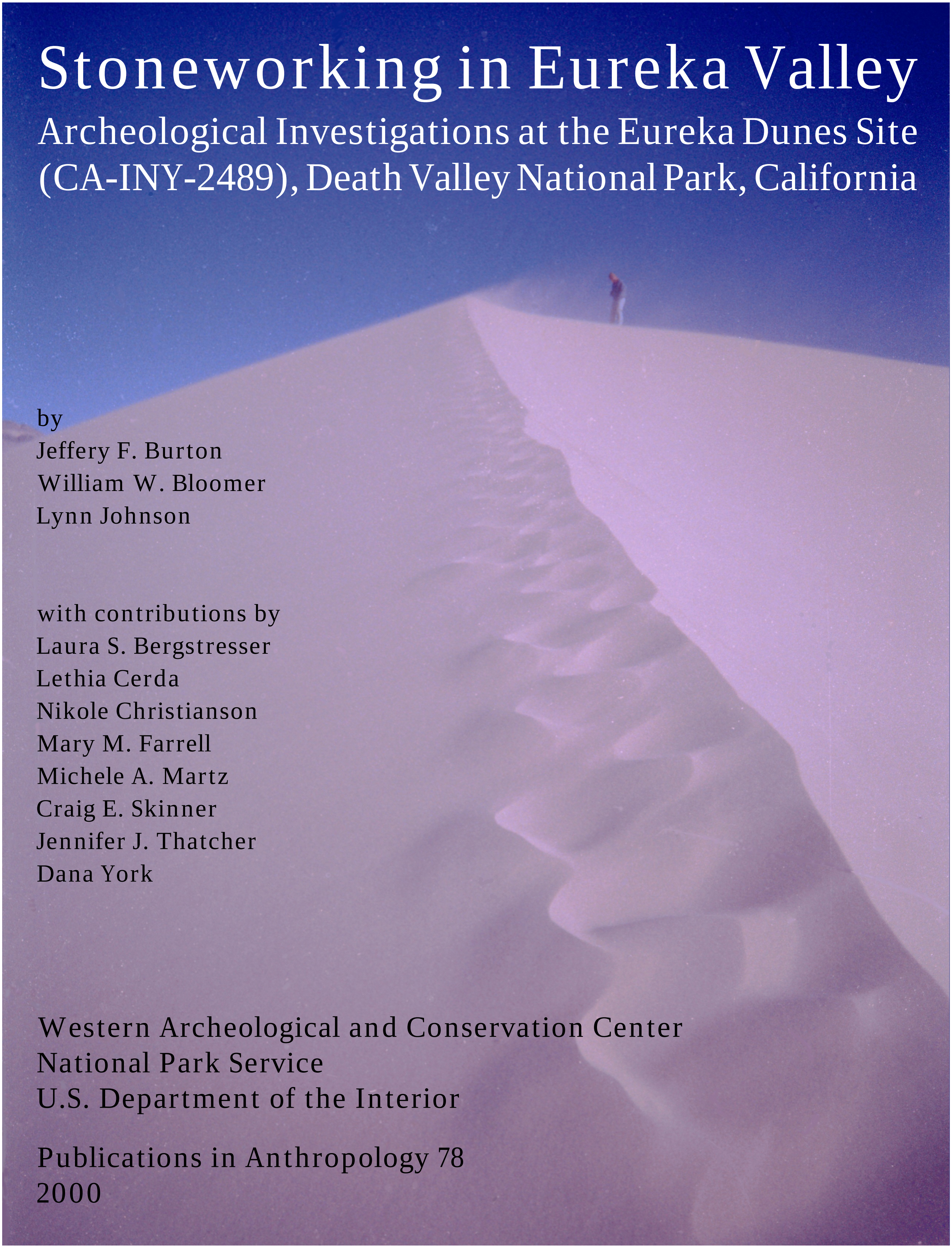

Stoneworking in Eureka Valley

Archeological Investigations at the Eureka Dunes Site (CA-INY-2489), Death Valley National Park, California

by
Jeffery F. Burton
William W. Bloomer
Lynn Johnson

with contributions by
Laura S. Bergstresser
Lethia Cerda
Nikole Christianson
Mary M. Farrell
Michele A. Martz
Craig E. Skinner
Jennifer J. Thatcher
Dana York

Western Archeological and Conservation Center
National Park Service
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Publications in Anthropology 78
2000

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East away from the Sierras, south from Panamint and Amargosa, east and south an uncounted mile, is the County of Lost Borders.

Ute, Paiute, Mojave, and Shoshone inhabit its frontiers, and as far into the heart of it as a man dare go. Not the law, but the land sets the limit.

Here you have no rain when all the earth cries for it, or quick downpours called cloud-bursts for violence. A land of lost rivers with little in it to love; yet a land that once visited must be come back to inevitably.

Mary Austin, *Land of Land Rain*, 1906

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Project Summary

Project Number: DEVA 1999 G.
Type of Project: Archeological Testing.
Project Supervisors: Jeff Burton and Tim Canaday.
Field Crew: Nicole Christianson, Peter Gavette, Lynn Johnson (CSU, Sacramento), and Michele Martz.
Volunteers: Kristen, Margaret, and Theresa Anderson, Angela Jayko, Kendall Schinke, and Dave Wagner.
Field Dates: June 21-22 and October 7-8, 1999, and February 7-19, 2000.
Person Days Spent in Field: 60.
Project Location: Eureka Dunes Site (CA-INY-2489), Eureka Valley, Death Valley National Park, Inyo County, California.
Project Scope: 114 20 m by 20 m units were surface collected and 109 shovel test units, seven 1 m by 2 m surface scrape units, and nine 1 m by 1 m units were excavated. In all, seven features were investigated.
National Register Status: None.
Collections Accession Number: DEVA 2374.

Cover: Winter day on the dunes.
Photograph by Jim Burton

Back Cover: Green-grey chert biface from the Eureka Dunes Site.
Photograph by Dick Lord

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Abstract

The National Park Service conducted archeological investigations at the Eureka Dunes archeological site (CA-INY-2489) within Death Valley National Park. Proposed developments to protect the unique Eureka Dunes ecosystem would affect less than ½ of 1 percent of the archeological site. However, the archeological work was designed to investigate the whole site. Archeological field work included mapping, intensive controlled surface collection, and subsurface testing. Over 26,000 artifacts were recovered, the overwhelming majority of which were flaked stone.

Chronological data indicate the site was used from as early as 4500 B.C. to late prehistoric times. The Eureka Dunes Site is primarily a surface manifestation, but evidence suggests that different parts of the 4 km-long site correspond, in large part, to different time periods. Numerous fire-cracked rock features were identified at the site and seven of the features were excavated. Because of the large size of the site, even the 42,975 square meters of surface collection and 34 square meters of excavation units completed constitute a small sample, and inferences must be considered preliminary. Nevertheless the investigations yielded intriguing data on the use of Saline Valley obsidian and Last Chance green-grey chert, both available locally and widely traded. Some evidence suggests the fire-cracked rock features may be related to the heat-treatment of chert to make it easier to fashion into stone tools.

Definitive interpretations await further research, but these investigations do indicate that the Eureka Dunes Site has the data and integrity necessary to address a number of significant research questions. The site therefore appears eligible for the National Register of Historic Places. Although the current work has mitigated the effects of the proposed developments, monitoring is recommended to ensure protection of the site, and additional research is recommended to realize the site's full information potential.

Acknowledgments

First and foremost I thank Dr. Tim Canaday for inviting us out to Death Valley to pick up where he left off – that is, the results of Tim's initial archeological investigations at the Eureka Dunes Site for a proposed construction project convinced him that more work should be done at the site as a whole. In addition to initiating the work at the Eureka Dunes Site, Tim also arranged for additional funding for specialized analyses, handled the Native American consultations, provided volunteers, helped us in the field, reviewed the draft report, and provided guidance throughout the project.

Field work was conducted by WACC archeologists Nikole Christianson, Michele Martz, and Peter Gavette, and consulting archeologist Lynn Johnson (California State University, Sacramento). Volunteers Kristen, Margaret, and Theresa Anderson, Angela Jayko, Kendall Schinke, and Dave Wagner provided valuable assistance. We were visited in the field by Timbasha Shoshone tribal elders Ed and Pauline Esteves and Grace Goad and tribal consultant Bill Helmer.

In addition to writing background chapters for this report, no small feat in itself, Lynn Johnson also shared her knowledge and passion for her research area with us recent Park Service interlopers. Lynn even brought along a small cadre of volunteers to help in the field.

Michele Martz single-handedly completed the initial laboratory processing, lithic sorts, and debitage summary tables. Nikole Christianson wrote the plan of work. Bill Bloomer of Lithic Arts analyzed the flaked stone artifacts and contributed greatly to the report. Laura Bergstresser analyzed most of the other artifact classes. Dana York helped in plant identification, Bill Gillespie examined the faunal remains, Craig Skinner and Lethia Cerda of Northwest Research Obsidian Studies Laboratory completed the specialized obsidian studies, and Jennifer Thatcher of Beta Analytic reported on the radiocarbon analysis.

At WACC, George Teague, Susan Wells, and Angela Nava handled myriad administrative chores, freeing me to do the fun stuff. Ron Beckwith produced the AutoCad® maps and volunteers Dick and Flo Lord photographed the artifacts. Mary Farrell helped write several chapters and edited the report. My son, Dan, provided insightful comments and diversions throughout the project and my brother Jim accompanied me out to the dunes for an initial field assessment on a bitter cold and windy January day.

The sketches at the close of each chapter are by E. Boyd Smith and were taken from Mary Austin's 1903 classic *The Land of Little Rain,* which I encourage everyone to read before venturing out to Shoshone Land.

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Chapter 1

Introduction

Jeffery F. Burton, Mary M. Farrell, Dana York, Nicole Christianson, and Lynn Johnson

The Eureka Dunes Site (CA-INY-2489) is located in the southeastern corner of Eureka Valley, within Death Valley National Park, California (Figure 1.1). This report discusses archeological investigations undertaken by the National Park Service to determine the site's significance and make management recommendations. The site sits at the northern edge of the Eureka Dunes, and the archeological work was triggered by proposed developments designed to protect the unique dune environment. Although these developments would affect less than ½ of 1 percent of the site area, investigation of the site as a whole is considered an agency responsibility under Section 110 of the National Historic Preservation Act (NHPA).

In recognition of the rare geologic and biological features of the area, the Eureka Dunes were designated a National Natural Landmark in 1983 while under the administration of the Bureau of Land Management (BLM). In the California Desert Protection Act of 1994, the Eureka Dunes and the surrounding area was incorporated into an enlarged Death Valley National Park, and administration was transferred to the National Park Service (NPS). The Act also designated most of the park addition as Wilderness. The margins of the Eureka Dunes are host to three endangered or rare plant species (Eureka Valley evening primrose, Eureka Valley dune grass, and shining milkvetch) and six varieties of endemic beetles. Currently, uncontrolled visitor use is damaging the habitat of these species. To comply with the Endangered Species Act, the NPS has proposed several actions to protect these species while maintaining visitor access and use.

The primary visitor facilities at Eureka Dunes now include unpaved parking areas, informal camping areas, and a picnic area with a vault toilet, all currently within or adjacent to the endangered species habitat on the dune margins. The principal parking area is now much larger than needed or desired: it is located in a low area subject to flooding whenever it rains, so that visitors looking for dry areas to park encroach on previously undisturbed areas. In addition, there is a network of superfluous roads (some within designated Wilderness); to curb motor vehicle traffic on the dunes themselves, a visually-intrusive metal pipe fence was constructed by BLM along the north side of the dune.

Proposed actions include the closure of existing parking areas and the closure of some of the extra roads to motorized travel. The parking areas would be scarified and allowed to reseed naturally: a BLM monument and interpretive sign would be removed. The pipe fence, which would become unnecessary, also would be removed. Two small unpaved parking lots would be constructed on high ground farther away from the dunes (Construction Loci 1 and 2 in Figure 1.2). Each new parking lot would include four campsites and one would include a vault toilet and interpretive displays. The existing vault toilet on the dune margins (Construction Locus 3) would be removed and the pit back-filled with material excavated for the construction of the new vault toilet (Anderson 1999; Tim Canaday, personal communication 2000).

The Eureka Dunes Archeological Site

In addition to its geological and natural significance, the Eureka Valley also contains potentially significant archeological resources: prehistoric cultural material was first recorded in the area of

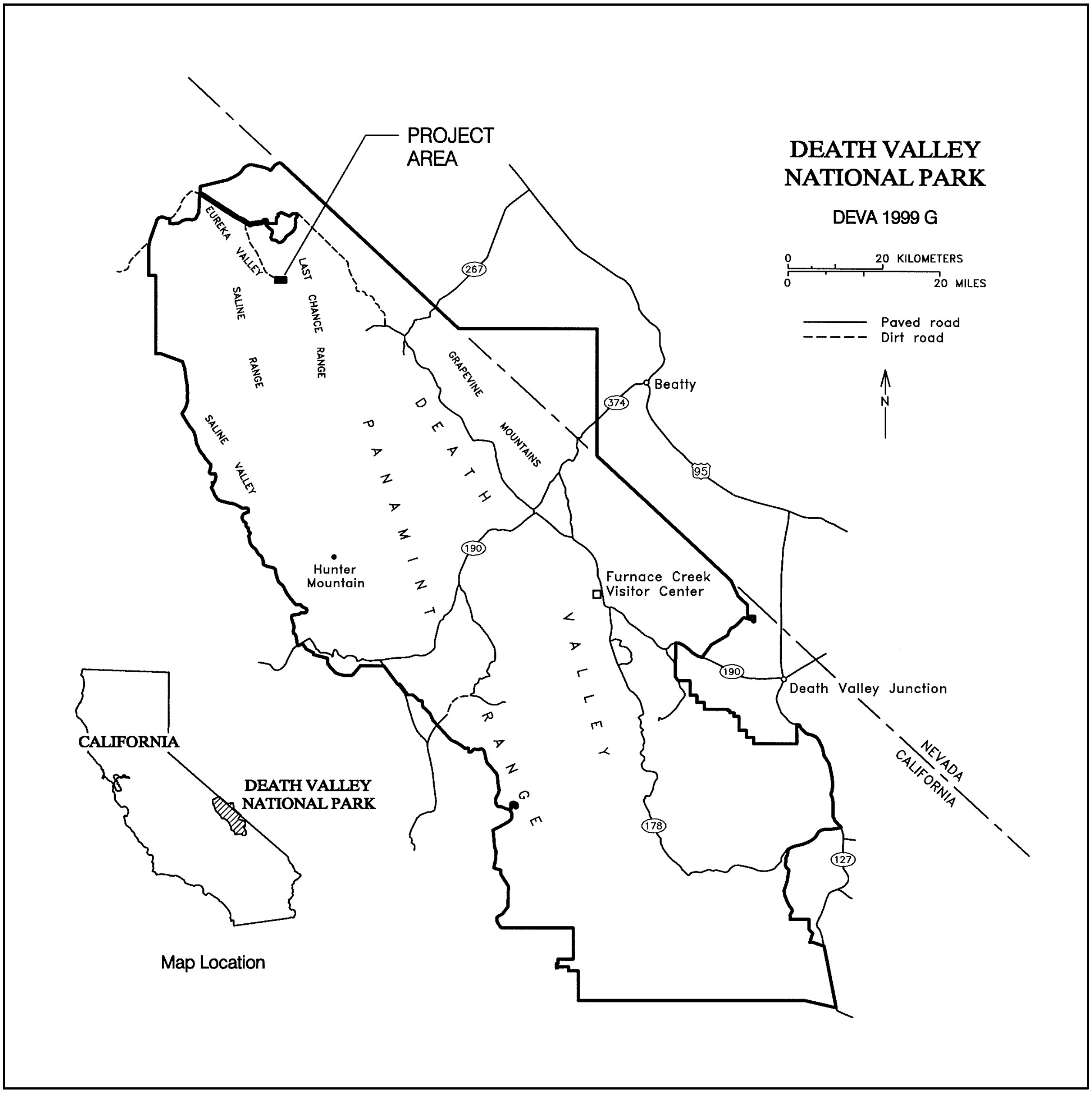


Figure 1.1. Location of the Eureka Dunes project area.

the Eureka Dunes in 1976, by H. Clough. She recorded four sites in what is now considered the Eureka Dune Site: CA-INY-2033, CA-INY-2488A, CA-INY-2488B, and CA-INY-2489. These sites, along with several others in the Eureka Valley, were considered eligible for the National Register of Historic Places, but the sites were never formally nominated. Subsequent archeological survey work in 1998 by the Archaeological Research Unit, University of California, Riverside (ARU) combined Clough's four sites into a single site designated UCR-ED-S1 (Brewer et al. 1999). This report uses the trinomial CA-INY-2489 to encompass the combined site, following Death Valley National Park usage.

As recorded by the ARU, the Eureka Dunes Site is over 830 acres in size and includes 30 separate lithic concentrations (loci) ranging in size from 275 to 22,000 square meters. Within the loci, artifact density was estimated to range up to 15 artifacts per square meter, while areas between the loci averaged less than 1 artifact per 5 square meters. Large quantities of obsidian, chert, and

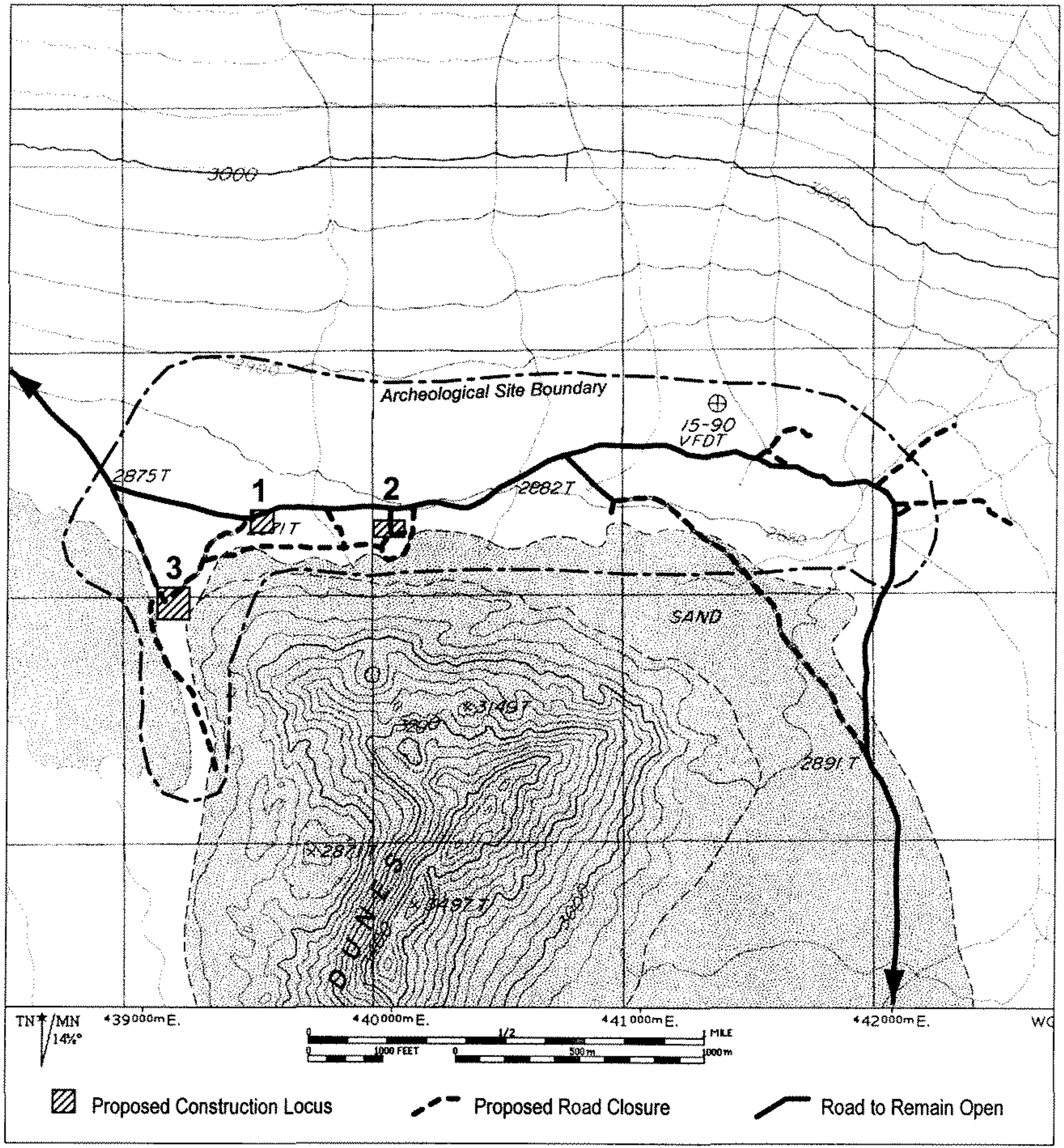


Figure 1.2. Eureka Dunes project area vicinity.

quartzite debitage and a fair number of ground and pecked stone artifacts were found, but only one of the loci included pottery (plain brown ware) and only three diagnostic projectile points (Gypsum, Humboldt Concave-base, and Rose Spring) were recorded. Twelve loci had ground stone artifacts. Fire-cracked rock was noted at one locus, but no features were observed at the site. Based on diagnostic artifacts, the site was considered to date to the Newberry, Haiwee, and Marana periods (1200 B.C. to historic times). The site is traversed by the South Eureka Valley Road, and encompasses all of the current visitor use areas mentioned above (Figure 1.3). Brewer et al. (1999) also pointed out that although the site had sustained damage from roads and off-road-vehicle use, it was in relatively good condition.

Figure 1.3. The South Eureka Valley Road with the Last Chance Range in the background.

Figure 1.4. Eureka Valley playa from the Eureka Dunes.

Environmental Setting

Eureka Valley is in the northern part of Death Valley National Park, about 25 miles east of the town of Big Pine, California. Located within the Basin and Range physiographic province, Eureka Valley is one of a series of wide, alluvium-filled basins (grabens) between elongated block-fault mountain ranges (horsts). Like most of the valleys in the region, Eureka Valley trends northwest-southeast, with the low point of the closed basin a large playa near the southern end (Figure 1.4). The Last Chance Range, a tilted block of Paleozoic marine sediments capped in part by olivine basalt, rises to over 7000 ft to the east; the Saline Range, reaching 6789 ft elevation, borders Eureka Valley on the west. To the east on the other side of the Last Chance Range lies Death Valley; Saline Valley is to the south and west of the Saline Range, and Deep Springs Valley and Fishlake Valley lie to the north.

In the closed basins of the Death Valley area, summers are hot and winters are cool, with less than 4½ inches of rain a year (Pavlik 1988). Most of the precipitation is during the winter, but in some years summer thunderstorms may account for a significant portion of the yearly rainfall. There are no permanent water sources in Eureka Valley, but tinajas are likely in the rocky canyons of the surrounding Last Chance and Saline ranges.

The largest of three dune fields in the valley, the Eureka Dunes cover an area 1½ by 3 miles east and southeast of the playa. The dunes are dominated by a single high linear ridge that runs roughly north-south, with lower transverse dunes to the west and south (Figure 1.5; Dean 1978). Over 680 feet high from base to crest, the Eureka Dunes are the tallest dunes in California (Figure 1.6; Bagley 1988). Although active, the dunes are relatively stable, with the general outline remaining constant. One geologist has postulated that they occupy a wind eddy formed by the configuration of the surrounding mountains (Norris 1988). It has also been suggested that the massive sand dunes act as a water reservoir, providing a reliable water supply for plants throughout much of the year (Bagley 1988). The Eureka Dunes are reportedly especially effective in this regard. Unlike most dunes, which form on the lee side of mountain ranges, the Eureka Dunes are on the west side of a prominent range and receive water from rains and snow that hit the Last Chance Range. The water collected in the dunes gradually percolates to the outer edges of the dunes throughout the hot summer. As a result, over 50 species of plants grow in and around Eureka dunes, compared to fewer than ten in other dune systems (Potashin 1991b).

Indeed, a sparse scrub-steppe grassland (including psammophytics [sand plants]) occurs on the dunes themselves. As the Mojave Desert's northernmost basin (Grayson 1993), Eureka Valley also contains two other major plant associations: creosote bush scrub on the bajada slopes of the mountain ranges, and saltbush scrub or allscale alkali on the edges of the playa and north of the dunes. All the vegetation is sparse, with plant cover generally less than 5 percent (Bagley 1988).

The Eureka Dunes Archeological Site extends 1,300 meters from the north edge of the dunes northward to the lower bajada slope of the Last Chance Range, and 3,200 meters from the playa eastward to the mountains. A wide, shallow ephemeral drainage bisects the site, dipping gradually from west to east from the base of the mountains to the playa. Smaller, slightly more incised tributary drainages traverse the bajada slope from north to south and east to west to join the main drainage along the north edge of the dunes. Overall, the portion of the site within the area of the present archeological investigations (that is, near the South Eureka Valley Road) is fairly flat, with sheet wash and wind erosion, and some small gullies. Soils consist of a thin discontinuous layer of wind-blown sand over compact silt. Few cobbles occur naturally within the site area; sand collects and mounds around the larger vegetation, and there are a few low sand dunes in the project area.

Over twenty plant species have been identified in the immediate site area (Table 1.1), but the dominant species within the project area is four-wing

Figure 1.5. The Eureka Dunes from the far eastern portion of the Eureka Dunes archeological site.

Figure 1.6. Sand mountain at Eureka Dunes.

saltbush, followed by grasses and creosote bush. There are extensive stands of ricegrass to the south of the site on the western side of the Eureka Dunes. Abundant Russian thistle and off-road vehicle tracks attest to ground disturbance in the area.

The local geology would have provided lithic material of economic value to the prehistoric inhabitants. Delacorte (1988) reports toolstone-quality chert sources about 5 miles north of the site in the Last Chance Range, and obsidian nodules, derived from rhyolitic tuffs, can be found in Saline Range, as well as in the the alluvial fans emanating from the east side of that range (Johnson et al. 1999).

Paleoenvironment

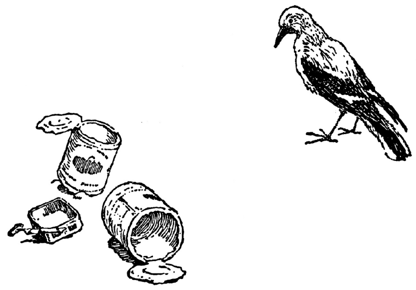
During the more humid periods of the Pleistocene and early Holocene, interior basins often contained large lakes (Grayson 1993). Death Valley, just 10 miles east, contained a lake up to 600 feet deep (Hunt 1975:12), and Searles Valley, to the south, held a large freshwater lake, one of a series of lakes united by the ancestral Owens River (Grayson 1993:101). Eureka Valley, with its relatively small watershed, may not have held enough water to overflow into the ancestral Owens River system, but shorelines visible on the slopes indicate much of the valley bottom was inundated at one time. Two slight rises in the present project area may represent old shorelines: elevation rises slightly but distinctly twice along the road from west to east, the first about 600 meters from the current playa edge (approx. 2875 ft amsl) and the second about 2,000 meters farther east (approx. 2885 ft amsl). Other higher shorelines are visible on the valley slopes.

At the end of the Pleistocene, the Death Valley region enjoyed mild winters and cooler summers. Vegetation was dominated by Utah juniper, rabbitbrush, and shadscale (Spaulding 1990). Botanists are still acquiring evidence for climatic change in the early Holocene, 10,000 to 7,500 B.P.; some data suggest summers were cooler with more rainfall, while other evidence argues that summers were 2-4 degrees warmer than they are now, with winters 2 degrees cooler (Grayson 1993:207). The Mojave Desert during the middle Holocene (7,500-4,500 B.P.) was generally warm and dry, but with short periods of cooler, moister conditions (Grayson 1993:215).

Beginning about 4,500 years ago conditions in the Death Valley region became similar to today’s. Conditions were generally cooler and moister than the middle Holocene, but not as cool and moist as the early Holocene (Grayson 1993:222-229). Creosote first appears in the northern Eureka Valley in packrat midden samples around 4,500 B.P. (Spaulding 1990). Grayson (1993:226) points out that there appears to be greater variability through time and across space in the late Holocene than in earlier periods. Grayson also notes, however, that the greater preservation of late-Holocene paleoclimatic evidence allows variability to be perceived more easily than for earlier epochs.

Table 1.1. Plant Species in the Project Area and Vicinity
(* important economic plants, after Delacorte 1990).

Scientific Name	Common Name
Achnatherum hymenoides	Indian ricegrass*
Ambrosia dumosa	white bursage
Astragalus lentiginosus var. *micans*	shining milkvetch
Atriplex confertifolia	shadscale saltbush*
Atriplex canescens	fourwing saltbush*
Baileya pleniradiata	woolly desert-marigold
Chaetadelpha wheeleri	dune broom
Cleome sparsifolia	naked cleome
Cryptantha sp.	Cryptantha
Dicoria canescens	desert dicoria
Eriogonum deflexum var. *rectum*	ladder buckwheat*
Erioneuron pulchellum	fluff grass*
Grayia spinosa	hop-sage
Larrea tridentata	creosote bush
Oenothera californica ssp. *eurekensis*	Eureka Dunes evening primrose*
Psorothamnus polydenius	dotted indigo bush, dotted dalea
Salsola paulsonii	barbwire Russian thistle
Sphaeralcea ambigua	desert mallow, apricot mallow*
Stanleya pinnata ssp. *inyoensis*	Inyo desert plume
Stephanomeria pauciflora var. *pauciflora*	wire lettuce
Swallenia alexandrae	Eureka Valley dune grass
Tiquilia plicata	string plant, crinklemat



Chapter 2

Overview of Previous Archeological Research

Lynn Johnson

Archeological research in Eureka Valley and the surrounding region commenced in the early 1930s. Julian Steward was the first to describe the archeological resources within the study area proper (1938:79-80), noting:

> … the vast archeological site which stretches for several miles along the northern foot of the dunes on the edge of the playa. The site has untold quantities of flint and obsidian chips but relatively few artifacts, except for some spherical stone mortars of the type commonly used by Shoshoni for grinding mesquite.

In 1931, Clifford Park Baldwin, affiliated with the Southwest Museum, and Mark Kerr, affiliated with the Eastern California Museum (Independence), led an archeological expedition into Saline Valley to investigate sites in the vicinity of Hunter Canyon and Upper Warm Springs (Baldwin 1931; Irwin 1980). The Baldwin party described and photographed rock shelters, rock rings, bedrock mortars, rock art, rock cairns, and cremation remains. A number of artifacts, including basketry, projectile points and other flaked stone tools, potsherds, glass trade beads, olivella shell beads, ground stone tools, obsidian nodules, snare sticks, and a chuckwalla hook were collected. Quantities of obsidian and grey-green chert chipping debris were merely noted. The Baldwin collection is curated at the Eastern California Museum; unfortunately, the artifacts are not well provenienced.

During the 1950s and 1960s numerous archeological investigations were conducted in nearby Panamint Valley (Clements 1956; Davis 1970; Davis and Winslow 1965; Davis et al. 1969; True et al. 1967) and Death Valley (Clements 1951, 1958; Clements and Clements 1953; Hunt 1960; Wallace 1954, 1957a, 1957b, 1958, 1962a, 1962b, 1965, 1968a, 1968b, 1976, 1986b; Wallace et al. 1959; Wallace and Taylor 1959), as well as in the mountains bordering Death Valley National Monument (Davis 1963; Kirk 1953; Kritzman 1966, 1967; Wallace 1957b, 1979a, 1988; Wallace and Taylor 1955, 1956). Summaries of these investigations are found in Brott et al. (1984), Fowler et al. (1994), Norwood et al. (1980), Raven (1985), and Wallace (1977a, 1977b),.

In contrast to Death and Panamint Valleys, archeological investigations in the study area and vicinity during the 1950s and 1960s were few. D.W. Lathrap and C.W. Meighan of the University of California Archeological Survey (UCAS) conducted a reconnaissance in the vicinity of Racetrack Playa in the northern Panamints east of Saline Valley. In general, only rock shelter sites were systematically sought (Lathrap and Meighan 1951). Thirteen rock shelters were recorded during this reconnaissance, and surface artifacts were collected from all but one. Because the rock shelters were readily accessible to looters, a UCAS field crew returned to the area later the same year and completely excavated six of the previously identified sites (Baumhoff 1953; Meighan 1953). The largest of these, CA-INY-222 (also known as the Coville Rock Shelter; Figure 2.1) yielded 354 artifacts, including many perishable items such as basketry, cordage, arrow shafts, horn and bone tools, rabbitskin blanket fragments, sandals, components of a fire starting kit, wooden hand game pieces, and floral and faunal remains. Nonperishable artifacts recovered include projectile points, bifaces, and flake tools of obsidian and chert, dolomite choppers and core tools, incised slate objects, pottery sherds, manos, metates, quartz crystals, raw sulfur, and ochre. The excavation also exposed several rock- and grass-lined cache pits

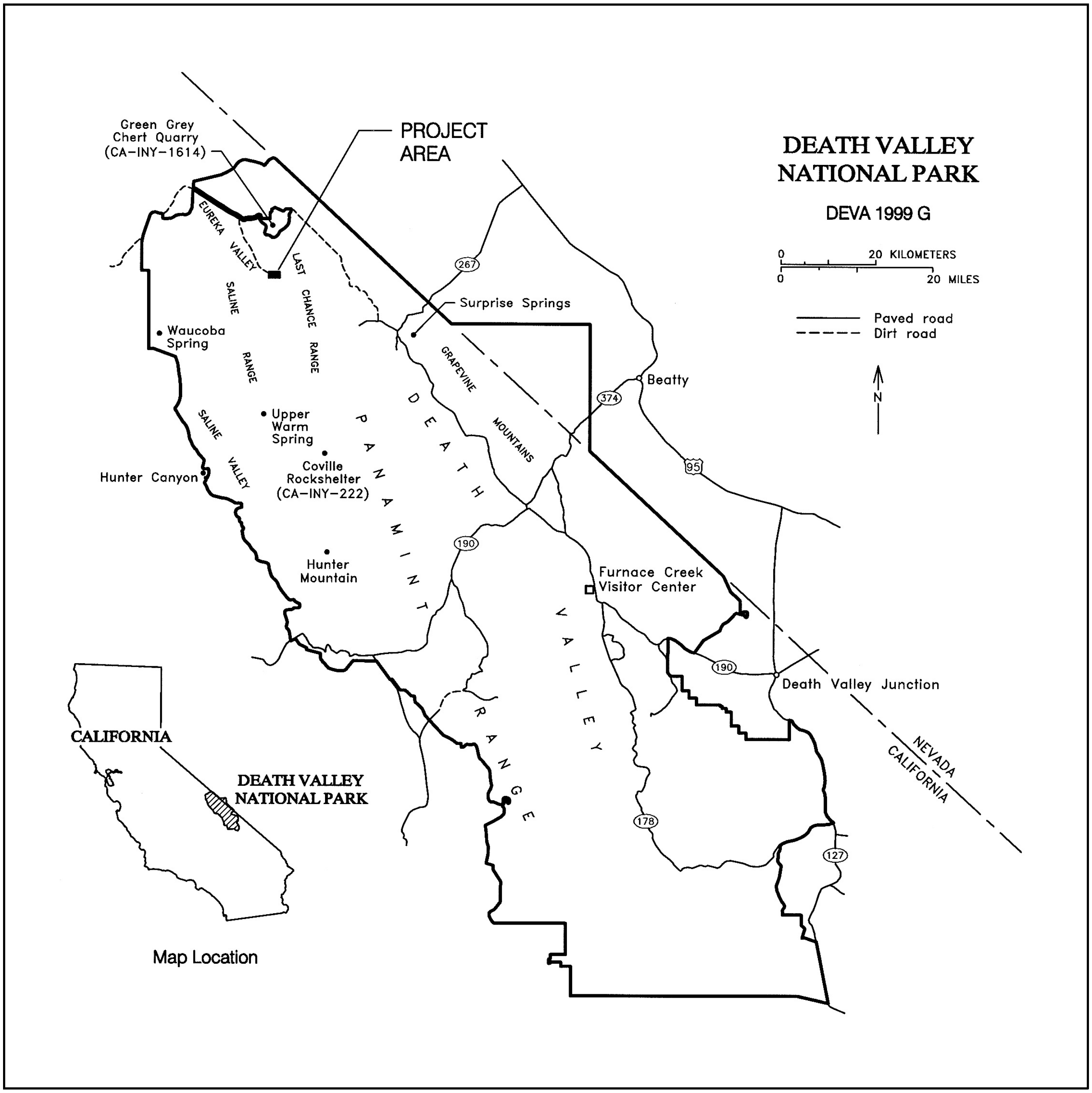


Figure 2.1. Investigated archeological sites near the Eureka Dunes project area.

(Meighan 1951; Wilke and McDonald 1989). Meighan (1951) concluded the shelter was occupied sporadically from approximately 1450 to 1750 A.D. Artifacts collected during both the field reconnaissance and the salvage excavation phases of the project are curated at the University of California, Berkeley.

Richard M. Patch (1951) investigated what he believed to be an aboriginal irrigation system just north of the dunes in Eureka Valley. Excavations conducted by Bettinger and Wilke in the 1970s showed that the putative irrigation system actually consisted of natural playa fissures (Bettinger 1982).

In 1965, Lewis Tadlock, then a graduate student at UCLA, conducted test excavations in Saline Valley at an open midden site near Waucoba Spring. This site is reported to be one of four Panamint Shoshoni winter villages located in the Saline Valley District (Steward 1938). Although the site had been heavily vandalized by the time Tadlock conducted his investigation, he collected surface artifacts from and excavated several units in what appeared to be undisturbed portions of a stratified midden. Pottery sherds, olivella shell beads, worked bone, and ground and flaked stone tools, including Desert Series, Rose Spring, Eastgate, and Pinto projectile points, were among the artifacts recovered (Tadlock 1965). Unfortunately, only a preliminary report was prepared, and the artifacts still await in-depth analyses. Although the collection is officially curated at the University of California, Los Angeles (UCLA), it remains in the possession of the principal investigator (Tadlock, personal communication 2000).

By 1972, when a proposal to inventory the archeological resources of the Saline-Eureka Valley area was prepared for the Bureau of Land Management (BLM), fewer than 30 sites had been officially recorded (Robarchek 1972). In addition to the sites recorded in Saline Valley by Baldwin, a number of sites in the mesquite dunes at the southern end of the valley had been recorded by Emma Lou Davis. Other formally recorded sites mentioned in the report include several occupation sites in Grapevine Canyon and on Hunter Mountain, a petroglyph site near Jackass Flats east of Waucoba Spring, and an occupation site located southwest of the playa in Eureka Valley. The latter site was reported to contain house rings, glass and shell beads, and Desert Side-notched, Eastgate, and Elko projectile points.

Between 1976 and 1977, surveys were conducted in the Eureka, Saline, Panamint, and Darwin Planning Units by members of the BLM cultural resources team of the Desert Planning Staff (Norwood et al. 1980). A phase III judgmental inventory was also carried out in areas where sites had previously been recorded, as well as in areas where the presence of sites seemed likely (Crowley 1978). As a result of this investigation, 43 prehistoric sites were identified in the Eureka Planning Unit and 67 in the Saline Planning unit (Norwood et al. 1980). Sites types identified for the Eureka Planning Unit, which was surveyed using an aligned systematic sample stratified according to ecological zones, include temporary camps (n=11), lithic scatters (30), and rock alignments (2). The Saline Planning Unit was sampled using a stratified unaligned systematic sample; site types identified include temporary camps (7), rock shelters (2), lithic scatters (52), rock art sites (2), a quarry site, a trail, a cairn site, and a pottery locus.

Studies of previously identified sites in the Hunter Canyon, Grapevine Canyon and Hunter Mountain areas (Crowley 1979) were conducted as part of the BLM Phase III inventory. Crowley's study is focused mainly on rock art, although artifacts and features present at the sites investigated are also described. In addition to abundant rock art, the Hunter Canyon site complex contains rock shelters, rock rings, rock concentrations, trails, hunting blinds, and bedrock mortars. Artifacts noted include ground stone tools, potsherds, debitage, and a basketry fragment. In Grapevine Canyon, three rock shelters, a trail, a possible hunting blind, bedrock slicks, and artifacts, including portable metates, manos, flaked stone tools, debitage and fire-affected rock, were noted in addition to the petroglyphs. Near the petroglyphs at Jackass Spring on Hunter Mountain, a scatter of debitage and potsherds was noted.

The Upper Warm Springs area, which, like Hunter Canyon, was also visited by the Baldwin party in 1931, was likewise investigated during the BLM Phase III inventory (Brook 1980). Rock shelters, cleared circles, rock cairns, lithic scatters, hunting blinds, a stone "hogan," and a lithic workshop were identified in the vicinity of Upper Warm Springs. Brook's study focused on the numerous hunting blind features located around the springs and along game trails. He postulates that the features were used for communal hunting, most likely of bighorn sheep. Diagnostic artifacts recovered include Pinto, Elko, Rosegate series, and Cottonwood projectile points and a glass trade bead.

Within the greater Death Valley region, archeological investigations in the past few decades have primarily been conducted in response to Caltrans, BLM, and NPS land management issues. Most of these investigations consist of surveys to assess the cultural resources in areas of potential impact (Antanaitis et al. 1995; Barton 1983; Basgall and Richman 1998; Brewer et al. 1999; Brott et al. 1984; Deal and D'Ascenzo 1987;Tagg 1984).

Two particularly important studies within the past decade were undertaken in areas where natural or human impact had damaged cultural resources. In 1992, test excavations were conducted at two small rockshelters (CA-INY-272) in Breakfast Canyon in Death Valley (Yohe and Valdez 1996). The project was undertaken because the cultural deposits in the shelters were damaged by erosion during a storm the previous winter. The excavations resulted in the discovery of two aboriginal food storage features dating to both late prehistoric (ca. 300 B.P) and historic (post-A.D. 1900) times. The storage features contained basketry fragments, cordage, historical artifacts, and various subsistence resources including mesquite pods, pine nuts, and cultigens. This was the first excavation reported in Death Valley for nearly 30 years, and the first time horticultural products had been recovered from an archeological context in Death Valley. This investigation made an important contribution to the understanding of Panamint and Timbisha food caching practices both before and after contact.

Closer to the current project area, the NPS conducted a survey in 1994 of 200 acres within a burn area in the pinyon zone on Hunter Mountain to inventory and record cultural resources potentially affected by the fire (Burton 1996). Nineteen sites were recorded, and a previously recorded site adjacent the project area was also inspected. This investigation made an important contribution by documenting Native American use of Hunter Mountain from ca. 7000 B.C to historic times. In addition, this study was the first in Death Valley National Park to incorporate obsidian sourcing and hydration studies in the research design. As such, the study made an important contribution to the understanding of prehistoric obsidian procurement and use patterns in the Death Valley region, as well as the effects of fire on hydration rims. Burton documented the use of obsidian from 14 sources, including the "Saline Valley" source and a geographically unknown source termed "Queen Imposter" (Burton 1996; Burton and Farrell 1996; Hughes 1996a). The Queen Imposter obsidian type turned up in the highest frequency yet reported (14%), indicating the source was likely located not far from Hunter Mountain (Johnson n.d.). This investigation also showed that fire can damage the hydration dating potential of obsidian artifacts.

In addition to cultural resource management projects, several academic research projects have been or are currently being conducted in the vicinity of the study area. Research in the Saline Range, located south and west of Eureka Dunes, has shown that three geochemically distinct obsidian types occur in the Saline Range volcanic field (Johnson et al. 1999). Due to the lack of named topographic features with which these glass types can be associated, they have been provisionally named Saline Valley Varieties 1, 2, and 3. Artifacts manufactured from all three geochemical types have been recovered from archeological sites in the southwestern Great Basin. The Saline Range obsidian varieties occur in nodular form within vitrophyres in volcanic tuffs. All deposits of tool grade obsidian identified thus far show evidence of aboriginal exploitation.

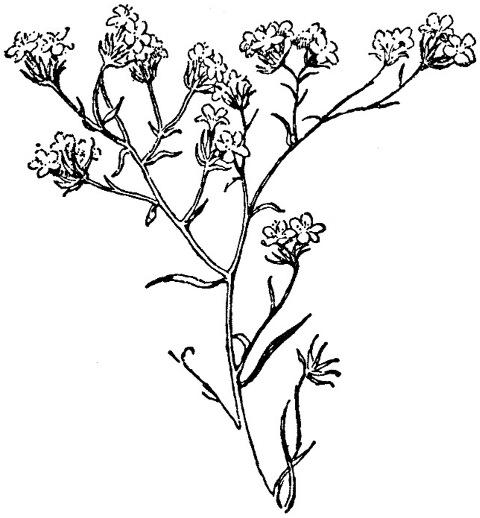
The Saline Range is the source area for a previously unknown glass type termed "Queen Imposter." First identified in an archeological context in 1986 (Basgall and McGuire 1988) this glass type was named Queen Imposter because of its remarkable geochemical similarity to the Truman/Queen source located east of Mono Lake (Hughes 1996b). Saline Valley Variety 1 (Queen Imposter) is the most abundant chemical type geologically, as well as the most significant archeologically.

Artifacts manufactured from Saline Valley Variety 1 obsidian have been recovered from sites in Long Valley to the north (Basgall 1989; Burton and Farrell 1991), Owens Valley to the west (Basgall and McGuire 1988; Basgall and Richman 1998; Burton 1996b, 1998; Delacorte 1999; Delacorte and McGuire 1993; Gilreath and Nelson 1999), the Mojave Desert to the south (Bouey and Mikkelsen 1989; Hughes 1998a), and the Toyaibe Range in Nevada to the east (Hughes 1998b), as well as from sites within Death Valley National Park (Burton 1996a; Burton and Farrell 1996; Hughes 1994, 1996a). All projectile point types included in the Great Basin typological scheme are represented in this artifact inventory, indicating a long temporal span for the exploitation of this source.

Saline Valley Variety 2 is the least abundant geologically. The occurrence of artifacts manufactured from this glass type has not been well documented. Artifacts manufactured from Saline Valley Variety 3, also known as the "Saline Valley" source, have been recovered from sites in Owens Valley (Basgall and McGuire 1988; Basgall and Richman 1998; Delacorte 1999; Gilreath and Nelson 1999), as well as from sites within Death Valley National Park (Burton 1996a; Burton and Farrell 1996; Hughes 1994, 1996a). The ongoing research in the Saline Range will further understandings of obsidian procurement and use in the Death Valley region.

In addition to his dissertation research in Deep Springs Valley (Delacorte 1990), Michael Delacorte made an important contribution to regional prehistory with his investigation of CA-INY-1614, a chert quarry in the Last Chance Range (Delacorte 1988). The quarry, which is located approximately 12 kilometers north of Eureka Dunes, was the source of a distinctive green-grey chert that was apparently highly valued for the production of bifaces. Delacorte's study documents a specialized regional biface industry for Deep Springs Valley, Northern Owens Valley, and the northern Death Valley region that coincides with an intensification in regional adaptations and major changes in land use patterns ca. 600 A.D.

A final study worth mentioning is the rock alignment investigation conducted by Jay von Werlhof. The rock alignments investigated by von Werlhof (1987) and photo-recorded by Harry Casey are located in Eureka, Panamint, Greenwater, and Death valleys. Rock alignments are particularly abundant in Panamint Valley. In fact, Panamint Valley contains the largest concentration of rock alignments known in North America. Three alignments and two cairn concentrations were identified in Eureka Valley not far from the project area. Von Werlhof assigns a ceremonial significance to the alignments in the Death Valley region.



Chapter 3

Ethnographic Background

Lynn Johnson

Formal ethnographic information regarding the Panamint Shoshone (now referred to as the Timbisha Shoshone), the Native American occupants of the region considered in this report, was first recorded by members of the 1891 Death Valley Expedition of the U.S. Biological Survey (Coville 1892; Dutcher 1893; Nelson 1891). Important data regarding habitation site locations and subsistence practices are included in these brief reports. Kroeber (1925) also provides a brief description of the territory, manufacturing technology, and subsistence practices of the Koso or Panamint Shoshone.

It was not until the 1930s, however, that detailed ethnographic accounts were made, thanks to the pioneering efforts of Julian Steward. Although Steward collected his information well after traditional lifeways had been seriously disrupted by Euro-American contact, valuable data regarding Panamint Shoshone territorial boundaries, subsistence practices, material culture, social-political organization, marriage and kinship practices, village locations, place names, and mythology were obtained (Steward 1938, 1941, 1942).

In 1980, C.N. Irwin published subsistence data and myths collected during the 1930s by botanist Mark Kerr. Interviews with contemporary Timbisha Shoshone conducted during the past decade by Fowler, Dufort, and Rusco (1994), Fowler (1995,1996), Moyer (1996), and Potashin (1991a, 1992a-c) have brought additional information to light. Except where noted, the following was summarized from Steward (1938).

Territorial Boundaries and Village Locations

The Panamint Shoshone territory included the southern half of Eureka Valley, all of Saline Valley, the northern halves of Death and Panamint Valleys, the Coso Mountain region, the southern shore of Owens Lake, the northern edge of the Mojave Desert in the vicinity of Little Lake, and a portion of the eastern slope of the Sierra Nevada (Krober 1925; Steward 1938). Steward divides this territory into four districts: Saline Valley, Panamint Valley, Northern Death Valley, and Little Lake/Koso Mountains. Districts were comprised of several subdivisions, each containing at least one lowland winter village located near a reliable water source (Figure 3.1).

The Saline Valley district had three subdivisions and four winter villages. The main village and subdivision, *Ko*'°, meaning deep place, was located on the western side of the valley near the mouth of Hunter Canyon. The second subdivision, *Pauwu'ji* (or *Pauwu'jiji*), comprised the low mountains between Saline and Eureka Valleys; the principal village, Icam'ba, meaning coyote water, was probably located near Waucoba Spring. A second village may have been located near Lead Canyon Spring. The third subdivision, *Sigai* (flat, on the mountaintop), consisted of the mountains separating Saline, Death, and Panamint Valleys. This subdivision contained two villages, *Tuhu*, meaning black(?), located near Goldbelt Spring, and *Navadu*, meaning big canyon, located near the springs in Cottonwood Canyon. Steward includes the southern portion of Eureka Valley, including Eureka Dunes, in the Saline Valley district. Eureka Valley is nearly waterless, and had no permanent winter villages.

Main villages in the Northern Death Valley District were located at Mesquite Springs, Grapevine Canyon, and Surveyor's Well. The Little Lake/Koso Mountain district had four permanent villages: Little Lake, Coso Hot Springs, Cold

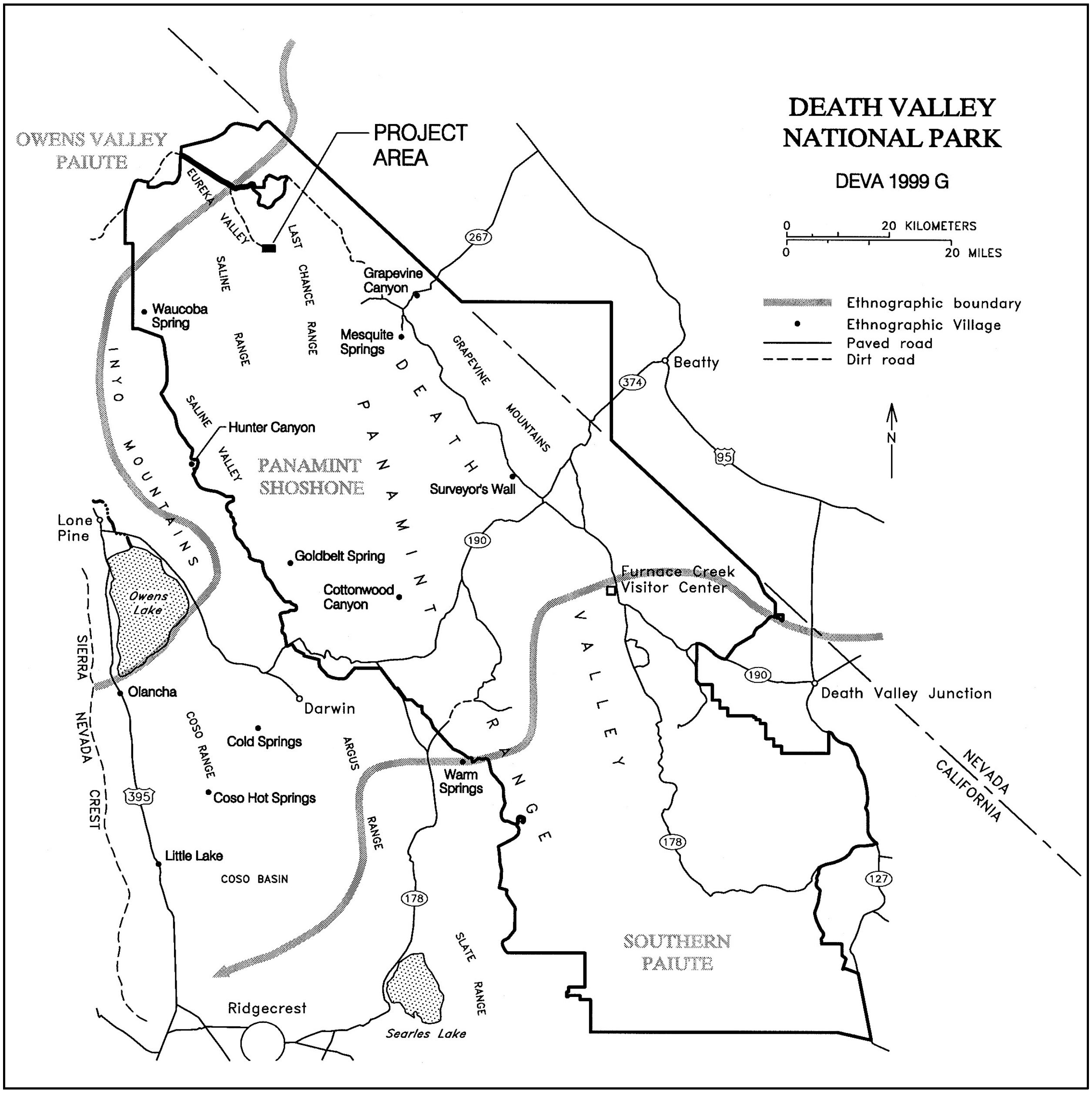


Figure 3.1. Panamint Shoshone ethnographic villages in the Death Valley area.

