To begin with, the sheer numbers of artifacts precludes analysis of each and every item. Selecting a fixed percentage is likewise unfeasible as some areas have many specimens and others comparatively few. This would produce little information on certain, potentially important contexts, requiring an alternative sampling strategy.

Much of the present thesis and other research in the region centers around the changing role of biface technology and shifts in quarry activity through time. With this in mind, only cortical and biface thinning flakes were selected for hydration, as they are the most indicative of these activities. All formal artifacts wee also subjected to hydration, give the comparative limited number of tools involved.

The debitage hydration sample consists of 100 flakes each from the cortical and biface thinning debitage categories. The number of flakes chosen from each vegetation zone depended on the relative proportion of each flake type within the zones. Thus, a zone contributing 25% of the cortical flakes would provide 25% of the cortical sample or 25 flakes. To ensure an adequate sample from every zone, however, a minimum of 20 specimens was selected from each regardless of its size. In only one instance, the cortical sample from the Lacustrine zone, was this impossible due to a lack of sufficient specimens.

A random number table was used to select units within each zone from which individual flakes were chosen for hydration analysis, but individual flakes were not chosen randomly. As all of the specimens are surface collected pieces, many have been weathered to some extent. This makes them less than ideal for hydration, so flakes with the least amount of weathering were selected. Even so, many artifacts exhibited some degree of weathering, such that a certain percentage were expected to yield no hydration rims.

Hydration results from temporally diagnostic projectile point types were used to develop a hydration rate applied to all artifacts that underwent hydration analysis. Each artifact was then assigned to a specific temporal period to track technological changes in obsidian use through time.

Hydration Process

An artifact selected for hydration analysis was first examined for an appropriate location for thin section removal. Two parallel cuts were then made into the edge of the piece using a Beuhler ISOMET low-speed saw mounted with two 4-inch diameter, diamond impregnated .004-inch thick blades. The blades were separated with a thin plastic spacer. The resulting wedges removed from each artifact were approximately 1.0 mm thick. Two to five of these sample wedges were then mounted on a microscope slide using thermoplastic cement. The wedges were then ground on a pane of glass in a figure-eight motion to evenly distribute pressure. The glass plate was coated with a slurry of water and 600-size silicon carbide powder. Once the thickness of the wedges was decreased by approximately one-third, the slide was cleaned and set aside for the cement to cure for, usually a day or longer. With the cement cured, the slide was heated to melt the cement and the wedges flipped. The slide was again ground until a thickness of approximately 30-50 μ was achieved. The slide was heated and cured a final time to smooth rough surfaces before the rim measurement was taken.

Prior to reading the slides, the specimens were topped with water, to improve refraction, and a plastic slide cover placed over the top. Specimens on the prepared slide were measured using a Leitz Dialux Pol-D petrographic microscope fitted with a 360° rotating mechanical stage and 10X filar scre micrometer. A Leitz Wetzlar 63X lens and a 1.25X eyepiece were used in conjunction with the micrometer, resulting in a magnification from all components of approximately 800 times normal. For measurements, a Sanyo color video camera (model VCC-3912) with a Navitar 0.3 m lens was mounted above the filar eyepiece. This transferred the microscope image to a 600 DPI computer screen where the measurements were taken. Hydration layers were first identified under polarized light with a Gypsum waveplate in place. Once a hydration layer was recognized it was scanned under normal light for suitable measurement locations. Rim measurements were taken from the computer image with the subject section in the center of the viewing area. If possible, ten rim measurements were taken on each artifact, though often fewer measurements were actually obtained. Hydration band thickness was calculated to the nearest 0.1μ, with measurements reported as mean values of all the readings obtained on a particular piece. Due to normal limitations of the equipment, hydration readings have an error range of ± 0.2 μ and rim measurements less than 1.0 μ are not reliably discernible.

Chapter 5

RESULTS: SURVEY AND LITHIC ANALYSIS

The overall research universe comprised 117 potential Observation Units (OU's), of which 60 were randomly selected for surface survey (121,500 m² or 0.12 km²). Fifty-one of these units had at least one artifact present. Two hundred and thirty-four flaked stone tools were encountered (not including five points collected as isolates, one assayed cobble, or debitage which was impractical to tally in every unit), for an average of one tool for every 519.2 m² surveyed; 114 tools were collected for more intensive analysis and dating purposes, including the five isolate points. Table 5.1 summarizes these data by artifact category and environmental zone.

Table 5.1. Flaked stone tools encountered by environmental zone.

Zone	Projectile Points	Bifaces	Formed Flake Tools	Simple Flake Tools	Cores	Total
Upper Desert Scrub	4	16	0	24	3	47
Pinyon-Juniper	4	57	10	9	33	113
Lower Desert Scrub	3	33	1	17	7	61
Lacustrine	1	8	2	7	0	18
Total	12	114	13	57	43	239

This chapter is organized into four sections corresponding to the environmental zones found in the research universe. Each section is further divided by the flaked stone artifact categories found within that zone, beginning with a description of select analysis results, discussion of those results, and an examination of the context in which the tools were found. Finally, each section concludes with an overview of the zone.

UPPER DESERT SCRUB

The upper desert scrub biotic zone was defined as any area above the pinyon-juniper woodland depicted on the Mt. Hicks quadrangle map. It includes 35 potential OU's, 18 of which were randomly chosen for survey. After ground truthing, one sample unit was found to lie within the pinyon-juniper zone; another unit, UD17, was randomly chosen in the field to replace the mis-attributed unit, keeping the number of units in the sample at 18 units, 15 of which contained archaeological remains. In all 36,450 m^2 was systematically surveyed in this stratum. In addition, there were two isolate projectile points recovered. The following discussion presents the most pertinent information on the material recovered in the Upper Desert Scrub stratum wit detailed metric and hydration data presented in Appendix A.

Projectile Points

A total of four projectile points was recovered from this zone (Table 5.1), two as isolates collected for dating purposes. This provides an average of one projectile point for every 18,225 m^2 surveyed (excluding the two specimens found outside OU's). The first of these points is attributed to the Elko series. Although very thin, the neck width of this specimen is greater than 10 mm, prompting its classification as a dart point. It is a highly fragmented medial section, missing the base and a tang, but retains enough of one corner and the neck for at least general classification. The second specimen is the proximal end of an Eastgate point, missing only a portion of one shoulder and the distal end, broken likely as the result of an impact fracture. The third specimen is the proximal end of an Elko Eared point. The distal end of which is missing due to an impact fracture. The fourth point can only be classified as a generic dart-size point (cf. Elko series), that appears to have shattered during use.

The most striking aspect of the three dart points is that all were broken, or shattered, through use, as was the single arrow point. The two recovered within OU's were found in areas of relatively dense artifacts (UD17 and UD33); UD17 also contained six simple flake tools and a biface; while UD33 yielded 27 unmodified flakes in a 15 x 15 m collection unit.

Bifaces

A total of 16 bifaces was encountered in this zone (Table 5.1), or one for every 2278.13 m² surveyed. Ten specimens were collected for obsidian hydration and more detailed analysis. Select attributes of all 16 bifaces are summarized in Table 5.2. The table also provides the expected number of bifaces for each environmental zone, which was calculated by multiplying the number of bifaces in the sample units by the proportional representation of each environmental zone within the research universe. The expected number of bifaces was calculated like this because it is the null hypothesis that artifacts are randomly distributed across the landscape; thus the probability of any one artifact being present in a given biotic community is equal the percentage that community in the research universe. Using the chi-square statistic to test the null hypothesis yields a chi-square value of 28.81. The critical range (the number which the chi-square value must exceed to reject the null hypothesis) is 11.34; therefore bifaces are not randomly

Table 5.2. Select attributes of encountered bifaces by environmental zone.

	Upper Desert Scrub	Pinyon-Juniper	Lower Desert Scrub	Lacustrine	Total
STAGE					
Early Stage	5	20	5	0	30
Middle Stage	6	28	19	7	60
Late Stage	5	9	9	1	24
CONDITION					
Whole	4	15	1	0	20
Near Complete	0	10	1	2	13
Proximal	1	2	2	1	6
Distal	3	5	5	1	14
End	4	20	15	3	42
Margin	2	4	6	1	13
Medial	2	1	3	0	6
USE-WEAR (collected specimens only)					
Yes	5	12	9	2	38
No	5	9	8	1	23
Total Observed	16	57	33	8	114
Expected Total	33	33	34	14	114
Adjusted Residual	-2.74	3.25	0.15	-1.35	-

distributed across the four biotic communities in the research universe. The chi-square statistic only shows if the null hypothesis can be rejected; however, other, related statistical tests can provide more focused results. The adjusted residual row of Table 5.2 indicates how much each zone deviated from the expected outcome; where the mean is 0 and the standard deviation is 1. Thus, any adjusted residual with a value exceeding 1.96 (either minus or plus) is statistically significant at the 0.005 confidence level. This statistic indicates if the actual number of bifaces observed in a given environmental zone is significantly different from what was expected. Note that usually there are two sets of statistical numbers given in adjusted residuals, one for the actual number and another for the expected; in the table only the number for the actual observed against the expected is provided. To determine the expected versus the actual simple change the +/- to its opposite.

Only four (25%) of the bifaces are whole, another four indeterminate end fragments, three (18.75%) distal end fragments, one (6.25%) a proximal end fragment, two (12.5%) medial sections, and two margin pieces. The bifaces are nearly evenly distributed between early (n=5), middle (n=6), and late (n=5) stages of manufacture.

More detailed information is available for the 10 collected bifaces which include two Stage 1, two Stage 2, four Stage 3, and two Stage 4 specimens. Maximum length for the collected artifacts ranges from 22.5-67.2 mm (average=42.06 mm), maximum width from 19.9-49.5 mm (average=39.18 mm), and maximum thickness from 4.0-17.6 mm (average=9.45 mm). Spine plane angles range from 40-50° (average=42.5°), although more than half are greater than 40°. Half of the tools exhibit some form of use-wear, two exhibiting unifacial edge-flaking, one bifacial edge-flaking, one unifacial micro-chipping, and two edge grinding. All of the collected bifaces are fragmentary, with four indeterminate end pieces, two distal ends, a proximal end, two margin sections, and a medial fragment. Weights for these tools vary from 1.7-43.1 g (average=18.67 g).

Analysis of the collected specimens indicates that some of the bifaces broke due to manufacturing error, but both late-stage pieces found within 500 m of obsidian outcrops, were probably dart points broken by impact fractures. Most of the bifaces were distributed in two units, UD2 (n=8) and UD22 (n=5). Unit UD2 is within a biface reduction workshop located over 1.5 km from the nearest obsidian outcrop. All of the bifaces in the unit are either early (n=4) or middle (n=4) stage forms that are broken. In contrast, unit UD22 is located within 20 m of an obsidian cobble outcrop eroding from the mountain slope. Four of the five bifaces in this unit are whole, including a single early stage, two middle stage, and two late stage bifaces. This probably reflect discarded tools that either reached the end of their use lives (in the case of the late stage forms) or were rejected for further reduction due to material flaws or manufacture errors. Support for this interpretation is provided by the fact that none of the early or middle stage bifaces are broken. The three remaining bifaces were found in three different units (units UD8, UD17, and UD28), and all are broken late stage forms that were probably dart points broken while hunting.

Simple Flake Tools

A total of 24 simple flake tools was encountered in the upper desert scrub zone (Table 5.1), or one for every 1,518.75 m² surveyed. Seventeen were collected for hydration studies and more intensive analysis. Select attributes of the simple flake tools are summarized in Table 5.3. The table also shows the expected number of simple flake tools for each environmental zone and the adjusted residual for the difference between expected and observed values calculated as before. Most of these tools are either whole or near-complete (n=17, 70.8%), the remainder including three (12.5%) distal ends, one (4.2%) proximal end, and three (12.5%) margin fragments. Seventeen (70.8%) of the tools have a single edge, and seven (29.2%) have two used margins. The most common type of use-wear was unifacial micro-chipping (n=20), followed by unifacial edge flaking (n=10), bifacial micro-chipping (n=3), and step-fracturing (n=1).

Table 5.3. Select attributes of encountered simple flake tools.

	Upper Desert Scrub	Pinyon-Juniper	Lower Desert Scrub	Lacustrine	Total
CONDITION					
Whole	13	5	10	3	31
Near Complete	5	2	5	1	13
Proximal	1	0	1	0	2
Distal	3	0	0	0	3
End	0	0	1	0	1
Margin	3	2	0	2	7
Medial	0	0	0	1	1
NUMBER OF EDGES					
One	19	5	11	5	40
Two	6	4	6	2	18
FLAKE TYPE (collected specimens only)					
Cortical	2	1	1	1	5
Interior	4	2	2	0	9
Biface Thinning	3	2	3	0	8
Indeterminate	8	1	2	2	13
Total	25	9	17	7	58
Expected Total	17	17	17	7	58
Adjusted Residual	1.55	-1.78	-	-	-

More than half (n=10, 58.8%) of the collected simple flake tools are either whole or near-complete, and three (17.6%) margin fragments, three distal ends (17.6%), and one (5.9%) proximal end. Thirteen (76.5%) of the specimens have a single edge and the remaining four (23.5%) two edges each. Among the collected sample unifacial micro-chipping is again the most common type of use-wear (n=17), followed by unifacial edge flaking (n=10), and bifacial micro-chipping (n=2). Two (11.8%) artifacts are made on cortical flakes, four (23.5%) on simple interior flakes, three (17.6%) on biface thinning flakes, and the remainder on undiagnostic flake fragments. In size the tools range from 23.8-62.7 mm (average=39.9 mm) in length, 18.7-47.1 mm (average=31.3 mm) in width, and 5.0-17.1 mm (average=10.0 mm) in thickness and weigh between 3.6 and 39.3 g (average=11.8 g).

Over half (62.5%, n=15) of the flake tools were distributed in two units (nine in UD22 and six in UD17). UD22 is near an obsidian outcrop and the large number of flake tools probably flake blanks that were being prepared for transport. The non-fragmentary nature of these tools suggests they were discarded soon after use or preparation and the low limited number of tools with multiple edges that they were not intensively used. This is not surprising given the abundance of raw material and is more evident here than in any other zone.

Cores

Three cores were encountered in the upper desert scrub zone (Table 5.1). All were found in UD22 and are complete. Two of the cores are bifacial, the third a unidirectional specimen. The first is 50.0 mm long, 40.0 mm wide, and 20.0 mm thick. The second measured 80.0 x 50.0 x 40.0 mm and the third, unidirectional specimen 85.0 x 45.0 x 40.0 mm.

Debitage

A total of 98 pieces of unmodified flaking debris was collected from 14 Debitage Collection Units. Most of these units measured 15 x 15 m but where flake densities were higher unit of only 2 x 2 m (located in UD17) and 5 x 5 m (located in UD22) were collected. This made for a total collection area of 2,729 m^2, or one flake for every 27.8 m^2 (incorporating the sterile units raises this to one flake per 37.0 m^2). Of the 98 flakes collected, 25 are technologically undiagnostic, being either percussion fragments or interior shatter. This leaves only 73 flakes for analysis as discussed below (Table 5.4). As with previous categories Table 5.4 also provides the expected and actual number of flakes for each environmental zone, and adjusted residuals for the difference between these figures.

Table 5.4. Size and morphological class of collected diagnostic debitage.

	Upper Desert Scrub	Pinyon-Juniper	Lower Desert Scrub	Lacustrine	Total
SIZE					
1	0	90	3	9	102
2	18	304	27	26	375
3	26	184	59	8	277
4	20	156	89	7	272
5	9	74	18	2	103
TYPE					
Cortical	14	178	53	1	246
Interior	21	152	65	8	246
Biface Thinning	38	345	73	34	490
Pressure	0	133	5	9	147
Total	73	808	196	52	1129
Expected Total	327	327	339	136	1129
Adjusted Residual	-14	20.25	-7.08	-6.4	-

Most of the debitage collected from the upper desert scrub zone is large, with none of the flakes smaller than 1.0 cm in diameter. Flakes falling in the 1.0-2.0 cm category make up 24.7% of the diagnostic debitage (n=18), those between 2.0 and 3.0 cm 35.6% (n=26), 3.0-5.0 cm 27.4% (n=20), and 5.0+ cm 12.3% (n=9). Technologically, 19.2% (n=14) of the flakes are cortical (primary decortication, n=1; secondary decortication, n=13), while 28.8% (n=21) are interior percussion (simple interior, n=18; complex interior, n=3), and the remaining 52.0% (n=38) are biface thinning flakes (early thinning n=36, late thinning n=2).

The large size of the flakes is to be expected since, given the widespread availability raw material. The technological profile indicates everything from initial raw material reduction through the early to middle stages of production. Though samples are small, individual units suggest still other trends. Thus, both units containing projectile points (UD17 and UD33) had lower percentages of cortical debris and near-equal amounts of both interior percussion and biface thinning flakes. The remaining units with more than 10 diagnostic flakes generally follow the overall pattern. Units with fewer than 10 diagnostic flakes, however, show an interesting divergence, with a large percentage of biface thinning flakes (64.7%, n=11), and equal amounts of cortical and interior flakes (17.6%, n=3 each). This probably reflects different activities in these units, with tool maintenance/finishing occurring in sparse units and early tool production/raw material acquisition in denser units.

Overview

A total of 45 tools (and two isolate projectile points) were found in this zone, for an average of one tool per 810.0 m² surveyed. This was the sparsest distribution of tools in any of the zones. More interesting than this is the biface to flake tool ratio of 0.7:1, which is the only one where flake tools outnumber bifaces. This pattern is driven by the fewer than expected bifaces (Table 5.2) and over-representation of simple flake tools (Table 5.3). Of further interest is the lack of formed flake tools that occur in every other zone. The lower than expected number of bifaces results, in part, from their abundance in the pinyon-juniper belt; although in other zones bifaces appear in more or less expected quantities (Table 5.3). The technological profile of the debitage fits well with the biface analysis, showing that biface production did not progress much past mid-stage forms with the few late-stage artifacts recovered apparently discarded dart point fragments.

On balance, then, the upper desert scrub appears to have been the least intensively exploited of any biotic zone in the research universe. This is probably related to the lack of resources there, most of which are more abundant in lower, more accessible areas. The most attractive resource in this environment would have been artiodactyls. Many units with late stage bifaces and projectile points were located in areas that would have been good for hunting. Indeed, the fact that this stratum had the highest percentage of late stage bifaces/points adds weight to the argument that hunting was an important activity.

Unlike other zones, there was no evidence of habitation or prolonged occupation apart from temporary hunting camps. Activities within the upper desert scrub zone appear fairly limited, with extraction of lithic resources likely occurring within the context of hunting activities. The seemingly specialized, short duration of visits to this zone may help to explain the limited number of formed artifacts. Put another way, less time expended in an area, the fewer tools that will be exhausted and discarded there. The same is true for raw material acquisition, i.e., the less conducted, the less production refuse and fewer discarded tools deposited. Reduced production levels are reflected in the lower than expected amounts of debitage in this zone. Again, this may be driven by the super-abundance of debitage in the pinyon-juniper woodland, but the adjusted residual (Table 5.4) for the upper desert scrub is nearly double or more than that for all other zones but the pinyon-juniper. It stands to reason that the same should be true of simple flake tools, but this is not the case (Table 5.3). The upper desert scrub contained more than the expected number of simple flake tools, whereas the pinyon-juniper belt had fewer and the other two zones close to the expected amounts. This suggests that simple flake tools were important hunting implements in this zone. Thus, while bifaces are frequently associated with hunting activities, the abundance of readily available raw material in this setting, however may have reduced the need to invest in more formalized tools, i.e., bifaces.

PINYON-JUNIPER

The pinyon-juniper zone was defined as any forested area marked on the Mt. Hicks quadrangle map. This resulted in 34 potential OU's, 17 of which were randomly selected for survey and collection (34425 m^2). Fifteen of these units contained archaeological material. In addition to these artifacts were an isolated projectile point and two features that were found while traveling from unit to unit. Detailed analytical data are located in Appendix A, with the following discussion presenting a summary of the more salient information.

Projectile Points

A total of four projectile points was recovered in this zone, corresponding to one projectile point for every 8606.3 m^2 surveyed (Table 5.1). All four are made of obsidian and are large, dart-sized points. The first of these is the proximal end of a Humboldt Basal-notched point, broken from an impact fracture. The second point is an Elko Eared point. The specimen is whole, with only a small section of one of the tangs missing at the base. The third point has been classified as a generic dart, but it compares favorably with the Elko series. Only the proximal end remains, the point having been shattered upon impact. The final specimen is an Elko series point. It is nearly complete, missing the tip and one shoulder. This specimen was also broken from an impact, and shows extensive reworking of its distal end.

It is interesting to note that the only whole projectile point recovered was located in a unit that was relatively dense in artifacts (PJ8), while the three remaining proximal pieces were found in very sparse units; PJ21 yielded only the projectile point and a core, PJ22 contained only a single flake and a simple flake tool, and PJ30 only a single flake. The indication here is that they were re-tooling while away from a camp. There is no reason to do this unless hunters are ill-prepared for an additional encounter, suggesting that hunting in this zone was not well organized or planned out. Even if this is true, however, it would not preclude broken points being discarded at camp sites. Such a small sample of points is less than definitive, but the implications bear further consideration.

Bifaces

A total of 57 bifaces was encountered in this zone, one biface for every 603.9 m^2 surveyed (Table 5.1). Twenty-one specimens were collected for more in-depth analysis and dating purposes. Nearly half of all these artifacts (n=25, 43.9%) are either whole or near-complete, another 20 (35.1%) are indeterminate end fragments, followed by five (8.8%) distal ends, four (7.0%) margin sections, two (3.5%) proximal ends, and one

(1.8%) is a medial section (Table 5.2). Bifaces are heavily skewed towards the early and middle stages of reduction; 20 (35.1%) are early stage, 28 (49.1%) are middle stage, and the remaining nine (15.8%) are late stage forms.

Of the 21 bifaces collected from this zone, four are Stage 1, three are Stage 2, 11 are Stage 3, two are Stage 4, and one is Stage 5. Maximum length for the tools range from 23.2-94.5 mm (average=46.6 mm), from 19.5-57.0 mm (average=38.9 mm) in maximum width, while for maximum thickness from 3.4-21.6 mm (average=11.4 mm). Spine plane angles for the tools range from 35-60° (average=44.3°). Just over half (n=10, 52.6%) of the tools show evidence of use-wear, with unifacial micro-chipping and edge-grinding the most prevalent types (five instances each), and single instances of unifacial edge flaking and bifacial micro-chipping. Only six tools are whole, accompanied by five indeterminate end pieces, four distal ends, two margin sections, three medial sections, and one proximal end. Weight for the collected bifaces range from 1.9-98.7 g (average=28.9 g).

All 57 tools were found in eight units, the bulk of which (n=51, 89.5%) were located in three quads. Of these three units, eight (14.0%) bifaces were found in PJ2, thirteen (22.8%) in UD5, and 30 (52.6%) were found in PJ5; all three of these units are within 500 m of an obsidian outcrop. In these three units the bifaces diagnostic for reduction stage include 18 (36.7%) early stage, 24 (49.0%) middle stage, and seven (14.3%) late stage; nearly half (n=24, 49.0%) are either whole or near-complete. The bulk of these tools were discarded due to manufacture error, including the whole pieces, which either have edges that could not be turned or have large flake removals that resulted in step terminations, making further reduction untenable. Unit PJ5 had five bifaces that were in close proximity to each other, all within a one meter square area. These five differ from others found in dense areas in that they are all fragmentary, at least two have been broken from impacts (both are likely dart fragments), and one specimen appears to be a point preform. This small, tight association of bifaces likely represents a discard and retooling area within the larger landscape. In contrast, the remaining six bifaces were located in five units, and are evenly distributed between the three general stages of reduction; of these six, only one (16.7%) was whole. In addition, three of these artifacts are probably dart sections, and all but one seem to have been discarded due to use or impact.

Formed Flake Tools

A total of 10 formed flake tools was encountered in the pinyon-juniper zone (Table 5.1), for an average of one tool for every 3442.5 m^2 surveyed; four of these were collected for intensive analysis and dating purposes. Nine of the 10 tools are either whole or nearly so. Looking only at the tools that were collected, five of the six are either whole or near complete, the sole fragmented tool being a distal end. Only one of the tools has a classic domed shape, the remainder being amorphous in form. Two of the tools are made on large cortical flakes, another on a simple interior flake, and the last is undiagnostic. Three of the tools have worked edges along their entire perimeters, while the fourth has two separate edges, both with a straight configuration. Other than edge flaking, the most common type of use-wear found on the tools is unifacial micro-chipping. Edge angles are very consistent, varying from 35-50° (average=43°). Maximum length for these tools range from 56.7-105.1 mm (average=78.5 mm), while maximum width ranges from 43.9-64.7 mm (average=52.7 mm), while for maximum thickness 12.9-27.3 mm (average=19.4 mm).

The relatively small numbers of this artifact class encountered make broad generalizations tentative at best. One pattern that emerged, however, is the high percentage of these tools that were whole/near-complete. This might lead to the conclusion that the tools were not intensively used, discarded well before breakage, it is also significant that they tend to be made on sturdy flakes that would survive a lot of use. This implies, in turn, that they were not probably curated, but abandoned soon after accomplishing their task. All tools in this class were found with relatively dense artifact scatters, none of which could be described as habitation areas but rather contexts of primary lithic acquisition or biface workshops. This suggests that they are actually rejected tools.

Simple Flake Tools

Only nine simple flake tools were found in this zone (Table 5.1), six collected for more intense analysis and dating purposes, for an average of one flake tool for every 3825 m² surveyed. Seven (77.8%) of the nine tools are either whole or near-complete, the remaining two being margin sections (Table 5.3). Five flake tools have a single edge, the remaining four have two. Unifacial edge flaking is the most common type of use-wear found on these tools, found on five specimens, followed closely by both unifacial and bifacial micro-chipping, with four instances each, then two occurrences of step-fracturing, and finally one occurrence of bifacial edge flaking. Six tools have multiple types of use-wear present.

The tools are fashioned on a variety of flake types; two on bifacial thinning flakes, two on interior percussion flakes, one on a cortical flake, the last is indeterminate in type. Measurements for the tools range from 19.6-75.8 mm (average=51.2 mm) in maximum length, from 12.2-51.7 mm (average=34.9 mm) in maximum width, and from 4.5-19.8 mm (average=11.1 mm) in maximum thickness. Weight varies from 1.2-67.8 g (average=23.3 g).

Over half of these tools (n=5) were found in a single unit, PJ5, two more in PJ23, and single specimens in PJ22 and UD5. Unit PJ5 had the densest artifact concentration of any unit in the research universe (UD5 not far behind) and is located on top of an obsidian cobble outcrop, it is likely that the flake tools found in this unit, as well as the single tool found in UD5 which is very near an outcrop, are actually flake blanks that were rejected before transport. The large size of the flakes would also seem to attest to this. While this is almost certainly the case for some of these tools, it is also possible that these tools were used in non-lithic resource extraction activities during lithic procurement. If these flakes were being prepared for transport then dulling of the edges should have occurred over the entire perimeter of the specimens, but this is not the case. That said, it is interesting to note that the tools are generally more massive than those found in the upper desert scrub zone, both in terms of dimensions and mass (over twice the mass). Given that the units are located in the zone with the largest and highest quality obsidian outcrops in the research universe this is not entirely surprising; there would have been little cause to conserve material. Many of the tools have multiple edges, suggesting the tasks they were employed in were extensive.

