PREHISTORIC REDUCTION AND CURATION OF TOPAZ MOUNTAIN, UTAH, OBSIDIAN: A TECHNOLOGICAL ANALYSIS OF TWO LITHIC SCATTERS

By

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A thesis submitted in partial fulfillment of
the requirements for the degree of

MASTER OF ARTS

WASHINGTON STATE UNIVERSITY
Department of Anthropology

1984

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ABSTRACT

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Washington State University, 1984

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In this study I discuss the technology of manufacture of flaked stone artifacts from two small lithic scatters, the Ni-rak and Strandline sites, in west central Utah. The sites consist solely of flaked Topaz Mountain obsidian, which also occurs as a lag deposit in the immediate vicinity of each site. The mobile hunter gatherers who occupied this region of the Great Basin must have transported the obsidian if they desired to use the material beyond the limits of its natural occurrence. A model is presented that describes the role of transportation and curation in lithic reduction and stone tool manufacturing technologies.

A method to help determine whether a site contains single or multiple occupations based on obsidian hydration measurements is described. The utility of the method is demonstrated with 10 radiocarbon associated samples of obsidian hydration measurements from California archaeological sites. The method is then applied to the undated Ni-rak and Strandline sites, indicating that the sites were not the result of multiple occupations. This determination

is important for a correct understanding of the technological behavior represented by the lithic artifacts at the two sites.

The technology of pebble core reduction and flake manufacture at the Ni-rak and Strandline sites is demonstrated with controlled replication experiments. Comparison of the archaeological and replicated collections indicates that many flakes are missing from the two sites. I argue that some flakes were transported out of the sites. I conclude this study with a discussion of prehistoric transportation and curation of tool stone with regard to hunter-gatherer mobility.

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CHAPTER 1

INTRODUCTION

Mobile hunter gatherers of the Great Basin, relied on scattered and seasonally abundant resources. Water, plant and animal foods, sleeping space, and raw materials rarely exist on the landscape so that their procurement and use occurs within the same location. Consequently, people hunted, gathered, and processed food and other materials in a sequence of different settlement locations (Steward 1938). Such an adaption required that acquisition and processing of some resources would occur at one location before transportation of the material to another location for further processing and use.

In west-central Utah, Topaz Mountain obsidian is a common, yet essential tool stone that was transported beyond the frontiers of its natural occurrence. A stone tool manufacturing technology that includes transportation tool stone is different from a technology that includes acquisition of raw material, and the manufacture, use, and discard of tools entirely within a single settlement. Debitage, the primary product of stone tool manufacture and use, can reflect the role of transportation in the lithic technology at an archaeological site. Through analysis of debitage, and replication of the aboriginal lithic reduction technology, this paper will demonstrate the role of tool stone transportation in the lithic technology at two archaeological sites occuring within the boundaries of the Topaz Mountain obsidian source.

In chapter 2, I discuss how Binford's (1979) model of "curation" and "expediency" can be employed to describe the role of transportation in lithic technology. I combine Binford's concepts with the process of flaked stone tool manufacture as developed primarily by Flenniken (1981). The chapter outlines how the debitage can reflect the role of transportation in the lithic technology at an archaeological site.

In chapter 3, I describe the two archaeological sites, the Ni-rak and Strandline sites, which occur as small lithic scatters in the Great Basin of west-central Utah (Figure 1). The chapter includes a discussion of the formation and distribution of Topaz Mountain obsidian that dominates each site assemblage. The chapter also provides past and current environmental information, as well as a brief sketch of the culture-history of the study area.

In chapter 4, I examine the results of analysis for obsidian hydration. Hydration measurements from 20 artifacts from the two sites were used to assess whether the sites contained one or multiple occupations.

Chapter 5 presents a technological analysis of flaked stone artifacts from the Strandline and Ni-rak sites. The analysis relies on replication of the aboriginal lithic reduction technology as represented by the archaeological

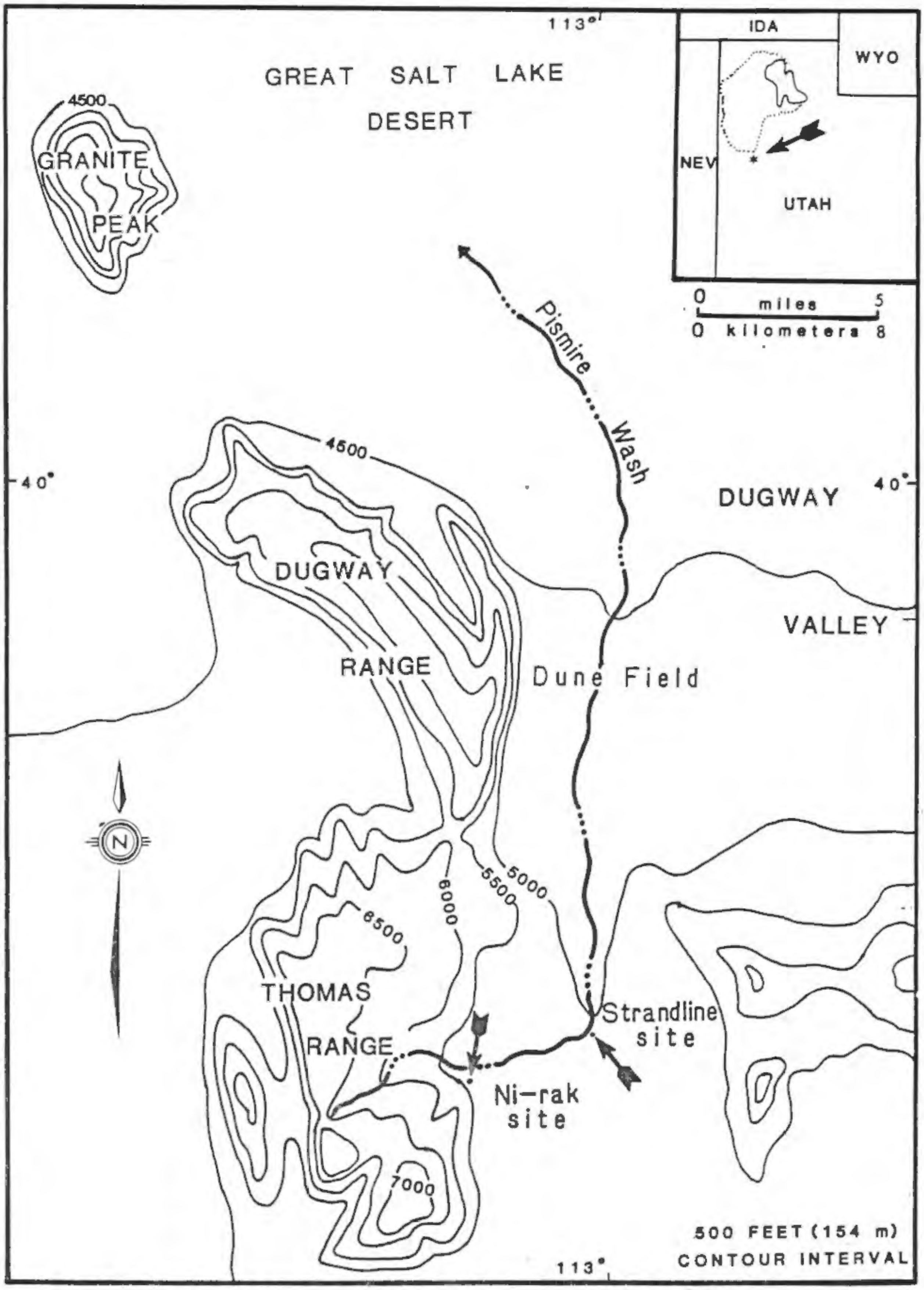


Fig. 1.--Location of the Ni-rak and Strandline sites.

collections. Replicative analysis provides answers to three questions regarding the technological behavior at each site. 1) What was the size and shape of the lithic material imported to the site before reduction commenced? 2) What reduction technology or technologies was applied to the tool stone? 3) Were any of the products of the lithic reduction technology transported out of the sites by the aboriginal inhabitants? Answers to these questions help to determine the role of transportation in the aboriginal stone tool manufacturing technology at the Ni-rak and Strandline sites. Chapter 6 concludes the study with a discussion of the results in light of other research on hunter-gatherer subsistence and mobility in the Great Basin.

CHAPTER 2

THE APPROACH

Lithic technology refers to the science of "systematic knowledge of forming stone into useful cutting, chopping and other functional implements" (Crabtree 1972:2). Lithic technology comprises two factors, the method and technique. The method refers to the mental process of stone reduction based on rules, mechanics, order, and procedure. Technique represents the application of methods to reduce a stone. The products of a lithic technology are tangible objects such as tools, cores, flakes and debitage. Among flaked stone tool users, the order and procedure of this body of knowledge (method) and its application (technique) will be altered according to the intended role of the prospective products. At a single archaeological site a lithic reduction process that results in items for transportation is different from a reduction process where items are manufactured, used and discarded at one location.

From his study of the mobile hunting and gathering Nunamiut Eskimo, Binford (1979) has observed how material items, and the techniques that produced them, will reflect the degree to which these artifacts will be transported and maintained. He developed the concept of curated and expedient technologies to illustrate this (Binford 1973, 1979).

Curated items incorporate elements of planning for future need, and are therefore designed with the intent of transportation and long term usage. Among mobile hunter-gatherers, curated items might compose an individual's "personal gear" which will be transported over long distances and maintained over a long time. A hunter-gatherer will invest relatively large amounts of time in manufacture and maintenance of curated tools (Binford 1979:263). Examples of curated stone artifacts might include hafted tools such as knives, projectile points and drills, cores from which flakes for tools could be derived, and blanks from which finished tools could be manufactured.

Expedient tools are produced and drafted into use for the purpose of carrying out a specific activity in response to specific conditions. Such items are expediently manufactured with respect to raw material type and availability. In other words, expedient tools are manufactured on the spot with materials immediately available, in response to short term needs (e.g., Flenniken 1981).

Examples of expedient tools include simple lithic flakes, derived from sources in the immediate environment when the situation demands. Expedient flake tools may also derive from curated cores maintained for the production of flakes and transported to the locus of use (Binford 1979: 266).

The manufacture and use of expedient tools and curated tools invoke different technological processes. An expedient technology comprises methods and techniques that produces, uses and discards tools at one location. A curated technology comprises methods (knowledge of rules, mechanics, and procedure) and techniques (application of methods) that result in items that will be maintained, transported, and altered over space and time. This differential organization of technology will result in differences in the composition of the debitage, and thus can be observed through a technologically oriented lithic analysis.

Curated and Expedient Lithic Technologies

As the residual material resulting from tool manufacture, debitage left at an archaeological site is not curated. However, its composition and variability will reflect the presence of a curated or expedient lithic technology. Flaked stone technology is a reduction process. As such this process is best viewed as a system composed of a series of component stages.

Collins (1975) identifies seven steps in a lithic system: raw material acquisition, core preparation, primary trimming, secondary trimming, use, refurbishment, and disposal. Flenniken (1981) outlines similar stages in a lithic technological system: selection of raw material, heat treatment (if necessary), application of the appropriate reduction techniques to produce the desired artifacts, hafting (if necessary) of the stone tools, use, rejuvenation and, ultimately, discard of the debitage and tools into the archaeological context (Figure 2). Each stage in any one lithic system results in distinctive products, primarily debitage, that are characteristic of that stage. For example, within a single lithic system the debitage produced upon quarring raw material is distinguishable from debitage produced further along the reduction sequence, such as notching a projectile point.

Stages are an analytical tool for lithic analysis (Gilreath 1983). We lack ethnographic data that documents an emic conception of stages by aboriginal flintknappers. However, many modern flintknappers and lithic analysts employ the stage concept to delineate different products of a lithic reduction and use sequence (e.g., Powell 1983, Frison and Bradley 1980:45-52, Callahan 1979).

As stated previously, the mobile adaption of Great Basin hunter-gatherers requires that procurement, processing, and use of raw material be conducted in steps, many of which occur at different locations. It follows that the process of raw material procurement, stone reduction, tool manufacture and tool use will also partition into steps, some of which are performed in different places. That is, transportation of the lithic items may occur between stages of the reduction system.

Each stage in a reduction system produces debitage distinctive of that stage. Therefore, the ability to discern

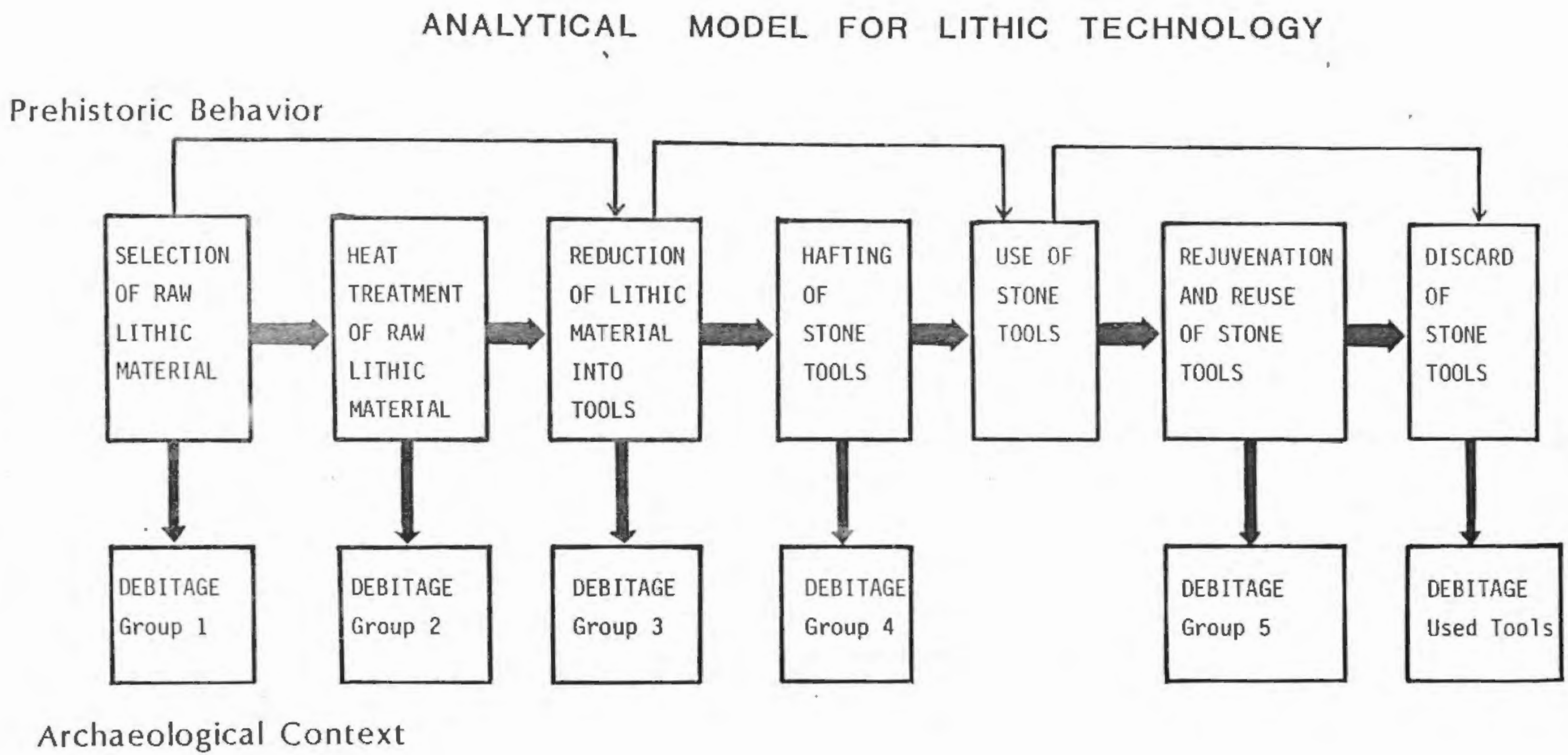


Fig. 2.--Model of stages for flaked stone technology (Flenniken 1981:4; Collins 1975:25)

the flaked stone technology at a site does not rest on direct inferences about tool kits, and tool function, but instead on the composition of the debitage with respect to the stage(s) of a lithic system(s) it reflects. Therefore, inferences about site activities based on the analysis of the flaked stone depends not only on what debitage is present, but also on what debitage is absent. The occurrence of a set of debitage at one location implies the presence of another set of debitage at another location.

Thus a curated lithic technology, that is, a technology which produces items to be maintained, transported and altered, is one in which the stages (lithic procurement, manufacture, and use) are separated in space and time. Curation produces sites with debitage that reflect only a segment or a few stages of a flaked stone tool manufacture, and use technology. The recovery of an isolated arrowhead is a case in point. Although the projectile may have been unleashed quite expediently as a prehistoric hunter unexpectedly encountered his prey, it is unlikely that the point was manufactured, hafted, and shot all at the same time and location. In light of the whole lithic system from which it has been lost, the isolated projectile point reflects a curated lithic technology.

Conversely, with regard to a single rock type, when space and time does not segregate the stages of the lithic technology, that is, when lithic products, including debitage contain evidence of procurement, manufacture, use, and discard then the site served as a locus of an expedient lithic technology (Newcomer 1979:675, Ebert 1979:65). Cahen et al. (1979) and Flenniken (1981) provide excellent examples of prehistoric expedient lithic technologies wherein tools are manufactured, used, and discarded all at the same time and place. Figure 3 schematically depicts the concept of curated and expedient behavior in light of stages that compose a lithic technology.

The analysis of flaked stone technology

I have argued that for mobile hunter-gatherers the composition of the debitage will reflect the number and kind of stages in the technology of stone tool manufacture at a site. The analysis of the debitage will indicate the role of transportation (i.e., curation or expediency) in the technology. Replicative analysis provides the best means to discern the stages in the lithic reduction technology at an archaeological site (Flenniken 1981). Replication is reproducing stone artifacts, including debitage, using the aboriginal artifacts as controls. Replication employs stoneworking implements similar to ones used prehistorically and uses the same raw materials to follow what can be demonstrated as the same reduction technology. Replication is successful if the end products, including debitage, possess the same or very similar morphologies, and categorical percentages as that produced aboriginally (Flenniken1 981:4).

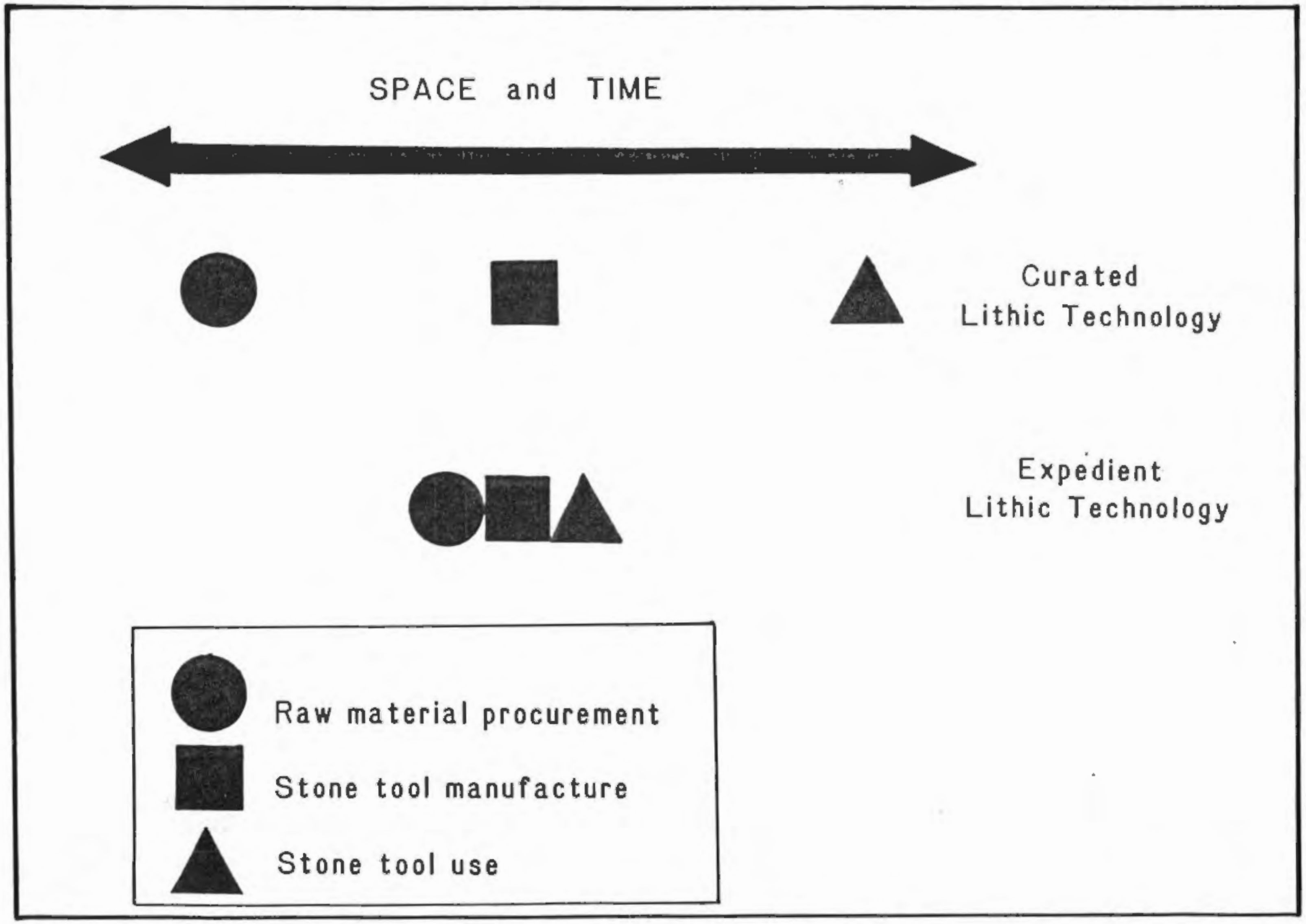


Figure 3. Schematic model for curated lithic technology and expedient lithic technology.

In this research, I employ replicative analysis to determine the stone procurement and tool manufacturing technology at the Ni-rak and Strandline sites. This analysis does not discuss, in detail, stone tool use for two reasons: 1) Analysis of wear from stone tool use is a complex and time consuming task requiring, like flintknapping, a lengthy training period; and 2) as the following technological analysis will show, stone tool use appears to be a small factor in the lithic technology of the Ni-rak and Strandline sites. However, the analysis of stone tool manufacturing technology provides data for inferences about how and where the tools may be ultimately used.

This replicative analysis was conducted in three steps. First,I described and categorized the artifacts with respect to the morphological attributes that reflect the technology of their manufacture. This step relied on over 80 flintknapping experiments designed to isolate the methods and techniques resulting in the aboriginal debitage. Second, formal replicative experiments were conducted to demonstrate the aboriginal lithic reduction technology. Finally, I compared the debitage produced in the replicative experiment with the debitage recovered from the archaeological sites.

Replication provides data in the form of debitage to demonstrate the aboriginal lithic technological behavior at the sites under investigation here. Replication analysis will indicate whether a stage or a complete lithic system composed the flake stone technology of the Ni-rak and Strandline sites. That is, was transportation and curation a factor in the technology?

The one-way, reductive nature of flintknapping requires the replicative analyst to answer two questions if the knapper is to successfully demonstrate the aboriginal reduction technology and explain the frequencies of archaeological debitage. First, what was the size, and shape of the lithic raw material imported into the site before reduction commenced? Replication, as in prehistory, must always begin with unaltered lithic material. A comparison between the debitage from the replication and archaeological assemblages will demonstrate whether the aboriginal sites incorporated the first stages of reduction of unaltered raw material, and by implication the role of transportation in the lithic technology.

Second, what, if any, by-products of the reduction technology where transported from the site by its occupants. In the process of manufacturing certain products of the reduction technology, cores, for example, the replicative experiments may necessarily produce other products that appear under-represented in the archaeological collection (e.g., flakes). If specific erosional changes of the archaeological assemblage can be ruled out, then a hypothesis can be made for transportation (curation) of flakes from the site.

In summary this chapter has explained how the transportation and mobility requirements of hunter-gatherers in the Great Basin will result in curated and expedient lithic technologies. A curated technology is one in which the stages in lithic reduction are separated in space and time. Whereas an archaeological site with an expedient lithic technology contains evidence of the entire lithic technological process including, procurement, manufacture, use and discard. Replicative analysis provides the best means to discern these technological behaviors at archaeological sites.

CHAPTER 3

BACKGROUND

The Sites

In this study I will examine the role of transportation in the lithic technology at two small lithic scatters in the eastern Great Basin. The sites occur in western Juab County in west-central Utah, near the southwestern margin of the Great Salt Desert (Figure 1).