Springs (about five miles south of Darwin), and Olancha, on the southwestern shore of Owens Lake. Less is known about the sparsely populated Panamint district; the principal and perhaps only permanent village was located at Warm Springs.

Sociopolitical Organization

Panamint Shoshone sociopolitical organization consisted of interactions on three levels: the nuclear family, the village, and the district. For most of the year, nuclear families functioned as self-sufficient economic units, foraging independently generally within the subsistence catchment of the winter village. Although several families from the same or neighboring villages occasionally gathered in the mountains for short periods in adjacent seed or pine nut harvesting areas, each family took care of its own subsistence needs.

During the winter months, related families congregated in permanent villages located in the lowlands close to reliable water sources and stores of cached seeds and pine nuts. Residence at winter villages was fluid, and no formal sociopolitical unit beyond the nuclear family was recognized. At times entire district populations congregated for communal game drives, as well as for annual fall festivals. People from surrounding districts also participated in fall festivals, which were usually held in conjunction with a rabbit drive. As such, the fall festival was the largest cooperative venture; it was during these events that deaths were mourned, marriages were arranged, and kinship ties were strengthened.

Most permanent villages had a chief or headman who was responsible for keeping village members informed of important events such as the ripening of seed and pine nut crops and the locations of communal hunts and fall festivals. This position was usually hereditary, passing from father to son or another male relative. The headman served as an advisor and director, but had no authority to compel others to follow his counsel.

Subsistence-Settlement System

An annual round based on gathering and hunting characterized the subsistence-settlement system of the Panamint Shoshone. During the spring, summer, and fall, families moved independently between temporary camps in pursuit of subsistence resources. Families usually foraged within a subsistence catchment that consisted of the lowlands around the winter village, as well as the surrounding uplands. The geographic distribution and seasonal availability of plant rather than animal resources usually dictated movement within the catchment; this movement generally progressed from lower to increasingly higher elevations from spring through fall. Game was usually hunted on an encounter basis, communal rabbit and antelope drives and perhaps bighorn sheep hunting being the exceptions.

Because resource availability within catchments differed from year to year due to environmental factors such as vagaries in rainfall, the gathering and hunting localities exploited varied from one year to the next (Fowler et al. 1994). Local resource availability was monitored carefully throughout the year to prevent shortfalls. When resource productivity was exceptionally poor, it was not uncommon for people to travel to surrounding subdivisions or districts to acquire their subsistence needs. People also traveled to distant locations to acquire resources that did not occur naturally within their territories, like mesquite and brine fly larvae. During the winter months when few subsistence resources were available, families returned to permanent villages in the lowlands and lived off of stored vegetal foods, primarily pine nuts.

The Panamint Shoshone annual round allowed for the exploitation of a wide variety of subsistence resources. As Steward (1938: 77) notes:

> The remarkable variety of habit zones and of species of both plants and animals within a comparatively small area enabled the Saline Valley people to maintain existence securely if not abundantly without having to exploit an inconveniently large area.

Nuts from the pinyon pine (*Pinus monophylla*) were by far the most important subsistence resource exploited by the Panamint Shoshone (Coville 1892; Steward 1938). Large tracts of pinyon were readily accessible to the occupants of the Saline Valley district, including those located west of the valley in the Inyo Mountains, on Hunter Mountain, which separates Saline and Panamint Valleys, and in the Last Chance Range east of the uplands separating Saline and Eureka Valleys. Using the brown cone procurement method, pine nuts were harvested in early fall when the cones opened to release the nuts. After the harvest, the nuts were carried back to lowland villages where they were stored for winter use. In most years, pine nuts comprised the bulk of the diet during the winter. In years of exceptionally high nut productivity, pine nuts were cached in the mountains to be retrieved as needed. Occasionally people wintered over in the mountains to remain close to pinyon caches.

Dutcher (1893) recorded pine nut collection and processing techniques employing the green cone procurement method practiced by a group of Panamint Shoshone encountered on Hunter Mountain in the latter part of the summer of 1891. With the green cone method, harvesting commenced in late summer after the cones matured, but before they opened to release the nuts. Cones were pulled from the trees with the aid of long hooked poles, then placed in large pits and slowly roasted until they opened. Once removed from the cones, the roasted nuts could be stored for as long as two years. Unroasted green cones could be stored in cache pits for up to a year. The green cone procurement method was more time consuming and labor intensive than the brown cone method, but served to increase nut yields by lengthening the harvest period and decreasing competition with other animals for the crop (Bettinger 1982).

Mesquite (*Prosopsis* sp.) was another vegetal resource that figured importantly in the Panamint Shoshone diet. Mesquite groves occur in the lowlands of Saline, Panamint, and Death Valleys. Both the honey (*P. juliflora*) and screwbean (*P. pubescens)* varieties were exploited. Green mesquite pods were eaten in spring; in summer the dried brown pods were collected and cached for later use. To process the dried pods for consumption, the seeds were first removed. The pods were then ground into flour in deep mortars of stone or mesquite wood using cylindrical stone pestles (Coville 1892; Fowler et al. 1994).

Because they were fairly abundant and could be readily stored for later use, seeds of a wide variety of plants were gathered when available. Some of the more important seed bearing plants exploited by the Panamint Shoshone include sand bunch or Indian rice grass (*Achnatherum hymenoides*), white-stemmed blazing star (*Mentzelia albicaulis*), primrose (*Oenothera* sp.), cottontop cactus *(Echinocactus polycephalus*), chia (*Salvia columbariae*), and Mormon tea (*Ephedra nevadensis*). Seeds were gathered by hand or beaten into a basket using a basketry seed beater, roasted in a basketry tray with hot coals, and ground using a mano and metate (Coville 1892; Irwin 1980; Steward 1938).

Several varieties of ethnographically important seed bearing plants grow in the vicinity of Eureka Dunes, including primrose and rice grass (DeDecker 1984). Steward (1938) reported that Panamint Shoshone from the Saline Valley district traveled to the southern end of Eureka Valley to gather rice grass seed and *pagampi* (unidentified). Mary DeDecker discovered a basket containing seeds of *Dicoria canescens* ssp. *clarkae* in a small rockshelter in Dedeckera Canyon, only a few kilometers south of Eureka Dunes (Potashin 1991b; Wilke et al. 1979). Although no ethnographic accounts exist for the procurement of *Dicoria* seeds, *D. canescens* ssp. *clarkae* grows in abundance at Eureka Dunes; the Panamint Shoshone likely consumed seeds from this species. *Dicoria* produces seeds during the winter when other subsistence resources are scarce, which may have added to its importance.

In addition to seeds, a variety of other vegetal resources were exploited, including greens, roots, tubers, flower buds, berries and fruits (Coville 1892; Fowler et al. 1994; Irwin 1980; Steward 1938). Greens from prince's plume (*Stanleya* sp.) were procured in early spring when stored foods were typically depleted, and provided an important safeguard against starvation (Steward 1938). Pads from the beavertail cactus (*Opuntia brasilaris*), as well as various fruits and berries, including those from the desert tomato (*Lycium andersonii*), could be dried and stored for later use.

While secondary in importance to plant foods, a variety of both large and small animals were taken when encountered. Small mammals, birds, and reptiles comprised the majority of animal foods consumed, although large game such as bighorn sheep, antelope and deer provided a welcome addition to the Panamint Shoshone diet. Hunting strategies employed in the procurement of large game included use of the bow and stone-tipped arrows, hunting blinds, and game drives. Men occasionally hunted together, driving large game toward waiting hunters. Jackrabbits were also hunted communally. The rabbits were driven into long nets strung across one end of the valley, and shot with bows and arrows or clubbed with sticks. Rabbit drives, which were organized by village headmen, were typically held in conjunction with the annual fall festival. Rodents, birds and lizards were captured using snares, traps, and sticks tipped with bone barbs; waterfowl and doves were hunted from blinds (Steward 1938; Wallace 1979b). Panamint Shoshone from Saline Valley occasionally traveled to the south shore of Owens Lake to hunt ducks and gather brine fly larvae.

By the time written accounts of their lifeways were made, the Panamint Shoshone were cultivating crops such as corn, beans, squash, watermelon and alfalfa at village sites in Saline, Panamint, and Death Valleys (Moyer 1996; Nelson 1891; Steward 1938). This practice was likely introduced after Euro-American contact, although a Colorado River origin has also been suggested (see Wallace 1980 and Yohe 1997).

Technology

Many kinds of baskets were employed in the procurement and preparation of vegetal foods, including seed beaters, conical burden baskets, trays for winnowing and parching seeds and nuts, and bowls for cooking and storage (Driver 1937; Steward 1941). Water was carried and stored in basketry jugs coated with pitch. Twining and coiling methods were both used by women to construct baskets from locally available materials such as willow (*Salix* sp.) and deergrass *(Muhlenbergia rigens*). Design elements were incorporated into coiled baskets using Joshua tree *(Yucca brevifolia*) roots and devil's claw (*Proboscidea parviflora*) pods (Coville 1892; Kirk 1952; Potashin 1991a, 1992a-c; Sennett-Graham 1990).

Pottery manufactured from locally available clays was also used for food preparation and storage (Irwin 1980; Wallace 1986b; Weaver 1986). Although pottery reportedly was no longer in use when enthnographers began documenting Panamint Shoshone lifeways (Coville 1892), informants interviewed during the 1930s retained knowledge of manufacturing techniques (Driver 1937; Irwin 1980; Steward 1941,). Clay was ground on a metate, mixed with juice extracted from desert mallow (*Sphaeralcea* sp.) or cactus (*Opuntia* sp.), and constructed into pots using the coil method. Sand was sometimes added as temper. The surface of the pot was scraped smooth using the fingers or a stick; rims were occasionally decorated with thumbnail incisions. After the pots dried, they were fired in an open fire fueled with mesquite wood or brush. Plain ware in three vessel styles, pointed-bottom, rounded-bottom, and flat-bottomed straight-walled, have been recovered from archeological sites in Panamint Shoshone territory (Steward 1941; Wallace 1986b).

Men manufactured cordage used in the construction of snares, rabbit nets, rabbit skin blankets, and bowstrings. Bows were manufactured from juniper staves and backed with sinew (Coville 1892). Although Coville reports that bow staves were obtained from dead wood, live juniper trees with bow stave removal scars similar to those reported in western Nevada by Wilke (1993) are known to occur in the Last Chance Range between Saline and Eureka Valleys (Johnson n.d.). Other items manufactured from wood include arrow shafts, fire starting kits, pinyon hooks, digging sticks and mesquite mortars.

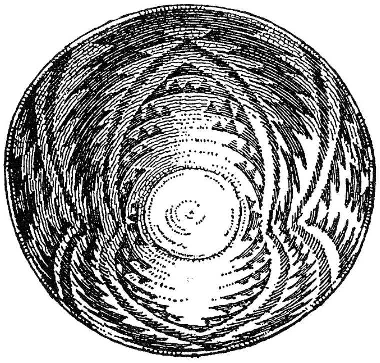
Ground stone implements were used to process a variety of plant foods. Seeds and pinyon nuts were ground with manos on metates or milling slicks. In addition to wooden mortars, bedrock mortars, as well as portable bowl mortars made of stone, were frequently used with stone pestles to process mesquite pods and other vegetal resources. Steward (1938) reported the presence of spherical stone mortars of the type commonly used by the Panamint Shoshone for grinding mesquite at Eureka Dunes, though mesquite does not occur in Eureka Valley. Steward (1941:227) illustrates mortars, pestles, metates, and handstones from Eureka Valley.

Although ethnographic accounts regarding the manufacture and use of flaked stone tools are rare (see Irwin 1980 and Potashin 1992a), numerous flaked stone tools and the chipping waste from their manufacture have been recovered from archeological sites attributable to Panamint Shoshone occupation (Burton 1996a; Hunt 1960; Tadlock 1965; Wallace 1977b). Obsidian and chert were apparently preferred for the manufacture of arrow points, flake tools, and bifacial knives (Irwin 1980; Potashin 1992a). Both chert and obsidian are available within Panamint Shoshone territory (Delacorte 1988; Hunt 1960; Johnson 1999; Johnson and Wagner 1988; Johnson et al. 1999a, 1999b; Kritzman 1967; Wallace 1977b). Studies of use wear patterns on flaked stone tools recovered from archeological contexts in other regions have shown that flaked stone implements were used to work a variety of materials, including wood, bone, plant fibers, and hide (Bamforth 1991).

Trade

Some trade existed between the Panamint Shoshone and neighboring tribes. A very pure salt obtained from the flats around Salt Lake in Saline Valley was traded to the Owens Valley Paiute (Potashin 1992b) in exchange for shell beads and other goods (Davis 1961; Steward 1938). While obsidian and chert are not listed as exchange items in ethnographic literature on the Panamint Shoshone, a number of other California and Great Basin groups, including the Owens Valley Paiute, engaged in toolstone trade (Davis 1961; Steward 1938).

Artifacts manufactured from gray-green chert and the Saline Valley obsidians have been recovered from Marana Period sites located outside Panamint Shoshone territory (Basgall and McGuire 1988; Bettinger 1989; Delacorte 1988, 1990; Gilreath and Nelson 1999) suggesting that in addition to salt, toolstone resources were also traded. Direct procurement of toolstone by outside groups may also explain this phenomenon, however, as quarry sites are located not far from Panamint Shoshone-Owens Valley Paiute territorial boundaries. Delacorte (1988, 1990) and Bettinger (1989) have noted an abundance of gray-green chert debitage at sites in both Owens and Deep Springs valleys, and Delacorte (1988:8-9) has suggested the chert was acquired through direct procurement, as the sites where the chert was noted are "primarily lowland occupation sites and pinyon camps … inhabited during winter months when subsistence activities were minimal, allowing time for other pursuits, including travel to distant raw material sources and tool manufacture."



Chapter 4

Research Objectives and Methods

Jeffery F. Burton

Field work was conducted at the Eureka Dunes Site (CA-INY-2489) in June 1999 and February 2000. The objective of the work was to gather sufficient data to assess the significance and research potential of the site, clarify its eligibility for listing on the National Register of Historic Places, and make informed recommendations regarding its future management. Specifically, the work was designed to: (1) investigate the site structure to discern any culturally derived patterning and assess integrity; (2) identify and determine the age of occupation; (3) define the quantity and quality of data categories present; and (4) assess the site's ability to address significant research questions.

Field Methods

The archeological work at the Eureka Dunes Site included surface collection, surface scrapes, shovel testing, feature excavation, and mapping. Most work at the site was centered along the South Eureka Valley Road, which provides a 4,000-m-long transect across the site. Not only does the area adjacent to the road provide a sample of the site terrain from playa edge to bajada slope, it is also the area most likely to be subject to future impacts. Further, the easy accessibility provided by the road-side units provided a greater level of efficiency, allowing more of the site to be investigated. The road corridor was also seen to have potential to provide information on past impacts. Most of the corridor appears fairly pristine, with little evidence of visitor use outside the road alignment. However some sections are heavily traveled, with off-road vehicle tracks and parking areas off the main road. To examine one of these heavy use areas, additional work was conducted at a spur road that provides access from the South Eureka Valley Road to a small camping area to the south.

In addition to the road corridors, Tim Canaday, Death Valley National Park Archeologist, completed archeological work using the same methods as within the road corridors at three "construction loci" where modifications have been proposed to better protect the dune habitat. Two are the proposed new parking/camping areas and the third is the existing restroom and parking area, which would be closed and revegetated.

Field work within the road corridors, totaling 55 person days, was conducted February 7-18, 2000, by a team of four archeologists and up to four volunteers under the supervision of the senior author. Work at the three construction loci was undertaken in June and October 1999 and completed in February 2000 concurrently with the work within the road corridors.

Three types of sample units were used: surface collection units (SCUs), shovel test units (STUs), and surface scrape units (SSUs). In addition, three features were excavated using standard 1 m by 1 m excavation units (Table 4.1). A total of 42,975 square meters was subjected to intensive examination during the course of field work, with 5 cubic meters (34 m^2) excavated. Field data were recorded on standardized forms tailored to each sample unit type. All units were laid out in the field using compass and tape. A site map was prepared to show the location of all units, excavated features, roads, and topographic features using GPS equipment, aerial photographs, and USGS maps (Figure 4.1). Temporary datums were placed only at Construction Loci 1 and 2.

Table 4.1. Archeological Work Completed at the Eureka Dunes Site (CA-INY-2489).

	Construction Loci	Road Corridors	Total
Surface Collection Units (SCU)	36	78	114
Shovel Test Units (STU)	27	82	109
Surface Scrape Units (SSU)	0	7	7
Feature Excavations*	1	2	3

*three additional features along the road corridor were tested, two using STUs and one using a SSU.

Surface Collection Units (SCUs)
A total of 114 surface collection units were completed, 16 at Construction Locus 1, 18 at Construction Locus 2, 2 at Construction Locus 3, and 78 within the road corridors (Figures 4.2-4.4). Surface collection units were 20 m by 20 m in size; those in the road corridor were aligned to the road; those at the three Construction Loci were laid out on a grid oriented to cardinal directions.

Each surface collection unit was walked or crawled (depending on artifact density) by one or more archeologists along parallel transects no greater than 1m apart. The unit was then rechecked using perpendicular transects to insure no artifacts were missed. Major vegetation, formal artifacts, features, debitage concentrations, topography, and disturbed areas were noted and plotted on detailed unit records. All prehistoric artifacts were collected. Fire-cracked rock was collected only when it occurred in isolation, away for features. Modern artifacts (such as bottle glass, crown caps, and cartridge shells) were noted but not collected. At some of the surface collection units in Construction Locus 2, debitage was only collected in a 5 m by 5m quarter because of the density of artifacts encountered. The entire 20 m by 20 m unit, however, was examined for flaked stone tools and other artifacts.

The 78 surface collection units within the road corridors were placed adjacent to the road, and identified with a two-part designation. The number is the distance of the closest corner of the unit to the road intersection at the western edge of the site as measured by tape along the road. “N” or “S” indicates whether they were located north or south of the road. For example, surface collection unit 800N is located 800 m east of the western edge of the site on the north side of the road. In the western half of the site, the units were placed at 40-meter intervals, with unit placement alternating from the north to the south side of the road. Two units south of the road were skipped because they partially overlapped with Construction Locus 1. From the point where a road spur takes off from the South Eureka Valley Road (just east of surface collection unit 1880S), to the east, surface collection units were placed along only the south side of the spur road and, with one exception, along the north side of the main road. These surface collection units were placed at 80 m intervals, except for the one unit placed on the south side of the South Eureka Valley Road between two other surface collection units.

Surface collection units within the construction loci were assigned numbers based on the locus number and collection unit number. For example, SCU 3-1 is the first collection unit within Construction Locus 3.

Surface Scrape Units (SSUs)
Surface scrape units, located within surface collection units, were 1 m by 2 m in size, and excavated by shovel to about 10 cm deep or slightly more.

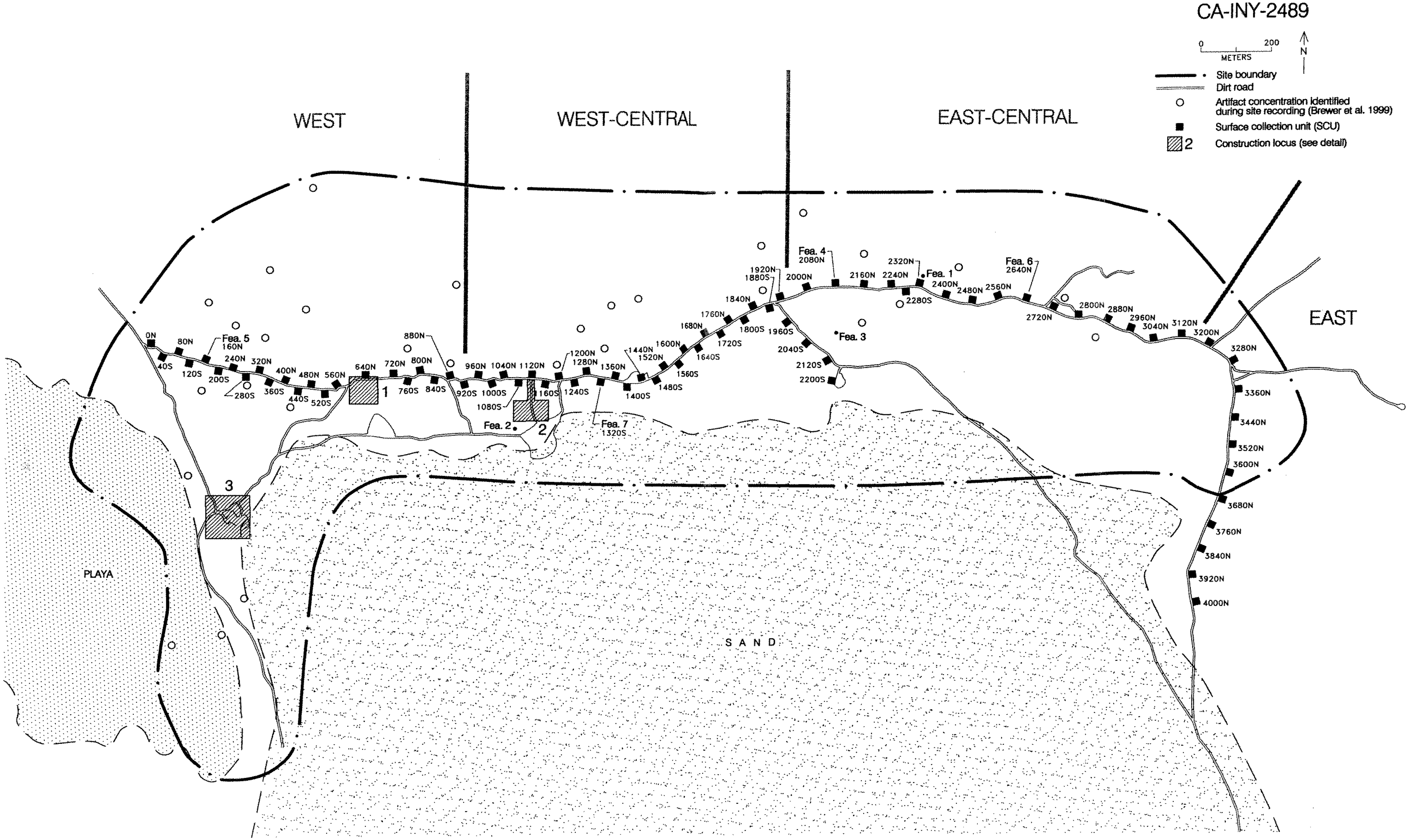


Figure 4.1. Eureka Dunes archeological site.

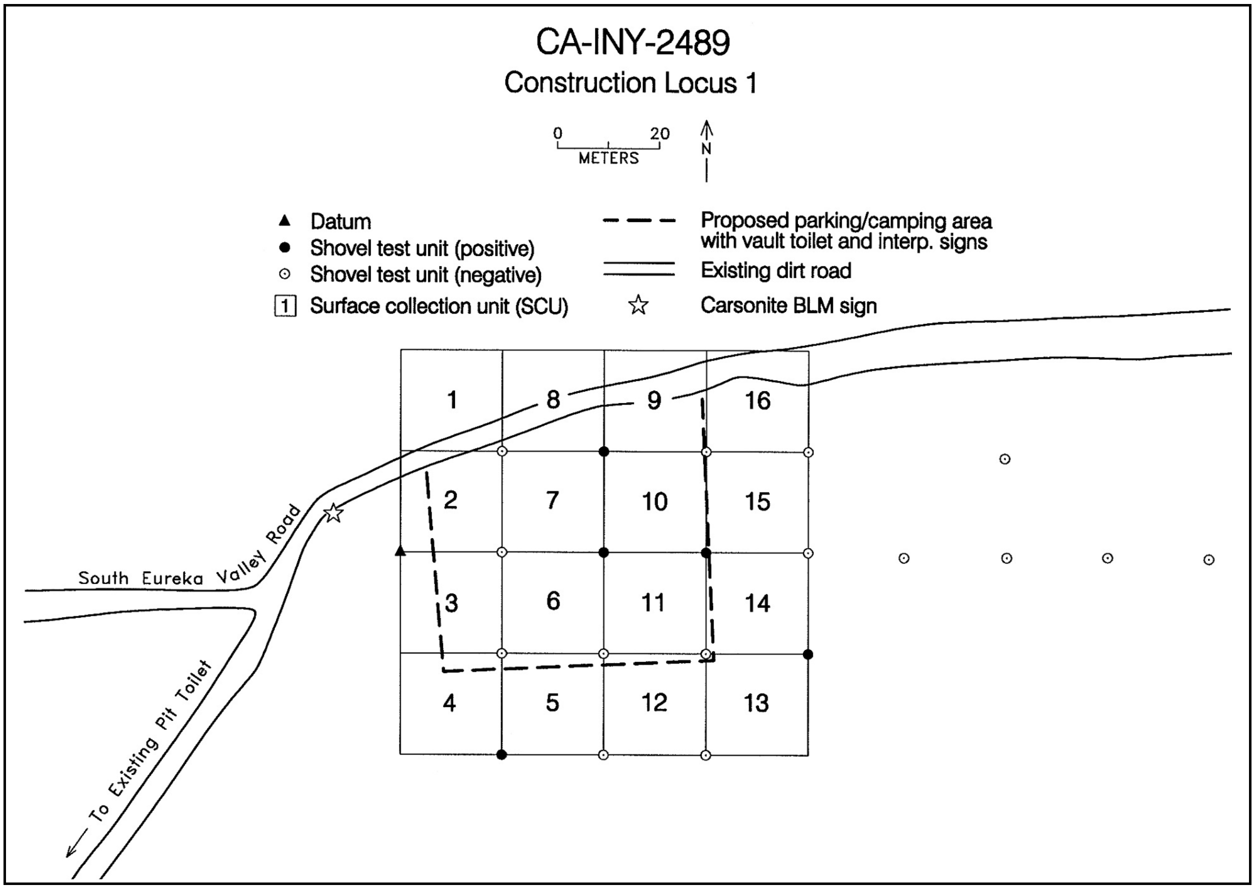


Figure 4.2. Construction Locus 1 at Eureka Dunes.

Excavated sediment was screened through À-inch mesh hardware cloth with all artifacts collected. These units were designed to provide a check on the surface collection units, since the fine-gauge screening would allow the retrieval of small debitage overlooked in surface collection. Although it was initially planned to complete one surface scrape unit within each surface collection unit, this strategy was quickly abandoned. So few artifacts were recovered from the screened sediments of the first units that it became apparent that the paucity of small debitage recovered from the surface collection units likely reflected the true nature of the assemblage rather than an observational bias. Ultimately, the surface scrape units were completed only where soil conditions and artifact density indicated the potential for subsurface deposits or the recovery of significant numbers of small flakes.

Shovel Test Units (STUs)

At least one shovel test unit was excavated within each surface collection unit, placed in the center of the surface collection unit unless another area appeared to have more potential for subsurface deposits. The shovel tests were approximately 30-cm-square, and excavated in 20-cm levels until indurated sediments or depth precluded further digging. Excavated sediments were screened through À-inch mesh hardware cloth with all artifacts collected.

Feature Excavations

During the course of field work, several fire-cracked rock concentrations were identified at the site. Three of these features were tested with one or more 1 m by 1 m units, depending on the areal extent of the rock concentration. The units were placed to bisect the excavated feature so it could be half-excavated and profiled. The remainder of the feature was then excavated. Feature fill was collected for later analyses. Sufficient charcoal from each of these features was recovered for radiocarbon dating. Excavation proceeded by 2 cm

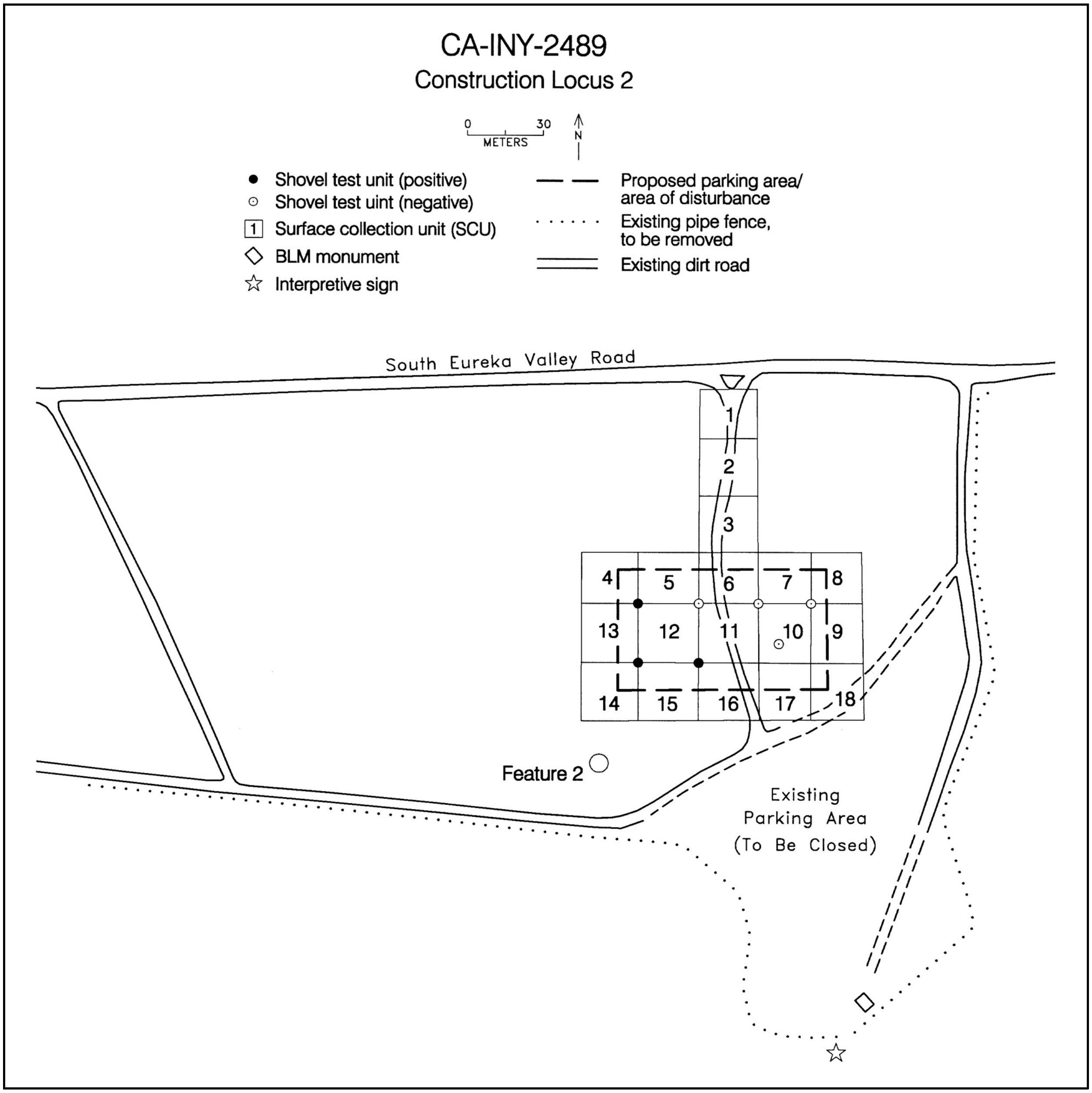


Figure 4.3. Construction Locus 2 at Eureka Dunes.

or smaller increments based on stratigraphy. Excavated sediment was screened through À-inch mesh hardware cloth with all artifacts collected. Fire-cracked rock was weighed and described and then discarded in the field. Three additional rock concentrations were also tested, two with shovel test units and one with a surface scrape unit.

Analysis

Initial processing of materials was undertaken at the Western Archeological and Conservation Center in Tucson, Arizona. Prehistoric artifacts were classified following the analytical procedures and nomenclature used by other researchers in the region (e.g., Basgall and McGuire 1988; Bettinger 1989; Burton 1996; Delacorte 1990; Gilreath and Hildebrandt 1997). Artifacts were first divided into categories based on gross morphology and presumed function. Subsequent analyses varied by artifact category, but included determination of material type, metric attributes, and condition and classification using established Great Basin typologies.

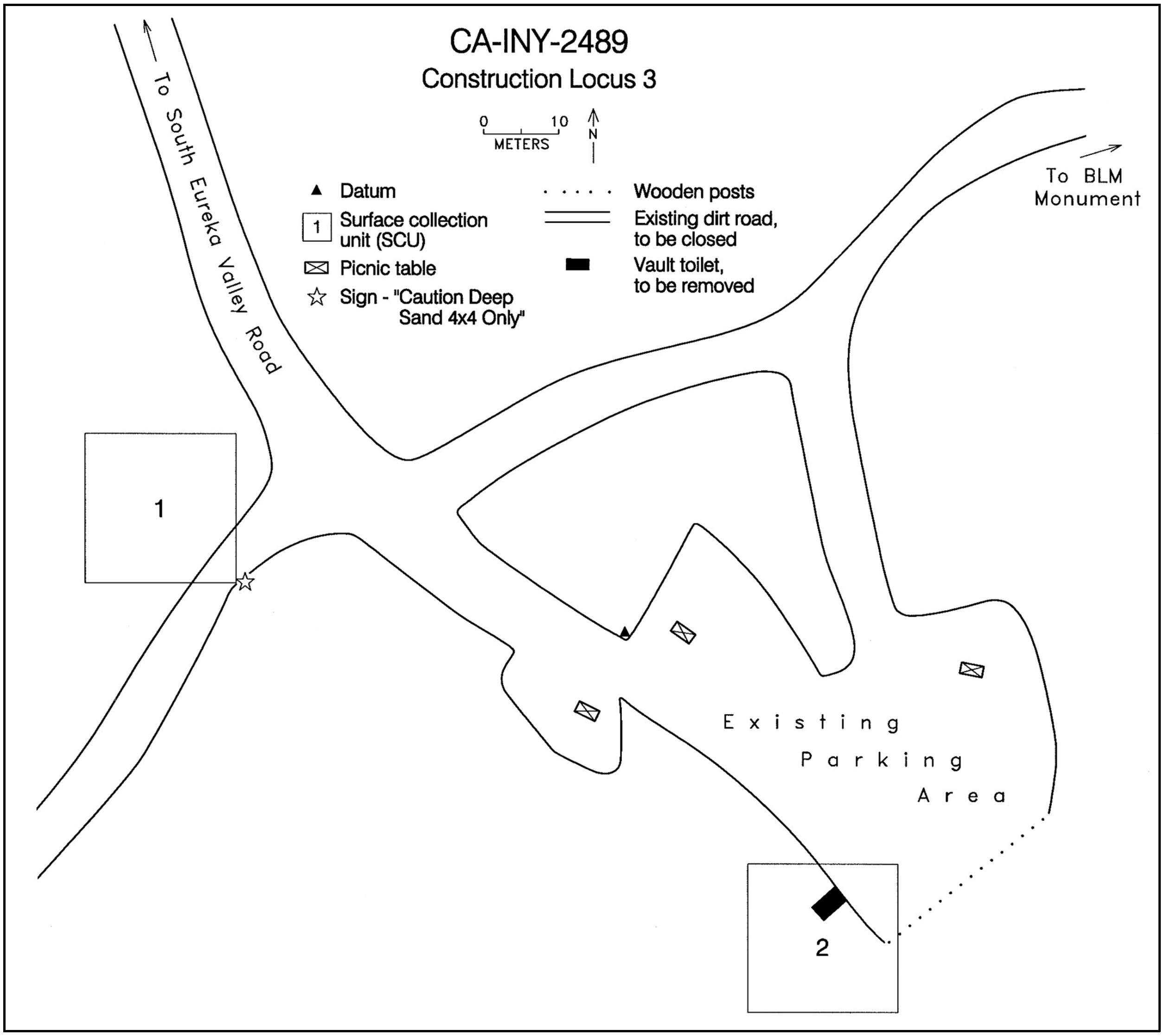
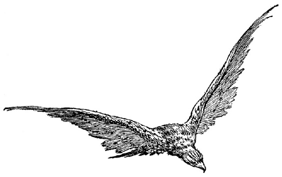


Figure 4.4. Construction Locus 3 at Eureka Dunes.

Flaked stone was sorted by material type: obsidian, green-grey chert, other chert (cryptocrystalline), and other materials (basalt, quartz, quartzite). All tools and other potentially worked pieces and a sample of debitage were sent to Bill Bloomer, Lithic Arts, Markleeville, California, for detailed morphological analysis. Selected obsidian specimens were submitted to the Northwest Research Obsidian Studies Laboratory for x-ray fluorescence (XRF) sourcing and obsidian hydration (dating) analyses. Samples for radiocarbon anaylsis were sent to Beta Analytic, Miami, Florida. Other samples and artifact classes were analyzed at WACC. At the completion of the project all field and analyses notes, artifacts, photographs, and other relevant materials were transferred to Death Valley National Park for curation (Acc. No. DEVA 2374).



Chapter 5

Site Structure

Jeffery F. Burton

The 1999-2000 archeological investigations suggest the Eureka Dunes Site (CA-INY-2489) is as extensive as previously recorded (Brewer et al. 1999): the portion of the site examined in this project extends nearly 4,000 m east-west. Our intensive examinations indicate numerous artifact concentrations, some with very high amounts of debitage. Several previously overlooked features (concentrations of fire-cracked rock) were also noted. However, subsurface testing indicates the site is almost completely confined to the surface, except in the westernmost part of the site. Nevertheless, as might be expected for a site this large, the Eureka Dunes Site appears to exhibit *horizontal* stratigraphy, with apparent patterning of cultural material across the site. This chapter describes the distribution of artifacts and features horizontally, as indicated by the surface unit results, as well as vertically, through the excavation unit results. The features at the site (fire-cracked rock concentrations) are described in some detail, for the insight they provide on site structure (e.g., depth and integrity of cultural deposit). Please note, interpretations of these distributions, as well as of the artifact classes and features, are considered in subsequent chapters.

Surface Artifact Distributions

Over 26,000 artifacts, the vast majority consisting of flaked stone debitage, were recovered from the Eureka Dunes Site (CA-INY-2489). Debitage collected from surface collection units (SCUs) included 26,372 flakes. Sixty-four percent of these are obsidian, 31 percent are green-grey chert, 5 percent are other types of chert, and 1 percent are other types of stone. There were100 flaked stone tools from the surface collection, 37 of which are obsidian, 52 are green-grey chert, ten are other types of chert, and one is quartzite. The surface collection also includes ten ground stone artifacts, three hammerstones, and fire-cracked rock not associated with a feature; 25 pieces of fire-cracked rock met this criterion. Though Brewer et al (1999) note the presence of ceramics within several of their identified loci, none were encountered during the present investigation. Artifacts are discussed in more detail in the following chapters, but their distributions across the site are discussed here by artifact category.

Flaked Stone Tools

Flaked stone tools recovered during surface collection include 13 projectile points or point fragments, 79 bifaces, a uniface, seven edge-modified flakes, and a core tool. The projectile points were fairly widely distributed across the site in our sample. The only apparent concentration of projectile points was in SCU 1800S, where three points were recovered. Considering the huge abundance of debitage at the Eureka Dunes Site, projectile points were rather scarce; possibly due in part to decades of unauthorized collecting by visitors. Still, one distribution pattern is apparent: the oldest point types were recovered from the western portion of the site.

The 79 bifaces recovered were from almost the entire length of the site. However, the distribution appears slightly clustered, with many of the surface collection units having more than one biface and many having none, suggesting activity areas. For example, there were six bifaces (and a projectile point) in SCU 3-1, and three other surface collection units contained five bifaces each; one of these surface collection units (1800S) also had three projectile points. Another pattern evident lies in the material types: while chert bifaces occur across the site, obsidian bifaces occur mostly in the central third of the site, in spite of the ubiquity of obsidian debitage.

The uniface, edge-modified flakes, and core tool exhibit a complimentary distribution: the uniface was from SCU 3360N in the far eastern portion of the site, while the core tool and edge-modified flakes were recovered from the western and central parts of the site.

Other Artifacts

Ground stone artifacts are also sparsely distributed across the site, with a slightly greater tendency to occur in the eastern half. However, the sample of ground stone is small (n=10), itself possibly more telling. Ground stone, and the few edge-modified flakes, are usually associated with subsistence activities, which apparently are not well represented at the Eureka Dunes Site. Most of the collected (i.e. scattered) fire-cracked rock was recovered from surface collection units in the central portion of the site. Most of the features (concentrations of fire-cracked rock) are also in this area, suggesting the isolated pieces were once associated with similar features and displaced either by erosion or other disturbances.

Debitage

It is easy to see why previous archeologists recorded the Eureka Dunes Site as several discreet sites: the debitage is not uniformly distributed. One surface collection unit had over 2,900 flakes, and eight had over 1,000 flakes, while other units had none (Appendix A, Figure 5.1). Over 26,000 pieces of debitage were surface-collected. Obsidian accounts for 64 percent of the debitage, green-grey chert 31 percent, other chert 5 percent, and other materials, such as basalt, quartzite, and quartz, 1 percent. Based on a random sample of obsidian sent for XRF-sourcing, the obsidian can be further broken down by source. Fifty percent of all obsidian debitage came from Saline Valley sources, 9 percent came from another likely nearby source termed “Unknown 1,” and 4 percent came from other sources (Appendix B, Figure 5.2). Combining the Saline Valley sources, the “Unknown 1” source, and the green-gray chert (which likely came from the Last Chance Range), over 90 percent of the debitage probably derived from sources within 10 miles of the site.

From the surface collection results, five broad areas of high surface density can be discerned at the site: (1) the western portion of the site between SCU 280S and 480N; (2) the central portion of the site between 1240S and 1480S; (3) the east-central area between SCU 1640S and 2280S (including the spur road); (4) the central portion of the site at Construction Locus 2; and (5) the southwestern portion of the site at Construction Locus 3.

Obsidian debitage is much more prevalent in relation to other material types west of SCU 1280N and east of SCU 2240N. This includes the western-most concentration between SCU 280S and 480N. Green-gray chert debitage outnumbers obsidian in only four of the road corridor SCUs (1400S, 1440N, 2160N, and 2200S, all in the central portion of the site) and in only one of the construction loci surface collection units (3-2) (Figures 5.3 and 5.4).

Total debitage weights by material type for each surface collection unit are shown in Appendix A. Table 5.1 shows that the mean weight of an obsidian flake at the Eureka Dunes Site is 0.75 g. The mean weight for the chert flakes is larger at 1.15 g, suggesting more initial reduction of chert at the site than of obsidian (see Chapter 7).

An estimated 0.8 percent of the site area was surface collected. Assuming the site’s areal extent is as recorded by Brewer et al. (1999) and assuming the present sample, with its dense and sparse areas, is representative, the total number and gross weight of debitage at the site can be estimated. Over 3 million flakes, weighing over 3.5 million grams (~8,000 pounds), could be expected for the entire site (Tables 5.2 and 5.3).

Features

The only features discovered at the Eureka Dunes Site consist of concentrations of rock: during field work dozens of discrete rock concentrations, many

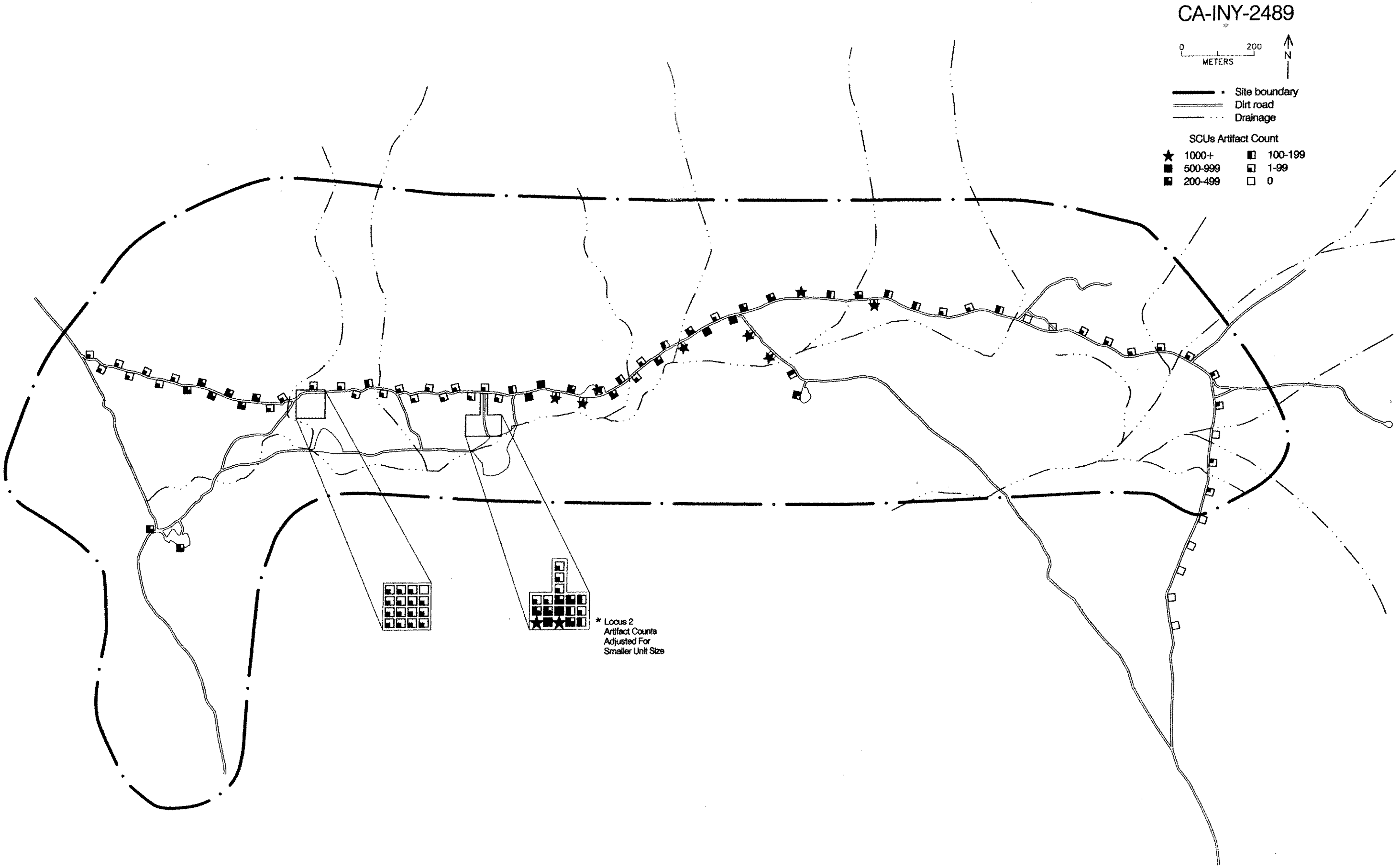


Figure 5.1. Artifact counts in surface collection units at the Eureka Dunes Site.

Table 5.1. Mean Weight for Debitage from Surface Collection Units.

	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
Mean Weight	0.75	1.15	1.04	5.76	0.93

Table 5.2. Debitage Count for Surface Collection Units.

Units	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
Road Corridor	14,635	7,320	1,001	206	23,162
Locus 1	291	21	9	3	324
Locus 2*	1,371	389	264	13	2,037
Locus 3	500	315	31	3	849
Total	19,820	9,035	1,830	315	31,000
Estimated Site Total†	2,477,500	1,129,375	228,750	39,375	3,875,000
Percentage	63.94%	29.15%	5.90%	1.02%	100.00%

* Count multiplied by 16 for 5 m by 5 m units
† Total weight multiplied by 125

Table 5.3. Debitage Weight for Surface Collection Units (in grams).

Units	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
Road Corridor	11,202	8,767	1,453	1,508	22,930
Locus 1	269	105	19	22	415
Locus 2*	2,918	1,179	406	256	4,759
Locus 3	418	369	34	29	850
Total Weight	14,807	10,420	1,912	1,815	28,954
Estimated Site Total†	1,850,875	1,302,500	239,000	226,875	3,619,250
Percentage	51.14%	35.99%	6.60%	6.27%	100.00%

* Weight multiplied by 16 for 5 m by 5 m units
† Total weight multiplied by 125

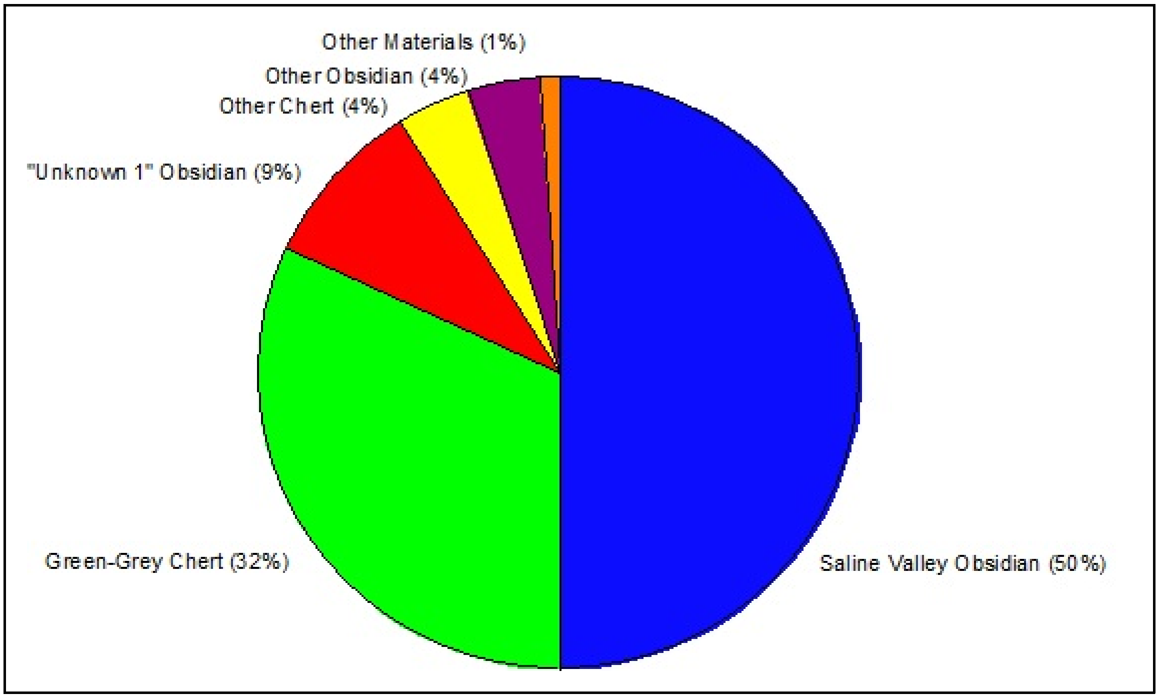


Figure 5.2. Percentages of different flaked-stone material types at the Eureka Dunes Site.

with apparent fire-cracked or fire-altered rock and some with dark (apparently charcoal-stained) soil, were observed. The rocks at these concentrations are generally fist-sized or smaller (less than 7 cm in diameter) and consist for the most part of vesicular basalt. Other rock types present include limestone, sandstone, and quartzite. The rocks of the features are generally larger than those in most of the site area and were probably carried in from the adjacent bajada slopes.

Only four of the rock concentrations were within the present study area. Three of these (Features 4-6) and three rock concentrations outside the study area (Features 1-3) were excavated and are described here. The unexcavated rock concentration within the project area (Feature 7) is also described below. All sediment from the feature excavations was screened through À-inch mesh or collected for flotation and radiocarbon analyses. A total of 41 flakes and one flaked stone tool fragment (of green-gray chert) were recovered during the feature excavations. While the total is low, the debitage differs from the site as a whole in the relatively high percentage of green-gray chert (49%) and other chert (9%) compared to obsidian (41%).

Feature 1 is a 2.5-m-diameter concentration of several hundred fire-cracked or fire-altered rocks (Figures 5.5 and 5.6), located in the east-central portion of the site, about 15 m northeast of SCU 2320N. Feature 1 had the darkest soil stain and was the best-defined of three rock concentrations in the immediate vicinity. A 2 m by 2 m block was excavated within the concentration, revealing a dish-shaped area of fire-cracked rock and dark charcoal-stained soil 1.2-1.8 m in size. The maximum depth of the staining was 10 cm; below the stained soil the subsoil consisted of compacted sand. Tabulated during excavation were 576 pieces of fire-cracked rock weighing a total of 39.8 kg. Two-thirds of the fire-cracked rock was from the surface within the excavation block. In addition to fire-cracked rock, five small unidentifiable large mammal bone fragments and a few miniscule pieces of charcoal were recovered from the feature fill. No artifacts or identifiable botanical specimens were recovered from the flotation sample. Soil sent for radiocarbon analysis yielded a date of 1300±70 B.P. (Appendix C).