Cores

A total of 33 cores was encountered in the pinyon-juniper zone (Table 5.1), 11 were collected for more in-depth analysis and dating purposes, for an average of one core for every 1043.2 m² surveyed. Twenty-six (78.8%) of the cores are either whole or near-complete, the remainder including five (15.2%) end pieces and two (6.0%) margins. Nearly half (n=16, 48.5%) of the cores are bifacial in configuration, with unidirectional (n=11, 33.3%) the next highest category, followed by multidirectional (n=3, 9.1%) and bidirectional (n=1, 3.0%). The bulk of the cores (n=27, 81.8%) were located in distance Band 0, with the remaining six (18.2%) in distance Band 2. Most core metrics were recorded in the field and are not as exact as collected specimens, but care was taken to obtain as accurate a measure as possible; maximum length varies for this artifact class from 37.0-140.0 mm (average=83.8 mm), for maximum width from 27.9-81.0 mm (average=60.7 mm), and for maximum thickness from 20.0-69.2 mm (average=34.5 mm). Of the eleven cores that were collected, most (n=7, 63.6%) are made on large flakes, with single (9.1%) specimens made from a globular cobble, an angular cobble, a small globular pebble, and one indeterminate as to its original form.

The most intriguing aspect of the cores, though not entirely surprising, is that the bulk of this artifact class was found in units that were on, or very near, primary sources of raw material; few were found outside of this context within this zone, and even fewer in other environmental zones. Apparently cores were not made primarily for transport from these primary acquisition locations, but for production of large flake blanks that were carried off. Only one unit away from a geologic source had a large number of flakes, PJ8, which represents a biface production workshop. This raises the question as to why prehistoric peoples would bother to make bifacial cores , the dominant core type found, if not for transport. While answering such a question is certainly beyond the scope of this work, it is possible that the shape of flakes removed from a bifacial platform are simply easier to form into biface tools and projectile points because, generally lacking a large platform, they would be easier to thin.

Debitage

A total of 1128 pieces of unmodified debitage was collected from 13 DCU's in the pinyon-juniper zone. Nine of these units measured 15x15 m; however, concentrations were such that in four units the collection units were reduced to 1x1 m. A total of 2029 m^2 was surface collected, for an average of one flake for per 1.8 m^2 (adding the four sterile units reduced this to one flake for every 2.6 m^2); this is by far the densest of any zone. Of the total flakes collected, 320 are technologically undiagnostic, leaving 808 for analysis (Table 5.4); all further percentages and discussion refer only to the diagnostic sample.

The size of the flakes found in this zone are weighted somewhat towards the smaller end of the spectrum. Size 1 account for 11.1% (n=90) of the sample, while Size 2 has the largest percentage at 37.6% (n=304). Size 3 is the next most abundant category at 22.8% (n=184), followed closely by Size 4 at 19.3% (n=156), and finally Size 5 at 9.2% (n=74). Technologically, cortical flakes make up 22.0% (n=178, including primary cortical, n=45; secondary cortical, n=125; and cortical shatter n=8) of the sample, while interior percussion flakes are slightly lower at 18.8% (n=152, including simple interior, n=126; complex interior, n=17; and linear interior n=9). Easily the largest category is biface thinning at 42.7% (n=345, including early biface thinning, n=300; and late biface thinning n=45), with the lowest category being pressure flakes at 16.5% (n=133, including linear pressure, n=9; rounded pressure, n=94; and indeterminate pressure, n=30). This last category is problematic as it likely includes small debris produced during a variety of reduction activities.

Overall, the debitage profile shows a full range of activities from initial raw material procurement to tool finishing. A closer look at individual units reveals differences in distribution across the zone. Unit UD5, which sits atop an outcrop, has much greater amounts of cortical flakes (60.8%) compared to the overall profile of the zone, with near the same proportion of interior flakes (19.4%), lower amounts of biface thinning flakes (16.7%), and very low amounts of pressure flakes (3.2%). In contrast, unit PJ5, which is near a major drainage bearing large amounts of obsidian cobbles and is a biface production workshop, has minimal amounts of cortical flakes (5.0%), slightly lower amounts of interior percussion flakes (15.1%), a very high proportion of biface thinning flakes (55.7%), and relatively high amounts of pressure flaking (24.1%) residues. All remaining units have relatively low amounts of debitage compared to UD5 and PJ5, and show still a different pattern. In general, these "sparse" units have high amounts of cortical flakes (41.1%), moderate amounts of interior percussion (33.7%), followed by biface thinning (24.2%), and a near absence of pressure debris (1.0%).

Features

Two features were identified while traveling between units in the pinyon-juniper zone. The first is a 3.5 x 2.5 m rock ring, likely a prehistoric house. Artifacts in the vicinity of the feature were relatively sparse in comparison to surrounding areas. A large milling slab was found approximately seven meters west of the feature, strengthening the likelihood that this represents a habitation area. Roughly 300 m east and 300 m north of this first feature, a second was also identified. This was a smaller rock ring, almost certainly a pinyon cache, found adjacent to a pinyon tree. This area had copious amounts of debitage as well as tools in the area surrounding the feature.

Overview

A total of 113 tools was encountered in this zone, for an average of one tool for every 304.6 m^2 surveyed; this is a relatively high number of tools. The biface to simple flake tool ratio is 6.3:1, by far the highest of any zone. This last pattern is driven by the more or less even distribution of simple flake tools across the environmental zones and an over-representation of bifaces (Tables 5.2 and 5.3). The debitage profile again fits well with the number and kinds of tools found in this zone; large numbers of bifaces and acquisition of raw material. As in the upper desert scrub zone, the average length of the simple flake tools corresponds with the larger end of the debitage size spectrum, even though it is far from being the largest category numerically, reinforcing the idea that these tools were selected for size, likely for ease of use and length of cutting edge.

This zone is the most intensively used of any in the research universe. The reason for this is two-fold; the first is simply that the largest quantity of raw material is available in this zone, both as primary outcrops and in secondary drainages, and is more accessible than outcrops located in higher elevations. The second, perhaps more important, reason is that a variety of activities were performed in this zone aside from lithic resource procurement. Some hunting activities were taking place, as well as pine nut procurement, and there was at least some habitation of this zone. Lithic procurement was likely embedded in these other resource extraction activities, as raw material would have been readily available.

LOWER DESERT SCRUB

The lower desert scrub zone was defined as any area below the pinyon-juniper belt but above the lowest elevations of adjacent Alkali Valley as marked on the Mt. Hicks quadrangle map. This resulted in 36 potential units, 18 of which were randomly selected for surface survey, for a total of 36,450 m^2 surveyed. Of these 18 units, 17 contained archaeological material. In addition, there were also two isolates and a feature encountered during travel between units in this zone.

Projectile Points

Three projectile points were recovered from this zone, two as isolate finds (Table 5.1). The first of these is a large side-notched dart specimen that compares favorably with the characteristics of a Fish Slough Side-Notched point. It is missing only the distal end which appears to have been broken off by an impact. The second point is an Elko Eared dart point. It is missing a shoulder, but has been reworked while still hafted. The last point, and the only one recovered from a unit, is a Gatecliff Split-stem form. It has suffered some damage along one edge of the blade portion of the point and also has had some reworking done to straighten it. This last point was recovered from a relatively sparse unit which contained only 15 pieces of debitage and no other tools.

Bifaces

A total of 33 bifaces was encountered in zone, for an average of one biface for every 1104.5 m^2 surveyed (Table 5.1). Seventeen of these tools were collected for more detailed analysis and dating purposes. Select attributes of these bifaces are presented in Table 5.2. Only two (6.1%) of the tools are either whole or near-complete, while 15 (45.5%) are indeterminate end pieces, five (15.2%) distal ends, two (6.1%) are proximal ends, three (9.1%) medial sections, and six (18.2%) margin sections. The bifaces are weighted most heavily towards mid-stage reduction (n=19, 57.6%), while late stage are next in number (n=9, 27.3%), and early stage are the least well represented (n=5).

The collected bifaces include a single Stage 2 specimen, 11 Stage 3, and five Stage 4 bifaces. Measurements for the collected tools range from 24.7-100.2 mm (average=43.6 mm) in maximum length, from 19.6-51.8 mm (average=33.5 mm) in maximum width, and from 5.0-21.0 mm (average=8.9 mm) in maximum thickness. Spine plane angles for the tools range from 30-55° (average=42.4°). Nine (52.9%) tools show some evidence of use-wear, with four instances each of unifacial micro-chipping and edge grinding, and three examples of unifacial edge-flaking. Five of the collected pieces are indeterminate ends, three are distal end pieces, a single specimen is a proximal fragment, with the remainder including five margin sections and three medial sections. Tool mass ranges from 2.9-60.6 g, with the average falling far nearer the lower end of the distribution at 13.9 g.

All 33 bifaces came from just six units, the bulk (n=28, 84.8%) found in just three units; 12 in DS24, nine in DS25, and seven in DS7. None of the bifaces were recovered from what could be described as sparse units, and there is no significant difference between the stages of those found in larger numbers from those found in fewer numbers. The tools are evenly split between those evidently discarded because of manufacture error and those broken during use; at least three of the bifaces were likely dart points before breaking.

Formed Flake Tool

A single formed flake tool from this environmental zone derived from unit DS7 (Table 5.1). The specimen is in near-complete condition and amorphous in overall shape. It has two worked edges, showing both unifacial micro-chipping and bifacial edge flaking. The artifact measured 50.0 mm in maximum length, 29.0 mm in maximum width, and 12.0 mm in maximum thickness; it was not collected.

Simple Flake Tools

A total of 17 simple flake tools was encountered in the lower desert scrub zone (Table 5.1), for an average of one tool per 2144.1 m^2 surveyed. Eight of these tools were collected for more intensive analysis and dating purposes. Select attributes of encountered simple flake tools are presented in Table 5.3. Fifteen of the tools are either whole or near-complete, accompanied by one proximal and one indeterminate end. Six (35.3%) tools have two edges, the remainder one. By far the most common type of use-wear is unifacial micro-chipping seen on 19 edges, followed by seven instances of unifacial edge flaking, four of bifacial micro-chipping, and a single example of step fracturing. Seven edges have multiple types of use-wear present.

The collected simple flake tools essentially mirror the larger sample both in terms of condition and use-wear. The tools are fashioned mostly on biface thinning flakes (n=3, 37.5%) but also include interior percussion flakes (n=2, 25.0%) and a single (12.5%) cortical flake; two tool blanks are undiagnostic as to original form. Measurements for the tools range from 35.7-72.7 mm (average=52.9 mm) in maximum length, from 25.8-51.8 mm (average=32.9 mm) in maximum width, and from 7.1-36.2 mm (average=13.8 mm) in maximum thickness. Tool mass ranged from 7.1-36.2 g (average=13.8 g).

All the tools were distributed among 10 units, but unlike many of the artifact classes are rather evenly distributed. Two units contained three flake tools each, another three units each had two, and the remaining five units yielded one example. Despite the long dimensions of the tools, comparable to the simple flake tools found in the pinyon-juniper zone, they are somewhat gracile, averaging 10.0 g lighter than the tools found in the former area. Unlike that zone, it is unlikely that any of the simple flake tools found in this zone were intended to be transported elsewhere, but were employed in local activities.

Cores

A total of seven cores was encountered in this zone (Table 5.1), resulting in an average of one tool for every 5207.1 m^2 surveyed. All seven of the cores are whole. Three of the tools are bifacial in overall configuration, two are unidirectional, and the remaining two multidirectional. Measurements for maximum length range from 60.0-137.0 mm (average=94.0 mm), from 63.0-123.0 mm (average=82.7 mm) for maximum width, and from 30.0-152.0 mm (average=64.4 mm) for maximum thickness.

The seven specimens were distributed between two units, six occurring in DS19 and one in DS8. Unit DS19 contains fairly dense artifactual debris, though the only other tool encountered was a simple flake tool. By contrast, DS8 is sparse but did contain two simple flake tools. The area encompassing DS19 likely represents a secondary reduction locus, as debitage from that unit contains cortical, interior, and few biface thinning flakes; DS3, however, is a small biface reduction area, with the few flakes present being dominated by biface thinning debris.

Debitage

A total of 267 pieces of unmodified flaking debris was recovered from this zone, distributed among 16 DCU's. Concentrations of debitage were sufficiently dense that only eight of the DCU's were 15 x 15 m in size, the remainder including three 1 x1 m, three 2 x 2 m, and single 5 x 5 m and 2 x 1 m units. The overall density averaged one flake for every 6.9 m^2 (dropping to one flake every 8.6 m^2 when sterile units are included). Seventy-one flakes are technologically undiagnostic and are excluded from the following percentages and discussion (Table 5.4).

Flake size profiles in this zone show a definite leaning towards large flakes. Only 1.5% (n=3) are >1.0 cm in diameter, 13.8% (n=27) are between 1.0 and 2.0 cm, with an increase of those between 2.0 and 3.0 cm at 30.1% (n=59), a near equal increase in percentage with the next category, 3.0 to 5.0, at 45.4% (n=89), and those 5.0 + dropping to 9.2% (n=18). Technologically, the analysis shows that 27.0% of the flakes are cortical (primary cortical, n =12; secondary cortical, n =41), 33.2% are interior percussion (simple interior, n =61; complex interior, n =1; linear interior, n =3), with biface thinning the largest category at 37.2% (early biface thinning, n =71; late biface thinning, n =2), and pressure flakes comprising the smallest category at 2.6% (linear pressure =5).

The debitage profile is surprisingly even, with no one category truly dominating the overall sample, indicating that all phases of flaked stone reduction were being performed in this zone, with the exception of perhaps pressure flaking during the finishing or retooling of implements. This last point may be perplexing as this zone had the greatest number of late-stage bifaces of any in the research universe, but pressure flaking can often be confused with edge preparation flakes and it is the category most easily overlooked in the field. Comparing the flakes of units shows some differences in the technological profiles of areas containing sparse amounts of debris and those with relatively dense materials. The denser units, all of which generally mirror one another, have very comparable proportions of cortical debris (27.7%), interior percussion (34.3%), and biface thinning flakes (33.5%). Given the context of these units, it seems likely that they represent secondary reduction locales and perhaps some biface workshop areas (only one unit was within 500 m of a cobble-bearing drainage and is the most "sparse" of the dense units). The sparse units do show lower proportions of cortical (25.4%) and interior percussion (27.1%) debris, but much higher frequencies of biface thinning flakes (45.8%). This last is especially interesting as no bifaces were found within the sparse units, where tools were restricted to one projectile point, a core, and a small number of simple flake tools; these narrow collections of artifacts possibly represent individual resource processing events. Likely these sparse scatters of artifacts are not associated with hunting, but probably reflect processing of smaller fauna and other resources.

Feature

Situated less than a kilometer west of Alkali Lake and about the same distance from pinyon-juniper areas (between units DS27 and DS29), the "feature" actually consists of seven rock rings. These vary in size from just under a meter in diameter to over 2.5 meters. Stone in the courses of the rings included some that were fire-affected as well as containing some ground stone artifacts.

Overview

A total of 59 tools was encountered in this zone, for an average of one tool for every 617.8 m² surveyed. Some 1.9 bifaces were found for every simple flake tool (very near the average for the entire research universe, which is exactly 2.0:1). The debitage profile matches well with the identified tools, not showing a strong tendency for any one behavior but rather more balanced representatives of diverse activities. As elsewhere, the maximum length of simple flake tools does not correspond to the most numerous debitage size category but falls more towards the larger end of the spectrum; in this zone the trend is especially pronounced as flakes were in general larger than in other strata.

Use of this zone seems to be geared towards general subsistence and biface production, with no one technology seeming dominant. Production of bifaces is important, but not nearly to the extent found in the pinyon-juniper zone. Initial reduction of raw lithic material is not a primary activity, and most artifactual remains are better understood in the context of secondary reduction. While not found in a formal survey unit, the location of the rock ring features appears ideal for exploitation of both lacustrine and pinyon resources. This suggests that a wide array of resources was being exploited from this area; the diverse and balanced number of tool classes supports the notion that this zone was used as a central location for gathering resources from varied environments.

LACUSTRINE ZONE

The lacustrine zone was defined as the area encompassed by Alkali Lake and its perimeter as indicated on the Mt. Hicks quadrangle map. This resulted in 13 potential

OU's, of which seven were selected for surface survey and collection; a total of 14,175 m^2 surveyed. Although some of the included areas could perhaps be identified as lower desert scrub, they were retained within the lacustrine zone because the lake boundaries have certainly changed over time and small patches of dune and playa sediments are apparent across the lowest elevations. Five units contained archaeological material, and a single isolate was found near Dead Horse Pond.

Projectile Point

A single projectile point was recovered as an isolate from this zone (Table 5.1). The artifact is the proximal end of an Elko Eared dart point, which appears to have been shattered from impact. The dearth of projectile points from this zone may seem perplexing at first, but the area is adjacent to the only roads that go into the valley and has been heavily visited (K. Halford, personal communication). The lone point does indicate some hunting activity around the lake during the Newberry period.

Bifaces

A total of eight bifaces was encountered in this zone (Table 5.1), producing an average of one for every 1771.9 m^2 surveyed. Select attributes of bifaces are presented in Table 5.2. Only two (25.0%) of the tools are near-complete, the others including three (37.5%) indeterminate ends, and singular examples (12.5%) of a distal end, proximal end, and margin section. Nearly all of the specimens are middle stage (n=7, 87.5%), with a single late-stage biface also present.

The collected specimens include the single late-stage biface encountered (Stage 4), the remaining two are Stage 3 items. The Stage 4 specimen, which is near-complete, has an incomplete length of 45.7 mm, a maximum width of 16.6 mm, and is 5.1 mm thick. It has a spine plane angle of 35°, shows edge grinding, and weighs 4.8 g. The second specimen is also near-complete, and has a partial length of 36.1 mm, width of 32.1 mm, and thickness of 9.5 mm. It has a spine plane angle of 45° and shows no evidence of use-wear; it weighs 11.0 g. The third specimen is a distal end too fragmentary to characterize metrically. It also has a spine plane angle of 45°, with unifacial micro-chipping along one edge; it weighs 7.2 g.

The eight bifaces were distributed between just three units, four in LC10 and two each in LC3 and LC5. All three of the collected bifaces were likely broken due to use rather than manufacture error. Two of the units containing bifaces also contained the bulk of the simple flake tools and a formed flake tool. These same two units also had the largest amount of debitage collected from this zone. The third biface-bearing unit, with two such tools, had the second lowest amount of debitage and had no other formal artifacts present.

Formed Flake Tools

Only two formed flake tools were recovered from this zone (Table 5.1), averaging one tool for every 7087.5 m^2 surveyed. Both tools were collected for more intensive analysis and dating purposes. The first tool is whole and shows unifacial edge flaking along its entire perimeter. Made from a cortical flake and amorphous in shape, it has a somewhat obtuse edge angle of 55°. It measures 82.8 mm in maximum length, 57.6 mm in width, 22.9 mm in thickness, and weighs 89.2 g. The second tool is near-complete and shows unifacial edge flaking along one convex edge. This specimen is made on a large biface thinning flake, and like the other tool is amorphous in shape, but has a more acute worked edge angle of 35°. This specimen measures 45.4 mm long, 53.2 mm wide, and 13.7 mm thick, and it weighs 45.4 g.

Both of these tools were found in units containing moderate amounts of debitage as well as other tool classes. Unit LC3 also contained two bifaces and four simple flake tools, while LC4 contained a simple flake tool and two cobble tools. The different edge angles, dimensions, and weights of the tools suggest that despite belonging to the same generic tool category, they were likely employed in rather different tasks; the heavier tool with the more obtuse edge for scraping tasks, the other for cutting tasks. This in turn suggests more general use of this area, perhaps sporadic habitation (fire-affected rocks and hearths were noted by crew members), as well as more resource specific activities. No other hearth features were noted in other strata, and the only other fire-affected rocks identified were used in construction of rock ring features in the lower desert scrub zone.

Simple Flake Tools

A total of seven simple flake tools was encountered in this zone (Table 5.1), providing an average of one tool for every 2025 m² surveyed. Three were collected for more intensive analysis and dating purposes. Select attributes of simple flake tools are presented in Table 5.3. Over half (n=4, 57.1%) of the tools are either whole or near-complete, the remainder comprising two (28.6%) margins and a single (14.3%) medial section. Two specimens have two edges each, the remaining five (71.4%) just a single edge. Use-wear on the tools is evenly represented between unifacial micro-chipping and unifacial edge flaking, with five instances each. Three edges have multiple types of use-wear present.

The first of the collected tools is a whole specimen made from a cortical flake. It has two edges, both unifacially edge flaked, with acute angles of 25° and 30°, respectively. The tool measures 44.7 mm long, 27.7 mm wide, 7.4 mm thick, and it weighs 8.0 g. The second tool is a margin section, the original flake type is undiagnostic. It has a single edge showing both unifacial edge flaking and unifacial micro-chipping, again with an acute angle of 35°. It is too fragmentary to provide useful metrics, but weighs 3.1 g. The third tool is also a margin section undiagnostic as to flake type. It has a single edge showing unifacial micro-chipping. Weighing 1.3 g, this piece is too incomplete to characterize fully.

The seven simple flake tools were found in three units, four in LC3, two in LC10, and one in LC4. Taking into account that one of the artifact-bearing units had only a single flake present, the distribution of flake tools is fairly even, being found in three of the remaining four units that had artifacts; simple flake tools appear to have been an integral part of the resource processing activities that were performed in this area.

Debitage

A total of 76 pieces of unmodified flaking debris was recovered from this zone, distributed among five DCU's. Densities were such that one unit was a 2 x 2 m square and another a 5 x 5 m square, for a total of 704 m² surface collected for debitage; this corresponds to one flake for every 9.3 m² collected (reduced to one flake for every 15.2 m² when sterile units are incorporated). The collected sample contained 23 technologically undiagnostic flakes, excluded in the following analysis and discussion (Table 5.4).

Debitage in this zone are small; 16.9% (n=9) are smaller than 1.0 cm in diameter, 49.1% (n=26) are between 1.0 and 2.0 cm, 15.1% (n=8) between 2.0 and 3.0 cm, 13.2% (n=7) between 3.0 and 5.0 cm, and just 3.8% (n=2) larger than 5.0 cm. Technologically, only one flake (1.9%) is cortical (secondary decortication), 15.1% (n=8) are interior percussion (simple interior, n = 6; complex interior, n = 2), while well over half are biface thinning (64.1%; early thinning, n = 28; late thinning, n = 6), and 16.9% are pressure flakes (rounded pressure, n = 7; indeterminate pressure, n = 2).

There are notable differences within flake type profiles of different units. The more dense units, LC10 and LC5 which between them yielded six of eight biface found in this zone, contain nothing but biface thinning (70.0%) and pressure flakes (30.0%). The more sparse units, in contrast, produced all of the interior percussion flakes (38.1%), and more modest amounts of biface thinning debris (61.9%). Overall, the debitage profile shows that biface maintenance, and perhaps finishing, were important lithic activities, while flake production is perhaps more important away from those areas. The absence of cores suggests that these flakes may have been imported; unlike the overall sample, over half of the interior percussion flakes are 3.0 cm in diameter or larger.

Overview

A total of 17 tools (not including the isolate point and two cobble tools) was encountered in this zone, for an average of one tool for every 833.8 m² surveyed. The biface to simple flake tool ratio in this zone is essentially even, at 1.1 to 1. This is especially important as none of the bifaces in this zone appear to have been discarded due to manufacture error. The debitage profile shows that biface maintenance and finishing were important tasks, but seem to have been performed in segregated areas away from more general activities. The single near-complete simple flake tool is much larger than the average size of debitage found in the zone, but the remaining tools are incomplete, it can only be observed that this zone seems to follow the trend in other zones for simple flake tools to be selected for their large size.

The lacustrine zone, even when expanded to encompass the lowermost elevations of the valley floor, comprises a very small portion of the research universe. This is further compounded by the fact that two of the units were unlikely to contain artifacts, LC7 located in the center of Alkali Lake and LC13 which was mostly confined to the lakebed area. Artifact distribution nonetheless clearly show two separate patterns of use. The first is represented by more dense artifact-bearing units, which contain large amounts of debitage and, to a lesser degree, bifaces. These units seem to be segregated areas devoted to biface maintenance and finishing. The more "sparse" units, in contrast, contain limited amounts of debitage but a wider array of formal artifacts, including two bifaces, five simple flake tools, two formed flake tools, and two cobble tools. These areas are likely devoted to non-lithic resource processing and perhaps habitation.

Lastly, it should be noted that LC3 is located at the northern end of the lake. This area, as mentioned during the debitage section, is at the end of several drainages that extend well to the east and up the slopes of Mt. Hicks. These drainages contain numerous obsidian cobbles and flakes.

DISCUSSION OF SURVEY RESULTS

It is evident that an environmental zone, and its associated resources, have a strong effect on how artifact classes are distributed across the research universe. This is best illustrated by contrasting the pinon-juniper and upper desert scrub zones. Both are near equally represented in the research universe and contain obsidian outcrops but differ in the amounts of artifacts present. The pinyon-juniper zone contains abundant food resources, including pine nuts which would likely have become available beginning 5,500 BP, extensive obsidian outcrops, and is lower in elevation than the upper desert scrub zone, making access to resources less costly. The only important resource in the upper desert scrub zone not readily available in lower zones is ungulates. This apparently led to very different exploitation patterns.

The pinyon-juniper belt yielded evidence of habitation, resource caching, and resource processing. The debitage profile (Table 5.4), number of bifaces (Table 5.2), and cores (Table 5.1) shows that biface manufacture and lithic procurement were important activities. Late-stage bifaces comprise the lowest percentage of reduction stage (15.8%), while mid-stage specimens dominate (49.1%). Much of this activity likely occurred in embedded contexts, but the presence of biface workshops suggest that obsidian was specifically targeted for acquisition as well. In contrast, there is no evidence of habitation in the upper desert scrub zone though there were areas that appear to be associated with hunting. These more limited forays resulted in the upper desert scrub zone being less intensively used. Obsidian exploitation seems to be predominantly restricted to embedded contexts. Lithic acquisition and biface manufacture do take place, but in limited amounts in comparison to the pinyon-juniper belt. Less time spent in this zone would have led to fewer formal artifacts reaching the end of their use-lives and discarded in this context; more importantly fewer production attempts would lead to fewer discarded tools due to manufacture error. Unlike the pinyon-juniper zone, late-stage bifaces are relatively equal (31.3%) in percentage to early- (31.3%) and late-stage (37.5%) specimens. The upper desert scrub zone did have greater than expected numbers of simple flake tools. It is possible that this is due to that tool class being favored for hunting in this context, but simple flake tools are expedient tools. Discard of expedient tools occurs, generally, more quickly than curated tools. This uneven discard rate likely contributes to the relatively high number simple flake tools and the low biface to simple flake tool ratio of this zone. This, however, does not explain the patterns completely; simple flake tools in both the lower desert scrub and lacustrine zones appear in expected numbers (Table 5.3), leaving the question open as to why they appear in more than expected amounts only in the upper desert scrub zone, while appearing more rarely only in the pinyon-juniper belt. Hunting is likely the only major activity consistently performed in the upper desert scrub zone that is not performed much in the pinyon-juniper belt, so it is probable that hunting is related to the higher than expected numbers of simple flake tools found in the upper desert scrub zone.