The sites occur in Dugway Valley near the banks of dry Pismire Wash, the principal drainage on the eastern flank of the Thomas and Dugway Ranges. The Strandline site, 42Jb273, lies on a small strandline bisected by Pismire Wash, at 5000 feet (1524 m) in elevation. The Ni-rak site, 42Jb282, occurs on an alluvial fan near the base of the Thomas Range at 5310 feet.(1618 m) in elevation. Both sites are small surface lithic scatters composed entirely of flaked obsidian. The Strandline site contained 266 pieces of flaked obsidian artifacts collected within a 75 square meter area. The Ni-rak site contained 52 pieces of flake obsidian artifacts recovered from an 8 square meter area. These artifacts represent all archaeological material observed and collected at the two sites. The following discussion provides a general review of the geological, climatic, vegetative, and cultural setting of this research area.

The Great Basin

The Great Basin extends from the Sierra Nevada on the west, to the Wasatch Range on the east, and from southeastern Oregon, and northwestern Utah and central Idaho in the north to southern California (Hunt 1974:313). During the course of his 1843-1844 expedition for the Army Corps of Topographical Engineers, John C. Fremont observed that this region was characterized by internal drainage and so named it the "Great Basin" (Cline 1963:214-15). However, subsequent researchers concluded that the Great Basin consists of over 150 basins of internal drainage rather than one large basin (Morrison 1965).

The major geological events that have shaped the eastern Great Basin include faulting, volcanism and Pleistocene lakes (Hunt 1974). The earliest geologic periods - late Precambrian (1.2 billion years ago) to the early Tertiary (40 million years ago) experienced extensive periods of marine sedimentation, that ultimately solidified, uplifted, and eroded into the many hills and mountains seen in the region today. During the mid-Tertiary period (about 30 million years ago) uplifting and block faulting occurred throughout the Great Basin. The mountain ranges or horsts seen today were uplifted relative to the valleys or grabens. Down-faulting and alluviation of the valleys followed. During the early Pleistocene the entire Great Basin experienced epeirogenic uplift to approximately a mile high. Block faulting continues today and may control the discharge of springs that occur along fault lines (Hunt 1974).

Pleistocene glaciation and the formation of pluvial lakes are among the most recent geological events to have shaped the Great Basin. At its maximum, about 14,200 years ago the largest of the pluvial lakes, Lake Bonneville, covered 52,700 square kilometers at an elevation of about 5200 feet (1585 m) (Currey and James 1982:31). While Lake Bonneville and other pluvial lakes occupied the valleys of the Great Basin, glaciers occupied the higher mountain ranges, including the Deep Creek (Bick 1966:97) and Raft River Mountains (Mehringer et al. 1971:47-48).

Desiccation of pluvial lakes and retreat of alpine glaciers accompanied an overall global warming at the close of the Pleistocene about 13,000 years ago. Still stands punctuated the rapid dessication of Lake Bonneville and left shoreline terraces and strandlines observable today. These include the Bonneville terrace at about 5200 feet (1585 m), and the Provo terrace at about 4850 (1478 m). Great Salt Lake at 4200 feet (1280 m) is but a salty remnant of this once vast inland sea (Currey and James 1982:34). The evidence of human occupation at Danger Cave at 4320 feet (1317 m) on the eastern edge of the Great Salt Desert from as early as 11,000 B.P. demonstrates the lowering of Lake Bonneville to that elevation (Jennings 1978:30).

Holocene Climate

Evidence for climatic conditions and changes in the Great Basin during the last 12,000 years comes from many types of research, including studies in arroyo cutting and filling, palynology, tephrachronology, Pleistocene lake level fluctuations, and glacial deposits (Mehringer 1977). Although no paleoclimatological studies have specifically centered in west-central Utah, the following provides a brief outline of general climatic events that probably occurred in the study region.

Currey and James (1982), like Antevs (1955) before them, outline a tripartite scheme for Holocene climatic change in the Bonneville Basin (Table 1). They base their climatic reconstruction on geological and biological evidence, including analysis of fossil pollen, coprolites, pack rat middens, plant macrofossils, and faunal remains. Antev's (1955) "Anathermal" and Currey and James' "Late Pluvial" is the earliest Holocene climatic period dating from about 12,500 B.P. to 7500 B.P. The period experienced the continued withdrawal of late Wisconsin age glaciers and regression of pluvial lakes that began about 12,500 years ago (Currey and James 1982:44). By 10,500 B.P. coniferous forests had moved upward in elevation replacing high elevation sagebrush in the Raft River Mountains (Mehringer et. al. 1971). In lower elevations along mountain pediments, sagebrush steppe replaced what had been the lower forest limit (Bright 1966).

Table 1. Holocene Climatic Periods of the Great Basin

Antevs (1955)	Years B.P.	Currey and James (1982)
	11,000	
	10,000	
Anathermal	9,000	Late Pluvial
	8,000	
	7,000	
Altithermal	6,000	Post Pluvial
	5,000	
	4,000	
	3,000	
Medithermal	2,000	Neopluvial
	1,000	
	present	

When compared to the Holocene average, wetter conditions characterized the Anathermal (Late Pluvial), until around 8,000 B.P., the Altithermal (Antevs 1955) or Postpluvial period (Currey and James 1982).

Based on studies of arroyo cutting and filling, as well as his understanding of paleo-climatic events in Scandinavia, Antevs (1955) proposed that relatively hot and dry conditions prevailed for a period from 7000-4500 B.P., the Altithermal. However, other paleoclimatic evidence paints a more complex picture for the Altithermal. Martin (1963:70) suggests that a change of seasonality and intensity in rainfall may have caused arroyo cutting in the American Southwest. Palynological studies indicate a dry warm climate characterized the Altithermal period in Oregon (Hansen 1947). Paleoclimatic studies in the eastern Great Basin suggest that a warm dry mid Holocene interval resulted in 150 m of upward shift in vegetation zones, and the virtual desiccation of Great Salt Lake (Currey and James 1982:37,44).

Antevs' "Medithermal" and Currey and James' "Neopluvial" period began around 5000 B.P. and continues to the present. The period is marked by the rebirth of some high Rocky Mountain glaciers and a rise of Great Salt Lake. From 3500 B.P. to 2000 B.P. a cooler and moister period forced upper timberlines to descend (Currey and James 1982:45) and the flooding of salt flats and marsh habitats

1977:121). Mesic conditions are also suggested by expansion of grassland around 1500 and 600 years B.P. (Harper and Alder 1970).

Present Climate

The modern climate of the eastern Great Basin produces a mid-latitude desert and steppe environment which is influenced considerably by topography and elevation. High mountain ranges such as the Deep Creek are characterized by a humid microthermal climate. In the valley floors, average maximum temperatures for July range between 85 to 95 degrees Fahrenheit, while below zero temperatures not uncommon in winter. Diurunal temperatures fluctuate as much as 40 degrees, Fahrenheit (James and Singer 1980:10-11, U.S. Dept. of Commerce 1965).

The average annual number of frost free days also varies with elevation. Lower elevations, such as the Bonneville Basin, have 150 to 170 frost free days per year. Elevations around 6000 feet have about 100 frost free days per year; and high mountains above 10,000 feet enjoy no more than 75 frost free days per year (James and Singer 1980:11, U.S. Dept. of Commerce 1965).

Average annual precipitation in the eastern Great Basin ranges from less than 11 cm at Wendover in the Great Salt Desert to 25 cm at Callao, 30 cm in Tooele, to over 75 cm atop the Deep Creek Range (U.S. Dept. of Commerce 1965). Based on this, the region where the study sites are located probably receives about 14 cm of rain annually.

Most of the precipitation in west-central Utah originates from one of two storm centers. In the winter and spring months, storms form over the Pacific and travel eastward across the Great Basin over west-central Utah and beyond. In the late summer, convectional storms originating from the Gulf of Mexico and Baja California occasionally penetrate as far north as the Great Salt Desert (Kay 1982: 76-77). These rains offer little amelioration to the high evapo-transpiration during the summer. Summer rains usually are too light to soak into the ground or too sudden, causing rapid surface runoff, and thus add little moisture to the soil (Allred 1976:6).

Vegetation

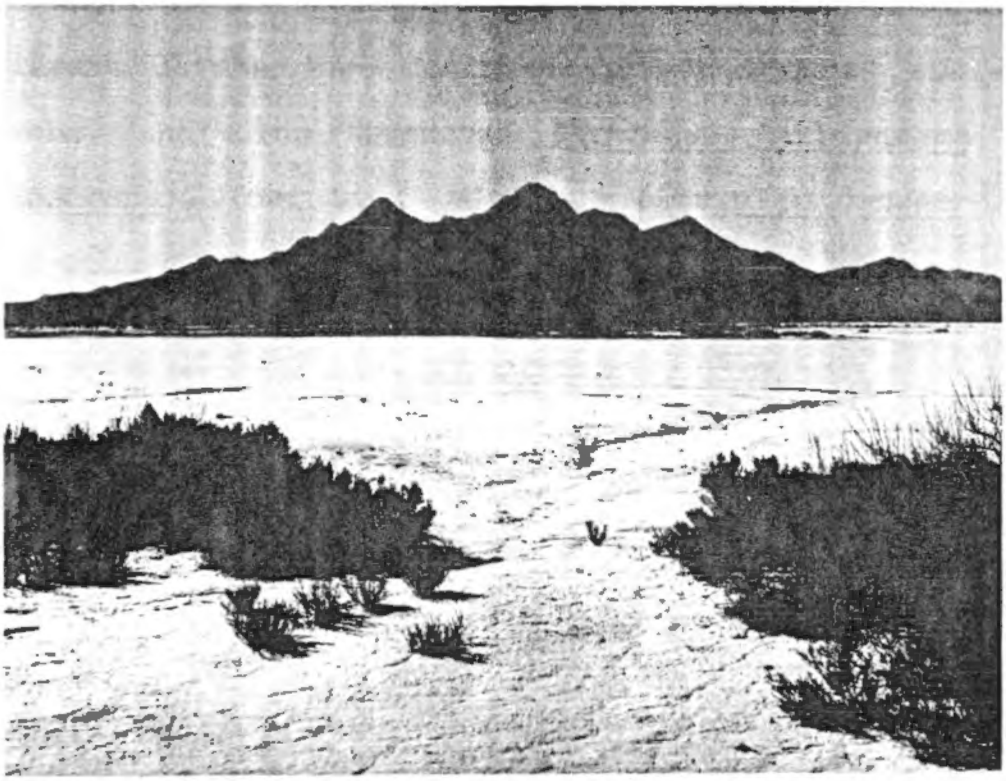
The vegetation of the study area is described in terms of a transect that follows Pismire Wash from where it sinks into the Great Salt desert upstream to its origin high in the Thomas Range. Below 4300 feet is the Great Salt Desert, the lowest part of the Bonneville Basin. This flat plain of fine clay and silt sediments shows the result of evaporation of the Holocene lake. Mud and salt pans which have low water permeability cover much of the Great Salt Desert. Where the desert is fed by rain or ground water, salts, including nitrates, sulphates and phosphates accumulate at the surface (Weyman and Weyman 1977:54). Large areas of the Great Salt Desert are devoid of vegetation (Figure 4).

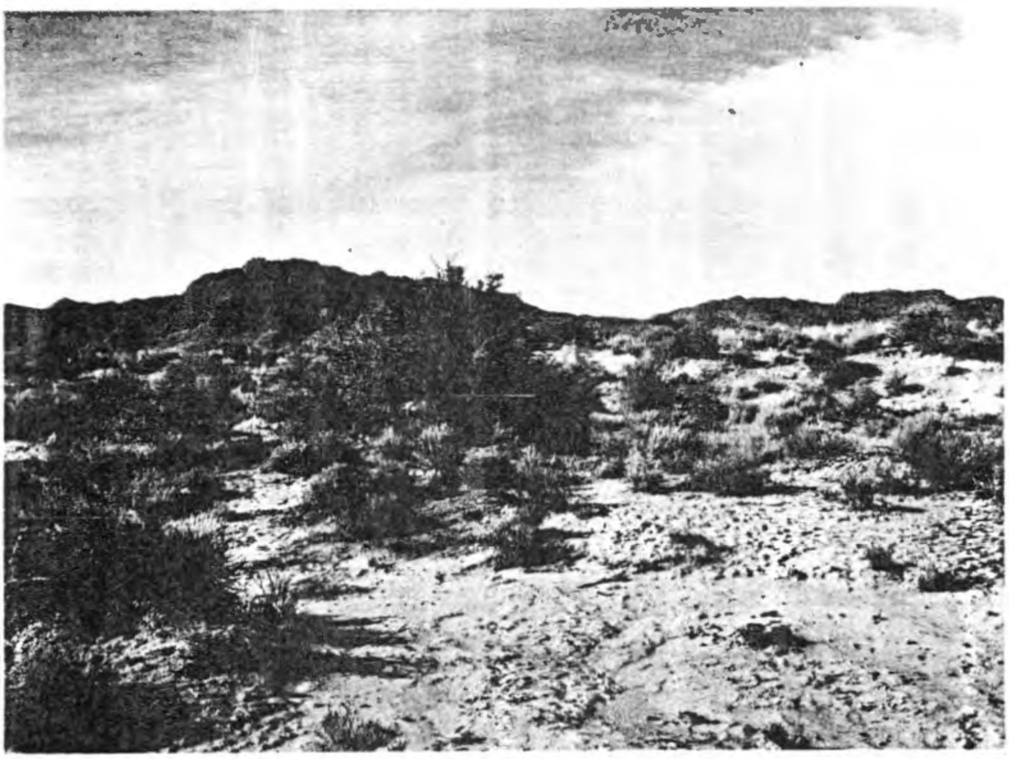
Climbing out of the Salt Desert into more friendly surroundings requires only a few feet of elevational gained onto the vast plain of Dugway Valley. The plain lies below the maximum level of ancient Lake Bonneville. The sediments consist primarily of clay and silt, although, sand and gravel are common near alluvial fans, Holocene rivers courses, and ancient shorelines. The retreating lake formed deltas, bars, spits, wavecut and wave-built terraces that today encircle the Great Salt Desert (Gilbert 1890). These features create physiographic diversity which have correspondingly different vegetation communities.

Shadscale (Atriplex confertifolia) dominates the silty clay and silty loam soils (Billings 1951). Other important shrubs include spiney-hop sage (Grayia spinosa), mormon tea (Ephedra nevadensis), winterfat (Eurotia lanata), bud sage (Artemisia spinescens) and horsebrush (Tetradymia spp.). Important grasses include galleta (Hilaria jamessii), and ricegrass (Oryzopsis hymenoides). Saline soils will contain the above plants but also marked increases in greasewood (Sarcobatus vermiculatus), salt grass (Distichlis spp.) and pickleweed (Allenrolfea occidentalis). (Staatz and Carr 1964:118). Well drained sand dunes, show marked increases in the grasses mentioned above as well as bottle brush squirreltail (Sitanion hystrix), needle and thread (Stipa spp.), sand dropseed (Sporabolus cryptandurus), and

Figure 4. Large areas of the Great Salt Desert lack vegetation. Newfoundland Island is in the background.

Figure 5. The Sand dunes along Pismire Wash.





and wheat grass (Agropyron spp.). Shadscale and other salt tolerant shrubs lose dominance on sand dunes while other shrubs, including sagebrush (*Artemisia tridentata* and *A. spinescens*), four wing salt bush (*Atriplex canescens*), and rabbitbrush (*Chrysothanmus* spp.), increase.

Along Pismire Wash in the Dugway Valley stabilized dunes occur at about 4300 feet (1311 m). The dunes form where entrenchment and erosion of the wash channel has exposed layers of clay, marl, silt and sand left by shrinking Lake Bonneville. Wind strips the silt and sand layers down to the more cohesive clay and marl layers, forming blowouts. Windblown sand and silt accumulates along the wash in dunes up to 3 meters high (Figure 5) (Staatz and Carr 1964:119).

The Pismire dune field appears to have been extremely important to the prehistoric inhabitants of the region. Previous surveys of the area have identified over 18 archaeological sites, while the surrounding Dugway valley plain contained no archaeological remains (Cartwright 1980).

At 5500 to 6000 feet (1676 to 1829 m), alluvial fans form where water courses emanate at the base of mountain ranges surrounding Dugway Valley. Further out from the mountain bases the fans merge forming an alluvial plain. This feature merges indistinctly with the sediments left by Lake Bonneville. One site, 42Jb273 occurs in this area, at 5000 feet (1524 m), along a small strandline, bisected by Pismire Wash (Figure 6). Another site 42Jb282 occurs on an alluvial fan created by Pismire Wash near the Bonneville Terrace at 5300 feet (1615 m) (Figure 7).

The vegetation on the alluvial sediments near the archaeological sites is a monotonous cover dominated by sagebrush (Artemisia tridentata and Artemisia nova). Other common plants include rabbitbrush, horsebrush and shadscale. Grasses include less salt tolerant species such as galleta, wheatgrass, squirreltail and ricegrass (Billings 1951:110-12).

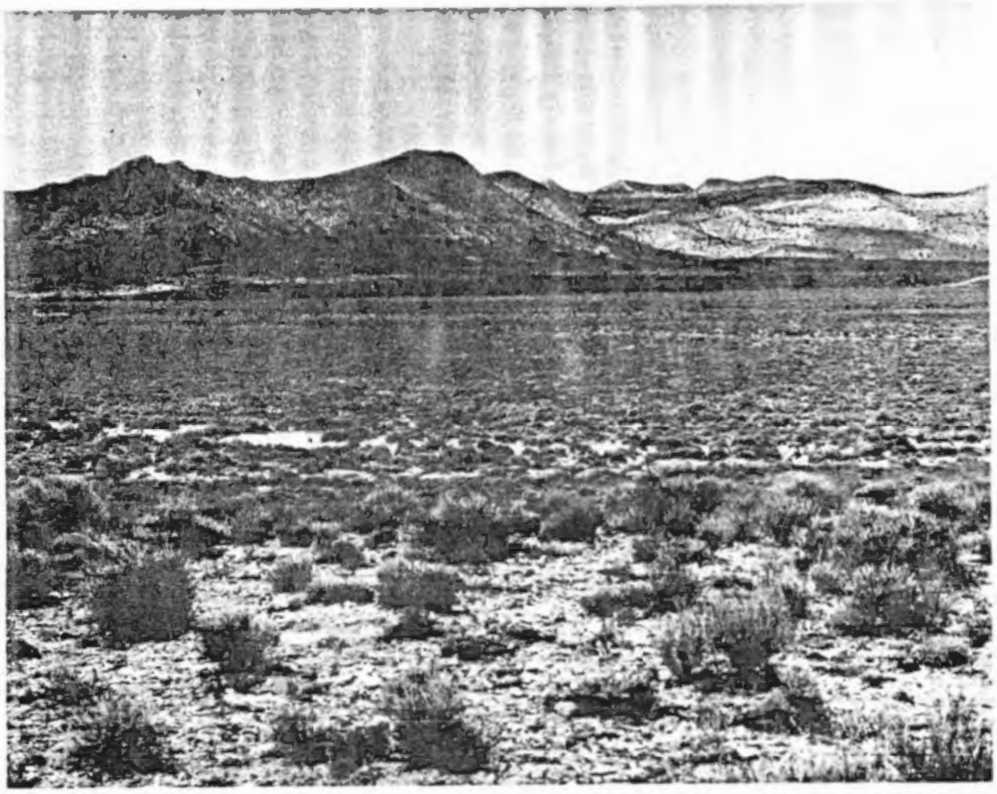
As one climbs higher in elevation in the Thomas Range, juniper (Juniperus osteosperma) and sagebrush dominate the vegetation mosaic (Figure 8 and 9). Above about 6000 feet (1829 m) to the summit of the Thomas Range several shrubs including cliffrose (Cowania mexicana stansburiana), bitterbrush (Purshia tridentata), woods rose (Rosa woodsii), chokecherry (Prunus virginia), currant (Ribes aureum), serviceberry (Amelanchier sp.) and mountain mahogany (Cercocarpus ledifolius) occur with the juniper and sagebrush. Pinyon pine (Pinus edilus) occurs only in the northern portion of the Thomas Range uplands (Staatz and Carr 1964:6).

Water

Fresh water resources are very limited in the vicinity of Pismire Wash, Dugway Valley, and the Salt Desert in general. Simpson Springs, 20 km from Pismire Wash served as a principal watering station on the Pony

Figure 6. Location of the Strandline site in Dugway Valley. Obsidian occurs as a lag deposit on the surface in this area.

Figure 7. Looking eastward, down an alluvial fan near the base of the Thomas Range. The Ni-rak site occurs in the middle-ground to the left of the road.



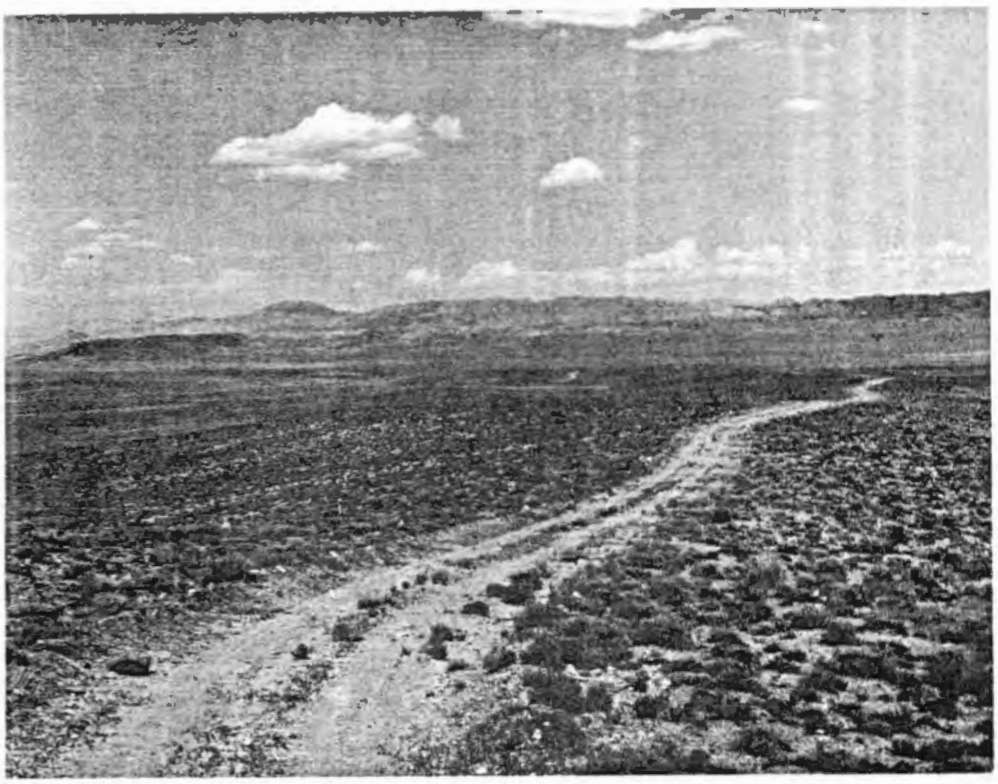


Figure 8. Looking up Pismire Wash in the Thomas Range.

Figure 9. Looking down Pismire Canyon from the top of the Thomas Range. A primary obsidian source occurs in the foreground.

Express Route (Fike and Headly 1978:61). Hangrock Spring occurs on the west side of Colored Pass in the Thomas Range at 6250 feet (Staatz and Carr 1964:6). Wildhorse spring issues at the base of the western slope of the Thomas Range. A fourth spring flows from the north end of Granite Mountain in the middle of the Great Salt Desert. Fish or Pangwich Springs, at the northeast end of the mountain range with the same name, is a large freshwater spring and salt marsh administered as a National Wildlife Refuge.

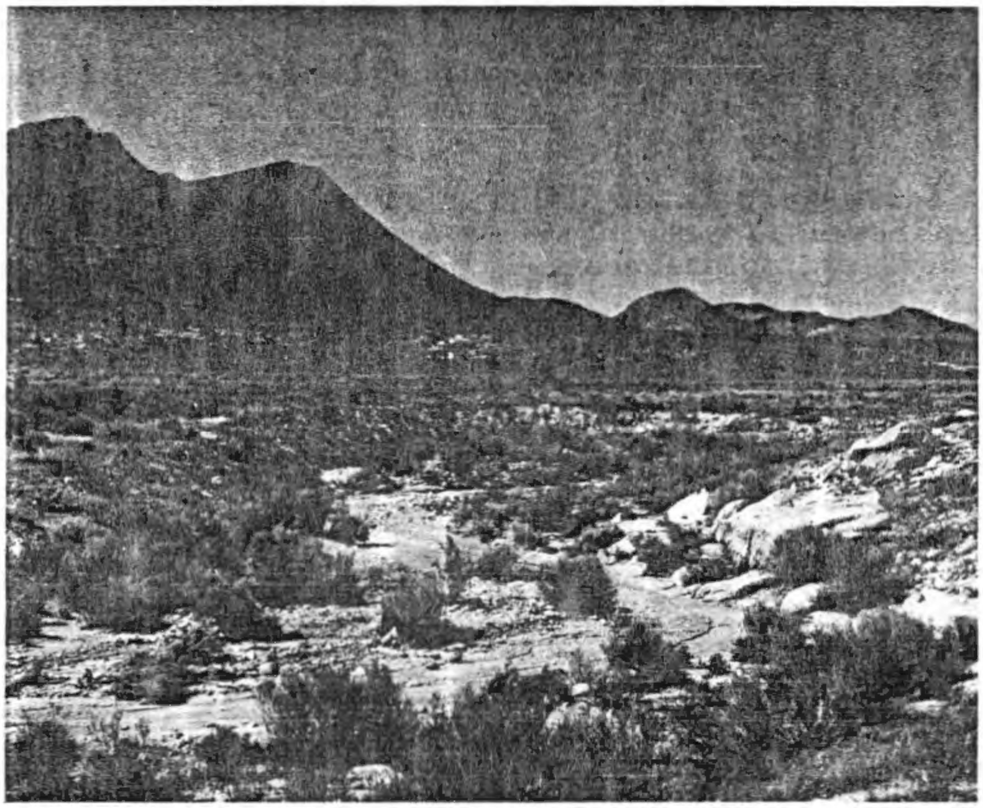
After a rainshower the alluvial sediments quickly drain Pismire Wash in the vicinity of the Ni-rak and Strandline sites (Figure 10). However, water pools in the channel of lower Pismire Wash where it bisects the Pismire dune field. Clays prevent water from draining deeper into the ground. Water remains in these pools for as much as two weeks after a rainstorm (Figure 11).

