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Front cover: Pigmented arrow and dart fragments from Gypsum Cave (Composite photo by Jelmer W. Eerkens).

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IN MEMORIAM

Alan Kelsey Brown

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With the passing of Alan Kelsey Brown, we have lost an exemplary scholar who meticulously translated and edited primary documents pertaining to first contacts with the native peoples of the Pacific Coast region. Alan's early work with Fr. Juan Crespí's journals of 1769–1770 and with mission records produced new information about California Indian societies, representing an interest that persisted throughout his career and led to an impressive number of original contributions. Alan's publications and his active correspondence with specialists in the disciplines of archaeology, history, and linguistics encouraged others to undertake their own ethnohistorical investigations in order to glean information about California's first peoples during the Spanish colonial period.

Alan Kelsey Brown was born in San Francisco on December 21, 1933. His parents were Orrin Henry ("Hank") Brown and Mary Electa Kelsey. Alan's father was one of the pioneers in the radio electronics industry in the San Francisco area, and his paternal great grandfather had been a forty-niner who emigrated from Chicago during the Gold Rush. Alan's mother was the daughter of Charles Edwin Kelsey, a San Jose attorney whose advocacy for California Indian rights had resulted in his appointment as Special Indian Agent in 1905. Alan was proud of his grandfather's service on behalf of California Indians, and this undoubtedly stimulated his long-lasting interest in the descriptions of native peoples found in the writings of Spanish missionaries and explorers. Alan grew up hearing his mother's childhood recollections of Ishi, the last Yahi, who once sat down and played with her when he was a guest for dinner at the Kelsey household.

Alan grew up in Redwood City. When he was a boy, he had his own row boat that he would take out into the south arm of San Francisco Bay, where he would observe the natural world of nearshore estuaries. His first published article in the *Junior Naturalist*, written when he was thirteen, expressed his concern about the "reclamation" of marshland and the resultant loss of habitat for the clapper rail and other native water birds (Brown 1947). Alan's parents divorced when he was about eleven or twelve years old. His mother, having undertaken graduate studies in English at Stanford University, taught English as a second language. As a result of his mother's profession, Alan became interested in foreign languages and developed a natural aptitude for their acquisition.[1]

Alan obtained his B.A. in English from Hamilton College, New York in 1956, having also studied for a year at the University of California, Berkeley. After two years of service in the U.S. Army in 1956–58, he began graduate studies in English philology at Stanford University. Having grown up next to San Francisco Bay, Alan had early on developed an interest in the history of the region, and as a teenager once wrote to Dr. Frank M. Stanger, a community college professor of history, to question him regarding something Stanger had written. Stanger invited Alan to attend meetings of the San Mateo County Historical Association and mentored him in California history (Brown 1988). Alan delved into archival sources, particularly sources pertaining to Spanish and Mexican California, in order to find out about the early history and natural environment of the region. Stanger edited the historical association's journal, *La Peninsula*, to which Alan contributed several articles both during and after undertaking his graduate studies at Stanford.

One of Alan's early collaborations with Stanger involved a special issue on the early history of Half Moon Bay, which was based in part upon a more detailed, unpublished manuscript that Alan had authored (Stanger and Brown 1960). In this issue, he suggested that Half Moon Bay should be considered a candidate location for Francis Drake's 1579 port of New Albion, because its probable shoreline in the sixteenth century resembled that shown in the famous Hondius map of Drake's voyage, and it was "at least as good for Drake's purposes as any [other bays] that have been considered." Alan noted that the former (Ohlone/Costanoan) Indian village of *Shagúnt*e was associated with a shellmound that might correspond to the location on the Hondius map where a group of Indians were shown gathered around a ceremonial fire. He compared the descriptions of Indian houses in Drake's account with the nearly identical terms that were used to describe native dwellings in the journals of the first Spanish land expedition that passed through the area. He commented that "there is no other place in California where this type of construction is known to have been regularly used" (Brown 1960a). Alan's proposal has found few adherents among the scholars who have subsequently considered the issue of Drake's landing place, but it did result in the first mayor of the recently incorporated city of Half Moon Bay issuing an official proclamation that their bay was where Drake had stopped, and "anyone not complying with this order shall be punished by carrying a rock as large as he or she can handle to the new breakwater."

Brown's comment about the first Spanish land expedition in his 1960 article reveals that his lifelong passion for probing explorers' diaries had already begun. Alan was an archival researcher par excellence, and his proficiency in Spanish and other European languages proved to be a great asset throughout his career. Although Alan's doctoral dissertation, completed in 1969, centered on eighth-century Latin and Old English texts, he continued to pursue his interests in locating original manuscripts containing the first descriptions of Alta California by Spanish explorers. Combining the zeal of a historian and linguist, Alan sought to read primary documents in their original Spanish and to trace the textual histories of manuscripts that had served as a basis for later versions that were eventually published. He was soon making discoveries involving details that other scholars had overlooked.

Upon being advanced to candidacy, Brown was hired in 1963 as an instructor in the Department of English at the University of Arizona. His archival research continued unabated, and the following year Alan announced the discovery of a hitherto unrecognized version of the journal of Fr. Juan Crespí, a missionary who accompanied the first Spanish expedition, led by Gaspar de Portolá, to explore coastal Alta California in 1769. He soon published his thoroughly documented analysis of the journal's textual genealogy and showed how Crespí's original account had been redacted by his superiors because it was deemed too wordy. Although attributed to Crespí, the version eventually published was actually a composite account that had been combined with portions of the more succinct diary kept by the expedition's engineer, Miguel Costansó (Brown 1965). Through his research, Alan had come to the conclusion that much remained to be done with regard to the political and documentary aspects of the Spanish exploration and settlement of Alta California. He approached the University of California Press with an ambitious proposal to publish a multi-volume work that would include a full translation of the original Crespí journals, other unpublished documents, and fresh translations of the diaries of Portolá and Costansó.[2] Although this comprehensive project was not funded at the time, Alan never wavered from his intention to achieve, one way or another, his goal of publishing Crespí's and other explorers' richly detailed first-hand descriptions of the native peoples and natural environment of California.