The lower desert scrub and lacustrine zones provide another interesting contrast in landscape use and exploitation. The lower desert scrub zone contains some obsidian cobbles within drainages, has resources that are expansive but generally high in cost, and is situated between two potentially very productive environments. The lacustrine zone is most distant from obsidian sources and has seasonally abundant food resources.

The lower desert scrub zone contained evidence of habitation located in an area that appears to be well situated to exploit resources in the pinyon-juniper belt, the lacustrine zone, and the lower desert scrub zone itself. This probably reflects a collector strategy. Both bifaces (Table 5.2) and simple flake tools (Table 5.3) were encountered in close to expected amounts, which may suggest a wide ranging number of activities with no one activity dominant. Middle-stage bifaces dominate the assemblage (57.6%), with lower amounts of early- (15.2%) and late-stage (27.2%) tools; note that middle-stage bifaces are even more dominant than in the pinyon-juniper belt but early-stage specimens substantially lower. Debitage was encountered in much less than expected amount to roughly the same degree as in the lacustrine zone but less so than the upper desert scrub zone (Table 5.4); this is not unexpected given the vast amount located in the pinyon-juniper zone. Also not surprising, given its modest amount of obsidian resources and distance from outcrops, is the debitage profile (Table 5.4) which indicates that secondary reduction of bifaces is slightly more prevalent than other lithic activities. The lacustrine zone, in contrast, was likely targeted by collector groups with residential bases in different environments. The presence of hearth features, however, suggests that it was at least occasionally used for habitation as well; this likely varied through time. The presence of ground stone artifacts could also indicate habitation, but groups may have processed plant resources before returning to residential bases. Bifaces were encountered in less than expected amounts (Table 5.2), though not to a great extent, and may simply be a result of the large number of bifaces located in the pinyon-juniper zone. Middle-stage bifaces are dominant (87.5%) followed by late-stage specimens (12.5%) and early-stage examples are not present; while this is much different than any other zone, only eight bifaces were encountered. Simple flake tools were found in expected amounts (Table 5.3) while debitage was, not surprisingly, found in less than expected amounts(Table 5.4). The near-even biface to flake tool ratio again suggests that a variety of activities were taking place. The debitage profile indicates that biface finishing/rejuvenation was a primary activity. The distance of this zone from obsidian cobbles likely explains the dearth of early reduction debris.

No two environmental zones were exploited in the same manner as evidenced by the relative amounts of tools contained within each zone as well as identified features, debitage profiles, and tool forms. Resources located within each zone, including both obsidian and food resources, and their distribution across the landscape likely strongly influenced the number, relative amounts, and form of artifacts.

Chapter 6

OBSIDIAN STUDIES

Developing a hydration rate for Mt. Hicks obsidian is problematic given the nature of the available data, based largely on a surface survey that lacks radiocarbon/ hydration pairings and large numbers of temporally diagnostic points. While it would be possible to proceed without a hydration rate, development of a preliminary rate enables the study to place Mt. Hicks within a regional temporal framework.

HYDRATION RATES IN THE WESTERN GREAT BASIN

Obsidian studies have been particularly important in eastern California where obsidian is abundant but other dateable materials (e.g., hearths amenable to radiocarbon dating) are scarce. Obsidian studies have examined such issues as problems in source identification (Hughes 1984), applications of hydration (R. Jackson 1984), and patterns of trans-Sierran exchange (Bouey and Basgall 1984). Today, obsidian source and hydration studies are routine parts of most archaeological investigations in eastern California. Over the years, numerous attempts to develop source-specific hydration rates have been undertaken in the region. Some of the most notable include rate derivations for Casa Diablo (Basgall and Delacorte 2003; Hall 1984; Hall and Jackson 1989), Coso (Basgall and McGuire 1988; Basgall 1990), Fish Springs (Bettinger 1982b; Delacorte and McGuire 1993), and Truman-Queen glass (Basgall and Giambastiani 1995; Giambastiani 2004).

Hall (1984) first proposed a curvilinear rate for Casa Diablo, that was later tested and refined (Hall and Jackson 1989). This derivation used Thomas' (1981) morphological classification to assign 108 projectile points to one of four temporal periods. Correlations were then made between the mean and median values for a given period and the midpoint of the appropriate temporal period. Period-specific hydration values were categorized in four different ways: all values for both surface and subsurface finds; all values with statistical outliers excluded using Chauvenet's criterion; values for exclusively subsurface specimens; and values from subsurface items with statistical outliers excluded. This allowed Hall to develop the maximum separation between pairs. Lastly, each of the variate pairs that resulted from the first two steps were used to calculate a total of 48 "potential" hydration rates. Hall (1984) found that a power function rate based on projectile points from subsurface contexts with extreme outliers eliminated provided the best results. Hall and Jackson (1984: 51) note that this does not signify that there is a significant difference between the hydration rates of surface and subsurface artifacts, but is simply the best empirical formulae.

Excavations at CA-INY-30 (Basgall and McGuire 1988; Basgall 1990) in Owens Valley furnished ten radiocarbon-hydration pairings for Coso obsidian. These were used to develop a source-specific rate for that source. The rate produced consistent dates for post-4000 BP, but exaggerated age estimates for micron values greater than 8.0 (Basgall and McGuire 1988). Basgall and McGuire surmised that the hydration of Coso obsidian is more accurately described by a linear than curvilinear function after 6.0-7.0 microns, but the reality of this is still unclear. Basgall (1990) later added a correction for effective hydration temperature.

The problem of inflated age estimates for greater (older) micron values, was also encountered in attempts to develop rates for other sources, such as Fish Springs (Basgall 2000; Delacorte and McGuire 1993), Truman-Queen (Basgall and Giambastiani 1995; Giambastiani 2004) and Casa Diablo obsidian (Hall and Jackson 1989).

Mt. Hicks Hydration Rate

Ericson (1975, 1978) was the first to develop hydration rates for Mt. Hicks on the basis of induced-hydration experiments. Evidently, no archaeological use was ever made of the rates, which is not surprising given the highly experimental nature of the rate development. Testing the latter of Ericson's two rates shows that the formula is not reliable. The average micron value for Elko series projectile points made of Mt. Hicks

Table 6.1. Age estimates for micron values derived from Ericson's (1978) Mt. Hicks hydration rate.

Micron value	Age estimate
1	597.47
2	844.95
3	1034.84
4	1194.93
5	1335.98
6	1463.49
7	1580.75
8	1689.89
9	1792.4
10	1889.35

obsidian in the project area is 4.29 (Table 6.2). Applying Ericson's rate of Years BP=597.466/microns$^{1/2}$ yields a date of 1237.49 years BP, or appreciably less than the expected age of 2675 BP.

Table 6.2. Projectile point hydration data used in developing the Mt. Hicks hydration rate.

Type	Reference	Measurement	Number	Mean	Std Dev
DSN	Halford 1998	NVH	1	-	-
RSG/ESG	Halford 1998, Martinez this thesis	1.5, 1.6, 2.0, 2.1, 2.2, 2.7, 3.5, 3.5	8	2.39	±0.78
Elko	Arkush 1995, Halford 1998, Martinez this thesis	2.6, 3.1, 3.8, 4.0, 4.3, 4.3, 4.4, 4.4, 4.5, 4.8, 5.0, 5.0, 5.1	13	4.29	±0.74
Pinto	Halford 1998	6.4, 6.8, 7, 7.2, 7.6	5	7	±0.45

Note: DSN-Desert Side-notched; RSG-Rosegate; ESG-Eastgate; NVH-No Visible Hydration; Std Dev-Standard Deviation.

Given the unreliability of the experimental rate, an empirical rate was developed using temporally diagnostic projectile points collected during the present fieldwork and other projects in the area (Arkush 1995; Halford 1998) that have similar temperature regimes (Table 6.2). Identification of previously sourced Mt. Hicks projectile points was accomplished using metric criteria based on Thomas (1981) and Basgall and Hall (2000). A method similar to Hall's (1984) was used to develop three potential rates with the data presented in Table 6.2. Least squares regression analysis was used to develop an exponential formulae for all three rates; no statistical outliers were identified by Chauvenet's criterion.

The first potential rate paired the mean hydration value of diagnostic point types with median age for the type. This resulted in three data pairs with a best-fit formula of: years BP=217.28xmicrons$^{1.7399}$. This rate has the best R^2 value (0.9995) of any of the three formulas, but seems to exaggerate micron values over 7.0. The second formula is similar, but following Hall (1984), additional data points were generated by calculating the separation between the hydration means successive point types or transition between time periods. This resulted in: years BP=297.2xmicrons$^{1.6489}$ and had the lowest R^2 value (0.9684) of the rate derivations. More importantly, this second rate greatly exaggerates age estimates for younger material around the 2.0 micron range. As such, both the first and second rate were discarded in favor of the third formulation.

The final rate was developed as before but the median values eliminated. This resulted in years BP=196.55xmicrons$^{1.7454}$, with an R^2 of 0.9711. More importantly, this rate has the highest success in placing projectile points within their correct time period, and does not exaggerate the age of larger (older) micron values. If anything, age estimates of larger micron values seem to be slightly younger than anticipated (Table 6.3).

Table 6.3 Age estimates for micron values derived from Mt. Hicks hydration rate (this thesis).

Micron value	Age estimate
1	196.55
2	659.01
3	1337.34
4	2209.57
5	3261.78
6	4483.92
7	5868.23
8	7408.43
9	9099.3
10	10936.37

The rate, however, does have limitations: first, there is the lack of radiocarbon dates to either establish or test the formulation; and secondly, and more important, there are no data for the Marana period. As such, the two Rosegate points with the lowest hydration readings fall within the Marana, not the appropriate Haiwee period. Although temporally diagnostic points may overlap time periods, their seemingly inaccurate dating underscores one of the problems with this rate, i.e., low micron value age estimates are likely too old. This rate must only be considered preliminary until it can be further refined with data ascribable to the Marana period. Nevertheless, the rate should capture broad temporal trends within the project area, and has the advantage of not grossly over-estimating the age of artifacts with larger micron values.

Using this rate, Marana period artifacts are represented by micron values of 2.0 and lower, the Haiwee period by values between 2.1 and 3.0, the Newberry interval by values between 3.1 and 5.6, and pre-Newberry remains with values of 5.7 and higher. The success of this hydration rate for younger material is poor, with only 50% (n=4) of Haiwee period projectile points falling within that time frame. Success for Newberry period points is much higher with 92.3% (n=12) of the age estimates falling in the correct time frame. Success for the Pinto points was even greater, with 100% (n=5) falling in the correct temporal period.

Mt. Hicks Hydration Rate and Effective Temperature

A substantial number of projectile points from the Volcanic Tablelands in Owens Valley have been sourced to Mt. Hicks (Giambastiani 2004: Table 9.6), and hydrate at a much faster rate than those in the cooler research area (Table 6.4). Indeed, the mean hydration values for Tablelands points are more than a micron greater for Haiwee points, over two microns larger for Newberry points, and nearly three microns higher for Pinto (pre-Newberry) points. The same is true for Casa Diablo obsidian that hydrates at an apparently faster rate on the Volcanic Tableland than it does in other, higher elevation localities (Giambastiani 2004: Table 9.5). This suggests that local temperatures greatly influence hydration rates of obsidian from various sources. As no adjustment for effective hydration temperature was calculated for the preliminary rate developed here, it can only be used in areas with temperature parameters similar to those at Mt. Hicks.

Table 6.4. Mean micron values for select projectile point types recovered from the Volcanic Tablelands (Giambastiani 2004:Table 9.6) sourced to Mt. Hicks.

Point Type	Number	Mean hydration value
Rosegate	4	3.4
Elko series	8	6
Pinto	3	9.8

Mt. Hicks Hydration Rate Versus Other Sources

Compared to other sources of obsidian with previously established hydration rates, Mt. Hicks appears to hydrate slower than Coso and Truman-Queen glass (Table 6.5), but somewhat faster than Casa Diablo material. Caution must be exercised, however, as effective hydration temperature strongly influences that rate at which water diffuses into obsidian. Care was taken to use projectile point data strictly from nearby areas with comparable temperatures parameters, in this case the Dry Lakes Plateau and CA-MNO-2122 in Mono Lake Basin.

Table 6.5. Mean micron values for select projectile point types made of Truman-Queen, Casa Diablo, Coso, and Mt. Hicks obsidian.

Point Type	Truman-Queen[1] (n)	Casa Diablo[2] (n)	Mt. Hicks[3] (n)
Desert side-notch	1.89±0.5 (13)	1.93±0.62 (13)	NVH (1)
Rosegate	3.45±0.6 (26)	3.02±0.92 (18)	2.39±0.78 (8)
Elko-series	-	4.19±0.7 (73)	4.29±0.75 (13)
Elko-eared	5.40±0.49 (38)	-	-
Elko-corner notch	5.99±0.83 (11)	-	-
Elko-contracting stem	5.73±0.56 (8)	-	-
Fish-Slough side-notch (not used in formulating hydration rate)	8.48±0.88 (20)	-	7.13±0.05 (3)
Pinto	10.77±1.64 (6)	6.48±0.97(6)	7.00±0.45 (5)

[1] - Giambastiani 2004.
[2] - Hall and Jackson 1989: Table 1. Using Basgall and Hall 2000, some points were reclassified as Pinto and Little Lake.
[3] - Arkush 1995, Martinez, this thesis; Halford 1998;using Basgall and Hall 2000, some points were reclassified Pinto, another was dropped for insufficient metrical data.

The Truman-Queen obsidian hydration data presented in Table 5.8 were collected from the comparatively warm Volcanic Tablelands which greatly influences hydration rate. Thus, when comparing the Truman-Queen and Mt. Hicks hydration rates, it is imperative that the data derive from areas with similar temperatures. When comparing the average micron values of temporally diagnostic projectile points made of Mt. Hicks and Truman-Queen obsidian from just the Volcanic Tablelands (Tables 6.4 and 6.5), the rates appear to be similar, with the average values for Haiwee, Newberry, and pre-Newberry points all within a micron of one another.

PRODUCTION CURVES

A total of 329 obsidian hydration readings was generated for the project. Each of the readings was assigned to one of six time periods developed in the previous section. The periods preceding the Newberry interval are still poorly understood, and thus all will be combined and simply referred to as pre-Newberry. The pre-Newberry era was divided into early and late phases, the cut-off being 6000 BP. The Newberry period was also divided into earlier and later phases, the separation which is the chronological center of the period. The Haiwee and Marana periods are not divided, though archaeological evidence from elsewhere suggests there were certainly changes during these intervals. There are, however, relatively few readings assigned to either period, such that further splitting would result in samples too small for meaningful comparison or statistical manipulation. The following section discusses the inclusive production curve as well as curves developed for each environmental zone. Trends in flaked stone production are also discussed in the following section, focusing on bifaces and simple flake tools. These artifact categories are the most numerous in the sample, and their importance to prehistoric peoples and archeological theory well established.

Inclusive Production Curve

The inclusive production curve (Chart 6.1) appears similar to that seen at the Bodie Hills, Coso, Casa Diablo, and Truman-Queen sources. A total of 14 (4.3%) measurements are assigned to the early pre-Newberry interval. This is to be expected given the limited population during this time, when comparatively little activity would

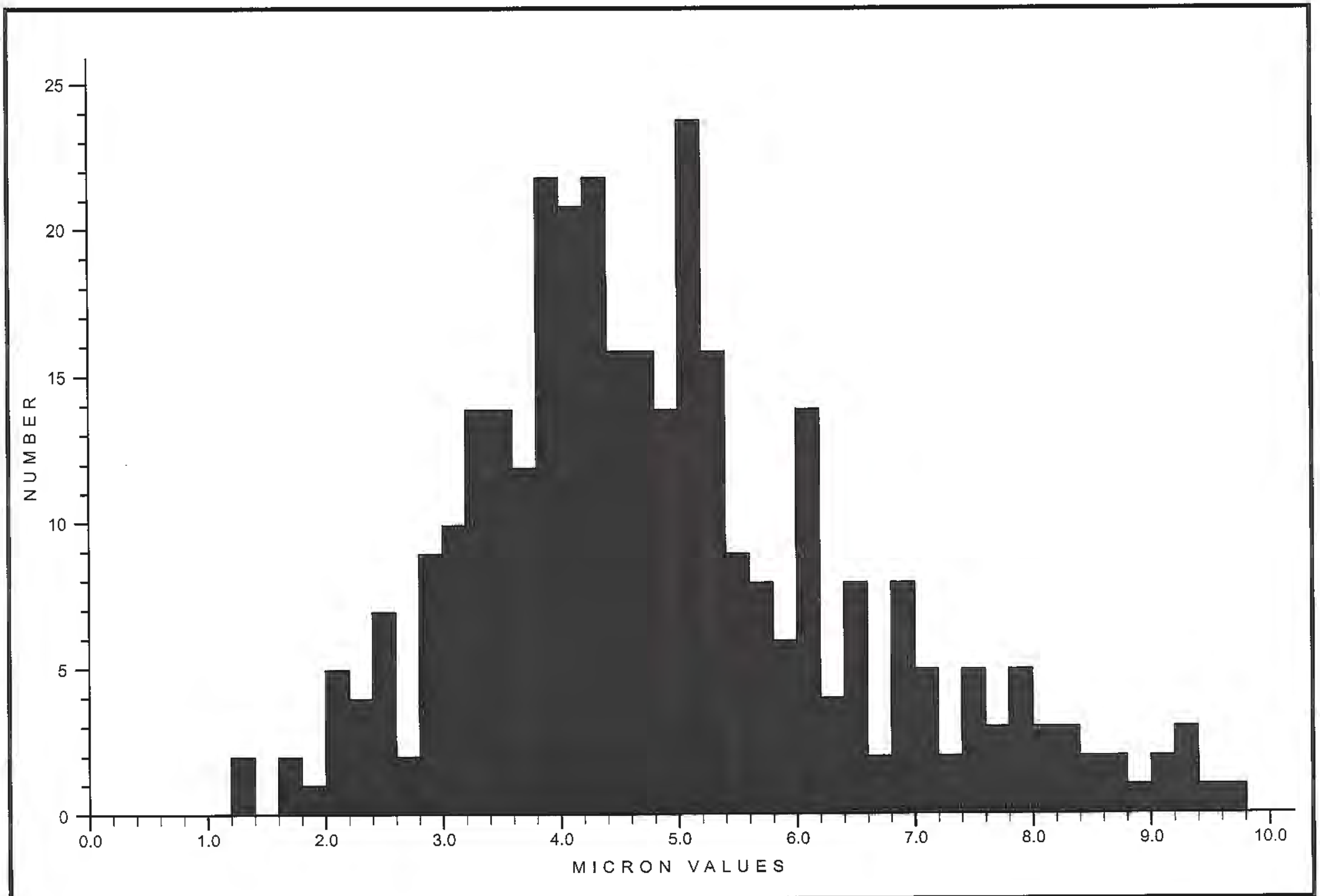


CHART 6.1. Overall Distribution of Hydration Readings from Mount Hicks Obsidian.

have presumably occurred at Mt. Hicks. There is a nearly six-fold increase in the number of readings during the late pre-Newberry interval, with a total of 76 (23.1%). This could be attributed to growing population as well as increased use of obsidian. The ensuing early Newberry period witnessed only a modest increase in hydration readings with a total of 90 (27.7%) specimens. The late Newberry era sees a larger jump in the number of reads with 118 (35.5%). As at other western Great Basin obsidian quarries, there is a drop in production during the Haiwee period, with only 26 (7.9%) hydration reading. Still another decline occurs during the Marana interval, when only five (1.5%) readings occur.

Flaked stone artifact classes assigned to each period are summarized in Table 6.6. As can be seen, the artifacts generally follow the overall pattern, with a notable exception in the case of simple flake tools. Simple flake tools are limited during the early pre-Newberry period, peak during the late pre-Newberry period, decline by half during the early and late Newberry intervals, and decline still further during the Haiwee period;

Table 6.6. Flaked stone artifacts by period.

			Newberry		Pre-Newberry		
Artifact Type	Marana	Haiwee	Late	Early	Late	Early	Total
Projectile Point	0	1	6	3	1	0	11
Biface	1	3	16	13	13	1	47
Simple Flake Tool	0	2	6	7	15	3	33
Formed Flake Tool	1	2	0	1	1	0	5
Core	0	1	1	3	3	0	8
Debitage (bif)	0	5	48	39	28	5	125
Debitage (cort)	3	12	41	24	15	5	100
Total	5	26	118	90	76	14	329

finally none are attributable to the Marana era. Formed flake tools follow a different pattern, with the greatest number assigned to the Haiwee. The total number of formed flake tools, however, is low enough that the discovery of a single additional tool could alter the pattern.

More interesting is the biface to simple flake tool ratio from each period. Simple flake tools are most abundant during the early pre-Newberry period when the ratio is 1:3. This figure is somewhat suspect given the limited sample, but the idea that simple flake tools were important during early times is supported by their continued dominance during the late pre-Newberry interval when the ratio is 1:1.15 and the samples are substantially larger. This trend is reversed during the early Newberry period when bifaces become dominant with a ratio of 1:0.5 and 1:0.4 during late Newberry times. The trend is reversed during the Haiwee period with a ratio of 1:0.7, though here again the sample is small. No ratio is possible for the Marana period given a lack of simple flake tools assigned to the period, but it does appear to fit the earlier trend.

Upper Desert Scrub Zone

A total of 65 hydration readings is available for artifacts from the upper desert scrub environmental zone. The production curve for this zone closely follows the inclusive pattern with only minor variation (Chart 6.2). Only two (3.0%) readings were assigned to the early pre-Newberry interval. As with the inclusive pattern there is a six-fold increase during the subsequent late pre-Newberry period, which contains 12 (18.5%)

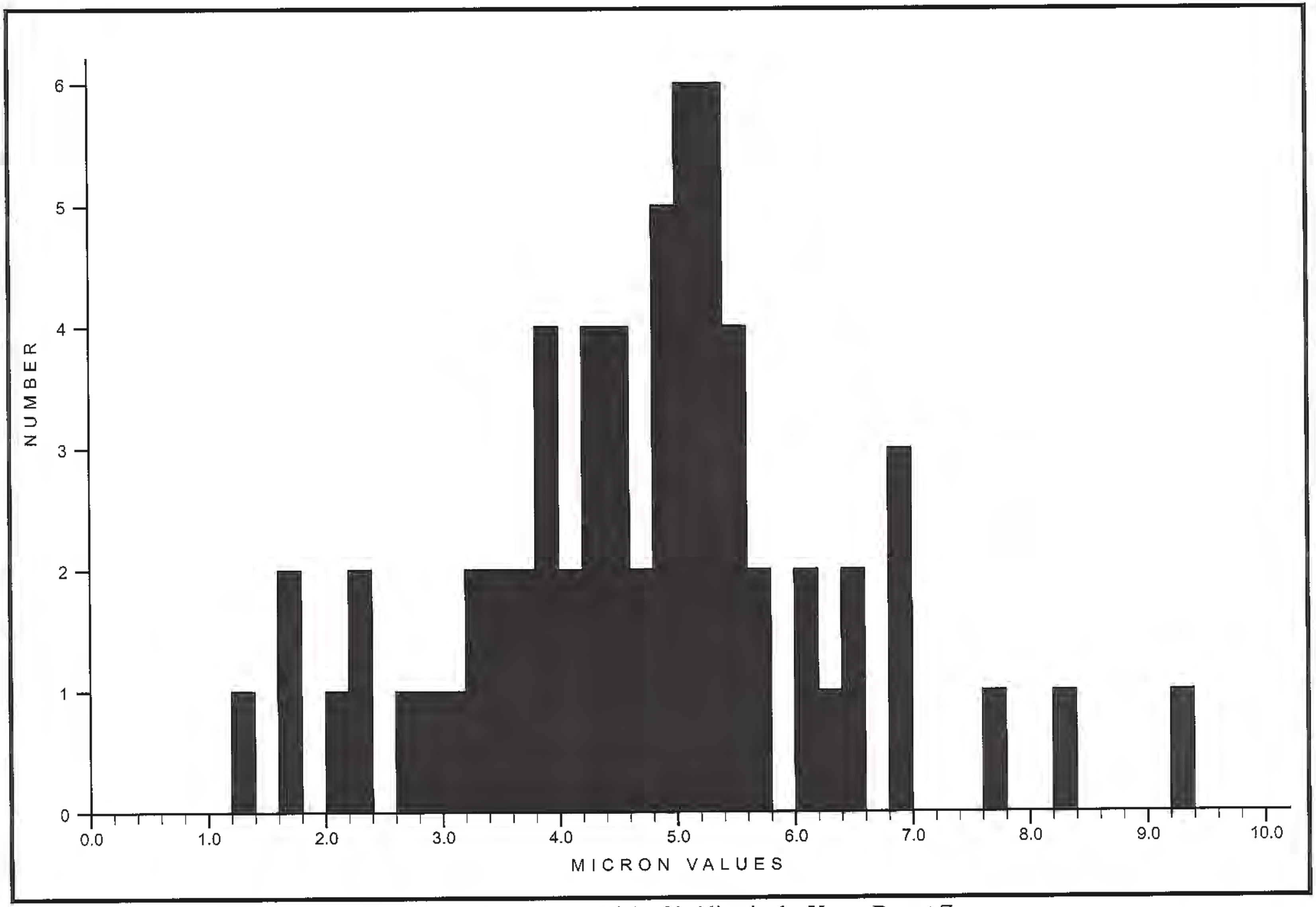


CHART 6.2. Distribution of Hydration Readings from Mount Hicks Obsidian in the Upper Desert Zone.

readings. The early Newberry period furnished more than twice the number of readings, 25 (38.5%). In contrast to the inclusive pattern, there is a minor drop in the number of readings during the late Newberry period, when only 18 (27.7%) values were identified. A substantially greater drop in hydration readings occurs during the Haiwee period, when only five (7.7%) measurements were recorded, followed by an additional decrease during the Marana interval (n=3, 4.6%).

Artifacts obtained from this zone are summarized in Table 6.7 by time period. Cores and formed flake tools are entirely lacking from this zone, and other tools present during only some periods. This suggests that cores and formed flake tools were never important in this zone, as confirmed by their limited number throughout the project universe. The temporally uneven occurrence of other tools, conversely, suggests that their importance may have varied over time.

Table 6.7. Upper desert flaked stone artifacts by period.

			Newberry		Pre-Newberry		
Artifact Type	Marana	Haiwee	Late	Early	Late	Early	Total
Projectile Point	0	1	1	1	0	0	3
Biface	1	0	1	6	2	0	10
Simple Flake Tool	0	1	4	6	6	0	17
Debitage (bif)	0	0	11	7	1	1	20
Debitage (cort)	2	3	1	5	3	1	15
Total	3	5	18	25	12	2	65

Simple flake tools are at least equal in importance to bifaces during all time periods except, interestingly, the Marana interval; simple flake tools were the dominant tool type during the late pre-Newberry and Haiwee periods. Biface to simple flake tool ratios for the periods they are available vary from 1:3 during the late pre-Newberry, to 1:1 during the early Newberry, and 1:4 during late Newberry times. No ground stone implements were seen in this biotic community, suggesting that plant resources were not important, but rather hunting of artiodactyls was a major activity. The relative unimportance of bifaces seems to contradict Ramos' hypothesis that bifaces were specialized butchering tools.