Geology of the Thomas Range and Topaz Mountain Obsidian

Approximately 50% of the rocks that comprise the Thomas Range are Paleozoic sedimentary rocks including quartzite, dolomite and limestone, which were deposited from cambrian to Mississippian time. Tertiary volcanic rocks lie unconformably above the Paleozoic sediments. In late Miocene and Pliocene times, rhyodacitic intrusions were followed by extrusions of porphyritic rhyolites and various welded tufts. Basin and range faulting began during the later part of this volcanic episode. During the Pliocene uplift and tilting of the Thomas Range accompanied further

Figure 10. Pismire Wash in the region of the Strandline and Ni-rak sites. Water rapidly drains through porous aluvial sediments.

Figure 11. At the dune field, water accumulates in clay floored Pismire Wash for up to two weeks after a rainshower.

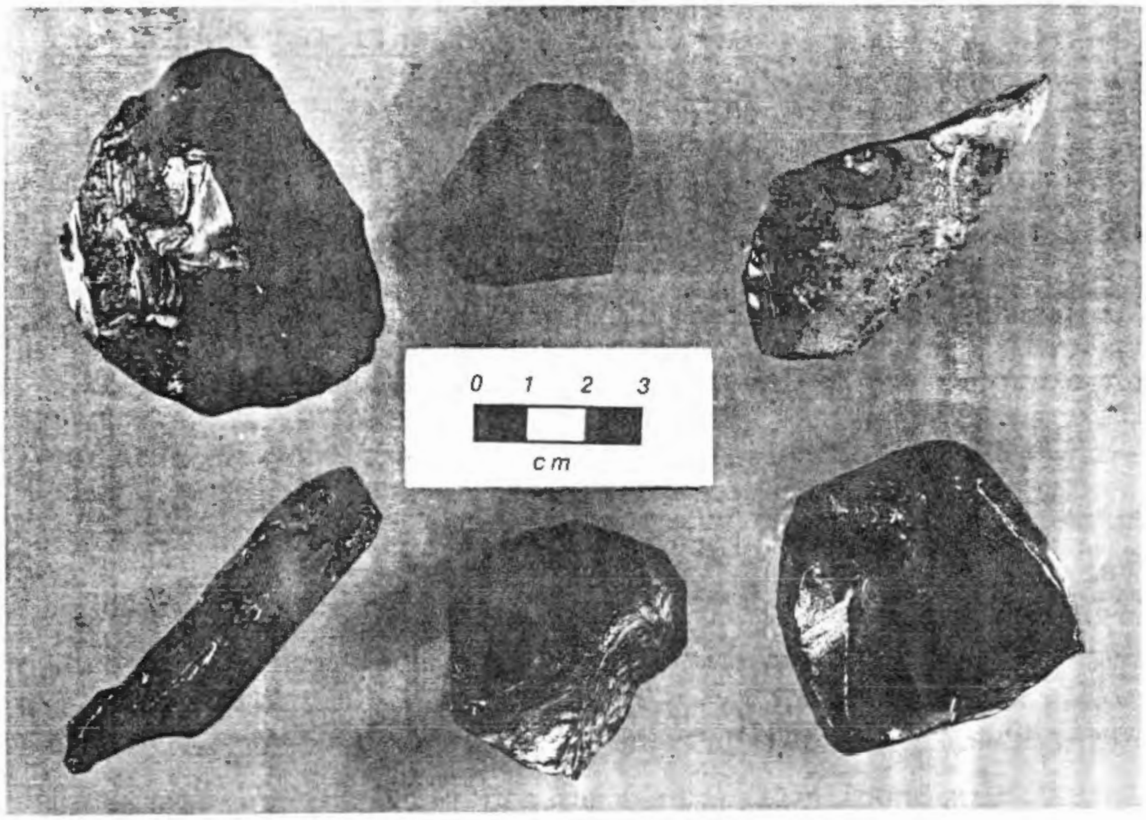


The primary source areas for Topaz Mountain obsidian are recognized where obsidian is actively eroding out of bedrock, and occurs as residual pebbles. The pebbles are angular to subangular, a shape that results from freeze/thaw fracture. The pebbles possess a natural cortex indicative of weathering in place (Figure 13). Although gray, red, brown, and "mahogany" obsidian do occur, both opaque and translucent black obsidian comprises the bulk of the material. The source locations are extremely dense with obsidian essentially paving the entire ground surface (Figure 9). Although Staatz and Carr (1964:94) report nodules up to 15 cm in diameter, the size of obsidian observed and collected by me range up to 6 cm in diameter. This discrepancy may be due to the presence of other obsidian source areas in the Thomas Range whose location is unpublished.

Personal reconnaissance revealed where erosion has formed secondary source areas of Topaz Mountain obsidian (Figure 12). Obsidian accumulates in alluvial and colluvial gravels and pebbles deposited on the lower flanks of the Thomas Range and in Dugway Valley. The presence of obsidian pebbles in these secondary deposits is highly sporadic but is generally more dense and consistent where major drainages, such as Pismire Wash, issue from the Thomas Range. The obsidian is subrounded and contains an incipient cone cortex (Figure 14). Obsidian comprises all of the chipped stone artifacts at the Ni-rak and Strandline sites.

Figure 13. Obsidian collected from the primary source areas on top of the Thomas Range.

Figure 14. Top row: Obsidian collected from the secondary source areas in the vicinity of the Ni-rak site. Bottom row: examples of obsidian pebbles from Glass Butte, Oregon used in the replication experiments.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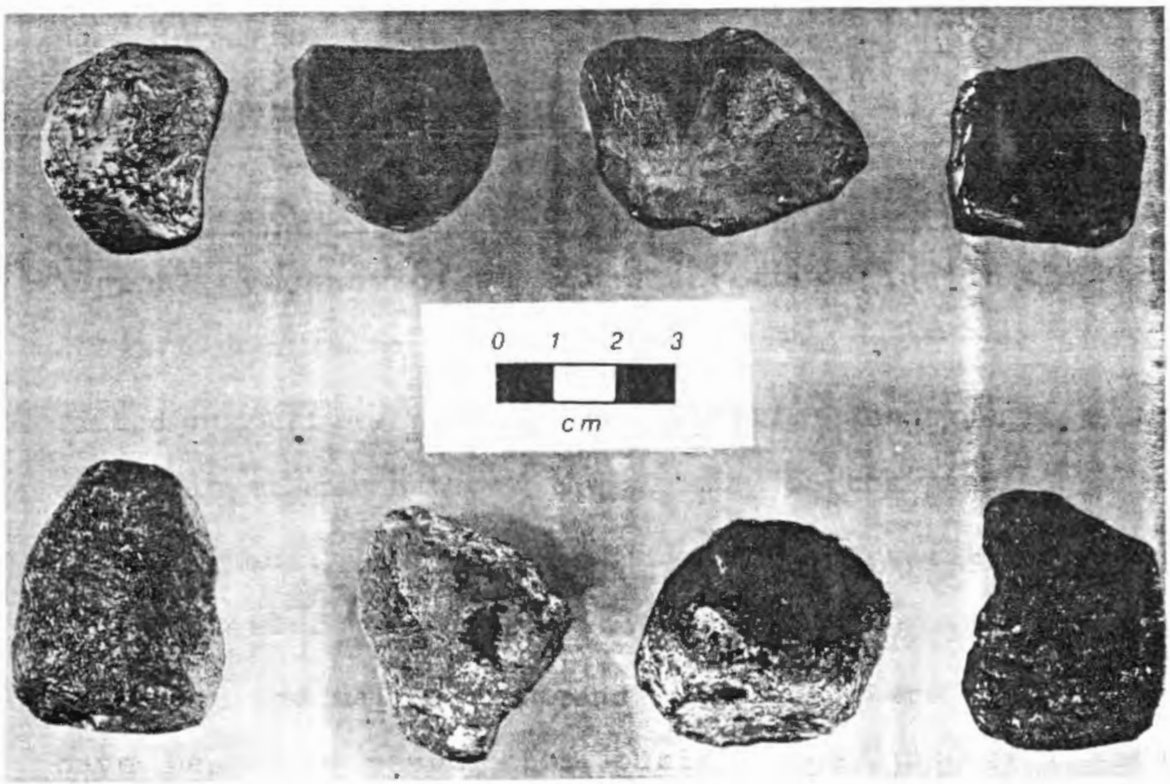
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The Cultural Setting

Interpretation of the Great Basin archaeological record has commonly stressed an intimate interaction between humans, with food and raw material resources in the environment. Apparent similarities between the ethnographic pattern (Steward 1938) and the archaeological record contributed to the formation of the Desert Culture hypothesis (Jennings 1957) as a model to describe and test interpretations of prehistoric Great Basin culture. The model posits that throughout much of the span of occupation, small mobile groups hunted and gathered a wide variety of foods and raw materials as the food became seasonally abundant. Scholars have acknowledged recently that the Desert Culture concept must be elaborated and modified according to local environmental and historical factors (Jennings 1973, Thomas 1981).

Paleoindian Period 12,000 - 10,000 B.P. Archaeological evidence of Paleoindian occupation in the Great Basin consists primarily of isolated surface finds of fluted projectile points (Tuohy 1974). Consequently, it is difficult to reconstruct the lifeway of the people who left these points. Interpretation of the Great Basin Paleoindian period relies on inferences drawn from the same period in the High Plains and Southwest where fluted points have been recovered from buried megafauna kill sites.

On the Plains Paleoindians hunted now extinct genera including mammoth and bison (Frison 1978). However, despite concerted efforts there is no conclusive evidence that associates humans with extinct megafauna in the Great Basin proper (Harrington 1934; Gruhn 1961; Orr 1956).

The Great Basin Paleoindian or pre-Archaic period is best represented by the Western Pluvial Lakes Tradition (Bedwell 1973; Hester 1973:62-68). The tradition includes many sites located near ancient lake shorelines including the Lake Mohave complex (Campbell and Campbell 1937), San Dieguito Complex (Warren 1967), and the Hascomat assemblages (Warren and Ranere 1968). These artifact assemblages, including fluted points and cresents, usually lack grinding stones that are commonly associated with vegetable food processing and the Desert Culture. Tuohy (1974) suggests that the Great Basin Paleoindian assemblages indicate a lifeway similar to their High Plains contemporaries.

Archaic Period 10,000 - 1500 B.P. As warmer and drier conditions caused Pleistocene lakes and glaciers to recede, Paleoindian lifeway yielded to the broad spectrum hunting and gathering adaption of the Archaic period. The grinding implements and basketry for collecting, processing and storing wild plant foods become diagnostic for this period (Jennings 1978:29). The atlatl and dart comes into use during the Archaic (Hester 1973) replacing the larger thrusting spears of Paleoindian hunters. In the eastern Great Basin, the Hogup (Aikens 1970) and Danger Cave (Jennings 1957) archaeological records demonstrate long continuous occupations with a material culture and technology that remained remarkably unchanged for millenia. On the other hand, during the mid-Holocene warm dry period, the Altithermal, the western and northern Great Basin archaeological record indicates virtual site abandonment (e.g., Dirty Shame Rockshelter, Connley Caves) in some regions (Baumhoff and Heizer 1965;.Bedwell 1973) new occupations near perennial springs (Layton and Thomas 1979), and significant changes in material culture (Heizer 1956, Heizer and Hester 1978) and subsistence orientation (O' Connell 1975). The apparently unchanged subsistence practices at Danger and Hogup caves may indicate stable resources not affected by climatic and environmental change. These caves may have served as temporary seasonal camps whose function remained similar throughout prehistory.

Archaeologists in the eastern Great Basin have organized data from a diverse array of sites to document both diachronic and synchronic prehistoric settlement and subsistence differences during the archaic period (Lindsay and Sargent 1977, James and Singer 1980; Madsen 1982a). Madsen and Berry (1974) have suggested that lake peripheries in the Bonneville Basin were occupied on a semi-permanant basis during the early Archaic from 10,000 to 5500 B.P. During the middle Archaic, from 5500 to 2500 B.P., a shift to greater use of upland areas is documented for northwestern Utah (Madsen 1982:215). This shift may have been a response to lake periphery and marsh flooding that resulted from increased effective moisture (Mehringer 1977:140, Curry and James 1982:45). The late Archaic archaeological record at Hogup Cave shows an *in situ* transition to the subsequent Fremont Culture (Aikens 1970, 1976:547-548).

Fremont Period 1500 - 600 B.P. Around 1500 years ago the prehistoric humans of the eastern Great Basin engaged in a radical subsistence and technological change, that is unknown in the western Great Basin. Horticulture, heralded by Fremont Dent maize, diffused northward from southern Utah to the fringes of the Great Salt Lake (Winter 1973). Other technological innovations that characterize this period include pottery, semi-subterranean pithouses, adobe surface structures, bows and arrows and a distinctive half rod and bundle basketry (Jennings 1978:156). Whether this new cultural complex was slowly assimilated by the previous Archaic period inhabitants or arrived full blown after an occupational haitus has been the subject of scholarly debate (Aikens 1976, Madsen and Berry 1975, Madsen 1982a:216).

The archaeological sites in this study occur within the territory of the Sevier variant of the Fremont culture (Madsen 1982:216-217). The Sevier group is distinguishable from other regional variants by virtue of a distinctive greyware and black on white pottery, and marshland subsistence and settlement locations (Wormington 1955, Marwitt 1970, Madsen 1979). Nearby, villages of the Great Salt Lake variant of the Fremont contained corn, beans, and squash (Steward 1933, Shields 1968, Mock 1971). Recently, Madsen (1979) has argued that horticulture and its associated sedentary lifeway was minimumly practiced by the Sevier Fremont. Rather, they maintained a close reliance on hunting and gathering marsh resources (Madsen 1978:720). Indeed, archaeologists have recovered little evidence of cultivated foods from many Fremont occupations near the Ni-rak and Strandline sites (e.g., Danger Cave, Jennings 1957; Hogup Cave, Aikens 1970; Scribble Shelter, Lindsay and Sargent 1977; Fish Springs, Madsen 1982b; Bear River, Shields and Dalley 1978; Backhoe Village, Madsen and Lindsay 1977).

Shoshoni Period 600 B.P. - Present. The Shoshoni period is marked by the spread of Numic speaking hunter-gatherers into the Great Basin around A.D. 1300 (Lamb 1958, Goss 1977). In western Utah the Numic speakers successfully replaced the Fremont who may have not been able to sucessfully compete for scarce resources in the face of environmental change (Madsen 1975).

Archaeologically, very little is known about Shoshonean groups who occupied the eastern Great Basin. Traditionally, Desert Side-notched projectile points and a distinctive paddle and anvil pottery has indicated their presence (Jennings 1978:235).

The study area is located within the region inhabited by the Numic speaking Gosiute Shoshoni, principally the Deep Creek and Skull Valley bands (Steward 1938:134 and Figure 12). Enthnographically, the Gosiute Shoshoni practiced an annual round with small bands moving from place to place as resources became seasonally available. The size and structure of the groups fluctuated during the year in response to the availability and kinds of resources exploited. As many as 15 families might winter over in villages near water, firewood, and food caches composed chiefly of pinyon nuts. With the arrival of spring the group split into individual family units and foraged for seeds, roots, tubers, berries, and game. This pattern continued throughout the summer until the autumn ripening of pinyon nuts drew the people together for harvest. The autumn was also a time for communal antelope and rabbit drives. Ethnographic data on the Gosiute and other Shoshonean groups in the Salt Lake vicinity are contained in: Beckwith (1854), Simpson (1869), Chamberlain (1911), Egan (1917), Steward (1938, 1942, 1943), Maulof (1940), Fowler and Fowler (1971) and Miller (1972).

CHAPTER 4

OBSIDIAN HYDRATION

In this chapter I report on the results of analysis for obsidian hydration on samples of artifacts from the Ni-rak and Strandline sites. These results come from a project concerning trace elements and hydration measurements from nine archaeological sites in the study area (Raymond 1983). In the present study, obsidian hydration measurements are used to help determine the occupational history of the Strandline and Ni-rak sites.

As surface lithic scatters, the Ni-rak and Strandline site pose a problem in archaeological interpretation because temporarilly discontinuous occupations cannot be distinguished stratigraphically as they can at stratified sites. Surface sites possess no cultural or natural stratigraphic layers that might aid in detecting potential multiple occupations. The same site may have been used once, or visited several times over thousands of years. Distinct multiple occupation events, perhaps reflecting multiple site activities and functions, are mixed on the surface, possibly resulting in erroneous reconstructions of the character of the occupation.

However, because these lithic scatters consist of obsidian, one can use obsidian hydration measurements to help assess their history of occupation. This section presents methods to aid in determining whether a sample of flaked obsidian artifacts was drawn from a population of artifacts that represents a single or multiple occupational event.

The method employs inferential statistics and exploratory data analysis on groups of obsidian hydration measurements. The first procedure submits the hydration data to the W test for normality (Shapiro & Wilk 1965). Secondly, box and whisker plots are constructed (McGill et al. 1978) to graphically display the hydration measurement data from each site. If necessary, outliers are rejected according to Chauvenet's criteria (Long and Rippeteau 1974) and the W test is applied again. Results of these procedures can then be used to assess the occupational history of a site. Application of the procedures relies on assumptions about the hydration phenomena, sample size, and our conception of archaeological time.

The statistical tests were applied first to 10 groups of radiocarbon dated, stratigraphically controlled collections of obsidian hydration rind measurements from California. This was done to demonstrate the utility of the tests for subsequent application to the Ni-rak and Strandline sites.

<u>Occupation Events and Deposition Events</u>

Occupational episodes do not necessarily coincide with archaeological deposition episodes (Binford 1982). A lithic scatter appears on the surface as a single depositional event. There is but one provenience designation with respect to vertical deposition. In terms of stratigraphy we have no way of knowing whether the surface confined assemblage represents one, two, or a multitude of occupational episodes. As a single depositional unit, the surface will obscure multiple occupation events if they occur at the same place.

This problem is perhaps more acute in confined space such as a cave. Here, however, we rely on the stratigraphic integrity and archaeological context of the depositional assemblage, in association with elements that mark time, to define occupational episodes. The amount of resolution inherent in the time marker and the amount of resolution discernable in the stratigraphic and archaeologic context will determine the degree of congruence between a depositional episode and an occupational episode.

For example, a dendrochronological date may provide precise temporal resolution, and when it is associated with a discrete depositional assemblage, a precise picture of an occupational event could result. In contrast, a radiocarbon date provides less time resolution than a dendrochronological date. When considering charcoal flecks from a hearth with a C-14 date of 500 $\pm$ 100 years B.P., we do not envision a fire that burned for 200 years, much less than 20 years. Yet we also do not know whether the date represents a fire that burned once, continuously for weeks or several times in the course of a century. In such a case the depositional event may not coincide with the occupational reality. But by convention, and by the limits of C-14 dating, we equate a single occupation with a depositional episode. That is, all artifacts associated with the radiocarbon date, and within the stratigraphic depositional unit in which the radiocarbon date occurs, reflect an occupation. The "occupation" may hold several occupational events, however, it may be considered a homogenous analytical unit from which inferences about past behavior are drawn. Measurement of obsidian hydration rinds do not mark ages directly. Yet they denote occupational events in a relative sense.

The Hydration Phenomena

Obsidian and artificial glass are thermodynamically unstable and undergo progressive and gradual absorption of moisture from the environment. As derived from the parent magma, rhyolitic obsidian contains 0.1-0.9 percent water by weight. After cooling, the obsidian incorporates molecular water through its surface. The water advances as a gradient of concentration, characterized by a diffusion front. The water content reaches 3.5 percent by weight, effecting a change in both density and volume of this hydrated layer. An increase in density raises the index of light refraction, while an increase in volume produces a mechanical strain at the mutual boundary between the layer of absorbed water and the nonhydrated interior of the obsidian. The change in volume causes an optical effect called "birefringence" or the power of double refraction. At a microscopic level, birefringence, coupled with the higher index of refraction, distinguishes the unaltered obsidian from the hydrated layer or hydration rind as it is called (Jackson 1982; see also Taylor 1976; Michels and Tsong 1970). When natural or cultural agencies break the obsidian to expose a fresh surface to the environment, hydration will commence on that surface.

Despite the infancy of research on the subject, a few key environmental and chemical variables have been shown to affect the rate of obsidian hydration. Michels and Tsong (1980), Findlow et al. (1975), Kimberlin (1976), and Ericson and Berger (1976) demonstrate that due to unique chemical compositions, each obsidian source has a different rate of hydration. Chemical variations between the silica based obsidian sources is reflected by proportions of trace elements, intrinsic water content, and the silicon-oxygen ratio.

The "effective hydration temperature" also affects the rate of obsidian hydration. For obsidian from the same source, those items exposed to higher mean annual temperature hydrate faster than obsidian exposed to lower mean temperatures. This has been demonstrated empirically by Findlow et al. (1982), and experimentally by Friedman and

Long (1976), Ambrose (1976), and Friedman et. al. (1966). Within the same geographic region, effective hydration temperature varies between surface, subsurface and above surface levels. Hydration rates for obsidian on the ground surface are faster than obsidian from the same source buried even slightly below the surface or suspended above the surface (Friedman 1976). Those regions, such as northern latitude, high elevation deserts, which experience radical diurnal and seasonal temperature fluctuations, show even greater differences between the hydration rates of surface and buried obsidians (Layton 1973; Friedman and Long 1976). Within about 100 cm of a buried deposit, however, the rate of obsidian hydration does not vary significantly (Findlow et. al. 1982). The hydration of obsidian occurs independently of atmospheric relative humidity (Ambrose 1976:90; Friedman and Smith 1960).

In light of these variables, the goal of many hydration studies has been to construct a mathematical equation that, in solving for time, describes the rate of rind formation for a chemically characterized obsidian that is culturally broken and deposited in a particular environment. Most of these rates are exponential (see Friedman and Long 1976; Findlow et al. 1975, 1982). The equations show that initially, hydration occurs rapidly, and then slows to a more constant rate.

To summarize, temporal inferences made from a sample of hydration measurements requires that the sample possesses (1) obsidian from a single source, and (2) a similiar post-depositional environmental (temperature) regime.

The Working Hypothesis

If the requirements outlined above are fulfilled, I submit the following hypothesis suggested by Timothy A. Kohler (1983, personal communication) about obsidian hydration. A population of obsidian flakes created during an occupational event exhibit a symetric distribution of rind measurements which is approximately normal. This assumes that the environmental events which affect hydration are controlled by processes which themselves are nonrandom in their effects, but which, in the aggregate, are so opposed in effects that over time the leptokurtotic (peaked) distribution of hydration rind thickness formed in a single event flattens out to a normal distribution. By analogy with spatial processes, Hodder and Orton (1976:54) have noted that when many simultaneous or sequential processes conflicting in their effects, act on a regular or clustered spatial distributions an apparently random distribution is eventually produced.

Consider a group of flakes produced by a prehistoric flintknapper from obsidian blanks that were derived from the same flow at a specific quarry. Discarded as waste, the flakes may be deposited together where, until the time of recovery by archaeologists, the environment remains similar, but not identical for all the flakes. Each flake experiences increases and/or decreases in hydration rate due to a small chemical variations among the flakes and microenvironmental variation, including spatial and temporal variations of shade and sunlight at the site during generations of growth and regrowth of vegetation. This "random" increase and decrease in hydration rate occurs around a "true" hydration rate which began when the flakes were struck off the parent blank. Thus the population of flakes should exhibit rind measurements that approximate a Gaussian, or normal distribution with their mean corresponding to this "true" rate. A sample drawn randomly from such a population should also correspond to a normal distribution.

<u>Testing the Hypothesis</u>

Testing the hypothesis requires samples of source specific obsidian artifacts with hydration rind measurements that are associated with absolutely dated, discreet depositional contexts. Such data are supplied by Findlow and others (1982) and presented in Table 2. Eighty-four hydration measurements came from 10 distinct archaeological deposits among seven different sites excavated in southern California.