Feature 2 is located 7.5 m south of the Construction Locus 2 surface collection grid, in an area of fine white silty soil. On the surface Feature 2 Insert

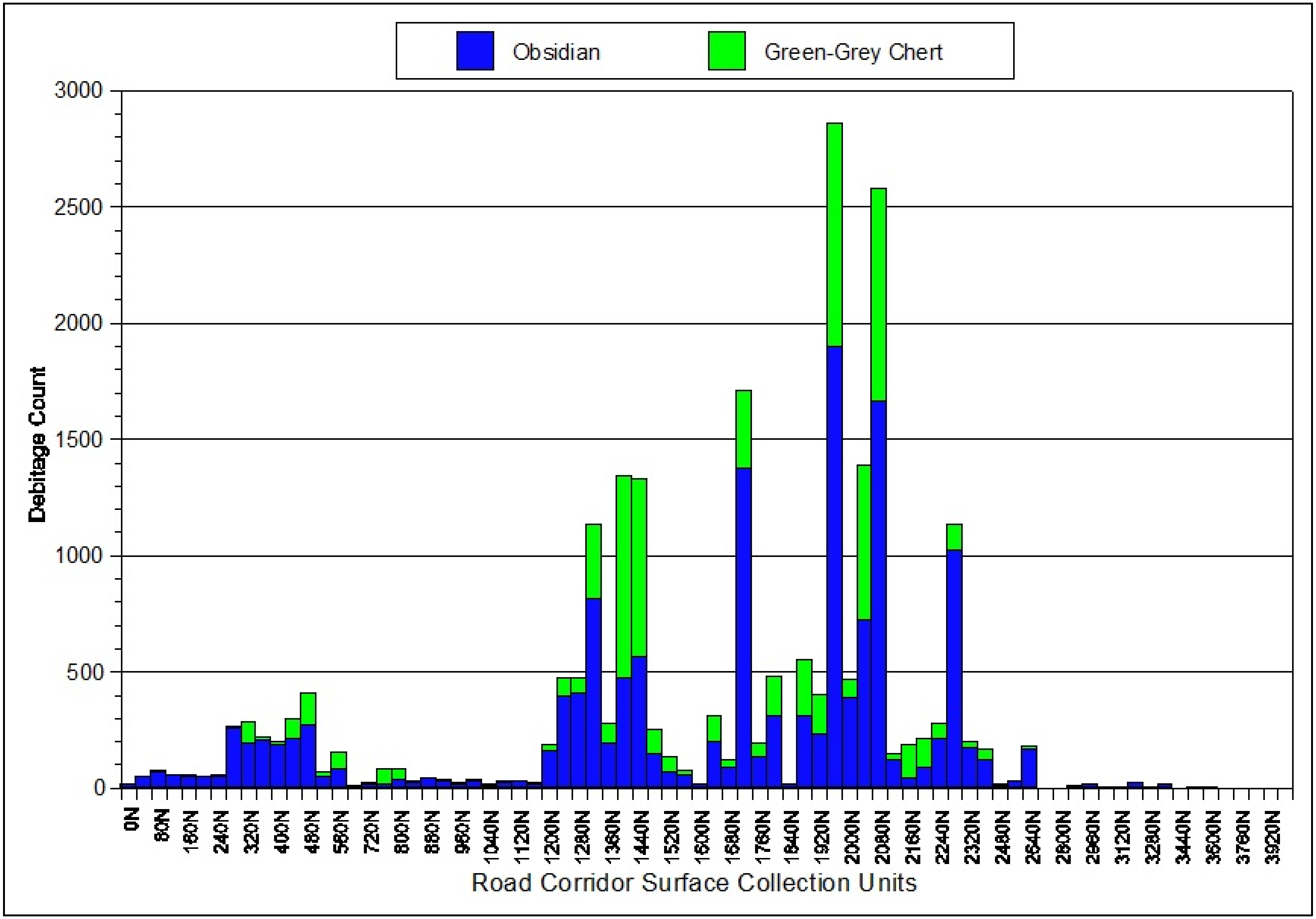


Figure 5.3. Obsidian and green-grey chert debitage in road corridor surface collection units.

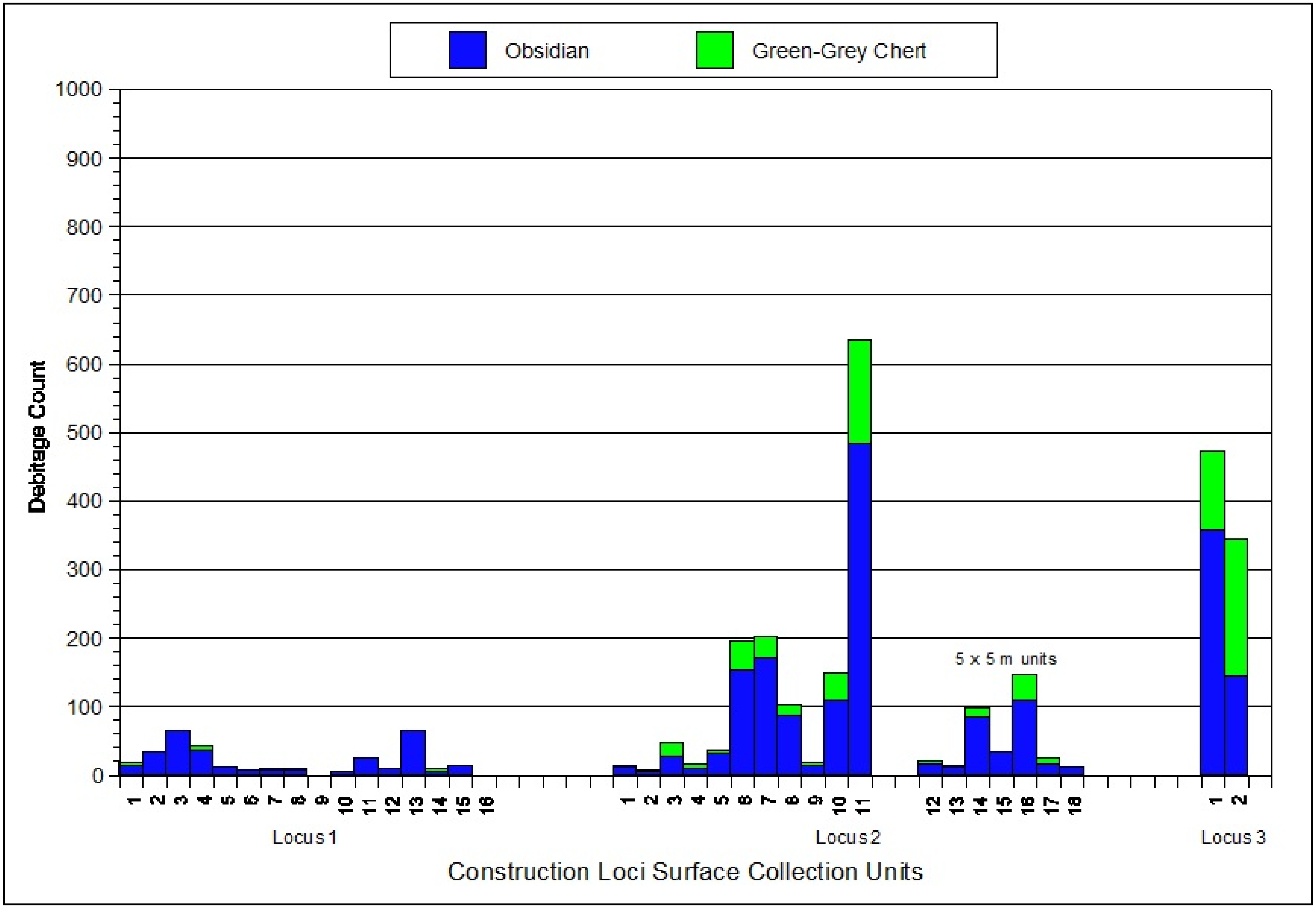


Figure 5.4. Obsidian and green-grey chert debitage in construction loci surface collection units.

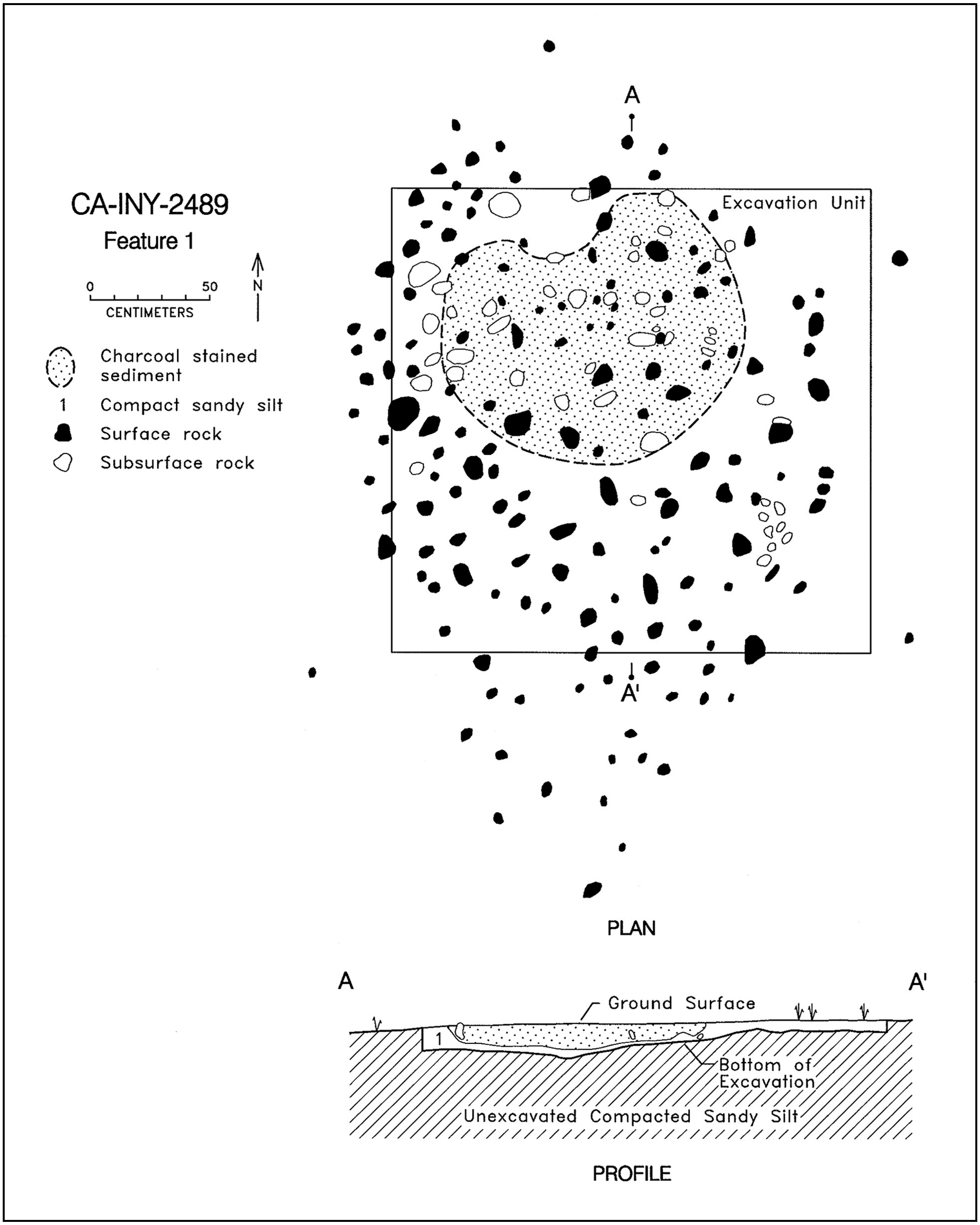


Figure 5.5. Plan map and profile of Feature 1 at the Eureka Dunes Site.

Figure 5.6. Feature 1 with the Last Chance Range in the background.

appeared as a sparse concentration of fire-cracked rocks (n=36) in an area 1.2 m in diameter (Figure 5.7). Among the rocks, two small pockets of eroding charcoal-mottled soil were also visible. A 1-m-by-l-m unit excavated centered within the concentration yielded three pieces of debitage from the upper 2 cm. Below 2 cm the outline of a 65-cm-diameter concentration of ashy charcoal-rich soil and fire-cracked rock became apparent. The basin-shaped feature was up to 10 cm deep. A total of 104 fire-cracked rocks weighing 7.9 kg was tabulated during excavation. The sediments in the feature fill were collected for flotation analysis, which yielded a small burned basalt cobble, two obsidian flakes, and 34 g of charcoal. No seeds were identified in the charcoal. A portion (about one-third) of the charcoal was radiocarbon dated to 650±50 B.P. (see Appendix C).

Feature 3 consists of over a hundred fire-cracked or fire-altered rocks in a 1.8-m-diameter concentration. It is located on a low sandy rise in the east-central portion of the site, 75 m northeast of SCU 2120S (Figures 5.8 and 5.9), near several other rock concentrations. A 2 m by 2 m block was excavated at this feature. After removal of about 1 cm of wind-blown sand, a 60 cm by 80 cm oval-shaped charcoal stain was apparent. The dark soil extended up to 8 cm deep. Below the dark soil there was a thin layer of discolored and fused (i.e. baked) sand. A total of 133 pieces of fire-cracked rock (8.2 kg) was tabulated from Feature 3, all but three recovered from the surface. Seven pieces of debitage were recovered from the surface prior to excavation and 30 pieces of debitage were recovered during excavation. No artifacts or charcoal was recovered from the flotation sample. Soil from this feature was radiocarbon dated to 1300±60 B.P. (see Appendix C).

Feature 4 is a 5-m-diameter concentration of fire-cracked rock located in the east-central portion of the site within SCU 2080N (Figures 5.10 and 5.11). Excavation of a 1-m-by-2-m surface scrape unit within this concentration revealed two separate charcoal-stained areas, each about 50 cm in diameter. One extended 6 cm deep and the other 13 cm deep. Tabulated fire-cracked rock on the surface of

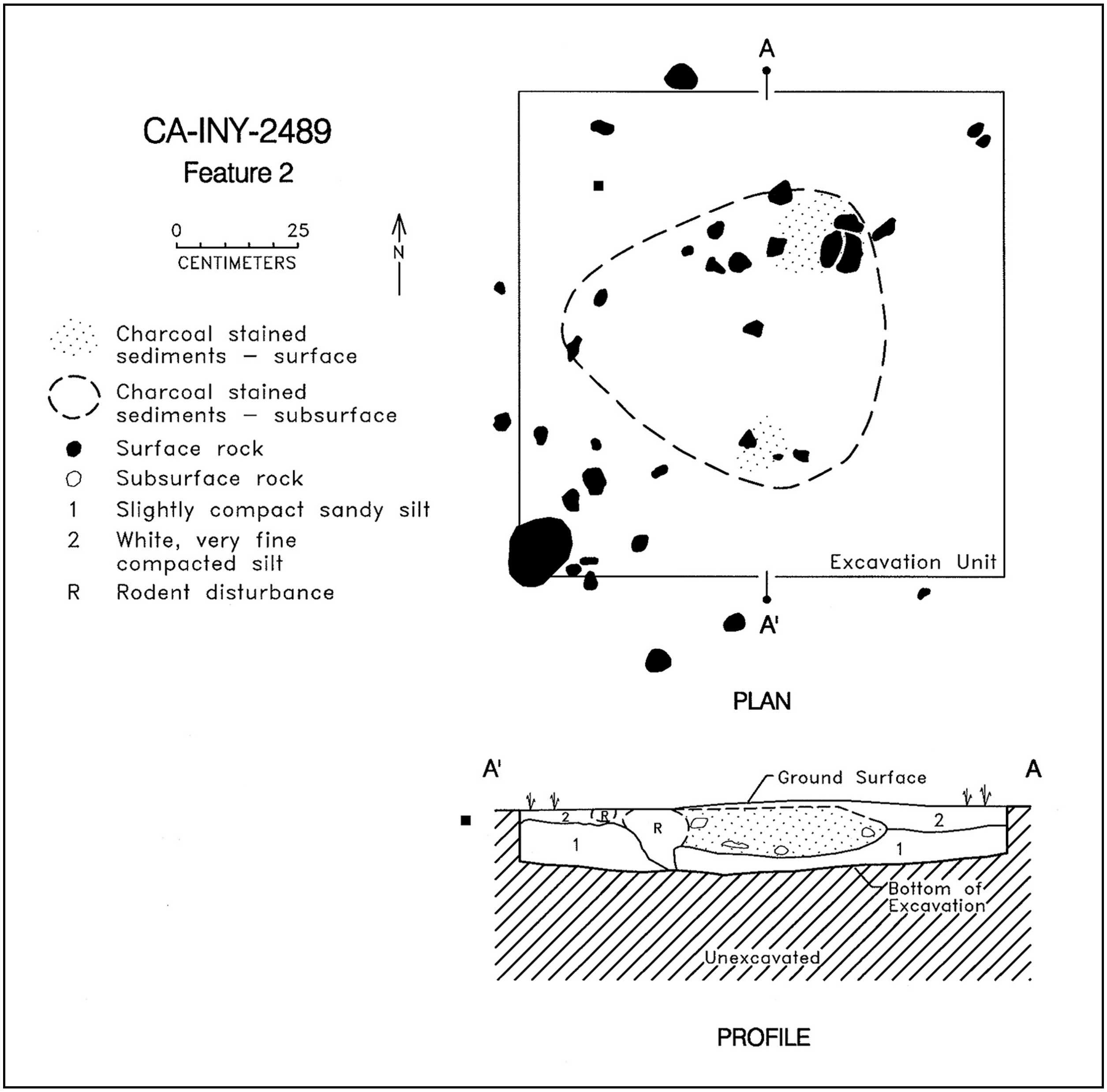


Figure 5.7. Plan map and profile of Feature 2 at the Eureka Dunes Site.

the excavation unit totaled 73 pieces (1.1 kg). Subsurface fire-cracked rock encountered during excavation totaled 52 pieces (1.4 kg). Fourteen pieces of debitage were recovered from the surface and subsurface; only one of these was from the charcoal-stained sediments. As much as possible of the charcoal-stained soil was collected for later analyses. No artifacts or charcoal was recovered from the flotation sample. Soil from the deeper of the two charcoal-stained areas was radiocarbon dated to 1890±60 B.P. (see Appendix C).

Feature 5 is located in the western portion of the site within SCU 240N. It consists of a 2-m-diameter cluster of basalt rocks and some possibly burned caliche along the edge of a small arroyo. None of the rock appeared to be fire-cracked. A 30-cm-by-30-cm shovel test unit was excavated in the center of the feature. A densely packed layer of sand was encountered at 12 to 18 cm depth and a few bits of charcoal were noted between 50 and 70 cm. No artifacts or fire-cracked rock were recovered from the unit.

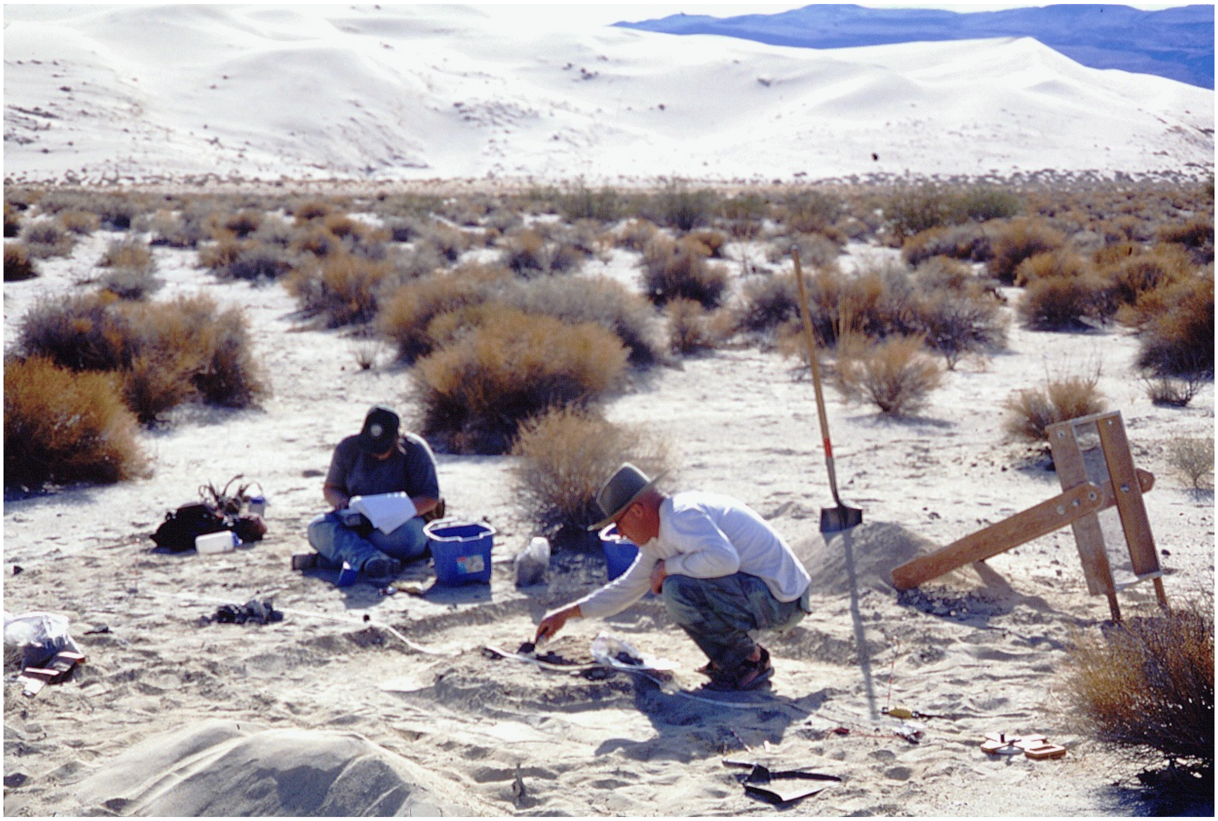


Figure 5.8. Excavation of Feature 3.

Feature 6, in the eastern portion of the site within SCU 2640N, consists of an irregularly-shaped 3-m-by-3-m concentration of 50 fire-cracked rocks (13.9 kg). A 30-cm-by-30-cm shovel test unit excavated within the feature encountered no dark soil nor additional fire-cracked rock. An obsidian flake was recovered from the 0-10 cm level. Excavation was halted at 15 cm depth due to the compactness of the soil. The lack of charcoal or fire-cracked rock below the surface may indicate more extensive soil deflation in this portion of the site.

Feature 7 is partially within SCU 1320S. It consists of a sparse scatter of fire-cracked rock intermixed with large pieces of caliche within a 8-m-diameter area. Although this feature lies within a surface collection unit, it is apparently surficial and was therefore not excavated. The sparse and scattered distribution of the rock and the lack of any discolored soil or any evident depth suggest this feature has been extensively disturbed by soil deflation.

In summary, the features tend to exhibit a dispersed pattern of fire-cracked rock on the surface, with loose concentrations of rock in areas ranging in size from 1.2m to 8m in diameter, with the largest area apparently the result of post-use disturbances. Excavations of the four that appear most intact indicate that the features were shallow, basin-shaped pits excavated into sterile soil. Charcoal and charcoal-staining corroborate the fire-cracked rocks' evidence that the features were used as fire or roasting pits. None of the features appears to be completely intact, and it is unclear how much of the rock dispersion is due to the use itself (that is, the dismantling of the feature once the "roasting" was done to retrieve the cooked items) or to subsequent erosion. The pits apparently most intact are about 10 cm deep, and given the erosion evident in the vicinity, 10 cm may be the minimum original depth. The areal extent is a little more problematic, since smearing might enlarge the area of charcoal staining and shearing could reduce it, but sizes ranged from Feature 4,

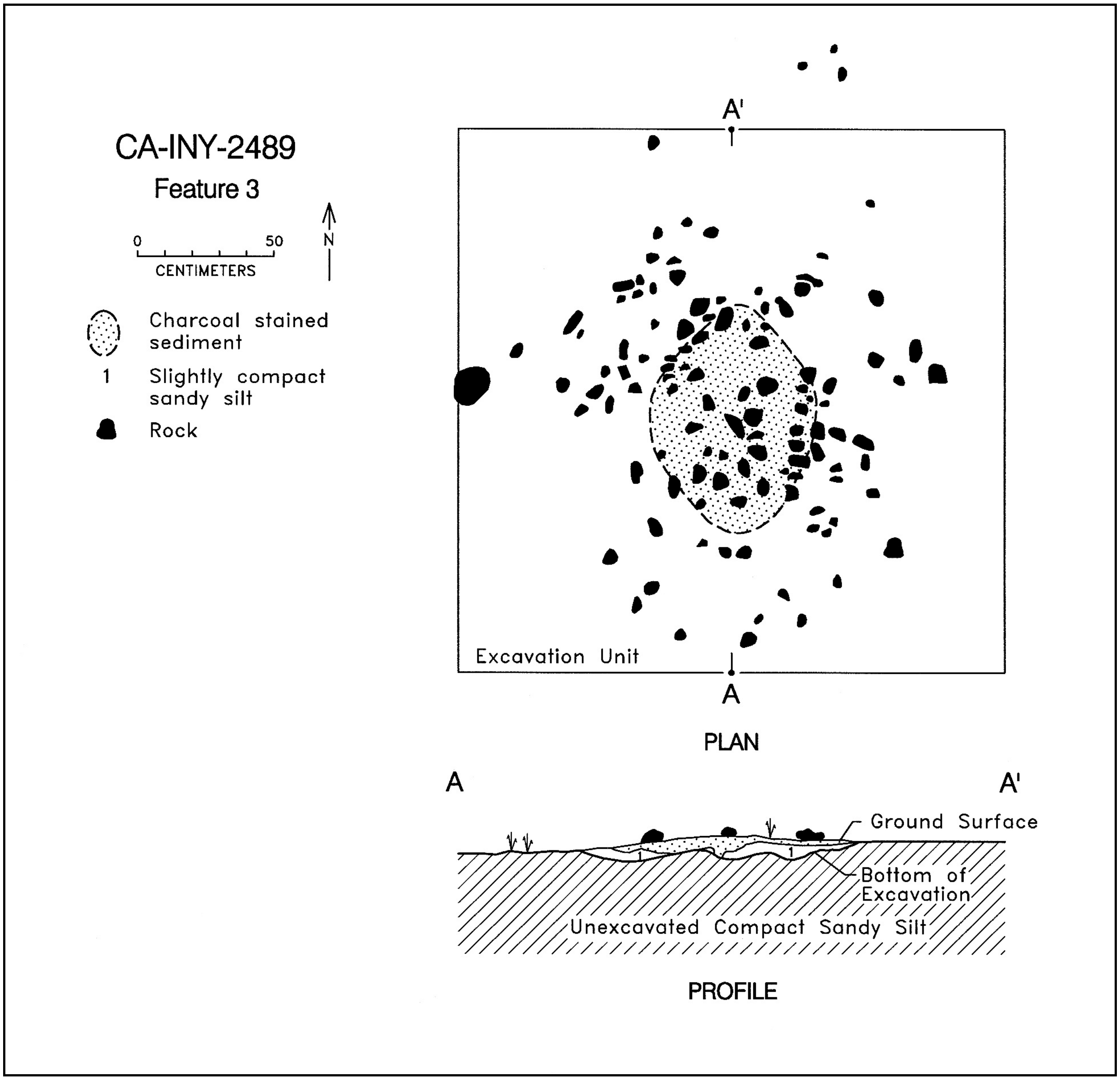


Figure 5.9. Plan map and profile of Feature 3 at the Eureka Dunes Sites.

with two pits 50 cm in diameter, to Feature 1, with a 1.2m by 1.8m oval of charcoal staining and fire-cracked rock.

Stratigraphy

Soils and sediments reflect the project's location on the lower bajada and valley floor, adjacent to the playa and dunes. On the surface, soils are finest near the playa, and consist of fine-grained silts and sands. Cobbles and gravels are more common on the surface at the east end of the project area, where the site surface grades from valley fill to the lower bajada slope. Scattered throughout the surface of the site area, especially around vegetation, are thin patches of wind-blown sand. Mud-cracked clayey silt occurs in low-lying areas. Below the surface, the soils consist of light brown sandy silt, increasingly compact with depth. Gravels are slightly more numerous in the upper 10 cm of the deposit, likely due to eolian deflation or vertical displacement.

Although the shovel tests excavated for this project did not provide a broad exposure of the soil

Figure 5.10. Excavation of Feature 4.

profile at any one location, their wide distribution allows some general inferences about characteristics of the stratigraphy of the project area as a whole. From west to east, the subsurface stratigraphy reflects the same gradation as the surface: soils are slightly siltier near the playa and contain more cobbles near the east end. As would be expected in a desert basin, caliche (sediments cemented by calcium carbonates) was encountered in most of the excavation units. The depth, extent, and hardness of the caliche varied. Near the center of the site, the caliche appears very rock-like: extremely indurated sediments occur on the surface, or at shallow depths (4 cm to 60 cm). Since caliche forms below the ground surface at the average rainfall penetration depth, these surface exposures indicate soil deflation. Further west, near the playa, a discontinuous layer of slightly indurated calcium carbonate sediments was encountered up to 80 cm below the ground surface. The greater depth, and lesser concentration, of the caliche in this part of the site may reflect the increased amounts of water, and the deeper saturation of the ground, near the ephemeral lake level. At the east end of the site, on the bajada slope, no caliche was encountered, probably due to the greater permeability of the slightly coarser bajada soils.

Trace amounts of volcanic ash were identified in some of the shovel test units throughout the project area. Its irregular distribution (in some units and not in others) and sparse quantities suggest that Eureka Valley may have received a very light dusting of ash which was redeposited by erosion into small pockets. Volcanic ash from pyroclastic explosions as far away as Yellowstone have been documented in Lake Tecopa, well south of Eureka Valley (Sharp and Glazner 1997) and Sarna- Wojcicki et al. (1983:65) note that ash from some eruptions in the Mono and Inyo Craters volcanic province in east-central California was transported in a south and southeast direction because of seasonal winds; small quantities of this ash may have reached the project area.

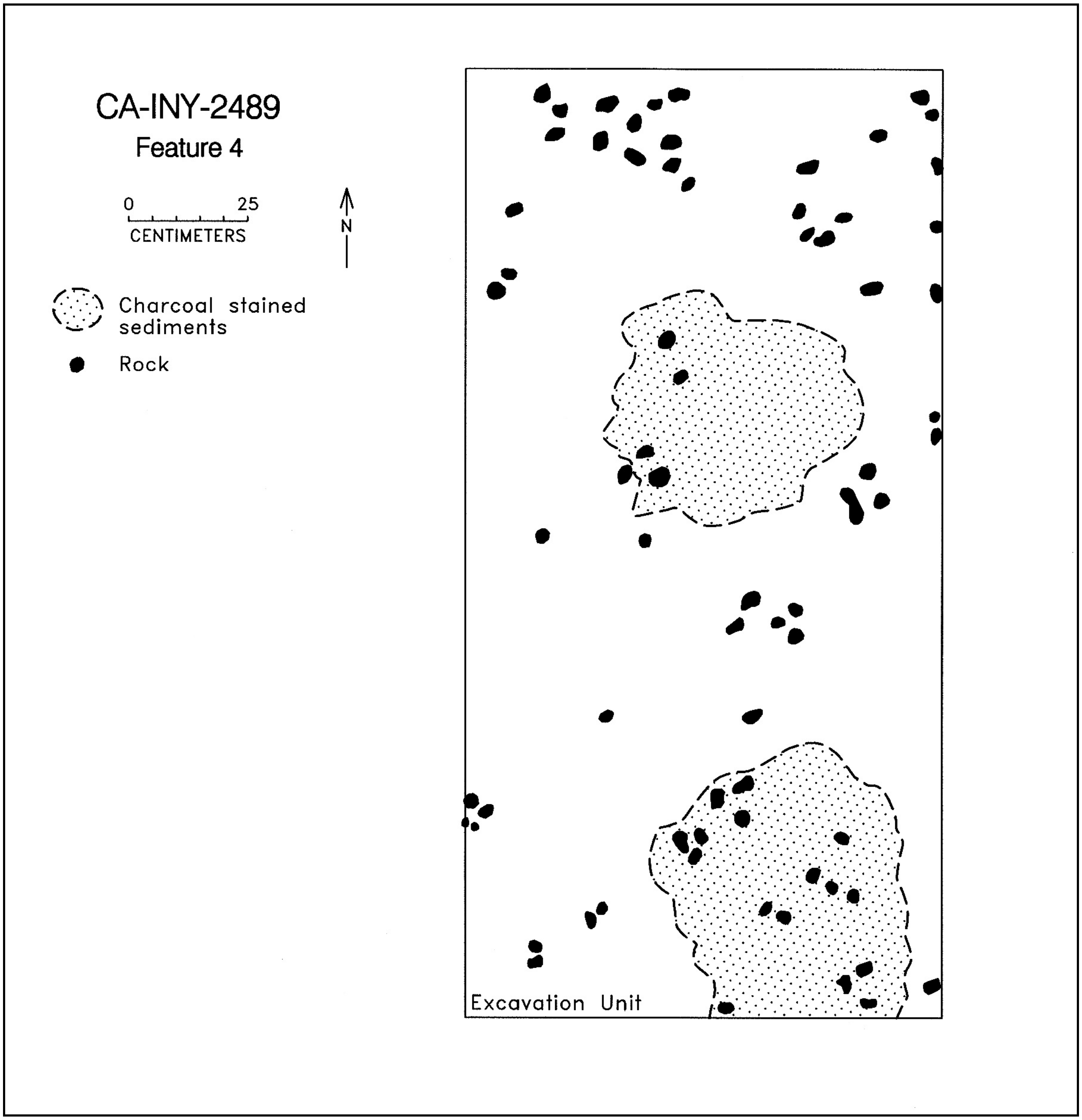


Figure 5.11. Plan map of Feature 4 at the Eureka Dunes Site.

Subsurface Artifact Distribution

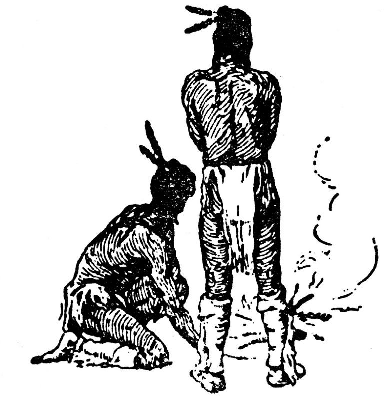
The vast majority of artifacts at the Eureka Dunes Site occur on or near the surface. Nearly two-thirds of the shovel test units excavated at the site encountered no artifacts at all (see Appendix A; Figure 5.12). In the central portion of the project area those areas with especially dense distributions of surface artifacts tended to have sparse subsurface cultural material up to 40 cm deep. Such distribution could be explained by normal pedoturbation. However, in the western one-third of the site, near the playa, debitage was found deeper than 40 cm below the surface in areas with few surface artifacts. In 80N, with the greatest total of artifacts from a shovel test unit, there were no artifacts in the 0-20 cm level, three artifacts from the 20-40 cm level, and 32 artifacts from between 40 and 100 cm depth. This subsurface cultural material could represent a secondary deposit, or the greater susceptibility of the softer soils in that area to rodent mixing, but it could also represent a buried occupation surface.

Figure 5.12. Subsurface artifacts in shovel test units at the Eureka Dunes Site.

The material type percentages encountered in the shovel test units differed from the percentages recovered from the site overall. In the shovel test units 77 percent of the flakes recovered were obsidian and 19 percent were green-grey chert, compared to 63 percent obsidian and 32 percent green-grey chert from the site as a whole. These differences probably reflect natural formation process: the obsidian flakes at the Eureka Dunes Site tend to be smaller than the green-grey chert flakes, and therefore more susceptible to pedoturbation.

The seven surface scrape units (each 1m by 2 m in size, and excavated 10 cm deep or deeper if sterile or compact sediments were not encountered) yielded just 148 flakes (see Appendix A). Seventy percent of these flakes (n=105) came from two units (within SCU 1240S and 1960S) located within dense concentrations of surface materials. The relative abundance of subsurface material in these two units is likely because soils at these areas are loose sands, more conducive to mixing. In contrast, the more compact soils encountered in most of the shovel test units and in the other surface scrape units are less susceptible to pedoturbation, and therefore to the downward movement of surface cultural materials.

One surface scrape unit was placed within SCU 800N, where two biface fragments, one of green-grey chert and one of white chert, were found. Each biface was within a small debitage concentration of similar material, suggesting that each concentration represented the waste from the production of the associated biface, abandoned when it fractured during manufacture. The surface scrape unit was placed where the two concentrations of debitage overlapped to recover the small biface thinning flakes expected; however, no flakes of white chert were recovered, and only five of green-grey chert.



Chapter 6

Chronology

Jeffery F. Burton and Mary M. Farrell

Temporally diagnostic artifacts, radiocarbon assays, and over 100 source-specific obsidian hydration readings provide an initial chronological assessment for the Eureka Dunes Site (CA-INY-2486). Together these data suggest the site was used, at least sporadically, for over 6,000 years. Each class of data is discussed below, followed by a discussion of the site chronology as a whole.

Temporally Diagnostic Artifacts

Morphological differences in Great Basin artifacts have been found to have temporal significance. Time-sensitive projectile points have led to the development of the following chronology for the Inyo-Mono region of Eastern California (Bettinger 1982):

> *Marana Period* (A.D. 1300 to ca. 1870) – indicated by Desert Side-notched and Cottonwood Triangular projectile points and brown ware ceramics.
>
> *Haiwee Period* (A.D. 600 to 1300) – indicated by Rose Spring and Eastgate series projectile points and Humboldt Basal-notched bifaces.
>
> *Newberry Period* (1200 B.C. to A.D. 600) – indicated by Elko series projectile points.
>
> *Little Lake Period* (3500 to 1200 B.C.) – indicated by Little Lake and Pinto series projectile points and Humboldt Concave-base bifaces.
>
> *Mohave Complex* (pre-3500 B.C.) – indicated by Mohave, Silver Lake, Great Basin Transverse, and Fish Slough Side-notched projectile points (Basgall and Giambastiani 1995).

Although researchers in the Mohave Desert have constructed a slightly different chronology (e.g. Warren and Crabtree 1986), Bettinger's chronology is used here because of the proximity of his research area to Eureka Valley. In Owens Valley, Deep Springs Valley, and others areas, these time periods have been found to correlate with important economic, subsistence, settlement, and perhaps ethnic changes.

Of the 13 projectile points recovered during the present work, six can be assigned to established Great Basin temporally diagnostic types (Bettinger and Taylor 1974; Thomas 1981). Morphological characterisics of the Eureka Dunes Site projectile points are described in Chapter 7; here we consider only their chronological implications. One is a Desert Side-notched, indicating use sometime between A.D. 1300 and the historic period, when this point type was common. The single Rose Spring Series point recovered dates to between A.D. 600 and 1300. The one Elko Corner-notched point would date to between 1200 B.C. and A.D. 600. A Northern Side-notched point and two Fish Slough Side-notched points are the oldest styles recovered from the Eureka Dunes Site, dating to around 5,000 to 6,500 B.P. (Basgall and Giambastiani 1995; Delacorte 1997). The remaining six specimens appear to be dart points rather than arrow points, suggesting a pre-A.D. 600 date for them. Other temporally diagnostic artifacts previously reported at the site (Brewer et al. 1999) include Gypsum and Rose Spring projectile points, a Humboldt biface, and plain ware ceramics. The Gypsum point indicates use between 2000 B.C. and A.D. 500 (Warren 1984), and the Pinto/Humboldt fragment between 3500 and 1200 B.C. The plain ware ceramics date to after ca. A.D. 1300 (Basgall and McGuire 1988).

Temporally diagnostic artifacts, therefore, indicate

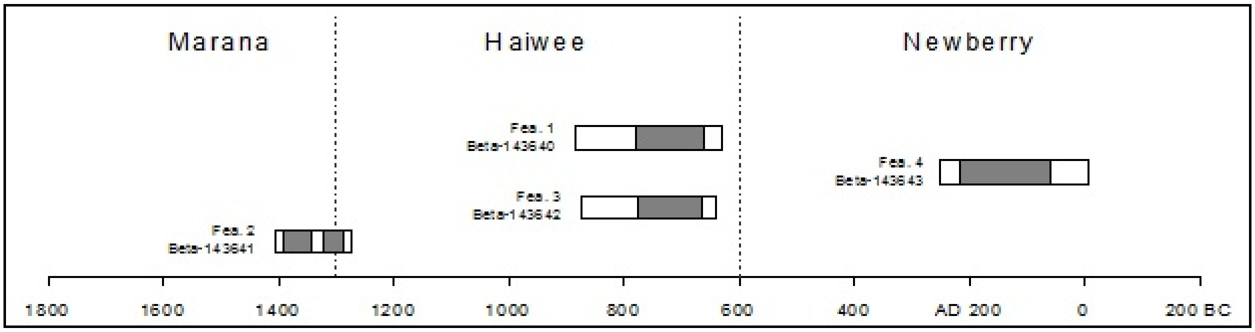


Figure 6.1. Calibrated radiocarbon dates from the Eureka Dunes Site, showing one and two sigma ranges.

the Eureka Dunes Site area was used for millennia: these artifacts could span over 6,000 years, from as early as 4500 B.C. to late prehistoric times. Interpretations are limited by the paucity of these temporally sensitive artifacts compared to the non-temporally diagnostic debitage, but the heaviest use of the Eureka Dunes Site, at least for hunting-related activities represented by the projectile points, appears to have been during the Mohave, Little Lake, and Newberry periods.

Radiocarbon Analysis

Four radiocarbon (C-14) dates were obtained from the Eureka Dunes Site. All were from charcoal or charcoal-stained soil associated with concentrations of fire-cracked rock (Features 1-4). Although all four of the sampled features are considered to be in the central portion of the site, the features are widely distributed: the furthest-east feature sampled is over a kilometer from that furthest west.

The Feature 1 sample (Beta 143640) yielded a conventional radiocarbon date of 1300±70 B.P. Feature 2 (Beta 143641) dated to 650±50 B.P. Feature 3 (Beta 143642) dated to 1300±60 B.P. Feature 4 (Beta 143643) dated to 1890±60 B.P. (see Appendix C). Calibrating the laboratory dates to calendar dates, the Feature 1 sample becomes A.D. 660 to 780 at one sigma and A.D. 630 to 885 at two sigma. Feature 2 dates to A.D. 1290 to 1325 and 1345 to 1395 at one sigma and A.D. 1275 to 1410 at two sigma. Feature 3 dates to A.D. 665 to 775 at one sigma and A.D. 640 to 875 at two sigma. Feature 4 dates to A.D. 60 to 215 at one sigma and 5 B.C. to A.D. 250 at two sigma (Figure 6.1).

The sample from Feature 2, the furthest west, is the most recent, dating to the early Marana period. The two samples taken from the features furthest east, Features 1 and 3, both fall within the Haiwee period. The sample from Feature 4, north of Feature 3, is the oldest, dating to the Newberry period. The fact that the radiocarbon dates do not extend as far back in time as the projectile points could signify that the fire-cracked rock concentrations are associated with a change in site use that occurred in the late Newberry period. However, sampling bias or preservation cannot be ruled out. For example, Feature 5 in the western portion of the site was so deflated that no charcoal-stained soil remained for potential dating.

Obsidian Studies

One hundred twenty-seven specimens, including 19 artifacts, 107 pieces of debitage, and a manuport, were submitted for x-ray fluorescence (XRF) and obsidian hydration analysis. The artifacts include all of the obsidian projectile points (n=13) and 25 percent (n=9) of the obsidian bifaces recovered during the present work. The XRF analysis indicates 79 percent of the specimens were made of obsidian from the Saline Valley sources, on the other side of the Saline Range from the Eureka Dunes Site. Fourteen percent came from “Unknown 1,” 4 percent from western Nevada sources, and one specimen each came from Casa Diablo, Fish Springs (an unworked cobble), and “Unknown 2” obsidian sources (see Appendix B).

Obsidian hydration analysis is widely used in California and the Great Basin as a chronometric technique, partially due to the abundance of obsidian and the relative paucity of other datable material. The technique is based on the fact that obsidian absorbs moisture from the environment, microscopically visible in thin section as a rind or "rim" that increases in depth or thickness through time. Of the submitted specimens, 117 had measurable rims, four had no visible hydration, and for six the optical quality of the hydration rim was too poor to accurately measure. Of the readable specimens, 18 had a vague diffusion front; these readings, which had to be estimated, are less precise (see Appendix C).

Since the initial development of obsidian hydration analysis, several factors have been found to influence the moisture absorption, including the ambient temperature and the chemical composition of the obsidian. To control for potential chemical-related variables, rates are developed for different volcanic events or "sources" with the assumption that obsidian from one source is similar enough in chemical composition to have similar rates of hydration. Intra-source variability may be a factor, but has seldom been examined.

Various methods have been used to derive chronometric data from the obsidian hydration phenomenon. In a few cases, researchers have estimated hydration rates by correlating hydration rim measurements with radiocarbon dates (Johnson 1969; Singer and Ericson 1977; Ericson 1977). However, the scarcity of clear associations between radiocarbon samples and obsidian has hindered this application. Experimentally-induced rates (e.g. Stevenson et al. 1989) offer promise in isolating and measuring relevant variables, and may eventually allow calculations of rates.

Probably the most common method of estimating hydration rates uses rim values for points that can be classified as temporally diagnostic (Basgall 1983; Hall 1983; Jackson 1981; Hall and Jackson 1990). The most rigorous applications of this method use large samples of independently dated projectile point types, often correlating the mean hydration rim values with the mid-point of the point type's time span and developing a rate through statistical analysis (see, for example, Hall and Jackson 1990).

Only one of the obsidian sources identified in the Eureka Dunes collection has had a reliable rate established. A Casa Diablo obsidian flake had a rim value of 4.8 microns. Using Hall and Jackson's (1990) rate of Years B.P.= $129.656x^{1.826}$, it dates to 2274 B.P. (~275 BC), within the Newberry period. Archeologists have found that during the Newberry period, Casa Diablo obsidian was extensively traded (Basgall 1983; Burton and Farrell 1990; Goldberg et al. 1990; Hall 1983, and others).

No rate has yet been derived for Saline Valley obsidian, which comprises almost 80 percent of the obsidian at the Eureka Dunes Site. The small sample of temporally diagnostic Saline Valley points recovered during this project does not allow for the construction of a rate based on mean hydration values. However, some crude calculations provide preliminary estimates of how Saline Valley hydration rim measurements might fall into the culturally significant temporal periods previously defined for the region. Available hydration readings for Saline Valley points (Table 6.1) suggest that rim values for the Marana Period would be less than 3.0 microns, Haiwee Period rim values would include specimens with hydration rim values of ca. 3.0 microns, and Little Lake and Mohave Period rim values would be ca. 7.4 microns and greater. By default, Newberry Period values would fall somewhere between ca. 3.0 and 7.4 microns. Additional clues are provided by the hydration rim measurements from Saline Valley flakes associated with Feature 4, which yielded a radiocarbon date of 1890±60 B.P., within the Newberry Period. A flake from the subsurface context associated with the radiocarbon date had a measurement of 5.4 microns; a second flake from the surface nearby measured 5.2 microns. Associated with Feature 3, radiocarbon- dated to the Haiwee Period, are surface flakes with rims of 4.2 and 5.0 microns. Given that the likelihood of multiple-period use of different areas of the site is at least as likely as variations in the hydration rate, we can take those rim measurements that seem to fit with the projectile point rim values and suggest that the boundary between the Haiwee and Newberry Periods is around 4.5 microns.

These estimates, albeit very rough, allow some preliminary interpretations of the 107 pieces of debitage, the nine bifaces, and the manuport submitted for obsidian hydration analysis. The debitage sample includes one flake selected at random from each of the surface collection units in the road corridor. One to three additional specimens were selected from a few of the densest surface collection units. Considering that the densest surface collection units had up to over 1,500 times the number of flakes as the sparser units, this sample is certainly not proportional: sparser areas constitute a disproportionately high percentage of the collection, and denser areas are under-represented. Seven additional flakes were from the proposed construction loci, and 17 flakes were from subsurface contexts. The selection of the flakes from excavation units was limited by flake size, since most were too small to be easily analyzed. Given these biases, the obsidian hydration sample provides direct information only about the range of occupation across time. Inferences about the intensity of "debitage production" and its implication for site use during any one time period requires more assumptions, and are therefore more tenuous.

Using the complete obsidian hydration sample, a histogram of the rim values forms a fairly normal bell curve, with few rim measurements less than 2.0 or greater than 11.0 microns, and most falling between 5.0 and 9.0 microns (Figure 6.2). Obsidian at the Eureka Dunes Site is predominantly from Saline Valley, located less than 15 miles southwest. If, as suggested above, we can assume ranges of micron values for various time periods, the hydration values suggest most obsidian reduction occurred in the late Little Lake period, throughout the Newberry period, and into the Haiwee period, with less intensive obsidian use in the early Little Lake and Marana periods.

Table 6.1. Obsidian Hydration Values of Temporally Diagnostic Projectile Points made of Saline Valley Obsidian.

Point Type	Hydration Reading	Reference
DSN	1.5	Burton n.d.
DSN	2.6	Burton n.d.
DSN	2.5	Burton n.d.
DSN	2.5	Burton n.d.
DSN	2.5	Burton n.d.
RSS*	2.8	this report
DSN	2.9	Burton n.d.
DSN**	3.0	Gilreath & Nelson 1989
RSS	3.0	Gilreath & Nelson 1989
RSS	3.0	Gilreath & Nelson 1989
dart	3.4/5.0	Burton n.d.
dart	6.1	this report
RSS**	6.5	Gilreath & Nelson 1989
FSS	7.4	this report
ESN	7.6	Gilreath & Nelson 1989
dart	8.0	this report
NSN	9.3	this report
FSS	9.5	this report
Pinto	12.7	Delacorte 1999

DSN - Desert Side-notched, RSS - Rose Spring series, ESN - Elko Side-notched, FSS - Fish Slough Side-notched, NSN - Northern Side-notched.

* - Saline Valley 2, ** - Saline Valley 3, all others - Saline Valley 1.

However, this assumes that the potential variability between the hydration rates of the different sources is small enough that some preliminary interpretations can be made. These interpretations, of

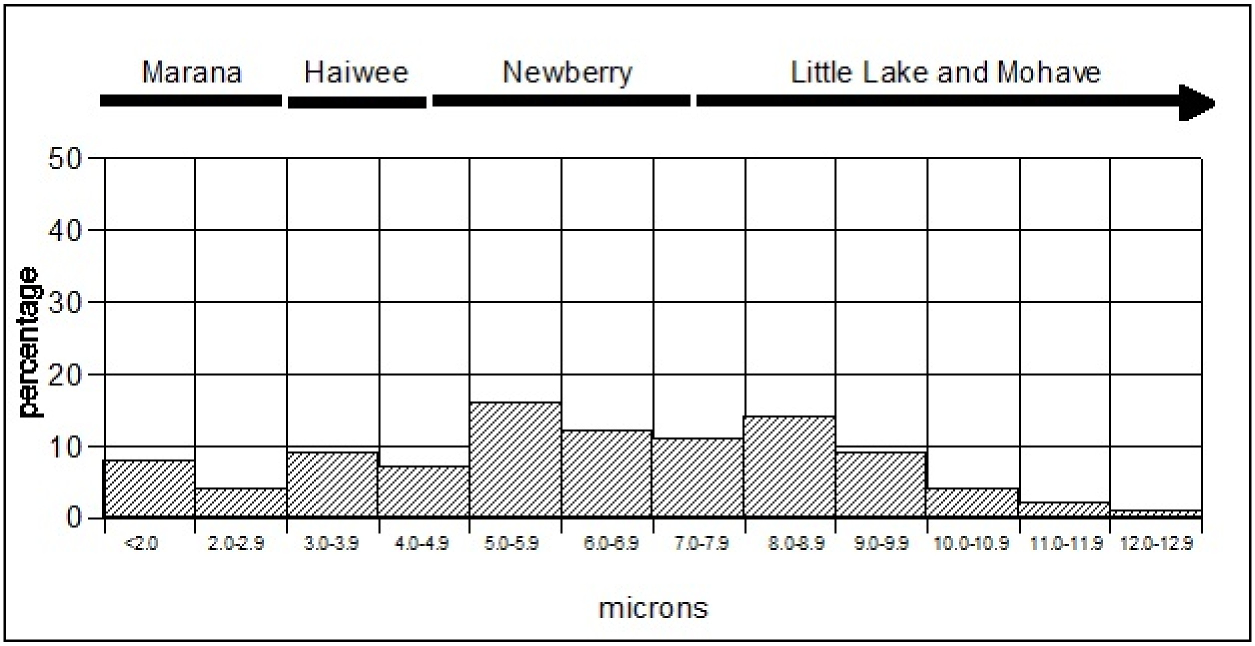


Figure 6.2. Compiled obsidian hydration results for the Eureka Dunes Site using all obsidian types (n=129 rim values).

course, merely suggest patterns that should be tested further once the hydration rates are refined.

Saline Valley obsidian has been divided into three types (Saline Valley 1, 2, and 3), based on chemical distinctions. Research is underway to determine the precise locations of the quarries or sources for each of the three types (Johnson n.d.), but that information, and the implications of the chemical differences for obsidian hydration rates, is unknown at this time.

Over 14 percent (n=19) of the Eureka Dunes Site obsidian sample came from unknown sources. Of these all but one were from a source labeled “Unknown 1.” The fact that this source supplied a relatively high percentage of the obsidian at the site (greater than varieties 2 and 3 of Saline Valley obsidian) suggests it is located nearby. Three Nevada sources (Fortymile, Montezuma Range, and Saccobatus Flat) represented in the sourced specimens are all located about 50 miles east. As mentioned above, one flake came from the Casa Diablo source, located 80 miles northwest.

Hydration rim values were plotted separately for each of the three Saline Valley types and the “Unknown 1” source. The three Nevada sources are also plotted separately, although the sample is far too small to allow reliable pattern interpretations. The 90 Saline Valley 1 rim values exhibit a fairly even distribution, with a normal curve not unlike that for all obsidian considered together. The smoothness of this curve is not surprising, since Saline Valley 1 is the most numerous obsidian at the site and the source is fairly close.

The sample for Saline Valley 2 is small, with only six rim values. If the inferred hydration rate for Saline Valley 1 holds for this type as well, most date to the Little Lake and early Newberry period and the Marana Period (Figure 6.4). The Rose Spring series projectile point of Saline Valley 2 obsidian from the Eureka Dunes Site has a rim value of 2.8 microns, slightly less than that of two Rose Spring series of Saline Valley 1 obsidian found in the Owens Valley (see Table 6.1; Gilreath and Nelson 1989) suggesting the rate of hydration of Saline Valley 2 obsidian is likely similar to that of Saline Valley 1.

Rim values for the Saline Valley 3 specimens suggest a peak in the Newberry period, with other use in the Haiwee and Marana periods (Figure 6.5).