Pinyon-Juniper Zone

A total of 173 obsidian hydration readings was obtained from artifacts in the pinyon-juniper zone, nearly three times that of any other zone. Indeed, it is the hydration profile from this zone that structures the inclusive production curve, which it closely resembles (Chart 6.3). Only five (2.9%) hydration readings were assigned to the early pre-Newberry interval, indicating little activity in this zone. The late pre-Newberry period is better represented with 26 (15.0%) of the readings, but it to suggests proportionately little activity. When compared to other pre-Newberry period artifacts, this zone appears more important with 35.7% of the early pre-Newberry and 34.2% of the late pre-Newberry remains. The early Newberry interval sees the first of two dramatic jumps in numbers of hydration readings that increase to 43 (24.9%). This is followed by the late Newberry period by an increase of 84 (48.6%) hydration readings. The Haiwee interval shows a dramatic drop in hydration to a point below that of the late pre-Newberry era, with only 13 (7.5%) readings. Finally, the Marana period contained only two hydration readings. The increase of hydration readings during the Newberry period is

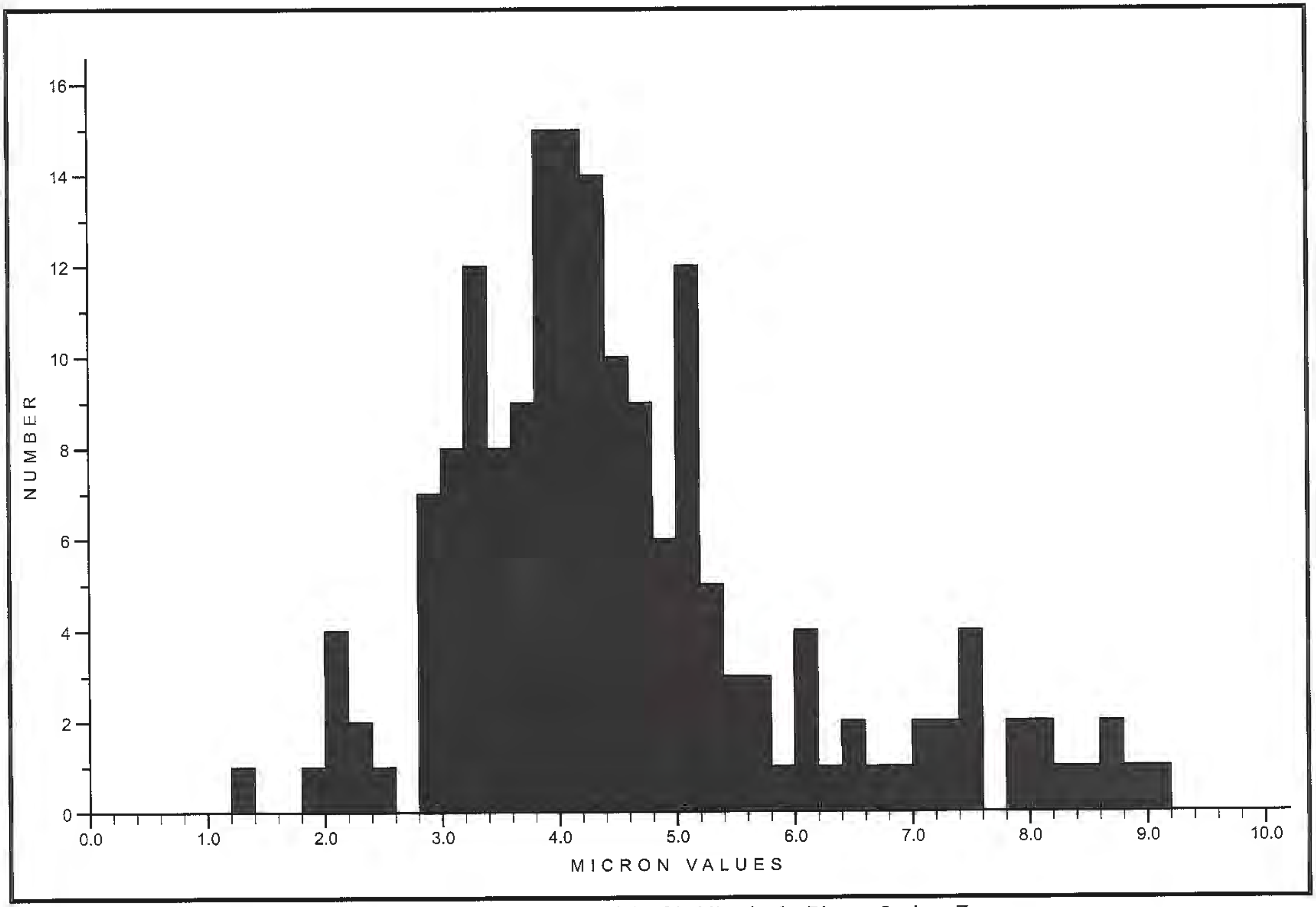


CHART 6.3. Distribution of Hydration Readings from Mount Hicks Obsidian in the Pinyon Juniper Zone.

likely due, in part, to increasing population and the increasing importance of pinyon nuts in the diet. A major factor in the amount of material found in this zone is also the abundant obsidian outcrops that are located there.

Table 6.8 summarizes artifacts from this zone. As might be expected, debitage parallels the production curve, being most abundant in the Newberry period. Cores show a similar pattern apart from the early pre-Newberry and Marana periods, when they are lacking. Projectile points are only found during the Newberry interval, but this to is consistent with the rise of activity at that time. Simple flake tools and, surprisingly, bifaces do not match the production curve as well. Simple flake tools are prevalent (n=3) only during the late pre-Newberry interval, with only one each during the early pre-Newberry, late Newberry, and Haiwee periods. Bifaces are more sporadic in occurrence; one during the early pre-Newberry, four during the late pre-Newberry, two during the early Newberry, nine during the late Newberry interval, two during the Haiwee, and none during the Marana. The proportionately low frequency of bifaces during the early

Table 6.8. Pinyon-juniper Zone flaked stone artifacts by period.

			Newberry		Pre-Newberry		
Artifact Type	Marana	Haiwee	Late	Early	Late	Early	Total
Projectile Point	0	0	3	1	0	0	4
Biface	0	2	9	2	4	1	18
Simple Flake Tool	0	1	1	0	3	1	6
Formed Flake Tool	1	1	0	0	1	0	3
Core	0	1	1	3	3	0	8
Debitage (bif)	0	5	31	21	9	2	68
Debitage (cort)	1	3	39	16	6	1	66
Total	2	13	84	43	26	5	173

Newberry period is surprising given the increase in biface thinning flakes from the previous interval. In fact, all tool types decrease during the early Newberry interval except projectile points and both debitage types. This may suggest the pinyon-juniper zone was exploited primarily for obsidian, with little time spent acquiring other resources.

Lower Desert Scrub Zone

A total of 62 hydration readings was obtained from the lower desert scrub zone. These provide a production curve that differs from the inclusive pattern (Chart 6.4). Six (9.7%) hydration readings date to the early pre-Newberry interval, the most identified for this period in any environmental zone. The number of readings increases substantially during the late pre-Newberry interval (n=24, 38.7%). Although proportionately not as great an increase as in other environmental zones, the actual number of late pre-Newberry readings is again higher than other zones. Both the early and late Newberry periods show a drop in readings, with 18 (29.0%) and eight (12.9%), respectively. The Haiwee interval has only a modest drop in hydration with six (9.7%) readings, followed by none during the Marana period.

Artifacts from the lower desert scrub zone are summarized in Table 6.9. As usual, flakes drive the production curve for this zone, given their overwhelming abundance and the sporadic occurrence of other artifacts. Interestingly, the late pre-Newberry, early Newberry, and late Newberry periods have equal numbers of bifaces. Use of this biotic community appears to peak during the late pre-Newberry interval, declining in

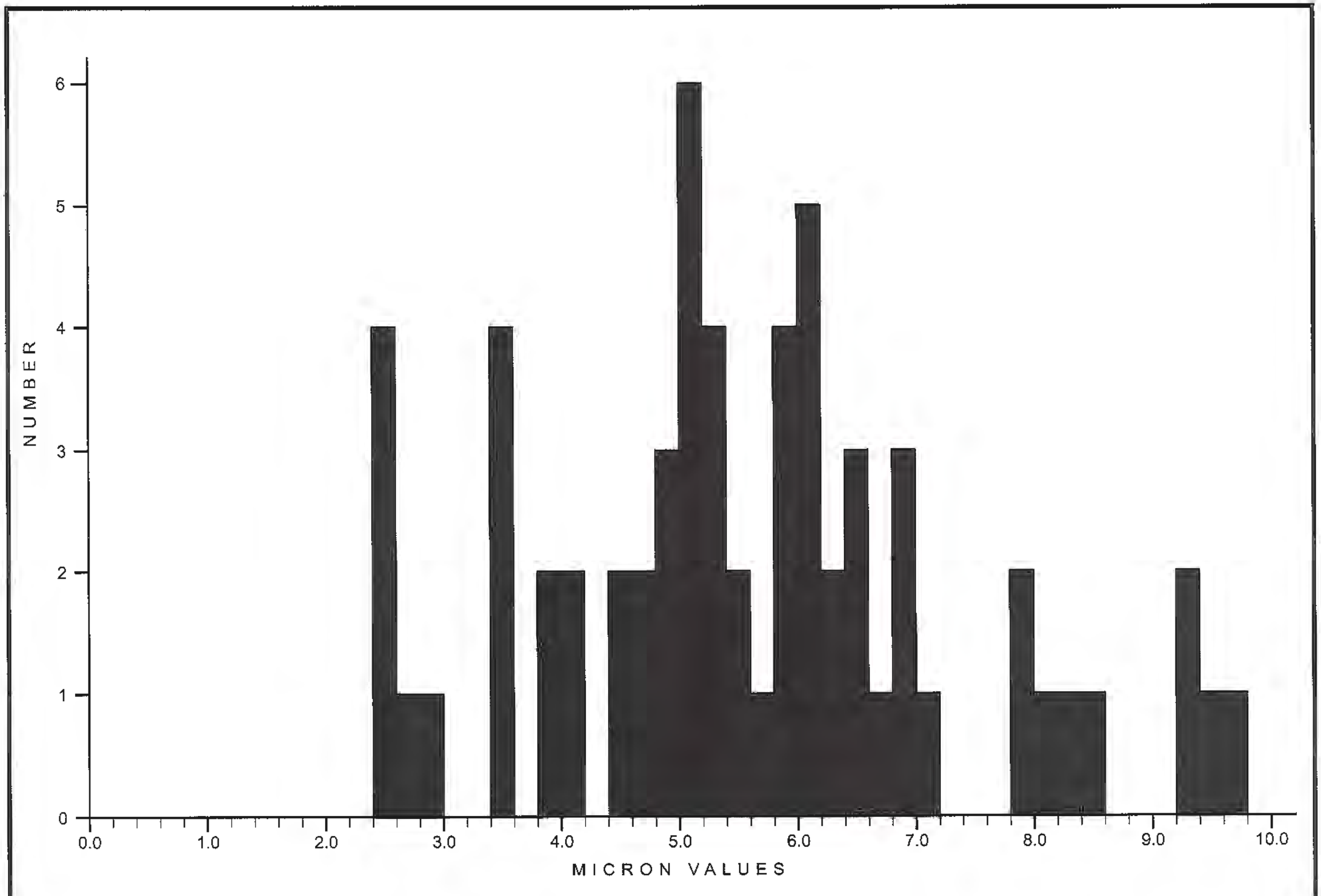


CHART 6.4. Distribution of Hydration Readings from Mount Hicks Obsidian in the Desert Scrub Zone.

Table 6.9. Lower desert scrub flaked stone artifacts by period.

			Newberry		Pre-Newberry		
Artifact Type	Marana	Haiwee	Late	Early	Late	Early	Total
Projectile Point	0	0	1	1	1	0	3
Biface	0	1	5	5	5	0	16
Simple Flake Tool	0	0	0	1	4	2	7
Debitage (bif)	0	0	1	8	8	1	18
Debitage (cort)	0	5	1	3	6	3	18
Total	0	6	8	18	25	6	62

importance with each subsequent period. This may reflect a change in climate. As discussed in Chapter Two, tree-line elevation was lower earlier in time, and Alkali Lake may have had more standing water for a longer portion of the year prior to the early Newberry. This would have made this elevation zone a more productive lacustrine environment, drawing prehistoric people.

Lacustrine Zone

A total of 29 hydration readings was obtained from artifacts in this zone (Chart 6.5). As with the surrounding desert scrub, the production curve in this zone differs from the inclusive curve. Only one (3.4%) reading dates to the early pre-Newberry interval. The ensuing late pre-Newberry period, however, accounts for nearly half of the hydration readings from this zone (n=14, 48.3%). This is followed by a substantial drop during the early Newberry period (n=4, 13.8%), and subsequent increase during the late Newberry interval (n=8, 27.5%). Another decrease occurs during the Haiwee period when only two (6.9%) readings were identified, followed by none during the Marana interval.

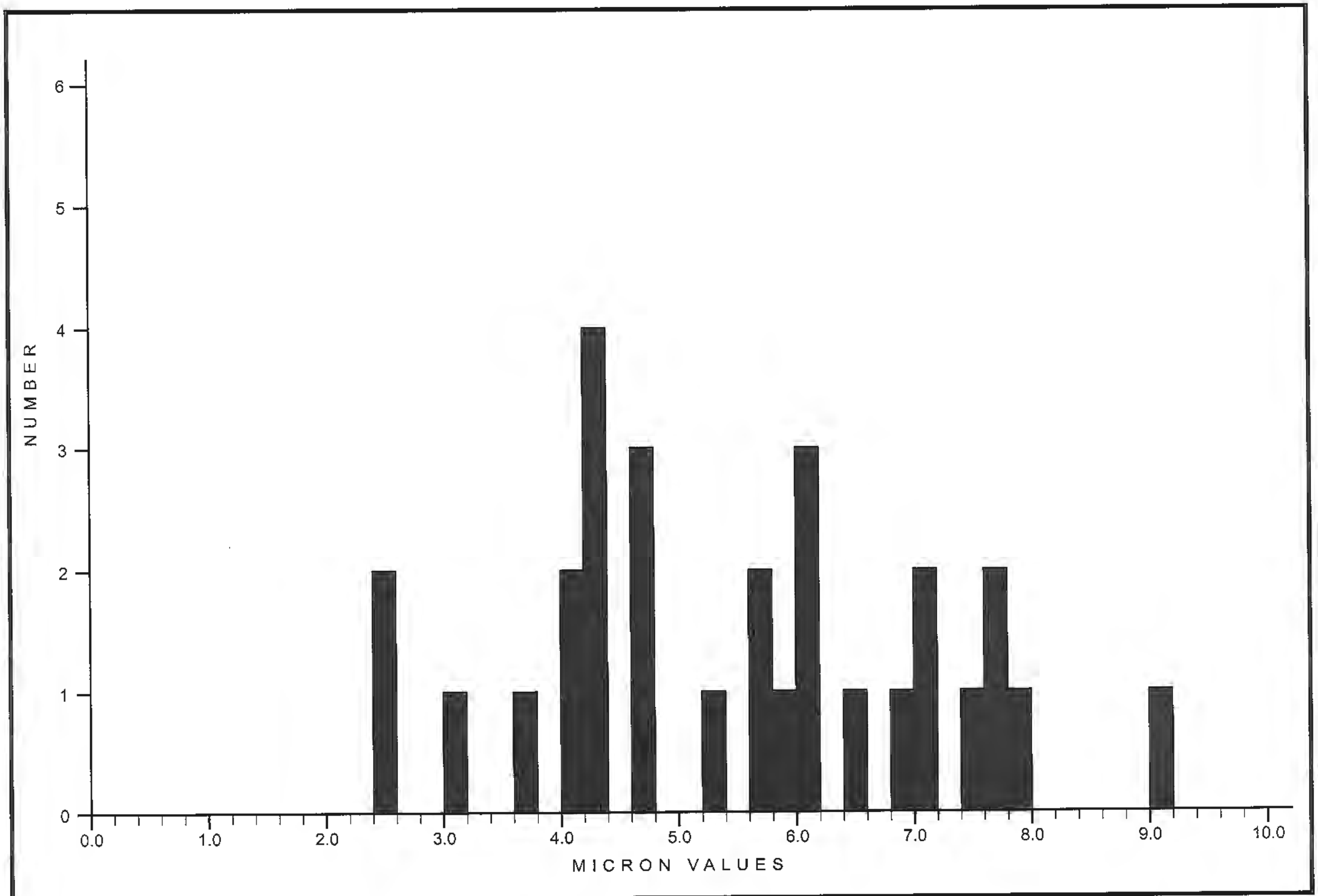


CHART 6.5. Distribution of Hydration Readings from Mount Hicks Obsidian in the Lacustrine Zone.

Artifacts from this zone are summarized in Table 6.10. As in the other zones, the abundance of debitage strongly influences the production curve of this zone. Other flaked stone artifacts (e.g., bifaces and simple flake tools) generally follow the production curve, although their numbers are very low. Simple flake tools continue to be important in the pre-Newberry interval, although bifaces are also abundant in the late pre-Newberry period. Only one cortical flake was recovered from this zone, the remaining flakes subjected to obsidian hydration analysis being biface thinning debris. This is not surprising given that the lacustrine zone is the furthest from any obsidian outcrop or obsidian cobble-bearing drainage.

Table 6.10. Lacustrine flaked stone artifacts by period.

			Newberry		Pre-Newberry		
Artifact Type	Marana	Haiwee	Late	Early	Late	Early	Total
Projectile Point	0	0	1	0	0	0	1
Biface	0	0	1	0	2	0	3
Simple Flake Tool	0	0	1	0	2	0	3
Formed Flake Tool	0	1	0	1	0	0	2
Debitage (bif)	0	0	5	3	10	1	19
Debitage (cort)	0	1	0	0	0	0	1
Total	0	2	8	4	14	1	29

CHANGES IN FLAKED STONE UTILIZATION THROUGH TIME AND ENVIRONMENTAL ZONE

The previous section discussed the production curves of each environmental zone. This section uses the same data to describe changes in flaked stone use through time and environmental zone. Select artifacts, including bifaces, simple flake tools, biface thinning flakes, and cortical debris, are discussed because of their greater abundance, their regional importance, and the fact that they are especially indicative of broad technological patterns. In addition, the early and late pre-Newberry is collapsed into a single interval, the pre-Newberry, and the Haiwee and Marana periods are collapsed into the post-Newberry interval. This is done to provide more robust numbers and still capture the broad patterns of flaked stone utilization through time.

Table 6.11 presents the results of a statistical analysis on the artifact count from each interval by environmental zone. The adjusted residual value indicates how much the artifact count in each zone deviated from the expected outcome; where the mean is 0 and the standard deviation is 1. Thus, any adjusted residual with a value exceeding 1.96 (either minus or plus) is statistically significant at the 0.05 confidence level. The function used to determine this also runs a Chi-square test, which indicates if the counts presented are due to chance. In this instance the level of confidence is 0.05 and there are nine degrees of freedom, making the critical region 16.91 (the Chi-square value that must be exceeded if the null hypothesis, in this case are the numbers accountable by chance, can be rejected). The Chi-square value is 47.62, indicating that the probability of the counts being due to chance is small.

Table 6.11. Adjusted residual analysis of artifact counts by interval and environmental zone.

Environmental Zone	Post-Newberry (count/residual)	Late Newberry (count/residual)	Early Newberry (count/residual)	Pre-Newberry (count/residual)	Total
Upper Desert Scrub	8/+0.89	18/-1.53	25/+2.24	14/-1.17	65
Pinyon-Juniper	15/-0.49	84/+5.05	43/-1.07	31/-4.04	173
Lower Desert Scrub	6/+0.08	8/-4.18	18/+0.33	30/+4.12	62
Lacustrine	2/-0.49	8/-0.97	4/-1.72	15/+3.08	29
Total	31	118	90	90	329

Table 6.12 uses the same statistic but for number of select artifacts by interval. The Chi-square value is 24.31, with nine degrees of freedom at 0.05 confidence the critical region is 16.91; it is unlikely these numbers are the result of chance.

Table 6.12. Residual analysis of select artifacts by interval.

Artifact	Post-Newberry (count/residual)	Late Newberry (count/residual)	Early Newberry (count/residual)	Pre-Newberry (count/residual)	Total
Biface	4/+0.00	16/-0.36	13/+0.07	14/+0.32	47
Simple Flake Tool	2/-0.54	6/-2.30	7/-0.82	18/+3.62	33
Biface Thinning Flakes	5/-2.36	48/+0.61	39/+1.30	33/-0.48	125
Cortical Flakes	15/+2.83	41/+1.17	24/-0.88	20/-2.14	100
Total	26	111	83	85	305

Finally, Table 6.13 presents the results of adjusted residual analysis of biface reduction stage by interval. The Chi-square value is 6.29, there are six degrees of freedom and at the 0.05 confidence level the critical range is 12.59. The null hypothesis, which is that biface reduction stage is randomly distributed across periods, cannot be rejected. The data also show that no reduction stage is significantly over- or under-represented during any interval. There does appear, however, to be a trend towards more refined tools later in time.

Table 6.13. Residual analysis of biface reduction stage by interval.

Reduction Stage	Post-Newberry (count/residual)	Late Newberry (count/residual)	Early Newberry (count/residual)	Pre-Newberry (count/residual)	Total
Early	1/-0.03	3/-0.24	2/-1.47	6/+1.77	12
Middle	1/-1.18	7/+0.06	11/+1.54	6/-0.92	25
Late	2/+1.47	3/+0.19	3/-0.30	2/-0.76	10
Total	4	13	16	14	47

Pre-Newberry Period

A total of 90 readings was obtained for the pre-Newberry interval. This included 14 bifaces, 18 simple flake tools, 33 biface thinning flakes, and 20 cortical flakes (Table 6.6).

Bifaces include six early-stage, six middle-stage, and two late-stage specimens (Table 6.13). Table 6.12 indicates that the number of bifaces is not significantly different than expected. Reduction stage of the bifaces appear in close to expected quantities (Table 6.13), though there does appear to be an emphasis on early-stage reduction. This is not surprising given that prehistoric groups during this interval are thought to be highly mobile. Early-stage bifaces retain the greatest amount of raw material; carrying them would reduce the risk of being caught in an area without lithic resources. Five of the specimens show definite evidence of use-wear, another more problematic damage.

Simple flake tools are more important during this interval (Table 6.12) than any other. This again is at odds with Ramos' (2004) hypothesis that bifaces are specialized butchering tools. Groups during this period are thought to have focused subsistence activities on large game. Also, the bulk of simple flake tools dating to this interval are found in the upper desert scrub zone (Tables 6.7-6.10). Inasmuch as vegetal resources are equally or more available and more easily exploited elsewhere, this zone was probably used for hunting. Adding weight to this is the lack of ground stone tools observed in that biotic community, the only one where this is true. Taken together, if any interval and biotic community should have an abundance of bifaces it is the upper desert scrub zone during the pre-Newberry interval. If hunting was a major activity in the upper desert scrub community, then the preferred butchering/processing tool would seem to be simple flake tools, give their abundance.

Biface thinning flakes are slightly under-represented, but not significantly, while cortical debris show significantly lower than expected counts (Table 6.12). This is likely due in part to the large quantities of cortical debris dating to the late Newberry period, but cannot wholly be attributed to that. A possible explanation is that groups during this interval were more willing to carry cortical material in order to maximize the amount of lithic resources at their disposal. The largest amount of cortical debris was found in the lower desert scrub zone (Tables 6.7-6.10), which is curious as the pinyon-juniper zone has far more available raw material.

Specific biotic communities during this period appear to have been targeted for more intensive exploitation than others (Table 6.11). In comparison to other intervals, the pinyon-juniper zone is significantly under-represented. The upper desert scrub zone also has fewer artifacts than expected, but not significantly. Both the lower desert scrub and lacustrine zones are significantly over-represented. This may seem surprising, but during this interval Alkali Lake probably had standing water year-round, or stayed productive for longer periods than in subsequent times. This would have made the lacustrine zone more productive and may have extended it into the lower reaches of the desert scrub community. In terms of raw artifact counts, the pinyon-juniper zone is as important as the lower desert scrub zone (Tables 6.8 and 6.9). This period precedes the arrival of pinyon, when the primary attraction must have been different.

Early Newberry Period

A total of 90 obsidian hydration readings date to this interval including13 bifaces, seven simple flake tools, 39 biface thinning flakes, and 24 cortical flakes (Table 6.6).

The 13 bifaces that date to this period include three early-stage, seven middle-stage, and three late-stage artifacts (Table 6.13). The quantity of bifaces is near the expected amount (Table 6.12). Reduction stage of specimens do not appear in significantly greater or lesser amounts (Table 6.13). Unlike the pre-Newberry, however, early-stage items are under-represented while middle-stage specimens are over-represented. This could signal a shift in technological needs from risk aversion (being caught without raw material) to ease of transport (less bulk to carry). None of the early-stage bifaces were located in or near primary workshop areas, and all three that were collected were from the upper desert scrub zone. Use-wear is evident on seven of the tools, including two of the early-stage artifacts. While reduction stage of bifaces is often taken as a measure of tool "finish"/serviceability, analytically "unfinished" tools were obviously used when raw material, functionality, and other circumstances required. Care must therefore be taken to not strictly equate early- or middle-stage forms with unfinished tools. The relatively large number of middle-, as well as the fewer early-stage specimens from this interval does not necessarily mean they were discarded before completion or use. Indeed the evidence implies that many of these artifacts were used as tools.

Simple flake tools are less than half as abundant from this than the pre-Newberry period (Table 6.12). Despite this, they are not significantly under-represented during this interval (Table 6.12). The distribution of this tool class, however, is highly interesting.

Only one specimen was recovered from the lower desert scrub zone, and the remaining six from the upper desert scrub zone. Simple flake tool use in the upper desert scrub zone continues to dominate during this period, again contrary to Ramos' (2004) hypothesis.

Early Newberry biface thinning flakes are over-represented to a large, though not significant, amount (Table 6.12). They are most abundant in the pinyon-juniper zone (Tables 6.7-6.10), unlike the pre-Newberry when they are most prevalent in the lacustrine zone. Fewer than expected cortical flakes date to this interval but not to a significant degree (Table 6.12), although there is a change from the pre-Newberry interval in their distribution. Cortical debris occurs in roughly equal amounts in both the pinyon-juniper and lower desert scrub zones during the previous period; during the early Newberry interval most occur in the pinyon-juniper zone. The reason for these changes in raw material acquisition may be a greater demand for obsidian and shifting technological needs; the pinyon-juniper zone has the greatest amount of available raw material of any biotic community and, as the biface discussion mentioned, there may have been a shift from risk aversion to ease of transport. A greater demand for more refined bifaces would result in larger amounts of biface thinning flakes in the area with the most abundant raw material.