Each of the 10 samples fulfills the requirements for hydration rind interpretation discussed earlier. Each group is exclusively composed of obsidian from a single source, i.e., either Coso Mountain or Casa Diablo obsidian. Within each group, the flakes experienced the same envi-

Table 2. Hydration Measurements with Associated Radiocarbon Age at California Archaeological Sites (Findlow et al. 1982).

Site	Hydra (Microns)	Centimeters Below Surface
Barrows		
1420 ± 70 B.P.	6.6	150
Coso Obsidian	6.4	150
	6.8	150
	6.6	150
	6.8	150
	4.8	150
INY 222		
1910 ± 60 B.P.	11.8	28-30
Coso Obsidian	12.9	28-30
	12.6	28-30
	11.7	28-30
	12.0	28-30
	11.6	28-30
	13.3	28-30
INY 372(a)		
2240 ± 145 B.P.	7.2	152-163
Coso Obsidian	10.6	152-163
	9.8	152-163
	6.3	152-163
	6.9	152-163
	7.6	152-163
	8.7	152-163
	7.1	152-163
INY 372(c)		
3580 ± 80 B.P.	11.4	244-259
Coso Obsidian	8.0	244-259
	8.2	244-259
	8.0	244-259
	8.3	244-259
	7.9	244-259
	8.4	244-259
SBC 128		
1400 ± 50 B.P.	4.4	30-40
Coso Obsidian	5.0	30-40
	4.4	30-40
	4.7	30-40
	4.7	30-40

Table 2. Continued

SITE	Hydra (Microns)	Centimeters Below Surface
MAD 179		
430 ± 110 B.P.	7.0	120-140
Casa Diablo Obsidian	7.6	120-140
	8.9	120-140
	4.4	120-140
	7.5	120-140
	7.3	120-140
	4.4	120-140
	7.0	120-140
	6.4	120-140
INY 372(d)		
3900 ± 180 B.P.	8.4	259-274
Coso Obsidian	8.6	259-274
	8.1	259-274
	7.5	259-274
	8.2	259-274
LAN 264		
1245 ± 60 B.P.	4.3	188-198
Coso Obsidian	5.8	203-218
	4.6	203-218
	2.2	209-218
MNO		
280 ± 55 B.P.	4.7	20-40
Coso Obsidian	2.8	20-40
	3.4	20-40
	3.7	20-40
	5.0	20-40
	4.6	20-40
	4.9	20-40
	3.9	20-40
	8.8	20-40
	4.9	20-40
	4.9	20-40
	6.0	20-40
	5.6	20-40
	8.8	20-40
	2.2	20-40
	2.8	20-40
	5.7	20-40
	3.4	20-40
	2.8	20-40
	5.0	20-40
	5.2	20-40
	4.7	20-40

ronmental/temperature regime since deposition. The recovery of each group of flakes from a single and spatially-narrow stratigraphic unit supports a second assumption. Each group of flakes is dated by virture of the group's association with a radiocarbon age. To the extent that a radiocarbon date represents a discrete point in time and a single occupational event, then the hydration measurements of obsidian flakes associated with the C-14 date also represent a discrete point in time. In addition, one must assume that each sample of rind measurements adequately represents the true population of rind measurements in all the obsidian associated with a particular C-14 date. Thus, the following hypothesis is proposed. Each of the 10 samples of obsidian flakes could have been drawn from a population of rind measurements which is normally distributed.

The Test Statistic

A statistical procedure, called the W test for normality (Shapiro and Wilk 1965; see also Gardiner and Gardiner 1979:35) supplies an appropriate sampling distribution to test the probability that the rind measurements in each sample are normally distributed. The W statistic is origin and scale invariant and particularly good for small sample sizes. Although the Statistical Analysis System program UNIVARIATE supplies the test procedure (SAS Institute 1979:427-432), its computation is explained here.

The procedure begins by ranking the observations in ascending order, and calculating the mean. Next, calculate the total squared deviation from the mean. Third, calculate a statistic b as:

$$b = \sum_{i=1}^{i=m} a_m(X_{n-i+1} - X_i)$$

where $m = n/2$ and a_1 to a_m represents a series of coefficients supplied in Shapiro and Wilk (1965:603-604). Then, calculate a ratio W, where b^2 is divided by the total squared deviation from the mean. Finally, refer the W statistic to a table given in Shapiro and Wilk (1965:605).

The 0.1 significance level demarcated rejection of the null hypothesis of no difference between the observed and a normal distribution. Computed values of the W statistic <u>smaller</u> than the tabulated value indicate significance, i.e., non-normality. The p value provides the probability of obtaining a computed W statistic as small or smaller than that actually computed, assuming the null hypothesis is true. Therefore, the p value is the probability of falsely rejecting a true null hypothesis. Here p values greater than 0.1 indicates failure to reject the null hypothesis at a 0.1 significance level and therefore suggesting that the sample could have been drawn from a normally distributed population of rind measurements.

Results

In Table 3 the results of the W test on the 10 California samples show significance (i.e., rejection of the null hypothesis) on four samples and nonsignificance (i.e., failure to reject the null hypothesis) in six samples. Four samples of rind measurements appear to not have been drawn from a normally distributed population. In six of the 10 samples the hypothesis that rind measurements from flakes produced during a single occupational episode show a normal distribution is supported.

Discussion

Four samples do not support the working hypothesis, yet they fulfill the criteria necessary to do so. Perhaps the assumptions and or the hypothesis are wrong. Answering this question may require further advances in understanding the hydration phenomena. But if the hypothesis is correct, the nonconfirmatory samples must be explained. Visual summaries such as box and whisker plots (Figure 15) provide another method of presenting the data (Hartwig and Dearing 1981, McGill et al. 1978).

Figure 16 illustrates box and whisker plots of the hydration data from the Californian site. The vertical lines or hinges forming the left and right sides of box enclose the "interquartile range" or midspread. The thick line within the box marks the median. Half of all the cases

Table 3. Results of W Test on Hydration Measurements from California Site Samples.

Site	N	W Stat	Prob $<$ W	H^o at 0.1 Significance Level
Barrow	6	.67	.01	reject
INY 222	7	.89	.35	fail to reject
+ INY 372(a)	8	.90	.35	fail to reject
INY 372(b)	8	.90	.35	reject
INY 372(c	10	.55	.01	reject
INY 372(d)	5	.93	.54	fail to reject
LAN 264	4	.95	.59	fail to reject
MAD 179	9	.88	.23	fail to reject
MNO	22	.88	.02	reject
SBC 128	5	.88	.34	fail to reject

Table 4. Results of W Test on Hydration Measurement After Chauvenet's Criteria Dictated Removal of Extreme Observations.

Site	N	W Stat	Prob $<$ W	H^o at 0.1 Significance Level
Barrow	5	.88	.35	fail to reject
INY 372(b)	7	.88	.28	fail to reject
INY 372(c)	9	.92	.43	fail to reject
MNO	20	.93	.20	fail to reject

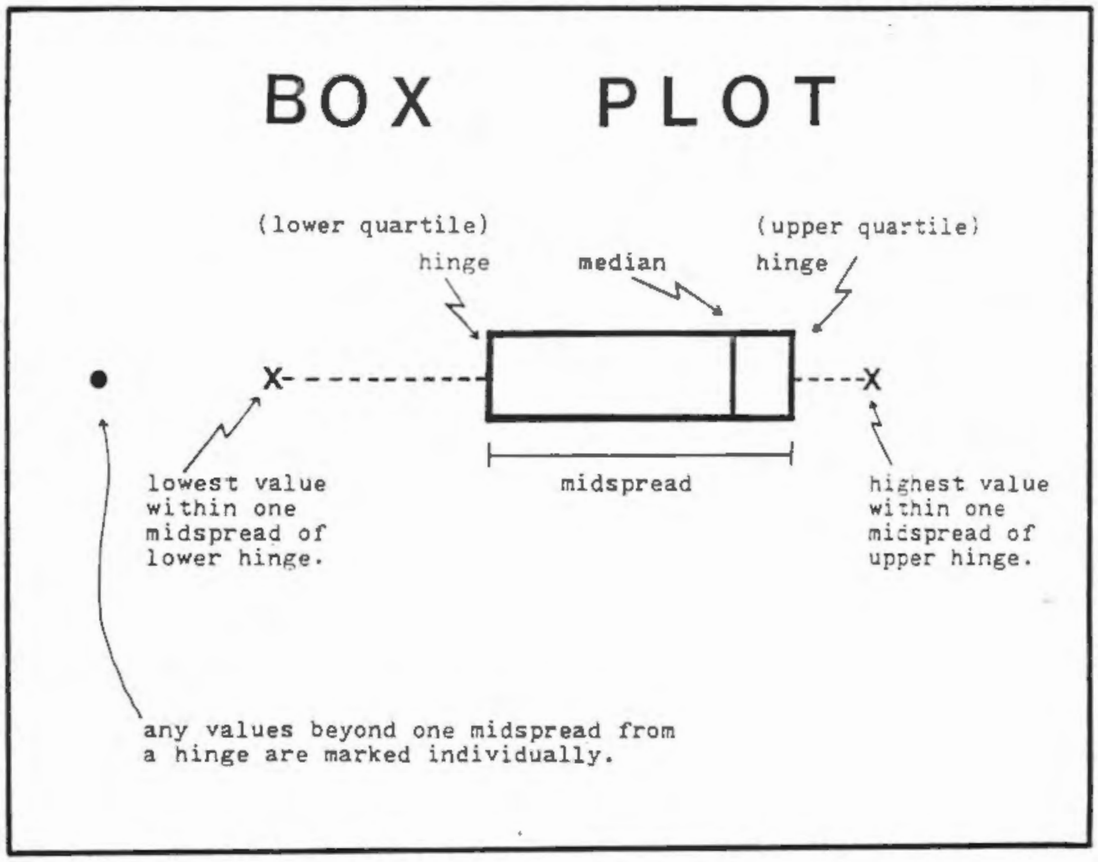

Fig. 15.--Key for box and whisker plots.

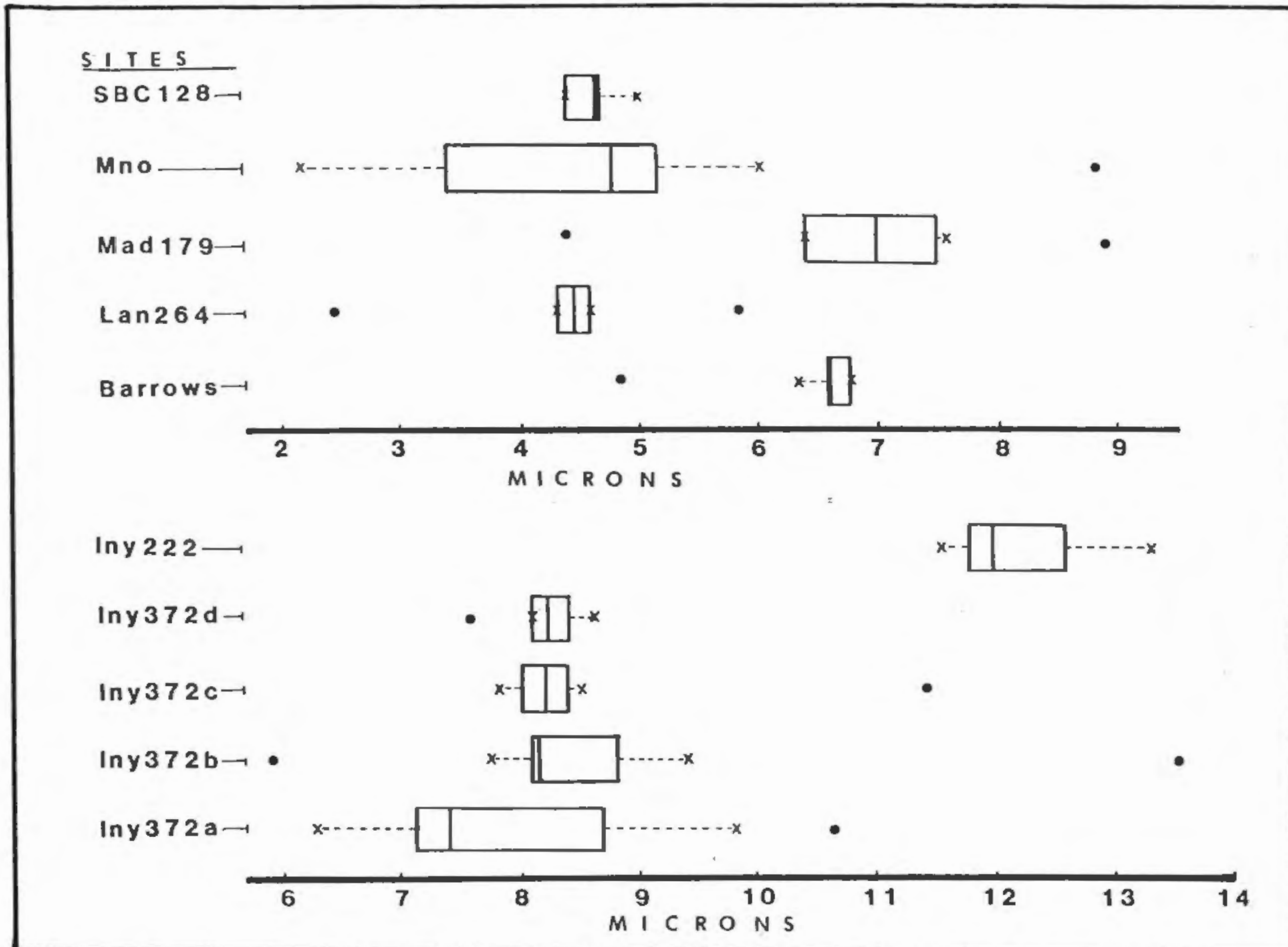

Fig. 16.--Box and whisker plot of hydration measurements from the California sites.

in the sample lie within the box. The "X's," connected to the box with dashed lines, known as whiskers, mark the cases farthest from, but still within one midspread of a hinge, cases beyond one midspread of a hinge are marked individually with closed circles (Figure 15).

Approximately 95% of all cases in a normal distribution will lie within the range defined by the endpoints of the whiskers. Thus, a box and whisker plot that contains a value that deviates widely from the whiskers, illustrated by individually marked values, may indicate a departure from normality (Hartwig and Dearing 1981:24).

Examination of the box and whisker plots show that four samples (Barrows, Iny 372b, In6 362c, and MNO) contain one or two extreme outlying cases. It is these four samples that fail to approximate a normal distribution in the W test. If the extreme values were removed from the four samples perhaps a W test of them would indicate a normal distribution.

Manipulation of the data in such a manner might be considered cheating. However, using Chauvenet's criterion (Long and Rippeteau 1974), one can justify such manipulaiton given certain archaeological knowledge about the data and site as a whole. If the source requirements and assumptions about the hydration phenomenon truly operate, then outliers should represent mixing of the deposits. The outliers are interpreted as coming from a population of flakes that were produced at another time. Cultural or environmental agencies mixed a small amount of obsidian from such an event, into the primary deposit which should exhibit a normal distribution. I cannot manipulate the California data with absolute confidence because I know nothing about the details of each site's stratigraphy. However, as an exploratory analysis with hydration measurements, some manipulation with the above cautions in mind, appear justified.

Chauvenet's criteria[1] dictates rejection of outlying values in each of the four samples (8.8, 16.5, 11.4, and 4.8 in MNO, Iny(b), Iny(c), and Barrows respectively) whose W statistic indicated rejection of the null hypothesis. Each sample then underwent a recomputation of the W statistic. The results (Table 4) show failure to reject a null hypothesis of normally distributed rind measurements If the removal of aberrant rind measurements can be justified, then these results lend further credence to the working hypothesis (i.e., obsidian artifacts created at the same time or within a short period of time exhibit normally distributed hydration measurements). Upon acceptance of this hypothesis, archaeologists can employ the W statistic to assist in an assessment of the integrity of archaeological sites or components that do not enjoy the virtures

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[1]The criteria of Chauvenet rejects data that has a probability of occurrence of less than 1/2n. Thus if 10 hydration measurements are averaged, any with a probability of occurence of less than 0.05 (i.e., greater than 1.96 standard deviation units from the total group mean) may be eliminated.

of clearcut stratigraphy and radiocarbon associations. To this end, I applied the working hypothesis and statistical procedure to the two undated lithic scatters under study in this report.

Using the W Test on the Strandline and Ni-rak Sites

The Ni-rak and Strandline sites occur on residual alluvial gravels within the secondary source deposit of Topaz Mountain obsidian. For this reason, one can conclude that all obsidian artifacts are derived from the same source i.e., Topaz Mountain. The next closest known obsidian source occurs in the Black Rock Desert 115 km south of Topaz Mountain.

The second requirement, that all artifacts experienced a similar post discard environment, is assumed. All artifacts were collected from the surface. Undoubtably, some artifacts are buried slightly as others become exposed to the surface, some are shaded by vegetation, others are exposed to direct sunlight. However, as the assumption dictates, over time the environmental factors affecting hydration rate occur at random on all artifacts.

Sample size is the third consideration. As yet there is no agreement on the absolute number or minimum relative proportion which should be sampled for hydration analysis. Samples of anywhere from 8 to 25 specimens per site or component seem to satisfy most hydration analysts (Jackson 1982, personal communication). The appropriate sample size also depends on the population size and the archaeological context of the obsidian artifacts. For the Ni-rak and Strandline sites the population consisted of all obsidian artifacts observed (and therefore collected) on the surface. Nine artifacts from the Strandline site and 10 artifacts from the Ni-rak representing 19.6% and 3.4% of the respective populations were selected and cut for hydration measurements (Table 5).

Results

For the two sites the W test will provide an objective guide as to whether the artifacts within each site represent a single or multiple occupational event, given that the assumptions described previously are correct and have been met. If the test statistic is significant, revealing a non-normal distribution of rind measurements, the artifacts representing such a site were probably not created within a short period of time. A non-significant W statistic suggests that the site contains a single and discrete occupation.

Using the same null hypothesis and significance level as before, the results of the W test on the two lithic scatters are summarized in Table 6. Both samples of hydration rind measurements failed to reject the null hypothesis at the 0.1 significance level, leading to the conclusion that those two sites contain artifacts that were created, used, and discarded within a single or short period of time. In addition the Box and Whisker plots of hydration measurements for the Strandline and Ni-rak sites indicate

Table 5. Obsidian Hydration Measurements from the Strandline and Ni-rak Sites.

Site	Hydra (Microns)
42Jb273	3.54
Strandline	2.52
	3.15
	3.21
	3.15
	2.78
	3.08
	2.84
	2.52
42Jb282	2.78
Ni-rak	2.61
	2.66
	3.13
	2.99
	2.55
	2.63
	2.77
	2.85
	2.40

Table 6. Results of the W Test on Hydration Measurements from the Strandline and Ni-rak Sites.

Site	N	W Stat	Prob $<$ W	H° AT 0.1 Significance Level
42Jb273	9	.94	.52	fail to reject
42Jb282	10	.98	.95	fail to reject

that artifacts were created at roughly the same time in prehistory (Figure 17).

Summary

I have demonstrated that, given certain assumptions about hydration, a sample of obsidian hydration measurements associated with a C-14 date and originating from a single stratigraphic unit will exhibit a normal distribution. The implications of this are important. If we understand that a radiocarbon date and stratigraphic cultural unit represent a discrete and single occupation of the site, then other sites, for example a surface site, which do not contain radiocarbon dates and/or well defined strata can be tested for single occupancy by performing the W test on a sample of hydration measurements. To this end, groups of hydration from two surface lithic scatters in west-central Utah received W test analysis. Statistical results indicate that the two sites probably contain single occupations. Although this statistical analysis does not replace detailed excavation and stratigraphic analysis, it does provide an alternative means to assess the occupational history of surface confined lithic scatters. This analysis is an important prerequisite for a technological analysis of a flaked stone artifacts because undetected multiple occupations would result in an erroneous description of the lithic technology.

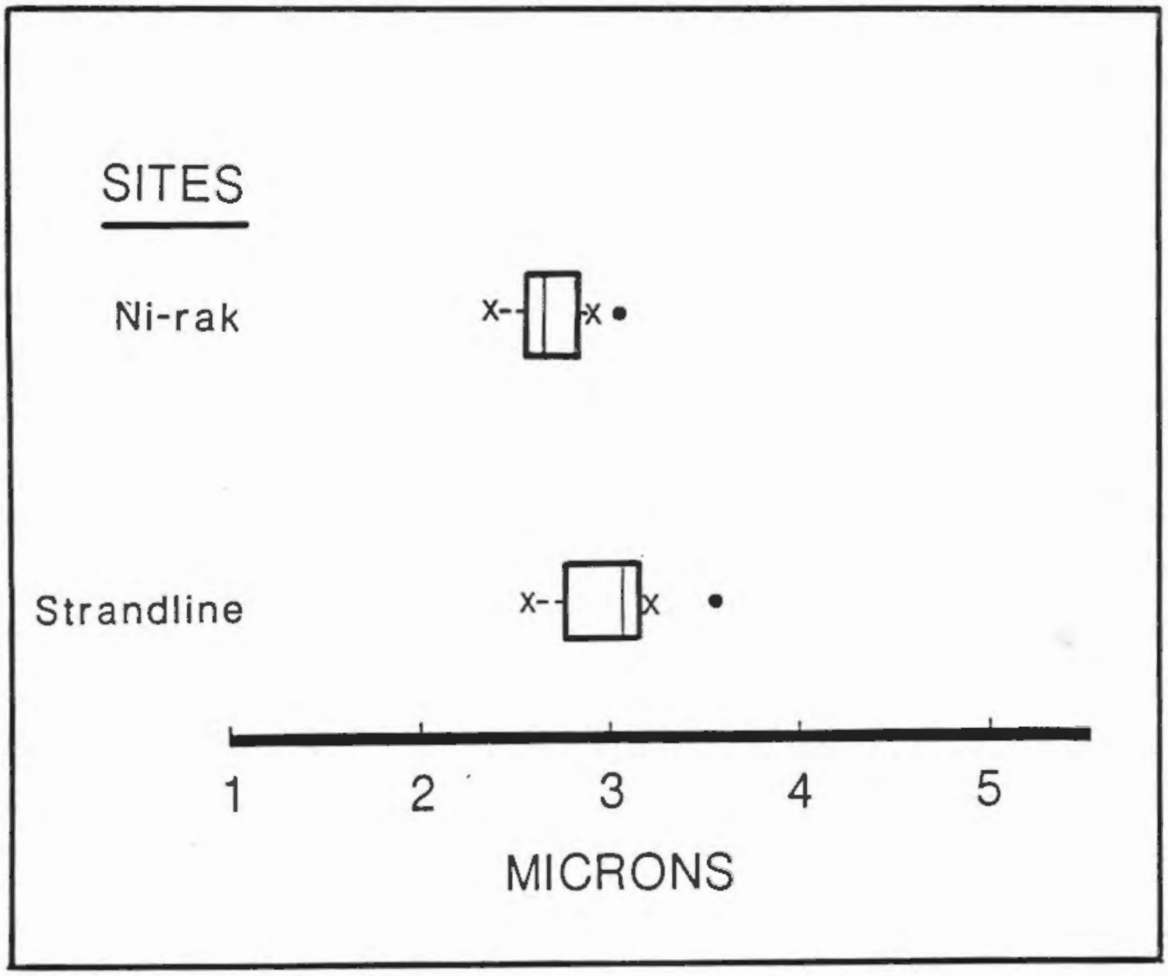


Fig. 17.--Box and whisker plots of hydration measurements from the Strandline and Ni-rak sites.

CHAPTER 5

ANALYSIS OF FLAKED STONE TECHNOLOGY AT THE NI-RAK AND STRANDLINE SITES

Methods and Procedure

All the flaked stone artifacts, including debitage produced and left at the Ni-rak and Strandline sites can be analyzed to determine the aboriginal lithic reduction technology. The archaeological debitage and other artifacts serve as raw data to guide replicative experiments that attempt to demonstrate the aboriginal reduction technology. Thus, the first step in this analysis involves a description of the aboriginal artifacts with respect to the morphological attributes that reflect the technology of their manufacture. This description is preceeded by a series of definitions of terms commonly used to describe flaked stone artifacts. Morphological attributes on the artifacts that do not directly reflect the reduction technology were not considered in this analysis. Recognition of the pertinant technological attributes relied on over 80 replicative flintknapping experiments by the author. In practice, this involved observation of aboriginal artifacts, followed by flintknapping experiments designed to create morphologically similar artifacts. The technology of manufacture was noted in each experiment. The flintknapping experiments were repeated until the technology of manufacture for each artifact in the archaeological collection was determined. Identification of the aboriginal artifacts in this manner provided a guide for the second step in the lithic analysis, formal replication.

The second step in this lithic analysis describes the results of 20 formal replication experiments. Replication is reproducing stone artifacts, using the aboriginal artifacts as controls, with stoneworking fabricators similar to ones used aboriginally, employing the same raw materials, and following what can be demonstrated as the same reduction technology (Flenniken 1981:2). The replication experiments described here demonstrate the aboriginal reduction technology at the Ni-rak and Strandline sites.