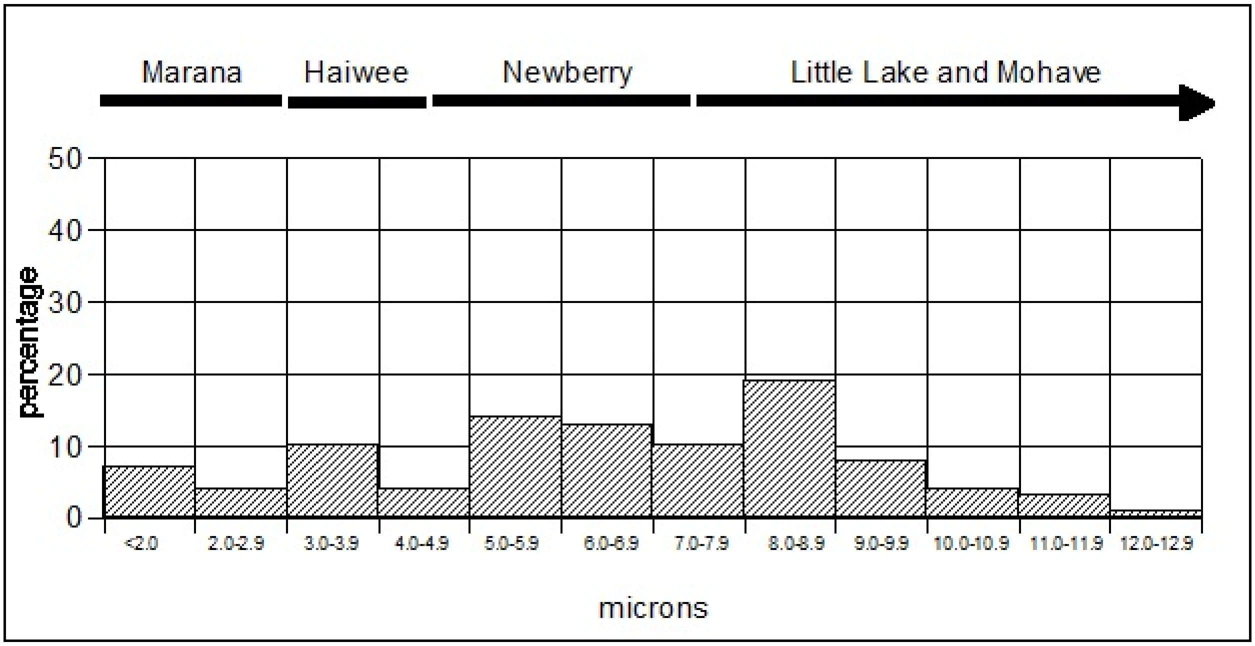


Figure 6.3. Compiled obsidian hydration results for Saline Valley 1 specimens from the Eureka Dunes Site (n=90 rim values).

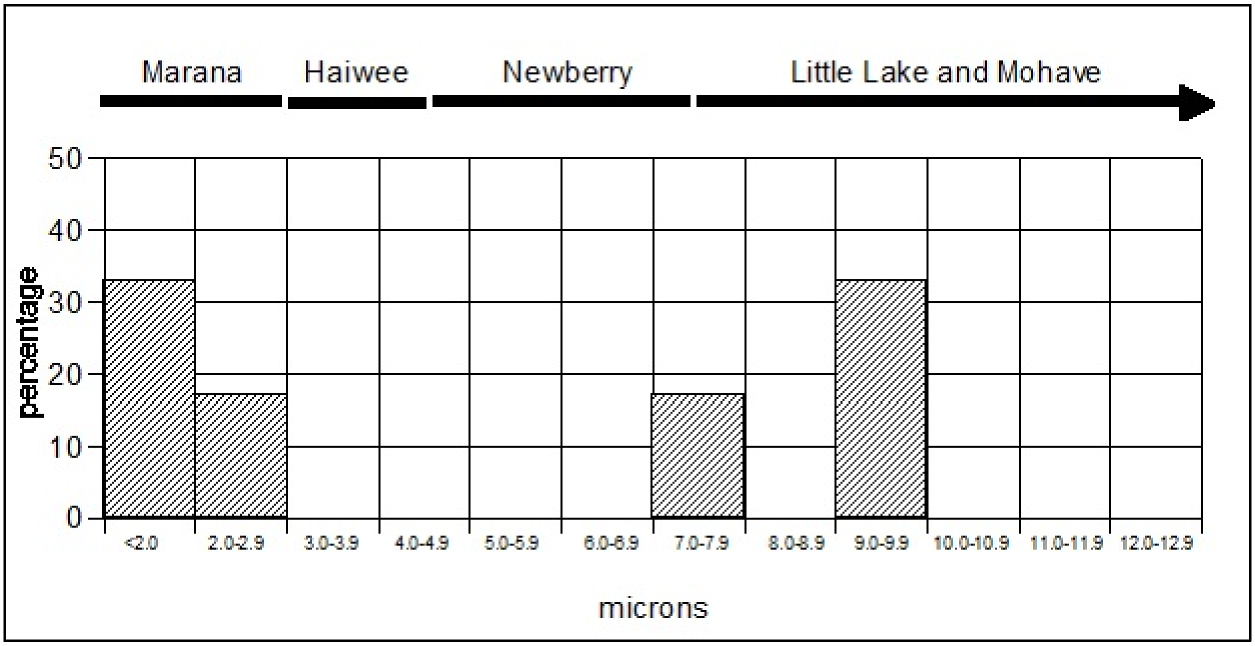


Figure 6.4. Compiled obsidian hydration results for Saline Valley 2 specimens from the Eureka Dunes Site (n=6 rim values).

However, the sample is small (n=7), and this interpretation may be further skewed by a faster hydration rate for this source. For example, a Desert Side-notched point had a rim value of 3.0 microns, and the rim of a Rose Spring series point measured 6.5 microns (see Table 6.1; Gilreath and Nelson 1989).

Most of the 18 rim values for the “Unknown 1” source fall between 4 and 7 microns. If hydration rates for this source are similar to that inferred for Saline Valley 1, the heaviest use of this material would be in the late Newberry and early Haiwee periods (Figure 6.6).

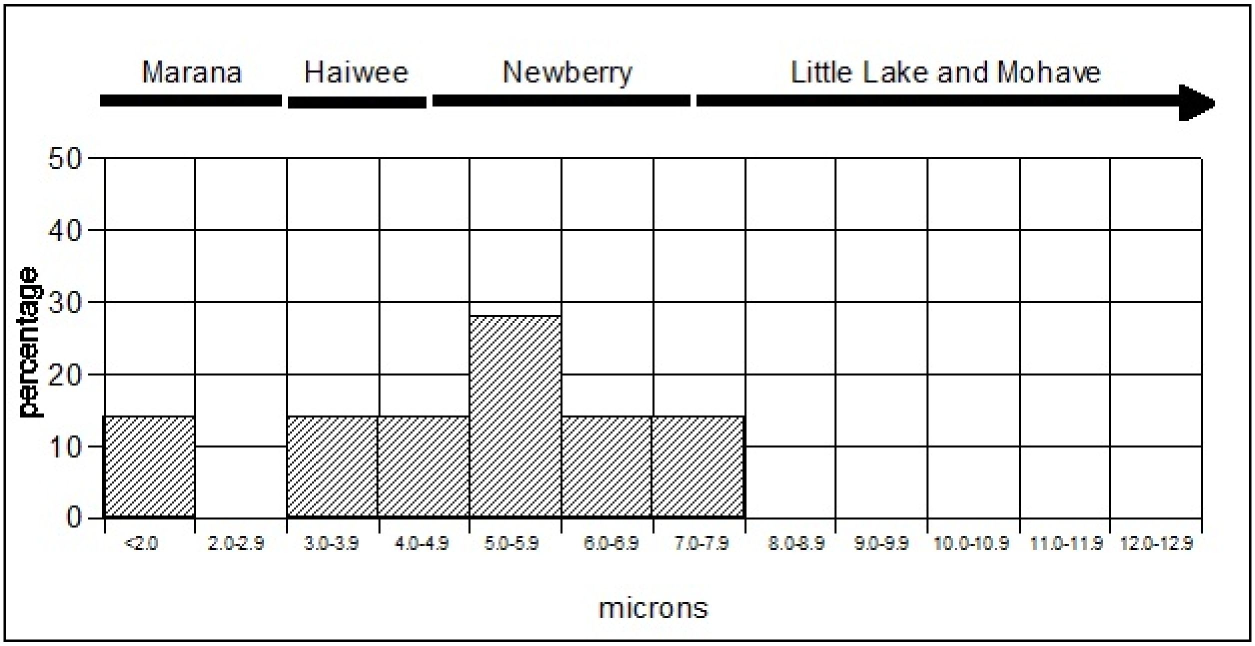


Figure 6.5. Compiled obsidian hydration results for Saline Valley 3 specimens from the Eureka Dunes Site (n=7 rim values).

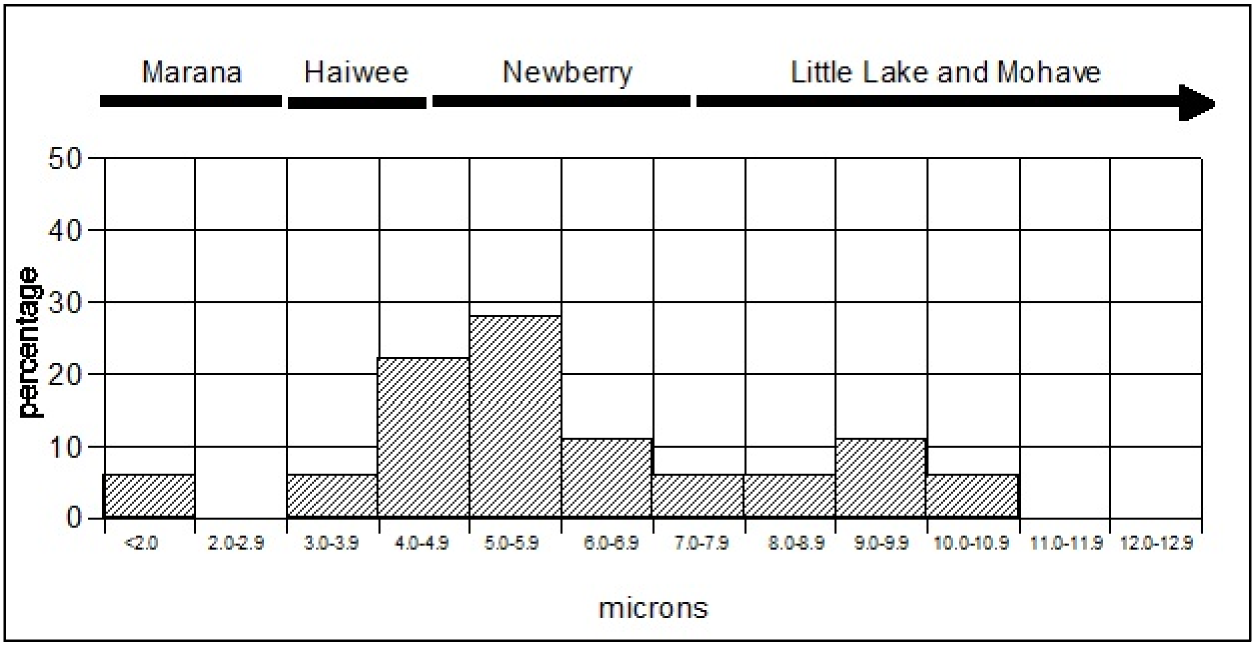


Figure 6.6. Compiled obsidian hydration results for “Unknown 1” specimens from the Eureka Dunes Site (n=18 rim values).

The six rim values from artifacts from the three Nevada sources range from no visible hydration to 10 microns, which may indicate use of Nevada sources at the Eureka Dunes Site over a wide time span, or that the hydration rates vary significantly between sources (Figure 6.7). Both scenarios are possible: three of the samples are dart points, which likely date to before A.D. 600. Two have high rim values of 6.6 and 7.2 microns which fall within the micron range expected for dart points of Saline Valley 1 obsidian. But the rim value for the third dart point fragment, a possible wide-stem variant of some antiquity, measured only 3 microns.

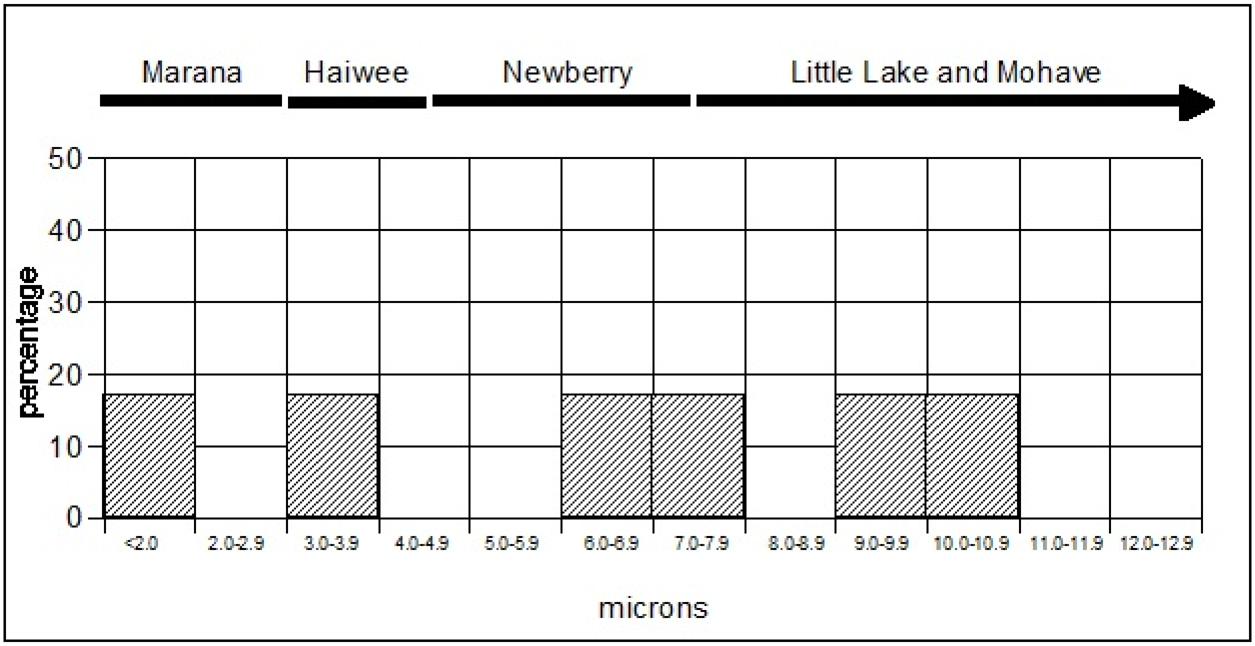


Figure 6.7. Compiled obsidian hydration results for Nevada obsidian specimens from the Eureka Dunes Site (n=6 rim values).

Some general trends in the use of the different portions of the site through time can be derived from the obsidian hydration rim values. Based on the expected correlations between rim values and time periods for Saline Valley 1 obsidian discussed above, Figures 6.8 through 6.12 show the distribution of obsidian flakes ascribed to different time periods across the site. Because the rim-time correlations were derived from Saline Valley 1 obsidian, only debitage from that source are plotted. Some "horizontal stratigraphy" is suggested. The earliest use at the site (Lake Mohave complex and Little Lake period) occurred in the western and to a lesser extent, the far eastern portion of the site. Over time use apparently shifted from the part of the site near the playa eastward. During the early Newberry period, use is concentrated in the west-central portion of the site, but in the late Newberry the use is more widespread scattered throughout the length of the site. The east-central portion of the site mostly dates to the Haiwee period. The most recent use, as indicated by the Marana projectile point and obsidian hydration values less than 3.0 microns, appears to have been more limited, with widely spaced samples from the center of the site. This patterning is not surprising, given the large size of the site: resources, or the inhabitants' preferences in camp or work locations, may have shifted slightly over time.

If indeed the site areas most intensively used shifted over time, we can make some preliminary estimates of the intensity of that use over time as well. That is, we can try to alleviate some of the bias introduced by selecting just one or a few flakes from each surface collection unit for analysis whether there were thousands or merely a few dozen flakes in that unit, by weighting the rim values by the density of the unit from which they were selected. Because Saline Valley 1 obsidian provided the bulk of the samples for our postulated correlations between rim values and time, this weighting relies only on obsidian hydration measurements from Saline Valley 1 specimens. First, each Saline Valley 1 specimen's rim value was placed into its presumed cultural time period. For argument's sake, we then assumed that all flakes in that surface collection unit dated to the same period. If two specimens from a unit were submitted for obsidian hydration analysis, each is weighted by half of the total number of flakes in that unit. In reality, it is unlikely that all flakes in our arbitrarily designated spatial units would date

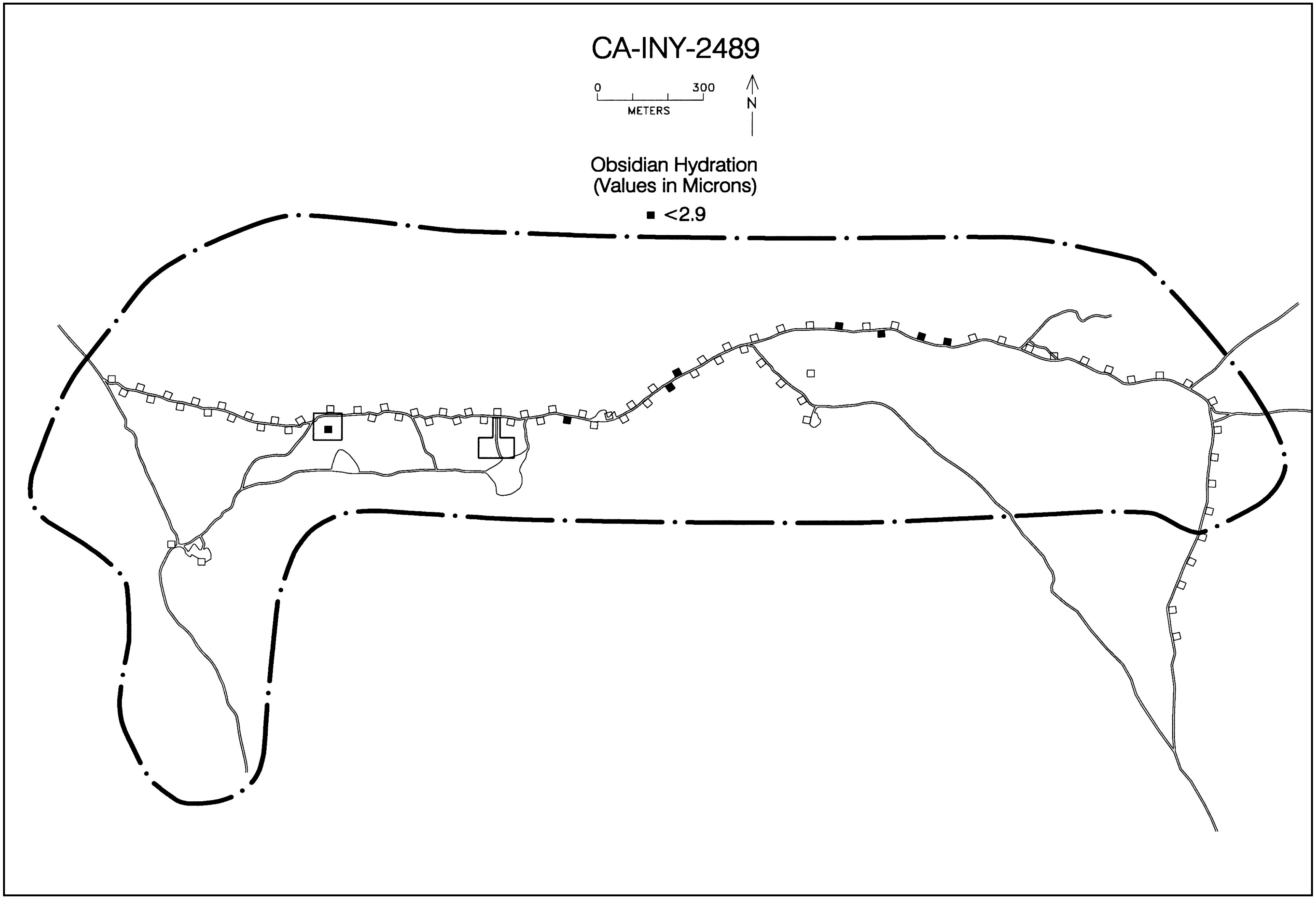


Figure 6.8. Distribution of Marana period Saline Valley 1 obsidian hydration values at the Eureka Dunes Site.

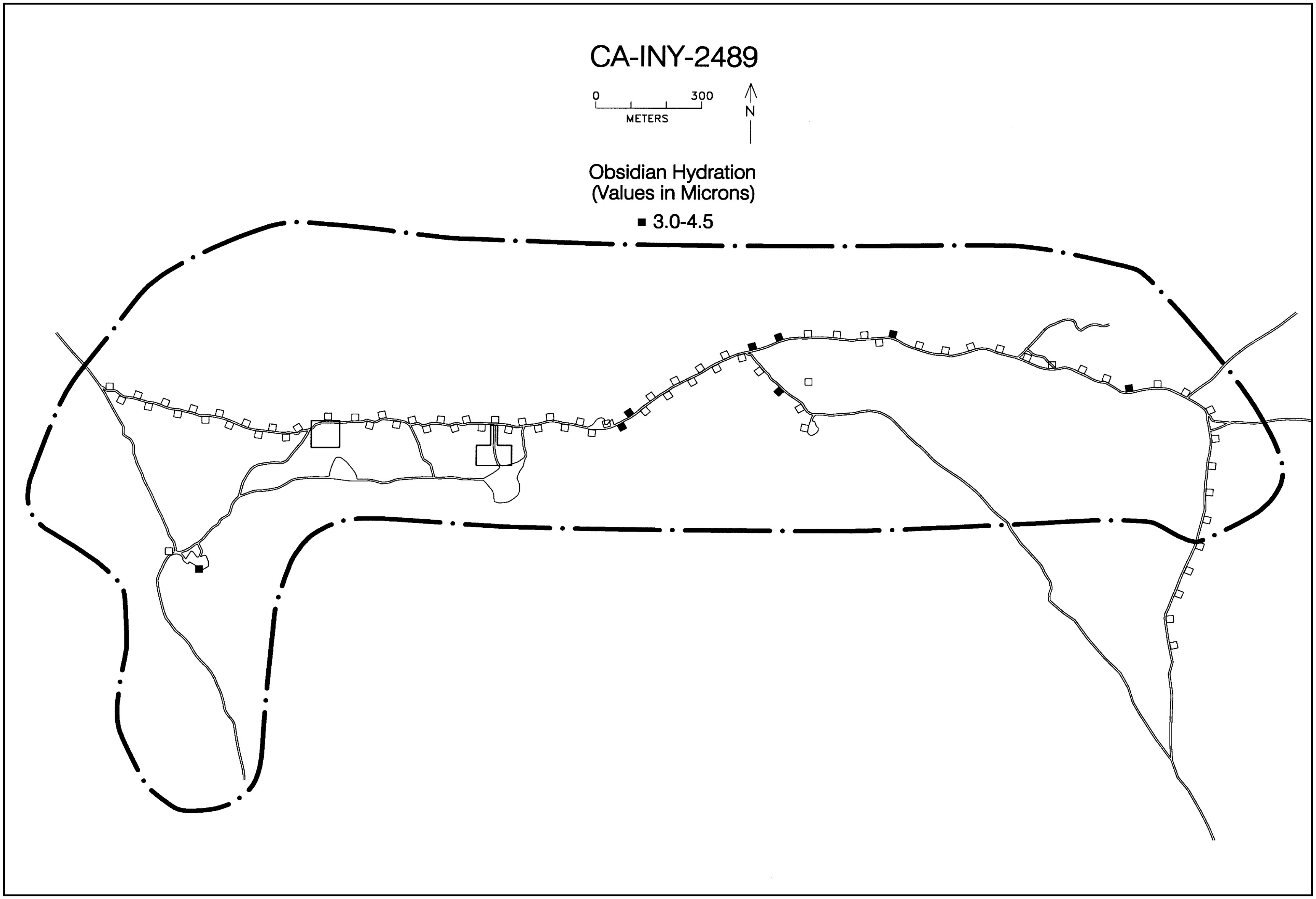


Figure 6.9. Distribution of Haiwee period Saline Valley 1 obsidian hydration values at the Eureka Dunes Site.

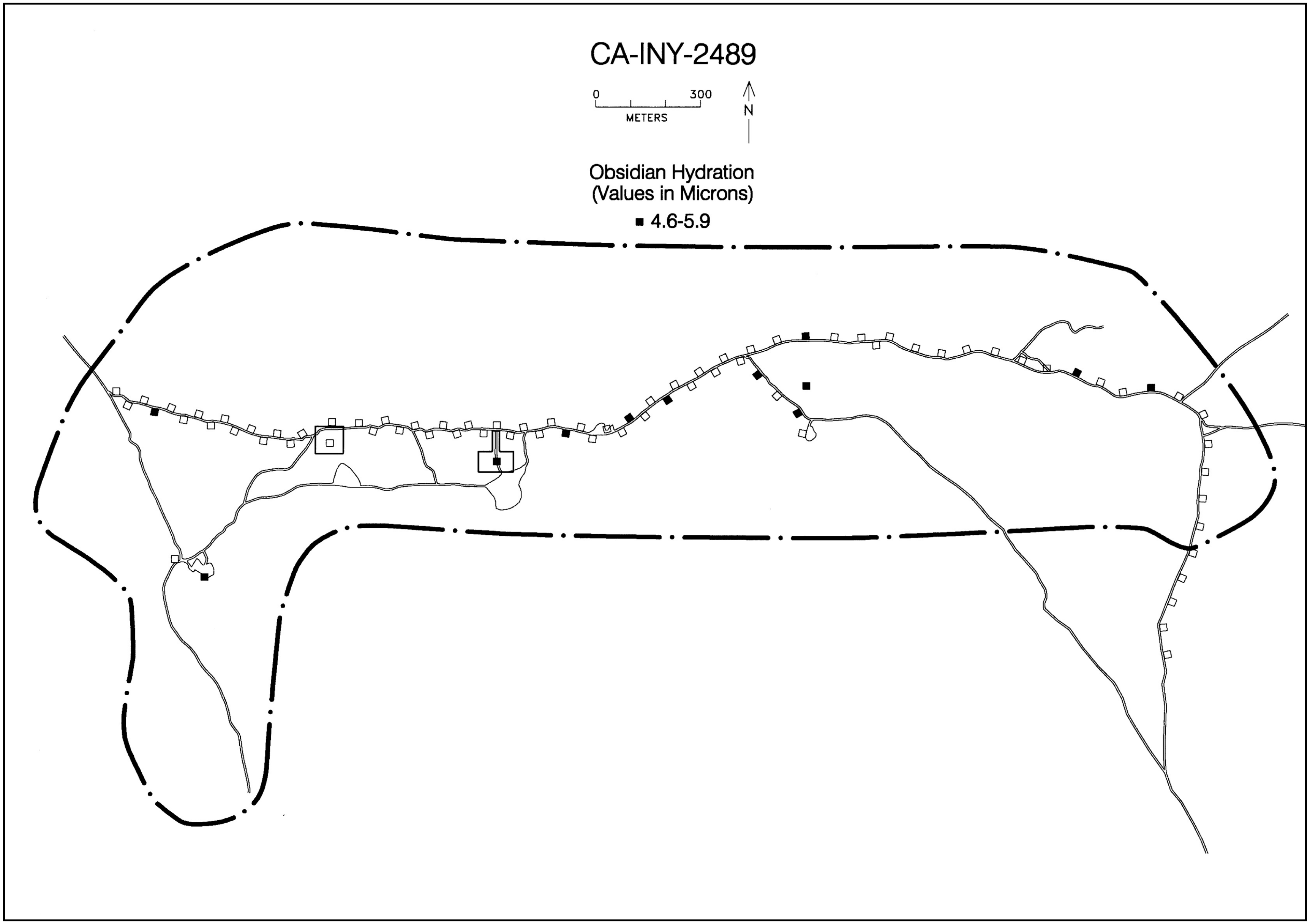


Figure 6.10. Distribution of late Newberry period Saline Valley 1 obsidian hydration values at the Eureka Dunes Site.

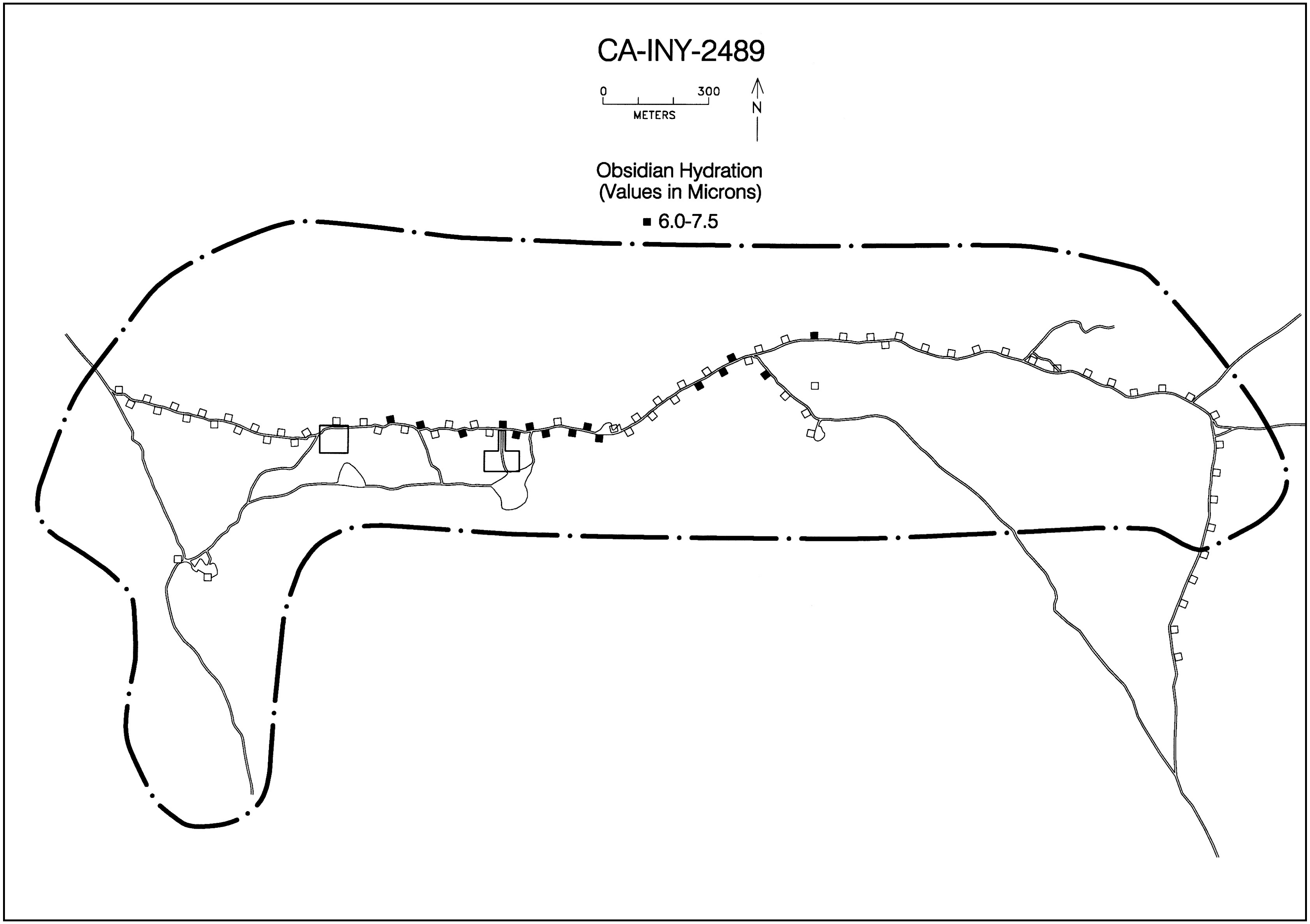


Figure 6.11. Distribution of early Newberry period Saline Valley 1 obsidian hydration values at the Eureka Dunes Site.

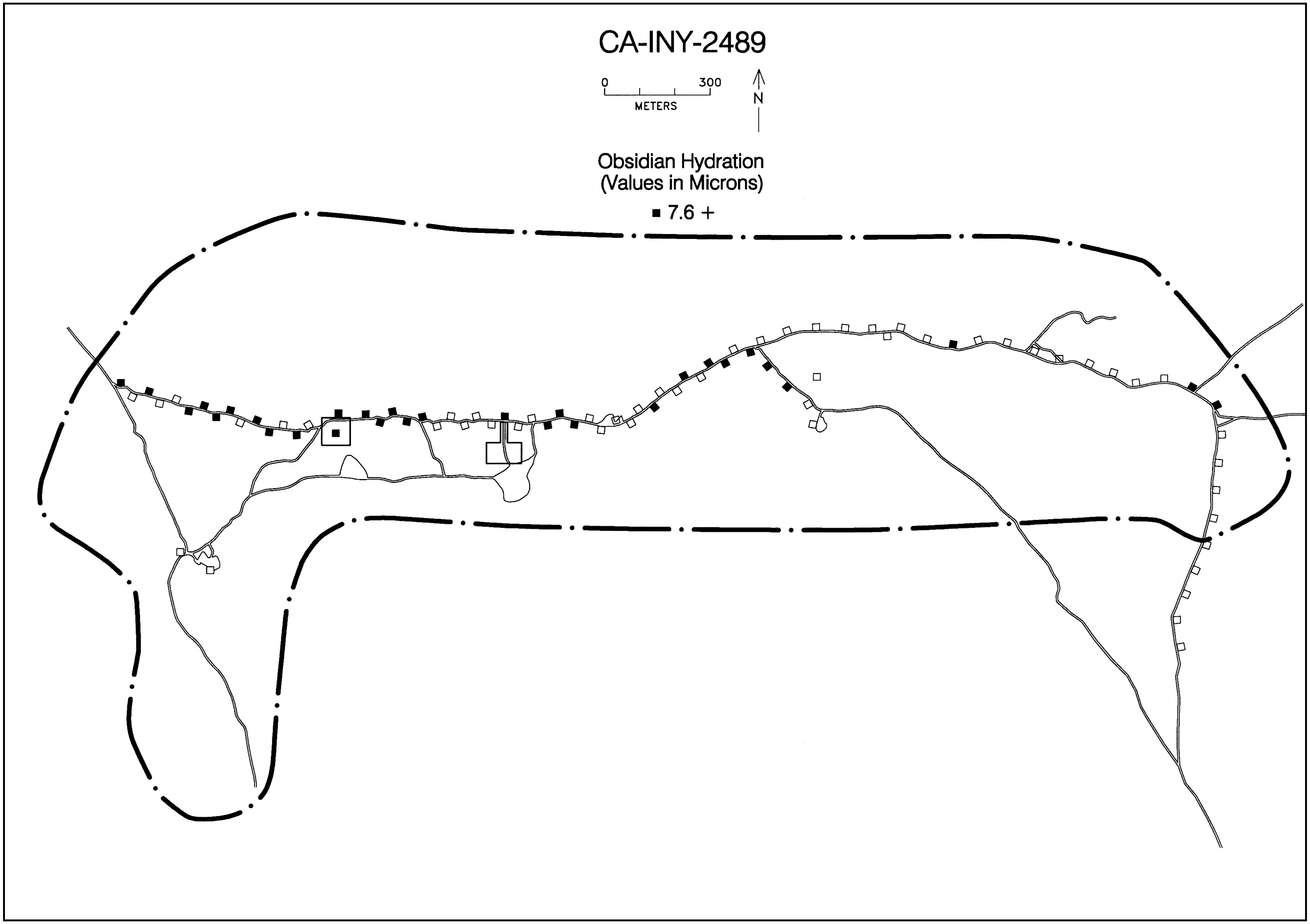


Figure 6.12. Distribution of Little Lake period and Lake Mohave complex Saline Valley 1 obsidian hydration values at the Eureka Dunes Site.

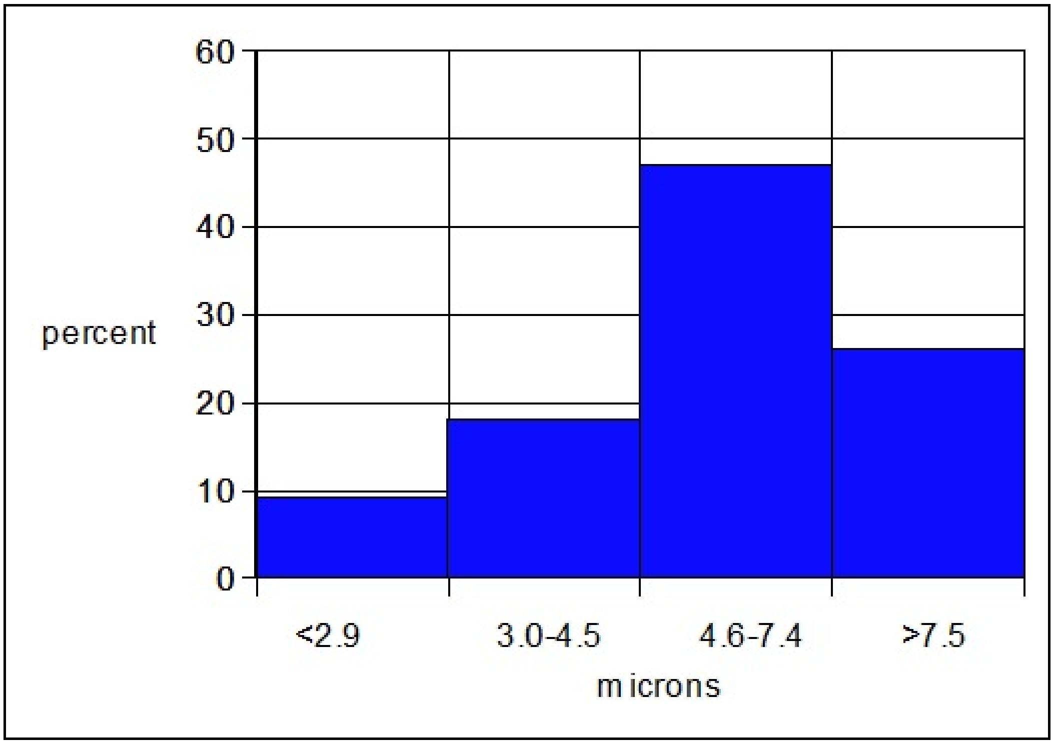


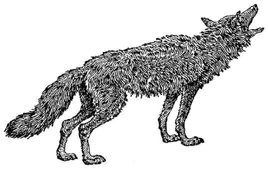
Figure 6.13. Weighted obsidian hydration results for Saline Valley 1 specimens from the Eureka Dunes Site.

to the same period, but the horizontal stratigraphy evident across the site suggests it can provide a fair preliminary estimate.

The weighted percentages indicate that the earliest use of the site is likely over-represented in the hydration sample. Although 38 of the rim values fall into the Little Lake and Mojave Periods, these samples came from sparse areas of the site. Although slightly fewer (n=36) rim values fall within the Newberry Period, those samples came from very dense areas of the site, suggesting more intensive occupation (at least for obsidian-flake-producing tasks) during the Newberry Period. Obsidian production is much decreased during the Haiwee period, tapering off even more during the Marana period (Figure 6.13).

Summary

The chronological information obtained in this project suggests long-lived use of the Eureka Dunes Site, from as early as ca. 6,000 B.P. to late prehistoric times. Although the chronometric sample is small relative to the spatial extent and artifact density of the site as a whole, the preliminary data suggest some changes in site use through time. Direct evidence of hunting (that is, projectile points) is greatest during the Mohave complex (pre-3500 B.C.). The excavated fire-cracked rock features at the site date to the late Newberry, Haiwee, and early Marana periods. Based on obsidian hydration analysis, obsidian reduction at the site was greatest during the Newberry and Haiwee periods. Chert use may be more recent: one of only two chert projectile points recovered from the site was a Desert Side-notched point, a style dated to the Marana period, and Delacorte (1988) has postulated that use of Last Chance green-grey chert intensified after A.D. 600.



Chapter 7

Flaked Stone Artifacts

William W. Bloomer

Archaeological investigations at the Eureka Dunes Site (CA-INY-2489) recovered 13 projectile points, 79 bifaces, one uniface, seven edge-modified flakes and one core tool (Table 7.1). Over 26,000 pieces of debitage were also recovered, including whole flakes, flake fragments, and shatter. All of the tools and a sample of the debitage were analyzed, focusing on the technology of tool production.

Obsidian, primarily from nearby Saline Valley sources (see Appendix B) and green-grey chert most likely from the Last Chance Range, north of Eureka Dunes, are predominant in the collection. Other chert (aka cryptocrystalline [CCS]), including chalcedony, is present in lesser amounts. Quartzite and basalt occur only in small numbers, primarily as debitage.

Flaked stone tool analysis incorporated the study of a suite of morphological characteristics and technological attributes to describe assemblage composition and infer tool manufacture patterns. The results describe an array of temporally-diagnostic projectile points, which serve as a foundation for chronological interpretations, and a tool assemblage that is a representative expression of site activities.

Analytical data for all tools include toolstone material, condition, dimensions, blank type, breakage type, and extant flaking technique, with specific comments for most artifacts. Additional recorded typological descriptions and morphological attributes are discussed below for each tool type.

Toolstone material was recorded as obsidian, green-grey chert, other chert, quartzite, or basalt. *Condition* classifies the artifact as a whole specimen, or as one of several fragment types. Condition was recorded as *whole*, *nearly complete*, *proximal*, *medial*, *distal*, *undifferentiated end*, *lateral margin*, *undifferentiated margin*, or *undifferentiated fragment*. The recorded *dimensions* include length, width, thickness, and weight.

Blank type describes the form of the unworked piece of toolstone at the beginning of artifact manufacture, and is therefore important for understanding toolstone procurement and the initial steps in tool manufacture. Blank types might include *cobble*, *tabular cobble*, *flake*, or any of the technologically diagnostic flake types defined below in the discussion of debitage analysis. *Indeterminate blanks* are worked beyond the point where original blank morphology is visible.

Breakage types often indicate whether an artifact was broken during manufacture, during use, or as a result of post-depositional processes. Unfortunately, generic *bending* fractures are the most common break type. They can result from manufacture impact, use impact, or post-depositional trampling, and so are not diagnostic. *Bending* fractures are typically flat and perpendicular to the longitudinal axis of the tool, caused by tension or compression from impact shock or trampling that bends the artifact beyond its limits. If concentric rings are visible on the break, they emanate from the center of one face. *Transverse bending* fractures, *perverse* fractures, *outre-passe* removals, *material flaws*, and some *thermal breaks* indicate manufacture failure. *Transverse bending* fractures are the same as generic bending fractures, except that the concentric rings emanate from one lateral edge. *Perverse* fractures are spiral or twisting breaks, initiated at the artifact's edge. An *outre-passe* is an "overshot"

Table 7.1. Flaked Stone Tools and Technological Debitage Sample.

	Toolstone					
	Obsidian	Green-Grey Chert	CCS	Quartzite	Basalt	Total
Projectile Points	11	2	0	0	0	13
Bifaces	26	47	6	0	0	79
Uniface	0	0	1	0	0	1
Edge Modified Flakes	0	3	3	1	0	7
Core Tool	0	1	0	0	0	1
Total	37	53	10	1	0	101
Debitage Sample	3,221	2,029	446	40	6	5,742

flake removal that went too far across the artifact's face, removing the opposite margin. *Material flaws* are material irregularities or natural fracture planes within the unworked toolstone, which become apparent during reduction. Thermal breaks, such as internal crenulations and curvilinear fractures, result from failed heat treatment during the manufacturing process. Thermal breaks such as pot lids and surface crazing result from post-depositional exposure to direct flame.

Use is sometimes indicated by *bending* fractures with *finial* terminations, which extend the fracture scar beyond the bending plane, lipping onto one face of the artifact. This lipped extension is often caused by a forceful impact at the tip of an artifact – such as when a projectile point hits a hard object.

Extant flaking technique concerns the method of flake removal, indicated by the types of negative flake scars apparent on the discarded artifact. Flaking techniques, including percussion, pressure, a combination of percussion and pressure, and bipolar, are recorded to identify reduction patterns that might vary by site area and through time. Sometimes, especially during the finishing stage of biface reduction, pressure flaking can obliterate the evidence of previous percussion reduction.

Projectile Points

Projectile points are typically bifacial tools with a pointed tip and basal hafting elements, such as notches or a stem, used to attach the point to an arrow or dart shaft. Point type classifications follow standards set by Bettinger and Taylor (1974) and Thomas (1970, 1981), which are commonly used in the analysis of southwestern Great Basin projectile point collections (Basgall and Giambastiani 1995; Bettinger 1989; Burton 1996; Gilreath and Hildebrandt 1997). Fragmentary points, which could not be accurately typed, were classified by size as arrow or dart points. Thomas's (1981) metric criteria were recorded for each point. Some bifacial tool fragments, such as distal tips and medial sections, might be projectile point parts, but were classified as biface fragments if they lacked evidence of hafting or distinctive projectile point shaping.

Thirteen projectile points in the Eureka Dunes collection include one Desert Side-notched, one point in the Rose Spring series, one Elko Corner-notched, two Fish Slough Side-notched points, one Northern Side-notched, and seven otherwise untypable dart points (Tables 7.2 and 7.3; Figure 7.1).

Desert Side-notched

Desert Side-notched points, first named by Baumhoff (1957), are relatively small triangular-shaped arrow points, with symmetrically opposing notches set high on the lateral margins (Lanning 1963; Thomas 1981). The one Desert Side-notched point present in the Eureka Dunes collection (FN 227) is a Sierra subtype (Baumhoff and Byrne 1959), with a distinctive basal notch. It was made from green-grey chert by pressure flaking a small thin flake blank. Desert Side-notched points reflect an age that post-dates 650 B.P. (Bettinger and Taylor 1974).

Rose Spring Series

The Rose Spring Series has been fully described by Lanning (1963), based on assemblages from the Rose Spring site in southeastern California, and reiterated by Yohe (1992) in his revisit of the Rose Spring site. Three small, lightweight, arrow point types are distinguished in the Rose Spring series. They include the typical Rose Spring Corner-notched, the Rose Spring Contracting stem, and the Rose Spring Side-notched. There is only one obsidian Rose Spring point in the Eureka Dune Site collection (FN 265). It has a broken base, but is probably a corner-notched form. This point has a hydration rim measuring 2.8 microns. The age range for Rose Spring series points is 1350 B.P. to 650 B.P. (Bettinger and Taylor 1974).

Elko Series

Elko points, first defined at Wagon Jack Shelter (Heizer and Baumhoff 1961), include large eared, corner-notched, contracting stem, and side-notched points, considered to have tipped atlatl darts (Heizer et al. 1968; O'Connell 1967). The obsidian Elko point in the Eureka Dunes collection (FN 698) is a corner-notched basal fragment, broken at its neck. The base has a distinctive triangular shape with a slightly convex basal margin. It had two hydration rims 8.4 and 11.7 microns. Elko series points are generally considered to date between 3150 and 1350 B.P. (Bettinger and Taylor 1974).

Fish Slough Side-notched

Fish Slough Side-notched points are described by Basgall and Giambastiani (1995) in their report of archaeological investigations on the Volcanic Tablelands, north of Bishop, California, as large with a fan-shaped base. The two obsidian Fish Slough Side-notched points from Eureka Dunes (FNs 131 and 621) are large basal fragments, broken at the neck. Both compare well with Fish Slough points illustrated from the Volcanic Tablelands (Basgall and Giambastiani 1995). Percussion scars on both specimens indicate they were made on percussion biface blanks, then pressure thinned and shaped to their final form. An irregularly shaped oblique bending break, emanating from a notch, suggests one of the Fish Spring Side-notched points (FN 131) may have been broken during manufacture. Hydration rim values for these points are 7.4 and 9.5 microns. Hydration rim measurements for Fish Slough points from the Volcanic Tablelands are typically large at 7.5 to nearly 12 microns, suggesting that Fish Slough Side-notched points were in use before 6500 B.P. (Basgall and Giambastiani 1995).

Northern Side-notched

The last point identifiable by type is a basal fragment of an obsidian Northern Side-notched point (FN 319). Northern Side-notched points are large triangular points, typically with concave bases and stylistically distinct wing-shaped basal ears. Notch openings are extremely narrow, often shaped like a comma. The Northern Side-notched is a common northern Great Basin point type (Heizer and Hester 1978), but is found only infrequently across the southern Great Basin. The Eureka Dunes specimen includes a large basal ear defined by a deep side notch. A break runs just above the notch removing all trace of the distal shoulder. While the basal ear is not as square as those of many NSN points from other portions of the Great Basin (Holmer 1986: 104, Figure 14), its concave base and wing-shaped ear compare favorably to illustrations of Northern Side-notched points from the northern Great Basin (Delacorte 1997; Heizer and Hester 1978; Hester and Heizer 1973: 27, Figure 6). The hydration rim on this Eureka Dunes specimen measures 9.3 microns. In the northern Great Basin, Northern Side-notched points are

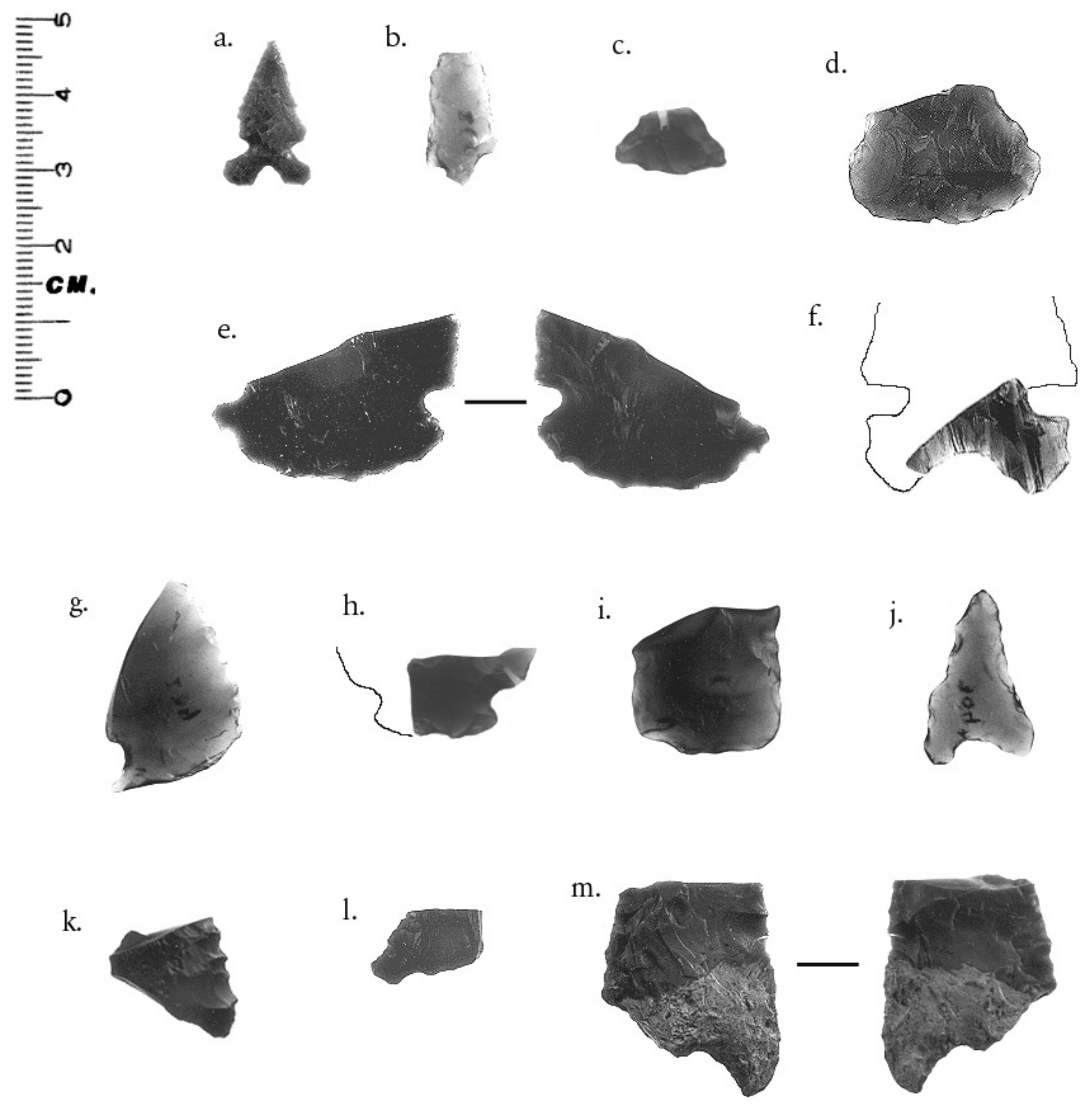


Figure 7.1. Projectile points from the Eureka Dunes Site; a. Desert Side-notched, b. Rose Spring series, c. Elko Corner-notched (with hydration cut), d-e. Fish Slough Side-notched, f. Northern Side-notched, g-m. dart-size (h. has hydration cut) (a. FN 227, b. FN 265, c. FN 698, d. FN 621, e. FN 131, f. FN 319, g. FN 234, h. FN 243, i. FN 310, j. FN 304, k. FN 317, l. FN 402, m. FN 574).

considered indicators of post-Mazama occupations, from 7000 to 5000 B.P. (Delacorte 1997).

Dart Points

The seven dart points include six small fragments, which lack obvious type attributes, and in some cases are so fragmentary that orientation is difficult (FNs 402 and 243). Most are obsidian, but one is green-grey chert (FN 574). Two may have been manufacture failures (FNs 234 and 574). One of the fragments (FN 310) resembles illustrated wide-stem variants from the Owens Valley (Basgall and Giambastiani 1995). Contradicting the age of this morphological type, the hydration rim measurement for this dart point fragment is only 3.0 microns, which overlaps the hydration range for arrow points. Nevertheless, the large size and a square-shaped stem indicate this fragment is a large dart point.