There are major changes in the importance of each biotic community during this period from the last (Table 6.11). The upper desert scrub zone is significantly over-represented with artifacts, the lower desert scrub and lacustrine zones shift from having significantly greater than expected amounts of artifacts to near expected and near significantly under-represented quantities, respectively. The pinyon-juniper zone is still under-represented, but no longer to a significant degree. These changes likely reflect increases in population and environment and the accompanying shifts in subsistence and mobility patterns. The lacustrine and lower desert scrub zones probably became less productive during this period, and an economy focused on hunting was likely no longer viable with a larger population. This would have necessitated a broader economy and a search for still valuable resources (artiodactyls) in more remote locations, thus the "leveling" of importance of most biotic communities and the increased significance of the upper desert scrub zone.

Late Newberry Period

A total of 118 artifacts was dated to this period (Table 6.6). This includes 16 bifaces, the most dating to any period, six simple flake tools, 48 biface thinning flakes, and 41 cortical flakes.

The 16 bifaces that date to this period include two early-stage, 11 middle-stage, and three late-stage specimens (Table 6.13). These items are slightly under-represented but occur in close to expected amounts (Table 6.12). Reduction stage of theses tools were found in close to expected amounts (Table 6.13). This is a change from the previous period where middle- and late-stage specimens appear to be over- and under-represented, respectively. The reason for this shift in biface technology is unclear, it is possible that groups were using the area more intensively and thus required a greater range of tool forms for various tasks. The upper desert scrub zone contained one late-stage biface, the pinyon-juniper zone two early- and seven middle-stage bifaces, the lower desert scrub four middle-stage and one late-stage specimen, the lacustrine zone one late-stage biface (Tables 6.7-6.10). Only one early-stage biface was found in a primary workshop area while six middle-stage forms were found in such contexts. Four of these, including the early-stage piece, show evidence of use-wear. But interestingly, all bifaces located more than 500 meters from an obsidian outcrop or cobble source showed definite use-wear. This includes bifaces of all reduction stages. While some of this "use" was related to manufacture (i.e., edge/platform preparation), it is clear that biface stage has limited meaning with respect to serviceability or tool use.

The decline of simple flake tools which began in the early Newberry period continues; these tools are significantly under-represented during the late Newberry interval (Table 6.12). This decline is driven by the increasing importance of biface technology, which reaches its zenith during this period. The distribution of late Newberry period simple flake tools generally follows the same pattern seen in the two previous intervals; four were located in the upper desert scrub and one each in the pinyon-juniper and lacustrine zones (Tables 6.7-6.10). The importance of simple flake tools remains high in the upper desert scrub zone despite the general decline of these artifacts during the late Newberry interval.

A total of 48 biface thinning flakes was dated to this period, a slight but not significant over-representation (Table 6.12). As during the early Newberry era, the bulk were in the pinyon-juniper community. Forty-one cortical flakes were dated to this period, a large but not significant over-representation (Table 6.12). Distribution of cortical debris is interesting; all but two of these artifacts were found in the pinyon-juniper zone (Tables 6.7-6.10). The trend of raw material acquisition focused in the pinyon-juniper community that began during the early Newberry period peaks during the late Newberry interval. Absolute counts of flaked stone artifacts are highest during this period, necessitating large amounts of raw material to meet demand. As mentioned, the pinyon-juniper zone has the most accessible obsidian in the research universe, making that zone an obvious choice for prehistoric groups to acquire lithic resources.

Artifacts found in the pinyon-juniper zone during the late Newberry period are significantly over-represented (Table 6.11). The lower desert scrub community, in contrast, is significantly under-represented, the upper desert scrub zone close to significantly under-represented, and the lacustrine zone under-represented but not to a significant degree. Primarily driving this pattern is the focus on raw material acquisition in the pinyon-juniper community. The distribution of simple flake tools and bifaces across the biotic communities, however, reveal interesting patterns (Tables 6.7-6.10). The pinyon-juniper zone had the greatest amount of these tools, including nine bifaces and one simple flake tool, or 11.9% of all artifacts dating to the late Newberry period in that zone, the lacustrine zone contained one biface and one simple flake tool (25.0%), the upper desert scrub community one biface and four simple flake tools (27.8%), and the lower desert scrub zone five bifaces (62.5%). This suggests that the pinyon-juniper zone was used primarily for raw material acquisition as well as other resource extraction activities, but the other biotic communities were also important areas during the late Newberry interval. Using the percentage of bifaces and simple flake tools in each zone as a measure of importance, the trend of expanded use of different biotic communities begun in the early Newberry period continues during the late Newberry interval.

Post-Newberry Period

A total of 31 artifacts dates to the post-Newberry interval (Table 6.6). Artifacts found include three bifaces, two simple flake tools, five biface thinning flakes, and 12 cortical flakes (Table 6.12).

Bifaces were found in expected amounts (Table 6.12). The four bifaces dating to this period include one early-, one middle-, and two late-stage specimens (Table 6.13). None of the biface reduction stage categories were found in significantly more or fewer amounts, though late-stage bifaces are close to significantly over-represented (Table 6.13). Two of the bifaces were found in the pinyon-juniper zone, and one each in the upper desert and lower desert scrub zones. Both items found in the pinyon-juniper zone and the specimen from the upper desert scrub community had evidence of use. It is interesting that bifaces, despite low numbers, appear in expected amounts; these tools keep their place in the flaked stone tool kit, but it is apparently the tool-kit as a whole that declines in importance as evidenced by comparatively low counts of flaked stone compared to other eras.

Two simple flake tools from the post-Newberry interval were found (Table 6.12). These tools are slightly under-represented, but essentially appear in close to expected amounts (Table 6.12). This is an increase in relative importance from the late Newberry era, where simple flake tools are significantly under-represented. One of the tools dating to this period was recovered from the pinyon-juniper zone and the other from the upper desert scrub community, continuing the trend of importance these tools have in the upper desert scrub zone.

A total of five biface thinning flakes dating to the post-Newberry was found, a number significantly less than expected (Table 6.12). All five biface thinning flakes dating to this period were found in the pinyon-juniper zone. Cortical flakes have a different pattern. Fifteen pieces of cortical debris were dated to the post-Newberry interval, significantly more than expected. The distribution of these artifacts, however, is more similar to the pre-Newberry period than any other interval (Tables 6.7-6.10), drastically changing the pattern of acquisition in the pinyon-juniper zone that began in early Newberry times. Cortical flakes are most abundant in the lower desert and upper desert scrub communities, though the pinyon-juniper is not far behind. With the decrease in importance of flaked stone technology, as well as the adoption of bow and arrow technology which requires less lithic mass to produce projectile points, it was likely no longer important to acquire obsidian from the most abundant sources; other areas with less raw material, or earlier deposits of waste material, would adequately meet lithic needs.

None of the artifact counts in the biotic communities are significantly either under- or over-represented (Table 6.11). The post-Newberry interval is the only one in which this is true, though a pattern of expanded use of various environmental zones has been evident since the early Newberry period. It is most apparent during the post-Newberry interval because the dominance of the pinyon-juniper zone for raw material acquisition and biface manufacture ends, though that zone still has the largest amount of artifacts. The post-Newberry period population is likely higher than during any interval, which would have stressed resource bases. The relatively even distribution of artifacts across biotic communities probably reflects an adaption to diminishing resources by more intensively exploiting environments that have greater abundance of food-stuffs but which are more labor intensive to process (e.g., green cone pine nut exploitation and grass seeds). This would have come at the expense of targeting large packages of resources with high return rates that are more scarce (hunting large artiodactyls). The post-Newberry period is also the interval when mobility patterns are apparently at a low both in terms of magnitude and frequency. Lower mobility reduces the risk of being caught without lithic resources, in turn lowering need for lithic material on hand. Another change during the post-Newberry, as mentioned above, was the adoption of bow and arrow technology. This would further have reduced the necessity for large amounts of obsidian.

Summary of Temporal Patterns

The relative importance of bifaces in the flaked stone tool-kit varies remarkably little through time (Table 6.12), never attaining adjusted residual values above +0.32, attained during the pre-Newberry interval, or below -0.36, during the late Newberry period. Reduction stages of these tools, however, do show a trend towards greater refinement (Table 6.13). Early-stage specimens during the pre-Newberry period are close to significantly over-represented, early Newberry interval middle-stage forms appear in greater than expected amounts, with a break in the pattern during the late Newberry period (when bifaces are most abundant) where all reduction stages appear in close to expected amounts, and late-stage bifaces are present in greater than expected amounts during the post-Newberry era (Table 6.13). Early prehistoric groups during the pre-Newberry period are thought to move frequently and for greater distances than subsequent people in the region. Early-stage bifaces would have served these groups well as both tools and cores. Movement of later groups gradually became more restricted. During those later times groups were no longer at great risk of being caught without lithic resources, and transportability of bifaces likely rose in importance. Middle-stage forms would have performed well, compromising mass with easier transport. Very late in time, during the post-Newberry interval, mass of bifaces would not have been a concern and smaller, more refined tools would have been adequate for needs. It is also possible that the function of these tools changed through time, requiring more refined forms.

The importance of simple flake tools within the flaked stone tool-kit varies over time (Table 6.12). They appear in significantly greater than expected amounts during the pre-Newberry period, decline to under-represented during the ensuing early Newberry interval, fall to a significantly less than expected amount during the late Newberry period, and then increase, relatively, to under-represented during the post Newberry era. Wether these tools were used for processing/butchering of game animals is problematic at best, but they are found in relative abundance in the upper desert scrub zone during all time intervals, where it is surmised hunting was the major activity (see below).

Raw material acquisition and biface production, as reflected in cortical and biface thinning flakes, respectively, appear to have divergent patterns (Table 6.12). Biface thinning flakes appear in the pre-Newberry in slightly fewer than expected amounts. This at first seems counter-intuitive because pre-Newberry interval bifaces are slightly over-represented, but during this interval bifaces tend to be early-stage forms which make less production debris. Biface thinning flakes appear in greater than expected quantities during the next two intervals, and then fall to significantly lower than expected amounts during the post-Newberry interval. Biface production debris declines sharply during the post-Newberry period, though bifaces appear in expected amounts. This is probably due to the, generally, more refined specimens of the post-Newberry era. Another likely factor is that fewer bifaces being produced for transport since mobility patterns are curtailed compared to previous intervals.

Raw material acquisition appears to pattern very differently (Table 6.12). The pre-Newberry period has significantly lower than expected amounts of cortical waste flakes, which steadily increases over the ensuing intervals until these artifacts are found in significantly greater than expected amounts during the post-Newberry era. This might be expected for both Newberry intervals when absolute numbers of flaked stone artifacts are at peaks, but not for the post-Newberry period when flaked stone and biface thinning flakes are at lows. Clearly raw material acquisition still occurred, but that material was used in fundamentally different ways than earlier in time. Bifaces are still found in expected numbers, simple flake tools are only slightly under-represented, and biface thinning flakes occur in significantly less than expected quantities during the post-

Newberry era – suggesting that it is biface manufacture which has undergone a change. Raw material is still being acquired, but large packages are no longer necessary for the smaller, more refined forms that were being produced during the post-Newberry era. Adding weight to this argument is the change in distribution of cortical flakes from the late Newberry period to the post-Newberry interval. Cortical flakes are almost entirely confined to the pinyon-juniper zone during the late Newberry period, where the most abundant obsidian sources are located. During the post-Newberry interval cortical flakes are found in every biotic community and are far more abundant away from the pinyon-juniper zone.

The relative number of artifacts found in each biotic community shows interesting patterns (Table 6.11). The pre-Newberry period artifacts were found in significantly greater than expected amounts in both the lacustrine and lower desert scrub zones, while the pinyon-juniper zone had significantly fewer than expected quantities of artifacts, and the upper desert scrub community is under-represented. This probably reflects targeting of the lacustrine and lower desert scrub zones for resources, and little exploitation in other environments. This changes during the early Newberry period, when only one zone, the upper desert scrub, had artifacts present in significantly more than expected amounts, likely reflecting exploitation of a broader spectrum of resources. The late Newberry interval apparently reverses this trend, when artifacts in the pinyon-juniper are very significantly over-represented, the lower desert scrub community significantly under-represented, and the remaining two zones with artifacts appearing in lower than expected amounts. The over-whelming number of biface thinning and cortical debris during the late Newberry era, almost all of it concentrated in the pinyon-juniper zone, masks utilization of the other zones. The distribution of simple flake tools and bifaces among the various biotic communities suggests that all of the zones were near equally used, with the largest number of tools found in the pinyon-juniper zone. During the post-Newberry period all environmental zones are more or less equally utilized, probably reflecting a subsistence strategy where a very broad spectrum of resources was exploited.

Lacking food remains for analysis, it is difficult to assess what food resources were being exploited in the research universe. That said, anecdotal evidence suggests that the upper desert scrub zone was used primarily for hunting. Plant resources present in the upper desert scrub community are more readily accessible and abundant at lower elevations. Although no ground stone artifacts were found within units, they were identified while traveling between units and some were just outside of OU's. Broken and burnt ground stone fragments were seen in the lacustrine zone, a milling slab in the pinyon-juniper belt, and the rock-ring features in the lower desert scrub community had some courses made with ground stone implements. While this is not direct evidence of plant use in those zones it is highly suggestive. No ground stone tools were seen in the upper desert scrub community despite its representation in the research universe. Lacking ground stone tools, the upper desert scrub biotic zone was probably used for hunting artiodactyls.

Chapter 7

CONCLUSIONS

This chapter presents conclusions of the thesis based on the survey results, lithic analysis, and hydration studies. It begins with the primary goal of the thesis, to develop a production curve for the Mt. Hicks obsidian quarry, then proceeds with a discussion of previous explanations for the late prehistoric drop in obsidian production at quarries throughout the western Great Basin, and ends by considering how the organization of technology may have influenced obsidian use.

PRODUCTION CURVE

The primary goal of the thesis was to determine the production history of Mt. Hicks obsidian use. Data suggest the production curve for Mt. Hicks obsidian is similar to that found at previously studied quarries in the western Great Basin only in a very broad manner. Use of obsidian is low until approximately 6000 BP, followed by steadily increasing use until around 1275 BP, when there was a sharp decline in quarry activity. This is most apparent in the inclusive production curve (Chart 6.1) and activity conducted in the obsidian-rich pinyon-juniper zone (Chart 6.3), which yielded the largest sample of obsidian. A more complex picture emerges, however, when the production curves from the other environmental zones are examined. Comparing the Mt. Hicks production curve to previously studied obsidian quarries in the western Great Basin proved interesting.

Community-Specific Use Histories

Peak obsidian production in the upper desert scrub zone occurs during the early Newberry period, followed by a more gradual decline than elsewhere (Chart 6.2). Peak production for the lower desert scrub zone begins somewhat earlier, during the late pre-Newberry period, followed again by a fairly gradual decline until the Marana period when no activity can be identified (Chart 6.4). The lacustrine zone shows the greatest deviation from the inclusive pattern, with a peak in activity during the late pre-Newberry interval, followed by a slight decline during early Newberry times, an increase during the late Newberry interval, a substantial drop during the Haiwee period, and seemingly no activity during the Marana era (Chart 6.5).

The pinyon-juniper zone conforms most closely to the pattern that has been described for previously studied quarries (Chart 6.3). This is not surprising given the abundance of obsidian resources available in the pinyon-juniper zone. In addition to raw material acquisition it is clear that each environmental zone varied in importance from period to period (Table 6.11). Thus, in the pinyon-juniper zone it is the focus on biface manufacture during the early Newberry and especially the late Newberry interval that structures the inclusive production curve. In other environments, by contrast, it is the extraction of non-lithic subsistence resources that drives toolstone production and other activity. In truth, the term "production curve" may be something of a misnomer in zones other than the pinyon-juniper woodland, because most activity was, at best, tangentially related to lithic procurement. As such, the term "use history" may be more appropriate in the latter settings, where most toolstone use was incidental to other pursuits, not directly linked to lithic procurement/manufacture.

Mt. Hicks Compared to Previous Obsidian Quarry Studies

The results of the current study were compared with previous investigations at the Bodie Hills (Singer and Ericson 1977), Casa Diablo (Hall 1989), Coso (Gilreath and Hildebrandt 1997), and Truman-Queen (Ramos 2000) obsidian sources. An adjusted residual statistical analysis was used to determine if there are subtle differences in the apparently similar production histories reported for each source. Given the various methods used by researchers to gather hydration data and differences in determining what time intervals hydration values should be assigned, the variation between obsidian sources is not subtle but great, and the production curve/history of each source resemble each other only broadly. The Coso source has the highest number of hydration values assigned to the pre-Newberry period, with large amounts reported for the Newberry interval followed by a large decrease in the subsequent Haiwee and Marana periods. The amount of pre-Newberry artifacts, however, appears depressed on a production curve because they are spread out over 6000 years or more. These counts only reflect hydration values obtained from quarry sites during the Coso investigation (Gilreath and Hildebrandt 1997) and not from non-quarry contexts. Hydration values for the Casa Diablo obsidian source were combined from several sites. A relatively low number of hydration values were assigned to the pre-Newberry interval, quantities rise sharply during the late Newberry period, decline a small amount during the Haiwee period, followed by a larger decline during the Marana period. It is important to note that the small drop during the Haiwee period for Casa Diablo obsidian seems consistent with Coso glass which, away from quarry contexts, has peak production values during the Haiwee era. The Bodie Hills source is most often used for comparison by researchers and matches the general pattern of western Great Basin obsidian production curves/histories well. The Truman-Queen source matches well with the general pattern also, but Ramos (2000) never developed an acceptable hydration rate and simply assigned hydration values to time periods based on the greatest number of temporally sensitive artifacts (projectile points) falling in a given interval of hydration values, in effect using hydration values as a method of relative, not absolute, dating. Table 7.1 presents the number of hydration values from each source by time period, adjusted to reflect the dating scheme used for the thesis, and the results of an adjusted residual statistical analysis. Truman-Queen obsidian is omitted because an acceptable rate was not developed and no proposed rates proposed by other researchers seemed to work (Ramos 2000: 155-158). The counts presented in Table 7.1 are taken from Ramos (2000: 18-27).

Table 7.1. Adjusted residual analysis by temporal period of selected western Great Basin obsidian sources.

Period	Coso (count/residual)	Casa Diablo (count/residual)	Bodie Hills (count/residual)	Mt. Hicks (count/residual)	Total
Marana	31/-15.95	171/+17.74	9/+2.91	5/-2.54	216
Haiwee	130/-25.52	477/+28.95	11/+0.07	26/-2.70	644
Late Newberry	834/-5.22	431/+3.82	22/-0.38	118/+3.42	1405
Early Newberry	460/+1.27	120/-5.92	15/+1.13	90/+7.60	685
Late Pre-Newberry	911/+12.53	123/-13.71	19/+0.02	76/+0.38	1129
Early Pre-Newberry	931/+21.18	39/-18.17	9/-2.11	14/-7.24	993
Total	3297	1361	85	329	5072

Compared to other obsidian quarries in the western Great Basin, Mt. Hicks has significantly lower quantities of hydration values assigned to the Marana, Haiwee, and early pre-Newberry periods, significantly higher amounts during the early and late Newberry intervals, and close to expected amounts only during the late pre-Newberry period. Indeed, of all the investigated quarries only the Bodie Hills source has more values appearing in close to expected rather than significantly over- or under-represented quantities. The Casa Diablo source is most divergent; all its counts are significantly different than expected. Mt. Hicks is broadly similar to previously studied obsidian sources, pre-Newberry period artifacts are fewer in amount, Newberry interval quantities are relatively high, followed by large drop in production during the Haiwee and Marana periods (though this last is not true for all sources during the Haiwee). Examined in detail, however, none of the sources closely resemble each other. Some of this divergence can probably be explained by how the data were gathered. Casa Diablo data were compiled from a number of sites, some of which are not located on the source itself. Charts 6.2-6.5 indicate that use histories away from the pinyon-juniper zone, where the most abundant obsidian raw material is available, differs from the inclusive curve (Chart 6.1). Data from this study suggests that lithic exploitation patterns changed during the Haiwee period. The later pattern appears to shift away from reduction at primary source locations to a more dispersed pattern of reduction. The largest quantities of Coso obsidian are dated to the Haiwee interval away from quarry contexts, adding weight to the argument. Other factors that may be influencing the divergent patterns of source use may also include differences in population densities across the western Great Basin through time.

Assessing Explanations for the Drop in Obsidian Production after the Newberry Era

Explanations for the drop in obsidian production after the Newberry period are discussed in Chapter One. Briefly, three explanations have been offered: variation in social interactions/trade across the Sierra Nevada; shifts in subsistence-settlement patterns; and technological change.

Shifts in trans-Sierran interactions/trade cannot account for the Haiwee period decline in Mt. Hicks biface production, because it was never extensively traded/ transported into Cismontane California, but has the same production curve/history as quarries where this was supposed to have happened (Singer and Ericson 1977; Bouey and Basgall 1984; Gilreath and Hildebrandt 1997). The same is true for the Truman-Queen obsidian quarry, where production plummets during the Haiwee interval and little material ever reached California (Ramos 2000). If increased territoriality in the vicinity of the Coso and other western Great Basin obsidian sources, or a breakdown in trade networks, were responsible for production declines, then the production curve at Mt. Hicks, and Truman-Queen, would presumably differ and show little or no decline during the Haiwee or Marana periods.

That western Sierran groups were responsible for the spike in production during the Newberry period is itself unlikely. Indeed, after examining obsidian source profiles for various sites in eastern California, Basgall (1989) concluded that local populations were both the producers and the consumers of eastern Californian obsidian. The present study supports this conclusion, given the numerous bifacial and other tools that were found in non-quarrying contexts. It is important to note, however, that while trans-Sierran social interactions do not account for the decline in obsidian production, trade and social interactions within the western Great Basin may have played a role.

Changes in subsistence and settlement patterns have been used to explain the decline in obsidian production. Gilreath and Hildebrandt (1997) believe this to be a contributing factor but provide no specific data or detailed explanation. Thus, whether they are referring to the growing reliance on seeds — which do not require flaked stone tools to exploit — a point made by Giambastiani (2004: 465), or to some other adaptive change cannot be ascertained. Data from the current study were limited to surface artifacts and lack food remains that might be used to directly test this hypothesis, but changes in adaptation and technology could have contributed to shifts in quarry use.

Ramos (2000) also uses shifting subsistence patterns to explain the decline in obsidian production, though in a more roundabout and testable fashion. He argues that bifaces were specialized artiodactyl butchering tool and as hunting became less important during the Haiwee and Marana periods fewer bifaces were needed. This resulted in decreased biface and waste flake manufacture and hence the regionally widespread decline in quarry production. The current study does not support this, given the lack of bifaces in the upper desert scrub zone, where little but hunting could have occurred. Clearly, if Ramos were correct, bifaces should dominate in this zone, but the opposite is true; the upper desert scrub is the only zone that has more simple flake tools than bifaces.

This pattern persists through time, with simple flake tools outnumbering bifaces in all intervals but the Marana period, where a single biface and no flake tools are recorded.

Still another explanation for the change in quarry activity is a shift in technology, including the introduction of the bow and arrow (Gilreath and Hildebrandt 1997). This is more easily tested using data from the current study, which in this case seem to support the explanation. As previously mentioned, there is a trend toward more refined bifaces through time. Bifaces during pre-Newberry times tend to be early-stage forms, gradually becoming more refined until they are more common in post-Newberry contexts. Similarly, there is a steady decline in average biface weight from the pre-Newberry interval until the post-Newberry period, excluding a single post-Newberry specimen from a quarry area. The absolute number of bifaces decreases during post-Newberry times likely due to changing mobility patterns. In keeping with these patterns, the debitage profiles show that biface production was waning, but acquisition of raw material more important during the post-Newberry interval. In fact, cortical flakes outnumber biface thinning flakes during the post-Newberry era, suggesting a flake/core oriented technology which produces less waste than biface manufacture. In a broader sense, the idea that changing technology was responsible for the decline in obsidian production is an obvious, but unsatisfying answer that begs the question why technology changed the way it did. More to the point, biface production has little to do with bow and arrow technology, with the decision to make bifaces or not likely dependent on other factors.

The previous section noted that the spike in obsidian production during the early and late Newberry periods was spurred by biface manufacture to produce highly efficient tools for geographically wide-ranging groups with predictably reliable access to raw material. A change to a less mobile pattern during the ensuing post-Newberry era would have reduced the need for bifaces, depressing the production curve from previous levels. Mobility, therefore, seems to be a major factor structuring the production curve. In Chapter One it was argued that groups exploiting Mt. Hicks were, probably, more mobile than those using other western Great Basin obsidian quarries. If true, it appears to have had little effect on the production curve or quarry history, changes which were governed by shifts in settlement mobility that appear to have occurred over much of the western Great Basin.

The reduction in mobility seen during the post-Newberry period is generally ascribed to increased population that is believed to have caused greater territoriality among late period prehistoric groups. This would have, in turn, curtailed access to obsidian sources and reduced foraging ranges (Giambastiani 2004), producing greater scavenging of previously deposited artifacts and waste flakes. With the switch to flake-based technologies accompanied with the reduced importance of bifaces due to decreased mobility, scavenging of waste flakes would have been sufficient to meet most technological needs, including the manufacture of projectile points. Nevertheless, presence of cortical flakes during the post-Newberry interval indicates that scavenging of old sites was insufficient to meet all technological needs.

In sum, growing populations in the late archaeological record of the western Great Basin led to increased territoriality as subsistence resources became increasingly scarce. This, in turn, led to decreased mobility, which had the dual effect of decreasing the demand and manufacture of bifaces that concomitantly spurred a shift to flake-based technologies. Coinciding with this was the introduction of the bow and arrow that allowed projectile points to be manufactured from flakes rather than larger bifacial blanks. The concurrence of these twin factors was likely responsible for the decline in obsidian production beginning in the early part of the post-Newberry period and continuing until the end of that interval.

ORGANIZATION OF TECHNOLOGY AND MT. HICKS

When examining how well organization of technology theory can account for the patterns at Mt. Hicks, two questions are of particular interest. The first relates to the pre-Newberry period focus on simple flake tools and the second is to the subsequent shift to middle-stage bifaces during the early and late Newberry intervals. Of further interest is whether embedded toolstone procurement can be identified in the data.

Simple Flake Tools and Bifaces During the Pre-Newberry Period

As Tables 6.12 clearly shows, there is a focus on simple flake tools during the pre-Newberry interval. As discussed in Chapter Two, pre-Newberry period settlement systems are believed highly mobile, wide-ranging, and flexible. As such, tool-kits tend to be highly specialized with apparent focus on flake tools seemingly at odds with many organization of technology assumptions, i.e., that flake-based oriented technologies are generally associated with more sedentary groups who run little risk of material shortfalls (although this is not always the case and some prehistoric groups used specialized blade technologies that are flake/core based). That no highly formalized tools (e.g., prepared cores, formed flake tools) of the type generally associated with pre-Newberry occupants were dated to the era underscores the apparent lack of a specialized tool-kit. The importance of simple flake tools and lack of specialized tools in the survey sample can easily be explained by the widespread abundance of lithic material at Mt. Hicks, which obviated the need for curated/maintainable technologies during the pre-Newberry era. Thus, simple flake tools could be made as needed without risk of running out of material. This would be true during all time periods because raw material availability stayed the same. The upper desert scrub zone, as noted, was probably visited to hunt large artiodactyls, not to exploit obsidian resources which were available in lower, more accessible settings. This zone, however contains most of the simple flake tools, which reinforces the idea that specialized butchering tools were on occasion replaced by more expedient flake tools when conditions allowed.