The third part of the lithic analysis includes a comparison of the frequencies of aboriginal and replicated artifact categories. This comparison provides data to discuss the role of transportation, curation and expediency in the lithic technology at the Ni-rak and Strandline sites.

The analysis of archaeological artifacts and demonstration of the aboriginal lithic reduction technology provides data to discuss two factors of the lithic reduction technology: 1) the size and shape of the raw material transported into the site before reduction commenced and, 2) the size and shape of lithic by-products transported out of the site of its prehistoric occupants. Successful replication of the aboriginal artifacts demands that the size, shape, and type of lithic raw material used in the replicative experiments be similar to the lithic material transported into, and used aboriginally at the Ni-rak and Strandline sites.

It is more difficult to accurately discuss the kinds of lithic by-products that may have been transported out of the site by its prehistoric occupants. A successful replication of the aboriginal lithic reduction technology may contain debitage types that are under-represented in the archaeological collection. However, does the under representation result from cultural selection and transportation of artifacts out of the site as part of the technological strategy practiced by the prehistoric occupants? Or, have natural and other cultural agencies, unrelated to the aboriginal technological behavior, removed artifacts from the sites?

The forces of erosion, sedimentation and soil formation may have removed artifacts from the Ni-rak and Strandline sites. Although these sites appear to be confined wholly to the surface, no subsurface excavation was conducted to verify this assumption. However, their locations on flat land-forms suggest that the artifacts have not been recently revealed to the surface by erosion. Furthermore, the small size, yet dense arrangement of artifacts of the Ni-rak and Strandline sites suggests that deflation and natural scattering of the artifacts has not greatly disturbed the original site contents.

However, the complete absence of artifacts smaller than 15 mm at the Ni-rak and Strandline sites suggests that something has affected these sites. Relic collecting appears to be an unlikely explanation. The sites occur in a remote area in a monotonous landscape that has little attraction to recreationists and amatuer archaeologists. My conversations with local relic collectors revealed that the Pismire Dune field, 16 km from the Ni-rak and Strandline site, was the favorite place for their exploits. Furthermore, most relic hunters do not collect flakes of stone smaller than 15 mm. Indeed, one wonders whether flakes smaller than 15 mm would have even interested the people who manufactured them prehistorically. We can never know this, but examination of debitage produced in replicative experiments that were smaller than 15 mm allows three general conclusions. First, over 70% of the debitage is smaller than 7 mm (and would fall through a 1/4 inch screen). Second, most of the flakes smaller than 15 mm are too small to hold comfortably for any use, and too thin to use without breaking. Finally, most of this material is shatter, the fragmentary bits and pieces of flakes that do not contain features diagnostic of the method and stage in lithic reduction. The first two observations would mitigate the possibility of selection and removal of this material by the prehistoric occupants at the Ni-rak and Strandline sites. The third observation indicates that these small flakes have little value in the technological analysis conducted during this research.

Experiments by Bruder (1979) have shown that at lithic scatters the smallest artifacts are lost due to winnowing, sedimentation, and soil formation. For the purposes of this study it will be assumed that at the Strandline and Ni-rak site the forces of erosion and sedimentation have removed artifacts smaller than 15 mm. Furthermore, the artifacts recovered from these sites represent the actual population of artifacts larger than 15 mm that were manufactured and left at these locations by the prehistoric occupants. Consequently, in all replication experiments artifacts produced that were smaller than 15 mm were removed from this lithic analysis.

Obsidian from Glass Butte, Oregon was used for the replication experiments. Not enough obsidian was collected from the Topaz Mountain source, especially the secondary deposits, to conduct extensive replications with this material. The Topaz Mountain obsidian was used as a standard from which obsidian pebbles from Glass Butte were evaluated for size, shape, surface texture, and flakeability. Glass Butte pebbles (4 to 64 mm in maximum dimension) sufficiently similar with the Topaz Mountain raw material were used in the replications. The pebbles used in the replications ranged from 30-64 mm in diameter and were subangular in shape. Figure 14 shows obsidian pebbles from Topaz Mountain and Glass Butte.

Definitions

The following includes definitions of terms commonly used in this lithic analysis. The reader is directed to Crabtree (1972) for further elaboration on these and other terms.

Blank. A usable piece of lithic material of adequate size and form for reduction and/or use as a tool. A blank might be an unmodified flake representing an early stage in a reduction process.

Bulb of Force. (Cone of force) The bulbar part, or the remanant cone on the ventral side at the proximal end of a flake. The bulb is the result of either pressure or percussion.

Core. Any flake or nodule from which flakes have been removed.

Cortex. The natural surface or rind on flakeable materials. Incipient cone cortex refers to a surface that is pock-marked due to numerous light applications of force as a result of rolling, and battering. It is common on redeposited raw material in colluvial and alluvial sediments. Natural geologic cortex resembles a smooth patination that results from in-place weathering where the obsidian was first exposed to the surface.

Debitage. This is the residual material, including flakes and shatter produced and left from all stages of stone reduction and tool manufacture.

Facet. See flake scar.

Flake. Any piece of stone removed from a larger mass by the application of force. Figure 18 illustrates the several common flake attributes. Length of a flake refers to the dimension defined by a line parallel with the direction of applied force from the platform to opposite or distal end. Width refers to the dimension defined by a line perpendicular and on the same plane as the length dimension.

Flake Scar. The facet or face left on an artifact as a result of flake removal. A positive flake scar shows remanants of the bulb of force. A negative flake scar shows remanants of the mirror surface of the cone of force, and is always on an item from which a flake was previously removed.

Platform. The surface area receiving the force necessary to detach a flake.

Artifact Description

The following artifact descriptions are based on morphological attributes that reflect the pebble core and flake technology. Recognition of these traits derives from over 80 replications by the author, and terminology established by Crabtree (1972), and Flenniken (1981). Four flaked stone artifact types characterize the pebble core and flake technology: split pebbles, flakes, exhausted cores, and unidentified shatter.

Split Pebbles. Two types of split pebbles occur in the archaeological collections,"split pebble flakes" and

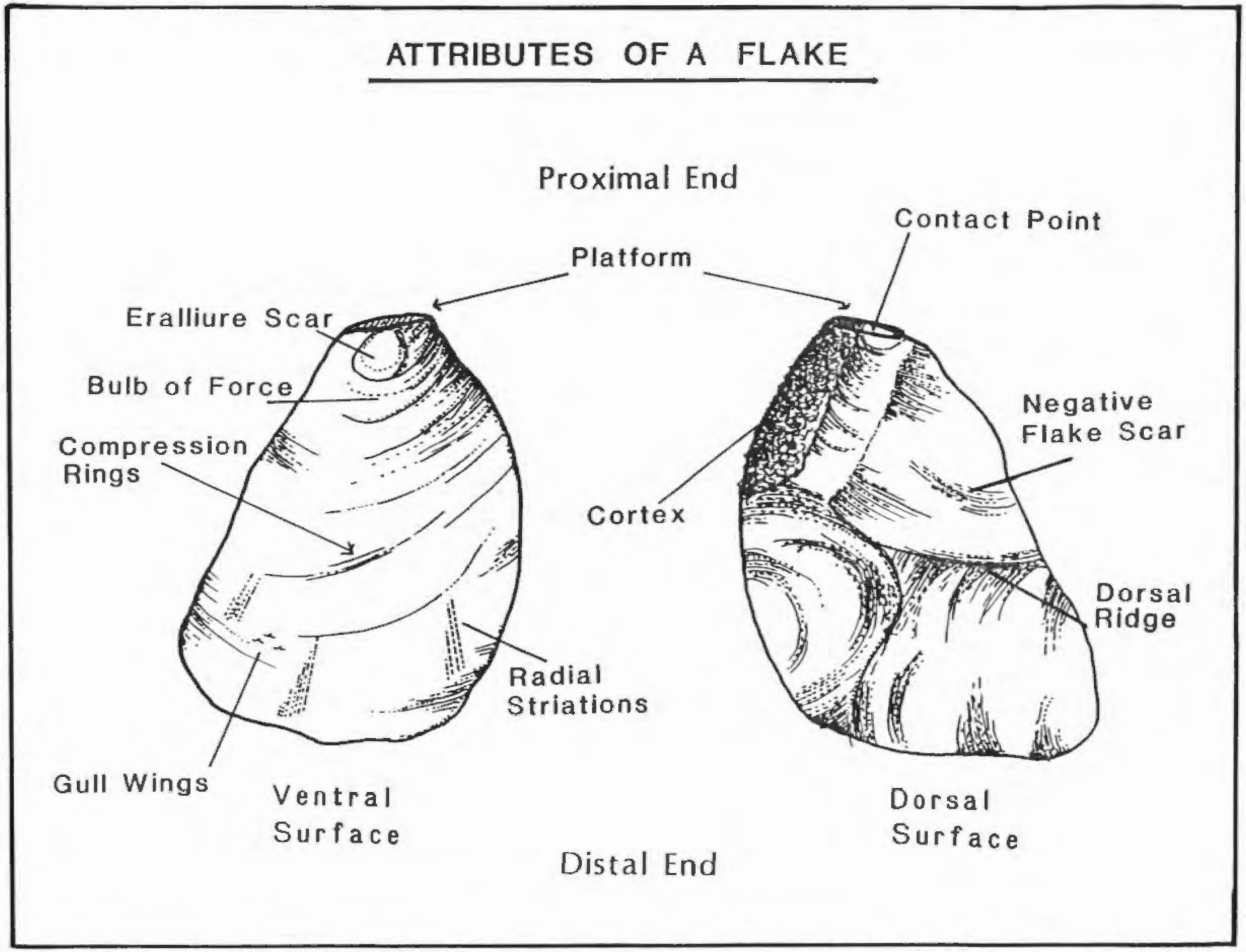


Figure 18. Attributes of a flake.

"split pebble cores". Split pebble flakes are completely covered with cortex on the dorsal surface and are completely covered with a single positive flake scar on the ventral surface. These flakes are from 3mm to 20 mm thick. Several of the thicker flakes may represent one half of an obsidian pebble. The Ni-rak site contains 11 split pebble flakes that refit with complimentary split pebble cores. Artifacts with a single negative bulbar scar on one face and totally covered with cortex on the opposite face represent the "split pebble core" from which the first split pebble flake was removed. Split pebble cores were only classified as such if they refit with a complimentary split pebble flake to form a whole pebble.

Flakes. Four flake types characterize the pebble core and flake technology at these two sites. 1) "Linear cortical flakes" are longer than they are wide. The dorsal surface is partially covered with cortex and contains only one negative flake scar. These flakes are frequently the largest and thickest in the assemblage and have a triangular cross section. With the second flake type, "broad cortical flakes", length is always less than or equal to width. These flakes may have one or more negative flake scars on their dorsal surfaces. Cortex usually occurs as a narrow band that starts at the platform and follows one lateral margin of the artifact. The distal end of these flakes often has a rounded cross-section indicating a hinge fracture termination (Crabtree 1972:68).

"Linear multifaceted flakes" are longer than wide, but unlike linear cortical flakes they contain more than one flake scar on their dorsal surfaces. Cortex may be present or absent on the dorsal surface of these flakes. "Shatter" includes all non-diagnostic flakes which were so fragmentary that they could not be placed in any of the flake categories. Although most flakes without platforms could be placed into one of the first three categories, flake missing considerable portions of their proximal, distal, and/or lateral ends comprise this fourth flake category.

Exhausted cores. Exhausted cores comprise the third major artifact category of this pebble core and flake technology. Exhausted cores are identified by the presence of flakes scars which exclusively contain negative bulbs of force. There are three categories of exhausted cores; 1) unificial, 2) faceted platform, and 3) core fragments.

"Unifacial exhausted cores" contain negative flake scars originating from one or more cortical platforms around the periphery of the core. The cortex covered margin serves as the platform, and cortex covers one face of the artifact entirely. Most exhausted unifacial cores contain several flakes scars indicative of many flake removals that failed to section the core completely. However, 13 of 58 (22.4%) exhausted unifacial cores at the Strandline site contain only one negative flake scar, indicating that the last flake removed left a scar that encompasses the entire face of the core. These artifacts are necesssarily classified as exhausted unifacial cores because matching split pebble flakes were not discovered during attempts to reconstrust pebbles.

"Exhausted faceted platform cores," like exhausted unifacial cores are covered by cortex on one face. However, the negative flake scars on these artifacts originate, not only from cortical platforms, but also from platforms created by other flake scars left by previous flake removals. The flake scars of one face serve as a platform for removal of flakes from another face.

"Core fragments" are pieces of unifacial or faceted platform cores. These are identified by the presence of a cortical face and a face faceted by flake removals. Yet these items also contain a flake scar indicative of breakage due to shearing of the cone of force, perhaps during an attempt to remove a flake. A shearing flake scar is flat with little or no bulb definition (Crabtree 1972:42; Trisk in Flenniken 1981:31).

Unidentified. This last artifact category includes non-diagnostic debitage. These items lack platforms and bulbs of force, and are usually small chunks (Binford and Quimby 1963:347). Unidentifiable shatter are fragments of split pebbles, flakes, and exhausted cores.

Tables 7 and 8 present the frequencies and percentages of artifact types from the Strandline and Ni-rak sites. In light of these data, replicative analysis was carried out

Table 7. Frequency and Percentages of Artifacts from the Strandline and Ni-rak Sites.

Artifact type	Ni-rak		Strandline	
	N	%	N	%
Split pebble flakes	17	32.1	29	10.9
Split pebble cores	11	21.0	-	-
Linear cortical flakes	2	3.9	18	6.8
Linear multi-scar flakes	2	3.9	30	11.3
Broad cortical flakes	3	5.8	44	16.5
Flake shatter	-	-	21	7.9
Unifacial exhausted cores	14	27.5	58	21.8
Faceted platform exhausted cores	3	5.8	22	8.3
Exhausted core fragment	1	2.0	21	7.9
Unidentified debitage	-	-	23	8.6
Total	51	100%	266	100%

Table 8. Summary of the Frequency and Percentages of Artifacts from the Strandline and Ni-rak Sites.*

Artifact type	Ni-rak		Strandline	
	N	%	N	%
Split pebble flakes & Split pebble cores	6	19.4	29	10.9
Flakes	7	22.5	113	42.5
Exhausted cores	18	58.0	101	38.0
Unidentified debitage	-	-	23	8.6
Total	31	100%	266	100%

*Note: The 22 matching split pebbles from the Ni-rak site were removed from the table.

to address three aspects of the lithic technology at the Ni-rak and Strandline sites: 1) The size and shape of the obsidian imported into the sites, 2) the reduction technology, and 3) whether or not the flaked stone products of the reduction technology were transported out of the sites.

PROCUREMENT OF RAW MATERIAL

The following observations indicate that obsidian reduced at the Ni-rak and Strandline sites was obtained from the immediate vicinity of each site. First, both sites occur within the secondary source areas. Second, incipient cone cortex, an attribute of the secondary source deposits, characterizes all aboriginal artifacts which contain cortex. Furthermore, large artifacts with cortex indicate that the unaltered raw material was subrounded to subangular in shape, a shape similar to unaltered obsidian pebbles from the secondary source deposits of Topaz Mountain. Finally, numerous small pebble and gravel size pieces of unaltered obsidian were recovered within the boundaries of both sites. It appears that procurement of raw material simply involved gathering obsidian pebbles from the secondary deposits, and establishing a site within this area. Obsidian pebbles from Glass Butte, Oregon with the same morphology as secondary source obsidian from Topaz Mountain were employed in the replication experiments. Figure 14 illustrates Topaz Mountain and Glass Butte obsidian pebbles.

THE PEBBLE CORE REDUCTION TECHNOLOGY

Splitting the Pebble

The first step in pebble core reduction (Figure 19) entails splitting the pebble and removal of the first flake. The small size and subangular to subrounded shape of the obsidian pebbles requires specific flintknapping techniques to remove a flake. The raw material does not contain many surfaces that are adjacent to another surface forming an angle less than 90 . On spherical pebbles, few surfaces can serve as platforms that upon the application of force would result in removal of a flake from the pebble. Before thin flakes can be removed in a systematic manner, spherical to subangular obsidian pebbles must be broken to produce a platform that forms angles less than 90 . The prehistoric flintknappers at the Strandline and Ni-rak sites chose two techniques to initiate pebble reduction, bipolar and direct freehand percussion.

Bipolar Percussion

This bipolar technique involves resting an obsidian pebble on a solid anvil support and striking that object via direct percussion with a stone, bone, wood, or antler percussor (Figure 20) (Flenniken 1981:32). Crabtree (1972:42) states that bulbs of force and corresponding compression rings are not necessarily present on both ends of bipolar flakes and nodules split in this manner. Bulbs may not be present because the force induced from the percussor and force induced by the anvil are directly

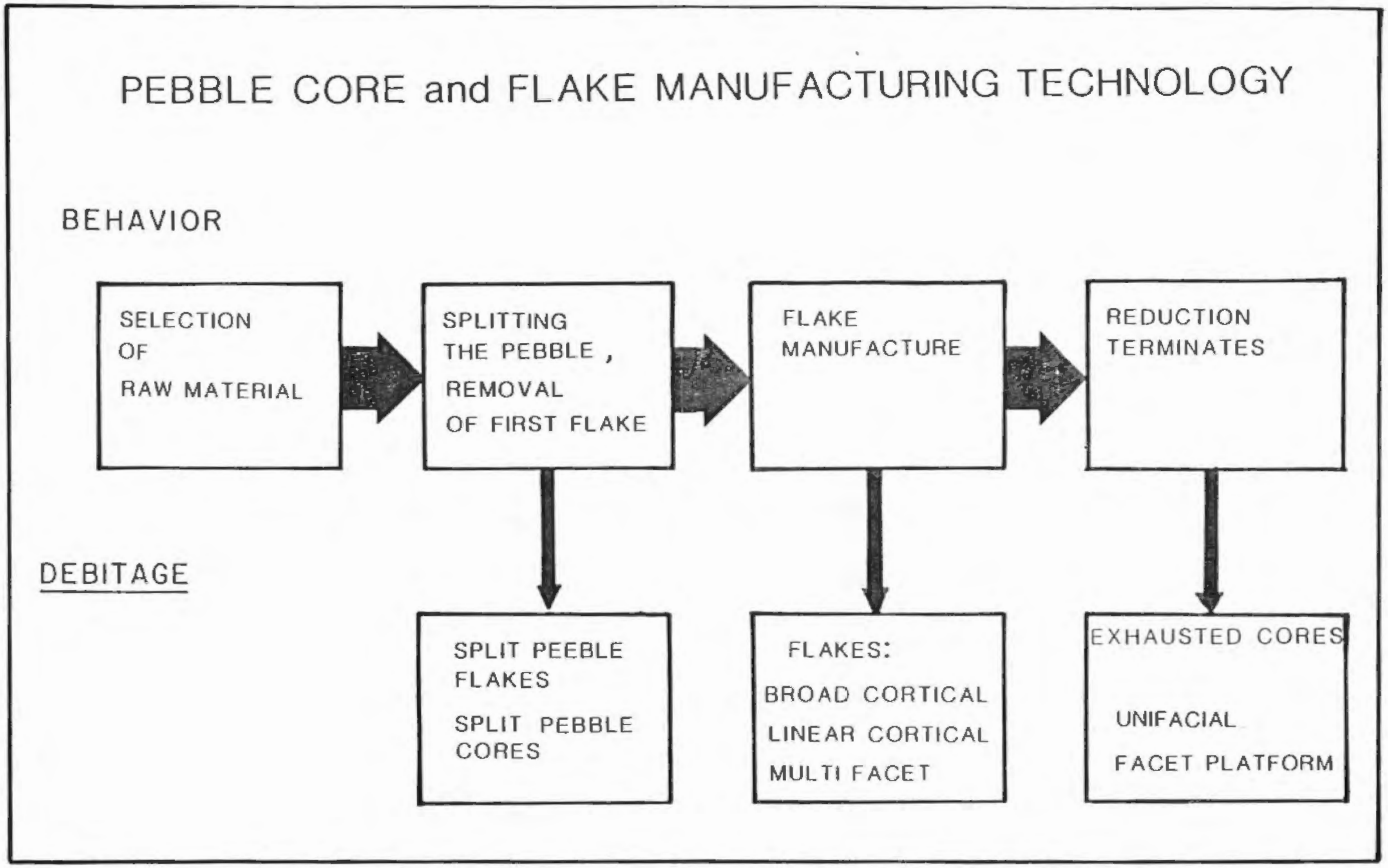
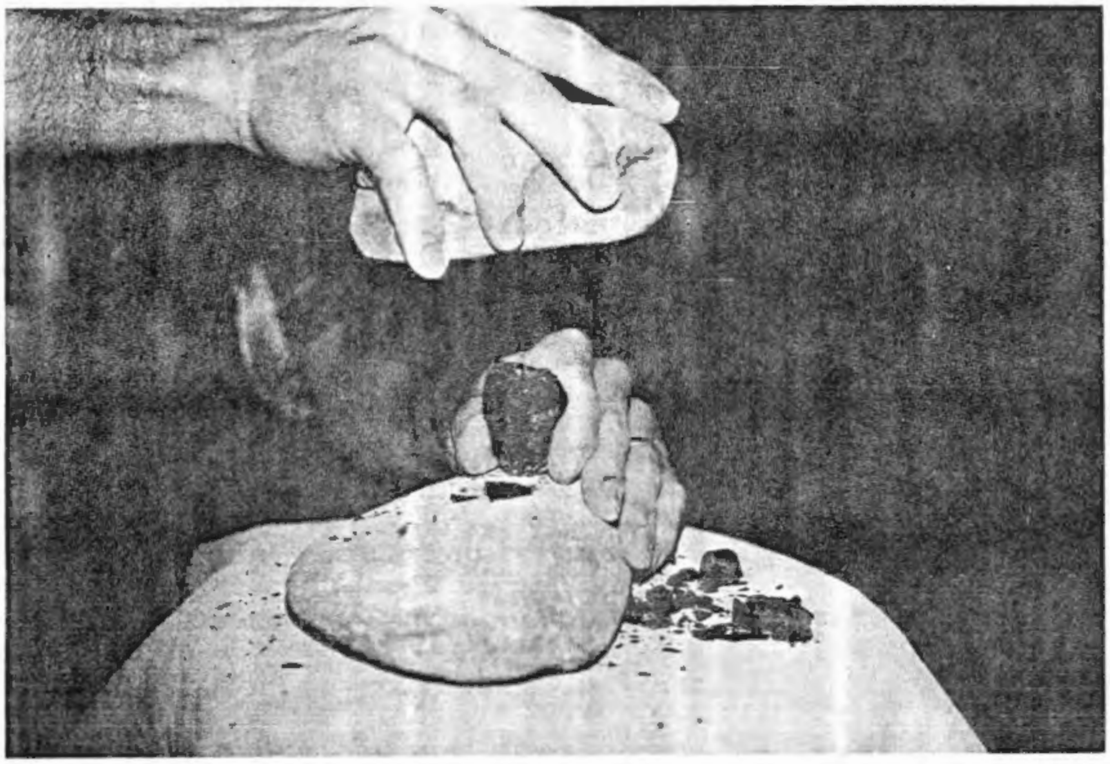
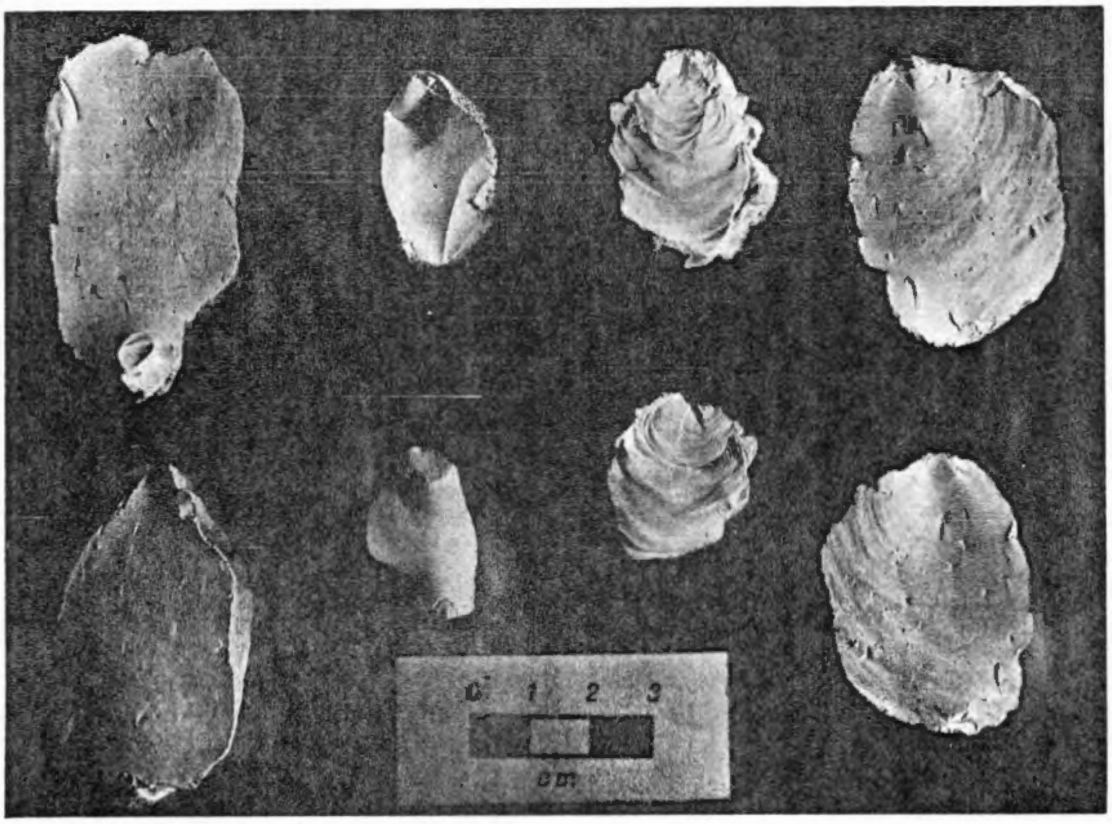


Fig. 19.--Pebble core and flake manufacturing technology.