One whole triangular point (FN 304) is unusually thin and small, resembling a deeply basal-notched Cottonwood point, which is a Late Archaic arrow point (Lanning 1963). It also resembles an uncharacteristically small version of Humboldt Basal-notched points in the Volcanic Tablelands collection (Basgall and Giambastiani 1995). Therefore, type classification is problematic. However, a hydration rim measurement of 6.1 microns speaks to the relatively ancient age of this otherwise untypable specimen. Based on the hydration data, it has been classified as a dart point.

Bifaces

Bifaces are flaked stone tools that are relatively ovate in shape, but pointed at one or both ends, with lenticular cross-sections at their greatest width. Bifaces differ from projectile points in that they have no distinct hafting elements, such as notches or a stem, for attachment to arrow or dart shafts. Finished bifacial tools are extensively shaped using percussion and/or pressure reduction techniques, which leave flake scars across both faces of the biface.

During manufacture, bifaces go through several technological stages of reduction from initial shaping to finishing. Therefore, in addition to the general flaked stone tool attributes, each biface in the collection has been classified by manufacturing stage to study the variability of tool production. Biface stage classifications follow a five-stage adaptation (Bloomer et al. 1992, 1997: Appendix H) of Callahan's (1979) more comprehensive stage classification system. In brief, stage categories are based on percussion and pressure flake scar patterning, which reflects the extent of reduction through the continuum of biface manufacture. Completeness of shape is also a variable, in that the shape becomes refined through manufacture from an irregular flake blank to a symmetrical and straight-edged final form. Stage 1 bifaces are essentially flake blanks showing only minimal reduction, which served to remove large irregularities. Stage 2 bifaces have undergone initial shaping and edge preparation to make a bifacial edge for further reduction and thinning. Initial biface thinning and shape regularization occurs during stage 3. Stage 4 bifaces show secondary thinning and are typically well-shaped. Finishing occurs during stage 5, usually with pressure reduction. Therefore, small fragments of finished bifacial tools are often classified as stage 5.

Seventy-nine bifaces are present in the collection (Table 7.4; Figures 7.2-7.4). Green-grey chert bifaces are most prevalent (n=47), constituting 60 percent of the collection. Obsidian bifaces account for 33 percent (n=26), while other chert bifaces make up just over 7 percent (n=6) of the collection. All but two (3%) of the bifaces are fragments, and one (1%) is nearly complete. Most are end fragments (n=47, 59%) that cannot be distinguished as either proximal (n=5, 6%) or distal (n=7, 9%). Medial fragments account for over 6 percent (n=5) of the bifaces, while lateral fragments (n=9), margin fragments (n=2), and one general fragment make up over 15 percent.

One of the two whole bifaces in the collection is a large thick green-grey chert stage 2 percussion biface (FN 175; Figure 7.2a), made on a tabular cortical cobble. It failed and was discarded because of a massive step fracture and multiple deep hinge fractures, which encumbered further reduction. The second whole biface is actually a green-grey chert stage 3 biface in two refittable pieces (FN 222/223; Figure 7.3a). It was broken on a material flaw into two pieces during manufacture; both pieces were found within the same surface collection unit (1360N) 17 m apart. One other green-grey chert biface is a nearly complete thin well-shaped stage 4 percussion/pressure biface (FN 49; Figure 7.3d). It failed during late stage percussion thinning after excessive heat-treatment created internal crenulation fractures, which probably weakened internal laminae. The tip is missing, but the overall form of the biface is apparent. These three green-grey chert bifaces – the large thick stage 2, the medium-size stage 3, and the nearly complete, thin stage 4 – represent the full extent of the predominant green-grey chert biface reduction

Table 7.2. Projectile Point Analytical Data.

Provenience	Type	Toolstone	Condition	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Blank	Break	Flaking	Comments	FN
L2-11	ECN	OBS	PRX	-9.0	-14.8	-3.2	0.4	Indet	Bend	Pres	5.8/11.7µ rims	698
L3-1	FFS	OBS	PRX	-18.8	-26.1	-7.1	3.5	Indet	Bend	Perc/pres	Prob. type classification; 9.5µ rim	621
~800N	FSS	OBS	PRX	-23.6	-32.3	-5.0	3.6	Indet	Bend	Perc/pres	Poss. manuf. notching failure; 7.4µ rim	131
1320S	Dart	OBS	FRG	-16.0	-9.2	-3.7	0.5	Indet	Bend	Pres	Cannot orient; shoulder or base; 6.6µ rim = Dart point	402
1360N	DSN	GGC	WHL	20.3	12.4	2.3	0.4	Flake	None	Pres	Sierran subtype	227
1440N	Dart	OBS	MRG	-14.1	-18.0	-5.1	0.9	Indet	Bend	Pres	Notched; hard to orient; 8.4µ rim	243
1680N	Dart	OBS	MED	-27.5	-20.3	-4.4	2.2	Flake	Bend	Perc/pres	Notched; prob. manuf. failure; minimal perc; 8.0µ rim	234
1800S	Dart	OBS	PRX	-30.3	-20.6	-5.7	2.9	Indet	Bend/finial	Perc/pres	Dart size, comparable to wide-stem variants, but 3.0µ rim; impact break	310
1800S	Dart	OBS	LAT	-16.8	-16.1	-5.5	1.3	Flake	Bend	Pres	Shoulder fragment; notched or contracting stem; 7.2µ rim	317
1800S	NSN	OBS	PRX	-15.1	-22.0	-4.4	1.0	Indet	Bend	Pres	Probable type classification; 9.3µ rim	319
1960S	Dart	OBS	WHL	23.6	15.4	3.4	0.9	Indet	None	Pres	Asymmetrical, basal notched CTN morph, but 6.1µ rim, so poss HBN	304
2000N	Dart	GGC	MED	-29.4	-24.5	5.1	3.8	Indet	Bend	Perc/pres	Asymmetrical; prob. ht; poss. manuf/maintenance failure	574
2640N	RSS	OBS	NCO	-18.5	10.0	3.2	0.6	Indet	Indet	Pres	Prob. corner-notched; basal breaks; 2.8µ rim	265

KEY: Bend/finial = bending scar lipped onto one face; Bend = bending fracture; CTN = Cottonwood; Dart = dart size atlatl projectile point; DSN = Desert Side-notched; ECN = Elko Corner-notched; FN = field catalog number; FRG = otherwise unidentifiable fragment; FSS = Fish Slough Side-notched; GGC = gray-green chert; HBN = Humboldt Basal-notched; ht = heat-treated; Indet = indeterminate; LAT = lateral margin; MED = medial; MRG = margin; NCO = nearly complete; NSN = Northern Side-notched; OBS = obsidian; Perc/pres = percusion and pressure; Pres = pressure; PRX = proximal fragment; RSS = Rose Spring series; WHL = whole; (-nn) = incomplete measurement.

Table 7.3. Projectile Point Metric Data.

Provenience	Type	Toolstone	Condition	LT (mm)	LA (mm)	LM (mm)	WM (mm)	WB (mm)	WN (mm)	Thk (mm)	Wt (g)	DSA (degrees)	PSA (degrees)	NO (degrees)	BIR	WB/WM	FN
L2-11	ECN	OBS	PRX	-9.0	-9.0	---	-14.8	14.8	8.4	-3.2	0.4	---	130	---	---	---	698
L3-1	FSS	OBS	PRX	-18.8	-18.8	---	-26.1	26.1	18.4	-7.1	3.5	---	140	---	---	---	621
~800N	FSS	OBS	PRX	-23.6	-23.6	---	-32.3	31.4	24.2	-5.0	3.6	190	135	55	---	---	131
1320S	Dart	OBS	FRG	-16.0	-16.0	---	-9.2	---	---	-3.7	0.5	---	---	---	---	---	402
1360N	DSN	GGC	WHL	20.3	17.4	---	12.4	12.4	6.1	2.3	0.4	200	160	40	0.86	1.0	227
1440N	Dart	OBS	MRG	-14.1	---	---	-18.0	---	---	-5.1	0.9	---	---	60	---	---	243
1680N	Dart	OBS	MED	-27.5	---	---	-20.3	---	---	-4.4	2.2	---	---	---	---	---	234
1800S	Dart	OBS	PRX	-30.3	-30.3	---	-20.6	20.5	---	-5.7	2.9	---	90	---	---	---	310
1800S	Dart	OBS	LAT	-16.8	-16.8	---	-16.1	---	---	-5.5	1.3	---	---	---	---	---	317
1800S	NSN	OBS	PRX	-15.1	-11.4	---	-22.0	-22.0	---	-4.4	1.0	---	185	---	---	---	319
1960S	Dart	OBS	WHL	23.6	20.9	3.0	15.4	15.4	---	3.4	0.9	---	---	---	0.89	1.0	304
2000N	Dart	GGC	MED	-29.4	-29.4	---	-24.5	---	---	5.1	3.8	120	---	---	---	---	574
2640N	RSS	OBS	NCO	-18.5	-18.5	---	10.0	---	4.3	3.2	0.6	175	---	---	---	---	265

KEY (see Thomas 1981 for metric attribute discussions): BIR = basal indentation ratio; Dart = dart size atlatl projectile point; DSA = distal shoulder angle; DSN = Desert Side-notched; ECN = Elko Corner-notched; FN = field catalog number; FRG = otherwise unidentifiable fragment; FSS = Fish Slough Side-notched; GGC = gray-green chert; LA = axial length; LAT = lateral margin; LM = maximum width position; LT = total length; MED = medial; MRG = margin; NCO = nearly complete; NO = notch opening; NSN = Northern Side-notched; OBS = obsidian; PRX = proximal fragment; PSA = proximal shoulder angle; RSS = Rose Spring series; Thk = thickness; WB = basal width; WB/WM = basal width/maximum width ratio; WHL = whole; WM = maximum width; WN = neck width; Wt = weight; (-nn) = incomplete measurement.

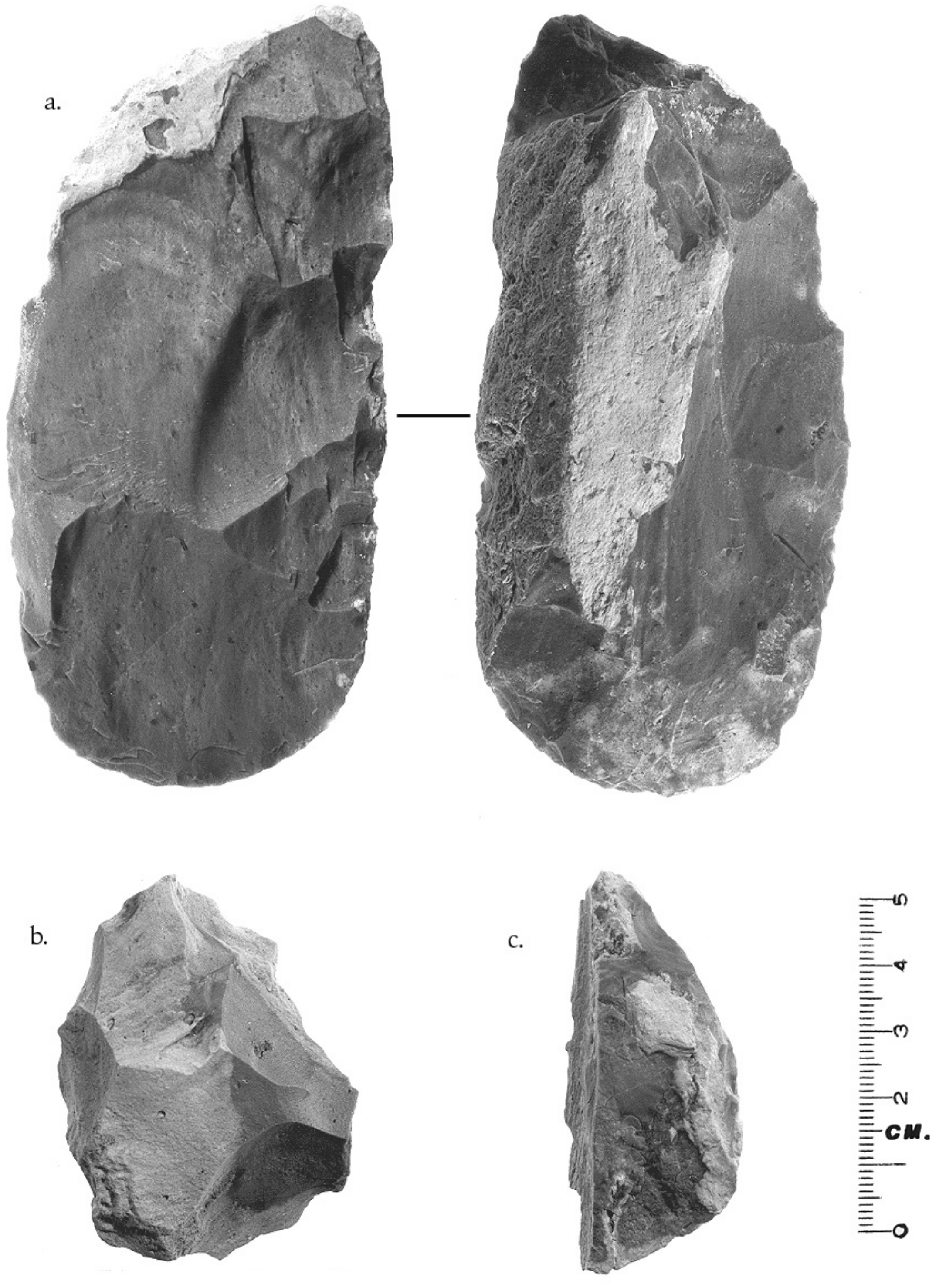


Figure 7.2. Stage 2 green-grey chert bifaces from the Eureka Dunes Site (a. FN 175, b. FN 318, c. FN 591).

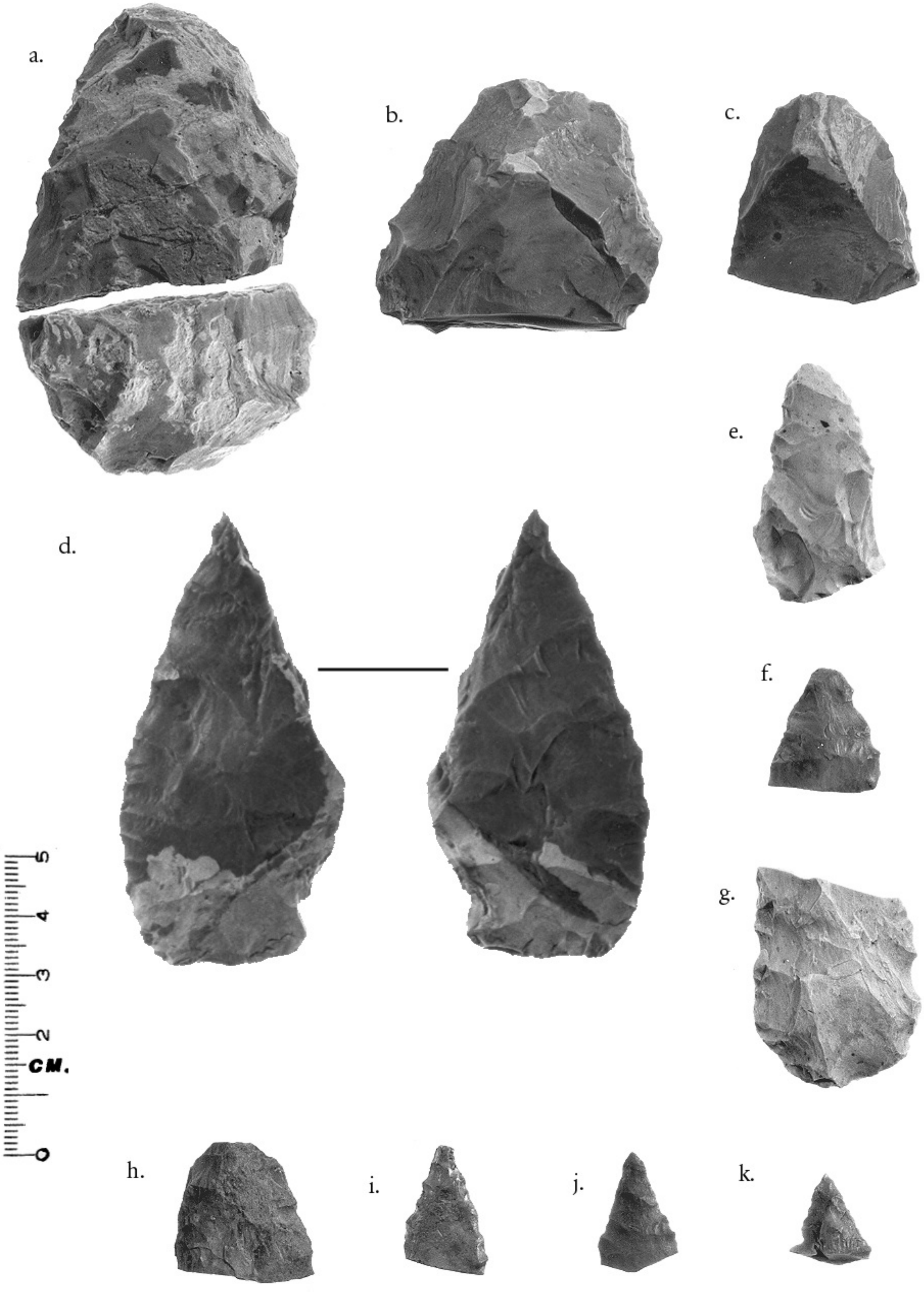


Figure 7.3. Green-grey chert bifaces from the Eureka Dunes Site; a-c. stage 3, d-h. stage 4, i-k. stage 5 (a. FN 222 & 223, b. FN 352, c. FN 261, d. FN 49, e. FN 207, f. FN 297, g. FN 534, h. FN 262, i. FN 225, j. FN 224, k. FN 192).

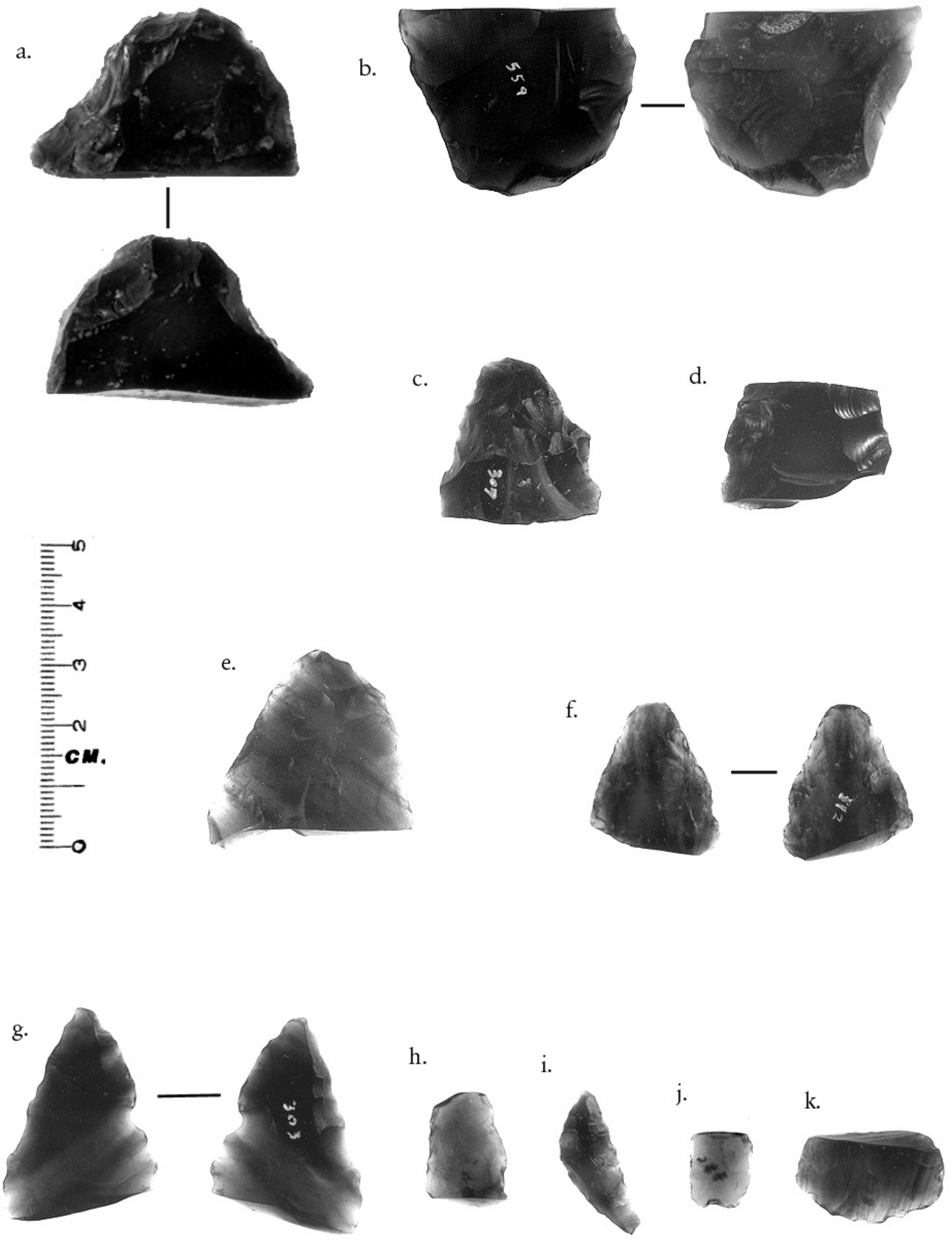


Figure 7.4. Obsidian bifaces from the Eureka Dunes Site; a-d. stage 3, e. early stage 4, f. stage 4, g. late stage 4, h-k. stage 5 (a. FN 674, b. FN 559, c. FN 307, d. FN 244, e. FN 322, f. FN 312, g. FN 303, h. FN 248, i. FN 238, j. FN 386, k. FN 238).

trajectory evident across the Eureka Dunes Site (see Figures 7.2 and 7.3).

Most of the green-grey chert bifaces are stage 2 (21%), stage 3 (26%), and stage 4 (32%), reflecting manufacture failure throughout the reduction continuum (Table 7.5). Biface blanks were thick and thin flakes, and tabular cobbles. Cortex and cortex-like laminations are generally common on the Eureka Dunes Site green-grey chert bifaces, probably contributing to manufacture failure. The stage 2 and stage 3 bifaces were percussion shaped, while the stage 4 bifaces often show percussion with some pressure flaking. Many of these production failures broke with bending fractures, including some outre-passe removals, as a result of knapping error. Others failures occurred because of material flaws or crenulation flaws created by excessive heat during heat-treatment.

A few stage 4 fragments with complete width and thickness measurements, as well as a few other large stage 4 fragments, indicate production size for green-grey chert bifaces was about 80 to 100 mm long by 30 to 50 mm wide by less than 10 mm thick. In fact, the nearly complete stage 4 biface (FN 49; see Figure 7.3d) is probably a fair representation of the typical biface form produced here, given that there is little evidence for extensive further reduction.

Stage 5 green-grey chert bifaces are infrequent, represented by just 13 percent of the collection. These pieces are typically small, primarily representing a small amount of green-grey chert dart-size projectile point manufacture, apart from the more prevalent green-grey chert biface production. One actual dart-size green-grey chert projectile point in the collection (FN 574, discussed above under projectile points), was probably also discarded in manufacture. Only one of the green-grey chert stage 5 biface fragments (FN 306) was a relatively large, very thin (6 to 1 width/thickness ratio), nearly finished biface when it failed. Because there is only one like this, either very few broke at this final stage, or most stage 4 bifaces were transported off-site for finishing or use with no further reduction. These were medium size bifaces, which could serve as cutting tools or large preforms for large dart-size projectile points.

Distinct attributes of heat-treatment are evident on at least 21 percent of the green-grey chert bifaces. Heat-treatment attributes include high luster, differential luster, and crenulations from over heating. These attributes were recorded on stage 3 and stage 4 bifaces, indicating that heat-treatment occurred between stage 2 and stage 3 reduction, during stage 3 reduction, or between stage 3 and stage 4 reduction.

The obsidian bifaces exhibit a slightly different pattern from the green-grey chert bifaces, primarily representing the later half of the reduction continuum (see Table 7.5; see Figure 7.4). The obsidian bifaces are all fragments, primarily comprised of stage 3 (23%), stage 4 (35%), and stage 5 (27%) forms. There is only one stage 2 obsidian biface fragment (FN 403). Blank types are primarily indistinct for this relatively late stage collection. Only one stage 3 (FN 598) and one small stage 4 (FN386) show flake blank morphology. Break types are primarily bending, although several transverse bending and outre-passe fractures indicate that most obsidian biface fragments are discards from manufacture failure. Like the green-grey chert bifaces, the stage 2 and stage 3 obsidian bifaces were percussion shaped, while the stage 4 bifaces show percussion with some pressure flaking. The stage 5 obsidian bifaces are relatively frequent. Most are probably dart-size projectile point fragments. Two of the stage 5 fragments have hydration rim values of 6.1 and 7.7 microns (FNs 599 and 238, respectively). One stage 5 fragment is probably an arrow point blade fragment (FN 248). Submitted for hydration analysis, it returned no visible hydration (NVH). It is not clear that any of the stage 5 fragments are point manufacture failures, because there are no obvious stage 5 manufacture failures and most stage 5 fragments appear to be finished points, probably broken in use. In fact, one fragment (FN 94) has a bending fracture and a lateral burination indicating it was probably broken by use impact. Another

Table 7.4. Biface Analytical Data.

Provenience	Stage	Toolstone	Condition	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Blank	Break	Flaking	Comments	FN
L1-1	4	GGC	MED	-20.3	-32.8	-7.3	4.7	Indet	Bend	Perc		683
L1-5	4	GGC	NCO	-78.6	38.1	8.7	22.4	Indet	Mat flaw/thermal	Perc/pres	Over heated crenulations	49
L1-16	4	OBS	END	-37.6	-28.9	-9.0	6.0	Indet	Bend	Perc	Early stage 4	85
L2-1	3	OBS	END	-29.0	-45.6	-12.7	16.8	Indet	Bend	Perc		674
L2-3	4	OBS	END	-27.0	-26.3	-8.0	5.4	Indet	Bend	Perc		666
L2-3	4	CCS	PRX	-11.5	-26.1	-4.3	1.3	Indet	Bend	Perc/pres	White; rounded base; poss. ppt preform	667
L2-5	5	OBS	FRG	-17.7	-16.9	-4.4	1.1	Indet	Bend/finial	Pres	Prob. ppt fragment; impact fracture	94
L2-6	3	GGC	LAT	-29.1	-36.5	-8.5	8.4	Indet	Bend	Perc	Prob. thin blank	101
L2-6	3	GGC	END	-47.8	27.2	12.5	16.7	Indet	Trans bend	Perc	Laminations	102
L2-6	4	GGC	END	-33.9	-30.9	-9.7	6.5	Indet	Trans bend	Perc		103
L2-6	4	OBS	LAT	-28.3	-9.9	-4.6	1.2	Indet	Trans bend	Perc/pres	Poss. stage 5, finished	662
L2-8	3	GGC	END	-72.3	-47.7	9.1	24.4	Indet	Mat flaw	Perc	Early stage 3; laminations	106
L2-11	3	OBS	END	-20.6	-22.4	-7.3	2.2	Indet	Bend	Perc		626
L2-18	5	GGC	DST	-28.5	-15.8	-4.4	2.0	Indet	Bend	Perc/pres	Poss. dart size point tip	122
L3-1	3	GGC	END	-52.0	-51.0	-16.6	27.0	Indet	Mat flaw/bend	Perc	Late stage 3; big biface part	133
L3-1	5	GGC	MED	-25.8	25.0	6.3	3.9	Indet	Bend	Perc/pres	Shaped shoulder; poss. large ppt part	622
L3-1	3	GGC	LAT	-60.9	-41.7	-10.5	25.9	Indet	Outre-passe	Perc	Width nearly complete	699
L3-1	Indet	GGC	LAT	-39.2	-24.5	-7.6	6.3	Indet	Bend	Perc	Late	700
L3-1	4	OBS	END	-15.7	-26.1	-4.3	1.9	Indet	Indet	Perc/pres	Poss. finished	701
L3-1	Indet	OBS	END	-16.0	-19.0	-7.8	1.6	Indet	Bend	Perc	Prob. stage 3	702
L3-2	4	GGC	END	-26.0	-21.7	-3.9	2.4	Indet	Bend	Perc/pres	Thin blank; poss. ppt preform	632
Feature 1	2	GGC	END	-49.7	-47.4	-26.7	92.8	Tab	Mat flaw	Perc		271
40S	3	GGC	PRX	-18.6	-43.6	-9.3	6.9	Indet	Bend	Perc		483
360S	2	GGC	WHL	118.4	58.3	22.7	153.9	Tab	None	Perc		175
440S	4	GGC	END	-43.7	-41.0	-8.0	11.8	Indet	Bend	Perc	Early stage 4; prob. tab; poor toolstone	493
480N	5	GGC	END	-24.4	-23.3	-5.5	3.7	Indet	Bend	Perc/pres		192
480N	2	GGC	END	-30.5	-39.9	-8.6	8.9	Flake	Thermal	Perc		697
560N	4	GGC	END	-38.0	28.5	6.8	8.1	Flake	Bend	Perc	Thin blank	534
760S	2	GGC	END	-35.3	-58.3	10.2	15.4	Tab	Mat flaw/bend	Perc		591
800N	4	GGC	DST	-51.0	-24.0	5.0	4.4	Indet	Perv	Perc	Luster, ht; two pieces	205
800N	4	CCS	END	-41.7	-22.1	7.3	6.8	Indet	Bend	Perc/pres	White; early stage 4; poss. ht	207
1240S	5	OBS	END	-20.5	-16.0	5.6	1.7	Indet	Indet	Perc/pres	Prob. reworked ppt fragment	421
1240S	4	GGC	END	-17.9	-26.8	-5.8	3.0	Indet	Bend	Perc/pres	Poss. mat flaw; luster	420
1320S	Indet	GGC	LAT	-39.6	-16.8	-7.5	3.9	Indet	Bend	Perc	Margin collapse; late	404
1320S	Indet	OBS	END	-24.8	-32.8	-6.6	5.2	Indet	Bend	Perc	Early	332
1320S	4	OBS	DST	-23.2	-19.9	-6.5	1.8	Indet	Outre-passe	Perc	Prob. basal thinning	401
1320S	2	OBS	END	-38.2	-32.3	-16.0	12.7	Indet	Outre-passe	Perc		403
1320S	4	OBS	END	-31.9	-33.9	-7.9	8.2	Indet	Bend	Perc	Poss. mat flaw	322
1360N	5	GGC	END	-16.3	-14.0	-3.5	0.5	Indet	Mat flaw/bend	Pres	Prob. ppt manuf failure	224
1360N	5	GGC	END	-21.1	-13.6	3.1	0.8	Indet	Bend	Pres	Like FN 224 - same knapper; Poss. ppt base	225
1360N	3	GGC	WHL	78.9	49.9	11.1	44.7	Indet	Mat flaw/bend	Perc	Laminations; two pieces with two FNs	222/223
1360N	5	OBS	LAT	-10.6	-11.2	-4.6	0.6	Indet	Indet	Pres	Poss. ppt part	226

Table 7.4. Biface Analytical Data (continued).

Provenience	Stage	Toolstone	Condition	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Blank	Break	Flaking	Comments	FN
1400S	5	GGC	MED	-24.3	-37.8	-6.2	6.1	Indet	Bend	Perc/pres	Prob. nearly finished; approx 6/1 W/Thk ratio	306
1440N	Indet	GGC	END	-10.5	-20.7	-5.1	1.0	Indet	Bend	Pres	Late	504
1440N	3	OBS	MED	-21.6	-27.8	-9.7	6.4	Indet	Trans bend	Perc	Poss. reuse attempt on one face	244
1480S	Indet	CCS	MRG	-27.5	-7.1	-5.6	0.9	Indet	Bend	Perc/pres	Tan/orange margin collapse	302
1480S	3	OBS	END	-27.6	-26.6	-11.8	7.3	Indet	Bend	Perc	Triangular cross-section	307
1480S	4	OBS	DST	-26.5	-21.4	-6.5	3.2	Indet	Bend	Perc/pres		312
1560S	4	GGC	DST	-21.5	-19.0	-5.2	2.1	Indet	Bend	Perc/pres		297
1680N	2	GGC	END	-35.5	-52.3	14.0	29.4	Tab	Mat flaw/bend	Perc	Laminations	439
1720S	4	GGC	END	-14.3	-29.7	-5.7	2.3	Indet	Bend	Perc		372
1720S	Indet	GGC	END	-27.5	-41.0	-8.1	5.6	Indet	Bend/thermal	Perc	Over heat-treated crenulations	703
1760N	4	GGC	END	-26.9	-49.1	-8.1	10.8	Indet	Bend	Perc	Poor toolstone; thermal altered	239
1760N	Indet	OBS	MRG	-23.5	-7.7	-5.0	0.7	Indet	Bend	Perc	Margin collapse	237
1760N	5	OBS	PRX	-15.8	-24.5	-7.0	2.8	Indet	Trans bend	Perc/pres	Poss. thick dart ppt base	238
1800S	5	OBS	END	-25.0	-13.0	-4.8	1.0	Indet	Indet	Pres	Poss. ppt stem or maintenanced tip	599
1800S	2	GGC	END	-59.4	-45.3	14.1	32.1	Tab	Indet	Perc	Poor toolstone	318
1800S	2	GGC	END	-57.4	-49.5	-14.0	32.1	Indet	Perc	Perc	Poor toolstone	318
1800S	4	GGC	DST	-21.2	-16.8	-4.8	1.4	Indet	Bend	Perc		597
1800S	3	OBS	END	-31.3	-36.8	-8.6	8.0	Flake	Bend	Perc		598
1920N	4	CCS	LAT	-36.2	-13.1	-5.5	2.9	Indet	Bend	Perc/pres	Poss. stage 5, finished	241
1960S	4	GGC	END	-30.9	-30.7	7.7	7.8	Indet	Trans bend	Perc	Over heated crenulations	387
1960S	3	GGC	END	-26.5	-36.6	-6.9	6.6	Indet	Bend/thermal	Perc	Over heated crenulations; thin blank	356
1960S	4	GGC	LAT	-38.1	-25.1	-6.6	7.3	Indet	Bend	Perc	Thin	305
1960S	4	OBS	END	-35.8	25.6	5.6	4.6	Indet	Bend	Perc/pres	Poss. stem or distal blade	303
1960S	5	OBS	PRX	-13.1	-10.5	2.9	0.5	Flake	Bend	Pres	Prob. ppt part; 5.7µ rim	386
2000N	2	GGC	END	-45.5	51.3	18.9	41.8	Flake	Bend	Perc	Early stage 2	575
2040S	3	GGC	END	-43.6	-46.5	-10.5	23.8	Indet	Bend	Perc	Over heated crenulations	352
2040S	2	GGC	END	-42.5	-50.1	-20.8	37.7	Indet	Bend	Perc		349
2080N	3	OBS	END	-32.0	-39.4	-9.7	14.5	Indet	Bend	Perc		559
2080N	5	CCS	END	-19.2	-14.6	-5.6	1.7	Indet	Bend	Pres	Poss. dart ppt tip; thermal damage	704
2160N	4	CCS	DST	-22.5	-14.5	-4.2	1.3	Flake	Mat flaw/bend	Perc/pres		262
2160N	3	GGC	END	-32.2	-49.3	-24.5	41.5	Indet	Bend	Perc	Early stage 3	254
2160N	3	GGC	END	-37.0	-32.4	-9.2	10.6	Indet	Bend	Perc	Differential luster	261
2160N	3	GGC	LAT	-27.0	-37.9	-11.2	15.0	Indet	Bend/thermal	Perc	Over heated at stage 3	569
2280S	4	GGC	END	-40.5	-46.3	-9.2	11.7	Indet	Outre-passe	Perc		705
2280S	2	GGC	END	-45.0	-62.4	-15.1	24.1	Tab	Bend	Perc	Margin collapse	706
2320N	4	OBS	PRX	-15.0	-31.4	-4.2	1.7	Indet	Bend	Perc/pres	Thin late stage 4; reworked break attempt	564
2480N	5	OBS	MED	-19.9	-13.5	4.6	1.4	Indet	Bend	Pres	Prob. arrow ppt part	248

KEY: Bend = bending fracture; Bend/finial = bend extending onto one face; CCS = cryptocrystalline chert; DST = distal; END = undifferentiated end; FRG = unidentifiable fragment; GGC = gray-green chert; ht = heat-treated; Indet = indeterminate; LAT = lateral margin; Mat = material; MED = medial; MRG = margin; NCO = nearly complete; OBS = obsidian; Perc = percussion; Perc/pres = percussion and pressure; Pres = pressure; ppt = projectile point; PRX = proximal; Tab = tabular cobble; Trans bend = bending from the margin; WHL = whole; (-nn) = incomplete measurement.

Table 7.5. Biface Stage Frequencies* by Toolstone.

	Toolstone		
	Obsidian	Gray-Green Chert	CCS
Stage 1	0%	0%	0%
Stage 2	4%	21%	0%
Stage 3	23%	27%	0%
Stage 4	38%	31%	67%
Stage 5	23%	13%	17%
Indeterminate	12%	8%	17%
Total	100%	100%	100%

* stage frequencies are rounded.

(FN 421) appears to have been reworked, and a third specimen (FN599) exhibits possible maintenance. Because of the large number of stage 4 obsidian biface fragments, and the probability that all obsidian stage 5 fragments are used point fragments, it is likely that most obsidian stage 4 bifaces were being transported off-site for use or further reduction.

Obsidian biface fragment size, though mostly incomplete, indicates production size for obsidian bifaces was probably slightly smaller than the production size for green-grey chert bifaces – roughly medium size at possibly 80 - 90 mm long by 25 to 40 mm wide by less than 10 mm thick. The stage 3 and 4 bifaces shown in Figure 7.4 (FNS 559, 674, 322, and 303) include the largest representative obsidian biface fragments in the collection.

The six other chert bifaces include four stage 4 fragments. One is a mottled green/white/red probable point tip (FN 262). One is a white possible point preform base (FN 667). Another white lateral fragment has a straight regular margin, and may have been a finished piece (FN 241). The fourth is an early stage 4 exhibiting heat-treatment attributes. All of the other chert bifaces show some degree of luster, indicating they were probably heat-treated during manufacture. The other two chert biface fragments are a red stage 5 possible dart-size point end (FN 704), and one translucent orange indeterminate stage margin fragment (FN 302). All of these specimens are probably remnants of relatively small bifaces or dart size projectile points.

Uniface

Unifaces are well-formed flake tools with an extensive unifacially shaped use edge. The unifacial use edge is often thick and steeply angled. Morphological attributes specifically recorded for the unifaces include the number of modified edges, the primary edge shape, and use wear.

The one uniface in the collection comes from SCU 3360N. It is a whole well-shaped tool, made on a brown chert interior flake (FN 279; Table 7.6; Figure 7.5a). Three edges are modified. The primary use edge was unifacially flaked to create a convex shape. The other two edges are slightly convex. Presence of use wear is indeterminate. Micro-stepping along the convex use edge might be the result of use, or repeated edge maintenance.

Edge-modified Flakes

Edge-modified flakes include reduction flakes, which have been intentionally modified by pre-

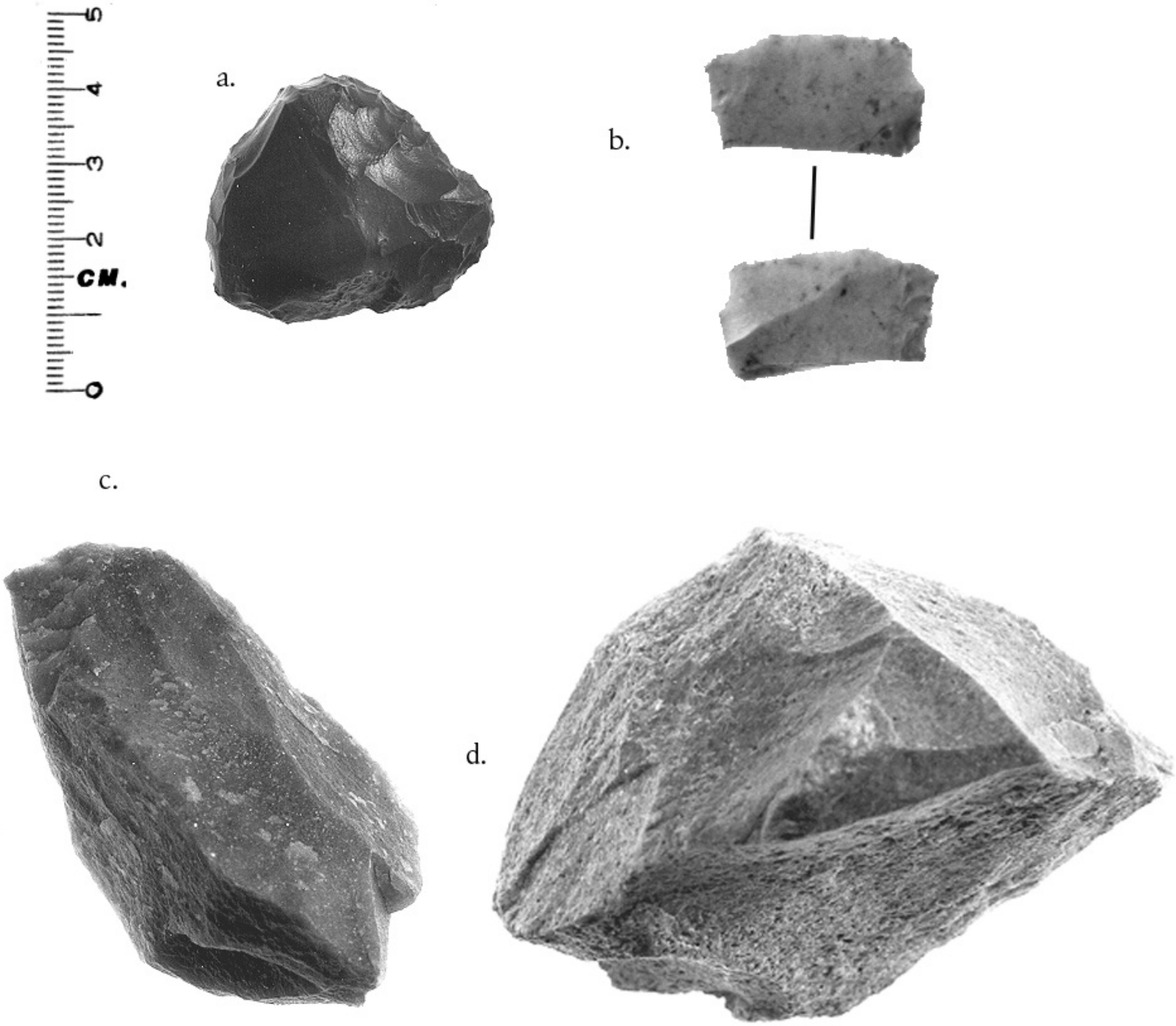


Figure 7.5. Flaked stone tools from the Eureka Dunes Site; a. uniface, b-c. edge-modified flakes, d. core tool (a. FN 279, b. FN 209, c. FN 186, d. FN 190).

cussion or pressure, as well as flakes with less invasive edge modifications that could have been produced directly by use. Unifacial flake tools are not as extensively well shaped as unifaces. Attributes recorded for the flake tools include number of modified edges, primary modification, primary edge shape, and use wear. Over a dozen obsidian flakes classified as potentially edge-modified in the field were examined and reclassified as debitage. All of these potential edge-modified flakes exhibited snap breaks and unpatterned invasive flake scars along one or more edges. Comparison with edge-damaged flakes in the obsidian debitage collection indicated that all of the obsidian potential edge-modified flakes were probably the result of unintentional edge damage. Any number of post-depositional weathering processes (Schiffer 1987; Tringham et al. 1974), including human trampling (Gifford-Gonzalez et al. 1985) typically cause flake edge damage.

Seven edge-modified flakes in the collection include three white chert, three green-grey chert, and one quartzite (Table 7.7). One white chert edge-modified flake is a nearly complete flake tool (FN 209; Figure 7.5b). It is bifacially well-shaped on one margin, but with an unshaped slightly convex use edge with unifacial micro-flake use

Table 7.6. Uniface Analytical Data.

Provenience	Toolstone	Condition	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Blank	Break	Flaking	No. Mod. Edges	Prim. Edge Shape	Use Wear	Comments	FN
3360N	CCS	WHL	37.5	35.5	11.2	18.6	Int	None	Perc/pres	3	Convex	Indet	Nice tool	279

KEY: CCS = cryptocrystalline chert; Indet = indeterminate; Int = interior; Perc/pres = percussion and pressure; WHL = whole.

Table 7.7. Edge Modified Flake Analytical Data.

Provenience	Toolstone	Condition	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Blank	Break	Flaking	No. Mod. Edges	Primary Mod.	Prim. Edge Shape	Use Wear	Comments	FN
400N	QTZ	WHL	74.7	42.1	30.5	91.0	Int	None	Indet	1	Unifacial	Straight	Micro	Prob. use edge	186
800N	CCS	NCO	32.0	-17.7	4.4	3.5	Int	Perv	Indet	3	Bifacial	Convex	Micro	White; bifical shaping	209
800N	GGC	END	-35.3	-47.2	-7.9	12.8	Cort	Bend	Perc	2	Bifacial	Convex	Indet	Poss. stage 2 biface	554
1360N	GGC	END	-12.1	-15.5	-2.4	0.4	Int	Bend	Pres	2	Bifacial	Convex	No	Prob. arrow preform	516
1840N	GGC	LAT	-39.0	-48.6	-11.6	14.0	Int	Bend	Indet	1	Alt unifacial	Concave	Indet	Poss. edge damage	137
2040S	CCS	END	-10.5	-14.5	-3.1	0.4	Int	Bend	Pres	2	Bifacial	Concave	Indet	White; arrow preform	378
2240N	CCS	PRX	-23.2	-25.4	-6.0	3.3	Int	Therm	Pres	2	Bifacial	Straight	Indet	White; weathered; prob. pres biface	579

KEY: KEY: Alt = alternate; Bend = bending fracture; CCS = cryptocrystalline chert; Cort = cortical; END = undifferentiated end; GGC = gray-green chert; Indet = indeterminate; Int = interior; LAT = lateral margin; NCO = nearly complete; Perc = percussion; Perc/pres = percussion and pressure; Perv = perverse; Pres = pressure; PRX = proximal; QTZ = quartzite; CCS; WHL = whole; (-nn) = incomplete measurement.

Table 7.8. Core Tool Analytical Data.

Provenience	Toolstone	Condition	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Blank	Break	Flaking	Core Type	Use Wear	Comments	FN
480N	GGC	WHL	53.4	85.5	65.2	268.0	Indet	None	Perc	Unidirectional	Crushing	Conical	190

KEY: GGC = gray-green chert; Indet = indeterminate; Perc = percussion; WHL = whole.

wear. Two other white chert edge-modified flakes are bifacially modified, but with less distinct morphology and use attributes. One small end fragment is possibly an arrow point preform (FN 378). The other piece is probably a pressure-flaked biface (FN579), but weathering obscures its attributes. The green-grey chert edge-modified flakes include another bifacial possible arrow point preform (FN516), and a relatively large bifacially modified end fragment, which might be a stage 2 production biface fragment (FN 554). Modification on this piece is only slightly invasive, suggesting it could be a large flake tool, but use wear is indeterminate. One other green-grey chert edge-modified flake fragment shows alternate unifacial modification to one concave edge (FN 137). The irregular pattern of this modification suggests it might result from post-depositional edge damage. The quartzite EMF is a large interior flake (FN 186; Figure 7.5c). Unifacial micro-flaking and crushing along one straight edge suggests it is probably a flake tool.

Core Tool

Core tools are intentionally modified masses of toolstone, primarily used for pounding or heavy cutting. Use results in crushed and stepped edges, sometimes producing spalls and large step flakes. This tool was also a core. Cores are masses of toolstone from which usable flakes were removed by percussion. Core types can include multi-directional, bifacial, unidirectional, and bipolar. Each type describes the flake scar patterning that reflects the technique used for producing flakes. Bipolar cores were struck while resting on an anvil, removing thin straight flakes from opposite directions at the same time.

This green-grey chert core tool was collected from SCU 480N (FN 190; Table 7.8; Figure 7.5d). It was first used as a core, and subsequently used as a core tool. As a core, flake production was unidirectional from a wide flat platform, producing a conical shape. The last flake removal scars are over 50 mm long – still big enough to have been used as flake tools or small biface blanks. Extensive crushing at one end and along the central distal ridge indicates this core was also used as a core tool for crushing or pulverizing.

Debitage

A technological debitage analysis was conducted for a sample of the debitage assemblage to characterize the predominant flaked stone reduction patterns across the site area. The analyzed surface collection units were chosen to sample tool production evenly along the project sample transect, while also representing three site areas which may have been used at different times, based on the obsidian hydration results. Chronology for each of these site areas is discussed in Chapter 5.

The analyzed sample includes hand-collected debitage recovered from three surface collection units within Construction Locus 2 and 3 (SCUs 2-11, 3-1 and 3-2) and from eight surface collection units within the road corridor (SCUs 440S, 480N, 760S, 800N, 1400S, 1720S, 2080N, 2280S). Debitage from SCUs 1400S, 1720S, 2080N, and 2280S was sub-sampled to reduce excessively large flake counts. Approximately half the green-grey chert sample from SCU 1400S was analyzed. Obsidian debitage from SCU 1720S and 2280S was divided roughly into thirds, and one third from each surface collection unit was analyzed. The large amounts of green-grey chert and obsidian debitage from SCU 2080N were quartered and one quarter of each were analyzed. Screen-collected debitage from all of the surface scrapes, shovel tests, and feature excavations were also analyzed.

The assumption behind technological analysis is that distinct reduction activities produce distinct debitage assemblages. For example, core reduction produces high percentages of cortical flakes and interior flakes, with only a low frequency of edge-preparation flakes and no biface thinning flakes or pressure flakes. Biface reduction, through the entire continuum of early (stage 2 and 3) to late (stage 4) stages and pressure finishing (stage 5), results in a relatively even representation of each flake type, though interior flakes and early stage biface thinning flakes are often most frequent. An assemblage entirely composed of late stage biface reduction debris will be dominated by late stage biface thinning flakes and pressure flakes, evincing only small frequencies of cortical flakes, interior flakes, edge preparation flakes, and early biface thinning flakes. When thin flake blanks are pressure flaked, with little or no initial percussion thinning, early pressure flakes are conspicuous in the assemblage. In this case, pressure flakes, including early and late pressure flakes, will comprise a large part of the debitage assemblage.

In addition, the extent of reduction through the core and biface reduction continuums indicates the kinds of tools that were made. Core reduction generally produced flakes for flake tools. Core reduction flakes also became flake blanks for bifacial tool manufacture. Biface reduction of a flake blank is the process of making bifacial edges and shaping bifacial forms. The biface goes through successive stages of reduction to produce a well-shaped relatively symmetrical and lenticular finished form. The further along the biface reduction continuum, the better shaped is the bifacial tool. At any point along the reduction continuum, a biface might have been used as a finished tool.

Twelve flake type categories are considered technologically diagnostic in this analysis. That is, the relative proportions of these flake types provide clues to the techniques and stages of tool manufacture, and to the kinds of tools being made. The diagnostic flake types include: cortical, simple interior, simple interior/complex platform, complex interior, complex interior/simple platform, edge preparation, early biface thinning, late biface thinning, early pressure, late pressure, notching pressure and bipolar. Five other flake type categories are considered non-diagnostic. The non-diagnostic flake types include platform preparation/pressure, simple fragment, complex fragment, cortical fragment and shatter. Flake type definitions are given below, following Bloomer et al. (1997: Appendix H).

Cortical – a flake with cortex generally covering over 25 percent of its dorsal surface. Other flake types with smaller amounts of cortex, such as biface thinning flakes, are not classified as cortical flakes. For green-grey chert toolstone, cortex-like laminations within the rock were not recorded as cortex. Only flakes with tabular cobble and sub-angular cobble cortex were recorded as cortical flakes.

Simple Interior – a non-cortical flake with three or fewer negative flake scars on its dorsal surface, not counting platform preparation scars. Negative flake scar patterning on the dorsal surface is typically linear along the axis of the flake. Simple, single-facet platforms are typical.

Simple Interior/Complex Platform – same as for a simple interior flake, but the platform is complex with multiple facets.

Complex Interior – a non-cortical flake with three or more negative flake scars on its dorsal surface, not counting platform preparation scars. Negative flake scar patterning on the dorsal surface is not typically linear along the axis of the flake, but shows a complexity of scars emanating from various and opposing directions. Platforms are usually complex with multiple facets.

Complex Interior/Simple Platform – same as for a complex interior flake, but the platform is simple, usually with a single facet.

Edge Preparation – a group of several distinct flake types which results from shaping an unworked edge of a flake blank. These flakes include *edge preparation flakes*, which are wider than they are long, with pronounced bulbs of percussion and large dorsal areas with no negative flake scars; *bulb removal flakes*, which retain a remnant of the flake blank's ventral bulb of percussion; and *alternate flakes*, which are wider than long, and wedge-shaped, resulting from the reduction of a thick square edge.

Early Biface Thinning – an often slightly curved flake with a simple or complex bifacial platform and a few dorsal flake scars which emanate generally from the flake's platform.

Late Biface Thinning – a curved or flat flake with a bifacial platform and multiple dorsal flake scars, which may reveal a complex pattern of previous flake removals. Typical late stage thinning flakes retain partial dorsal scars showing previous flake removals from the opposite edge of the biface.

Early Pressure – the first pressure flakes removed from a flake blank or early stage biface show few to no dorsal flake scars, depending on the morphology of the worked surface. Platforms may be perpendicular or oblique to the longitudinal axis of the flake. Shapes vary from wide and short to long and narrow.