As discussed in Chapter Three, bifaces are often associated with curated technologies, and curated technologies with highly mobile groups like those during the pre-Newberry interval. Bifaces are easily maintained, efficient tools, and versatile. Therefore, it is not surprising that during the pre-Newberry period bifaces are proportionately most abundant (Table 6.12). An important feature of pre-Newberry bifaces is that they tend to be early-stage forms (Table 6.13). Early-stage bifaces would have maximized the amount of lithic material pre-Newberry period groups carried with them, thus reducing shortfall risk.

Organization of technology expectations are supported by the survey and analysis results. The apparent lack of a specialized tool-kit and the abundance and form of bifaces during the pre-Newberry period can both be explained using organization of technology theory.

Bifaces During the Newberry Periods

The early focus on simple flake tools shifts to bifaces during the early Newberry period and continues through the late Newberry interval. There is also a major increase in biface thinning flakes both proportionately and in absolute numbers from the pre-Newberry period to the early and late Newberry intervals (Table 6.12). In both the early and late Newberry periods biface thinning flakes are over-represented. Bifaces, although proportionately more important than simple flake tools, appear in close to expected numbers. This suggests that the increase in biface production was primarily for transport to other locations, not for local use.

As discussed in Chapter Two, the mobility patterns for the Newberry period groups are believed to remain wide-ranging but more regularized. This would have reduced the risk of running out of lithic materials because people would have had a clear idea of where and when they could access lithic resources. Maximizing lithic mass carried during travel, as appears in the pre-Newberry period, in early-stage bifacial forms would no longer be important. Other characteristics of bifaces, namely their versatility, efficiency, and their ease of transport, would probably have increased their importance during the early and late Newberry periods. In short, middle-stage bifaces are an excellent technological choice for groups with a highly regularized settlement pattern, like the Newberry intervals, that insured reliable sources of lithic raw material at all times. In fact, the data presented in Table 6.13 show that middle-stage bifaces are most prevalent during the early and late Newberry periods, as might be expected.

APPENDIX A
Artifact Analytical Data

APPENDIX A.1. Projectile Point Analytical Data.

Catalogue Number	Zone	Unit	Point Type	Wt.	ML	AL	SL	MW	BW	NW	MTH	DSA	PSA	NOA	State	I/FR
1	UD	ISO	Elko	3.5	-24.0	-24.0	9	26.1	9	11.7	5.0	9	9	9	0	2
2	PJ	ISO	H Basal Notch	8.4	-39.9	-31.3	-21.2	29.9	9	25.8	6.9	9	9	9	0	2
3	DS	ISO	Large SN (cf FSSN)	15.7	-54.7	-54.7	16.6	30.1	21.1	20.0	8.1	9	9	9	0	2
4	DS	ISO	Elko Eared	6.7	48.3	46.1	13.0	24.1	21.6	17.1	6.4	196	124	72	1	2
5	UD	ISO	Eastgate	1.7	-23.5	-21.2	7.3	19.4	9.5	8.9	3.6	137	90	47	0	1
6	LC	ISO	Elko Eared	5.5	-32.1	-25.6	-9.6	-27.7	-20.9	19.0	-6.3	9	9	9	0	2
40	UD	UD17	Elko Eared	8.2	-36.8	-29.6	-13.7	31.7	23.1	20.9	6.7	144	101	43	0	1
63	UD	UD33	Dart (cf. Elko Series)	3.6	-24.4	-24.4	-6.6	-22.6	9	22.8	6.8	9	9	9	0	2
101	PJ	PJ8	Elko Eared	8.2	64.9	58.4	9.2	31.3	23.9	22.1	6.3	148	121	27	0	0
111	PJ	PJ22	Dart (cf. Elko Series)	9.5	-35.0	-35.0	9	-37.3	9	22.0	6.8	9	9	9	0	2
117	PJ	PJ30	Elko Series	5.9	-41.8	-41.1	10.7	-24.9	21.5	18.4	6.0	201	144	57	0	1
165	DS	DS27	Gatecliff Split-stem	4.6	46.6	43.2	14.8	21.0	11.1	11.7	6.0	180	90	90	0	0

Note: Zone (DS - lower desert scrub, LC - lacustrine, PJ - pinyon-juniper, UD - upper desert scrub); Wt. - weight in grams; ML - maximum length; AL - axial length; SL - stem length; MW - maximum width; BW - basal width; NW - neck width; MTH - maximum thickness; DSA - distal shoulder angle; PSA - proximal shoulder angle; NOA - notch opening angle; State - evidence of weathering or patina (0 - none, 1 - slight); I/FR - evidence of impact fracture (0 - no evidence, 1 - slight evidence, 2 - strong evidence). All measurements are in mm, negative values denote incomplete measurements (9 - indeterminate)

APPENDIX A.2. Biface Analytical Data.

Catalogue Number	Unit	Zone	Mtrl.	Cond.	Wt.	Coll.	ML	MW	MTH	Stage	No. of Arrises	SPA	End Shape	Size	Use	Form	Period	Avg. Hyd. Value
7	UD2	UD	OBS	MRG	43.1	Y	-67.2	-42.6	-17.6	1	1	45	8	3	2	2	N2	4.52
7	UD2	UD	OBS	MRG	43.1	Y	-67.2	-42.6	-17.6	1	1	45	8	3	2	2	M	1.35
11	UD2	UD	OBS	MRG	6.2	Y	-26.3	-31.8	-6.9	2	1	40	-	9	0	2	P1	5.64
12	UD2	UD	OBS	END	29.9	Y	-62.9	-39.3	-12.1	3	2	45	8	3	5	2	N2	5.32
13	UD2	UD	OBS	PRX	16.0	Y	-43.0	-43.2	-8.6	3	1	40	8	3	5	2	N2	5.23
14	UD2	UD	OBS	END	25.5	Y	-48.6	-45.8	-12.3	3	1	45	1	3	0	2	P1	5.73
15	UD2	UD	OBS	END	16.7	Y	-35.7	-49.5	-8.9	1	1	40	3	3	0	2	N2	5.36
16	UD2	UD	OBS	END	15.3	Y	-30.2	-48.8	-8.8	2	1	40	3	3	1,3	2	N2	5.01
17	UD2	UD	OBS	DST	28.5	Y	-56.7	-46.7	-9.7	3	1	50	2	3	1	2	-	-
29	UD5	PJ	OBS	END	58.2	Y	-52.3	-52.9	-20.5	2	1	50	2	3	1,3,4,5	2	-	-
30	UD5	PJ	OBS	WHL	70.8	Y	86.3	43.4	-16.5	1	1	60	7,7	3	0	2	P2	9.04
31	UD5	PJ	OBS	DST	21.9	Y	-47.9	-44.1	-8.5	3	3	35	1	3	0	2	N1	3.02
32	UD5	PJ	OBS	WHL	73.6	Y	75.3	57.0	18.7	1	1	60	3,8	3	3	2	P1	5.7
33	UD5	PJ	OBS	WHL	53.8	Y	86.3	42.0	15.7	1	1	45	8,8	3	3	2	P1	6.19
35	UD8	UD	OBS	MED	3.8	Y	-27.5	-24.2	-5.6	4	3	40	-	2	0	2	N2	4.88
61	UD28	UD	OBS	DST	1.7	Y	-22.5	-19.9	-4.0	4	2	40	2	2	0	2	N1	4.26

APPENDIX A.2. Biface Analytical Data (continued).

Catalogue Number	Unit	Zone	Mtrl.	Cond.	Wt.	Coll.	ML	MW	MTH	Stage	No. of Arrises	SPA	End Shape	Size	Use	Form	Period	Avg. Hyd. Value
70	LC3	LC	OBS	NC	4.8	Y	-45.7	16.7	5.1	4	3	35	1	2	5	2	N1	3.21
71	LC3	LC	OBS	NC	11.0	Y	-36.1	32.1	9.5	3	2	45	8,3	2	0	2	P1	7.55
75	LC5	LC	OBS	DST	7.2	Y	-34.1	-26.4	-8.2	3	1	45	2	2	3	2	P1	6.02
83	PJ2	PJ	OBS	WHL	98.7	Y	94.5	50.4	21.6	1	1	40	8,8	3	0	2	P1	8.06
84	PJ2	PJ	OBS	END	17.6	Y	-58.3	-37.8	-12.7	3	2	60	3	2	0	2	N1	3.33
89	PJ5	PJ	OBS	PRX	41.2	Y	-55.6	-45.0	-13.0	3	2	40	1	3	1	3	H	2.9
90	PJ5	PJ	OBS	WHL	14.9	Y	54.3	40.5	9.4	2	1	35	1,3	2	3	2	N1	4.1
91	PJ5	PJ	OBS	WHL	18.1	Y	61.4	28.8	10.0	3	1	30	8,3	2	0	2	N1	3.86
94	PJ5	PJ	OBS	END	6.0	Y	-23.7	-30.8	-8.2	3	1	50	1	9	5	2	N1	3.87
95	PJ5	PJ	OBS	END	9.8	Y	-50.2	-33.5	-4.9	3	1	40	3	3	3	2	N1	3.55
96	PJ5	PJ	OBS	MRG	5.5	Y	-23.2	-45.9	-5.7	3	2	45	-	3	1,3	9	N1	3.9
97	PJ5	PJ	OBS	DST	5.7	Y	-36.4	-26.7	-6.1	3	2	40	6	2	-	3	N2	5.51
98	PJ5	PJ	OBS	DST	1.9	Y	-29.3	-19.5	-3.4	5	4	40	6	2	-	3	P1	7.11
100	PJ6	PJ	OBS	END	17.8	Y	-32.7	-41.8	-11.5	2	1	55	2	3	5	2	N1	4.06
109	PJ19	PJ	OBS	MRG	26.5	Y	-69.3	-39.8	-10.3	3	2	35	-	3	5	3	N1	3.56
116	PJ23	PJ	OBS	END	12.8	Y	-45.0	-33.0	-7.4	3	2	40	2	3	-	2	-	-
119	PJ32	PJ	OBS	MED	3.6	Y	-28.2	-21.5	-4.8	4	3	40	-	2	-	3	N2	5.05
120	PJ32	PJ	OBS	DST	12.3	Y	-60.4	-26.9	-7.1	4	2	45	2	3	5	3	H	2.39
131	DS7	DS	OBS	MRG	2.9	Y	-24.7	-25.8	-8.4	3	2	45	-	9	5	9	N2	5.04
132	DS7	DS	OBS	MRG	19.5	Y	-61.3	-39.9	-9.6	3	1	50	-	3	-	9	P1	6.52
133	DS7	DS	OBS	END	13.9	Y	-42.8	-39.4	-9.9	3	2	50	3	3	-	2	N2	5.12
134	DS7	DS	OBS	DST	3.6	Y	-34.8	-19.6	-6.5	4	2	35	2	2	-	2	N2	5.05
135	DS7	DS	OBS	PRX	60.6	Y	-53.6	-51.8	-21.0	2	1	55	1	3	-	2	P1	6.24
139	DS9	DS	OBS	MRG	43.8	Y	-100.2	-62.0	-14.2	3	2	45	-	3	1,3	9	P1	6.88
140	DS9	DS	OBS	END	11.3	Y	-35.8	-40.6	-9.3	3	1	35	2	3	-	2	P1	6.06
149	DS18	DS	OBS	END	7.4	Y	-36.1	-25.8	-8.8	4	2	50	2	9	-	2	-	-
153	DS24	DS	OBS	DST	8.0	Y	-38.8	-30.2	-6.3	4	2	35	2	3	5	2	P1	5.63
154	DS24	DS	OBS	DST	13.6	Y	-53.5	-38.6	-9.2	3	2	50	3	3	1	2	N2	5.05
155	DS24	DS	OBS	MED	8.6	Y	-45.8	-22.1	-6.9	4	3	45	-	2	3	2	N1	4.22
157	DS25	DS	OBS	END	4.1	Y	-32.7	-25.5	-5.0	4	2	30	2	2	-	2	H	2.56
158	DS25	DS	OBS	END	17.2	Y	-59.9	-33.2	-9.0	3	1	40	2	3	-	2	N1	3.52
159	DS25	DS	OBS	MED	6.9	Y	-28.0	-40.5	-7.6	3	1	30	-	3	3	2	N1	3.93
160	DS25	DS	OBS	MED	5.5	Y	-29.1	-27.3	-8.0	3	1	50	-	2	1,3	2	N2	4.55
161	DS25	DS	OBS	MRG	5.5	Y	-37.6	-22.1	-6.9	3	1	30	-	2	5	2	N1	3.61
162	DS25	DS	OBS	MRG	3.7	Y	-26.3	-24.3	-5.9	3	1	45	-	9	5	2	N1	3.59
169	PJ2	PJ	OBS	MRG	36.8	Y	-72.8	-40.1	-15.6	3	1	45	-	3	5	2	-	-
170	UD22	UD	OBS	MED	-	N	-	-	-	-	-	-	-	-	-	-	-	-
175	UD22	UD	OBS	WHL	-	N	55.0	30.0	20.0	-	-	-	-	-	-	-	-	-
180	UD22	UD	OBS	WHL	-	N	30.0	25.0	5.0	-	-	-	-	-	-	-	-	-
181	UD22	UD	OBS	WHL	-	N	40.0	50.0	10.0	-	-	-	-	-	-	-	-	-

APPENDIX A.2. Biface Analytical Data (continued).

Catalogue Number	Unit	Zone	Mtrl.	Cond.	Wt.	Coll.	ML	MW	MTH	Stage	No. of Arrises	SPA	End Shape	Size	Use	Form	Period	Avg. Hyd. Value
182	UD22	UD	OBS	WHL	-	N	35.0	30.0	10.0	-	-	-	-	-	-	-	-	-
184	DS24	DS	OBS	END	-	N	35.0	30.0	5.0	-	-	-	-	-	-	-	-	-
185	DS24	DS	OBS	DST	-	N	35.0	35.0	7.0	-	-	-	-	-	-	-	-	-
186	DS24	DS	OBS	DST	-	N	60.0	25.0	7.0	-	-	-	-	-	-	-	-	-
187	DS24	DS	OBS	END	-	N	35.0	30.0	5.0	-	-	-	-	-	-	-	-	-
188	DS24	DS	OBS	PRX	-	N	35.0	35.0	10.0	-	-	-	-	-	-	-	-	-
189	DS24	DS	OBS	END	-	N	30.0	30.0	5.0	-	-	-	-	-	-	-	-	-
190	DS24	DS	OBS	END	-	N	30.0	30.0	5.0	-	-	-	-	-	-	-	-	-
191	DS24	DS	OBS	END	-	N	40.0	25.0	5.0	-	-	-	-	-	-	-	-	-
192	DS24	DS	OBS	END	-	N	40.0	25.0	5.0	-	-	-	-	-	-	-	-	-
198	UD5	PJ	OBS	WHL	-	N	80.0	45.0	15.0	-	-	-	-	-	-	-	-	-
199	UD5	PJ	OBS	END	-	N	45.0	50.0	15.0	-	-	-	-	-	-	-	-	-
205	UD5	PJ	OBS	WHL	-	N	50.0	40.0	10.0	-	-	-	-	-	-	-	-	-
209	UD5	PJ	OBS	WHL	-	N	90.0	45.0	15.0	-	-	-	-	-	-	-	-	-
212	UD5	PJ	OBS	NC	-	N	60.0	45.0	10.0	-	-	-	-	-	-	-	-	-
213	UD5	PJ	OBS	END	-	N	55.0	45.0	5.0	-	-	-	-	-	-	-	-	-
214	UD5	PJ	OBS	END	-	N	75.0	55.0	15.0	-	-	-	-	-	-	-	-	-
215	UD5	PJ	OBS	END	-	N	50.0	60.0	15.0	-	-	-	-	-	-	-	-	-
217	PJ2	PJ	OBS	WHL	-	N	95.0	60.0	25.0	-	-	-	-	-	-	-	-	-
219	PJ2	PJ	OBS	NC	-	N	60.0	40.0	75.0	-	-	-	-	-	-	-	-	-
222	PJ2	PJ	OBS	WHL	-	N	65.0	60.0	15.0	-	-	-	-	-	-	-	-	-
223	PJ2	PJ	OBS	NC	-	N	80.0	60.0	15.0	-	-	-	-	-	-	-	-	-
224	PJ2	PJ	OBS	WHL	-	N	60.0	60.0	15.0	-	-	-	-	-	-	-	-	-
228	PJ5	PJ	OBS	NC	-	N	60.0	40.0	10.0	-	-	-	-	-	-	-	-	-
230	PJ5	PJ	OBS	END	-	N	42.0	20.0	2.0	-	-	-	-	-	-	-	-	-
232	PJ5	PJ	OBS	NC	-	N	50.0	40.0	5.0	-	-	-	-	-	-	-	-	-
235	PJ5	PJ	OBS	END	-	N	23.0	26.0	2.0	-	-	-	-	-	-	-	-	-
237	PJ5	PJ	OBS	NC	-	N	55.0	32.0	11.0	-	-	-	-	-	-	-	-	-
238	PJ5	PJ	OBS	END	-	N	60.0	45.0	9.0	-	-	-	-	-	-	-	-	-
240	PJ5	PJ	OBS	DST	-	N	27.0	23.0	4.0	-	-	-	-	-	-	-	-	-
241	PJ5	PJ	OBS	PRX	-	N	32.0	27.0	2.0	-	-	-	-	-	-	-	-	-
242	PJ5	PJ	OBS	END	-	N	49.0	19.0	4.0	-	-	-	-	-	-	-	-	-
243	PJ5	PJ	OBS	END	-	N	51.0	24.0	4.0	-	-	-	-	-	-	-	-	-
244	PJ5	PJ	OBS	END	-	N	34.0	70.0	5.0	-	-	-	-	-	-	-	-	-
245	PJ5	PJ	OBS	WHL	-	N	81.0	49.0	24.0	-	-	-	-	-	-	-	-	-
246	PJ5	PJ	OBS	NC	-	N	64.0	35.0	5.0	-	-	-	-	-	-	-	-	-
249	PJ5	PJ	OBS	WHL	-	N	80.0	43.0	17.0	-	-	-	-	-	-	-	-	-
250	PJ5	PJ	OBS	MRG	-	N	27.0	27.0	3.0	-	-	-	-	-	-	-	-	-
251	PJ5	PJ	OBS	END	-	N	37.0	47.0	5.0	-	-	-	-	-	-	-	-	-
252	PJ5	PJ	OBS	NC	-	N	76.0	52.0	7.0	-	-	-	-	-	-	-	-	-

APPENDIX A.2. Biface Analytical Data (continued).

Catalogue Number	Unit	Zone	Mtrl.	Cond.	Wt.	Coll.	ML	MW	MTH	Stage	No. of Arrises	SPA	End Shape	Size	Use	Form	Period	Avg. Hyd. Value
253	PJ5	PJ	OBS	END	-	N	32.0	32.0	5.0	-	-	-	-	-	-	-	-	-
254	PJ5	PJ	OBS	END	-	N	44.0	60.0	13.0	-	-	-	-	-	-	-	-	-
255	PJ5	PJ	OBS	END	-	N	46.0	51.0	11.0	-	-	-	-	-	-	-	-	-
256	PJ5	PJ	OBS	NC	-	N	56.0	52.0	14.0	-	-	-	-	-	-	-	-	-
257	PJ5	PJ	OBS	NC	-	N	46.0	34.0	5.0	-	-	-	-	-	-	-	-	-
259	DS7	DS	OBS	END	-	N	45.0	38.0	10.0	-	-	-	-	-	-	-	-	-
261	DS7	DS	OBS	NC	-	N	73.0	34.0	10.0	-	-	-	-	-	-	-	-	-
263	DS2	DS	OBS	END	-	N	45.0	36.0	4.0	-	-	-	-	-	-	-	-	-
268	DS9	DS	OBS	MRG	-	N	65.0	62.0	14.0	-	-	-	-	-	-	-	-	-
272	LC5	LC	OBS	END	-	N	46.0	34.0	9.0	-	-	-	-	-	-	-	-	-
274	LC10	LC	OBS	END	-	N	32.0	42.0	-.0	-	-	-	-	-	-	-	-	-
275	LC10	LC	OBS	MRG	-	N	55.0	40.0	10.0	-	-	-	-	-	-	-	-	-
277	LC10	LC	OBS	END	-	N	28.0	47.0	8.0	-	-	-	-	-	-	-	-	-
278	LC10	LC	OBS	PRX	-	N	25.0	38.0	7.0	-	-	-	-	-	-	-	-	-
282	PJ8	PJ	OBS	WHL	-	N	67.0	45.0	24.0	-	-	-	-	-	-	-	-	-
285	UD17	UD	OBS	DST	-	N	20.0	11.0	2.0	-	-	-	-	-	-	-	-	-
293	DS25	DS	OBS	WHL	-	N	45.0	34.0	5.0	-	-	-	-	-	-	-	-	-
294	DS25	DS	OBS	END	-	N	57.0	27.0	3.0	-	-	-	-	-	-	-	-	-
295	DS25	DS	OBS	END	-	N	32.0	43.0	2.0	-	-	-	-	-	-	-	-	-

Note: Zone (DS - lower desert scrub, LC - lacustrine, PJ - pinyon-juniper, UD - upper desert scrub); Mtrl. - material (OBS - obsidian); Cond. - condition (DST - distal end fragment, END - indeterminate end fragment, MRG - margin fragment, NC - nearly complete, PRX - proximal end fragment, WHL - whole); Wt. - weight in grams; Coll. - collected (Y/N - yes/no); ML - maximum length; MW - maximum width; MTH - maximum thickness; Stage - reduction stage; No. of Arrises - actual number of arrises per cm; SPA - spine plane angle; End Shape - proximal end shape listed first (1 - rectangular, 2 - convex pointed, 3 - convex rounded, 6 - triangular, 7 - irregular, 8 - unworked or snapped end); Size - flake size (1 [<1.0 cm in daimeter], 2 [1.0-2.0 cm in diameter], 3 [2.0-3.0 cm in diameter], 4 [3.0-5.0 cm in diameter], 5 [>5.0 cm in diameter]); Use - evidence of use wear (0 - none observed, 1 - unifacial edge-flaked, 2 - bifacial edge-flaked, 3 - unifacial micro-chipping, 4 - bifacial micro-chipping, 5 - edge ground); Form - original form (2 - flake base, 3 - biface base, 9 - indeterminate); Avg. Hyd. Value - average hydration value. All measurements are in mm, negative values denote incomplete measurements.

APPENDIX A.3. Formed Flake Tool Analytical Data.

Catalogue Number	Zone	Unit	Cond.	Wt.	ML	MW	MTH	Flake Type	Morph.	No of Edges	Surf. Used	Edge Shape	Edge Modif.	Edge Angle	Avg. Hyd. Value
27	PJ	UD5	DST	41.5	-56.7	-43.9	-21.6	10	2	1	1	10A	1,5	45	6.15
28	PJ	UD5	WHL	67.7	92.0	52.5	12.9	2	1	1	3	10A	1,6	40	3.01
65	LC	LC3	WHL	89.2	82.8	57.6	22.9	2	2	1	1	10A	5	55	2.54
72	LC	LC4	NC	45.4	53.2	74.7	13.7	7	2	1	1	2A	5	35	4.65
82	PJ	PJ2	WHL	42.1	-60.1	-49.6	-15.7	2	2	2	1	3A/3B	5/6	35/45	1.27
168	PJ	PJ2	NC	164.2	105.1	64.7	27.3	4	2	1	3	10A	1,6	50	-

Note: Zone (LC - lacustrine, PJ - pinyon-juniper); Cond. - condition (DST - distal end fragment, NC - nearly complete, WHL - whole); Wt. - weight in grams; ML - maximum length; MW - maximum width; MTH - maximum thickness; Morph. - morphological type (1 - domed uniface, 2 - amorphous); No. of Edges - number of worked edges; Surf. Used - surface used (1 - dorsal, 3 - both dorsal and ventral); Edge Shape (2 - convex, 3 - straight, 10 - , A - even, B - jagged, irregular); Edge Modif. - edge modification (1 - unifacial micro-chipping, 5 - unifacial edge flaked, 6 - bifacial edge flaked); Avg. Hyd. Value - average hydration value. All measurements are in mm, negative values denote incomplete measurement.

APPENDIX A.4. Simple Flake Analytical Data.

Catalogue Number	Zone	Unit	Mtrl.	Cond.	Wt.	Coll.	Avg. Hyd. Value
9	UD	UD2	OBS	NC	5.7	Y	5.62
10	UD	UD2	OBS	PRX	7.2	Y	4.8
20	PJ	UD5	OBS	NC	1.2	Y	2.34
34	UD	UD8	OBS	WHL	39.3	Y	5.76
39	UD	UD16	OBS	WHL	17.2	Y	5.03
41	UD	UD17	OBS	WHL	8.0	Y	4.15
42	UD	UD17	OBS	MRG	7.8	Y	6.07
43	UD	UD17	OBS	DST	3.6	Y	4.03
44	UD	UD17	OBS	NC	9.9	Y	4.54
46	UD	UD18	OBS	NC	4.5	Y	2.91
50	UD	UD22	OBS	WHL	9.3	Y	3.58
51	UD	UD22	OBS	NC	13.4	Y	7.79
52	UD	UD22	OBS	NC	23.7	Y	5.57
53	UD	UD22	OBS	MRG	10.8	Y	7.04
55	UD	UD22	OBS	MRG	13.1	Y	6.63
57	UD	UD26	OBS	WHL	17.3	Y	6.97
58	UD	UD26	OBS	DST	4.8	Y	4.82
59	UD	UD26	OBS	DST	5.6	Y	4.04
66	LC	LC3	OBS	WHL	8.0	Y	6.5
67	LC	LC3	OBS	MRG	3.1	Y	4.43
68	LC	LC3	OBS	MRG	1.3	Y	8.02
86	PJ	PJ5	OBS	WHL	11.8	Y	7.59
87	PJ	PJ5	OBS	WHL	27.7	Y	8.55

APPENDIX A.4. Simple Flake Analytical Data.