Figure 20. Preparing to split a pebble with the bipolar technique.

Figure 21. Replicated split pebbles produced with the bipolar technique. Coated with ammonium chloride.

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opposite causing a severing, and occasionally shattering, of the cone of force (Crabtree 1972:10).

In this case the desired products produced from the bipolar technique are pebbles split into two pieces. However, when the knapper employs too much force the cone of force will shatter, split the pebble along several planes, and produce many long narrow flakes that are triangular in cross section. Technological attributes found on a split pebble core resulting from the bipolar technique often include pronounced compression rings, diffuse and/or severed bulbs of force, collapsed and crushed platforms, and anvil resting points, plano flake scar, and cortex covering one face of the artifact (Figure 21) (Hayden 1980, Flenniken 1981:32).

Many of the replicated split pebbles do not contain all the classic attributes of the bipolar technique, despite the use of this technique. These artifacts result from shearing the pebble. Shearing occurs when the force applied in a bipolar technique does not define a straight fracture plane through the pebble, but instead, travels only part way through the length of the core (Flenniken 1981:32). Shearing may happen for one or more of the following reasons: 1) there is poor purchase between the anvil and pebble; 2) the pebble receives a glancing blow; and 3) the blow to split the pebble, or remove a flake fails to supply enough force to send a cone completely through the stone along an axis defined by the point of percussion and anvil resting point.

The morphological characteristics of shearing products are remarkably similar to the flakes produced by direct freehand percussion of obsidian pebbles split by the bipolar technique.

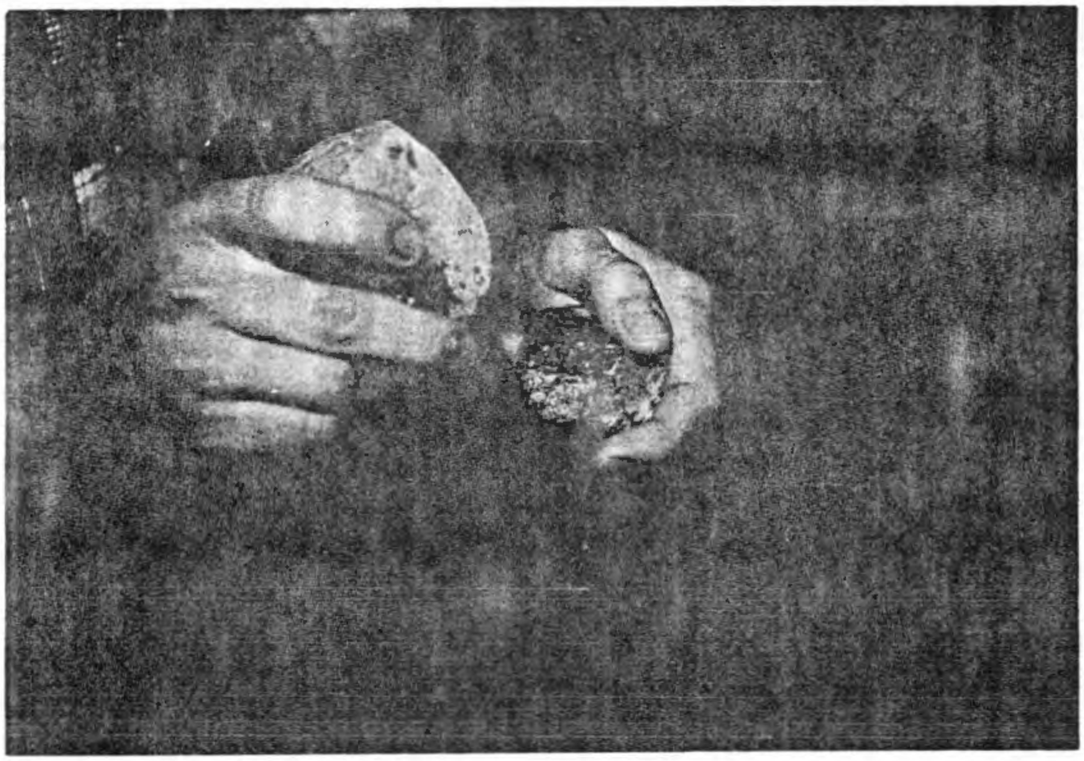
Direct Freehand Percussion

The second technique used to initially fracture small obsidian pebbles is direct freehand percussion. This technique involves firmly holding the obsidian pebble, in one hand without use of an auxillary support and striking that piece with a percussor of stone, to detach flakes (Figure 22). These flakes contain distinctive morphological features indicative of direct freehand percussion, including a pronounced bulb of force, diffuse compression rings, presence of radial striations, a curved profile, and one face covered with cortex (Crabtree 1972:12,44). Figure 23 presents replicated specimens of pebbles that have been split with direct freehand percussion.

Replication experiments indicate that direct freehand percussion is less successful than the bipolar technique at splitting pebbles into approximately equal halves. When applied to a sub-angular obsidian pebble, direct freehand percussion less often "split" a pebble into two halves, but instead "peeled" a large thick flake from the pebble core. Figures 24 and 25 illustrate aboriginal and replicated split pebble flakes and split pebble cores produced with direct freehand percussion.

Figure 22. Preparing to split a pebble with the direct freehand percussion technique.

Figure 23. Replicated split pebbles produced by direct freehand percussion. Top: flakes, Bottom: cores. Coated with ammonium chloride.



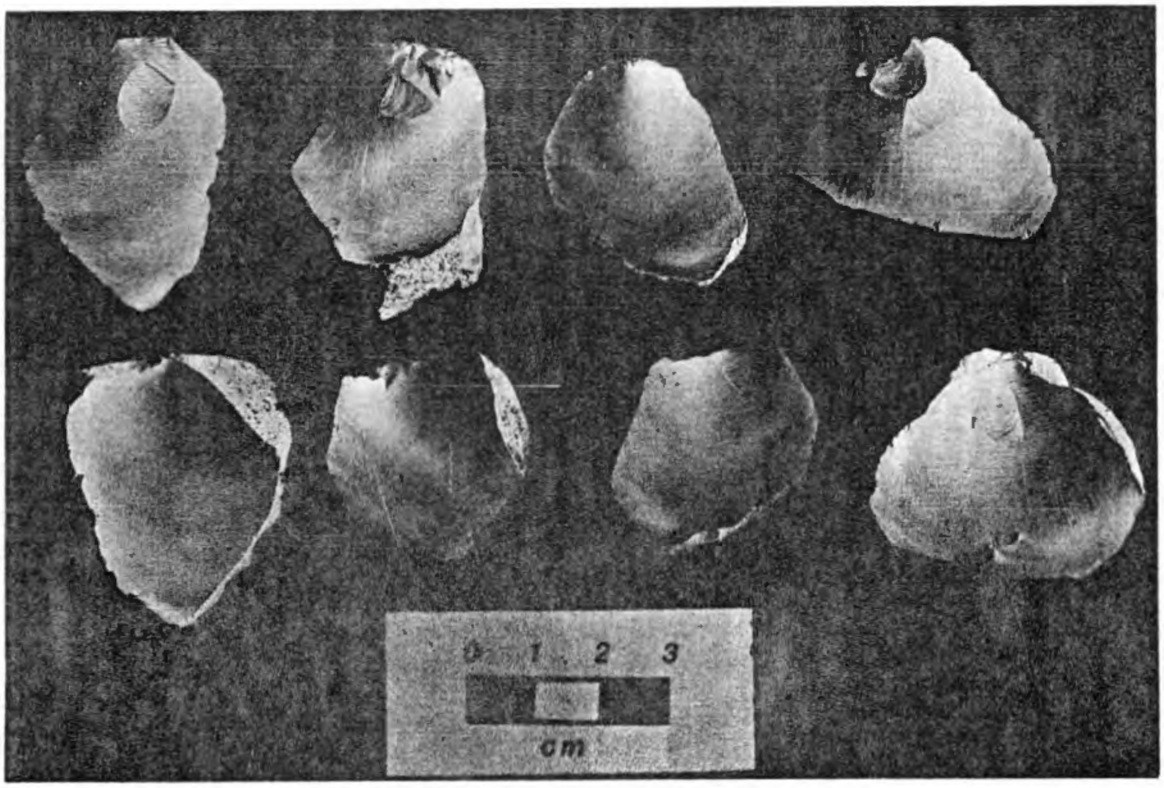

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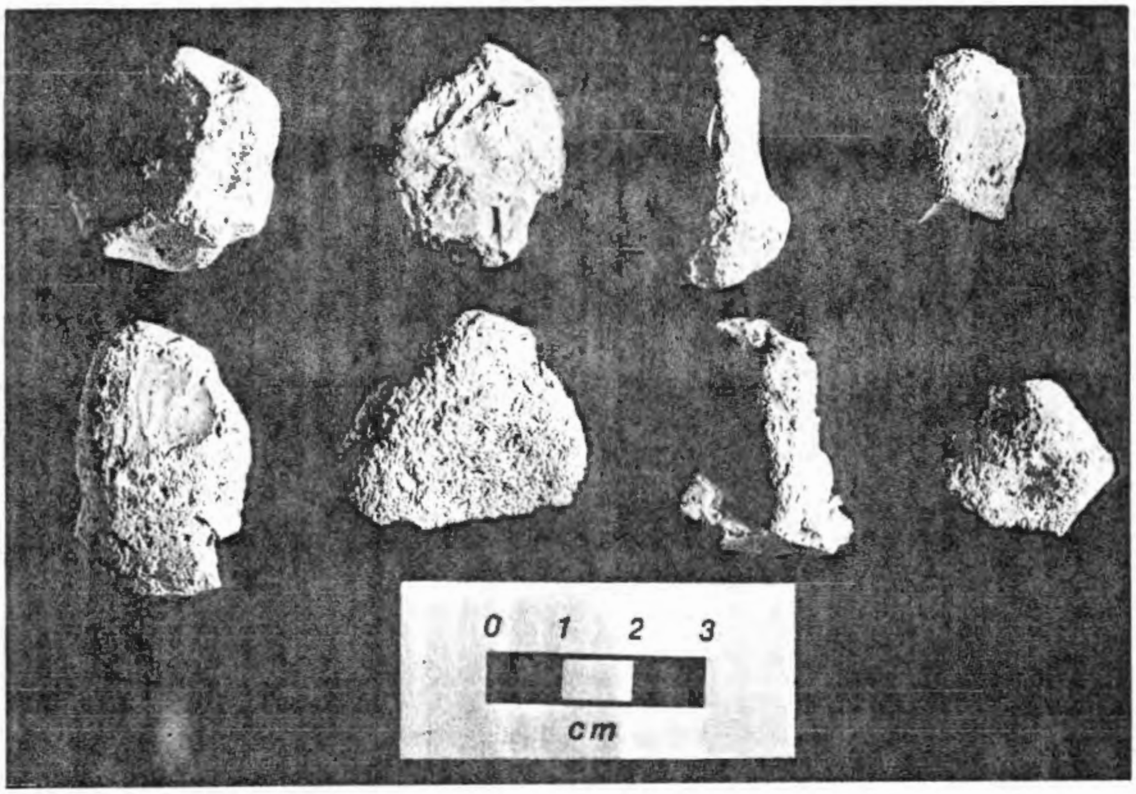
Figure 24. Dorsal surface of split pebble flakes.
Top: aboriginal, Bottom: replicated.
Coated with ammonium chloride.

Figure 25. Ventral surface of split pebble flakes.
Top: aboriginal, Bottom: replicated.
Coated with ammonium chloride.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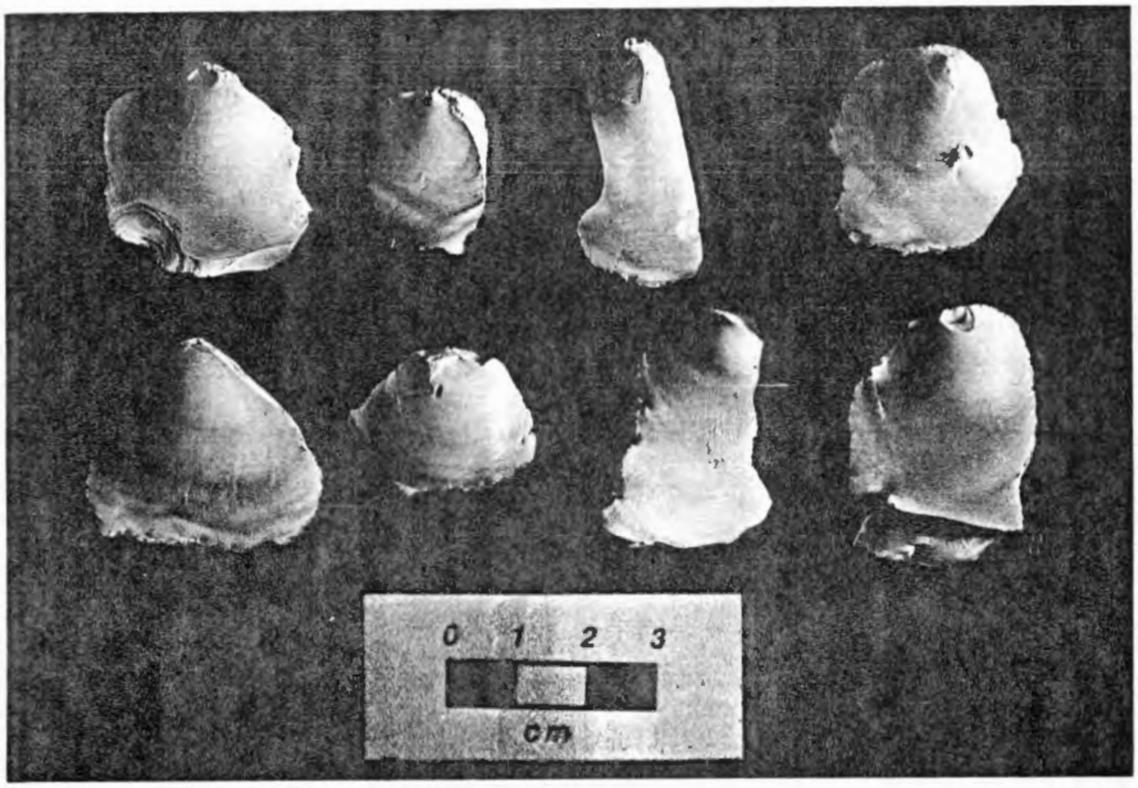
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A comparison of Figures 21 and 23 reveals that pebbles split by bipolar, and direct freehand percussion contain continuum of technological flintknapping attributes despite the distinct differences of technique used to produce them. For the aboriginal collections it serves little to debate whether one technique occurs in higher frequency than another. The prehistoric flintknappers used both techniques, depending on the shape of the unaltered pebble. Bipolar is most suitable for round pebbles, while direct freehand percussion allows the predictable removal of flakes from more angular pebbles. Although the choice of technique depended on raw material shape, it was secondary to the basic goal of initiating a fracture and splitting a pebble.

Twenty obsidian pebbles (Table 9) were selected for the final replication experiment. Pebbles 1 through 15 were split with direct, freehand percussion and 16 through 20 were split with the bipolar technique. The shape of the raw material dictated whether bipolar or direct freehand percussion techniques were used. Only 5 pebbles were selected for bipolar splitting because the lack of classic bipolar attributes on all, except 2 archaeological split pebble flakes, suggests that bipolar techniques had a limited role in aboriginal reduction technology. However, direct freehand percussion flaking of a core previously produced by bipolar techniques will obliterate attributes that would allow an archaeologist to identify the use of bipolar.

Table 9. Metric Attributes of Obsidian Pebbles Used in the Replication Experiments.

No.	Size (mm) length	width	thickness	Weight (grams)
1.	54	44	31	94
2.	49	39	37	95
3.	51	43	24	60
4.	39	32	31	63
5.	43	39	35	66
6.	35	23	26	47
7.	54	50	34	116
8.	45	40	27	63
9.	39	35	36	43
10.	39	34	27	50
11.	34	30	20	25
12.	41	39	18	39
13.	36	23	20	23
14.	35	34	23	30
15.	46	32	30	47
16.	51	35	28	60
17.	50	49	38	106
18.	57	40	34	84
19.	47	44	31	89
20.	42	46	33	61
$\bar{X}$	44.4	37.5	29.2	63.1

<u>Selecting a Split Pebble for Flake Production</u>

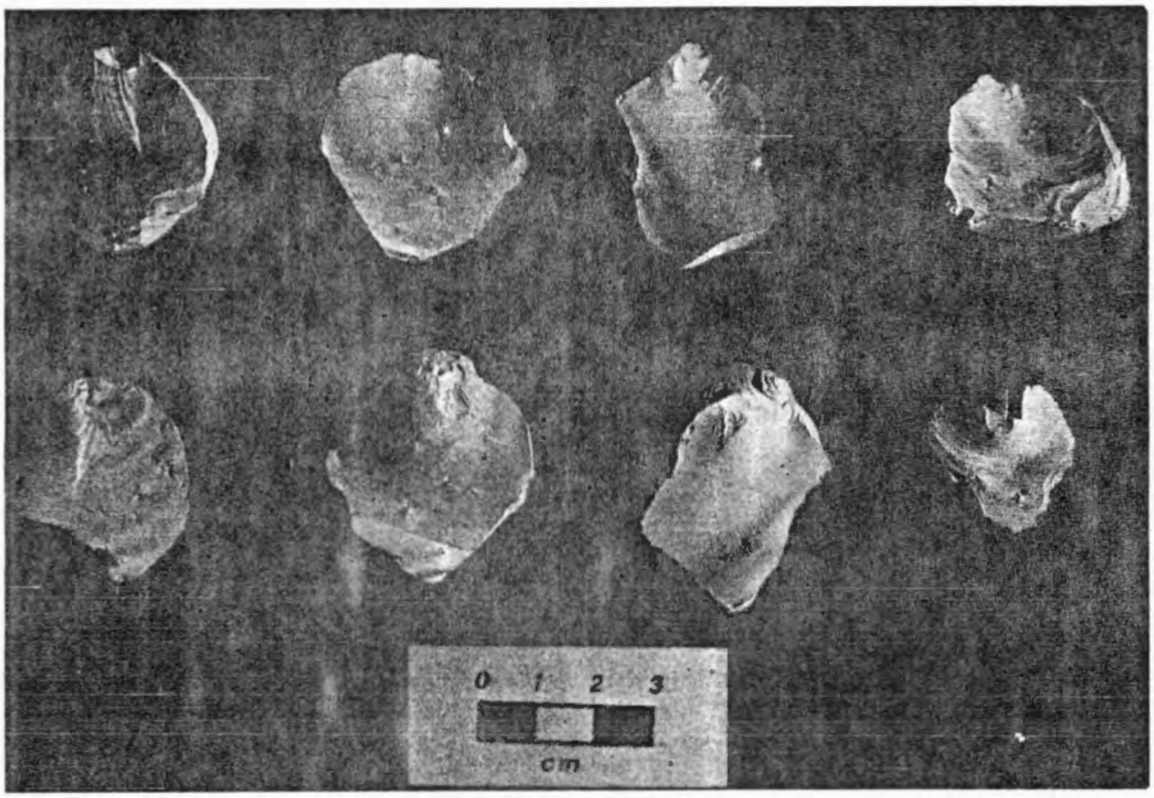
The Ni-rak site provides an interesting insight into aboriginal raw material selection behavior. Eleven split pebble cores refit with complimentary split pebble flakes forming a complete pebble. Thus, eleven times the aboriginal flintknapper split a rock and discarded both resulting pieces. These 22 artifacts comprise 43.1% of the whole collection. Why were these rocks unsuitable?

A close look at the flake scars may provide some answers. In 3 pairs the split pebbles shows phenocryst inclusions (Figure 26). Another pair reveals that a bubble of gas had been trapped inside the cooling obsidian as it coalsed into a pebble (Figure 27). Another pebble was not split completely through; the flake terminated in a reverse hinge fracture. These "imperfect" split pebble cores and flakes were probably perceived as unsuitable for further reduction and flake manufacture. Because the Ni-rak site is located within the secondary source area for Topaz Mountain obsidian, the prehistoric flintknapper(s) did not need to conserve this material. Instead they could abandon these pebbles and simply reach to the ground, and split open another pebble until they produced something that satisfied there needs.

After the pebble was split removing the first flake, the second step in the reduction process would commence. This involved selecting one or both of the split pebble artifacts to serve as a core from which flakes could be

Figure 26. Archaeological examples of matching split pebble cores and flakes from the Ni-rak site. Coated with ammonium chloride. Note saw cuts for hydration measurement.

Figure 27. Archaeological examples of matching split pebble cores and flakes from the Ni-rak site. Coated with ammonium chloride.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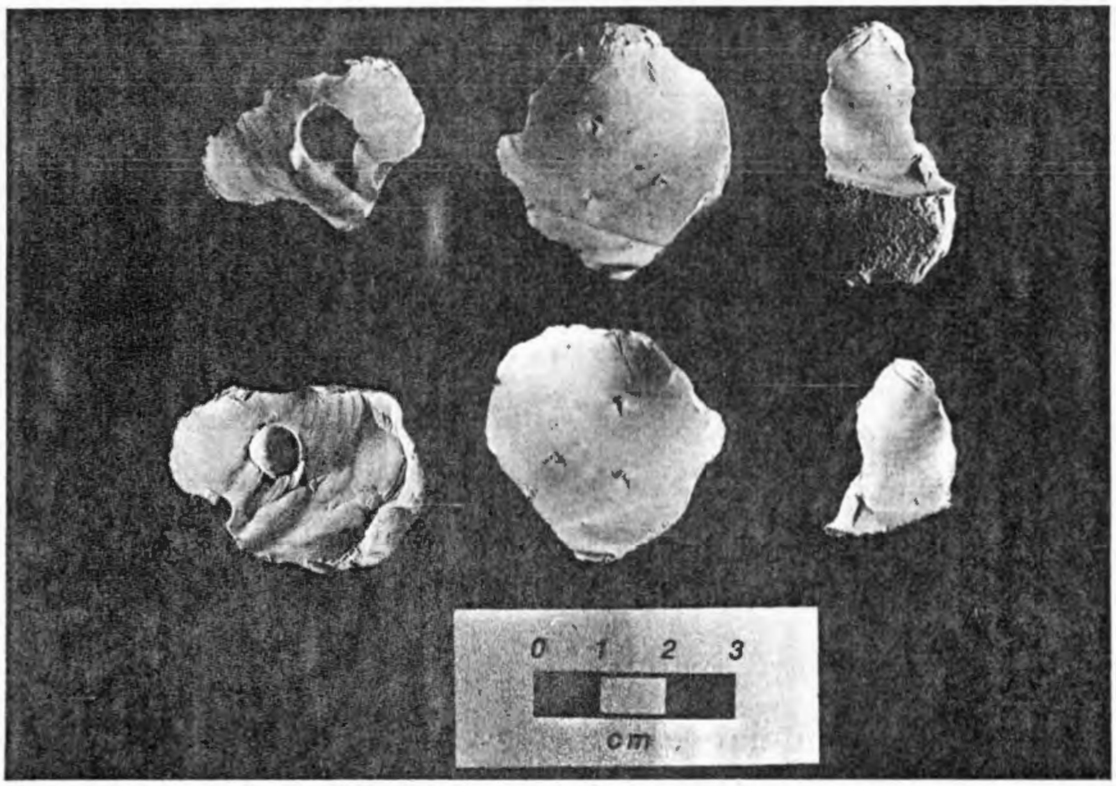
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produced. The choice depended on the size of the split pebble artifacts. In the replication experiments all the split pebble flakes (n=33) manufactured by direct freehand percussion were too small to hold firmly when the force of the percussor was delivered. Consequently the split pebble flakes did not serve as pebble cores in the 20 replication experiments. However, the split pebble cores from which these flakes were struck served well for further reduction. The bipolar technique created split pebble flakes and split pebble cores of approximately equal size, and therefore both these artifacts could and did serve as cores in subsequent flake manufacture.