Several themes run through Brown's work on California. His early fascination with the history of the San Francisco Bay region resulted in publications on local placenames and their origins (Brown 1964, 1975a). His research into explorers' diaries and the earliest maps of the region not only provided evidence for when placenames first appeared, but also fed other strong interests pertaining to California Indians and the natural environment that they inhabited at the time of contact. His first major publication, based upon the diaries of Crespí and other members of the 1769–1770 expedition, was *The Aboriginal Population of the Santa Barbara Channel* (1967), which appeared in the *Reports of the University of California Archaeological Survey* series. This masterful study combined data from explorers' accounts, mission baptismal records, and archaeological reports to reconstruct aboriginal settlement patterns in the Santa Barbara Channel region and derive population estimates for each of the coastal Chumash towns. Brown's ethnohistorical approach was a revelation to archaeologists working in the region, and his work soon became an essential reference for those who wished to understand the people behind the artifacts being excavated. Stimulated by Brown's successful use of mission records to recover information about the past, a number of archaeologists began using these documents to shed light on settlement geography, demographic patterns, and intervillage kin relationships throughout the Chumash region.[3]

Alan's mother had remarried in 1953 and had moved to live with her husband, Thomas Patterson, who was a professor in the Drama Department at the University of North Carolina. During visits to his mother's home, Alan became acquainted with Isabel Masterton, whose family lived next door. Isabel was working at the Duke University library when she went on her first date with Alan about 1964. After completing his Ph.D. in 1969, Alan sought a permanent faculty position; he was hired by the English Department at Ohio State University the following year. Isabel and he were married immediately thereafter, and their daughter Meta and son Stephen followed within a few years. At Ohio State University, Alan taught courses in Medieval and Renaissance studies, Old English, and the History of the English Language. His courses in these subjects were enlivened by his ability to perform the ancient poetry in class. As one of his colleagues remembered:

> Using his knowledge of early musical modes and his careful analysis of the bard-scenes in old Germanic poetry, [Alan] constructed an Anglo-Saxon lyre upon which he would perform sections of the poetry that students were in the process of studying. Certainly one of his most memorable contributions to the university community at large was his annual appearance at the Medieval/Renaissance Fair. Dressed in robes and with lyre in hand, he would perform *Beowulf* from memory, a performance that took several hours to complete. Thronging together at his feet were scores of undergraduates, entranced both by the music and by the costumed figure giving it voice.[4]

Being a renaissance scholar himself, Brown was not content with concentrating merely on texts pertaining to *Beowulf*, the Venerable Bede, and the Epinal Glossary. He never lost sight of his goal of contributing to his separate field of study regarding the Spanish archival records of early California. During the same year that he completed his Ph.D. in English philology, Alan collaborated with Frank Stanger on *Who Discovered the Golden Gate?* (1969), a work which included an analysis of the routes traveled by the members of the various expeditions who discovered and mapped San Francisco Bay in 1769–1776. Brown's translations of the explorers' own accounts comprised more than half of the volume. His interest in using colonial documents to shed light on the California Indian experience may be seen in both "The Indians of San Mateo County" (1973a) and "Pomponio's World" (1975b). Because of his interest in linguistic topics, Brown recognized the importance of early Spanish observations on language affinities among indigenous groups, word lists collected by explorers, and the rich documentary record of placenames and personal names contained in mission registers. He advocated the use of such sources in his essay on "San Francisco Bay Costanoan," published in the *International Journal of American Linguistics* (1973b).

Although his teaching and professional responsibilities at Ohio State University delayed Alan from his objective of publishing a complete edition of the Crespí diaries, he generously allowed portions of his translations to be excerpted and published by others in various venues (Brown 2001:138). In addition to the partial listing of examples given in the bibliography below, Alan would always respond promptly and positively to requests by anthropologists and archaeologists working in various parts of California to include quotations from the Crespí journals in their reports and articles. One such researcher, Randall Milliken, included Brown as an outside member of his graduate committee for his M.A. thesis, which involved a detailed ethnogeographic study of the original sociopolitical groups on the San Francisco peninsula, utilizing mission records and other Spanish documents.

Brown's goal of publishing translations of the principal documents from the "First Expedition" of 1769–1770 was gradually met over time. In 1983, he provided an English translation of a Spanish book about Gaspar de Portolá, the first Governor of the Californias. This biography was authored by Dr. Fernando Boneu Companys, a native of Portolá's home town of Balaguer in Catalonia. With Boneu's permission, the English edition of this work incorporated the results of Brown's archival research in Mexico and the United States, and presented fresh translations of the expeditionary diaries of Portolá and Costansó. These translations improved upon previous publications, because Brown carefully compared the two extant copies of Portolá's journal and the eight surviving versions of Costansó's account and added details that were amended or omitted when the original manuscripts were recopied and revised following the conclusion of the expedition. It was typical of Brown's thorough scholarship that he fully documented his work in a translator's introduction and annotations.