Catalogue Number	Zone	Unit	Mtrl.	Cond.	Wt.	Coll.	Avg. Hyd. Value
88	PJ	PJ5	OBS	WHL	22.2	Y	6.67
112	PJ	PJ22	OBS	WHL	67.8	Y	4.23
115	PJ	PJ23	OBS	NC	8.8	Y	7.53
124	DS	DS2	OBS	WHL	36.2	Y	8.03
126	DS	DS3	OBS	WHL	13.7	Y	6.03
128	DS	DS6	OBS	WHL	8.8	Y	4.7
136	DS	DS8	OBS	NC	7.1	Y	-
143	DS	DS14	OBS	END	7.3	Y	9.4
144	DS	DS14	OBS	WHL	13.6	Y	9.82
148	DS	DS18	OBS	-	9.5	Y	6.19
167	DS	DS30	OBS	WHL	13.8	Y	6.38
172	UD	UD22	OBS	WHL	-	N	-
174	UD	UD22	OBS	WHL	-	N	-
177	UD	UD22	OBS	WHL	-	N	-
178	UD	UD22	OBS	WHL	-	N	-
183	LC	LC3	OBS	MED	-	N	-
193	DS	DS24	OBS	NC	-	N	-
194	DS	DS24	OBS	WHL	-	N	-
195	UD	UD2	OBS	WHL	-	N	-
233	PJ	PJ5	OBS	MRG	-	N	-
247	PJ	PJ5	OBS	WHL	-	N	-
258	DS	DS7	OBS	WHL	-	N	-
260	DS	DS7	OBS	PRX	-	N	-
262	DS	DS7	OBS	WHL	-	N	-
264	DS	DS2	OBS	WHL	-	N	-
265	DS	DS2	OBS	NC	-	N	-
267	DS	DS3	OBS	NC	-	N	-
269	PJ	PJ23	OBS	MRG	-	N	-
271	LC	LC4	OBS	WHL	-	N	-
273	LC	LC10	OBS	NC	-	N	-
276	LC	LC10	OBS	WHL	-	N	-
283	UD	UD17	OBS	WHL	-	N	-
284	UD	UD17	OBS	WHL	-	N	-
290	DS	DS19	OBS	WHL	-	N	-

Note: Zone (DS - lower desert scrub, LC - lacustrine, PJ - pinyon-juniper, UD - upper desert scrub); Mtrl. - material (OBS - obsidian); Cond. - condition (DST - distal end fragment, END - indeterminate end fragment, MED - medial fragment, MRG - margin fragment, NC - nearly complete, PRX - proximal end fragment, WHL - whole); Wt. - weight in grams; Coll. - collected (Y/N - yes/no); Avg. Hyd. Value - average hydration value. All measurements are in mm, negative values denote incomplete measurements.

APPENDIX A.5. Core Analytical Data.

Catalogue Number	Zone	Unit	Cond.	Wt.	Coll.	ML	MW	MTH	Core Form	Core Type	No. of Plats.	Plat. Conf.	Plat Type	Flake Len.	Avg.Hyd. Value
21	PJ	UD5	MRG	28.9	Y	-48.2	-27.9	-25.8	9	4	1	4	2	36.0	7.64
22	PJ	UD5	END	89.2	Y	81.7	56.6	24.4	6	4	1	4	3	41.7	4.75
23	PJ	UD5	WHL	174.3	Y	98.8	60.3	33	6	4	1	4	3	46.8	-
24	PJ	UD5	WHL	151.9	Y	94.2	50.5	38.6	3	4	2	4/4	3/3	39.5/40.8	5.41
25	PJ	UD5	WHL	215.5	Y	105.9	72.1	33.9	6	1	1	1	3	44.5	6.49
26	PJ	UD5	WHL	280.5	Y	139.3	72	34.6	6	3	2	1/4	1/3	41.1/32.4	-
93	PJ	PJ5	WHL	183.6	Y	69.9	74.3	37.3	6	3	2	1/4	1/2	48.8/28.0	5.26
103	PJ	PJ8	WHL	66.8	Y	40.7	74.5	23.8	6	2	2	1/1	2/2	32.227.6	7.27
104	PJ	PJ8	WHL	470	Y	107.8	70.9	69.2	2	1	1	1	1	63.5	2.97
105	PJ	PJ8	END	63	Y	-70.7	-52.5	-20.5	6	4	1	4	2	34.3	3.54
110	PJ	PJ21	WHL	82.7	Y	43.1	53.9	35.1	10	1	1	1	2	40.0	-
171	UD	UD22	WHL	-	N	50.0	40.0	20.0	-	4	-	-	-	-	-
173	UD	UD22	WHL	-	N	85.0	45.0	45.0	-	1	-	-	-	-	-
179	UD	UD22	WHL	-	N	80.0	50.0	40.0	-	4	-	-	-	-	-
196	PJ	UD5	WHL	-	N	70.0	35.0	20.0	-	4	-	-	-	-	-
197	PJ	UD5	WHL	-	N	90.0	60.0	40.0	-	1	-	-	-	-	-
201	PJ	UD5	END	-	N	60.0	40.0	30.0	-	1	-	-	-	-	-
202	PJ	UD5	WHL	-	N	90.0	70.0	30.0	-	4	-	-	-	-	-
203	PJ	UD5	WHL	-	N	120.0	80.0	70.0	-	3	-	-	-	-	-
204	PJ	UD5	WHL	-	N	55.0	60.0	20.0	-	1	-	-	-	-	-
206	PJ	UD5	WHL	-	N	80.0	60.0	30.0	-	4	-	-	-	-	-
208	PJ	UD5	WHL	-	N	80.0	70.0	30.0	-	1	-	-	-	-	-
210	PJ	UD5	WHL	-	N	80.0	60.0	40.0	-	1	-	-	-	-	-
216	PJ	PJ2	NC	-	N	95.0	60.0	30.0	-	4	-	-	-	-	-
220	PJ	PJ2	MRG	-	N	120.0	30.0	30.0	-	4	-	-	-	-	-
221	PJ	PJ2	WHL	-	N	140.0	60.0	50.0	-	4	-	-	-	-	-
225	PJ	PJ2	WHL	-	N	130.0	80.0	35.0	-	4	-	-	-	-	-
226	PJ	PJ2	END	-	N	90.0	65.0	25.0	-	4	-	-	-	-	-
227	PJ	PJ2	NC	-	N	80.0	60.0	20.0	-	1	-	-	-	-	-
229	PJ	PJ5	WHL	-	N	90.0	70.0	45.0	-	4	-	-	-	-	-
234	PJ	PJ5	WHL	-	N	80.0	70.0	40.0	-	3	-	-	-	-	-
236	PJ	PJ5	NC	-	N	70.0	50.0	21.0	-	4	-	-	-	-	-
239	PJ	PJ5	END	-	N	59.0	81.0	37.0	-	4	-	-	-	-	-
248	PJ	PJ5	WHL	-	N	74.0	37.0	20.0	-	1	-	-	-	-	-
266	DS	DS8	WHL	-	N	60.0	77.0	30.0	-	4	-	-	-	-	-
279	PJ	PJ8	WHL	-	N	37.0	71.0	55.0	-	1	-	-	-	-	-
280	PJ	PJ8	WHL	-	N	75.0	69.0	43.0	-	3	-	-	-	-	-
286	DS	DS19	WHL	-	N	93.0	63.0	46.0	-	1	-	-	-	-	-
287	DS	DS19	WHL	-	N	94.0	63.0	46.0	-	4	-	-	-	-	-
288	DS	DS19	WHL	-	N	110.0	123.0	152.0	-	1	-	-	-	-	-

APPENDIX A.5. Core Analytical Data.

Catalogue Number	Zone	Unit	Cond.	Wt.	Coll.	ML	MW	MTH	Core Form	Core Type	No. of Plats.	Plat. Conf.	Plat Type	Flake Len.	Avg.Hyd. Value
289	DS	DS19	WHL	-	N	77.0	72.0	54.0	-	3	-	-	-	-	-
291	DS	DS19	WHL	-	N	87.0	67.0	60.0	-	4	-	-	-	-	-
292	DS	DS19	WHL	-	N	137.0	114.0	63.0	-	3	-	-	-	-	-

Note: Zone (DS - lower desert scrub, PJ - pinyon-juniper, UD - upper desert scrub); Cond. - condition (END - indeterminate end fragment, MRG - margin fragment, NC - nearly complete, WHL - whole); Wt. - weight in grams; ML - maximum length; MW - maximum width; MTH - maximum thickness; Core Form (2 - globular cobble, 3 - angular cobble, 6 - flake/core, 9 - indeterminate, 10 - globular pebble); Core Type (1 - unidirectional, 2 - bidirectional, 3 - multidirectional, 4 - bifacial); No. of Plats. - number of platforms; Platform Conf. - platform configuration (1 - unidirectional, 4 - bifacial); Platform Type (1 - cortical, 2 - interior, 4 - cortical and interior); Flake Len. - length of maximum flake removal scar; Avg, Hyd. Value - average hydration value. All measurements are in mm, negative values denote incomplete measurements.

APPENDIX A.6. Debitage Analytical Data.

Catalogue Number	No.	Size	Type	Wt.	Unit	Zone
8	1	2	4	0.3	UD2	UD
8	1	2	10	0.2	UD2	UD
8	1	3	8	2.0	UD2	UD
8	1	3	10	0.9	UD2	UD
8	1	5	7	7.9	UD2	UD
8	3	4	7	12.4	UD2	UD
18	1	4	10	4.7	UD4	UD
18	1	4	7	3.3	UD4	UD
18	2	2	10	1.1	UD4	UD
19	2	1	15	0.1	UD5	PJ
19	2	3	3	8.0	UD5	PJ
19	2	1	3	0.1	UD5	PJ
19	2	5	7	22.7	UD5	PJ
19	1	1	9	0.2	UD5	PJ
19	1	5	4	15.3	UD5	PJ
19	3	3	1	4.8	UD5	PJ
19	4	1	13	0.1	UD5	PJ
19	4	4	8	18.0	UD5	PJ
19	5	4	5	22.9	UD5	PJ
19	6	2	10	2.4	UD5	PJ
19	7	2	7	1.9	UD5	PJ
19	7	4	10	16.9	UD5	PJ
19	7	4	7	35.6	UD5	PJ
19	8	3	4	15.7	UD5	PJ
19	9	2	1	7.6	UD5	PJ
19	10	3	2	19.9	UD5	PJ
19	10	2	4	4.8	UD5	PJ
19	11	3	7	12.4	UD5	PJ
19	12	4	1	129.2	UD5	PJ
19	12	4	4	89.3	UD5	PJ
19	13	2	2	9.8	UD5	PJ
19	13	3	10	15.6	UD5	PJ
19	13	5	1	655.2	UD5	PJ
19	20	5	2	1124.6	UD5	PJ
19	29	4	2	219.4	UD5	PJ
36	1	2	7	0.2	UD8	UD
36	1	5	1	19.1	UD8	UD
36	1	4	8	3.8	UD8	UD
36	1	4	7	1.7	UD8	UD
36	1	3	10	1.3	UD8	UD
36	1	3	2	2.5	UD8	UD
36	2	4	4	6.8	UD8	UD
36	2	4	10	7.6	UD8	UD
36	2	3	4	4.0	UD8	UD
36	3	3	7	3.9	UD8	UD
37	1	5	2	21.1	UD10	UD
38	1	4	4	3.6	UD11	UD
45	1	3	2	2.4	UD17	UD
45	3	2	10	1.9	UD17	UD
45	3	3	4	5.3	UD17	UD
45	4	2	7	2.5	UD17	UD
45	4	3	10	4.1	UD17	UD
47	1	4	10	3.4	UD18	UD
47	2	4	7	9.9	UD18	UD
48	1	2	10	0.2	UD19	UD
49	2	3	7	1.6	UD21	UD
49	1	2	7	0.5	UD21	UD
54	2	4	2	6.9	UD22	UD
54	2	4	7	7.1	UD22	UD
54	2	3	2	3.9	UD22	UD

APPENDIX A.6. Debitage Analytical Data (continued).

Catalogue Number	No.	Size	Type	Wt.	Unit	Zone
54	2	2	7	1.1	UD22	UD
54	1	3	4	2.0	UD22	UD
54	1	5	4	36.2	UD22	UD
54	1	2	10	0.6	UD22	UD
54	1	5	2	29.1	UD22	UD
54	4	3	7	7.2	UD22	UD
56	1	2	10	0.2	UD26	UD
60	1	5	2	48.5	UD27	UD
60	1	2	2	1.6	UD27	UD
62	1	5	5	30.0	UD28	UD
64	1	4	10	4.0	UD33	UD
64	1	4	5	7.4	UD33	UD
64	1	2	10	0.4	UD33	UD
64	1	4	7	1.6	UD33	UD
64	1	5	4	5.9	UD33	UD
64	1	5	5	9.7	UD33	UD
64	3	3	4	5.0	UD33	UD
64	3	3	7	3.2	UD33	UD
64	3	2	2	1.8	UD33	UD
64	3	4	4	12.0	UD33	UD
64	4	3	10	3.2	UD33	UD
64	5	2	7	1.1	UD33	UD
69	2	2	10	0.8	LC3	LC
69	2	3	10	1.8	LC3	LC
69	2	3	4	5.3	LC3	LC
69	1	4	10	1.9	LC3	LC
69	1	5	10	15.4	LC3	LC
69	1	3	7	2.3	LC3	LC
69	1	4	2	2.5	LC3	LC
69	1	4	7	3.8	LC3	LC
69	1	2	7	0.4	LC3	LC
69	1	5	5	13.5	LC3	LC
69	1	4	4	3.4	LC3	LC
69	1	2	4	0.4	LC3	LC
73	1	4	5	5.9	LC4	LC
73	1	2	8	0.7	LC4	LC
74	1	4	10	2.8	LC4	LC
74	1	4	4	5.9	LC4	LC
74	1	3	7	1.4	LC4	LC
74	2	3	10	1.6	LC4	LC
74	2	3	8	2.5	LC4	LC
74	2	2	10	0.4	LC4	LC
74	2	2	8	0.9	LC4	LC
74	4	2	7	1.0	LC4	LC
76	1	4	7	7.1	LC5	LC
76	1	3	7	0.7	LC5	LC
76	1	4	10	2.3	LC5	LC
76	1	1	10	0.1	LC5	LC
76	3	3	10	2.7	LC5	LC
76	3	2	7	0.8	LC5	LC
77	2	2	10	0.1	LC10	LC
78	1	2	9	0.2	LC10	LC
79	1	4	8	1.8	LC10	LC
79	1	3	7	0.7	LC10	LC
79	2	3	10	1.0	LC10	LC
79	2	1	15	0.1	LC10	LC
79	3	2	10	0.6	LC10	LC
79	7	1	13	0.2	LC10	LC
79	14	2	7	2.3	LC10	LC
80	1	5	4	22.8	LC13	LC

APPENDIX A.6. Debitage Analytical Data (continued).

Catalogue Number	No.	Size	Type	Wt.	Unit	Zone
81	1	2	10	0.4	PJ2	PJ
81	1	3	2	1.8	PJ2	PJ
81	2	4	10	14.2	PJ2	PJ
81	2	3	7	2.3	PJ2	PJ
81	2	3	10	1.6	PJ2	PJ
81	2	5	1	37.7	PJ2	PJ
81	2	4	7	11.0	PJ2	PJ
81	2	4	6	6.0	PJ2	PJ
81	3	3	4	4.8	PJ2	PJ
81	3	4	2	18.8	PJ2	PJ
81	8	5	2	1061.1	PJ2	PJ
81	8	5	4	289.9	PJ2	PJ
85	1	5	7	11.1	PJ5	PJ
85	1	5	4	11.7	PJ5	PJ
85	1	5	5	38.3	PJ5	PJ
85	1	5	10	10.7	PJ5	PJ
85	2	1	12	0.1	PJ5	PJ
85	2	2	3	2.6	PJ5	PJ
85	2	3	3	3.3	PJ5	PJ
85	2	4	5	10.8	PJ5	PJ
85	3	5	2	62.5	PJ5	PJ
85	4	4	2	22.5	PJ5	PJ
85	4	4	8	16.7	PJ5	PJ
85	5	3	6	4.5	PJ5	PJ
85	7	2	12	0.6	PJ5	PJ
85	7	3	2	9.2	PJ5	PJ
85	8	2	2	6.0	PJ5	PJ
85	8	3	5	12.1	PJ5	PJ
85	9	3	8	9.3	PJ5	PJ
85	13	1	10	1.1	PJ5	PJ
85	17	4	4	73.2	PJ5	PJ
85	20	4	10	51.5	PJ5	PJ
85	22	3	4	25.6	PJ5	PJ
85	23	2	4	11.0	PJ5	PJ
85	25	4	7	81.0	PJ5	PJ
85	26	2	8	10.1	PJ5	PJ
85	28	1	15	0.8	PJ5	PJ
85	37	2	13	3.3	PJ5	PJ
85	52	1	13	2.5	PJ5	PJ
85	55	3	10	53.3	PJ5	PJ
85	71	3	7	80.8	PJ5	PJ
85	155	2	7	43.2	PJ5	PJ
85	187	2	10	42.7	PJ5	PJ
92	1	5	2	153.1	PJ5	PJ
99	1	4	2	4.3	PJ6	PJ
99	1	5	10	15.2	PJ6	PJ
99	1	4	10	2.1	PJ6	PJ
99	1	3	10	0.6	PJ6	PJ
99	1	3	2	1.2	PJ6	PJ
99	1	5	1	42.0	PJ6	PJ
99	1	3	7	1.4	PJ6	PJ
99	1	4	7	2.7	PJ6	PJ
102	1	5	5	11.6	PJ8	PJ
102	1	3	10	1.7	PJ8	PJ
102	1	3	7	1.0	PJ8	PJ
102	1	4	10	3.8	PJ8	PJ
102	1	4	6	3.1	PJ8	PJ
102	1	5	1	59.1	PJ8	PJ
102	1	3	1	2.3	PJ8	PJ

APPENDIX A.6. Debitage Analytical Data (continued).

Catalogue Number	No.	Size	Type	Wt.	Unit	Zone
102	1	4	1	1.2	PJ8	PJ
102	1	3	4	1.8	PJ8	PJ
102	1	2	7	0.3	PJ8	PJ
102	1	4	4	9.7	PJ8	PJ
102	2	5	2	64.3	PJ8	PJ
102	3	5	4	98.3	PJ8	PJ
102	5	4	2	43.4	PJ8	PJ
106	1	5	1	9.7	PJ12	PJ
106	1	2	4	0.7	PJ12	PJ
106	1	4	4	11.2	PJ12	PJ
107	1	4	7	1.3	PJ17	PJ
107	1	2	10	0.2	PJ17	PJ
108	1	5	4	7.4	PJ19	PJ
108	1	4	1	5.2	PJ19	PJ
108	1	2	2	0.6	PJ19	PJ
108	1	2	10	0.4	PJ19	PJ
108	1	2	13	0.1	PJ19	PJ
108	1	4	10	2.1	PJ19	PJ
108	2	3	8	2.5	PJ19	PJ
108	2	2	4	1.3	PJ19	PJ
108	2	3	10	4.1	PJ19	PJ
108	2	4	2	12.4	PJ19	PJ
108	3	3	2	6.5	PJ19	PJ
108	3	3	4	3.9	PJ19	PJ
108	3	4	7	16.2	PJ19	PJ
108	3	4	4	14.1	PJ19	PJ
108	5	3	7	5.0	PJ19	PJ
113	1	5	4	45.1	PJ22	PJ
114	1	4	2	10.5	PJ23	PJ
114	1	4	4	3.5	PJ23	PJ
114	1	5	7	12.9	PJ23	PJ
114	2	4	10	12.2	PJ23	PJ
114	2	3	7	1.8	PJ23	PJ
118	1	5	6	4.7	PJ30	PJ
121	1	2	4	0.7	PJ32	PJ
122	1	4	7	2.7	PJ33	PJ
122	2	4	4	9.5	PJ33	PJ
122	2	4	2	12.4	PJ33	PJ
123	1	4	1	13.5	DS1	DS
123	1	3	7	0.8	DS1	DS
123	1	4	10	7.6	DS1	DS
123	1	4	7	1.6	DS1	DS
123	1	4	4	3.3	DS1	DS
123	2	3	2	2.9	DS1	DS
123	2	2	4	1.4	DS1	DS
125	1	4	4	2.1	DS2	DS
125	1	3	4	1.8	DS2	DS
125	1	5	4	82.2	DS2	DS
125	1	4	6	2.4	DS2	DS
125	1	4	5	5.3	DS2	DS
125	2	3	7	2.0	DS2	DS
125	2	3	2	2.7	DS2	DS
125	2	4	2	16.4	DS2	DS
125	2	3	10	2.1	DS2	DS
125	3	4	7	11.7	DS2	DS
125	3	5	2	35.3	DS2	DS
127	1	5	7	10.1	DS3	DS
127	1	4	4	2.8	DS3	DS
127	2	2	7	0.8	DS3	DS

APPENDIX A.6. Debitage Analytical Data (continued).

Catalogue Number	No.	Size	Type	Wt.	Unit	Zone
127	2	3	7	1.7	DS3	DS
127	3	3	10	3.0	DS3	DS
129	1	2	10	0.8	DS6	DS
129	1	1	13	0.1	DS6	DS
129	2	2	7	0.6	DS6	DS
129	2	4	10	9.1	DS6	DS
129	3	3	7	4.4	DS6	DS
130	1	3	10	0.9	DS7	DS
130	1	4	2	8.4	DS7	DS
130	1	3	4	0.9	DS7	DS
130	2	2	7	0.6	DS7	DS
130	2	4	4	17.1	DS7	DS
130	2	4	1	16.9	DS7	DS
130	2	1	13	0.1	DS7	DS
130	2	2	1	0.6	DS7	DS
130	3	3	7	3.1	DS7	DS
130	4	3	2	9.6	DS7	DS
130	6	2	10	1.7	DS7	DS
137	1	4	2	3.7	DS8	DS
137	1	4	6	1.7	DS8	DS
137	1	3	4	3.4	DS8	DS
137	1	3	10	0.9	DS8	DS
137	1	4	4	3.3	DS8	DS
138	1	5	6	7.1	DS9	DS
138	1	5	2	14.2	DS9	DS
138	1	2	7	0.2	DS9	DS
138	1	5	4	31.4	DS9	DS
138	2	3	4	2.9	DS9	DS
138	2	4	10	5.0	DS9	DS
138	2	3	7	3.2	DS9	DS
138	2	4	2	8.9	DS9	DS
138	3	3	10	2.5	DS9	DS
138	3	4	1	9.9	DS9	DS
138	4	4	4	29.1	DS9	DS
138	7	4	7	21.3	DS9	DS
141	1	3	10	2.4	DS11	DS
141	1	4	7	3.0	DS11	DS
142	1	2	7	0.4	DS14	DS
142	1	2	10	0.6	DS14	DS
142	1	5	1	23.6	DS14	DS
142	1	3	4	4.1	DS14	DS
142	1	4	7	4.3	DS14	DS
142	2	4	10	5.5	DS14	DS
142	3	4	2	14.1	DS14	DS
145	1	3	4	1.8	DS17	DS
145	1	4	2	4.5	DS17	DS
145	1	4	7	2.7	DS17	DS
146	1	4	7	1.8	DS18	DS
146	1	3	4	1.3	DS18	DS
146	1	5	4	11.8	DS18	DS
146	1	4	8	2.9	DS18	DS
146	2	2	4	1.0	DS18	DS
146	2	2	13	0.2	DS18	DS
146	2	4	10	12.5	DS18	DS
146	2	1	10	0.2	DS18	DS
146	3	4	4	9.2	DS18	DS
146	4	3	10	2.3	DS18	DS
146	5	2	7	1.3	DS18	DS
146	5	3	7	4.9	DS18	DS

APPENDIX A.6. Debitage Analytical Data (continued).

Catalogue Number	No.	Size	Type	Wt.	Unit	Zone
146	10	2	10	3.7	DS18	DS
147	1	3	4	2.1	DS18	DS
150	1	3	4	2.2	DS18	DS
151	1	2	7	0.3	DS19	DS
151	1	5	2	78.1	DS19	DS
151	2	4	7	3.1	DS19	DS
151	3	4	10	15.1	DS19	DS
151	3	4	1	23.9	DS19	DS
151	3	3	2	5.4	DS19	DS
151	4	3	7	2.9	DS19	DS
151	4	3	4	5.8	DS19	DS
151	5	2	10	2.2	DS19	DS
151	5	3	10	6.2	DS19	DS
151	6	4	2	37.8	DS19	DS
151	7	4	4	42.2	DS19	DS
152	1	2	10	0.9	DS24	DS
152	1	4	2	2.8	DS24	DS
152	2	5	4	31.9	DS24	DS
152	3	4	7	23.8	DS24	DS
152	5	4	4	26.5	DS24	DS
156	1	2	7	0.5	DS25	DS
156	1	5	10	8.1	DS25	DS
156	1	4	10	2.3	DS25	DS
156	1	4	2	4.2	DS25	DS
156	1	5	7	7.8	DS25	DS
156	1	2	8	0.8	DS25	DS
156	2	4	7	7.2	DS25	DS
156	3	3	4	4.4	DS25	DS
156	3	2	4	1.0	DS25	DS
156	3	3	10	4.0	DS25	DS
156	3	2	10	0.7	DS25	DS
156	4	4	4	16.4	DS25	DS
156	5	3	7	5.2	DS25	DS
163	1	3	7	0.8	DS27	DS
163	1	5	2	32.3	DS27	DS
163	1	3	10	0.6	DS27	DS
163	1	3	4	2.1	DS27	DS
163	2	4	4	5.2	DS27	DS
163	2	4	2	6.5	DS27	DS
164	1	3	10	0.4	DS27	DS
164	1	4	7	1.0	DS27	DS
164	1	4	10	0.8	DS27	DS
164	2	4	2	6.4	DS27	DS
164	2	3	7	0.8	DS27	DS
166	1	5	7	11.8	DS29	DS
166	2	5	2	31.8	DS29	DS

Note: Size - flake size (1 [<1.0 cm in daimeter], 2 [1.0-2.0 cm in diameter], 3 [2.0-3.0 cm in diameter], 4 [3.0-5.0 cm in diameter], 5 [>5.0 cm in diameter]); Type - flake type (1 - primary decortication, 2 - secondary decortication, 3 - cortical shatter, 4 - simple interior percussion, 5 - complex interior percussion, 6 - linear interior percussion, 7 - early biface thinning, 8 - late biface thinning, 9 - angular percussion, 10 - percussion fragment, 12 - linear pressure, 13 - rounded pressure, 15 - indeterminate pressure); Wt. - weight in grams; Zone (DS - lower desert scrub, LC - lacustrine, PJ - pinyon-juniper, UD - upper desert scrub).

APPENDIX B
Plates of Selected Artifacts

PLATE B.1. Selected projectile points from project areas.

PLATE B:2. Selected bifaces from project areas.

PLATE B.3. Selected flake tools from project areas.