Late Pressure – late pressure flakes have a complex dorsal surface, and platforms are typically oblique to the longitudinal axis of the flake. Shapes are most often long and narrow, and either straight or doglegged.

Notching Pressure – notching flakes result from notching a projectile point. Notching flakes are fan shaped, short and round, with the platform set into a depression.

Bipolar – bipolar flakes are a result of percussion from opposite directions at the same time, typically from placing the toolstone mass on an anvil and then down striking with a hard hammerstone from above. Flake attributes include crushing at opposite ends, with distinct cones of percussion and straight ventral and dorsal surfaces.

Platform Preparation/Pressure – platform preparation flakes typically result from the light percussion of a bifacial edge to prepare a flake detachment platform. Pressure flakes are often indistinguishable from platform preparation flakes, and so this category subsumes less distinctive flakes, which may have resulted from pressure reduction.

Simple Fragments – fragments of simple interior flakes.

Complex Fragments – fragments of complex interior flakes or biface thinning flakes.

Cortical Fragments – fragments of cortical flakes.

Shatter – angular fragments of toolstone without typical flake attributes. Shatter includes fragments and potlids from unintentional thermal alteration.

Results

The technological debitage sample includes 3,221 obsidian, 2,029 green-grey chert, 446 other chert, 40 quartzite, and 6 basalt. Obsidian, green-grey chert and other chert were predominant in tool production, and are the focus for this analysis. Quartzite and basalt debitage are briefly described. Most of the debitage was recovered from the hand-collected surface collection units. As a result, the typically small pressure flakes, platform preparation flakes, and small flake fragments and shatter are nearly absent from the sample. Therefore, technological analysis of the Surface collection unit collections addresses only percussion reduction technology. Analysis of the screened excavations addresses percussion and pressure reduction. Because of the different debitage collection techniques, analytical results are described separately for the hand-collected surface collection units and the screened excavations.

Surface Collection Units

As mentioned above, the analyzed surface collection units were chosen to sample tool production evenly along the project sample transect, while also representing three site areas that appear to exhibit temporal distinctions. Because of the chronological variability and the expansive site area, results of the surface collection unit analysis are described separately for the western, west-central, and east-central site area, which includes the construction loci. Debitage from the eastern portion of the site, where only 25 pieces of debitage collected, was not analyzed.

The western sample comes from SCUs 440S, 480N, 760S and 800N. It includes 517 pieces of obsidian, 341 green-grey chert, 77 other chert, 13 quartzite, and just four basalt flakes. This comprises 36 percent of the debitage collected from the western portion of the site.

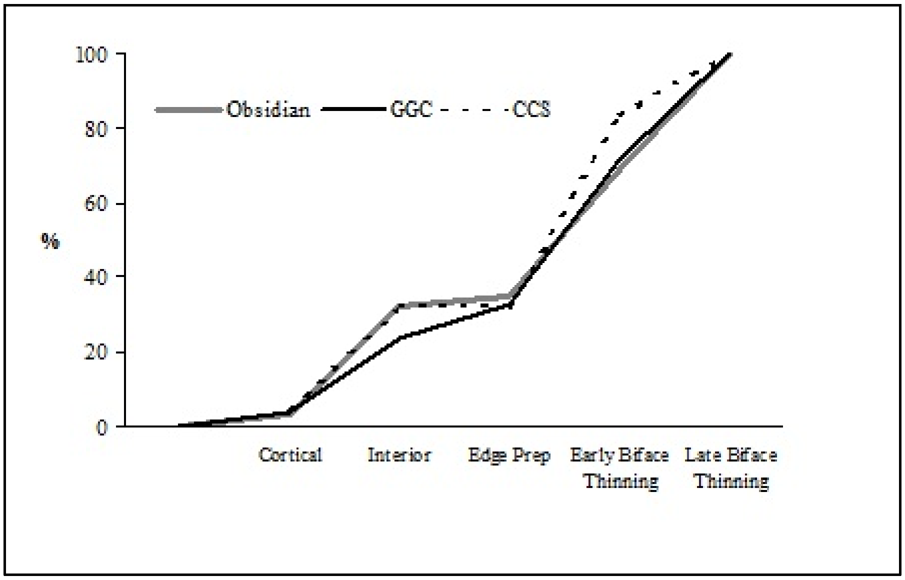


Figure 7.6. Cumulative line graph of technological flake type proportions for the western portion of the Eureka Dunes Site.

Table 7.9. Debitage Data by Toolstone for the Western Portion of the Eureka Dunes Site.

	OBS		GGC		CCS	
	Count	Analytic %	Count	Analytic %	Count	Analytic %
Cortical	9	3.2%	9	3.8%	2	3.8%
Simple Interior	74	26.7%	37	15.8%	11	20.8%
Simple Interior/CP	0	0.0%	6	2.6%	2	3.8%
Complex Interior	6	2.2%	0	0.0%	0	0.0%
Complex Interior/SP	0	0.0%	3	1.3%	2	3.8%
Edge Preparation	8	2.9%	21	9.0%	0	0.0%
Early Biface Thinning	94	33.9%	91	38.9%	27	50.9%
Late Biface Thinning	86	31.0%	67	28.6%	9	17.0%
Early Pressure	0	0.0%	0	0.0%	0	0.0%
Late Pressure	0	0.0%	0	0.0%	0	0.0%
Notching Pressure	0	0.0%	0	0.0%	0	0.0%
Subtotal	277	100.0%	234	100.0%	53	100.0%
Bipolar	0	0.0%	0	0.0%	0	0.0%
Diagnostic Total	277		234		53	
Plat Prep/Pressure	1		2		1	
Simple Fragment	115		47		13	
Complex Fragment	106		50		8	
Cortical Fragment	5		6		1	
Shatter	13		2		1	
Sample Total	517		341		77	

The quartzite and basalt flakes in the western sample include cortical flakes, interior flakes, and flake fragments, indicative of core reduction. Both quartzite and basalt were probably used, albeit infrequently, to make flake blanks for flake tool use.

Technologically diagnostic flakes comprise 54 percent of the obsidian debitage sample (Table 7.9). The rest of the obsidian sample primarily consists of nearly even amounts of non-diagnostic simple and complex flake fragments, a small number of cortical flakes and shatter, and one platform preparation/pressure flake. Cortical flakes constitute just over 3 percent of the diagnostic flakes, while simple and complex interior flakes make up another 29 percent of the diagnostic sample.

Together, the low frequency of cortical and interior flakes suggests that core reduction and the initial reduction of flake blanks were not the predominant obsidian reduction activities. Early stages of biface reduction, including edge preparation (stage 2) and early biface thinning (stage 3) were more common, represented by about 3 percent edge preparation flakes and nearly 34 percent early stage biface thinning flakes. Late stage biface thinning (stage 4) represented by 31 percent of the collection was almost as frequent as early stage biface thinning. Together the high frequency of early and late stage biface thinning flakes (65%), combined with the low frequency of cortical and interior flakes, indicates a focus on obsidian biface thinning, from early through late stages.

Diagnostic flakes make up 69 percent of green-grey chert debitage sample (see Table 7.9). Like obsidian, the numbers of simple and complex green-grey chert flake fragments are relatively similar, with small amounts of the other non-diagnostic flakes. Cortical green-grey chert flakes account for about 4 percent of the diagnostic flakes. Simple and complex interior flakes make up only about 20 percent of the diagnostic green-grey chert sample. In contrast, 9 percent edge preparation flakes and nearly 39 percent early stage biface thinning flakes represent a predominance of the early stages of green-grey chert biface reduction. Late stage biface thinning was common, but not as frequent as early stage biface thinning, represented by about 29 percent of the diagnostic sample. The focus for green-grey chert was on biface thinning (68%) with an emphasis on early stage thinning.

Diagnostic flakes also comprise 69 percent of the other chert sample (Table 7.9). But for non-green-grey chert, the profile is skewed towards the early stages of biface production. Cortical (4%) and interior flakes make up just over 32 percent of the other chert sample. In addition, 51 percent of the sample is early biface thinning flakes. Late stage thinning flakes only account for 17 percent of the sample. Although this diagnostic non-green-grey chert sample is small, the emphasis on early stage biface production is clear.

The cumulative line graphs in Figure 7.6 illustrate the relative frequencies of key technological flake types for each toolstone, showing the overwhelming emphasis on percussion biface thinning. Early stage bifaces (stage 2 and early stage 3) were the most common form of obsidian, green-grey chert and other chert transported to the western site area for biface production. The generally low frequencies of cortical flakes and interior flakes indicate that cobbles, cores and large unworked flake blanks were infrequently transported to the western site area for reduction. However, the greater frequency of green-grey chert edge preparation flakes indicates that unworked green-grey chert flake blanks were more likely to have been transported to the western site area than obsidian or other chert flake blanks. At the same time, the low frequency of green-grey chert interior flakes suggests that green-grey chert flake blanks were relatively thin and well formed – ready for edge preparation and initial thinning. High frequencies of obsidian and green-grey chert late stage biface thinning flakes indicate reduction through stage 4, producing thin well-shaped bifaces. Other chert reduction produced a lesser amount of stage 4 bifaces.

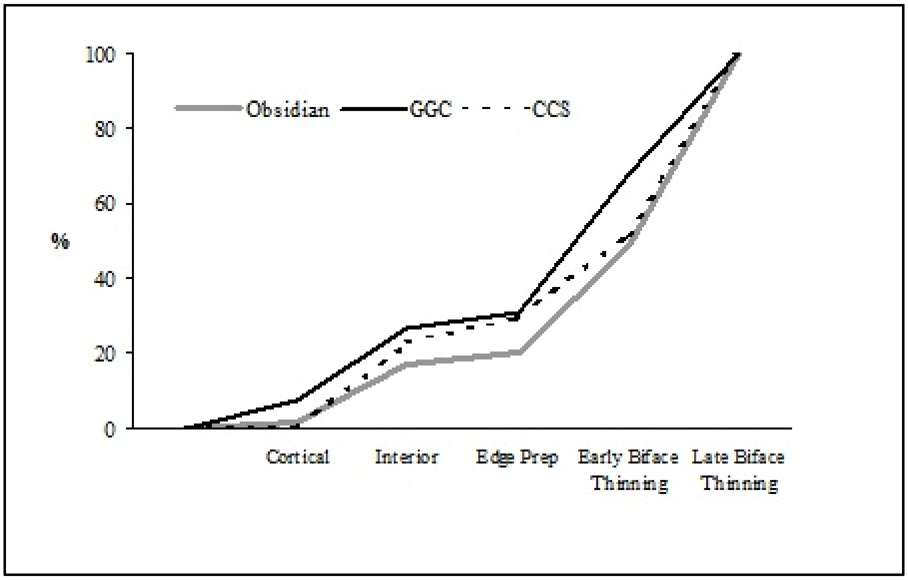


Figure 7.7. Cumulative line graph of technological flake type proportions for the west-central portion of the Eureka Dunes Site.

Table 7.10. Debitage Data by Toolstone for the West-Central Portion of the Eureka Dunes Site.

	OBS		GGC		CCS	
	Count	Analytic %	Count	Analytic %	Count	Analytic %
Cortical	5	1.4%	28	7.5%	0	0.0%
Simple Interior	50	14.0%	63	17.0%	7	22.6%
Simple Interior/CP	2	0.6%	8	2.2%	0	0.0%
Complex Interior	4	1.1%	0	0.0%	0	0.0%
Complex Interior/SP	1	0.3%	0	0.0%	0	0.0%
Edge Preparation	10	2.8%	17	4.6%	2	6.5%
Early Biface Thinning	100	28.0%	136	36.7%	7	22.6%
Late Biface Thinning	184	51.5%	119	32.1%	14	45.2%
Early Pressure	0	0.0%	0	0.0%	0	0.0%
Late Pressure	1	0.3%	0	0.0%	1	3.2%
Notching Pressure	0	0.0%	0	0.0%	0	0.0%
Subtotal	357	100.0%	371	100.0%	31	100.0%
Bipolar	0	0.0%	0	0.0%	0	0.0%
Diagnostic Total	357		371		31	
Plat Prep/Pressure	19		7		0	
Simple Fragment	174		161		13	
Complex Fragment	186		125		18	
Cortical Fragment	7		28		1	
Shatter	33		7		6	
Sample Total	776		699		69	

The west-central sample comes from SCUs 1400S and 1720S. It includes 776 pieces of obsidian, 699 green-grey chert, 69 other chert, and 12 quartzite flakes. This comprises 15 percent of the debitage collected from the west-central portion of the site.

The quartzite flakes in the west-central sample are cortical flakes, interior flakes, and flake fragments, indicative of core reduction to make flake blanks for flake tools.

The west-central area obsidian sample is represented by 46 percent diagnostic flakes (Table 7.10). Like the western area, the numbers of simple and complex flake fragments are relatively similar, with small amounts of the other non-diagnostic flakes. Cortical flakes constitute only about 1 percent of the diagnostic flakes, while simple and complex interior flakes account for just 16 percent of the diagnostic sample.

Again, the low frequency of cortical and interior flakes suggests that core reduction and the initial reduction of flake blanks were infrequent obsidian reduction activities. Early stage biface reduction was somewhat more common, represented by about 3 percent edge preparation flakes and 28 percent early stage biface thinning flakes. In contrast to the western site area, late stage biface thinning was much more frequent than early stage biface thinning, represented by nearly 52 percent of the diagnostic sample. The high frequency of early and late stage biface thinning flakes together (80%) indicates a predominance of obsidian biface thinning, with an emphasis on late stage thinning. The presence of one large pressure flake indicates the occurrence of pressure reduction.

Diagnostic flakes make up 53 percent of green-grey chert debitage sample (see Table 7.10). Cortical green-grey chert flakes account for about 8 percent of the diagnostic flakes. Simple and complex interior flakes make up only about 19 percent of the diagnostic green-grey chert sample. About 5 percent edge preparation flakes and nearly 37 percent early stage biface thinning flakes represent early stage green-grey chert biface reduction. Late stage biface thinning was nearly as frequent as early stage biface thinning, represented by about 32 percent of the diagnostic sample. The green-grey chert reduction focus was on biface thinning (69%) with a slightly greater frequency of early stage thinning.

The other chert reduction profile, represented by 45 percent diagnostic flakes, is much the same as the obsidian profile in its emphasis on late stage thinning. There are no cortical flakes and interior flakes make up just about 23 percent. About 7 percent edge preparation flakes and nearly 23 percent early biface thinning flakes reflect early biface reduction. Like obsidian, late stage thinning flakes are most frequent, at over 45 percent of the sample. This diagnostic non-green-grey chert sample is small, but the emphasis tends towards late stage biface production. Again, a single pressure flake indicates pressure reduction.

The cumulative line graphs in Figure 7.7 show the general emphasis on percussion biface thinning, while pointing up similar frequencies of late stage reduction for obsidian and other chert, and differences in green-grey chert reduction. The graphs show that more cortical green-grey chert, such as cobbles and cortical flake blanks, were transported to the middle site area, compared with the lack of cortical obsidian and other chert. In addition, higher interior flake frequencies indicate a greater amount of initial green-grey chert flake blank reduction. Nevertheless, early stage bifaces (stage 2 and early stage 3) were again the most common form of obsidian, green-grey chert and other chert transported to the middle site area for biface production. High frequencies of late stage biface thinning flakes for all toolstone indicate reduction through stage 4, producing thin well-shaped biface.

The east-central and construction loci sample comes from SCUs 2080N, 2280S, 2-11, 3-1, and 3-2. This sample includes 1,757 pieces of obsidian, 847 green-grey chert, 280 other chert, 15 quartzite, and two basalt flakes. This comprises 22 percent of the debitage collected from the east-central portion of the site and the construction loci.

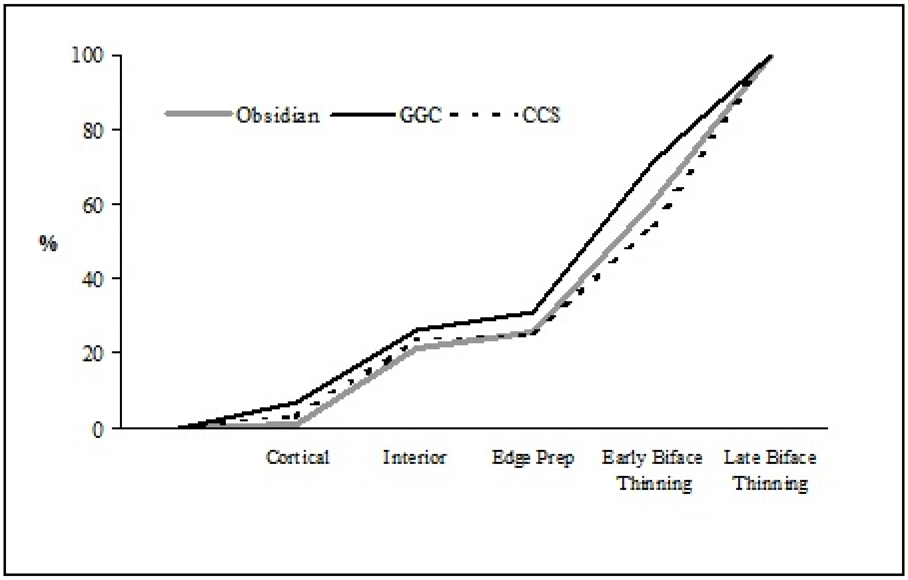


Figure 7.8. Cumulative line graph of technological flake type proportions for the construction loci and the east-central portion of the Eureka Dunes Site.

Table 7.11. Debitage Data by Toolstone for the Construction Loci and East-Central Site Area.

	OBS		GGC		CCS	
	Count	Analytic %	Count	Analytic %	Count	Analytic %
Cortical	7	0.9%	33	6.9%	5	3.4%
Simple Interior	128	17.3%	88	18.3%	22	15.2%
Simple Interior/CP	9	1.2%	3	0.6%	6	4.1%
Complex Interior	14	1.9%	0	0.0%	0	0.0%
Complex Interior/SP	3	0.4%	2	0.4%	1	0.7%
Edge Preparation	29	3.9%	22	4.6%	2	1.4%
Early Biface Thinning	259	35.1%	195	40.6%	43	29.7%
Late Biface Thinning	288	39.0%	136	28.3%	66	45.5%
Early Pressure	0	0.0%	0	0.0%	0	0.0%
Late Pressure	1	0.1%	1	0.2%	0	0.0%
Notching Pressure	0	0.0%	0	0.0%	0	0.0%
Subtotal	738	100.0%	480	100.0%	145	100.0%
Bipolar	0	0.0%	0	0.0%	0	0.0%
Diagnostic Total	738		480		145	
Plat Prep/Pressure	16		5		2	
Simple Fragment	482		178		62	
Complex Fragment	468		153		56	
Cortical Fragment	9		43		4	
Shatter	44		15		11	
Sample Total	1757		874		280	

The quartzite flakes are essentially the same as those from the other site areas. They include cortical flakes, interior flakes, and flake fragments, indicative of core reduction to make flake blanks for flake tools. One of the two basalt flakes is a late stage biface thinning flake, probably from tool maintenance or a very limited amount of late stage tool manufacture. The other is a cortical flake fragment.

Obsidian reduction in the east-central portion of the site is represented by 42 percent diagnostic flakes (Table 7.11). Cortical flakes constitute only about 1 percent of the diagnostic flakes, while simple and complex interior flakes account for about 20 percent of the diagnostic sample.

Similar to obsidian reduction across the rest of the site, core reduction and the initial reduction of flake blanks is a typically infrequent obsidian reduction activity in the east-central site area. Like the western site area, early stage and late stage obsidian biface reduction were equally common, representing 78 percent of the east-central area obsidian sample. One large pressure flake is again present in the sample.

Green-grey chert reduction, represented by 55 percent diagnostic flakes, was similar to green-grey chert reduction in the western area. Cortical green-grey chert flakes account for about 7 percent of the diagnostic flakes. Simple and complex interior flakes make up only just over 19 percent of the diagnostic green-grey chert sample. About 5 percent edge preparation flakes and nearly 41 percent early stage biface thinning flakes represent a predominance of early stage green-grey chert biface reduction. Late stage biface thinning is represented by just over 28 percent of the diagnostic sample. As in the western site area, the focus of green-grey chert reduction in the east-central site area was on biface thinning (69%) with an emphasis on early stage thinning. One pressure flake is present in the east-central area sample.

Non-green-grey chert reduction in the east-central portion of the site, represented by 52 percent diagnostic flakes, is similar to non-green-grey reduction in the western portion. There are just over 3 percent cortical flakes, and interior flakes make up 20 percent of the diagnostic sample. Just over 1 percent edge preparation flakes and nearly 30 percent early biface thinning flakes reflect early biface reduction. Late stage thinning flakes are most frequent at over 45 percent of the sample. The emphasis here is on late stage biface production.

The cumulative line graphs in Figure 7.8 are nearly identical, showing little variability in the typical site-wide emphasis on percussion biface reduction. Minor differences in reduction profiles include a tendency for a higher frequency of green-grey chert early biface thinning, while other chert shows a tendency towards later biface thinning.

Screened Excavations

The screened excavation units, spread across the site, recovered a total of 323 flakes, including 180 obsidian flakes, 118 green-grey chert, and 25 other chert (roughly 1% of the total collection; Table 7.12). Only 144 of those (45%) are whole, technologically diagnostic flakes. Very few diagnostic flakes were recovered from any specific provenience. Therefore, all samples were lumped to assess the site wide expression of pressure reduction in relation to the predominance of percussion biface production, and to quantify the frequencies of debitage in each size grade.

Like the surface collection unit samples, percussion early stage and late stage biface production produced the majority of the diagnostic flakes in the screened samples. Frequencies of cortical and interior flakes are also similar to the surface collection unit samples. Late stage thinning comprises the highest frequency for each toolstone, including green-grey chert – a point of contrast to the predominance of early thinning in the surface collection unit green-grey chert samples. Pressure flakes make up just over 12 percent of the obsidian sample and nearly 38 percent of the other chert, but are absent from the green-grey chert samples, The obsidian pressure flakes reflect the low

Table 7.12. Debitage Data by Toolstone for Screened Excavations.

	OBS		GGC		CCS	
	Count	Analytic %	Count	Analytic %	Count	Analytic %
Cortical	0	0.0%	6	10.7%	0	0.0%
Simple Interior	22	27.5%	10	17.9%	1	12.5%
Simple Interior/CP	0	0.0%	0	0.0%	0	0.0%
Complex Interior	1	1.3%	2	3.6%	1	12.5%
Complex Interior/SP	0	0.0%	0	0.0%	0	0.0%
Edge Preparation	0	0.0%	4	7.1%	0	0.0%
Early Biface Thinning	17	21.3%	16	28.6%	0	0.0%
Late Biface Thinning	30	37.5%	18	32.1%	3	37.5%
Early Pressure	1	1.3%	0	0.0%	3	37.5%
Late Pressure	9	11.3%	0	0.0%	0	0.0%
Notching Pressure	0	0.0%	0	0.0%	0	0.0%
Subtotal	80	100.0%	56	100.0%	8	100.0%
Bipolar	0	0.0%	0	0.0%	0	0.0%
Diagnostic Total	80		56		8	
Plat Prep/Pressure	6		4		1	
Simple Fragment	44		35		10	
Complex Fragment	35		19		4	
Cortical Fragment	0		2		0	
Shatter	15		2		2	
Sample Total	180		118		25	

frequency of obsidian percussion bifaces that were pressure finished on-site, whereas most of the other chert bifaces show pressure reduction. Some pressure flakes may also result from limited projectile point manufacture and tool maintenance. The lack of green-grey chert pressure flakes suggests that green-grey chert percussion bifaces were not generally pressure-finished at the site, although the sample is small, and a number of stage 4 green-grey chert bifaces show pressure reduction scars.

Flake Size

The analyzed debitage from one surface collection unit (1960S) and all the À-inch screened surface scrapes, shovel tests, and feature excavations was sifted through nested screens, sorting it into five size grades: ≥2 inch; ≥1 inch; ≥½ inch; ≥¼ inch; and ≥À inch. Each size grade represents the mesh size that will hold the debitage. Size grading was conducted to characterize artifact size through the reduction continuum, specifically, to estimate the size of the manufactured artifacts.

Size grading the screened obsidian sample revealed about 5 percent ½-inch size flakes, 43 percent ¼-inch size, and 52 percent À-inch size (Table 7.13). The majority of the ½-inch obsidian flakes are late biface thinning flakes and complex flake fragments. Most of the ¼-inch diagnostic flakes are late biface thinning, but with nearly equal numbers of complex and simple fragments. Interior flakes are present in small numbers. A single pressure flake was recovered in the ¼-inch screen. The À-inch sample contains about 41 percent simple interior flakes and 31 percent biface thinning flakes, with simple flake fragments more numerous than complex fragments. Obsidian pressure flakes are common in the À-inch size grade at just over 28 percent.

Size grade frequencies for the green-grey chert sample are about 25 percent ½-inch size flakes, 50

Table 7.13. Obsidian Debitage Data by Size Grade.

	1/2"		1/4"		1/8"	
	Count	Analytic %	Count	Analytic %	Count	Analytic %
Cortical	0	0.0%	0	0.0%	0	0.0%
Simple Interior	0	0.0%	8	19.0%	13	40.6%
Simple Interior/CP	0	0.0%	0	0.0%	0	0.0%
Complex Interior	0	0.0%	1	2.4%	0	0.0%
Complex Interior/SP	0	0.0%	0	0.0%	0	0.0%
Edge Preparation	0	0.0%	0	0.0%	0	0.0%
Early Biface Thinning	1	20.0%	11	26.2%	5	15.6%
Late Biface Thinning	4	80.0%	21	50.0%	5	15.6%
Early Pressure	0	0.0%	0	0.0%	1	3.1%
Late Pressure	0	0.0%	1	2.4%	8	25.0%
Notching Pressure	0	0.0%	0	0.0%	0	0.0%
Subtotal	5	100.0%	42	100.0%	32	100.0%
Bipolar	0	0.0%	0	0.0%	0	0.0%
Diagnostic Total	5		42		32	
Plat Prep/Pressure	0		0		6	
Simple Fragment	1		15		29	
Complex Fragment	3		19		13	
Cortical Fragment	0		0		0	
Shatter	0		2		13	
Sample Total	9		78		93	

percent ¼-inch size, and 25 percent À-inch size (Table 7.14). Early and late thinning flakes are equally prevalent in the ½-inch size, but two cortical flakes, several interior flakes and an edge preparation flake are also present. Biface thinning is predominant in the ¼-inch size grade, again with several cortical and interior flakes, and an edge preparation flake. The small amount of À-inch size debitage is dominated by interior flakes and simple flake fragments.

Most of the ½-inch size flakes for both green-grey chert and obsidian are early and late stage percussion biface thinning flakes and complex fragments. Obsidian pressure flaking becomes apparent with the ¼-inch size flakes, but biface production accounts for most of the ¼-inch size obsidian and green-grey chert debitage. The high number of À-inch size obsidian debitage also reflects a high frequency of early and late stage biface production whereas biface production is absent in the À-inch green-grey chert. Overall, the flake size frequencies support the biface data, indicating that most of the manufactured obsidian and green-grey chert bifaces were medium size. The diagnostic non-green-grey chert sample is too small to be representative, therefore size grade frequencies were not tabulated.

Obsidian and green-grey chert debitage from SCU 1960S were size sorted to compare hand-collected flake size data with the screened excavation flake size data (Table 7.15). Size grade frequencies for the obsidian Surface collection unit sample are less than 1 percent one inch size flakes, 16 percent ½-inch size flakes, 52 percent ¼-inch size, and 32 percent À-inch size. Compared with the screened excavation, obsidian debitage hand-collection recovered about 20 percent less À-inch size flakes. The frequencies of ¼-inch size debitage are about equal. The larger debitage, ½-inch and 1-inch size, are better represented in the hand-collected obsid-

Table 7.14. Green-Grey Chert Debitage Data by Size Grade.

	1/2"		1/4"		1/8"	
	Count	Analytic %	Count	Analytic %	Count	Analytic %
Cortical	2	5.0%	4	13.8%	0	0.0%
Simple Interior	3	15.0%	3	10.3%	4	66.7%
Simple Interior/CP	0	0.0%	0	0.0%	0	0.0%
Complex Interior	1	5.0%	1	3.4%	0	0.0%
Complex Interior/SP	0	0.0%	0	0.0%	0	0.0%
Edge Preparation	1	5.0%	1	3.4%	2	33.3%
Early Biface Thinning	7	35.0%	9	31.0%	0	0.0%
Late Biface Thinning	7	35.0%	11	37.9%	0	0.0%
Early Pressure	0	0.0%	0	0.0%	0	0.0%
Late Pressure	0	0.0%	0	0.0%	0	0.0%
Notching Pressure	0	0.0%	0	0.0%	0	0.0%
Subtotal	21	100.0%	29	100.0%	6	100.0%
Bipolar	0	0.0%	0	0.0%	0	0.0%
Diagnostic Total	21		29		6	
Plat Prep/Pressure	0		0		4	
Simple Fragment	2		17		16	
Complex Fragment	5		13		1	
Cortical Fragment	1		1		0	
Shatter	0		0		2	
Sample Total	29		60		29	

ian sample because most of the screen excavations were conducted within previously hand-collected surface collection units and most of the larger flakes apparently occur on the surface. Size grade frequencies for the green-grey chert surface collection unit sample are about 1 percent 1-inch size flakes, 18 percent ½-inch size flakes, 59 percent ¼-inch size, and 21 percent À-inch size. Green-grey chert hand-collection recovered only about 4 percent fewer À-inch size flakes than the screened excavation. Hand-collection recovered 9 percent more ¼-inch size flakes, but 6 percent fewer ½-inch size flakes.

Essentially, hand-collection was slightly less likely to recover as many À-inch size flakes as the screened excavations. This is most apparent for obsidian, in the lack of obsidian pressure flakes in the surface collection units (see Tables 7.9-7.11). Obsidian pressure flakes are better represented in the screened sample, however, even the screened sample suggests only a minimal amount of on-site obsidian pressure flaking (see Table 7.13). For green-grey chert, the screened excavations recovered only a slightly greater frequency of À-inch size green-grey chert flakes, and none are pressure flakes. Therefore, it appears that the surface collection unit green-grey chert sample is representative of the fact that green-grey chert pressure flaking was not common at Eureka Dunes.

Last Chance Green-Grey Chert Knapability and Heat-treatment

Ten of the 47 green-grey chert bifaces in the collection show evidence of heat-treatment. Therefore, replicative knapping and heat-treatment, using green-grey chert collected from private property in the Last Chance Range, were conducted to study the parameters and effects of green-grey chert heat-treatment. Three small green-grey chert cobbles of slightly variable toolstone quality and slightly different color were used in the

Table 7.15. Size-Sort Data for SCU 1960S.

	1-inch		½-inch		¼-inch		⅛-inch	
	no.	%	no.	%	no.	%	no.	%
Obsidian	1	nil	306	16	978	52	614	32
Green-Grey Chert	14	1	174	18	567	59	203	21
Other Chert	2	8	5	21	15	63	2	8
Other Materials	2	8	14	58	7	29	1	4

replications. One is a very fine grain, dark green cobble with a slight natural luster. Irregular wavy light and dark green bands characterize a second fine grain slightly lustrous cobble. The third fine grain cobble is light green with a nonlustrous matte surface. All were percussion reduced to stage 2 or early stage 3 forms with granite and then sandstone hammerstones. These three bifaces, and several large unworked flakes from initial cobble reduction, were heat-treated. Heat-treatment was conducted in a small electric kiln, heated gradually over a period of 6 hours to 450° F. After slowly cooling in the kiln for several hours, the bifaces were percussion reduced to late stage 3 and early stage 4 forms. The heat-treated flakes were minimally flaked to assess the effects of heat-treatment.

All three bifaces, and the flakes, were successfully heat-treated at 450° F. The result of heat-treatment for each biface was much greater compliance to directed percussion, facilitating increased control in thinning. Before heat-treatment, greater force was required to initiate a flake removal, and flake removals were prone to end prematurely in hinge terminations. In short, each biface was easier to knap after heat-treatment. Heat-treatment turned the texture of the dark green-grey chert from a slight luster to a high luster. Luster on the banded cobble also increased to a high gloss. The light green matte biface attained only a slight luster. There was no indication of excessive over-heating at 450° F. Over-heating creates internal crenulation and curvilinear fractures, which either break apart during heat-treatment or release during post heat-treatment reduction. Several green-grey chert bifaces in the Eureka Dunes Site collection failed because of over heat-treatment. Failed heat-treatment replications using other chert have shown a fine line between heat-treatment and over heat-treatment. Therefore, failed heat-treatment ovens must have attained temperatures greater than 450° F, but possibly not much greater.

The results of replicative heat treatment suggest that many green-grey chert bifaces manufactured at Eureka Dunes were heat-treated during production. Although only 21 percent (n=10) of green-grey chert bifaces show distinct heat-treatment attributes, in the form of differential flake scar luster or thermal fractures, many stage 3 and 4 bifaces evince flake scar patterning that reflects the high degree of toolstone compliance and well-controlled percussion thinning. That is likely associated with heat treatment. In addition, although only distinct luster was recorded, most late stage bifaces show at least some degree of luster. Indistinct luster was not recorded for the bifaces because much of the observed luster might result from sandblast weathering, if sand blasting smooths and polishes an otherwise dull surface. Nevertheless, the results of the replicative experiments as well as the crenulations and curvilinear fractures in the collection suggest that heat treatment played an important role in green-grey chert biface production at Eureka Dunes between stage 2 and stage 3 reduction, during stage 3 reduction, or between stage 3 and stage 4 reduction.

Discussion

The large number of production stage bifaces attests to the primacy of biface production at Eureka Dunes. No other flaked stone tool is as frequent in the collection. Even accounting for possibly decades of artifact hunting at the site, the projectile point count is low. The chronologically diagnostic projectile points indicate an occupational history spanning over 6,000 years (see chapter 5), but there are only 13 points in the collection. There is only one uniface, and only two of the seven edge-modified flakes are distinct flake tools. Most of the others are possibly small point preform fragments or early stage biface fragments. One conical core, later used as a core tool, represents only a minimal amount of flake blank production that might have been associated with flake tool manufacture. In fact, these points, uniface, edge-modified flakes, and the core tool represent probably limited residential subsistence activities conducted in conjunction with extended periods of biface manufacture at a biface production workshop.

Technological debitage analysis quantified biface thinning flakes at 60 percent to 80 percent of the diagnostic flake sample, documenting the major contribution of biface production to the debitage assemblage. It is safe to say that most other flake types also result from biface production. This is true all across the site, with no significant technological variation between the sampled areas of the site.

Based on the investigations conducted for this project, debitage across the Eureka Dunes Site is roughly estimated at over 3 million flakes, with a total weight estimated at over 3.5 million grams – 51 percent obsidian, 37 percent green-grey chert, 6 percent other chert, and 6 percent other, by weight (see Chapter 4). The quantity of bifaces represented by over 3 million flakes is difficult to estimate, given unknown breakage rates and the variable stages of completeness attained prior to off-site transport. Nevertheless, previous replications of chert biface manufacture provide some perspective on the magnitude of green-grey chert biface production at the Eureka Dunes Site, which might be extrapolated to consider the probably greater amount of obsidian biface production.

Opalite biface replications, conducted in conjunction with archaeological investigations at Tosawihi Opalite Quarry in north central Nevada, provide average statistics for medium to large size biface production (Bloomer and Ingbar 1992). The Tosawihi opalite is essentially white chert, not unlike the green-grey Last Chance chert in toolstone quality. Tosawihi bifaces and replications are on average probably larger than the green-grey bifaces produced at Eureka Dunes. In addition, the opalite replicative data cover the entire continuum of biface production from stage 1 blank preparation through stage 5. Still, the replicative data provides a basis for estimating the amount of green-grey chert bifaces manufactured at Eureka Dunes.

Replicative opalite biface manufacture produced an average debitage weight of about 2,400 gr/biface. Considering that opalite bifaces were generally larger than green-grey chert bifaces, and that the reduction trajectory represented by the opalite replications was more inclusive than green-grey chert reduction, the average debitage weight can heuristically be divided in half, reduced to 1,200 gr/biface. Debitage sample weights in the Eureka Dunes Site surface collection unit collection indicate 1,200 grams is roughly equivalent to 1364 green-grey chert flakes and 1905 obsidian flakes. This statistic may be a low estimate, because it comes from surface collection unit collections, which are probably slightly skewed towards the inclusion of larger flakes at the expense of the small debitage. The difference in flake counts for 1,200 grams of obsidian and green-grey chert debitage reflects the difference in the mean flake weight for each material. Mean flake weight for obsidian is 0.63 grams, while green-grey chert mean flake weight is 0.88 grams (see Chapter 4).

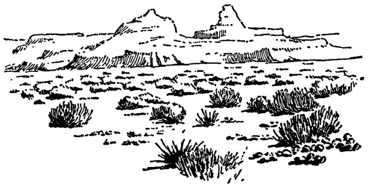
Extrapolating the numbers and weight of debitage in the recovered sample across the site as a whole, there is an estimated 3.5 million grams of debitage at the Eureka Dunes site. If green-grey chert debitage makes up 37 percent of the total debitage, then there are roughly 1.3 million grams of green-grey chert flakes at the Eureka Dunes Site. Given 1,200 g/biface, over 1,000 green-grey chert bifaces were manufactured at Eureka Dunes. If the same measure of biface production is used for obsidian, given nearly 1.8 million grams of obsidian flakes, approximately 1,500 obsidian bifaces were manufactured. These are very rough estimates of biface production. Even so, the estimates serve as an initial foundation for considering the magnitude of biface production at the Eureka Dunes Site. Especially considering the fact that Last Chance green-grey chert bifaces are distributed throughout northern Death Valley, Owens Valley, and Deep Springs, and may represent a specialized post-1350 B.P. exchange item (Delacorte 1988).

Delacorte's (1988) description of biface manufacture at the Last Chance quarry conforms to stage 2 and early stage 3 biface production. Last Chance green-grey chert entered the Eureka Dunes Site primarily as stage 2 and early stage 3 bifaces. Most were further reduced at Eureka Dunes to stage 4 bifaces and were transported off-site. Production size for green-grey chert bifaces was about 80 to 100 mm long by 30 to 50 mm wide by less than 10 mm thick – generally the size of green-grey chert bifaces considered to have been exchange items (Delacorte 1988). It is tempting to speculate that the Eureka Dunes Site served as a major workshop for the production of Last Chance green-grey chert bifaces for localized exchange.

Most obsidian entered the Eureka Dunes site also as stage 2 and early stage 3 bifaces from local Saline Valley sources, but there was a greater tendency for obsidian bifaces to be further along in the reduction continuum. Unworked or minimally worked obsidian flake blanks and cobble blanks were probably less often brought to the site than green-grey chert flake and cobble blanks. Obsidian bifaces were further reduced at Eureka Dunes to stage 4 bifaces. Pressure finishing was more common for obsidian than for green-grey chert and the production size of stage 4 obsidian bifaces was slightly smaller than the green-grey chert bifaces.

It is interesting that the number of green-grey chert bifaces in the collection is twice the number of obsidian bifaces, when obsidian debitage and the implied biface production was double that of green-grey chert. This could be due to differential manufacture failure rates, where green-grey chert bifaces are broken more often. Obsidian is compliant to percussion reduction throughout the reduction continuum, where initial green-grey chert reduction is moderately difficult. Then, after heat-treatment, green-grey chert becomes more compliant, but breaks easier, and is still not as compliant as obsidian. On the other hand, obsidian biface production probably occurred throughout the site's long occupational history, whereas green-grey chert reduction may have been a relatively short-term late activity. If so, over 6,000 years of obsidian biface scavenging and reuse may have played a significant role in reducing their numbers. In addition, obsidian debitage would have had a much longer time to accumulate. Modern formation processes may also be a factor: artifact collectors may have removed a larger proportion of obsidian bifaces, since obsidian is more visible on the ground surface.

As for the other chert at the Eureka Dunes Site, it is primarily white, and much less frequent than green-grey chert. What little white chert reduction there was essentially followed the same biface production technology as green-grey chert and obsidian. White chert was probably collected from the Last Chance Mountains or from more distant sources as people went about their business on the way to Eureka Dunes.



Chapter 8

Other Artifacts and Ecofacts

Jeffery F. Burton and Laura S. Bergstresser

Besides the voluminous flaked-stone artifacts, ten ground stone artifacts, three hammerstones, 25 pieces of fire-cracked rock, five animal bones, and a manuport were collected during the present field work at the Eureka Dunes Site (CA-INY-2489). During recording of the Eureka Dunes Site in 1999 forty pieces of ground stone, 12 hammerstones, and 15 pieces of fire-altered basalt were tabulated (Brewer et al. 1999). None of the "spherical stone mortars" noted at the site by Steward in 1938 was relocated during the present investigations or during the 1998 ARU survey (Brewer et al. 1999). However a spherical stone mortar was recently reported to be at a nearby site (Tim Canaday, personal communication 2000).

Ground-stone Artifacts

Ground-stone artifacts from CA-INY-2489 include four mano fragments, two complete or nearly complete handstones, and four possible ground-stone fragments (Table 8.1; Figure 8.1). All of the fragmentary specimens appear to be fire-cracked. Materials are locally available, if not within the site boundary a short distance up the bajada slope. Two of the mano fragments (FN 188 and 351) are made from basalt and fit the description of flat manos (Adams 1996), as they have flat grinding surfaces and are not ground on their ends. Each has a utilized surface and is unmodified on the opposing surface. The third mano fragment (FN 609) is quartzite and consists of four conjoining pieces. It is ground on both sides, and the ends appear to have been smoothed or shaped. One side of the mano is reddened, possibly due to weathering or burning. The four mano pieces were found spread across a 15-m-wide area within SCU 2160N. The fourth mano fragment (FN 707) is quartzite and consists of three conjoining pieces. The face is ground and the portion of the end present and the adjacent side appear pecked, possibly shaped.

The two handstones (FN 176 and 213) are quartzite. These could have been used with basin metates, as both have one slightly convex primary grinding surface. Otherwise, these artifacts are generally rounded and of a size and shape that would fit easily in a person's hand. One of these handstones (FN 176) has an additional small grinding surface adjacent to the primary one. On both of these grinding surfaces the wear is disproportionately heavy on one-half of the face.

Of the four possible ground-stone fragments, three are basalt (FN 220, 221 and 350) and one is quartzite (FN 610). FN 220 has two adjacent faces that might have been utilized. The other three fragments display at least some rounded, worn outer surface that could be the result of human modification, but could also have occurred naturally. In addition to general surface wear, one of the basalt fragments (FN 350) has a possible groove. Because of the small size of the fragments, it is difficult to determine if these pieces are ground stone or fire-cracked ventifacts (wind-polished) (see Waters 1992:208-209).

Most of the ground stone appears to be fire-cracked, as though recycled for stone-boiling or for use in an oven or hearth. Given the low number and expedient nature of the ground stone artifacts recovered, compared to the over 26,000 pieces of flaked stone, the subsistence activities represented in the sample are greatly overshadowed by evidence for stone-working. This suggests food processing was not the primary activity at the site.

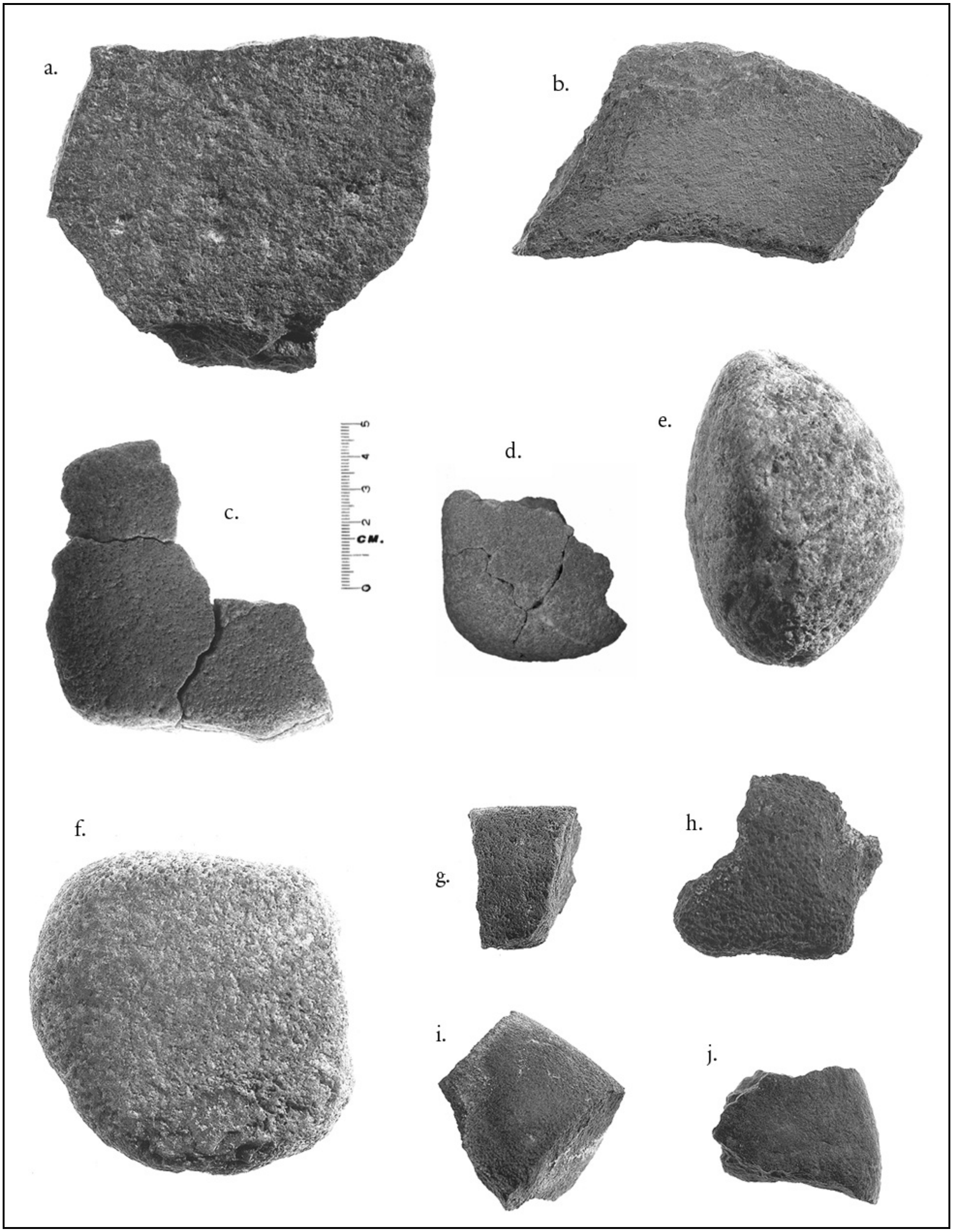


Figure 8.1. Ground stone artifacts from the Eureka Dunes Site; a-d. flat manos, e-f. handstones, g-j. unclassified fragments (a. FN 351, b. FN 188, c. FN 609, d. FN 707, e. FN 176, f. FN 213, g. FN 610, h. FN 220, i. FN 221, j. FN 350).

Table 8.1. Attributes of Ground-Stone Artifacts from the Eureka Dunes site (CA-INY-2489).

Provenience	Artifact Type	Length (mm)	Width (mm)	Thick (mm)	Weight (g)	Material	Comment	FN
280S	handstone	92	70	60	515	quartzite	wear on two adjacent surfaces	176
440S	mano	131	89	30	278	basalt		188
1120N	handstone	104	96	67	827	quartzite	one well-worn surface	213
1360N	ground stone	66	61	34	124	basalt	two adjacent ground surfaces	220
1360N	ground stone	68	62	50	152	basalt		221
2040S	mano	123	116	28	482	basalt		351
2040S	ground stone	56	40	24	72	basalt	groove on face	350
2080N	mano	68	55	32	104	quartzite	3 pieces, one well-worn surface	707
2160N	mano	110	81	49	265	quartzite	4 pieces, slight reddening	609
2160N	ground stone	58	43	32	90	quartzite		610

Table 8.2. Attributes of Hammerstones from the Eureka Dunes site (CA-INY-2489).

Provenience	Length (mm)	Width (mm)	Thick (mm)	Weight (g)	Material	Comment	FN
480N	62	58	35	150	quartzite	disk-shaped	193
1800S	90	77	59	553	quartzite	possible battering damage	315
2240N	84	79	68	492	quartz	little battering damage	272

Hammerstones

Three hammerstones were recovered from CA-INY- 2489 (Table 8.2, Figure 8.2). Two of these (FN 193 and 315) are quartzite, and one (FN 272) is quartz. FN 193 is disc-shaped, and appears to have been battered on several edges. FN 315 is large and ovoid and has potential hammering damage on three edges. FN 272 is a large fragment of a rounded quartz cobble that appears to have been battered along one edge.

The relative paucity of hammerstones is somewhat unexpected compared to the abundant debitage. Hammerstones were likely curated, taken off-site for use elsewhere, or possibly recycled as boiling/heating stones, where evidence of their use as hammerstones is obscured by fire-cracking.

Fire-cracked Rock

As mentioned in Chapter 4, fire-cracked rock that formed concentrations was counted, weighed, and

Table 8.3. Attributes of Fire-Cracked Rock from the Eureka Dunes Site (CA-INY-2489).

Provenience	Length (mm)	Width (mm)	Thick (mm)	Weight (g)	Material	Comments	FN
1320S	71	14	50	61	basalt	angular chunk	405
1400S	65	31	48	121	basalt	angular chunk	392
1400S	75	21	56	81	basalt	angular chunk	392
1400S	39	19	37	20	basalt	angular chunk	392
1400S	89	22	34	65	quartzite	angular chunk	392
1400S	75	18	45	69	quartzite	reddened outer surface	505
1640S	48	30	33	50	quartzite	reddish, burned?	549
1680N	55	33	42	54	sandstone	angular chunk	234
1760N	58	27	48	59	quartzite	angular chunk, unburned?	427
1800S	63	24	43	57	basalt	angular chunk	600
1800S	46	23	35	32	quartzite	reddened outer surface	600
2040S	56	33	53	64	quartzite	angular, burned?	381
2080N	40	20	26	27	quartzite	angular chunk	561
2080N	43	22	28	21	quartzite	angular chunk	561
2080N	26	14	18	8	quartzite	angular chunk	561
2080N	50	29	42	49	quartzite	angular chunk	561
2120S	45	24	33	39	quartzite	reddened outer surface	253
2160N	72	35	35	93	basalt	angular chunk	255
2160N	58	34	47	85	basalt	angular chunk	255
2160N	50	23	36	38	quartzite	some reddening	255
2200S	84	36	71	170	basalt	angular chunk	412
2240N	39	19	26	16	quartzite	angular chunk, unburned?	580
2240N	60	12	35	24	quartzite	angular chunk, unburned?	580
2320N	54	25	49	74	quartzite	one possible polished surface	565
2320N	60	26	44	69	quartzite	reddened outer surface	565

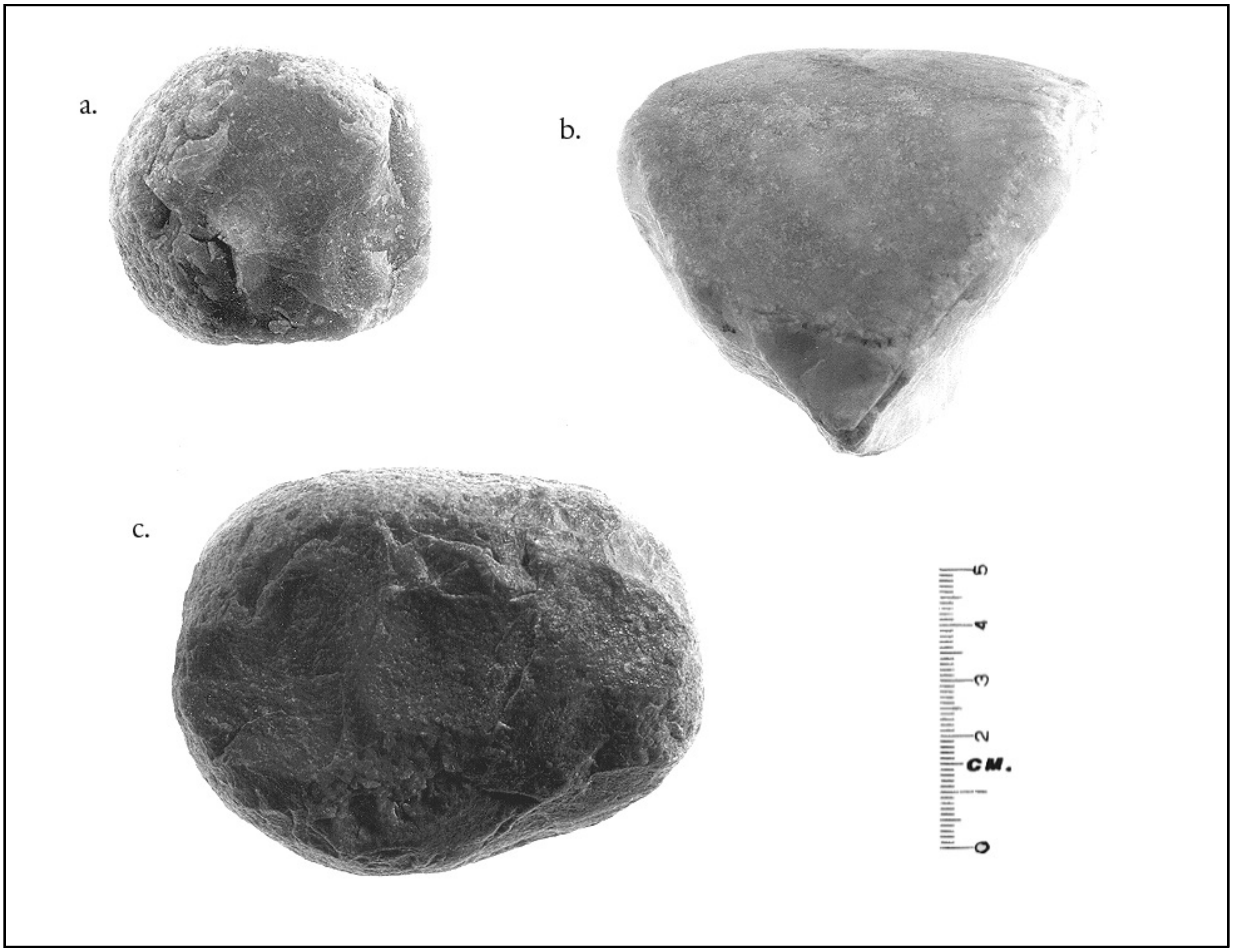


Figure 8.2. Hammerstones from the Eureka Dunes Site (a. FN 193, b. FN 772, c. FN 315).

described as part of feature descriptions, but was not collected. Besides the fire-cracked groundstone discussed above, 25 other pieces of fire-cracked rock occurring as isolated pieces were recovered during surface collection at CA- INY-2489 (Table 8.3) Sixteen of these are quartzite, eight are basalt, and one is sandstone. All of the pieces are angular, and some of the quartzite pieces exhibit reddening, possibly the result of burning. Fire-cracked rock concentrations in surface collection units (SCUs) 240N, 280N, 1320S, and 2640N are discussed under Features in Chapter 4.