Although most of Brown's publications in the 1980s and 1990s pertained to his professional specialization in Old English and Middle English literature, he did find time to attend conferences involving his interest in early California. He spoke at an international conference on the "Spanish Beginnings of California" at U.C. Santa Barbara in July, 1991[5], and presented a paper on "The Name Olhone/Ohlone, with Some Notes on the People" at a symposium entitled "The Ohlone: A Continuing Tradition" that was held at California State University, Hayward in November, 1992.

A persistent ailment forced Brown to retire from his faculty position in 1997. When he was visited by a minister in his hospital room, Alan told him, "I can't go now, I have books to write." As his wife Isabel testifies, Alan's soul was in the California material, and his retirement enabled him to return to his unfinished work on the Crespí journals.[6] Brown's *magnum opus* on Crespí, *A Description of Distant Roads: Original Journals of the First Expedition into California, 1769–1770*, was published by San Diego State University in 2001.[7] Brown's introduction to this volume practically constituted a book in itself; it presented a masterful history of Spanish knowledge of California in the centuries leading to the 1769 expedition, a summary of the expedition, and a bibliographic history of the manuscripts produced by the expedition's participants. The Crespí journals comprised the major portion of this definitive volume, with both the first version of the diary and Crespí's revised text presented side by side, with Spanish transcripts and English translations on facing pages.

With the full publication of the original Crespí journals finally realized, Alan turned his attention to other interests. He devoted himself to a study of the environmental and historical landscapes in the vicinities of Santa Clara and San José (Brown 2005b). As part of this research, Alan investigated the question of whether traces of oak-root fungus in fruit orchards might provide a clue regarding the original distribution of oak woodland habitats (Brown 2002). He had long been interested in the descriptions of Juan Bautista de Ánza and Fr. Pedro Font pertaining to their reconnaissance of the San Francisco Bay region (Brown 1998; Stanger and Brown 1969:164–166), so he was excited in 2005 to learn that a hitherto unknown version of Fr. Font's journal had been discovered in Italy. After his daughter's wedding in 2007, Alan and Isabel traveled to the Franciscan Historical Archives in Rome, where he spent a week researching

Alan K. Brown with colleagues at Pitiquito, Sonora, February 18, 2008; the last mission where Fr. Pedro Font served as minister (L–R: Glenn Farris, Alan Brown, John Johnson, Robert Senkewicz, and Laurence Gould), courtesy of Luther Bertrando.

Font. He was very pleased with what he discovered, and he was soon working on a new, comprehensive book that would integrate new material from the recently discovered manuscript of Font's original field diary with passages added from three later versions that Font had prepared. As he had done with the Crespí journals, Brown's goal was to bring all of Font's observations on the expedition and the indigenous peoples encountered along the way to the attention of a wider audience. In several articles and in his introduction to the volume, Brown fleshed out the historical and biographical context of Font's life (Brown 2006, 2007, 2011).

Brown's manuscript for the Font book was virtually complete when he passed away on September 17, 2009. The book had already been accepted as the inaugural volume in the *Early California Commentaries* series, to be published by the Arthur H. Clark Company in collaboration with the University of Oklahoma Press. Rose Marie Beebe and Robert Senkewicz, the series editors, corresponded with Alan extensively prior to his death and kept true to his vision by seeing *With Anza to California in 1775–1776: The Journal of Pedro Font, O.F.M.* through to completion (Brown 2011).

In addition to the book based on Font's journals, Alan was working on several other manuscripts that are as yet unpublished. One of these is a paper about Cortes and the naming of California, which Brown originally presented at an annual conference of the Society for the History of Discoveries. A second manuscript is entitled "The Founder of California" and concerns José de Gálvez, who during his appointment as Visitador for the Spanish Council of the Indies implemented the plan that led to the colonization of Alta California. That paper was originally presented at the annual conference of the California Mission Studies Association in Carmel, where Alan was presented the Norman Neuerburg Award in recognition of his outstanding contributions to the study of California's Spanish Period.

Alan's legacy is tremendous. He was a quiet, dedicated, and generous individual, and was passionately devoted to early California history. Anyone who wants to understand California Indian society as it was when first encountered at the dawn of the Mission Period owes a debt of gratitude to the thorough scholarship of Alan K. Brown. Thanks to his lifelong work, definitive editions are available of the principal expedition diaries, which give us priceless, detailed information about the natural and tribal landscape of California before it was changed forever.

NOTES

1 After he became a professor at Ohio State University, Brown often served as an outside member of committees for people receiving degrees in foreign languages. In addition to his specialization in Old English, Alan acquired a mastery of Latin, Old French, Old Spanish, Old and Middle High German, the medieval Scandinavian languages, the medieval English vernaculars, and the Celtic languages. His wife Isabel remembers that he would amuse himself by reading grammars of Turkish and Finnish (interview notes, December 3, 2009).

2 Brown to Lloyd Lyman, Assistant Director, University of California Press, December 8, 1965, with "A Proposed Narrative and Documentary Publication on the Spanish Occupation of Upper California, Including a Translation of the Journals of the Reverend Juan Crespí, O.F.M., and Other Original Accounts," manuscript on file, Santa Barbara Mission Archive-Library.

3 Among archaeologists who were influenced by Brown's 1967 seminal publication and subsequently initiated their own studies of mission records for the Chumash region were Gary Coombs, Bob Edberg, Stephen Horne, Chester King, Robert Lopez, and Claude Warren. The seed to undertake mission register research was planted for me after I read a copy of Brown's *Aboriginal Population of the Santa Barbara Channel*, which was loaned to me by Laurence Spanne in 1974.

4 Lisa Kiser, "Memorial Essay on Professor Alan K. Brown and His Work" [http://english.osu.edu/newsEvents/features/yr2009/10-06_brown.cfm, accessed 28 November 2009].