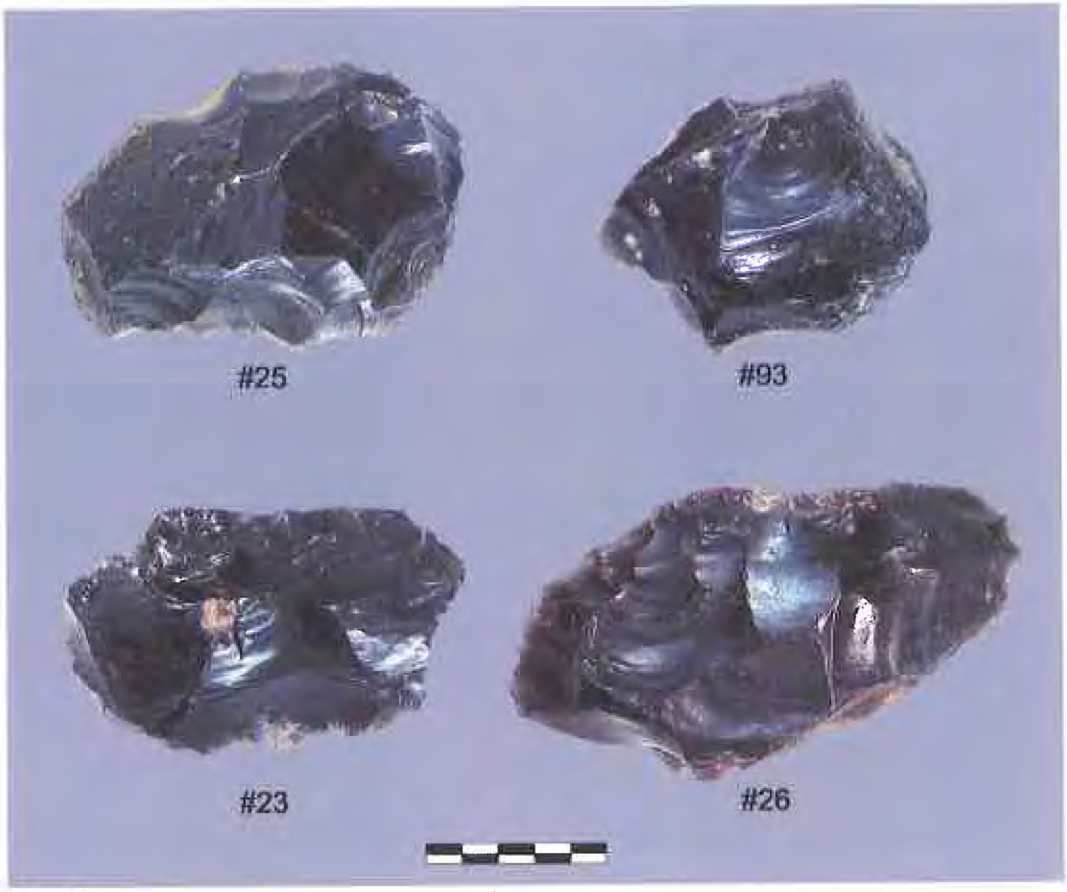


PLATE B.4. Selected cores from project areas.

APPENDIX C
Observation Unit UTM Locations

APPENDIX C. UTM Coordinates for Southwest Corner of 15 X 15 Meter Collection Units.

Unit Name	Easting	Northing	Unit Name	Easting	Northing
LC 3	346000	4238000	PJ 12	343000	4238000
LC 4	346500	4238000	PJ 16	343000	4237500
LC 5	347000	4238000	PJ 17	343500	4237500
LC 7	346500	4237500	PJ 19	344000	4237000
LC 10	346500	4237000	PJ 20	344500	4237000
LC 12	346500	4236500	PJ 21	341000	4236500
LC 13	347000	4236500	PJ 22	341500	4236500
DS 1	344500	4240000	PJ 23	343500	4236500
DS 2	345000	4240000	PJ 28	341000	4236000
DS 3	345500	4240000	PJ 30	343500	4236000
DS 5	346500	4240000	PJ 32	345500	4236000
DS 6	347000	4240000	PJ 33	343500	4237000
DS 7	344500	4239500	UD 1	341000	4240000
DS 8	345000	4239500	UD 2	341500	4240000
DS 9	345500	4239500	UD 4	342500	4240000
DS 11	346500	4239500	UD 5	343000	4240000
DS 14	345000	4239000	UD 8	342000	4239500
DS 17	346500	4239000	UD 10	341000	4239000
DS 18	347000	4239000	UD 11	341500	4239000
DS 19	344500	4238500	UD 16	342000	4238500
DS 24	345500	4238000	UD 18	341000	4238000
DS 25	344500	4237500	UD 19	341500	4238000
DS 27	345500	4237500	UD 20	342000	4238000
DS 29	345500	4237000	UD 21	342500	4238000
DS 30	346000	4236500	UD 22	341000	4237500
PJ 2	344000	4240000	UD 26	341000	4237000
PJ 5	344000	4239500	UD 27	341500	4237000
PJ 6	343000	4239000	UD 28	342000	4237000
PJ 8	344000	4239000	UD 31	342000	4236500
PJ 10	343500	4238500	UD 33	343000	4236500

REFERENCES CITED

Andrefsky, W.

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

Arkush, B. S.

1995 *The Archaeology of CA-MNO-2122: A Study of Pre-Contact and Post-Contact Lifeways Among the Mono Basin Paiute.* Anthropological Records Vol. 31. University of California Press, Berkeley.

Bamforth, D. B.

1990 Technological Efficiency and Tool Curation. *American Antiquity* 51(1):38-50.

1991 Technological Organization and Hunter-Gatherer Land Use: A California Example. *American Antiquity* 56(2): 216-234.

Bamforth, D. B., and M. S. Becker

2000 Core/Biface Ratios, Mobility, Refitting, and Artifact Use-Lives: A Paleoindian Example. *Plains Anthropologist* 45(173): 273-290.

Basgall, M. E.

1987 Resource Intensification Among Hunter-Gatherers: Acorn Economies in Prehistoric California. *Research in Economic Anthropology* 9: 21-52.

1988 The Archaeology of CA-MNO-679: A Pre-Archaic Site in Long Valley Caldera, Mono County, California. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface.* J.A. Willig, C.M. Aikens, and J.L. Fagan, eds., pp. 103-119. Nevada State Museum Papers Number 21.

1989 Obsidian Acquisition and Use in Prehistoric Central-Eastern California: A Preliminary Assessment. In *Current Directions in California Obsidian Studies,* R.E. Hughes, ed. University of California Archaeological Research Facility Contributions 48: 111-126.

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

1993 Pre-Newberry Period. In *Report of Archaeological Test Evaluations at 23 Sites in Owens Valley, California,* by M.G. Delacorte and K.R. McGuire, pp. 273-278. Report on file, Contel of California Inc., and the Department of the Interior, Bureau of Land Management, California Desert District.

1998 *Phase II Evaluation of Archeological Site CA-MNO-1977, on the Little Walker River, Mono County California.* Report submitted to California Department of Transportation District 06, Fresno.

2000 *Phase II Excavation Plan for Eight Archaeological Sites Along Route 395, Inyo County, California.* Report submitted to the California Department of Transportation, Fresno.

2002 Chronometrics. In *Results of Phase II Investigations at 26 Archaeological Sites for the Aberdeen-Blackrock Four-Lane Project on Highway 395, Inyo County, California.* D. W. Zeanah and A. T. Leigh. Report prepared for Caltrans, Central California Cultural Resources Branch, Fresno.

Basgall, M. E., K. R. Bethard, and J. E. Martinez

2005 *Archaeological Assessment of 15 Prehistoric Sites in the Gypsum Ridge and Quackenbush lake Training Areas, Marine Corps Air Ground Combat Center, Twentynine Palms, California.* Report on file, Marine Corps Air Ground Combat Center, Twentynine Palms, California.

Basgall, M. E., and M. G. Delacorte

2003 *Phase II Evaluations at Nine Archeological Sites Near Independence, Inyo County, California.* Report submitted to the California Department of Transportation, Fresno.

Basgall, M. E., M. G. Delacorte, and M. C. Hall

1995 Fish Slough Side-notched Projectile Points: An Early Holocene Time Marker in the Western Great Basin. *Current Research in the Pleistocene* 12: 1-4.

Basgall, M. E., M. G. Delacorte, and D. W. Zeanah

2003 *An Archaeological Evaluation of Five Prehistoric Sites Near Bishop, Inyo County, California.* Report submitted to California Department of Transportation, Fresno.

Basgall, M. E., and M. A. Giambastiani
1995 *Prehistoric Use of a Marginal Environment: Continuity and Change in Occupation of the Volcanic Tablelands, Mono and Inyo Counties, California.* Center for Archaeological Research at Davis Publication Number 12.

Basgall, M. E., and M. C. Hall
2000 Morphological and Temporal Variation in Bifurcate-Stemmed Dart Points of the Western Great Basin. *Journal of California and Great Basin Anthropology* 2: 237-276.

Basgall, M.E., and K.R. McGuire
1988 *The Archaeology of CA-INY-30: Prehistoric Culture Change in the Southern Owens Valley, California.* Report on file, California Department of Transportation, Bishop.

Beck, C., and G. T. Jones
1989 Western Pluvial Lakes Tradition Occupation in Butte Valley, Eastern Nevada. In *Early Human Occupation in Far Western North American: The Clovis-Archaic Interface.* J.A. Willig, C.M. Aikens, and J.L. Fagan, eds., pp. 273-302. Nevada State Museum Papers Number 21.

1990 Toolstone Selection and Lithic Technology in Early Great Basin Prehistory. *Journal of Field Archaeology* 17: 283-299.

Bethard, K. R., M. E. Basgall, and J. E. Martinez
2005 *Archaeological Assessment of Six Prehistoric Quarry/Workshop Locations in the Gays Pass Training Area, Marine Corps Air Ground Combat Center, Twentynine Palms, California.* Document prepared for United States Marine Corps, Marine Corps Air Ground Combat Center, Twentynine Palms, California.

Bettinger, R. L.
1977 Aboriginal Human Ecology in Owens Valley, Eastern California: Prehistoric Change in the Great Basin. *American Antiquity* 43: 3-17.

1982a *Archaeology East of the Range of Light: Aboriginal Human Ecology of the Inyo-Mono Region, California.* Monographs in California and Great Basin Anthropology Number 1.

1982b Aboriginal Exchange and Territoriality in Owens Valley, California. In *Contexts for Prehistoric Exchange.* J.E. Ericson and T.K. Earle , eds., pp. 103-127. Academic Press, New York.

1990 *The Archaeology of Pinyon House, Two Eagles, and Crater Middens: Three Residential Sites in Owens Valley, Eastern California.* Anthropological Papers of the American Museum of Natural History, Number 67, New York.

1991 Aboriginal Occupation at High Altitude: Alpine Villages in the White Mountain of Eastern California. *American Anthropologist* 93: 656-679.

1999 From Traveler to Processor: Regional Trajectories of Hunter-Gatherer Sedentism in the Inyo-Mono Region, California. In *Fifty Years Since Viru: Theoretical Advances and Contributions of Settlement Pattern Studies in the Americas.* B.R. Billman and G.M. Feinman, eds. Smithsonian Institution, Washington, D.C.

Bettinger, R. L., and M. A. Baumhoff

1982 The Numic Spread: Great Basin Cultures in Competition. *American Antiquity* 47: 485-503.

1983 Return Rates and Intensity of Resource Use in Numic and Prenumic Adaptive Strategies. *American Antiquity* 48(4): 830-834.

Bettinger, R. L., and R. E. Taylor

1974 Suggested Revisions in Archaeological Sequences of the Great Basin and Interior Southern California. *Nevada Archaeological Survey Research Paper* 5:1-26.

Bieling, D. G.

1983 *Perspectives on Behavior Gained from Lithic Analysis and Archaeological Investigations Near Bridgeport, Mono County, California.* Masters thesis submitted to California State University, Sonoma.

Billings, W. D.

1951 Vegetational Zonation in the Great Basin of Western North America. In Les Basis Ecologiques de la Reservation de la Vegetation des Zones Andes. *Union of International Society of Biology* 9: 101-122, Series 5. Paris.

Binford, L. R.

1979 Organizational and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Reserch* 35: 255-273.

1980 Willow Smoke and Dog's Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45: 4-20.

Bleed, P.
1986 The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity* 51(4): 737-747.

Bouey, P. D., and M. E. Basgall
1984 Trans-Sierran Exchange in Prehistoric California: The Concept of Economic Articulation. In *Obsidian Studies in the Great Basin.* R.E. Hughes, ed. University of California Archaeological Research Facility Contributions 45: 135-172.

Bousman, C. B.
1993 Hunter-Gatherer Adaptations, Economic Risk, and Tool Design. *Lithic Technology* 18:59-86.

Brady, R. T.
2007 *Prehistoric Wetland Use in the Mono Lake Basin, Eastern California.* Master's thesis submitted to California State University, Sacramento.

Brantingham, P. J., and J. W. Olsen
2000 Raw Material and Prepared Core Technologies in Northeast Asia. *Journal of Archaeological Science* 27: 255-271.

Cole, K.
1983 Late Pleistocene Vegetation of Kings Canyon, Sierra Nevada, California. *Quaternary Research* 19:117-129.

Davis, E. L.
1964 The Desert Culture of the Western Great Basin: A Lifeway of Seasonal Transhumance. *American Antiquity* 29(2): 202-212.

Delacorte, M. G.
1990 *The Prehistory of Deep Springs Valley, Eastern California.: Adaptive Variation in the Western Great Basin.* Unpublished Ph.D dissertation, Department of Anthropology, University of California, Davis.

1997 *Culture Change Along the Eastern Sierra Nevada/Cascade Front: Volume VII. Pah Rah Uplands.* Report submitted to the Tuscarora Gas Transmission Company, Reno.

1999 *Changing Role of Riverine Environments in the Prehistory of the Central-Western Great Basin: Data Recovery Excavations at Six Prehistoric Sites in Owens Valley, California.* Report submitted to California Department of Transportation District 9, Bishop.

Delacorte, M. G., M. C. Hall, and M. E. Basgall
1995 *Final Report on the Evaluation of Twelve Archaeological Sites in the Southern Owens Valley, Inyo County, California.* Report on file, California Department of Transportation, District 9, Bishop.

Delacorte, M. G., and K. R. McGuire
1993 *Report of Archaeological Test Evaluations at 23 Sites in Owens Valley, California.* Report on file, Contel of California Inc., and the Department of the Interior, Bureau of Land Management, California Desert District.

Dunnell, R. C.
1992 The Notion Site. In *Space, Time, and Archaeological Landscapes.* J. Rossignol and L. Wandsnider, eds., pp. 21-41. Plenum Press, New York.

Dunnell, R. C., and W. S. Dancey
1983 The Siteless Survey: A Regional Scale Data Collection Strategy. In *Advances in Archaeological Method and Theory, vol. 6.* M.B. Schiffer, ed., pp. 267-287. Academic Press, Tucson.

Ebert, J.
1992 *Distributional Archaeology.* University of New Mexico Press, Albuquerque.

Elston, R. G.
1982 Good Times, Hard Times: Prehistoric Culture Change in the Western Great Basin. In *Man and Environment in the Great Basin.* D.B. Madsen and J.F. O'Connell, eds., pp. 186-206. Society for American Archaeology Papers 2.

1986 Prehistory of the Western Region. In *Handbook of North American Indians, Volume 11: Great Basin.* W. d'Azevedo, ed., pp. 195-205. Smithsonian Institution, Washington, D.C.

1992 Economics and Strategies of Lithic Production at Tosawihi. In *Archaeological Investigations at Tosawihi, A Great Basin Quarry.* R.E. Raven, ed., pp. 775-802. Intermountain Research. Silver City, NV.

Ericson, J. E.
1975 New Results in Obsidian Hydration Dating. *World Archaeology* 7(2): 151-159.

1978 Obsidian Hydration Dating in California. *Society for California Archaeology, Occasional Papers in Method and Theory* 2:45-52.

1984 Toward the Analysis of Lithic Production Systems. In *Contexts for Prehistoric Exchange.* J.E. Ericson and B.A. Purdy, eds., pp. 1-9. Cambridge University Press. Cambridge.

Foley, R.
1981 A Model of Regional Archaeological Structure. *Proceedings of the Prehistoric Society* 47:1-17.

Fowler, C.
1982 Settlement Patterns and Subsistence Systems in the Great Basin: The Ethnographic Record. In *Man and Environment in the Great Basin.* edited by D. B. Madsen and J. F. O'Connell, pp. 121-138. Society for American Archaeology Papers No. 2.

1992 *In the Shadow of Fox Peak: An Ethnography of the Cattail Eater Northern Paiute People at Stillwater Marsh.* U.S. Department of the Interior, Fish and Wildlife Service (Region 1), Cultural Resources Series 5. U.S. Government Printing Office, Washington, D.C.

Fowler, C., and S. Liljeblad
1986 Northern Paiute. In *Handbook of North American Indians, Vol. 11, Great Basin.* W. d' Azevedo, ed., pp. 435-465. Smithsonian Institution, Washington, D.C.

Giambastiani, M. A., and M. E. Basgall
1999 *An Evaluation of Eighteen Archaeological Sites at Wood Canyon, Quackenbush Lake Training Area, Marine Corps Air ground Combat Center, Twentynine Palms, California.* Report on file, Marine Corps Air Ground Combat Center, Twentynine Palms, California.

Gilreath, A. J., and W. R. Hildebrandt
1990 Prehistoric Human Occupation of the Coso Volcanic Field, Inyo County, California. Paper presented at the Annual Meeting of the Society for American Archaeology, Las Vegas.

1997 *Prehistoric Use of the Coso Volcanic Fields.* Contributions of the University of California Archaeological Research Facility Number 56.

Gramly, R.
1980 Raw Materials, Source Areas, and "Curated" Tool Assemblages. *American Antiquity* 45: 823-833.

Grayson, D. K.
1982 Toward a History of Great Basin Mammals During the Past 15,000 Years. In *Man and Environment in the Great Basin,* edited by D. B. Madsen and J. F. O'Connell, pp. 82-101. SAA Papers No. 2. Society for American Archaeology, Washington D.C.

1993 *The Desert's Past.* Smithsonian Institution Press, Washington D.C. and London.

Halford, F. K.
1998 *Archaeology and Environment on the Dry Lakes Plateau, Bodie Hills, California: Hunter-Gatherer Coping Strategies for Holocene Environmental Variability.* Master's Thesis submitted to University of Nevada, Reno.

Hall, C. A.
1991 *Natural History of the White-Inyo Range, Eastern California.* C. A. Hall, editor. University of California Press. Berkeley.

Hall, M. C.
1982 *Late Holocene Hunter-Gatherers and Volcanism in the Long Valley-Mono Basin Region: Prehistoric Culture Change in the Eastern Sierra Nevada.* PhD. dissertation submitted to University of California, Riverside.

1983 *Late Holocene Hunter-gatherers and Volcanism in the Long Valley-Mono Basin Region: Prehistoric Culture Change in the Eastern Sierra Nevada.* Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Riverside.

1984 Obsidian, Paleoeconomy, and Volcanism in the Eastern Sierra Nevada. Paper presented at the Biennial Meeting of the Great Basin Anthropological Conference, Boise, Idaho.

1990 *The OXBOW Archaeological Incident: Investigations at Twenty-three Locations Between Owens Valley, Eastern California, and Walker Basin, Southwestern Nevada.* Report on file, Oxbow Geothermal Company, Reno, Nevada.

Hall, M. C., and R. Jackson
1989 Obsidian Hydration Rates in California. In *Current Directions in California Obsidian Studies.* R.E. Hughes, ed., pp. 31-58. Contributions of the University of California Archaeological Research Facility 48. University of California, Berkeley.

Harrington, M. R.
1957 A Pinto Site at Little Lake. *Southwestern Museum Papers* 17. Los Angeles.

Hughes, R. E.
1984 Obsidian Sourcing Studies in the Great Basin: Problems and Prospects. In *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 1-19. Contributions of the University of California Archaeological Research Facility No. 45.

Jackson, R. J.
1984 Obsidian Hydration: Applications in the Western Great Basin. In Obsidian Studies in the Great Basin, edited by R. E. Hughes, pp. 173-192. *University of California Archaeological Research Facility Contributions* No. 45.

1985 *An Archaeological Survey of the Wet, Antelope, Railroad, and Ford Timber Sale Compartments in the Inyo National Forest.* Report submitted to U.S. Forest Service, Inyo National Forest, Bishop.

Jackson, T. L.
1988 Amending Models of Trans-Sierran Obsidian Tool Production and Exchange. *Journal of California and Great Basin Anthropology* 10(1): 62-72.

Jennings, J. A., and D. L. Elliott-Fisk
1993 Packrat Midden Evidence of Late Quaternary Vegetation Change in the White Mountains, California-Nevada. *Quaternary Research* 39: 214-221.

Jurich, D. M.
2003 Flaked Stone Assemblage. In *Phase II Evaluations at Nine Archaeological Sites Near Independence, Inyo County, California.* By M.E. Bsgall and M.G. Delacorte, pp. 165-193. Report submitted to the California Department of Transportation, Fresno.

Kelly, R. L.
1985 *Hunter-Gatherer Mobility and Sedentism: A Great Basin Study.* Unpublished Ph.D. dissertation, Department of Anthropology, University of Michigan.

1988 The Three Sides of a Biface. *American Antiquity* 53: 717-734

Kelly, R. L., and L. Todd

1988 Coming into the Country: Early Paleoindian Hunting and Mobility. *American Antiquity* 53: 717-734.

Koehler, P. A., and R. S. Anderson

1995 Thirty Thousand Years of Vegetation Change in the Alabama Hills, Owens Valley, California. *Quaternary Research* 43: 238-248.

Kuhn, S. L.

1992 On Planning and Curated Technologies in the Middle Paleolithic. *Journal of Anthropological Research* 48(3): 185-213.

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

Lanner, R. M.

1981 *The Pinyon Pine: a Natural and Cultural History.* University of Nevada Press, Reno.

Lanner, R. M., and T. R.Van Devender

1998 Pinyon pines in the American Southwest. *In Ecology and Biogeography of Pinus*. D.M. Richardson, ed., pp. 171-182. Cambridge University Press. Cambridge.

Lindstrom, S.

1990 Submerged Tree Stumps as Indicators of Mid-Holocene Aridity in the Lake Tahoe Region. *Journal of California and Great Basin Anthropology* 12 (2): 146-157.

Madsen, D. B., and J. F. O'Connell (editors)

1982 Man and Environment in the Great Basin. *Society for American Archaeology Papers* 2.

Mehringer, P. J.

1985 Late-Quaternary Pollen Records from the Interior Pacific Northwest and Northern Great Basin of the United States. In *Pollen Records of Late-Quaternary North American Sediments.* V.M. Bryant and R.G. Jolloway, eds., pp. 167-190. American Association of Stratigraphic Palynologist.

1986 Past Environments. In *Great Basin,* edited by W. L. d'Azevedo, pp. 412-434. Handbook of North American Indians, vol. 11, W. C. Sturtevant, general editor. Smithsonian Institution, Washington D. C.

Meighan, C. W.
1955 Notes on the Archaeology of Mono County, California. *University of California Archaeological Survey Report* 28: 6-29.

Miflin, M. D., and M. M. Wheat
1979 Pluvial Lakes and Estimated Pluvial Climates of Nevada. *Nevada Bureau of Mines and Geology Bulletin* 94.

Milliken, R., and W. R. Hildebrandt
1997 *Culture Change Along the Eastern Sierra Nevada/Cascade Front, Volume V: Honey Lake Basin.* Report submitted to Tuscarora Gas Transmission Company.

Morrow
1996 Bigger is Better: Comments on Kuhn's Formal Approach to Mobile Tool Kits. *American Antiquity* 61: 581-590.

Nelson, M. C.
1991 The Study of Technological Organization. In *Archaeological Method and Theory, vol. 3.* M.B. Schiffer, ed., pp. 57-100. University of Arizona Press, Tucson.

Parry, W. J., and R. L. Kelly
1987 Expedient Core Technology and Sedentism. In *The Organization of core Technology.* C.A. Morrow, ed., pp. 285-304. Westview Press, Boulder.

Pierce, W.
2004 *The Organization of Prehistoric Technology in the Owens Valley and Adjacent Areas.* Unpublished Master's thesis, Department of Anthropology, California State University, Sacramento.

Powell, D. R., and H. E. Klieforth
1992 Weather and Climate. In *Natural History of the White-Inyo Range, Eastern California.* C.A. Hall, ed., pp.3-26. University of California Press, Berkeley.

Ramos, B. A.
2000 *Prehistoric Obsidian Quarry Use and Technological Change in the Western Great Basin: Examining Lithic Procurement at the Truman/Queen Obsidian Source, California and Nevada.* Ph.D dissertation submitted Department of Anthropology, University of California, Davis.

Raven, C., and R. G. Elston, (eds.)
1989 *Prehistoric Human Geography in the Carson Desert, Part I: A Predictive Model of Land-Use in the Stillwater Wildlife Management Area.* Prepared for U.S. Fish and Wildlife Service, Portland, Oregon.

Rickliss, R. A., and K. A. Cox
1993 Examining Lithic Technological Organization as a Dynamic Subsystem: The Advantages of an Explicitly Spatial Approach. *American Antiquity* 58(3): 444-461.

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

Ryser, F.
1985 *Birds of the Great Basin: A Natural History.* University of Nevada Press, Reno.

Shott, M. J.
1986 Technological Organization and Settlement Mobility: An Ethnographic Examination. *Journal of Anthropological Research* 42(1): 15-51.

1996 An Exegesis of the Curation Concept. *Journal of Anthropological Research* 52(3): 259-280.

Simms, S. R.
1983 Comments on Bettinger and Baumhoff's Explanation of the "Numic Spread" in the Great Basin. *American Antiquity* vol. 48 (4): 825-830.

Singer, C., and J. E. Ericson
1977 Quarry Analysis at Bodie Hills, Mono County California: A Case Study. In *Exchange Systems in Prehistory.* T.K. Earle and J.E. Ericson, eds., pp. 171-190. Academic Press, New York.

Smith, E. A., and B. Winterhalder
1992 Evolutionary Ecology and Human Behavior. Aldine De Gruyter, New York.

Smith, G.
2000 *Sierra East.* University of California Press, Berkeley.

Steward, J. H.

1933 Ethnography of the Owens Valley Paiute. *University of California Publications in American Archaeology and Ethnology* vol. 33(3): 233-338.

1938 Basin-Plateau Aboriginal Sociopolitical Groups. *Smithsonian Institution Bureau of American Ethnology Bulletin* 120. United States Government Printing Office, Washington, D.C.

Stine, S.

1987 *Mono Lake: The Last 4,000 Years.* Ph.D. dissertation, University of California, Berkeley. University Microfilms, Ann Arbor.

1990 Late Holocene Fluctuation of Mono Lake, Eastern California. *Palaeogeography, Palaeoclimatology, Palaeoecology* 78: 333-381.

Thomas, D. H.

1973 An Empirical Test for Steward's Model of Great Basin Settlement Patterns. *American Antiquity* 38: 155-176.

1975 Nonsite Sampling in Archeology: Up the Creek Without a Site? In *Sampling in Archaeology.* G.W. Mueller, ed., pp. 61-81. University of California Press, Tucson.

1981 How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Archaeology* 3: 7-43.

1983 Exploring Variability in the Protohistoric Great Basin. In *The Archaeology of Monitor Valley 1. Epistemology*, pp. 24-39. Anthropological Papers of American Museum of Natural History 58: 1. American Museum of Natural History, New York.

1985 *The Archaeology of Hidden Cave.* Anthropological Papers of the American Museum of Natural History, Vol. 61, Part 1. New York.

USDA

1991 *Soil Survey of Mineral County Area, Nevada.* United States Government Printing Office. Washington, D.C.

Willig, J. A., and C. M. Aikens

1988 The Clovis-Archaic Interface in Far Western North America. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface.* J.A. Willig, C.M. Aikens, and J.L. Fagan, eds., pp. 1-40. Nevada State Museum Papers Number 21.

Wood, C. A., and A. Kienle
1990 *Volcanoes of North America: United States and Canada*. Cambridge University Press. Cambridge.

Zeanah, D. W., and A. T. Leigh
2002 *Final Report on Phase II Investigations at 26 Archaeological Sites for the Aberdeen-Blackrock Four-Lane Project on Highway 395, Inyo County, California.* Report on file at the California Department of Transportation, Fresno.