Flake Production

The next step in the pebble core and flake technology entails the manufacture of flakes. Replication experiments indicate that direct freehand percussion was exclusively employed to manufacture the flakes at these two sites. All flakes contain pronounced bulbs of force, compression rings and hinge or feather terminations characteristic of direct freehand percussion.

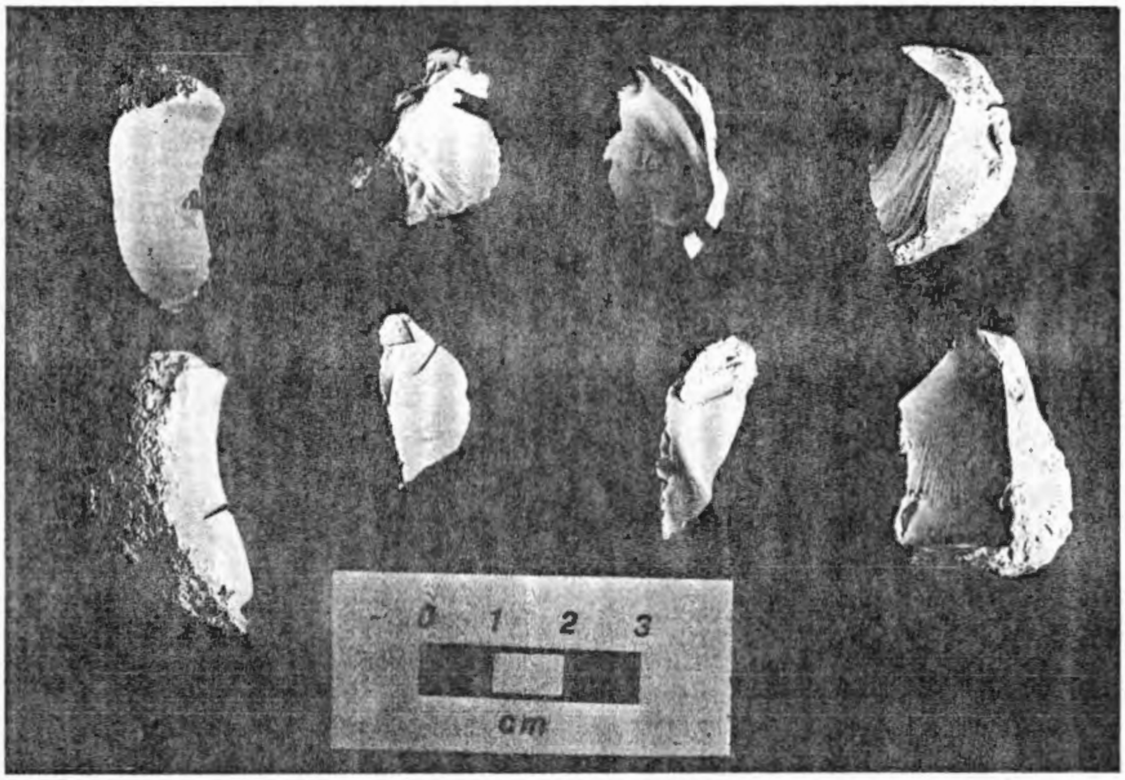
Attempts by the author to replicate the aboriginal flakes with bipolar techniques were unsuccessful. Furthermore, exhausted bipolar cores and flakes do not occur in the aboriginal collections. Despite the small size of the raw material, the bipolar technique was not employed aboriginally beyond initial splitting of the pebble. Replication experiments indicates that flake manufacture by the bipolar technique is less predictable than by direct freehand percussion. Pebbles of obsidian, being more brittle than most flakeable stone materials, is perhaps more conducive to direct freehand percussion than harder materials of the same size and morphology.

The replication experiments produced the four flake types that occur in the archaeological collections from the Strandline and Ni-rak sites. Linear cortical flakes reflect the flintknappers attempt to flatten the surface of a split pebble core that has a concave facet. This step is necessary if large flat flakes are to be subsequently removed from the core. Replication experiments indicate that a cortical platform is required for the manufacture of linear cortical flakes. The platform occurs above and in line with an axis that divides the dorsal surface of the prospective flake into a portion containing cortex and a portion containing a segment of the facet left by removal of the first split pebble flake. Figure 28 shows aboriginal and replicated specimens of linear cortical flakes.

Replication experiments produced broad cortical flakes after linear cortical flakes were removed from the core. To replicate broad cortical flakes the knapper must hold the split pebble in one hand, with the split facet side facing away from the knapper. The other hand uses a hammerstone to strike the cortex of the pebble just above the

Figure 28. Linear cortical flakes, dorsal surface. Top: aboriginal, Bottom: replicated. Coated with ammonium chloride. Note saw cuts for hydration measurement.

Figure 29. Broad cortical flakes. Top: aboriginal, Bottom: replicated. Coated with ammonium chloride. Note saw cuts for hydration measurement.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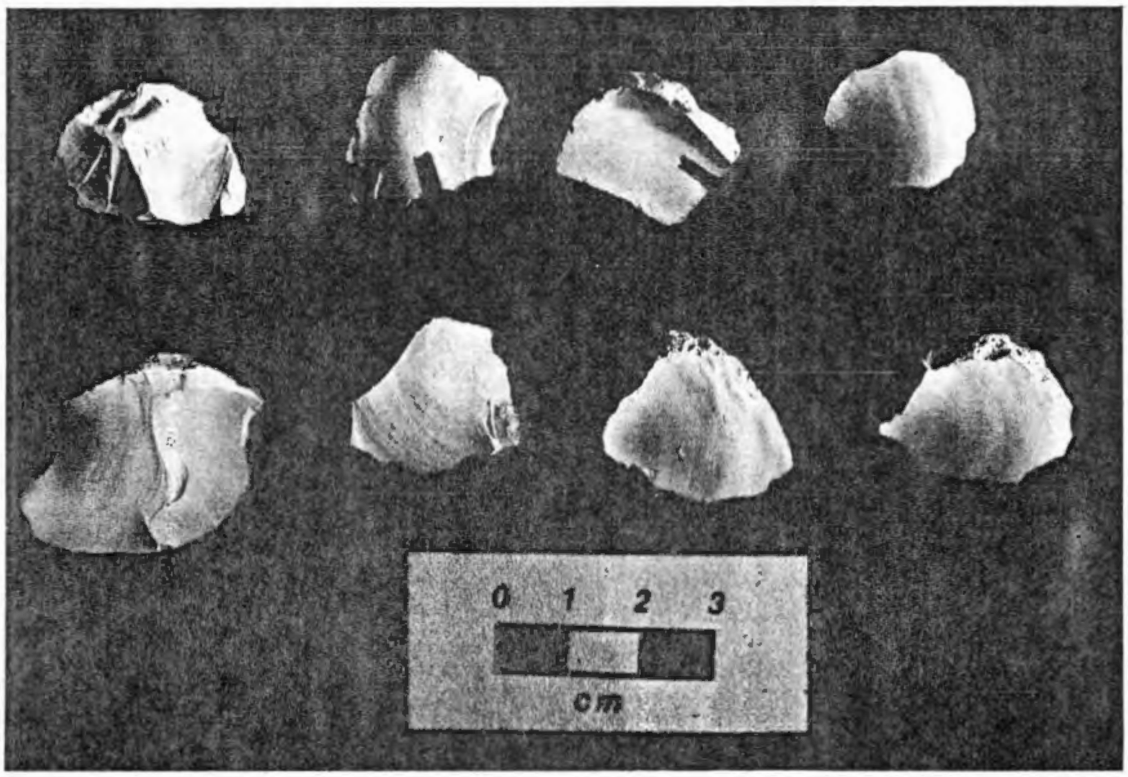
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perimeter of the split pebble face via direct freehand percussion. The point chosen for a platform depends on the angle formed by the core's ventral face and adjacent cortical surface. Generally the most suitable location for a platform is in line with a ridge or undulation on the cores ventral surface and at a ridge or area of large mass on the exterior cortical surface of the pebble.

The replications demonstrate that under ideal circumstances the applied force travels all the way through the pebble core. This results in the largest and widest possible flake and can be viewed as a successful "section" or "slice" of the pebble core. Less ideally, the flake terminates with a hinge fracture in the middle of the ventral face of the core. Such "unsuccessful" flakes, dominate the sample of broad cortical flakes recovered from the Strandline and Ni-rak site, while the replicated sample contains many more "successful" large and wide flakes in the broad cortical flake category. Figure 29 shows aboriginal and replicated examples of broad cortical flakes.

As production of broad cortical flakes continued, the flintknapper rotated the split pebble core on an axis perpendicular to its ventral surface, aligning cortical platforms with ventral surface morphology for further flake removals. In the process the core becomes smaller, yet the original cortex surface remains on the dorsal face.

Linear multifaced flakes are manufactured in the same way as broad cortical flakes but are morphologically distinct in that they are longer than wide. This is due to a ventral surface topography of the pebble-core which guides the applied force along one margin, or along the ridge in the center of the core. The uneven surface topography of the core prevents an equal spreading of applied force across the face of the core. Therefore, a flake that is as wide as the pebble core is not produced. The replication experiments required the intentional manufacture of linear multifaceted flakes to flatten the ventral surface of the pebble core. This allowed for the subsequent removal of more broad cortical flakes. Figure 30 illustrates aboriginal and replicated linear multifaceted flakes.

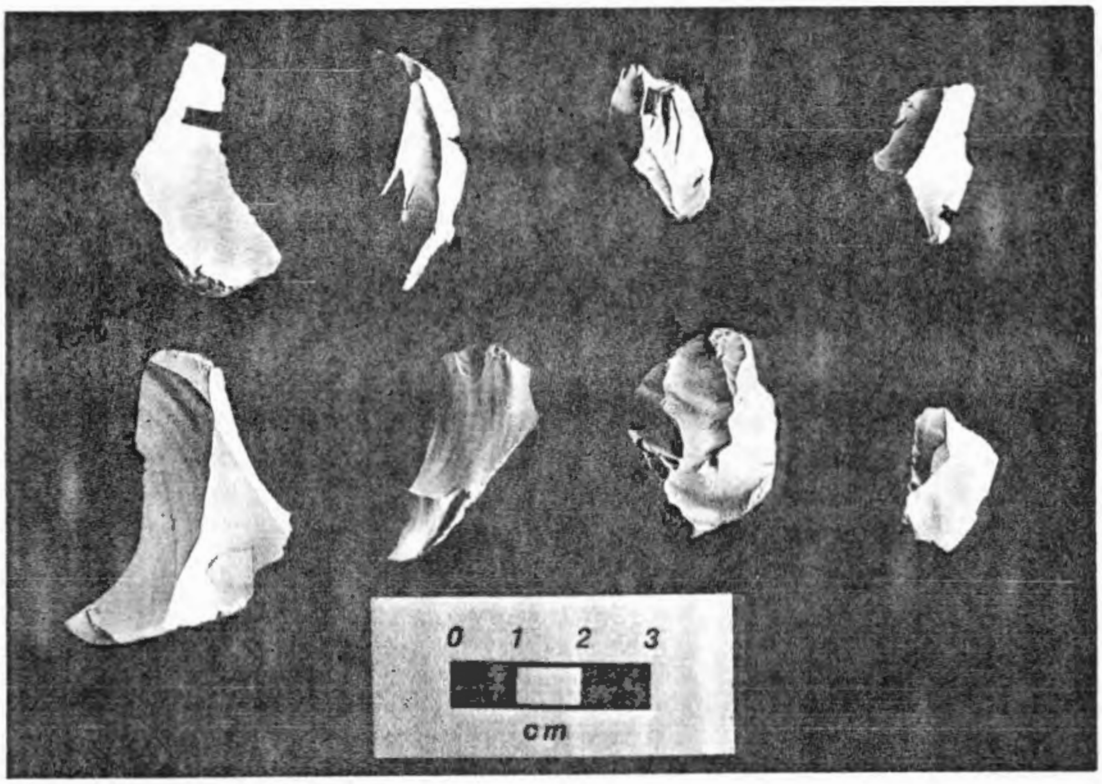
Exhausted Cores and Core Rejuvenation

The replication experiments revealed that after removal of the first 4 or 5 flakes from a pebble-core, it became almost impossible to produce a successful broad cortical flake that encompassed the entire width and length of the pebble core. The flakes removed from the unifacial cores leave many large negative flake scars, producing a concave survace on the faceted face of the pebble core. Furthermore, the core became too small to hold and withstand the inertia of the hammerstone.

The replication experiments indicated that a decision had to be made at this point in the reduction sequence: abandon the core, or attempt to rejuvenate the core. The decision was based on the morphology and size of the core.

Figure 30. Linear multifaceted flakes. Top: aboriginal, Bottom: replicated. Coated with ammonium chloride. Note saw cuts for hydration measurement.

Figure 31. Exhausted cores. Top: aboriginnal, Bottom: replicated. Coated with ammonium chloride.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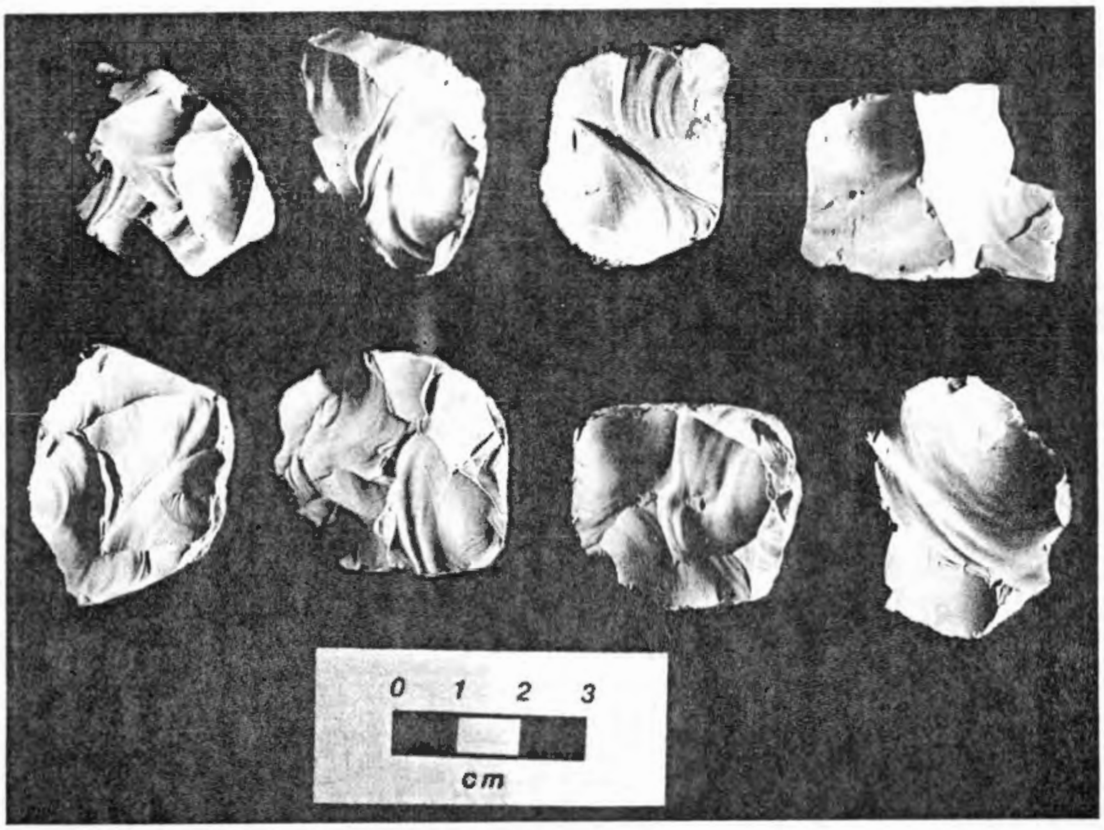
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Generally larger and sub-angular cores were rejuvinated while smaller sub-rounded cores were abandoned.

Unifacial cores were rejuvenated by changing them to faceted platform cores. The flintknapper would choose a platform on the faceted unifacial surface of the core in order to remove flakes from the cortical surface. The replications showed that this would often create a platform, that would align with the original unifacially flaked surface, which was suitable for the removal more flakes from that surface. Ultimately, these rejuvenated cores were discarded because they became too small to hold easily for further flake removal. The replication experiments indicated that exhausted core fragments were produced when overly strong percussive forces were loaded into the core. Twenty nine exhausted cores were produced from the twenty original pebbles used in the replication experiments. Figure 31 illustrates replicated and aboriginal exhausted cores.

Comparison of the Archaeological and Replicated Lithic Collections

The replications provide data that demonstrates the procedure involved in pebble core reduction and flake manufacture at the Ni-rak and Strandline sites. The relications provide a perspective to develop inferences about the aboriginal lithic technological behavior. Furthermore, the replications provide data in the form of frequencies of artifact types (Tables 10 and 11) that can be compared with the frequencies of artifacts in the aboriginal collection (Tables 7 and 8) to explain specific aspects of

Table 10. Frequency and Percentages of Replicated Artifacts Produced by the Pebble Core and Flake Manufacturing Technology

Artifact Type	Replication 1-15		Replication 16-20		Total	
	N	%	N	%	N	%
Split pebble flakes	33	20.1	4	3.7	37	13.6
Split pebble cores	-	-	-	-	-	-
Linear cortical flakes	18	11.0	3	3.8	21	7.7
Linear multifaceted flakes	26	15.8	32	29.9	58	21.4
Broad cortical flakes	65	39.7	43	49.2	108	39.8
Flake-shatter	-	-	-	-	-	-
Unifacial exhausted cores	14	8.6	13	12.1	27	10.7
Faceted exhausted cores	2	1.2	-	-	-	-
Exhausted core fragments	-	-	-	-	-	-
Unidentified debitage	6	3.6	12	11.2	18	6.6
Total	164	100%	107	99.9%	271	99.8%

the prehistoric technology. The replication experiments represent a pure expression of the pebble core and flake technology. It has not been subjected to the forces of erosion and cultural selection like the prehistoric assemblage. Therefore, the aboriginal assemblage must be compared with the replicated assemblage with the intent of determining why the two assemblages are different.

A comparison of the replicated and aboriginal percentages of exhausted cores and flakes reveals some intriguing differences. In the replications, cores comprise only 10.9% of the total assemblage (Table 11) while cores comprise 38% and 58% of the assemblages at the Strandline and Ni-rak sites (Table 8). In addition the proportion of cores is inversely related to the proportion of flakes. In the replication, flakes comprise 69% of the collection, while they occur in much smaller frequencies, 42.5% and 22.6%, at the Strandline and Ni-rak sites. It will be argued that these differences can be explained in part by the relative amount of bipolar and direct freehand percussion technique employed at the initial step in pebble core reduction. It will also be argued that the differences in flake proportions document the selection and transportation of flakes out of the archaeological sites.

Fifteen of the twenty replication experiments employed direct freehand percussion to initially "split" and remove the first flake from the obsidian pebble. In five other replication experiments I used the bipolar technique to

Table 11. Summary of the Frequency and Percentages of Replicated Artifacts Produced by the Pebble Core and Flake Technology

Artifact Type	N	%
Split pebble flakes & Split pebble flakes	37	13.6
All flakes	187	69.0
Exhausted cores	29	10.7
Undiagnostic debitage	18	6.6
Total	271	99.9

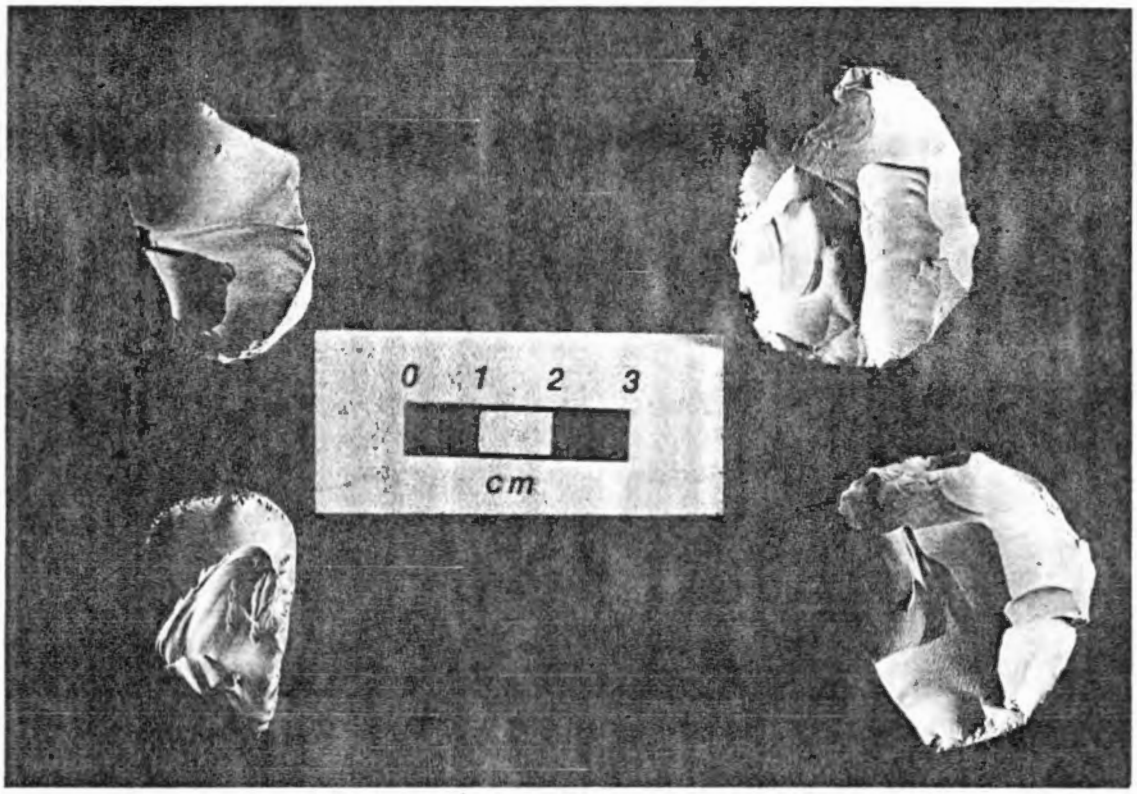
initially split the obsidian pebbles. A change in the relative use of direct freehand percussion and bipolar in the first step in pebble core reduction will affect a change in the proportion of other flake types subsequently produced.

In the 15 direct freehand percussion experiments, the ratio of split pebble flakes (n=33) to exhausted cores (n=16) computes at about 2:1 (Table 10). The same ratio in the aboriginal collections is 1:3 at the Ni-rak site, and 1:3.5 at the Strandline site (Table 7). Conversly, the 5 bipolar replication experiments resulted in a 1:3 ratio of split pebble flakes (n=4) to exhausted cores (n=13) (Table 10). This ratio occurs because the bipolar technique usually splits the obsidian pebble into two relatively equal halves, and therefore provides two pebble cores suitable for the manufacture of flakes, and leaves no split pebble flake debitage. Alternately, direct freehand percussion does not always split the pebble in half. Often, a "layer" of cortex is "peeled off" the pebble and is too small to serve as a core itself. Although these ratios suggest that the bipolar technique was extensively used at the Ni-rak and Strandline sites, other evidence fails to support this.

Bipolar does not appear to be a common technique to split pebble at the archaeological sites for 3 reasons. First, bipolar flakes are almost wholly lacking at the archaeological sites. As mentioned previously only two flakes could be positively identified as resulting from the bipolar technique. There are 97 nonfragmentary exhausted cores at the two sites (Table 7). If a maximum of two exhausted cores result from the reduction of one obsidian pebble, then at least 48 pebbles were reduced between the two archaeological sites. If bipolar was used to split these pebbles, one would expect that more bipolar flakes would have been produced which were too small to serve as cores and therefore occur in the archaeological collection. Second, ten of the eleven refitted split pebble cores and flakes that occur at the Ni-rak site contain technological attributes indicative of direct freehand percussion. If bipolar techniques were used to split pebbles why are there so many pebbles split with direct freehand percussion? Third, the prehistoric occupants of the Ni-rak and Strandline sites have used split pebble flakes, created by direct freehand percussion, as cores for further flake manufacture. This is evident in four exhausted cores from the Strandline site. These cores contain remanants of a positive bulb of force (Figure 32). This indicates that these four cores were formerly split pebble flakes previously removed from a presumably large split pebble core. The remanant positive bulbs of force were not obliterated by the subsequent removal of flakes. In fact the prehistoric flintknappers who produced these cores were unsuccessful in producing broad cortical flakes that completely sectioned these cores. If split pebble flakes were reduced into cores in the replication experiments a smaller percentage of split pebble flakes would have resulted.

Figure 32. Exhausted cores made from split pebble flakes. Left: aboriginal, Right: replicated. Coated with ammonium chloride.