5 Brown's paper was entitled, "The Journals of Juan Crespí: New Findings." I first met Alan in person at this conference, which was sponsored by the Santa Barbara Trust for Historic Preservation.

6 Isabel M. Brown, personal communication, December 3, 2009.

7 This publication was facilitated by Lynn Gamble, then a member of the anthropology faculty at SDSU.

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Out Where the Living is Good: Subsistence Activities on the Landscape of Joshua Tree National Monument

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A stratified random-sample inventory of Joshua Tree National Monument between 1991 and 1993 produced the first statistically-nonbiased data available for the Joshua Tree region. We examine these data using several methods. Although the sample is relatively small, the resulting data reveal that archaeological phenomena are unevenly distributed across the landscape, and that site frequencies and site types are associated with specific vegetation zones. Our results may be useful for predictive modeling in similar environments.

This paper reports the results of a stratified random-sample inventory of archaeological sites in Joshua Tree National Monument (hereafter Joshua Tree) that was conducted in 1991–1993. It should be noted that it does not include the substantial parcels of land that were added to the Monument when it became Joshua Tree National Park. The present paper is based primarily on data derived from Warren and Schneider's Phase I and Phase II reports (1993, 2000) to the National Park Service, where interested individuals can find further background information and methodologically-specific data. Joshua Tree is located in Riverside and San Bernardino counties, California, and encompasses the transition between the Mojave and Colorado deserts (Fig. 1).

For the most part, we deal here with the latest period of prehistory, and for that reason do not discuss the chronological sequence for the desert region. Recent packrat midden studies show that vegetation in the Mojave Desert has remained consistent throughout the last 4,500 years (Koehler et al. 2005); therefore, the relationship between humans and vegetation has probably been fairly stable in the Mojave Desert during the recent past. (Readers interested in the chronological parameters for the Mojave Desert and adjacent areas in California should consult such sources as Moratto [1984], Jones and Klar [2007], and Warren and Schneider [2000].)

Details on the history of archaeological research in Joshua Tree, as well as general background information on the region, have been the subject of two volumes, one by Thomas F. King in 1975 and the other by Michael Newland in 2008. In addition, the Phase II Project Report (Warren and Schneider 2000) submitted to the National Park Service contains a lengthy contextual chapter (Chapter 2) describing the background of the study; it includes information on the physical setting, geology, hydrology, climate, flora and fauna, chronological framework, and history of archaeology in Joshua Tree, as well as ethnographic data on the several native groups known to have lived within, had resources in, or traveled through the region. The reader is referred to these extensive and readily available sources.

The indigenous groups in the Joshua Tree region included the Cahuilla, Serrano, Chemehuevi, and Mohave. One characteristic of these four groups was their similar adaptation to the desert environment. While this might be expected, the similarities make the job of the archaeologist either difficult or impossible when research questions are focused primarily on distinguishing one cultural