Faunal Remains

Five small discolored bone fragments were recovered from the charcoal-stained fill of Feature 1. Two pairs of the bones refit, so they represent a maximum of three separate specimens and all may be from a single bone. While they can only be reliably classified as “unidentified large mammal,” they are most likely from limb bones of an artiodactyl. The brown discoloration of the bones may be from heating (for example, boiling), but they were not exposed to fire directly (William Gillespie, personal communication 2000).

Manuport

The largest obsidian piece from the Eureka Dunes Site is an unworked cobble collected from just west of SCU 1880S. It measures 70 mm by 60 mm by 57 mm and weighs 256.4 g (FN 316; Figure 8.3). It is the only piece from the site sourced to the Fish Springs quarry, located 25 miles east. It is not likely mis-sourced: not only is it visually consistent with Fish Springs material, the sourcing analysis was done twice with the same result. The entire cobble was a little too large to comfortably position in the spectrometer, so a small piece of the cobble was sawn off for re-analysis to make sure the first results were not spurious (Craig Skinner, personal communication, 2000). The cobble may have been transported to the site prehistorically and never used. However, given the current popularity of the Eureka Dunes area, it is also possible that a rock hound or archaeologist lost or discarded the obsidian after visiting the Fish Springs quarry. The piece had a hydration rim value of approximately 26 microns.

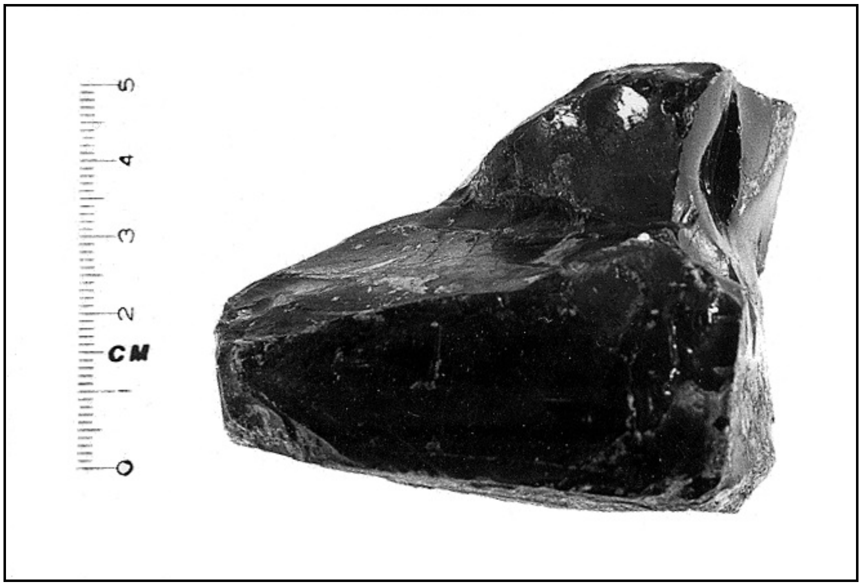


Figure 8.3. Fish Springs obsidian cobble (FN 316) recovered from the Eureka Dunes Site.

Chapter 9

Conclusions and Recommendations

Jeffery F. Burton, Mary M. Farrell, and William W. Bloomer

In June and October 1999 and February 2000, archeologists with the National Park Service conducted investigations at the Eureka Dunes Site (CA-INY-2489), within Death Valley National Park. Recorded as an extensive lithic scatter, the site covers over 830 acres, and the portion of the site examined in this project extends nearly 4,000 m east-west. The objective of the work was to gather sufficient data to assess the significance and research potential of the site, clarify its eligibility for listing on the National Register of Historic Places, and make informed recommendations regarding its future management. Specifically, the work was designed to: (1) investigate the site structure to discern any culturally derived patterning and assess integrity; (2) identify and determine the age of occupation; (3) define the quantity and quality of data categories present; and (4) assess the site's ability to address significant research questions. Below, the results of the current investigations are applied to each of these in turn.

Site Structure and Integrity

Subsurface testing indicates that the vast majority of artifacts at the Eureka Dunes Site occur on or near the surface. Nearly two-thirds of the 107 shovel test units excavated at the site encountered no artifacts at all. In the central portion of the site, those areas with especially dense distributions of surface artifacts tended to have some subsurface cultural material, but the presence of the relatively small and sparsely distributed flakes here could be explained by normal pedoturbation. The only exception was found in a small area within the western one-third of the site, near the playa. In several shovel test units there, quantities of subsurface debitage were found where there were few surface artifacts. This subsurface cultural material could represent a secondary deposit, or the greater susceptibility of the softer soils in that area to rodent mixing, but it could also represent a buried occupation surface.

However, in spite of the lack of vertical stratigraphy within most of the Eureka Dunes Site, there does appear to be fairly good *horizontal* stratigraphy. That is, cultural material exhibits spatial patterning which appears to have functional and even temporal implications. First, debitage is not evenly distributed within the site boundaries, but rather there are numerous artifact concentrations, some with very high amounts of debitage. From the surface collection results, five broad areas of high surface density can be discerned at the site: (1) the western portion of the site between surface collection units (SCUs) 280S and 480N; (2) the central portion of the site between SCUs 1240S and 1480S; (3) the east-central area between SCUs 1640S and 2280S; (4) the central portion of the site at Construction Locus 2; and (5) the southwestern portion of the site at Construction Locus 3.

Second, tools also exhibit some spatial patterning. Although the 79 bifaces recovered were from almost the entire length of the site, the distribution appears clustered, with many of the surface collection units having more than one biface and many having none, suggesting activity areas. For example, there were six bifaces (and a projectile point) in SCU 3-1, and three other surface collection units within the road corridor contained five bifaces each. Another surface collection unit (800N) may contain evidence of an individual's or small group's workshop area: there, two biface fragments were surrounded by debitage of like material, suggesting the bifaces had been worked at that spot, and then discarded when they fractured unexpectedly during the manufacturing process.

Third, another potential pattern lies in the distribution of material types: while chert bifaces occur across the site, obsidian bifaces occur mostly in the central third of the site, in spite of the ubiquity of obsidian debitage. In fact, obsidian debitage is much more prevalent in relation to other material types west of SCU 1280N and east of SCU 2240N. This includes the western most concentration between SCUs 280S and 480N. Green-grey chert debitage outnumbers obsidian in only four of the road corridor surface collection units (1400S, 1440N, 2160N, and 2200S), all in the central portion of the site) and in only one of the construction loci surface collection units (3-2).

Nevertheless, there are nearly 9,000 chert flakes in the collection from this project, and an estimated 1.1 million chert flakes across the site as a whole. The previously overlooked rock-concentration features may also attest to the importance of chert working at the Eureka Dunes Site. During field work, dozens of discrete rock concentrations, many with apparent fire-cracked or fire-altered rock and some with dark (apparently charcoal-stained) soil, were observed. The features have the appearance of the remains of hearths or roasting pits, and could be interpreted to represent food processing. However, of the six features tested, none yielded botanical materials, and only one yielded potential food remains: three small fragments of heated (but not directly burned) large mammal bone.

The features, or at least some of the features, could be related to heat-treatment of chert. Unlike samples from most of the site, excavations of the features yielded more chert than obsidian flakes. More tellingly, the results of replicative heat treatment suggest that many green-grey chert bifaces manufactured at Eureka Dunes were probably heat-treated during production. Generally, in the heat-treatment process the chert to be treated is buried under a rock hearth or possibly within an oven lined with heated rocks; during heating and re-heating, the rocks used as the heat source could have become fire-cracked like those of the features at the Eureka Dunes Site. Twenty one percent of the grey-green chert bifaces from the Eureka Dunes Site exhibit the luster expected of heat-treated rock, and failed heat treatment, evident in the form of crenulations and curvilinear internal fractures that are exposed during post-heat-treatment reduction. If, as evidence suggests, heat treatment improved the workability of the green-grey chert, one reason the Eureka Dunes area may have been attractive is the abundance of sand: sand is a good medium for distributing heat evenly, and keeping the rock to be treated from coming in direct contact with the heat source.

Some patterns are difficult to discern from current project results. For example, ground stone artifacts occur with a slightly greater frequency in the eastern half of the site. However, the sample of ground stone is so small, it is impossible to speculate about greater food-processing activities in the eastern half of the site. Further, the ground stone appears to have been recycled: eight out of ten of the ground-stone artifacts are fire-cracked, indicating their last use was for roasting (perhaps the heat-treatment of chert discussed above) or stone boiling rather than seed grinding.

Chronological patterning is discussed below, but the horizontal stratigraphy suggested by the current project results indicates that the Eureka Dune Site does have the integrity necessary for research, in spite of the lack of intact vertically stratified deposits. The surface nature of the site has made it susceptible to disturbance by casual collection, however. The most blatant example is that in the current investigations not one of the stone bowl mortars reported by Steward (1938) was encountered. It is possible that the stone bowl mortars were located outside of our project area, which included less than 1 percent of the site area. Most of the current work focused on areas within 20 meters of the road or in existing use areas, such as parking lots and picnic areas. These are probably the areas most susceptible to vandalism, and it is possible that if such obvious artifacts did occur near the road, they have been carted off. Indeed, in her 1972 survey report, Robarchek noted that archeological researchers reported relic hunters with shovels and screens searching for points in the Eureka Valley Dunes area in the late 1950s. However, stone bowl mortars were also not observed during site recording in 1976 and 1998, by which time whatever mortars were present in the 1930s may have been removed from the entire site. However, it is also possible that Steward himself collected the mortars (Michael Delacourte, personal communication to Lynn Johnson 2000). If so, there is a chance they are stored at Deep Springs College, although according to Delacourte the college discarded some of the artifacts in their collection some years ago.

Another integrity issue concerns the natural formation processes of the site, which have to be considered in future studies. In parts of the site caliche is at or very near the current ground surface, forming a rock-hard surface; in other parts of the site, sand blows across the site surface. The lithic analysis revealed two ways the site soils could skew interpretations. For one thing, several of the flakes were initially classified as worked (i.e., expedient tools for use in subsistence or the production or use maintenance of wooden, leather, or other tools). However, further analysis indicated that the microflakes taken off these flakes were probably the result of post-depositional trampling, by humans or other animals, on the hard-packed ground. Secondly, many of the flakes were sand-blasted, with edges and flake scars rounded and obscured; it is possible that extensive sand-blasting could remove some of the hydration rind that is used in obsidian hydration dating. However, both of these processes leave enough traces that their effects can be identified, and accounted for.

Age of Occupation

Temporally diagnostic artifacts, radiocarbon assays, and over 100 source-specific obsidian hydration readings suggest the Eureka Dunes Site was used, at least sporadically, for over 6,000 years, from as early as 4500 B.C. to late prehistoric times. The focus of site use apparently changed over time. The heaviest use for hunting-related activities, as represented by the projectile points, appears to have been during the Mohave, Little Lake, and Newberry periods. However, it should be noted that there are only 13 points in the collection, which together could span as much as 6,500 years. The points and other tools (a uniface, edge-modified flakes, and a core tool) represent probably limited residential subsistence activities conducted in conjunction with extended periods of biface manufacture at a biface production workshop.

The fire-cracked rock concentrations tested were radiocarbon-dated to late Newberry, Haiwee, and early Marana periods. The fact that the radiocarbon dates do not extend as far back in time as the projectile points could signify that the fire-cracked rock concentrations are associated with a change in site use that occurred in the late Newberry period. It should be noted, however, that only four of the dozens of fire-cracked rock concentrations present at the site were sampled for radiocarbon dates, so it is possible this apparent “cluster” of dates (that is, spanning only centuries instead of the millennia that the Eureka Dunes Site was used) is due to sample bias.

The 127 specimens submitted for x-ray fluorescence (XRF) and obsidian hydration analysis (including 19 artifacts, 107 pieces of debitage, and a manuport) can provide only preliminary chronometric information, since no hydration rate has yet been derived for Saline Valley obsidian, which comprises almost 80 percent of the obsidian at the Eureka Dunes Site. However, some general trends in the use of different portions of the site through time can be estimated from the obsidian hydration rim values. The earliest use at the site (Lake Mohave complex and Little Lake period) occurred in the western and to a lesser extent, the far eastern portion of the site. Over time use apparently shifted from the playa edge eastward. During the early Newberry period, use is concentrated in the west-central portion of the site, but by the late Newberry use is more widespread, scattered throughout the length of the site. The east-central portion of the site mostly dates to the Haiwee period. The most recent use, in the Marana period, appears to have been more limited, with widely spaced samples from the center of the site.

Correlating this postulated temporal-spatial patterning with the distribution of debitage, it seems the most intensive occupation (at least for obsidian-flake-producing tasks) occurred during the Newberry Period. Obsidian production is much decreased during the Haiwee period, tapering off even more during the Marana period.

Chert use, on the other hand, may be more recent: Delacorte (1988) has postulated that use of Last Chance green-grey chert intensified after A.D. 600 and one of only two chert projectile points recovered from the site was a Desert Side-notched point, a style dated to the Marana period, and. The late Newberry through early Marana period radiocarbon dates for the concentrations of fire-cracked rock further support late chert processing, if indeed the features represent chert ovens.

Data Categories Present at the Eureka Dunes Site

With over 26,000 flakes recovered in this project's sample, and an estimated 3 million flakes in the entire site, there is a wealth of data about the technology of stone-working at the Eureka Dunes Site. The large number of production stage bifaces and biface thinning flakes attest to the primacy of biface production at Eureka Dunes. Obsidian, mostly from Saline Valley sources, arrived as crudely worked bifaces, which were finished at Eureka Dunes Site to bifaces usable as rough tools or trade items. Chert, mostly from the Last Chance Range, arrived at a slightly earlier stage of production, but was also finished into rough tools or trade items. The results of replicative heat treatment suggest that most green-grey chert bifaces manufactured at the Eureka Dunes Site were heat-treated during production.

Based on debitage amounts extrapolated for the entire site, it is likely that over 1,000 green-grey chert bifaces and approximately 1,500 obsidian bifaces were manufactured at Eureka Dunes. Although these are very rough estimates, they do suggest that the Eureka Dunes Site could have been particularly important in the specialized chert exchange postulated for after 1350 B.P. in the northern Death Valley, Owens Valley, and Deep Springs areas (Delacorte 1988). The presence of obsidian from different sources, from the Montezuma Range, Sarcobatus Flat, and Fortymile/Tonopah/Yucca Wash in Nevada to the east to the Casa Diablo source in Mono County to the northwest, indicate the site can also provide information about trade or travel routes.

Abundant chronometric data would be available at the Eureka Dunes Site through obsidian hydration analysis, once hydration rates for Saline Valley obsidian are determined. The features have potential for chronometric data through radiocarbon analysis, and the features could even help refine the obsidian hydration rates, since obsidian is found in association. The rock concentrations also have potential for subsistence data: although some were possibly used for cooking chert, some may have been used for cooking food, as suggested by the few animal bone fragments found in one of the features.

That some food was processed at the site is suggested by the stone bowl mortars reported by Steward and by the few pieces of ground stone recovered during these investigations. And even though only 10 pieces of ground stone were encountered, these themselves may indicate a change in subsistence. The more formal manos, with evidence of intensive use (flat faces) and shaping (pecked ends), were all very fragmentary, fire-cracked specimens. Their still-substantial thickness indicates they were recycled as stone boilers or in hearths well before their grinding use-life had expired. The only whole ground stones encountered were two slightly used hand stones, casual artifacts with no evidence of shaping or even particular care in selection. If formal manos were supplanted by expedient hand stones in Eureka Valley, as has been documented elsewhere in California (e.g. Goldberg et al. 1986), this change in technology may signal a change in resources exploited, or even a change in the identity of the exploiters. Therefore, technological, trade, and subsistence data could also shed light on larger themes, such as local vs. inter-regional trade and its implications (cf. Delacorte 1988) or the distribution and redistribution of goods and ethnicity (cf. Bettinger and Baumhoff 1982).

It is interesting that no contact-period artifacts were identified during these investigations, even though Eureka Valley was known to be within the territory of the Panamint Shoshone. The spherical stone mortars reported at the site by Steward were the type commonly used by the Shoshone for grinding mesquite (Steward 1938), and Brewer et al. (1999) reported brown ware ceramics at the site. It is possible that contact-period artifacts would be found in a larger sample of the site.

Potential to Address Research Questions

The results from the current testing must be considered tentative, if provocative: they only suggest patterns and questions for further research. For example, exploration of more of the features could provide details about the heat treatment suggested in the testing. Successful heat treatment hearths are hard to recognize, but failed heat treatment will result in curvilinear shatter and crenulated fragments of blanks and early stage bifaces. In-field lithic analysis of debitage associated with the features could help elucidate this technology. Alternatively, the features might provide information on subsistence, which is not well represented in the current sample. The Eureka Dunes Site also has potential for providing information on local or intra-regional trade, since a variety of stone, from several sources, is represented at the site.

Chronological information could be refined, with the potential of correlating obsidian hydration and radiocarbon dating in the features, or, across the site, when hydration rates for the different obsidian sources are determined through work elsewhere. Once obsidian hydration rates are established, the temporal and spatial patterns suggested by the testing could be tested and refined. Tighter chronological control would be particularly useful for assessing the importance of the Eureka Dunes Site in Last Chance chert or Saline Valley obsidian biface production. If, for example, use and production was constant over time, the site was occupied for so long that one visitor producing one or two bifaces at the site every couple of years could have been responsible for the entire assemblage. Conversely, if tighter chronological control showed most biface production occurred within a century or two, the production would have been intensive, with greater implications for the local economy.

Management Recommendations

The legal guidelines for evaluation and management of archeological sites on public land are outlined by the National Historic Preservation Act, as amended, and specified in the Code of Federal Regulations, Title 36, Section 60.6, which states:

> The quality of significance in American history, architecture, archeology, and culture is present in districts, sites, building, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:
>
> (A) that are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (B) that are associated with the lives of persons significant in our past; or
>
> (C) that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> (D) that have yielded, or may be likely to yield, information important in prehistory or history.

Archeological sites are usually evaluated against criterion D: the ability to provide information important in prehistory or history. Implicit in criterion D is the need to measure sites against viable research questions. The Advisory Council on Historic Preservation, in *Treatment of Archaeological Properties: A Handbook* (1980) states that archeological sites "... are important ... because they may contribute to the study of important research problems" (Principle III, p. 8). For its information potential, the Eureka Dunes Site is therefore considered eligible for the National Register of Historic Places under criterion D. As such, it is recommended that its information potential be protected:

1. Any ground disturbance within the Eureka Dunes Site boundary should be monitored by an archeologist.

2. The work conducted during the current investigation would suffice to mitigate the effects of the proposed protective measures. However, if new construction is proposed outside the road corridor or the loci tested, additional data recovery should include surface collection or infield analysis of debitage, especially around features and at discreet reduction loci. Features within any newly-proposed disturbance areas warrant excavation and radiocarbon dating.

3. The condition of the Eureka Dunes Site should be monitored periodically, to determine if the proposed management actions do protect the area from unauthorized roads, camping, and other disturbance as planned.

4. The Eureka Dunes Site should be resurveyed and mapped in sufficient detail to provide baseline data for monitoring and to determine the number and extent of the fire-cracked rock concentration features that were overlooked in previous surveys.

5. When funding allows, the western portion of the Eureka Dunes Site where subsurface artifacts were encountered below 40 cm depth should be more fully tested, to determine if there is a significant buried cultural deposit present.

6. No cultural material dating to the early contact period was encountered in the present investigations, but brown ware ceramics and stone bowl mortars reported by other researchers suggest Shoshone use of the site area. The Timbisha Shoshone and possibly other groups would have to be consulted to determine if the Eureka Dunes Site could also be eligible to the National Register as a traditional cultural property (TCP).

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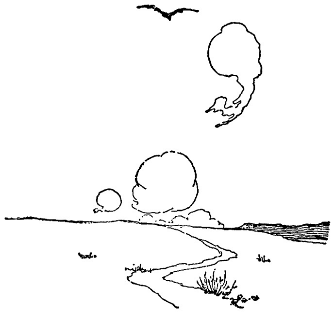

Appendix A

Debitage Summary Tables

Michele A. Martz

Table A.1. Road Corridor Surface Collection Units (SCU) Debitage Counts.

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
0 N	14	2	0	0	16
40 S	44	0	2	1	47
80 N	68	2	0	0	70
120 S	52	1	0	0	53
160 N	46	9	6	1	62
200 S	48	2	0	1	51
240 N	50	1	0	0	51
280 S	254	8	3	1	266
320 N	188	96	7	0	291
360 S	204	14	8	17	243
400 N	181	17	8	1	207
440 S	210	84	15	7	316
480 N	266	141	26	10	443
520 S	45	21	3	2	71
560 N	77	76	1	2	156
640 N	5	4	0	0	9
720 N	15	6	2	0	23
760 S	13	65	4	3	85
800 N	32	48	29	3	112
840 S	22	2	1	0	25
880 N	38	3	7	0	48
920 S	27	4	0	0	31
960 N	15	3	1	0	19
1000 S	28	3	0	1	32
1040 N	10	1	1	1	13
1080 S	23	5	1	0	29
1120 N	28	0	0	1	29
1160 S	17	2	2	2	23
1200 N	159	24	2	0	185

Table A.1. Road Corridor Surface Collection Units (SCU) Debitage Counts.

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
1240 S	392	77	62	3	534
1280 N	409	63	61	9	542
1320 S	810	320	64	6	1200
1360 N	191	82	21	0	294
1400 S	474	868	54	2	1398
1440 N	562	767	125	8	1462
1480 S	148	101	16	1	266
1520 N	68	65	27	3	163
1560 S	52	21	2	2	77
1600 N	12	4	0	0	16
1640 S	195	112	6	2	315
1680 N	85	34	7	5	131
1720 S	1375	331	11	15	1732
1760 N	131	59	7	6	203
1800 S	306	175	26	4	511
1840 N	12	1	2	0	15
1880 S	310	239	15	5	569
1920 N	232	165	7	3	407
1960 S	1899	958	24	24	2905
2000 N	386	81	6	2	475
2040 S	717	669	96	20	1502
2080 N	1663	913	139	20	2735
2120 S	118	29	6	4	157
2160 N	42	141	7	5	195
2200 S	84	127	14	1	226
2240 N	212	65	23	1	301
2280 S	1021	112	16	0	1149
2320 N	168	27	2	0	197
2400 N	117	45	16	1	179

Table A.1. Road Corridor Surface Collection Units (SCU) Debitage Counts.

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
2480 N	10	3	1	0	14
2560 N	29	1	1	0	31
2640 N	161	19	5	0	185
2720 N	0	0	0	0	0
2800 N	0	0	0	0	0
2880 N	7	0	0	0	7
2960 N	12	0	0	0	12
3040 N	3	0	0	0	3
3120 N	2	1	0	0	3
3200 N	19	0	0	0	19
3280 N	4	0	0	0	4
3360 N	16	0	3	0	19
3440 N	0	0	0	0	0
3520 N	1	0	0	0	1
3600 N	1	1	0	0	2
3680 N	0	0	0	0	0
3760 N	0	0	0	0	0
3840 N	0	0	0	0	0
3920 N	0	0	0	0	0
4000 N	0	0	0	0	0
Total	14635	7320	1001	206	23162

Table A.2. Construction Loci Surface Collection Units (SCU) Debitage Counts.

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
1-1	12	5	2	0	19
1-2	33	0	0	0	33
1-3	63	1	1	0	65
1-4	36	5	0	0	41
1-5	10	0	0	0	10
1-6	6	0	0	0	6
1-7	6	2	0	0	8
1-8	6	3	0	0	9
1-9	0	0	1	0	1
1-10	4	0	0	0	4
1-11	24	1	0	0	25
1-12	9	0	0	0	9
1-13	64	1	0	0	65
1-14	5	3	5	3	16
1-15	13	0	0	0	13
1-16	0	0	0	0	0
Locus 1 total	291	21	9	3	324
2-1	10	4	0	1	15
2-2	5	2	2	0	9
2-3	26	21	1	1	49
2-4	9	7	6	0	22
2-5	30	6	2	0	38
2-6	152	42	40	1	235
2-7	170	31	41	1	243
2-8	87	14	17	0	118
2-9	13	4	4	0	21
2-10	109	39	31	0	179
2-11	482	152	85	3	722
2-12*	16	4	4	0	24

Table A.2. Construction Loci Surface Collection Units (SCU) Debitage Counts.

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
2-13*	11	3	3	3	20
2-14*	83	14	7	2	106
2-15*	32	1	4	0	37
2-16*	109	38	14	1	162
2-17*	16	7	3	0	26
2-18*	11	0	0	0	11
Locus 2 total	1371	389	264	13	2037
3-1	357	115	13	1	486
3-2	143	200	18	2	363
Locus 3 total	500	315	31	3	849
Loci total	2162	725	304	19	3210

* only 5 m by 5 m area collected

Table A.3. Road Corridor Surface Collection Units Debitage Weight
(in grams, rounded to 1 g, <1 g = 1 g).

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
0 N	25	11			36
40 S	80		2	2	84
80 N	255	3			258
120 S	119	3			122
160 N	79	56	42	1	178
200 S	47	3		1	51
240 N	113	2			115
280 S	248	13	3	2	266
320 N	173	25	7		205
360 S	382	21	7	333	743
400 N	308	97	23	82	510
440 S	293	200	44	72	609
480 N	345	338	47	160	890
520 S	44	73	2	3	122
560 N	77	262	2	44	385
640 N	6	11			17
720 N	35	26	3		64
760 S	19	146	36	30	231
800 N	61	88	47	49	245
840 S	16	8	1		25
880 N	39	3	2		44
920 S	13	7			20
960 N	25	4	3		32
1000 S	30	1		19	50
1040 N	7	2	1	12	22
1080 S	19	7	1		27
1120 N	30			1	31
1160 S	7	4	2	36	49
1200 N	59	16	2		77

Table A.3. Road Corridor Surface Collection Units Debitage Weight
(in grams, rounded to 1 g, <1 g = 1 g).

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
1240 S	154	72	23	36	285
1280 N	400	79	146	57	682
1320 S	600	250	78	7	935
1360 N	137	114	22		273
1400 S	230	552	106	1	889
1440 N	268	781	53	32	1134
1480 S	97	86	7	5	195
1520 N	77	93	52	75	297
1560 S	71	48	1	45	165
1600 N	8	6			14
1640 S	81	68	12	1	162
1680 N	136	39	5	3	183
1720 S	582	413	16	62	1073
1760 N	145	101	8	55	309
1800 S	343	178	42	18	581
1840 N	17	1	1		19
1880 S	241	275	22	5	543
1920 N	177	268	10	11	466
1960 S	1371	902	49	111	2433
2000 N	130	607	10	5	752
2040 S	471	593	56	12	1132
2080 N	1106	590	143	29	1868
2120 S	49	26	14	18	107
2160 N	40	400	29	49	518
2200 S	38	125	19	1	183
2240 N	232	131	37	21	421
2280 S	549	360	14		923
2320 N	224	65	2		291
2400 N	95	103	109	2	309

Table A.3. Road Corridor Surface Collection Units Debitage Weight (in grams, rounded to 1 g, <1 g = 1 g).

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
2480 N	4	3	37		44
2560 N	24	1	4		29
2640 N	81	5	2		88
2720 N					0
2800 N					0
2880 N	5				5
2960 N	5				5
3040 N	5				5
3120 N	1	1			2
3200 N	36				36
3280 N	4				4
3360 N	12		47		59
3440 N					0
3520 N	1				1
3600 N	1	1			2
3680 N					0
3760 N					0
3840 N					0
3920 N					0
4000 N					0
Total	11202	8767	1453	1508	22930

Table A.4. Construction Loci Surface Collection Units Debitage Weight (in grams, rounded to 1 g, <1 g = 1 g).

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
1-1	8	47	1		56
1-2	34				34
1-3	31	30	1		62
1-4	28	6			34
1-5	13				13
1-6	10				10
1-7	3	3			6
1-8	10	11			21
1-9			2		2
1-10	5				5
1-11	36	6			42
1-12	7				7
1-13	73	1			74
1-14	6	1	15	22	44
1-15	5				5
1-16					0
Locus 1 total	269	105	19	22	415
2-1	6	12		19	37
2-2	14	5	8		27
2-3	31	53	1	3	88
2-4	11	27	5		43
2-5	41	22	4		67
2-6	97	28	23	1	149
2-7	85	60	22	2	169
2-8	58	23	8		89
2-9	6	3	2		11
2-10	57	46	54		157
2-11	336	196	71	23	626
2-12*	10	7	1		18

Table A.4. Construction Loci Surface Collection Units Debitage Weight (in grams, rounded to 1 g, <1 g = 1 g).

Unit	Obsidian	Green-Grey Chert	Other Chert	Other Materials	Total
2-13*	8	3	6	11	28
2-14*	44	9	1	1	55
2-15*	14	1	2		17
2-16*	42	17	2	1	62
2-17*	15	7	1		23
2-18*	3				3
Locus 2 total	878	519	211	61	1669
3-1	367	188	21	18	594
3-2	51	181	13	11	256
Locus 3 total	418	369	34	29	850
Total	1297	888	245	90	2519

* 5 m by 5 m unit

Table A.5. Surface Scrape Units (SSU) Debitage Count.

Unit	Obsidian	Green-Grey Chert	Other Chert	Total
0N	1	0	0	1
40S	0	0	0	0
800N	4	5	0	9
1240S	26	2	8	36
1960S	28	41	0	69
2080N #1	6	7	2	15
2080N #2 (Fea. 4)	9	9	0	18
Total	74	64	10	148

Table A.6. Construction Loci 1 and 2 Shovel Test Units (STU) Debitage Counts (unexcavated levels shaded; * = Green-Grey Chert, all others Obsidian).

Unit	0-20 cm	20-40 cm	40-60 cm	60-80 cm	80-100 cm	Total
1	0	0	0	0		0
2	0	2	1			3
3	0	1*	0	0		1*
4	0	0				0
5	0	0	0	0		0
6	0	0	0	0		0
7	0	0	0	0		0
8	0	0	0			0
9	1	0				1
10	0	0	0	0		0
11	0	0	0	0		0
12	1	0	0	0		1
13	0	0	0	0		0
14	0					0
15	0	0	0			0
16	0					0
17	0	0	0			0
18	0	0	0			0
19	0	0	0			0
20	0	0	0			0
21	0	0				0
22	0	0	0	0		0
23	0	0				0
24	1*	0	0			1*
25	2	0				2
26	3					3
27	0	0	0			0
Loci Total	7, 1*	3	1	0	0	12, 1*

Table A. 7. Road Corridor Shovel Test Units (STU) Debitage Counts (unexcavated levels shaded; * = Green-Grey Chert,† = Other Chert, all others Obsidian).

Unit	0-20 cm	20-40 cm	40-60 cm	60-80 cm	80-100 cm	Total
0N-1	0	0	0	1		1
0N-2	0	0	0	6	0	6
40S	0	0	0	2	0	2
80N	0	3	3	19, 3*	5, 2*	30, 5*
120S	0	0	0	0		0
160N	0	1†	1, 2*	0	0	1, 2*, 1†
200S	0	0	0	2	1	3
240N-1	0					0
240N-2 (F. 5)	0	0	0	0		0
280S	0	2	0	0	0	2
320N	0	1	0	0	0	1
360S	0	0	0	0	0	0
400N	0	1	3	0		4
440S	1	0	0	1	0	2
480N	0	1	0	0		1
520S	0	0				0
560N	0	0	0	0		0
640N	2, 1*	1	0			3, 1*
720N	0	0	1, 3*	0		1, 3*
760S	3*	0	0			3*
800N	0	2	0	0		2
840S	0	0	0			0
880N	0	0	0			0
920N	0	1	0			1
960N	0	0	0			0
1000S	0	0	0			0
1040N	0	0	0			0
1080S	0	0				0
1120N	0	0				0
1160S	0	0	0			0

Table A. 7. Road Corridor Shovel Test Units (STU) Debitage Counts (unexcavated levels shaded; * = Green-Grey Chert,† = Other Chert, all others Obsidian).

Unit	0-20 cm	20-40 cm	40-60 cm	60-80 cm	80-100 cm	Total
1200N	0	0	0			0
1240S	0	0				0
1280N-1	0	0				0
1280N-2	0					0
1280N-3	0	0				0
1320S	1	0	0			1
1360N	0	0				0
1400S	3, 2†					3, 2*
1440N	1, 1†					1, 1†
1480S	2	0				2
1520N	1†	0				1†
1560S	0	1	0			1
1600N	0	0				0
1640S	2, 1*	0	0			2, 1*
1680N	0	0	0			0
1720S	1	2	0			3
1760N	0	0	0			0
1800S	0	0	0	0		0
1840N	0	0	0	0		0
1880S	0	1*	0			1*
1920N	0	0				0
1960S	1*					1*
2000N	0					0
2040S	2, 1*	0				2, 1*
2080N	1					1
2120S	1	0				1
2160N	0					0
2200S	2*	1, 1*	0			1, 3*
2240N	1					1
2280S	0					0

Table A. 7. Road Corridor Shovel Test Units (STU) Debitage Counts (unexcavated levels shaded; * = Green-Grey Chert,† = Other Chert, all others Obsidian).

Unit	0-20 cm	20-40 cm	40-60 cm	60-80 cm	80-100 cm	Total
2320N	0					0
2400N	0					0
2480N	0	0				0
2560N	0	0				0
2640N (F. 6)	1					1
2720N	0	0	0			0
2800	0	0				0
2880	0					0
2960N	0	0				0
3040N	0	0				0
3120N	0	0				0
3200N	0	0	0	0		0
3280N	0	0	0	0		0
3360N	0	0				0
3440N	0	0	0	0		0
3520N	0	0				0
3600N	0	0	0			0
3680N	0	0	0	0		0
3760N	0	0	0	0		0
3840N	0	0	0	0		0
3920N	0	0	0	0		0
4000N	0	0	0			0
Road Total	19, 9*, 4†	16, 2*, 1†	8, 5*	31, 3*	6, 2*	80, 21*, 5†

Table A.8. Feature Units Debitage Count.

Unit	Obsidian	Green-Grey Chert	Other Chert	Total
Fea. 2, E½, 0-2 cm	1	1		2
Fea. 2, E½, fill	1			1
Fea. 2, W½, 0-2 cm	2			2
Fea. 2 total	4	1		5
Fea. 3, surface	4	3	1	8
Fea. 3, E½, 0-10 cm	6	8	2	16
Fea. 3, W½, 0-10 cm	7	9	1	17
Fea. 3 total	17	20	4	41

Appendix B

Results of X-Ray Fluorescence and Obsidian Hydration Analysis

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Northwest Research Obsidian Studies Laboratory Report 2000-27

X-Ray Fluorescence Analysis and Obsidian Hydration Analysis of Artifact Obsidian from the Eureka Dunes Site, Death Valley National Park, Inyo County, California

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Jennifer J. Thatcher
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One hundred and twenty-seven obsidian artifacts from the Eureka Dunes Site, Death Valley National Park, Inyo County, California, were submitted for energy dispersive X-ray fluorescence trace element provenience analysis. The specimens were also processed for hydration measurements. The samples were prepared and analyzed at the Northwest Research Obsidian Studies Laboratory under the accession number 2000-27.

Analytical Methods

X-Ray Fluorescence Analysis. Nondestructive trace element analysis of the samples was completed using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area 30 mm^2. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHZ Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a rhodium target, and 5 mil Be window. The tube is driven by a 50 kV 1 mA high voltage power supply, providing a voltage range of 4 to 50 kV. Specific analytical conditions used for the analysis of the elements reported in Table A-1 are available at the Northwest Research Obsidian Studies Laboratory World Wide Web site at *www.obsidianlab.com.*

The diagnostic trace element values used to characterize the samples are compared directly to those for known obsidian sources reported in the literature and with unpublished trace element data collected through analysis of geologic source samples (Skinner 2000). Artifacts are correlated to a parent obsidian source or geochemical source group if diagnostic trace element values fall within about two standard deviations of the analytical uncertainty of the known upper and lower limits of chemical variability recorded for the source. Occasionally, visual attributes are used to corroborate the source assignments although sources are never assigned solely on the basis of megascopic characteristics.

Obsidian Hydration Analysis. An appropriate section of each artifact is selected for hydration slide preparation. Two parallel cuts are made into the edge of the artifact using a lapidary saw equipped with 4-inch diameter diamond-impregnated .004" thick blades. The resultant cross-section of the artifact (approximately one millimeter thick) is removed and mounted on a petrographic microscope slide with Lakeside thermoplastic cement and is then ground to a final thickness of 30-50 microns.

The prepared slide is measured using an Olympus BHT petrographic microscope fitted with a filar screw micrometer eyepiece. When a clearly defined hydration layer is identified, the section is centered in the field of view to minimize parallax effects. Four rim measurements are typically recorded for each artifact or examined surface. Hydration rinds smaller than one micron often cannot be resolved by optical microscopy. Hydration thicknesses are reported to the nearest 0.1 μm and represent the mean value for all readings. Standard deviation values for each measured surface indicate the variability for hydration thickness measurements recorded for each specimen. It is important to note that these values reflect only the reading uncertainty of the rim values and do not take into account the resolution limitations of the microscope or other sources of uncertainty that enter into the formation of hydration rims.

Additional details about specific analytical methods and procedures used for the analysis of the elements reported in Table A-1 and the preparation and measurement of hydration rims are available at the Northwest Research Obsidian Studies Laboratory World Wide Web site at *www.obsidianlab.com.*

Results

Ten geochemical obsidian sources, eight of which were correlated with known sources, were identified among the 127 obsidian artifacts that were characterized by X-ray fluorescence analysis. The locations of the Eureka Dunes Site and the identified obsidian sources are shown in Figure 1. Analytical results are presented in Table A-1 in the Appendix and are summarized in Table 1 and Figure 2. Descriptive information about the obsidian sources is presented in Table 2.

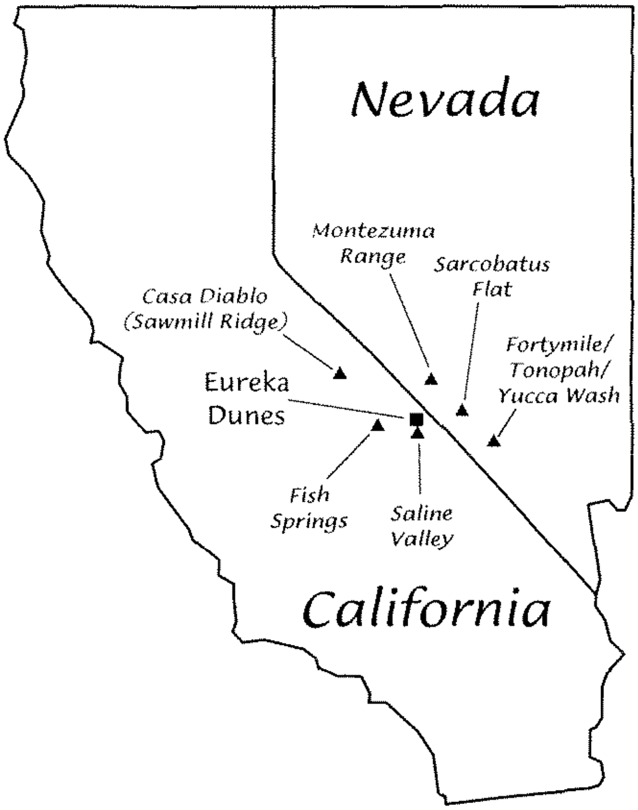
Table 1. Summary of results of trace element analysis of obsidian artifacts.

Site	N=	Percent
Casa Diablo (Sawmill Ridge)	1	0.8
Fish Springs	1	0.8
Fortymile/Tonopah/Yucca Wash	1	0.8
Montezuma Range?	3	2.4
Saline Valley 1	86	67.7
Saline Valley 2	7	5.5
Saline Valley 3	8	6.3
Sarcobatus Flat A (Obsidian Butte Variety H-3)	1	0.8
Unknown 1	18	14.2
Unknown 2	1	0.8
Total: Obsidian	**127**	**100.1**

Nearly 80 percent of the analyzed artifacts originated from one of the three geochemical sources recently identified in the nearby Saline Range – Saline Valley varieties 1, 2, and 3 (Johnson et al. 1999a and 1999b). The remainder of the identified sources are located in southeastern and east-central California or in southwestern Nevada and have been encountered in previous trace element investigations of artifacts from sites in the Death Valley region.

We were unable to correlate 19 of the characterized artifacts with any obsidian sources contained in our source reference database. This database contains not only the trace element results of geologic source samples analyzed by Northwest Research but also include comparable compositional data from other source and artifact studies carried out in the Death Valley region (e.g., those undertaken by Richard E. Hughes, Geochemical Research, and M. Steven Shackley, University of California). Although the geologic sources of the two probable geochemical groups present among the unknowns was not found in our reference database, the large proportion of artifacts from the Unknown 1 source suggests that it is located somewhere in the general vicinity of the Eureka Dunes Site.

Figure 1. Location of the Eureka Dunes Site and the sources obsidian identified through trace element studies of artifacts.



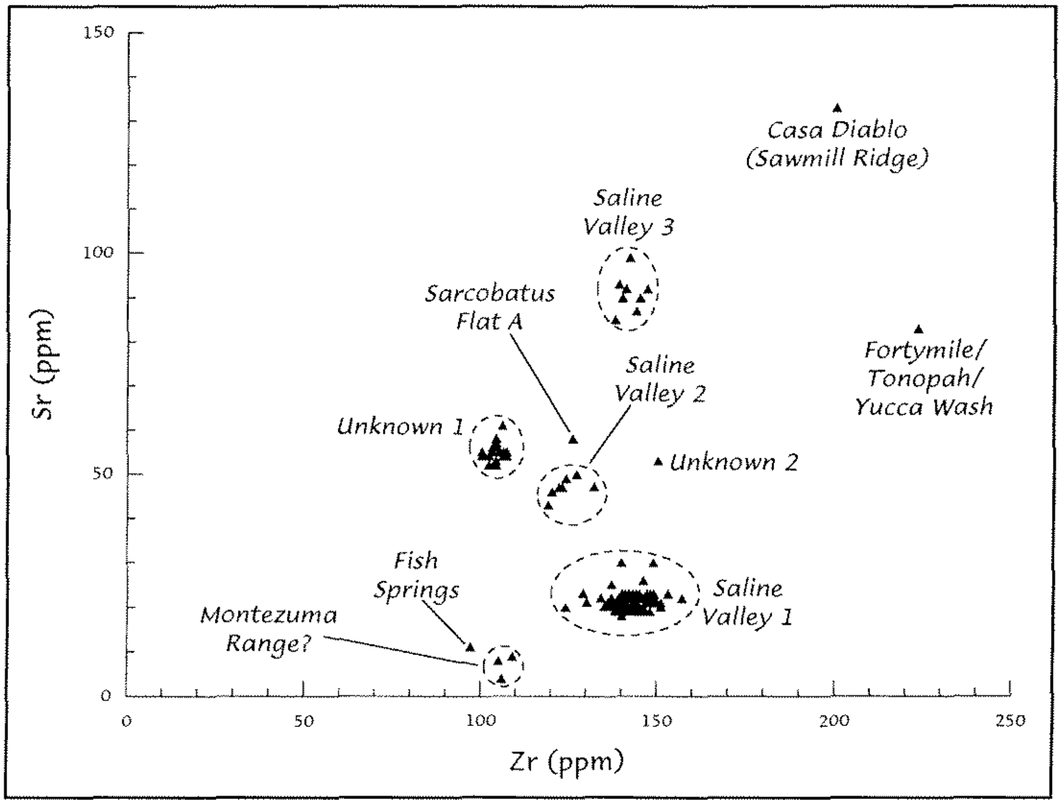


Figure 2. Scatterplot of strontium (Sr) plotted versus zirconium (Zr) for artifacts from the Eureka Dunes Site.

Table 2. Descriptions of obsidian sources identified in the current investigation. Summaries include results of unpublished field and geochemical source research conducted by Northwest Research (Skinner 2000). Table is continued on the following page.

Geologic Source	Location	Description	References
Casa Diablo (Lookout Mountain)	Mono County, Long Valley Caldera, eastern California	The Casa Diablo source complex is located within Long Valley Caldera, a large volcanic depression located at the eastern base of the Sierra Nevada Mountains in eastern California. The source complex is composed of three geochemically distinguishable subgroups – Lookout Mountain, Sawmill Ridge, and Hot Creek. Prehistoric use of obsidian from Casa Diablo, primarily from the Lookout Mountain and Sawmill Ridge sources, was extensive throughout eastern and central California. Evidence of trans-Sierran procurement and exchange of large quantities of glass from the source area is well-documented at many sites located in the west-central Sierra Nevada Mountains, the Central Valley, and the central and south-central coast of California.	Bailey 1989 Bailey et al. 1976 Basgall 1989 Bouey and Basgall 1984 Ericson 1981, 1982 Ericson et al. 1976 Goldberg et al. 1990 Hughes 1994 Jackson 1984 Jackson and Ericson 1994
Fish Springs	Inyo County, southeastern California	This obsidian and perlite deposit is located in the central Owens Valley about 11 km south of Big Pine. Glass suitable for tool production occurs over a rather limited area. Obsidian from the source is megascopically distinctive and has been the subject of controlled visual characterization investigations concerning the identification of territorial boundaries in the Owens Valley. Prehistoric use of Fish Springs glass appears to generally be restricted to the local region surrounding the source. Characterized artifacts have been identified primarily from archaeological sites in Inyo County and the area immediately to the west in Sequoia and Kings Canyon national parks. A few Fish Springs artifacts have also been identified at sites along the south-central California coast.	Bettinger 1982, 1989 Ericson 1981 Ericson et al. 1976 Hughes and Bettinger 1984 Roper Wickstrom 1992, 1993
Fortymile/Tonopah/ Yucca Wash	Nye County, southwestern Nevada	This poorly known source is located northeast of Beatty, Nevada, within the boundaries of Nellis Air Force Base. Prehistoric use of the source is not well-documented and is known primarily from limited characterization studies of artifacts from the Death Valley region.	Benson 1998
Montezuma Range	Esmeralda County, southwestern Nevada	This source is situated in the Montezuma Range approximately 80 km southwest of Tonopah, Nevada. Prehistoric use of the source is not well-documented and is known primarily from limited characterization studies of artifacts from within the Tonopah Ranger District of the Toiyabe National Forest, Nevada.	Benson 1998
Saline Valley	Inyo County, Death Valley National Park, southeastern California	The Saline Range, a remote volcanic tableland located within Death Valley National Park in the southwestern Great Basin, has recently been reported as a source of archaeological obsidian. Rhyolitic obsidian-bearing tuffs in the Saline Range were emplaced over preexisting topography and later disrupted by Basin and Range faulting, creating complex outcrop patterns. Obsidian nodules eroded from the tuffs have been transported and redeposited more than 20 km from primary outcrops. Neutron activation analysis and X-ray fluorescence analysis studies indicate that three different geochemical varieties of glass can be distinguished from among the Saline range sources (Saline Valley 1, 2, and 3). The Saline Valley 1 variety was previously known as the Queen Imposter because of the similarity in trace element composition with that source. As evidenced by trace element studies of obsidian from the regions immediately surrounding the Saline Range, this source (particularly the Saline Valley 1 variety) was extensively used during the prehistoric period.	Johnson 1999a, 1999b

Table 2 (continued). Descriptions of obsidian sources identified in the current investigation.

Geologic Source	Location	Description	References
Sarcobatus Flat A	Nye County, southwestern Nevada	Also known as the Tolicha Wash and Obsidian Butte source, obsidian nodules occurring as surface float are found at Sarcobatus Flat in western Nevada. The nodules originate from nearby Obsidian Butte, a source area that lies within Nellis Air Force Base and that is closed to the public. Trace element studies of obsidian collected at Sarcobatus Flat indicate that two geochemical varieties (A and B) are present. These two varieties have also been designated as Obsidian Butte Variety H-3 (Sarcobatus Flat A) and Obsidian Butte Variety H-5 (Sarcobatus Flat B).	Moore 1997

Obsidian Hydration Analysis. The 127 characterized obsidian artifacts from the Eureka Dunes Site were also prepared for obsidian hydration measurements and yielded 118 measurable rims. The specimen slides are curated at the Northwest Research Obsidian Studies Laboratory under accession number 2000-27. The results are summarized in Table 3 and are reported in Table B-1 in the Appendix.

Although many different hydration rates have been proposed for obsidian from the Casa Diablo source complex (Hall and Jackson 1989), no hydration rate information exists for any other sources in the current investigation that were associated with successful rim measurements.

Table 3. Summary of obsidian hydration measurements for analyzed artifacts.