Figure 33. Large, broad cortical flakes manufactured in the replication experiments.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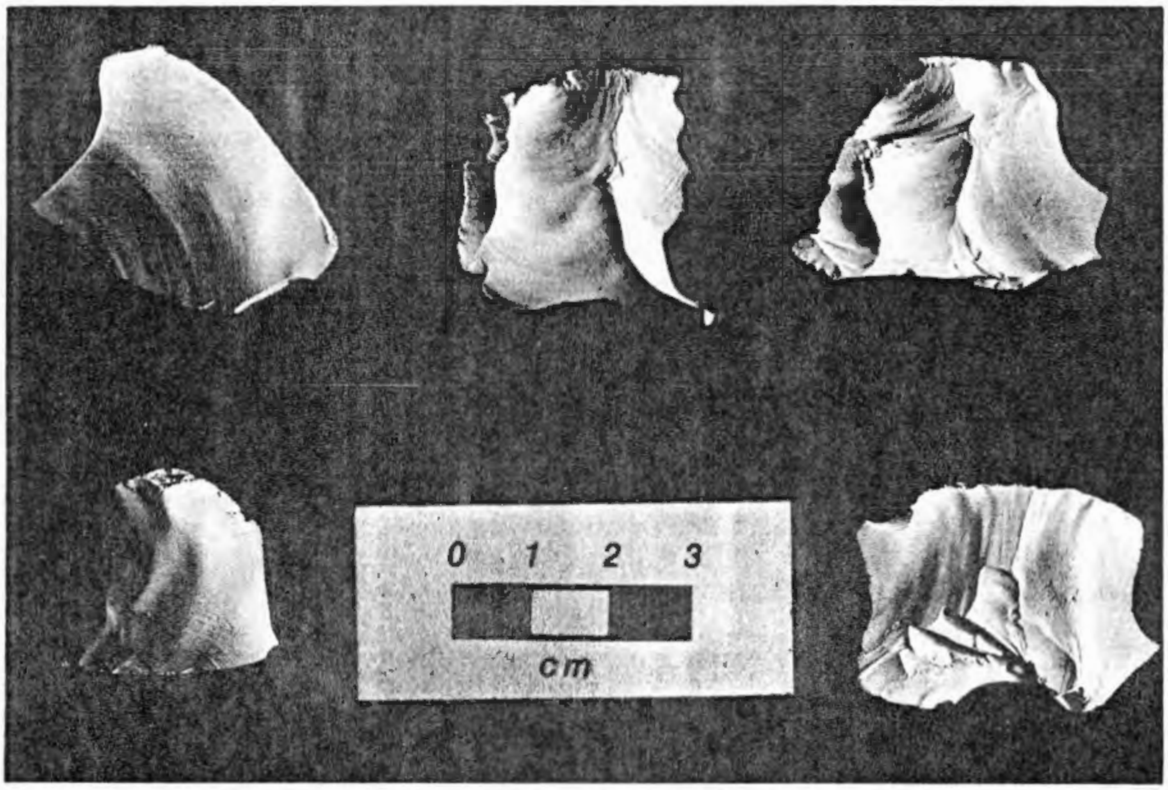
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In conclusion, the discrepancy between the aboriginal and replicated ratios of exhausted cores to split pebble flakes may be partially explained by a higher incidence of the bipolar technique in the aboriginal collection. However this discrepancy is better explained by the use and reduction of split pebble flakes into cores by the prehistoric occupants of the Ni-rak and Strandline sites.

Comparison of the replicated and archaeological assemblages also provides insights into the role of transportation in the lithic technology at the Ni-rak and Strandline sites. A comparison of Table 11 with Table 8 shows that flakes comprise 69% of the replicated collection, while the Strandline and Ni-rak sites contain percentages of 42.5% and 22.6% respectively. The proportion of flakes to exhausted cores is 5.6:1 in the replications, about 1:1 at the Strandline site, and 1:2.6 at the Ni-rak site. The prehistoric occupants of the Ni-rak and Strandline site abandoned 97 complete and 22 fragmentary exhausted pebble cores (Table 7). The replication experiments indicate that 5.6 flakes should have been produced for every pebble core. Even if only two flakes were manufactured for each of the 97 complete exhausted cores then 194 flakes should have been recovered in the archaeological collections. Indeed, 233 separate negative flake scars were counted on the 97 exhausted cores. If each flake scar represents a flake removal then 233 flakes should occur in the archaeological collections. But only 120 flakes were recovered. As mentioned previously all flakes smaller than 15 mm were removed from the replicated collections because the lack of these small flakes in the archaeological collections suggests that erosion and sedimentation has altered the archaeological sites. It appears unlikely that erosion and sedimentation removed so many of these larger flakes as well. Many of the broad cortical flakes produced in the replications have length and width dimensions larger than the exhausted cores. I contend that there is one good reason for the obvious lack of flakes; they were transported out of the sites by the flintknappers who manufactured them.

DISCUSSION

Curated lithic technology

A curated lithic technology separates in space and time the products of stone procurement, reduction, use, and disposal. In other words the procurement and initial reduction of a rock would occur in a different location than final reduction, use, and disposal. The aboriginal reduction technology at the Strandline and Ni-rak sites implies the manufacture of many flakes, however, the absence of these flakes suggests that they were transported to another location.

Among the three flake types, linear cortical, linear multifaceted, and broad cortical, produced by the pebble-core reduction technology, the latter appears to be the preferred items selected and transported out of the sites.

In the replications, broad cortical flakes comprise 57.7% of the flakes produced. At the Ni-rak and Strandline site broad cortical flakes respectively comprise 42.8% and 38.9% of the flake population.

Although this difference in relative proportion may not appear significant, it does reflect prehistoric selection of the largest and flattest, broad cortical flakes from the aboriginal assemblage. The replication experiments demonstrate that large, flat flakes are easily produced using the techniques of the pebble core and flake manufacturing technology (Figure 33). However, these large flakes were not recovered from the archaeological context. These flakes were selected and removed by the aboriginal flintknappers leaving an assemblage that contained relatively fewer broad cortical flakes than predicted by the replication experiments. Furthermore the broad cortical flakes recovered from the Ni-rak and Strandline sites are typically shorter, due to hinge fracture termination and more curved and irregular in cross-section than the largest and flattest flakes produced in the replications.

The flakes manufactured at the Ni-rak and Strandline sites may have served as blanks for further reduction and use. A blank is an unmodified flake that contains only a little excess material that must be removed to manufacture a tool. Blanks are therefore larger than the proposed tool that will be manufactured. Furthermore, flake-blanks imply the early stages in the manufacture of specific lithic tools

(Crabtree 1972:42). However, it is difficult to determine whether the flake-blanks were reduced into tools at the sites of their manufacture or whether the blanks were transported from the sites for reduction and use at another location.

The size of material that must be removed to reduce the blanks into projectile points, for example, is too small (less than 15 mm) to be monitored in this lithic analysis. In fact, most archaeological recovery techniques and lithic analyses do not recover or record most of the minute debitage produced by the reduction of small objects such as broad cortical flakes. However, if the flake-blanks manufactured at the Ni-rak and Strandline sites were also reduced into tools one would expect to find flake-blanks that were partially reduced but rejected due to breakage or unsuitability. Close inspection of every flake in the archaeological collection revealed the complete absence of flake scars that might be indicative of intentional reduction, particularly pressure flaking.

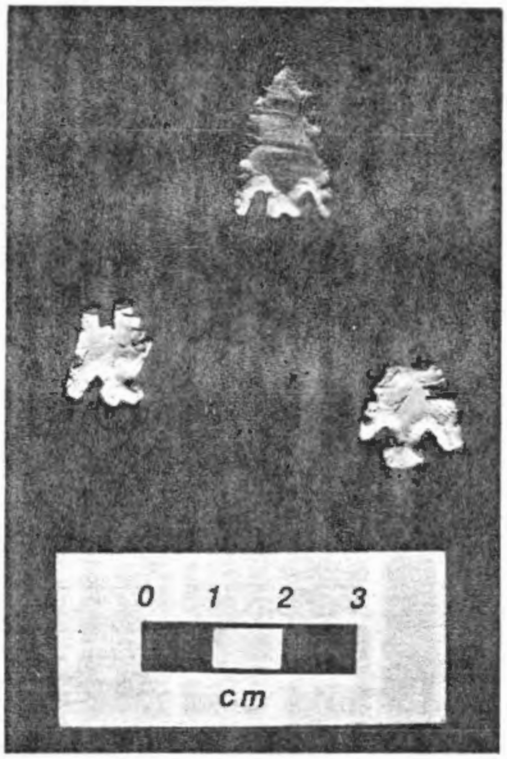
Another possibility includes prehistoric use of the flake-blanks as tools, without any further modification, at the Ni-rak and Strandline sites. Use of flake tools does may not leave any visable debitage; and determination of use requires special skills and time that is not within the scope of this study. However, direct use of flakes cannot explain the overwhelming absence of flake-blanks at the archaeological sites, unless they were transported from the site after use.

The flake-blanks produced at the Strandline and Nirak sites may have served for subsequent manufacture of projectile points at another unknown location. Although a flake blank, does not disclose the shape of the final product (e.g., projectile point), the final product may disclose the nature of the stone from which it was derived.

Two obsidian projectile points from Scribble Rockshelter (42Jb148), 70 km from the Topaz Mountain obsidian source, appear to have been manufactured from flake-blanks. Trace element analysis of the projectile points indicate that they were fashioned from Topaz Mountain obsidian (Sappington 1983). One face of each point contains a large flake scar that has been truncated by small short pressure flake scars. Replication of these projectile points involved reducing a flake-blank, derived from a pebble core with small short pressure flakes until the desired shape was achieved. The replication experiments showed that the ventral surface (detachment scar) of the original flake-blank was not completely obliterated by pressure flaking. This resulted in an "island" in the middle of the projectile point that represents a portion of the original ventral surface of the flake-blank (Figure 34).

The preceding discussion does not mean to imply that blanks produced in a pebble core and flake production technology were transported to Scribble Rockshelter. Such a determination would require a detailed lithic analysis of the material from that site. The projectile points from the

Figure 34. Projectile points manufactured from flakes show a remanant flake scar. Top: replicated, Bottom: aboriginal.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rockshelter only serve as an example of how the blanks produced at the Ni-rak and Strandline sites may have been used.

As blanks suitable for further reduction into a variety of tools, the flakes produced and removed from the Ni-rak and Strandline site may have contributed to a prehistoric cache or "personal tool kit". Archaeological recovery of caches and tool kits contain, not only finished tools but also, several slightly modified flakes that would presumably serve as blanks for further reduction into finished tools (Pavesic 1966, Cressman 1977:154 Benson 1982). The technological behavior at the Ni-rak and Strandline sites, as well as the recovery of caches and "tool kits" provide evidence for curated lithic technological behavior in prehistory.

Hunter-gatherer mobility

I have argued that flakes produced by a pebble core reduction technology have been transported out of the Ni-rak and Strandline sites as part of a curated lithic technology. The following discussion addresses why hunter gatherers might have chosen this technological strategy.

Like many areas in the Great Basin, this region near the southwest corner of the Great Salt Desert does not contain water, food, and raw material resources in the same locations. As a stone tool resource, Topaz Mountain obsidian naturally occurs in a limited area. This area does not contain enough other resources that would enable hunter-gatherers to settle within its boundaries. In fact, the immediate environment around the Ni-rak and Strandline sites offers few subsistence resources beyond obsidian. Surface water is absent most of the year. The alluvial soil quickly drains rainfall that might accumulate in the adjacent Pismire Wash. In addition, the sites do not occur in or near any areas of topographic or edaphic diversity which would influence a vegetation growth that is more diverse than the shadscale that dominates the vicinity of each site.

Archaeologists (e.g., Reher and Witter 1977:115, 124) have demonstrated that hunter-gatherer habitation sites often occur in areas of high vegetative diversity. While special resource extraction sites occur in areas where the target items are most abundant (Thomas 1983:79-85). Ecologists (Odum 1971:158) have shown that higher animal abundance and diversity may also occur in areas of high vegetation diversity. It appears, therefore, that the Ni-rak and Strandline locations are not the most ideal places to settle. Food resources and water are not abundant. Obsidian is abundant, but unedible. Consequently the Ni-rak and Strandline sites were only occupied to manufacture obsidian flakes for transportation to another location.

Recently, archaeologists (e.g., Thomas 1983, Binford, 1980) have attempted to use archaeological and ethnographic data to develop models that define the relationship between different site functions for mobile hunter-gatherers. The pebble core reduction and flake manufacturing technology at the Ni-rak and Strandline sites illuminates these models. In general, models of hunter-gatherer mobility have proposed a basic dichotomy between a "residential base" and a "field base".

A residential base is the hub of all subsistence activities; where most processing, manufacturing and maintenance of food and artifacts occurs (Thomas 1983:73, Binford 1980:9). Residential bases are loci from which foraging parties originate and return. Field bases, on the other hand, function as temporary operation centers where a particular extractive, or processing task occurs. There are different archaeological consequences for these two site types.

Residential bases support a wide range of subsistence activities; therefore a wide range of chipped stone artifacts should be present. If residential bases are loci to plan and "gear up" for excursions to other locations (Binford 1979:263), then one expects the artifact inventory to include items indicative of tool manufacture, use, and discard (Thomas 1983:77-78). Specially quarried lithic material is brought back to residential bases (Gould 1980: 26) for further manufacture and maintenance of tools. Therefore a residential base should contain a variety of lithic materials and reduction technologies. The procurement, manufacture, use, and discard of expedient tools may be present alongside different stages from one or more curated lithic technologies.

The activities conducted at a field base are limited to the demands of the target resource (Binford 1980:10). Therefore, they should possess a specialized and homogeneous artifact assemblage. A field base will possess a limited expression of a lithic technological system, that is, a single discreet stage in one lithic reduction and use technology. For example, a field base may contain much material indicative of tool use and discard, but contain very little debitage from the manufacture of those tools, which was presumably conducted at another place (residential base) and time. Field bases may also exclusively show a complete expedient lithic technological system designed to respond to a unique and unexpected situation. Although each field base will have artifactual homogeneity within itself, the nature of the resources they were designed to exploit should differentiate them (Binford 1980:10).

In summary then residential bases and field bases can be distinguished by the kind and amount of lithic technological stages present at each. Residential bases should show the products of several lithic technologies in various stages of reduction and degrees of curative organization. Field bases, on the other hand should reflect the products of a single stage from a single curated lithic system, or, a complete procurement, manufacture, use and discard sequence with a single rock type. Figure 35 schema-

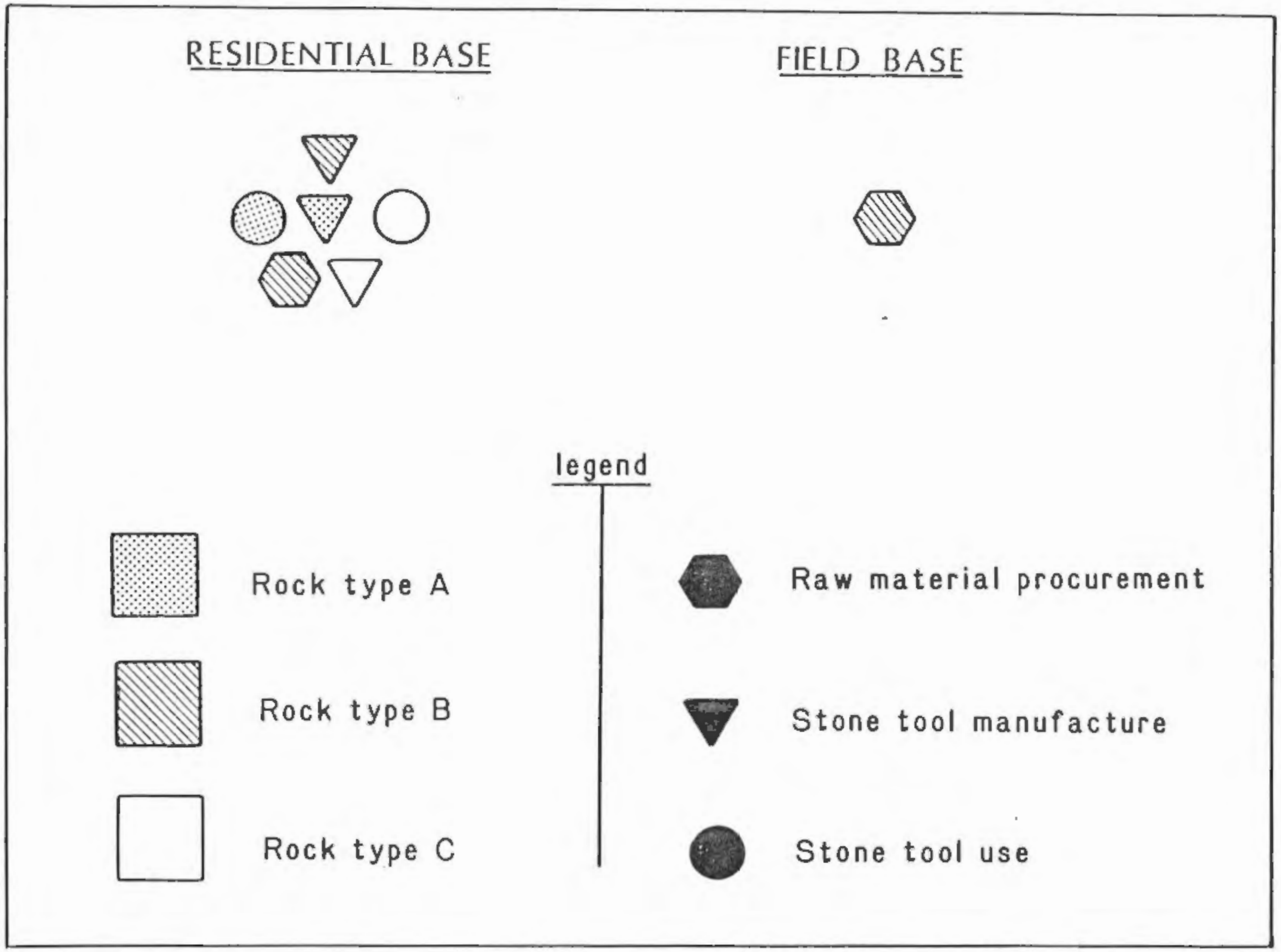

Fig. 35.--Model of lithic technology at residential bases and field bases.

tically depicts the difference between these two site types.

It is evident from this discussion that the Ni-rak and Strandline site served as field bases connected to a mobility system that contains other site types including residential bases. The Ni-rak and Strandline sites exhibit the earliest stage in a curated lithic technology that manufactured flakes for transport to another site (Figure 36).

Other (residential?) archaeological sites occur in the Pismire dune field about 10 km downstream from the Ni-rak and Strandline sites. As mentioned previously the Pismire dune field contains a relatively diverse and abundant vegetation, including relatively permanant water resources. Over 18 sites have been recorded in a 2 sq/km area. A cursory examination (Table 12) of the flaked stone and other artifacts recovered from two sites in the Pismire dune field shows a diverse range of rock and technological types. This suggests a complex of activities including flake stone reduction, that is far more diverse than indicated by the assemblages at the Strandline and Ni-rak sites. However, only a lithic analysis can reveal if flake-blanks similar to the ones produced at the Strandline and Ni-rak sites were reduced at the Pismire dune field sites.

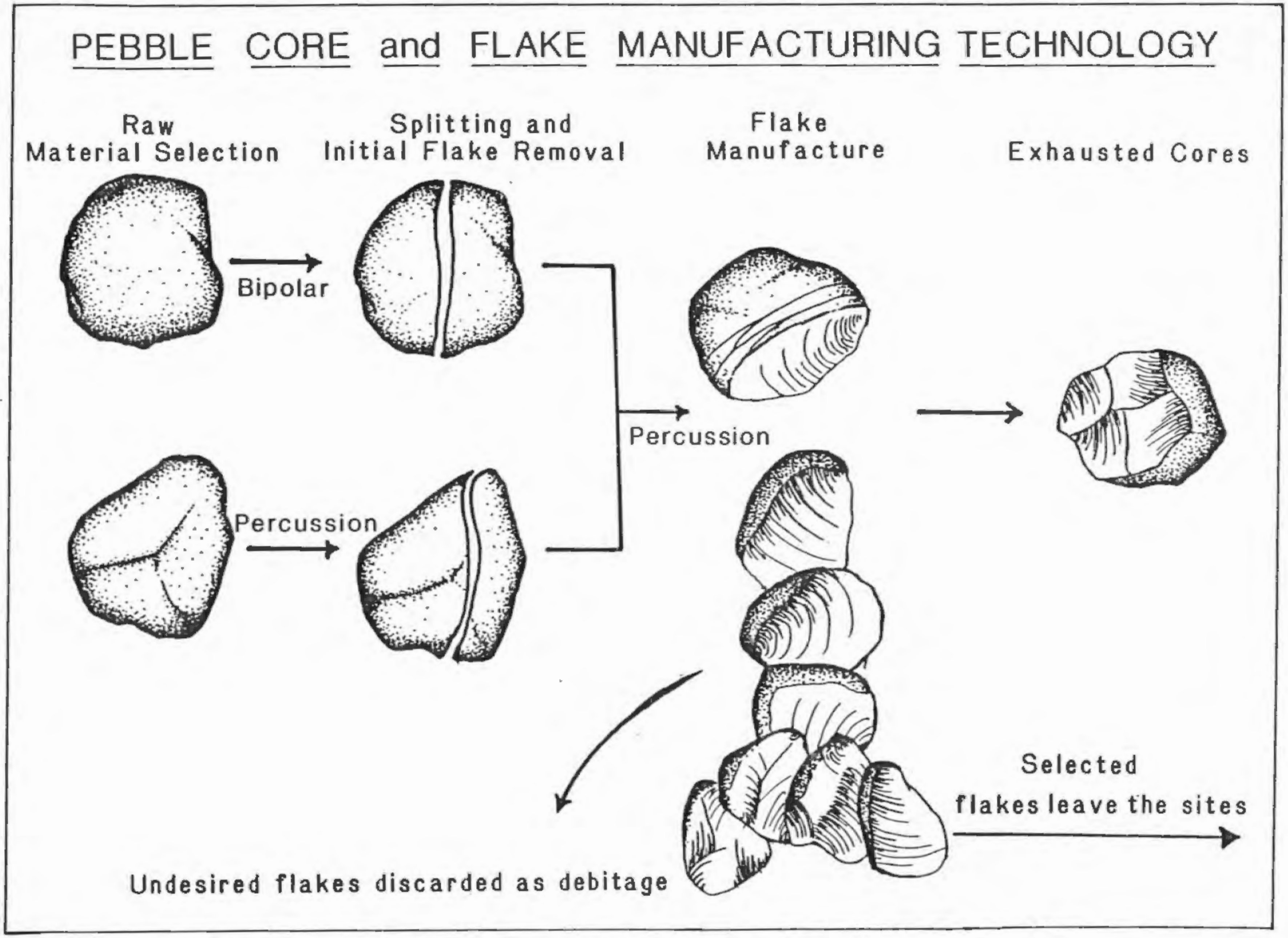

Figure 36. Pebble core and flake manufacturing technology

Table 12. Artifact Inventory of Two Sites in the Pismire Dune Field.

		42To202	42To254
Obsidian	Flakes	481	383
	Bifaces	18	4
Chert	Flakes	25	67
	Bifaces	1	-
Basalt	Flakes	-	22
	Bifaces	-	-
Quartzite	Flakes	1	10
	Bifaces	3	-
Other	Flakes	2	26
	Bifaces	-	-
Fire Cracked Rock		Present	Present
Groundstone		Absent	Present

CHAPTER 6

SUMMARY

This study has been concerned with the manufacturing technology of flaked stone artifacts from two small lithic scatters that occur in the erosional source area for Topaz Mountain, Utah obsidian. The lithic reduction technology at these sites is of interest because Topaz Mountain obsidian naturally occurs in a relatively small area. The mobile hunter gatherers who occupied this region of west-central Utah must have transported the obsidian if they desired to use this material outside the frontiers of its natural occurrence. A model for a curated lithic technology has been offered to describe the role of transportation in stone tool manufacture. Hunter gatherers that employ curated lithic technology separate in space and time the process of raw material procurement, lithic reduction, tool manufacture, use and discard. That is, transportation occurs between the stages of a lithic reduction and use sequence. The tool stone is maintained or curated between the stages.

Before analysis of the flaked stone artifacts proceeded, it was necessary to examine the results of obsidian hydration meaurements on a sample of those artifacts. This analysis employed statistical techniques that helped to determine that the Ni-rak and Strandline sites each contained one and not multiple occupations. This determination is important for a correct understanding of the technological behavior represented by the lithic artifacts.

In the lithic analysis I described the attributes of the archaeological specimens based on the technological processes that produced them. The technology of obsidian pebble reduction and flake manufacture was demonstrated with controlled replication experiments. Comparison of the archaeological and replicated collections indicates that many flakes are missing from the archaeological collections. I have argued that the prehistoric occupants at the Ni-rak and Strandline sites transported flake blanks out of the sites. I conclude the study with a discussion of lithic technology, transportation of flake stone artifacts, and prehistoric hunter-gatherer mobility.

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