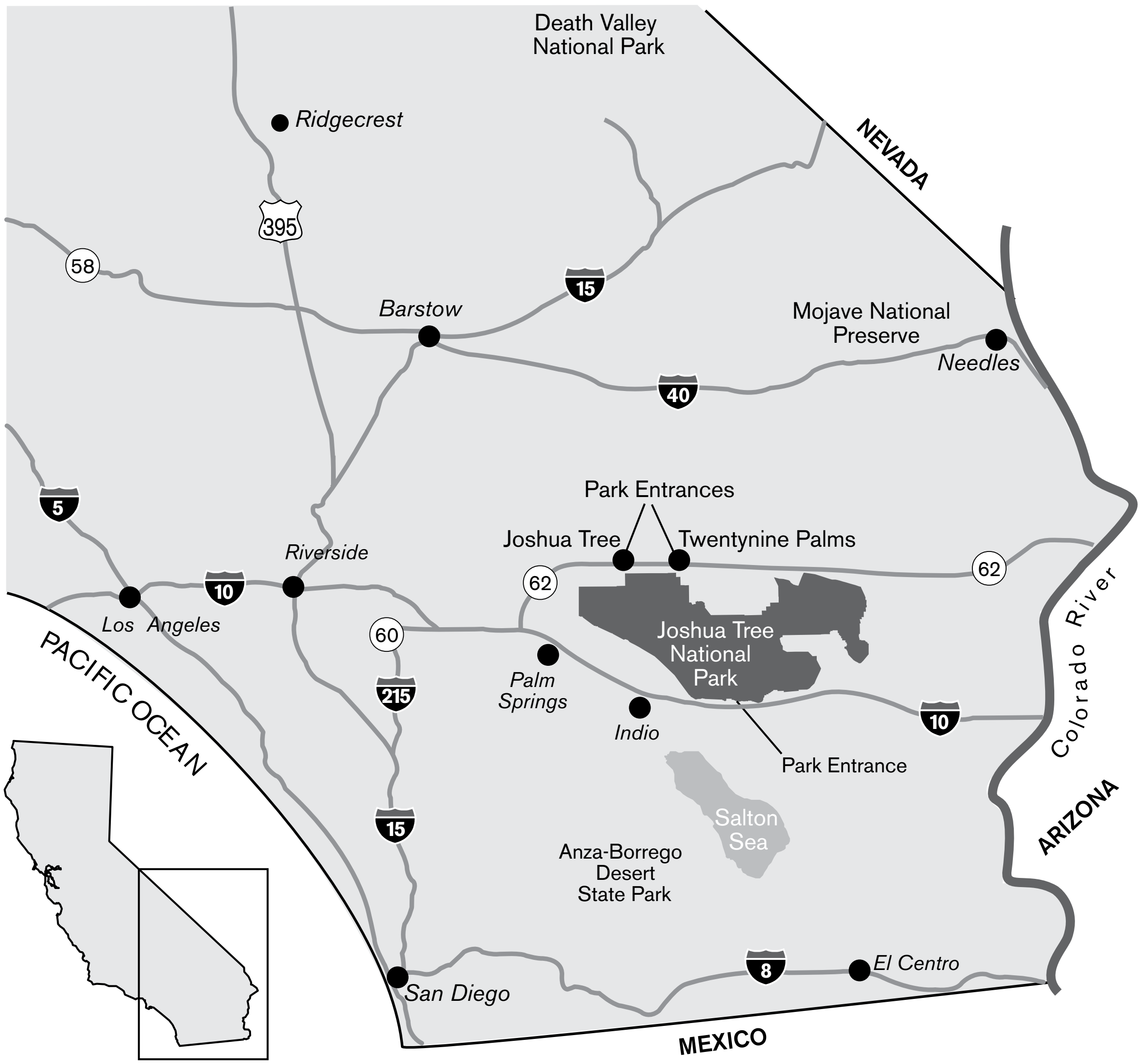

Figure 1. Location of Joshua Tree National Park in the southern California region. The shape of the Park includes lands that were added after the study reported in this paper (cf. Figs. 2, 3). Adapted from the National Park Service web pages.

group from another; for this reason, we do not attempt to do so here. Territorial boundaries are fuzzy, at best, between hunter-gatherer peoples. There is a substantial problem in distinguishing ethnic groups in terms of their material culture. Suffice it to say that the late prehistoric population of Joshua Tree was necessarily a mobile one because of the environmental challenges of desert living, and that transhumance was a general pattern.

Phase I of the study consisted of a stratified random-sample pedestrian survey of Joshua Tree National Monument. Between the fall of 1991 and the spring of 1993, a team of archaeologists—consisting of graduate and undergraduate students from the University of Nevada Las Vegas, Department of Anthropology and Ethnic Studies, and directed by Claude N. Warren and Joan S. Schneider—conducted an extensive pedestrian inventory in 105 transects; each transect consisted of 100,000 m.[2] All archaeological sites and isolated occurrences were recorded; all prehistoric cultural materials (with the exception of burned rocks) were collected, cataloged, and quantified.

The random sample was first stratified by five regions within Joshua Tree (Covington Flats, Queen/Lost Horse, East Pinto, West Pinto, and Cottonwood; see Fig. 2), and then by vegetation zone, following Leary (1977). Within a region, each vegetation zone was sampled in proportion

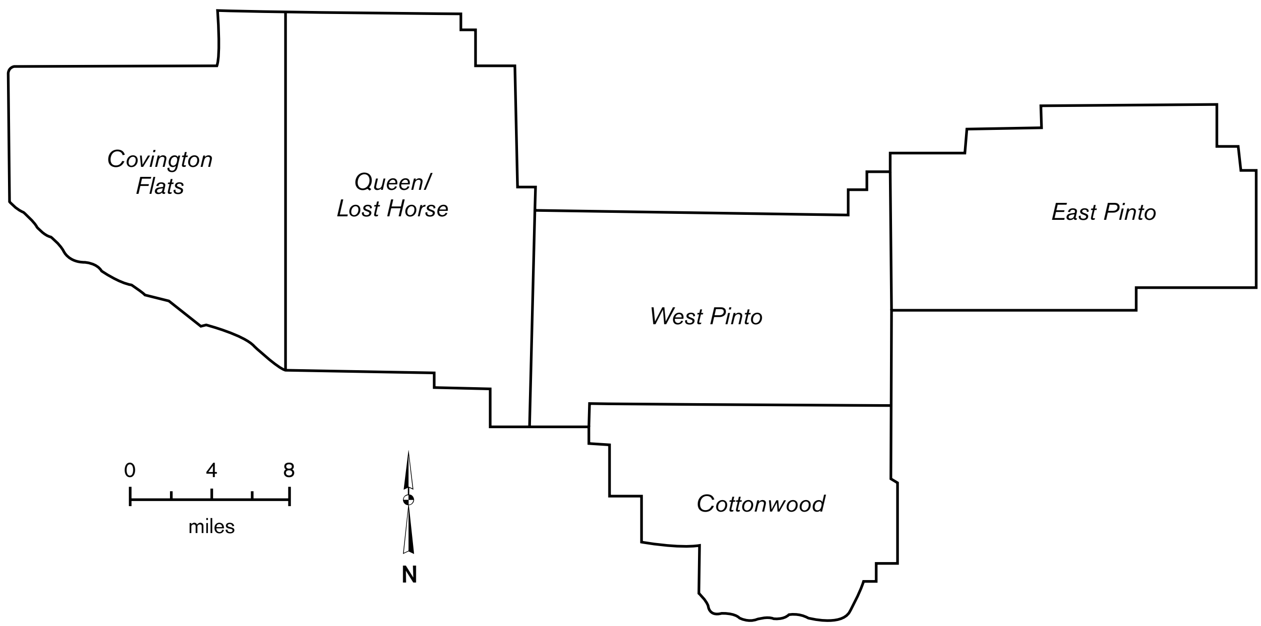

Figure 2. Regions of Joshua Tree National Monument as used to stratify the sample of Joshua Tree.

to the areal extent of the vegetation community within that region, as outlined by Leary. The vegetation-zone sample strata included the Southern Bench/Granitic Outcrop Community (Zone A); the Creosote Bush Community (Zone B); the Oak and Pine Woodlands Community (Zone C); the Juniper Woodlands Community (Zone D); the Blackbrush and Burroweed Community (Zone E); the Joshua Tree Community (Zone F); the Mojave Yucca Community (Zone G); and the Playa Margin Community (Zone H) (Fig. 3). Later, the Juniper Woodlands Community (D), found only on the steep southern slope of Joshua Tree, was omitted from the sample because it proved to be inaccessible due to the lack of roads and the extremely steep terrain. The methods used for sample selection are detailed in the Phase I report (Warren and Schneider 1993:4–7).