Site	N=	**Hydration Rim Width (microns)**
Casa Diablo (Sawmill Ridge)	1	4.8
Fish Springs	0	NA
Fortymile/Tonopah/Yucca Wash	1	6.6
Montezuma Range	3	7.2, 9.7, 10.0
Saline Valley 1	84	2.1, 2.3, 2.8, 2.8 3.1, 3.3, 3.3, 3.5, 3.6, 3.7, 3.8, 3.9, 3.9 4.1, 4.4, 4.6, 4.8 5.0, 5.0, 5.1, 5.2, 5.3, 5.3, 5.4, 5.4, 5.7, 5.7, 5.8, 5.9, 5.9 6.0, 6.1, 6.1, 6.1, 6.2, 6.2, 6.2, 6.2, 6.3, 6.5, 6.6, 6.7 7.1, 7.1, 7.2, 7.3, 7.4, 7.7, 7.7, 7.9, 7.9, 7.9 8.0, 8.0, 8.0, 8.1, 8.1, 8.1, 8.1, 8.2, 8.2, 8.2, 8.3, 8.3, 8.4, 8.6, 8.8, 8.9, 8.9 9.1, 9.1, 9.3, 9.3, 9.5, 9.5, 9.5 10.0, 10.0, 10.6, 10.9 11.1, 11.1, 11.7 12.2
Saline Valley 2	4	2.8. 7.9, 9.1, 9.4
Saline Valley 3	6	3.5, 4.4, 5.2, 5.3, 6.2, 7.5
Sarcobatus Flat A	1	3.0
Unknown 1	17	3.7, 4.0, 4.2, 4.4, 4.6 5.0, 5.1, 5.1, 5.5, 5.7, 6.1, 6.3 7.0, 8.6 9.0, 9.3, 10.7
Unknown 2	1	7.0
Total: Obsidian	**118**	—

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Appendix

Results of X-Ray Fluorescence and Obsidian Hydration Analysis

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Eureka Dunes, Death Valley National Park, Inyo County, California

	Specimen			Trace Element Concentrations											Ratios		
Site	No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe2O3^T	Fe:Mn	Fe:Ti	Artifact Source
Eureka Dunes	1	13		42	26	183	22	31	143	38	556	376	NM	0.67	19.0	41.0	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	2	25		52	26	186	22	34	157	33	615	398	NM	0.72	19.0	39.7	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	3	40		34	34	148	52	16	104	25	431	220	154	0.41	23.5	34.4	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	4	68		43	26	174	22	30	149	38	654	387	NM	0.73	19.8	37.8	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	5	100		43	30	171	19	28	143	34	627	361	NM	0.62	18.5	34.1	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	6	104		46	29	176	20	32	140	38	728	487	NM	0.89	18.3	40.7	Saline Valley 1
			±	7	3	3	7	3	7	2	96	48	NM	0.11			
Eureka Dunes	7	113		24	31	145	57	18	104	24	559	330	192	0.71	23.1	42.8	Unknown 1
			±	7	2	3	7	3	7	1	96	47	12	0.11			
Eureka Dunes	8	114		36	30	149	61	17	106	21	452	261	207	0.52	23.2	40.1	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	9	127		79	34	146	58	20	104	23	522	188	NM	0.32	23.6	23.5	Unknown 1 *
			±	8	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	10	131		58	30	169	19	31	138	36	763	457	NM	0.87	19.3	38.2	Saline Valley 1
			±	6	3	3	7	3	7	1	96	47	NM	0.11			
Eureka Dunes	11	132		44	27	176	21	32	147	40	757	534	NM	0.96	17.8	42.0	Saline Valley 1
			±	7	3	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	12	134		39	31	178	22	31	144	35	533	376	NM	0.69	19.6	44.1	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	13	150		49	29	152	49	24	124	32	539	376	NM	0.58	16.7	37.4	Saline Valley 2
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	14	152		58	32	185	22	35	145	38	580	416	NM	0.72	18.1	42.2	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	15	154		54	31	146	46	22	120	35	753	345	204	0.51	16.6	24.3	Saline Valley 2
			±	7	3	3	7	3	7	2	96	47	13	0.11			
Eureka Dunes	16	155		44	35	152	53	18	104	25	646	303	194	0.60	22.2	32.4	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Eureka Dunes, Death Valley National Park, Inyo County, California

	Specimen			Trace Element Concentrations											Ratios		
Site	No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe2O3^T	Fe:Mn	Fe:Ti	Artifact Source
Eureka Dunes	17	156		42	34	161	47	24	122	34	498	325	NM	0.52	18.0	36.7	Saline Valley 2
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	18	159		55	41	350	9	46	109	41	415	440	13	0.59	14.1	48.3	Montezuma Range?
			±	7	3	4	7	3	7	2	95	47	15	0.11			
Eureka Dunes	19	169		45	34	183	21	34	143	40	473	333	NM	0.56	18.6	40.9	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	20	170		40	30	176	21	31	144	34	769	459	NM	0.87	19.1	37.8	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	21	171		36	37	147	55	17	103	20	642	325	183	0.71	23.6	37.7	Unknown 1
			±	6	2	3	7	3	7	1	96	47	13	0.11			
Eureka Dunes	22	172		41	27	163	20	31	138	37	440	277	NM	0.45	19.3	36.8	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	23	173		44	31	181	20	30	144	37	705	502	NM	0.92	18.3	43.4	Saline Valley 1
			±	6	2	3	7	3	7	2	96	48	NM	0.11			
Eureka Dunes	24	174		35	32	143	55	16	105	22	637	332	183	0.76	24.5	40.2	Unknown 1
			±	6	3	3	7	3	7	1	96	47	12	0.11			
Eureka Dunes	25	177		45	30	184	19	30	141	38	587	408	NM	0.73	18.7	42.0	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	26	178		37	33	174	20	33	141	34	725	432	NM	0.79	18.7	36.5	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	27	185		43	29	167	21	33	141	34	774	498	NM	0.95	19.0	40.8	Saline Valley 1
			±	6	2	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	28	187		32	33	167	23	31	143	36	802	516	38	1.02	19.4	41.7	Saline Valley 1
			±	7	2	3	7	3	7	1	96	48	13	0.11			
Eureka Dunes	29	189		36	31	147	92	24	141	30	748	390	NM	0.81	21.6	36.5	Saline Valley 3
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	30	194		37	32	171	22	32	143	31	678	476	NM	0.87	18.4	42.6	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	31	196		46	32	173	20	34	137	36	662	423	NM	0.80	19.3	40.3	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	32	198		52	33	173	23	30	143	33	617	402	NM	0.70	18.2	38.5	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Eureka Dunes, Death Valley National Park, Inyo County, California

	Specimen			Trace Element Concentrations											Ratios		
Site	No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe2O3^T	Fe:Mn	Fe:Ti	Artifact Source
Eureka Dunes	33	201		43	33	174	22	31	145	36	656	416	NM	0.78	19.4	40.1	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	34	202		55	32	173	20	25	135	34	581	468	37	0.51	11.7	31.1	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	13	0.11			
Eureka Dunes	35	203		37	32	148	93	25	139	31	1003	403	311	0.87	22.1	29.0	Saline Valley 3
			±	7	3	3	7	3	7	2	96	47	12	0.11			
Eureka Dunes	36	204		48	27	181	23	31	145	31	822	444	NM	0.90	20.5	36.6	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	37	210		34	36	178	21	32	141	38	684	503	NM	0.92	18.2	44.4	Saline Valley 1
			±	7	2	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	38	211		50	34	168	133	18	200	16	641	185	1127	0.77	50.4	40.4	Casa Diablo (Sawmill Ridge)
			±	7	3	4	7	3	7	2	96	47	18	0.11			
Eureka Dunes	39	212		47	31	174	20	32	141	36	751	496	NM	0.98	19.5	43.0	Saline Valley 1
			±	6	3	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	40	214		41	28	184	21	32	144	32	669	453	NM	0.82	18.4	41.1	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	41	215		41	26	173	21	32	141	35	780	480	NM	0.92	19.1	39.0	Saline Valley 1
			±	7	3	3	7	3	7	2	96	48	NM	0.11			
Eureka Dunes	42	218		39	26	169	22	30	141	35	664	438	NM	0.82	19.0	41.2	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	43	219		47	31	184	21	33	149	38	724	481	NM	0.93	19.4	42.8	Saline Valley 1
			±	6	3	3	7	3	7	2	96	48	NM	0.11			
Eureka Dunes	44	229		48	28	175	22	31	137	39	712	479	NM	0.86	18.1	40.3	Saline Valley 1
			±	6	3	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	45	230		26	33	146	54	17	100	22	710	284	190	0.60	23.8	29.3	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	46	232		46	36	156	47	25	132	32	538	383	NM	0.66	18.3	41.7	Saline Valley 2
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	47	233		71	38	180	23	27	143	39	365	231	NM	0.31	17.8	32.6	Saline Valley 1
			±	8	4	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	48	234		47	33	174	20	30	140	38	710	413	NM	0.76	19.1	36.3	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Eureka Dunes, Death Valley National Park, Inyo County, California

	Specimen			Trace Element Concentrations											Ratios		
Site	No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe2O3^T	Fe:Mn	Fe:Ti	Artifact Source
Eureka Dunes	49	236		40	29	177	19	33	140	36	770	479	NM	0.93	19.4	40.1	Saline Valley 1
			±	7	3	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	50	238		51	30	187	21	30	138	40	717	378	NM	0.69	19.4	33.0	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	51	240		40	36	145	54	17	107	23	582	265	195	0.53	23.2	32.1	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	52	245		41	35	178	25	32	137	36	516	311	NM	0.53	19.2	35.9	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	53	248		46	28	177	20	31	151	35	569	424	NM	0.73	18.0	43.5	Saline Valley 1
			±	6	2	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	54	249		102	35	187	21	34	151	36	1495	412	26	0.74	18.6	17.0	Saline Valley 1
			±	7	3	4	7	3	7	2	96	47	14	0.11			
Eureka Dunes	55	250		37	32	181	19	33	148	38	702	440	NM	0.81	18.8	38.6	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	56	251		40	28	187	20	32	145	36	636	377	NM	0.64	18.3	34.8	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	57	252		38	32	182	22	33	142	38	710	434	NM	0.81	19.0	38.1	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	58	256		39	33	142	90	24	140	29	780	408	NM	0.87	21.7	37.1	Saline Valley 3
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	59	259		46	32	178	19	35	148	38	716	512	NM	0.97	18.7	44.6	Saline Valley 1
			±	6	2	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	60	265		40	32	166	50	24	127	35	370	284	NM	0.40	17.1	39.4	Saline Valley 2
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	61	270		37	32	179	19	28	142	38	677	408	NM	0.70	17.9	35.0	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	62	274		43	33	179	20	28	139	35	736	442	NM	0.78	18.2	35.9	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	63	275		43	31	177	20	32	140	37	619	328	36	0.51	17.5	29.3	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	13	0.11			
Eureka Dunes	64	277		35	29	144	54	17	102	22	742	320	200	0.70	23.7	32.3	Unknown 1
			±	7	3	3	7	3	7	1	96	47	13	0.11			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

Table A-1. Results of XRF Studies: Eureka Dunes, Death Valley National Park, Inyo County, California

	Specimen			Trace Element Concentrations											Ratios		
Site	No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe2O3^T	Fe:Mn	Fe:Ti	Artifact Source
Eureka Dunes	65	278		42	27	155	47	24	123	33	663	439	197	0.80	18.7	40.5	Saline Valley 2
			±	6	3	3	7	3	7	2	96	47	13	0.11			
Eureka Dunes	66	280		26	34	143	54	18	106	22	533	299	187	0.57	21.3	36.9	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	67	281		39	34	150	90	25	145	31	604	361	NM	0.67	19.8	37.8	Saline Valley 3
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	68	282		33	33	159	92	26	147	27	484	276	NM	0.50	20.9	36.2	Saline Valley 3
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	69	283		54	28	172	23	23	129	38	506	496	40	0.56	11.9	38.2	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	70	284		34	30	168	23	32	140	38	677	430	NM	0.74	17.8	37.1	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	71	285		59	29	178	21	23	130	34	642	493	54	0.58	12.3	31.3	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	72	286		45	28	177	20	32	140	36	696	458	NM	0.87	19.3	41.8	Saline Valley 1
			±	6	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	73	287		44	33	183	23	29	142	34	651	439	NM	0.79	18.4	40.7	Saline Valley 1
			±	6	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	74	290		60	32	189	19	27	146	33	727	391	NM	0.72	19.3	33.8	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	75	291		50	28	174	21	29	139	35	789	420	NM	0.81	19.7	34.5	Saline Valley 1
			±	6	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	76	292		54	30	188	23	31	147	37	730	494	NM	0.92	18.6	41.9	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	77	293		39	30	173	20	30	139	34	842	449	NM	0.81	18.3	32.3	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	78	295		49	28	172	22	32	144	35	359	280	NM	0.46	19.3	45.2	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	79	296		51	34	181	23	31	144	33	701	412	NM	0.76	19.1	36.7	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	80	298		36	31	173	22	27	137	32	676	315	55	0.54	19.2	28.2	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	13	0.11			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

Table A-1. Results of XRF Studies: Eureka Dunes, Death Valley National Park, Inyo County, California

	Specimen			Trace Element Concentrations											Ratios		
Site	No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	Artifact Source
Eureka Dunes	81	299		58	35	208	53	32	150	40	416	279	50	0.44	18.7	37.9	Unknown 2
			±	8	3	4	7	3	7	2	95	47	16	0.11			
Eureka Dunes	82	301		42	29	172	19	33	140	32	824	481	NM	0.94	19.5	38.0	Saline Valley 1
			±	6	3	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	83	303		43	30	177	20	33	143	39	631	456	NM	0.82	18.3	43.6	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	84	304		56	34	174	20	22	124	35	575	425	52	0.46	12.0	28.9	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	13	0.11			
Eureka Dunes	85	308		29	33	145	54	16	102	22	538	244	200	0.49	24.0	32.3	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	86	310		32	26	176	58	27	126	25	733	351	276	1.02	29.8	45.7	Sarcobatus Flat A [Obsidian Butte Variety H-3]
			±	7	3	3	7	3	7	1	96	47	13	0.11			
Eureka Dunes	87	312		29	40	148	55	17	100	19	559	288	210	0.62	24.1	38.2	Unknown 1
			±	7	2	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	88	313		43	30	179	22	31	147	38	720	427	NM	0.77	18.6	36.0	Saline Valley 1
			±	6	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	89	314		34	32	175	21	31	147	36	700	357	NM	0.63	19.0	31.0	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	90	316		47	45	214	11	32	97	45	368	772	22	0.62	8.1	57.1	Fish Springs
			±	7	3	3	7	3	7	2	95	48	13	0.11			
Eureka Dunes	91	317		53	32	329	8	43	105	38	232	409	4	0.51	13.7	74.3	Montezuma Range?
			±	7	3	4	7	3	7	2	95	47	12	0.11			
Eureka Dunes	92	319		38	30	185	23	33	149	37	483	326	NM	0.54	18.5	39.0	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	93	320		46	34	155	99	22	142	31	786	417	NM	0.91	22.2	38.6	Saline Valley 3
			±	6	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	94	322		40	29	173	19	33	146	34	681	467	NM	0.81	17.6	39.9	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	95	325		80	39	181	26	36	146	34	576	234	26	0.34	19.0	22.7	Saline Valley 1 *
			±	8	3	4	7	3	7	2	95	47	16	0.11			
Eureka Dunes	96	326		52	24	189	21	29	136	37	489	326	NM	0.57	19.3	40.3	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

Table A-1. Results of XRF Studies: Eureka Dunes, Death Valley National Park, Inyo County, California

	Specimen			Trace Element Concentrations											Ratios		
Site	No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe2O3^T	Fe:Mn	Fe:Ti	Artifact Source
Eureka Dunes	97	327		54	35	201	23	37	153	35	468	366	NM	0.61	18.0	44.7	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	98	330		50	36	179	21	30	151	36	422	314	NM	0.54	19.3	44.4	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	99	333		39	32	180	20	33	141	35	727	455	NM	0.81	18.1	37.3	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	100	334		30	28	167	22	32	134	36	640	368	NM	0.65	18.8	34.7	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	101	335		48	29	175	20	30	145	34	531	379	NM	0.66	18.5	42.3	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	102	337		46	34	201	30	30	149	36	540	374	NM	0.66	18.7	41.4	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	103	338		39	33	188	23	34	148	36	798	437	NM	0.78	18.3	33.0	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	104	340		40	31	179	23	35	141	33	801	475	NM	0.95	20.0	39.5	Saline Valley 1
			±	6	3	3	7	3	7	2	96	48	NM	0.11			
Eureka Dunes	105	341		36	36	152	55	15	106	24	358	247	173	0.45	22.2	44.7	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	106	342		51	34	182	22	32	146	38	688	481	NM	0.91	19.0	44.0	Saline Valley 1
			±	7	3	3	7	3	7	2	96	48	NM	0.11			
Eureka Dunes	107	353		37	31	178	19	32	146	39	780	382	11	0.67	18.5	29.4	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	19	0.11			
Eureka Dunes	108	355		30	39	150	55	14	107	25	414	269	190	0.53	22.8	44.4	Unknown 1
			±	7	3	3	7	3	7	2	95	47	13	0.11			
Eureka Dunes	109	357		29	36	160	56	18	104	23	498	253	194	0.49	22.8	34.6	Unknown 1
			±	7	3	3	7	3	7	2	95	47	14	0.11			
Eureka Dunes	110	379		41	30	174	18	32	140	34	726	440	NM	0.78	18.2	36.3	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	111	380		50	28	186	19	33	145	39	638	440	NM	0.81	18.9	42.7	Saline Valley 1
			±	7	3	3	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	112	386		53	33	183	21	32	150	39	439	304	NM	0.54	19.9	42.4	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

Table A-1. Results of XRF Studies: Eureka Dunes, Death Valley National Park, Inyo County, California

	Specimen			Trace Element Concentrations											Ratios		
Site	No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe2O3^{T}	Fe:Mn	Fe:Ti	Artifact Source
Eureka Dunes	113	400		37	30	175	22	31	139	33	783	516	NM	0.97	18.5	40.9	Saline Valley 1
			±	6	2	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	114	402		52	32	212	83	28	223	33	605	181	527	0.60	41.6	34.2	Fortymile, Tonopah Yucca Wash *
			±	7	3	4	7	3	7	2	96	47	14	0.11			
Eureka Dunes	115	403		25	32	134	52	16	102	23	577	285	186	0.63	24.7	37.5	Unknown 1
			±	7	2	3	7	3	7	1	95	47	12	0.11			
Eureka Dunes	116	440		53	25	168	20	30	139	34	742	516	NM	0.97	18.6	43.2	Saline Valley 1
			±	6	2	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	117	484		61	32	335	4	44	106	38	470	526	8	0.81	15.4	56.8	Montezuma Range?
			±	6	3	4	8	3	7	2	95	48	38	0.11			
Eureka Dunes	118	535		34	27	145	43	26	119	31	666	406	NM	0.74	19.0	37.6	Saline Valley 2
			±	6	3	3	7	3	7	1	96	47	NM	0.11			
Eureka Dunes	119	538		32	31	141	85	21	138	33	847	421	NM	0.93	22.3	36.5	Saline Valley 3
			±	7	2	3	7	3	7	1	96	47	NM	0.11			
Eureka Dunes	120	559		40	30	174	21	29	140	36	772	517	NM	0.97	18.6	41.7	Saline Valley 1
			±	6	2	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	121	560		29	32	146	56	19	103	21	612	335	193	0.76	24.2	41.8	Unknown 1
			±	7	3	3	7	3	7	1	95	47	12	0.11			
Eureka Dunes	122	564		38	31	149	87	24	144	30	649	367	NM	0.71	20.5	37.0	Saline Valley 3
			±	7	3	3	7	3	7	2	96	47	NM	0.11			
Eureka Dunes	123	573		44	32	176	20	32	146	35	661	540	NM	0.89	16.4	44.8	Saline Valley 1
			±	7	3	3	7	3	7	1	96	48	NM	0.11			
Eureka Dunes	124	599		56	34	180	23	35	144	41	452	249	NM	0.37	18.5	30.2	Saline Valley 1
			±	7	3	4	7	3	7	2	95	47	NM	0.11			
Eureka Dunes	125	621		58	31	168	30	31	140	37	774	431	54	0.81	19.4	35.4	Saline Valley 1
			±	7	3	3	7	3	7	2	96	47	13	0.11			
Eureka Dunes	126	243		31	31	158	14	31	129	30	408	274	41	0.46	18.6	42.2	Saline Valley 1
			±	7	3	3	10	3	6	2	68	43	14	0.12			
Eureka Dunes	127	698		28	23	110	10	23	97	19	283	202	35	0.32	19.5	46.0	Saline Valley 1
			±	7	3	3	10	3	6	2	68	43	14	0.12			
NA	RGM-1	RGM-1		44	25	158	109	26	221	9	1600	279	NM	1.82	67.1	36.6	RGM-1 Reference Standard
			±	7	3	3	7	3	7	2	97	47	NM	0.11			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

Abbreviations and Definitions Used in the Comments Column

A, B, C - 1st, 2nd, and 3rd cuts, respectively.
All hydration rim measurements are recorded in microns.

BEV - (Beveled). Artifact morphology or cut configuration resulted in a beveled thin section edge.

BRE - (BREak). The thin section cut was made across a broken edge of the artifact. Resulting hydration measurements may reveal when the artifact was broken, relative to its time of manufacture.

DES - (DEStroyed). The artifact or flake was destroyed in the process of thin section preparation. This sometimes occurs during the preparation of extremely small items, such as pressure flakes.

DFV - (Diffusion Front Vague). The diffusion front, or the visual boundary between hydrated and unhydrated portions of the specimen, are poorly defined. This can result in less precise measurements than can be obtained from sharply demarcated diffusion fronts. The technician must often estimate the hydration boundary because a vague diffusion front often appears as a relatively thick, dark line or a gradation in color or brightness between hydrated and unhydrated layers.

DIS - (DIScontinuous). A discontinuous or interrupted hydration rind was observed on the thin section.

HV - (Highly Variable). The hydration rind exhibits variable thickness along continuous surfaces. This variability can occur with very well- defined bands as well as those with irregular or vague diffusion fronts.

IRR - (IRRegular). The surfaces of the thin section (the outer surfaces of the artifact) are uneven and measurement is difficult.

1SO - (1 Surface Only). Hydration was observed on only one surface or side of the thin section.

NOT - (NOT obsidian). Petrographic characteristics of the artifact or obsidian specimen indicate that the specimen is not obsidian.

NVH - (No Visible Hydration). No hydration rind was observed on one or more surfaces of the specimen. This does not mean that hydration is absent, only that hydration was not observed. Hydration rinds smaller than one micron often are not birefringent and thus cannot be seen by optical microscopy. "NVH" may be reported for the manufacture surface of a tool while a hydration measurement is reported for another surface, e.g. a remnant ventral flake surface.

OPA - (OPAque). The specimen is too opaque for measurement and cannot be further reduced in thickness.

PAT - (PATinated). This description is usually noted when there is a problem in measuring the thickness of the hydration rind, and refers to the unmagnified surface characteristics of the artifact, possibly indicating the source of the measurement problem. Only extreme patination is normally noted.

REC - (RECut). More than one thin section was prepared from an archaeological specimen. Multiple thin sections are made if preparation quality on the initial specimen is suspect or obviously poor. Additional thin sections may also be prepared if it is perceived that more information concerning an artifact's manufacture or use can be obtained.

UNR - (UNReadable). The optical quality of the hydration rind is so poor that accurate measurement is not possible. Poor thin section preparation is not a cause.

WEA - (WEAthered). The artifact surface appears to be damaged by wind erosion or other mechanical action.

Appendix C

Radiocarbon Dating
Analytical Procedures and Final Report

Lethia Cerda
Beta Analytic, Inc.

BETA

Consistent Accuracy
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MR. DARDEN HOOD
Director

Mr. Ronald Hatfield
Laboratory Manager

Mr. Christopher Patrick
Ms Teresa Zilko-Miller
Associate Managers

July 8, 2000

Mr. Jeff Burton
National Park Service
Western Archaeological and Conservation Center
1415 N. 6th Avenue
Tucson, AZ 85705
USA

Dear Mr. Burton:

Enclosed are radiocarbon dating results for one charcoal and three sediment samples recently sent to us. They provided plenty of carbon for reliable measurements and the analysis went normally. The report sheet contains the dating results, method used, material type, applied pretreatments and calendar calibration results (where applicable) for each sample.

This report has been both mailed and sent electronically, along with a graphical representation of a calendar calibration, if appropriate. Calendar calibrations are available as individual Windows metafiles (wmf) upon request. These are useful for incorporating directly into your reports. Calibrations are calculated using the newest (1998) calibration data. References are quoted on the bottom of each calibration page. The upper limit is about 20,000 years for calendar calibration. Multiple probability ranges may appear in some cases, due to short term variations in the atmospheric 14C contents at certain time periods. Examining the calibration graphs will help you understand this phenomenon.

We analyzed these samples on a sole priority basis. No students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. They were analyzed by our full-time professional staff.

Information pages are also enclosed with the mailed copy of this report. They should answer most of any questions you may have, if they do not, please do not hesitate to contact us for specific discussions. Someone is always available to talk to you.

The cost of the analysis was charged to your MASTERCARD. A receipt is enclosed. Thank you.

Sincerely,
Lethia Cerda

Lethia Cerda

BETA ANALYTIC INC.
RADIOCARBON DATING SERVICES

Mr. DARDEN G. HOOD
Director

RONALD E. HATFIEL
Laboratory Manage

CHRISTOPHER PATRIC
TERESA A. ZILKO-MILLE
Associate Manager

ANALYTICAL PROCEDURES AND FINAL REPORT

FINAL REPORT

This package includes the final date report, this statement outlining our analytical procedures, a glossary of pretreatment terms, calendar calibration information, billing documents (containing balance/credit information and the number of samples submitted within the yearly discount period), and peripheral items to use with future submittals. The final report includes the individual analysis method, the delivery basis, the material type and the individual pretreatments applied. Please recall any correspondences or communications we may have had regarding sample integrity, size, special considerations or conversions from one analytical technique to another (e.g. radiometric to AMS). The final report has also been sent by fax or e-mail, where available.

PRETREATMENT

Results were obtained on the portion of suitable carbon remaining after any necessary chemical and mechanical pretreatments of the submitted material. Pretreatments were applied, where necessary, to isolate ^{14}C which may best represent the time event of interest. Individual pretreatments are listed on the report next to each result and are defined in the enclosed glossary. When interpreting the results, it is important to consider the pretreatments. Some samples cannot be fully pretreated making their ^{14}C ages more subjective than samples which can be fully pretreated. Some materials receive no pretreatments. Please read the pretreatment glossary.

ANALYSIS

Materials measured by the radiometric technique were analyzed by synthesizing sample carbon to benzene (92% C), measuring for ^{14}C content in a scintillation spectrometer, and then calculating for radiocarbon age. If the Extended Counting Service was used, the ^{14}C content was measured for a greatly extended period of time. AMS results were derived from reduction of sample carbon to graphite (100 %C), along with standards and backgrounds. The graphite was then sent for ^{14}C measurement in an accelerator-mass-spectrometer located at one of six collaborating research facilities, who return the results to us for verification, isotopic fractionation correction, calendar calibration, and reporting.

THE RADIOCARBON AGE AND CALENDAR CALIBRATION

The "Conventional C14 Age (*)" is the result after applying C13/C12 corrections to the measured age and is the most appropriate radiocarbon age (the "*" is discussed at the bottom of the final report). Applicable calendar calibrations are included for organic materials and fresh water carbonates between 0 and 10,000 BP and for marine carbonates between 0 and 8,300 BP. If certain calibrations are not included with this report, the results were either too young, too old, or inappropriate for calibration.

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PRETREATMENT GLOSSARY

Pretreatment of submitted materials is required to eliminate secondary carbon components. These components, if not eliminated, could result in a radiocarbon date which is too young or too old. Pretreatment does not ensure that the radiocarbon date will represent the time event of interest. This is determined by the sample integrity. The old wood effect, burned intrusive roots, bioturbation, secondary deposition, secondary biogenic activity incorporating recent carbon (bacteria) and the analysis of multiple components of differing age are just some examples of potential problems. The pretreatment philosophy is to reduce the sample to a single component, where possible, to minimize the added subjectivity associated with these types of problems.

id/alkali/acid"

The sample was first gently crushed/dispersed in deionized water. It was then given hot HCl acid washes to eliminate carbonates and alkali washes (NaOH) to remove secondary organic acids. The alkali washes were followed by a final acid rinse to neutralize the solution prior to drying. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of the sample. Each chemical solution was neutralized prior to application of the next. During these serial rinses, mechanical contaminants such as associated sediments and rootlets were eliminated. This type of pretreatment is considered a "full pretreatment". On occasion the report will list the pretreatment as "acid/alkali/acid - insolubles" to specify which fraction of the sample was analyzed. This is done on occasion with sediments (See "acid/alkali/acid - solubles"

Typically applied to: charcoal, wood, some peats, some sediments, textiles

d/alkali/acid - solubles"

On occasion the alkali soluble fraction will be analyzed. This is a special case where soil conditions imply that the soluble fraction will provide a more accurate date. It is also used on some occasions to verify the present/absence or degree of contamination present from secondary organic acids. The sample was first pretreated with acid to remove any carbonates and to weaken organic bonds. After the alkali washes (as discussed above) are used, the solution containing the alkali soluble fraction is isolated/filtered and combined with acid. The soluble fraction which precipitates is rinsed and dried prior to combustion.

washes"

Surface area was increased as much a possible. Solid chunks were crushed, fibrous materials were shredded, and sediments were dispersed. Acid (HCl) was applied repeatedly to ensure the absence of carbonates. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of each sample. The sample, for a number of reasons, could not be subjected to alkali washes to ensure the absence of secondary organic acids. The most common reason is that the primary carbon is soluble in the alkali. Dating results reflect the total organic content of the analyzed material. Their accuracy depends on the researcher's ability to subjectively eliminate potential contaminants based on contextual facts.

Typically applied to: organic sediments, some peats, small wood or charcoal, special cases

gen extraction"

The material was first tested for friability ("softness"). Very soft bone material is an indication of the potential absence of the collagen fraction (basal bone protein acting as a "reinforcing agent" within the crystalline apatite structure). It was then washed in de-ionized water and gently crushed. Dilute, cold HCl acid was repeatedly applied and replenished until the mineral fraction (bone apatite) was eliminated. The collagen was then dissected and inspected for rootlets. Any rootlets present were also removed when replenishing the acid solutions. Where possible, usually dependant on the amount of collagen available, alkali (NaOH) was also applied to ensure the absence of secondary organic acids.

Typically applied to: bones

"acid etch"

The calcareous material was first washed in de-ionized water, removing associated organic sediments and debris (where present). The material was then crushed/dispersed and repeatedly subjected to HCl etches to eliminate secondary carbonate components. In the case of thick shells, the surfaces were physically abraded prior to etching down to a hard, primary core remained. In the case of porous carbonate nodules and caliche, very long exposure times were applied to allow infiltration of the acid. Acid exposure times, concentrations, and number of repetitions, were applied accordingly with the uniqueness of the sample.

Typically applied to: shells, caliche, calcareous nodules

"neutralized"

Carbonates precipitated from ground water are usually submitted in an alkaline condition (ammonium hydroxide or sodium hydroxide solution). Typically this solution is neutralized in the original sample container, using deionized water. If larger volume dilution was required, the precipitate and solution were transferred to a sealed separatory flask and rinsed to neutrality. Exposure to atmosphere was minimal.

Typically applied to: Strontium carbonate, Barium carbonate
(i.e. precipitated ground water samples)

"none"

No laboratory pretreatments were applied. Special requests and pre-laboratory pretreatment usually accounts for this.

"acid/alkali/acid/cellulose extraction"

Following full acid/alkali/acid pretreatments, the sample is rinsed in NaClO2 under very controlled conditions (Ph = 3, temperature = 70 degrees C). This eliminates all components except wood cellulose. It is useful for woods which are either very old or highly contaminated.

Applied to: wood

"carbonate precipitation"

Dissolved carbon dioxide and carbonate species are precipitated from submitted water by complexing them as amonium carbonate. Strontium chloride is added to the ammonium carbonate solution and strontium carbonate is precipitated for the analysis. The result is representative of the dissolved inorganic carbon within the water. Results are reported as "water DIC".

Applied to: water

BETA
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REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jeff Burton
National Park Service

Report Date: 7/8/2000
Material Received: 5/26/2000

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 143640 SAMPLE : DEVA1999G266 ANALYSIS : Radiometric-Standard delivery (bulk low carbon analysis on sediment) MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal AD 630 to 885 (Cal BP 1320 to 1065)	1300 +/- 70 BP	-25.0* o/oo	1300 +/- 70* BP
Beta - 143641 SAMPLE : DEVA1999G358 ANALYSIS : Radiometric-Standard delivery (concentration of charcoal from within sediment matrix) MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1275 to 1410 (Cal BP 675 to 540)	650 +/- 50 BP	-25.0* o/oo	650 +/- 50* BP
Beta - 143642 SAMPLE : DEVA1999G361 ANALYSIS : Radiometric-Standard delivery (bulk low carbon analysis on sediment) MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal AD 640 to 875 (Cal BP 1310 to 1075)	1300 +/- 60 BP	-25.0* o/oo	1300 +/- 60* BP
Beta - 143643 SAMPLE : DEVA1999G365 ANALYSIS : Radiometric-Standard delivery (bulk low carbon analysis on sediment) MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal BC 5 to Cal AD 250 (Cal BP 1955 to 1700)	1890 +/- 60 BP	-25.0* o/oo	1890 +/- 60* BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = 1950A.D.). By International convention, the modern reference standard was 95% of the C14 content of the National Bureau of Standards' Oxalic Acid & calculated using the Libby C14 half life (5568 years). Quoted errors represent 1 standard deviation statistics (68% probability) & are based on combined measurements of the sample, background, and modern reference standards.

Measured C13/C12 ratios were calculated relative to the PDB-1 international standard and the RCYBP ages were normalized to -25 per mil. If the ratio and age are accompanied by an (*), then the C13/C12 value was estimated, based on values typical of the material type. The quoted results are NOT calibrated to calendar years. Calibration to calendar years should be calculated using the Conventional C14 age.

BETA ANALYTIC INC.
RADIOCARBON DATING LABORATORY
CALIBRATED C-14 DATING RESULTS

Calibrations of radiocarbon age determinations are applied to convert BP results to calendar years. The short term difference between the two is caused by fluctuations in the heliomagnetic modulation of the galactic cosmic radiation and, recently, large scale burning of fossil fuels and nuclear devices testing. Geomagnetic variations are the probable cause of longer term differences.

The parameters used for the corrections have been obtained through precise analyses of hundreds of samples taken from known-age tree rings of oak, sequoia, and fir up to about 10,000 BP. Calibration using tree-rings to about 12,000 BP is still being researched and provides somewhat less precise correlation. Beyond that, up to about 20,000 BP, correlation using a modeled curve determined from U/Th measurements on corals is used. This data is still highly subjective. Calibrations are provided up to about 19,000 years BP using the most recent calibration data available (Radiocarbon, Vol 40, No. 3, 1998).

The Pretoria Calibration Procedure (Radiocarbon, Vol 35, No. 1, 1993, pg 317) program has been chosen for these calendar calibrations. It uses splines through the tree-ring data as calibration curves, which eliminates a large part of the statistical scatter of the actual data points. The spline calibration allows adjustment of the average curve by a quantified closeness-of-fit parameter to the measured data points. A single spline is used for the precise correlation data available back to 9900 BP for terrestrial samples and about 6900 BP for marine samples. Beyond that, splines are taken on the error limits of the correlation curve to account for the lack of precision in the data points.

In describing our calibration curves, the solid bars represent one sigma statistics (68% probability) and the hollow bars represent two sigma statistics (95% probability). Marine carbonate samples that have been corrected for δ 13/12C, have also been corrected for both global and local geographic reservoir effects (as published in Radiocarbon, Volume 35, Number 1, 1993) prior to the calibration. Marine carbonates that have not been corrected for δ 13/12C are adjusted by an assumed value of 0 ‰ in addition to the reservoir corrections. Reservoir corrections for fresh water carbonates are usually unknown and are generally not accounted for in those calibrations. In the absence of measured δ 13/12C ratios, a typical value of -5 ‰ is assumed for freshwater carbonates.

(Caveat: the correlation curve for organic materials assume that the material dated was living for exactly ten years (e.g. a collection of 10 individual tree rings taken from the outer portion of a tree that was cut down to produce the sample in the feature dated). For other materials, the maximum and minimum calibrated age ranges given by the computer program are uncertain. The possibility of an "old wood effect" must also be considered. as well as the potential inclusion of younger or older material in matrix samples. Since these factors are indeterminant error in most cases, these calendar calibration results should be used only for illustrative purposes. In the case of carbonates, reservoir correction is theoretical and the local variations are real, highly variable and dependant on provenience. Since imprecision in the correlation data beyond 10,00 years is high, calibrations in this range are likely to change in the future with refinement in the correlation curve. The age ranges and especially the intercept ages generated by the program, must be considered as approximations.)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

ariables used in the
alculation of age calibration →

(Variables: est. C13/C12=-25:lab. mult=1)

The uncalibrated Conventional
Radiocarbon Age (± 1 sigma)

Laboratory number: **Beta-123456**

Conventional radiocarbon age[1]: **2400±60 BP**

e calendar age
nge in both
lendar years
D or BC) and in
adiocarbon Years
P) →

2 Sigma calibrated result: **Cal BC 770 to 380 (Cal BP 2720 to 2330)**
(95% probability)

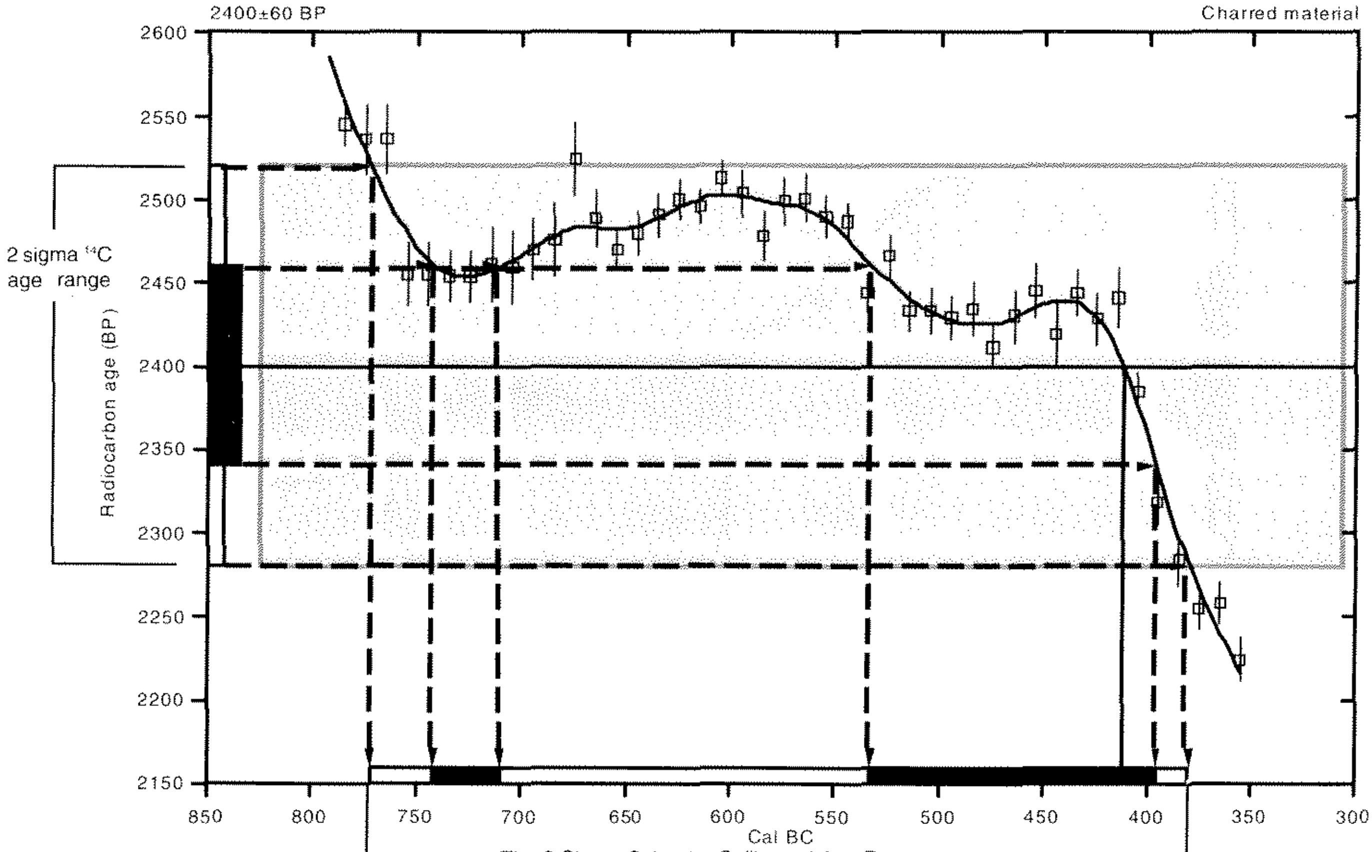
[1] *C13/C12 ratio estimated*

The intercept between the average radiocarbon age and the calibrated curve time scale. This value is illustrative and should not be used by itself.

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 410 (Cal BP 2360)

1 Sigma calibrated result: Cal BC 740 to 710 (Cal BP 2690 to 2660) and
(68% probability) Cal BC 535 to 395 (Cal BP 2485 to 2345)



The 2 Sigma Calendar Calibrated Age Range

This range is determined by the portion of the curve that is in a "box" drawn from the 2 sigma limits on the radiocarbon age. If a section of the curve goes outside of the "box", multiple ranges will occur as shown by the two 1 sigma ranges which occur from sections going outside of a similar "box" which would be drawn at the 1 sigma limits.

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Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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References for the calibration da
and the mathematics applied to
data. These references, as well
the Conventional Radiocarbon A
and the 13C/12C ratio used sho
be included in your papers.

Beta Analytic Radiocarbon Dating Laboratory

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

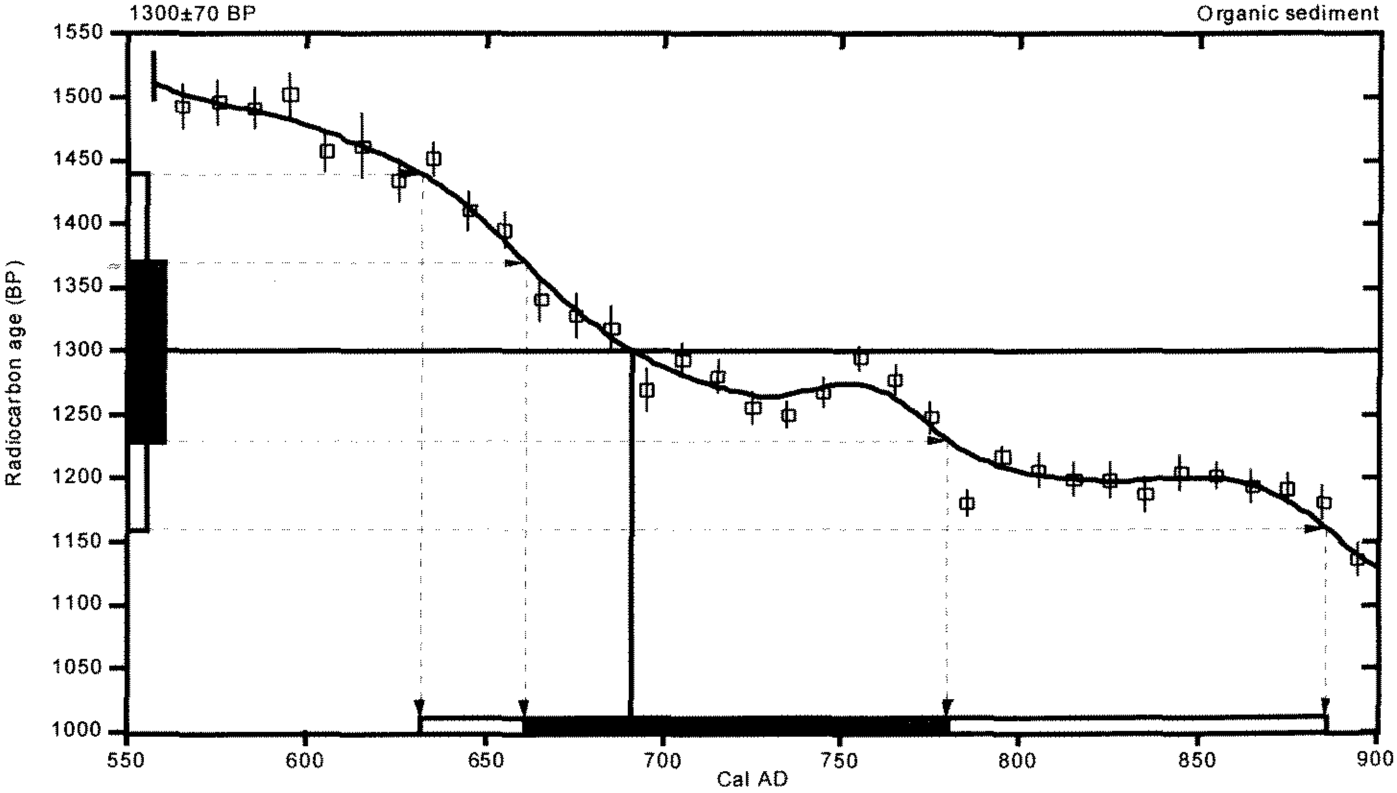
(Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number:	**Beta-143640**
Conventional radiocarbon age[1]:	**1300±70 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 630 to 885 (Cal BP 1320 to 1065)**

[1] *C13/C12 ratio estimated*

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 690 (Cal BP 1260)
1 Sigma calibrated result: (68% probability)	Cal AD 660 to 780 (Cal BP 1290 to 1170)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

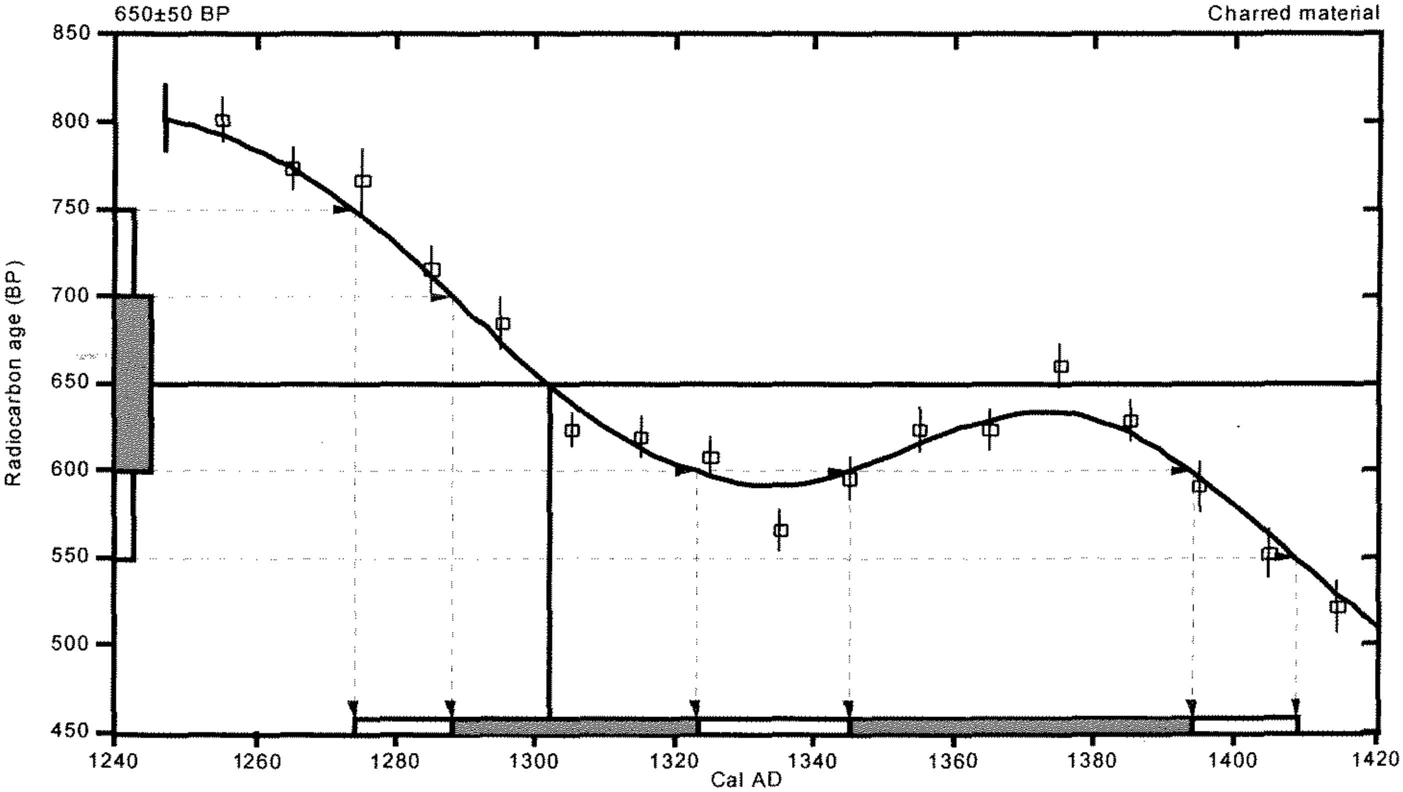
(Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number:	**Beta-143641**
Conventional radiocarbon age[1]:	**650±50 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 1275 to 1410 (Cal BP 675 to 540)**

[1] *C13/C12 ratio estimated*

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1300 (Cal BP 650)
1 Sigma calibrated results: (68% probability)	Cal AD 1290 to 1325 (Cal BP 660 to 625) and Cal AD 1345 to 1395 (Cal BP 605 to 555)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

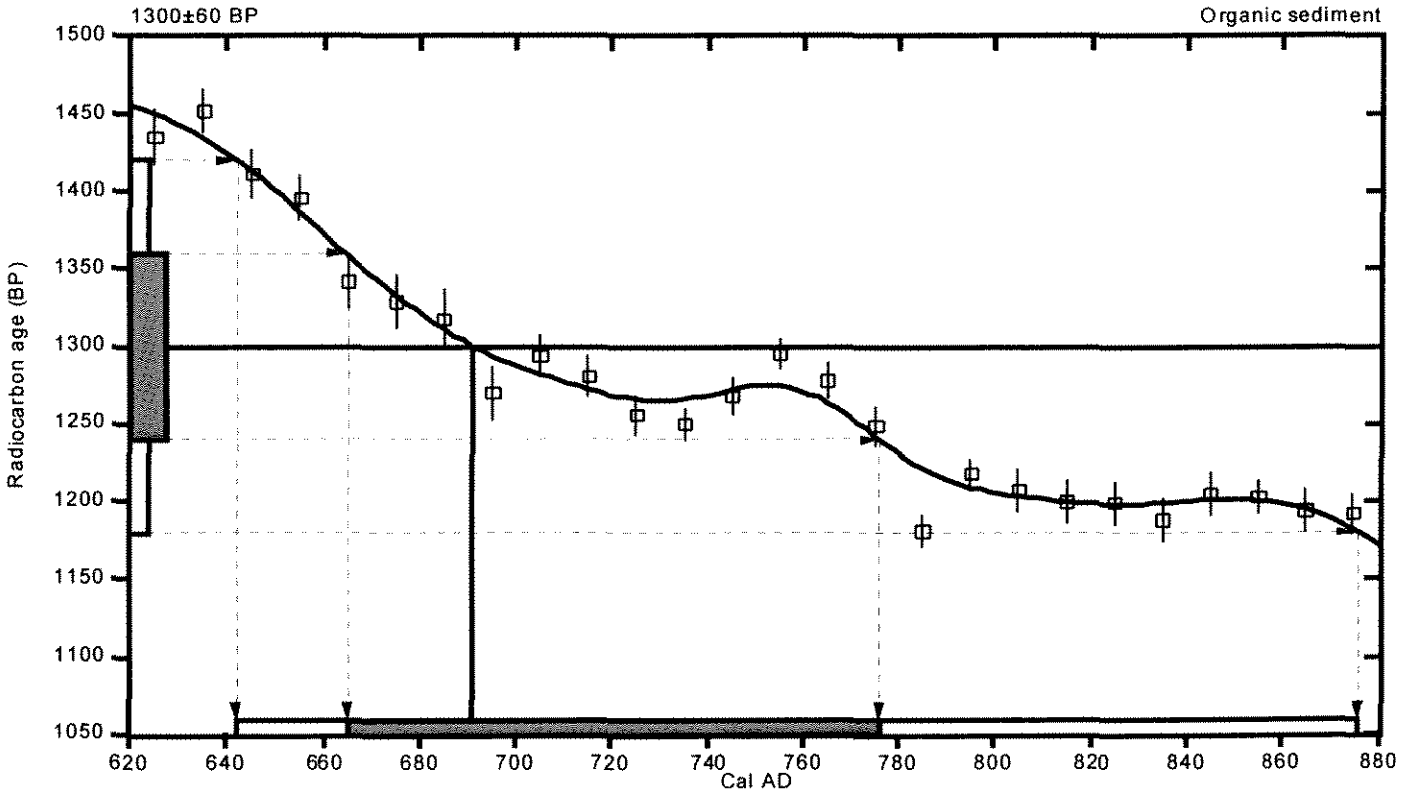
(Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number:	**Beta-143642**
Conventional radiocarbon age[1]:	**1300±60 BP**
2 Sigma calibrated result: **(95% probability)**	**Cal AD 640 to 875 (Cal BP 1310 to 1075)**

[1] C13/C12 ratio estimated

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 690 (Cal BP 1260)
1 Sigma calibrated result: (68% probability)	Cal AD 665 to 775 (Cal BP 1285 to 1175)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number: **Beta-143643**

Conventional radiocarbon age[1]: **1890±60 BP**

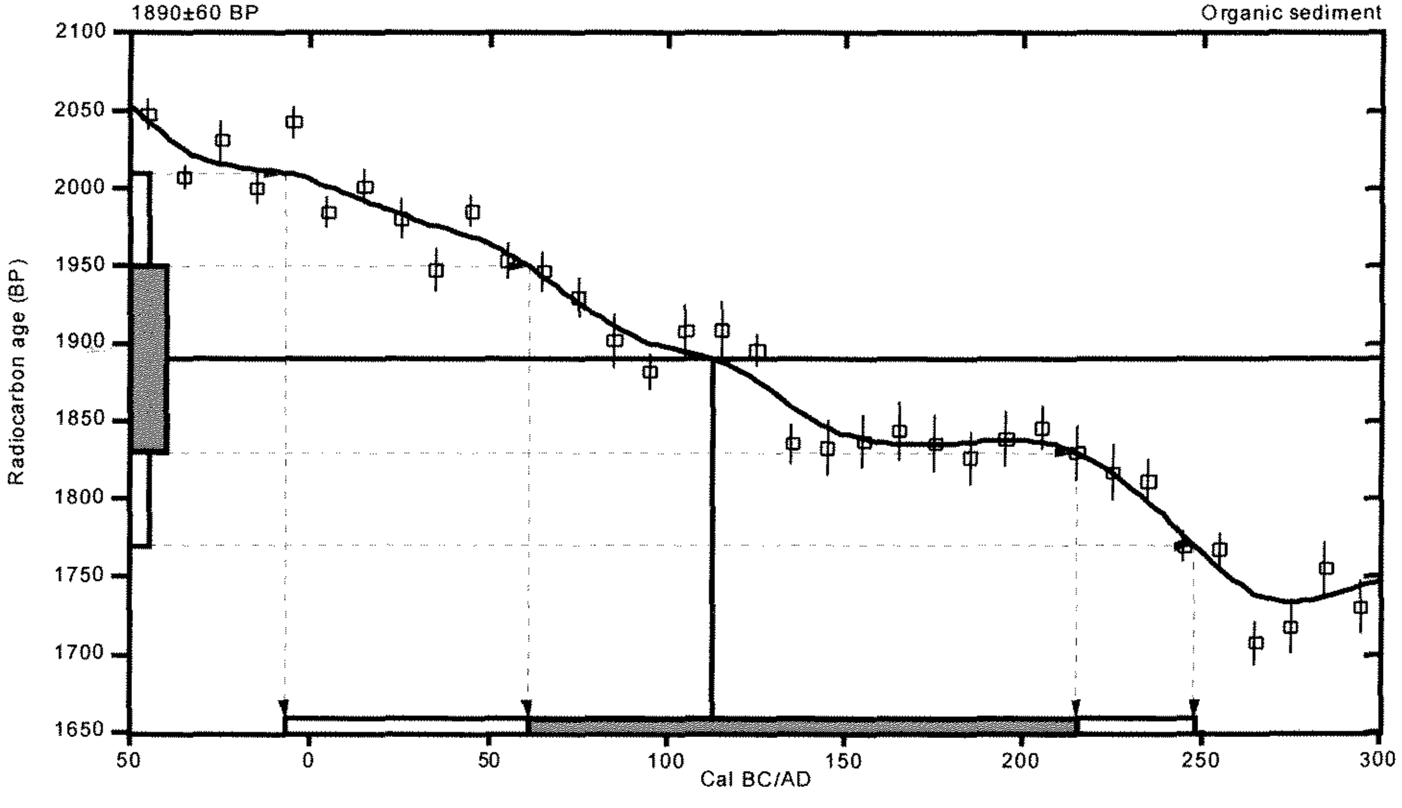
2 Sigma calibrated result: (95% probability) **Cal BC 5 to Cal AD 250 (Cal BP 1955 to 1700)**

[1] *C13/C12 ratio estimated*

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 115 (Cal BP 1835)

1 Sigma calibrated result: (68% probability) Cal AD 60 to 215 (Cal BP 1890 to 1735)



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