The purpose of this paper is to use this stratified random sample to examine the relationship of late-prehistoric subsistence strategies to the landscape and its resources.[1] Here, we develop information regarding site types, subsistence-tool assemblages, and their relationships to the resources found in different vegetation zones. We recognize that the data presented here are limited and are best suited to the development of a model or models from which hypotheses may be deduced and tested through future research.

SITE TYPOLOGY

The site taxonomy used here assumes that the prehistoric inhabitants of Joshua Tree were hunter-gatherers who moved about the landscape on a seasonal basis, often—but not always—revisiting favored locations year after year. The sites are organized into two primary descriptive/functional categories: *domestic* and *specialized* sites.

Domestic Sites

Wherever people moved during their seasonal round, they occupied sites in which the domestic activities of preparing and storing food, making and repairing equipment, eating, sleeping, and social interaction took place. The domestic sites included *residential sites* at which the largest number of people came together at a point or points during the seasonal economic round. The residential site was the base from which people departed and to which people returned when venturing forth to conduct specialized activities and tasks. It was the site that was most reflective of the number of people and the range of activities of a human group. As such, it would contain a functionally-varied artifact assemblage, as well as an indication of more intensive and longer-duration occupation. Domestic sites, however, would exhibit some diversity. As people progressed through the seasonal round, they usually broke into smaller groups

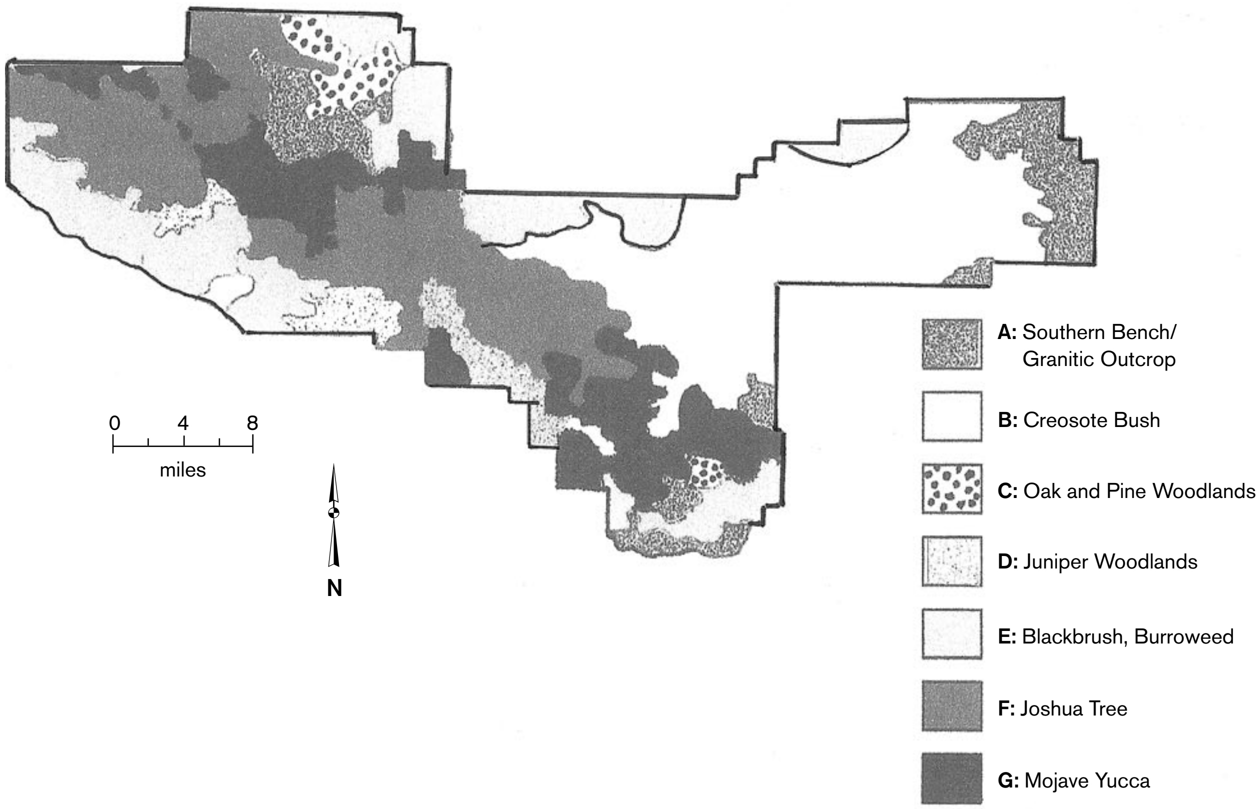

Figure 3. Major vegetation zones used to stratify the sample of Joshua Tree. Many microclimates are not represented in the figure because the scale made this impossible. In reality, the situation is far more complex. Zone H is not shown because of its small size. The figure shows larger vegetation areas only and is designed to help the reader to visualize the vegetation mosaic present in each of the five regions of Joshua Tree (after Leary 1977).

during some seasons; the domestic sites became smaller, and were represented by what we recognize here as *camps* or *sparse artifact scatters* with far less complexity, but which served the same function as larger residential sites. Domestic sites, in our model, are divided into three categories: (1) residential sites, (2) camps, and (3) sparse artifact scatters. These are defined as follows.

Residential sites. These are stable in the sense that they are returned to regularly during the seasonal economic round. They have more permanent features than other site types. Features are more numerous and more permanent and may include temporary-to-semi-permanent structures, hearths, and possibly spatial arrangements of artifacts and cultural debris suggestive of segregated work areas. Artifact assemblages are more variable, both in form and function, than at specialized sites. Middens are present, and faunal and floral remains are relatively numerous and more variable than at specialized sites.

Camps. These are temporary residential sites occupied by a group for a short time. The artifact assemblage may be functionally varied, but artifacts are not numerous. Midden is absent or very limited. Features, such as hearths, are temporary. Built structures are not present.

Sparse artifact scatters. These are ephemeral sites containing few functional artifact types. If any temporary features are present, they will be extremely limited in number. Although these sites have few artifacts, the artifacts reflect variability in domestic activities. This site type is assumed to be a "one stop," one event, or overnight domestic site.

Specialized Sites

Wherever the prehistoric people of Joshua Tree lived, they conducted specialized economic activities at locations separated from the domestic sites. These specialized sites were not generally used by all members of the society, but only by those conducting the specific activity or activities carried out at the site locations. Variation in these prehistoric activities, therefore, would be reflected in both the location and the features present, as well as in the artifact assemblages. The specialized activity sites of the desert people reflect the numerous subsistence-related, as well as the socially- and ritually-related, activities utilizing the specialized tools and features involved in a single or relatively few activities. We recognize the following specialized site types in Joshua Tree.

Milling Stations.[2] These are locations with one or more slicks, metates, and/or mortars. They are often found on bedrock or large boulders in proximity to one another and to the resources being processed. A milling station may also consist of one or more milling stones occurring in groups, usually in association with a water source or with plant resources. Milling stations may also represent individual loci of larger residential site complexes where they are associated with other features and artifacts indicating the varied activities of a domestic site.

Lithic Reduction sites. These vary from scatters of flakes with a small number of diagnostic[3] flakes (e.g., biface reduction flakes) to reduction sites where cores and blocky detritus are found along with a variety of flake types and—more rarely—broken, flaked-stone artifacts.

Quarry sites. These are source locations for stone that was used for or worked into tools; i.e., the location where stone was "mined" and prepared for removal. A quarry site may vary from multiple prospects (i.e., where cobbles are broken open and rejected), to large bedrock quarries where the material is worked extensively and large quantities of detritus, broken artifacts, cores, and stone-working tools occur. A quarry may be an eroding or secondary surface deposit, an exposed rock stratum, or an exposure of nodules of workable material such as a cliff face.

Rock Art sites. These are locations where petroglyphs or pictographs occur. Rock art is often located in places isolated from other indications of human activity, but in some cases it may be found in rockshelters that also contain residential or camp sites. For this study, we recorded the site as "residential or camp site with rock art."

Storage sites. These are locations where either structures or containers have been used for the storage of seeds, personal possessions, or other resources. These are almost always found in rockshelters, where stone-lined storage pits are constructed and/or where ceramic vessels are placed for storage. Today, most of these storage sites are represented by clusters of sherds or individual broken ceramic vessels, the result of destruction.

Rock Rings. These are roughly circular arrangements of rocks on the surface of the ground, sometimes associated with artifacts, but often not. Although their function is uncertain, they may have been supporting bases for large or small basketry storage granaries or the foundations of brush houses. Rock rings are a recurrent feature in the California deserts.

Sherd Scatters and Pot Drops. These are scatters of broken pottery on the surface of the ground. The sherds may be the result of a single pot being dropped while its owner was traversing a stretch of desert. In that case, an isolated group of sherds can often be recognized as being part of the same pot. Much more common is the sherd scatter, which may also occur in an isolated situation as the result of a dropped pot, but one whose sherds cannot be recognized as being part of the same vessel, or—more commonly—consists of a collection of sherds of several different ceramic types. The latter may represent a sample of the ceramic vessels once used at the site.

"*Spirit Sticks*." These were first reported and named in 1931 by Elizabeth and William Campbell (Campbell 1931). Spirit sticks are large branches from a variety of trees and shrubs (often forked and stripped of bark and leaves) that are placed, standing upright, within or in front of rockshelter entrances. The rockshelters often contain caches of pottery vessels or other equipment. Since the interpretation of these phenomena is problematic, we forego interpretation and designate these sites by name only.

Other. These are sites that do not fit into the above categories.

ARCHAEOLOGICAL SITES AND VEGETATION ZONES

An examination of the distribution of sites recorded in our stratified sample survey reveals that archaeological data are unevenly distributed across the landscape of Joshua Tree. We analyse this uneven distribution using several methods. First, we summarize the data from each vegetation zone, listing the frequencies and types of sites, and adding comments (when appropriate). Second, we present a summary and analysis of (1) the distribution of site frequencies and site types in each vegetation zone, (2) the distribution of functional artifact types by site type and vegetation zone, and (3) the distribution of faunal remains by site type and vegetation zone. Finally, we summarize our discussion and offer some conclusions based on the data derived from our analyses.

The following sections summarize our work and our findings in each vegetation zone of the stratified random-sample inventory.

Archaeological Sites of Zone A
(Granitic Outcrop/Southern Bench Association Zone)

The Granitic Outcrop/Southern Bench Vegetation Association contains the greatest number of sites per square kilometer of any vegetation zone, with 17.3 sites per square kilometer (km.^{2}). This vegetation zone also has a greater *variety* of site types than any other zone. Seven of these sites are residential and camp sites that appear to have been used regularly (presumably on a seasonal basis). Four others are sparse artifact scatters that may represent temporary camps since they do not appear to represent specialized activities.

The special activity sites in Zone A are more varied than in other zones, with two milling stations, two storage sites, and one each of lithic reduction, quarry, sherd scatter/pot drop, and "spirit stick" sites. In this zone, mesquite, oak, pinyon, cacti, and various grasses and shrubs are found in proximity to one another along washes and at the bases of rock cliffs and inselbergs. These occurrences result in an ecotone unusually rich in food plants within the granitic outcrops in Joshua Tree. There is a similarly enriched ecotone along the upper edge of the Southern Bench Zone where there are unusually rich stands of chia and grasses, as well as trees and shrubs in abundance, in and bordering washes issuing from the scarp at the upper edge of the Southern Bench area.

Archaeological Sites of Zone B
(Creosote Bush Vegetation Association Zone)

The Creosote Bush Zone has fewer resources than other zones in Joshua Tree. The great expanses of creosote bush are areas in which springs are rare, plant resources are sparse, and the few that are present are generally not important food plants. That humans carried out few activities in this zone is reflected in the types of sites recorded during our inventory. The Creosote Bush Zone has a site density of just 2.3 sites per km.^{2}, the lowest frequency of sites per km.^{2} found during this study.

The prehistoric sites are few in number but show some variability. There is one residential site, but it was found at the extreme edge of the Creosote Bush Zone in the Coxcomb Mountains in Pinto Basin. This site, consisting of two rockshelters, a substantial midden deposit, and surface artifacts, is not only near the edge of the Creosote Zone, but is also very close to a spring. These two factors probably explain its existence in the Creosote Zone.

In addition to the single residential site, there are two sparse artifact scatters, one milling station, two quarries, two sherd scatters/pot drops, and two sites, each of which consists of secondary deposits of archaeological materials in areas of outwash and alluvial fan accumulation; the artifacts have been redistributed over wide areas. These materials may have been derived from residential sites or from the variety of specialized and domestic sites farther upslope in areas which were not included in the randomly selected transects.

In addition to these sites, 13 tools from 10 different transects were recovered as isolates. This suggests that the Creosote Bush Zone was used sparingly and occupied hardly at all. The archaeological evidence seems to indicate that, while people certainly traversed this area, they made little use of its limited resources (except in the Pinto Wash area—an area eliminated from our inventory due to a recent survey of the wash area [Schroth 1994]). An exception to this general statement may lie along travel corridors in the Creosote Bush Zone. In such a case, a greater site density than predicted by our model might indicate the existence of a travel corridor.

Archaeological Sites of Zone C
(Oak and Pine Woodlands Vegetation Association Zone)

The Oak and Pine Woodlands Zone ranks second in number of sites with 16.3 sites per km.^{2} This zone, like that of the Granitic Outcrop/Southern Bench, contains a wide variety of plant foods in relatively small areas, making it a food-rich zone. The sites include three residential sites, three camps, one milling station, three lithic reduction sites, and three rock art sites. If one eliminates the rock art sites, the specialized activity sites are restricted to only the one milling station and three lithic reduction sites, with less of a variety of site types than in the Granite Outcrop/Southern Bench Vegetation Association.

Archaeological Sites of Zone E
(Blackbush and Burroweed Vegetation Association Zone)

This vegetation zone is dominated by blackbush and burroweed. The biological resources used by human populations are limited, but probably are somewhat greater in number than those in the Creosote Bush Zone (Zone B). Sites in the Blackbush/Burroweed Association Zone are relatively few in number and are generally small special-activity sites. No residential sites are present. The Blackbush/Burroweed Zone contains just 7.8 sites per km.^{2} A total of seven sites were recorded in this zone. Two are sparse artifact scatters, two are milling stations, one is a rock ring, and two are sherd scatters/pot drops.

Archaeological Sites of Zone F
(Joshua Tree Vegetation Association Zone)

The six prehistoric sites found in the Joshua Tree Vegetation Association include one camp, two sparse artifact scatters, two milling stations, and one rock art site. The small number of sites and total lack of larger residential and multipurpose sites suggests that the resources of this zone were limited. The site density of the Joshua Tree Zone is 6.7 sites per km.^{2}, next to the lowest in this study, but is probably not significantly different from either the Blackbush/Burroweed Zone or the Mojave Yucca Zone.

Archaeological Sites of Zone G
(Mojave Yucca Vegetation Association Zone)

Eighteen sites were recorded in the Mojave Yucca Vegetation Association. There are two residential sites, three camp sites, three sparse artifact scatters, four milling stations, two lithic reduction sites, one rock ring, and three sherd scatters/pot drops. The Mojave Yucca Vegetation Zone ranks second in the number of sites recorded, but ties for fourth rank in the density of sites with 7.8 per km.^{2} It has a number of residential and camp sites, comparable to the Granitic Outcrop/Southern Bench (Zone A) and the Oak and Pine Woodlands (Zone C).

Archaeological Sites of Zone H
(Playa Margin Vegetation Association Zone)

The Playa Margin Vegetation Association is an exceptional zone in that it occurs only in the Queen Valley-Lost Horse Region, and it is limited to an area of about two km.^{2} in and surrounding the only playa (dry lake) within Joshua Tree. At the time this report was written, the only major food resource in the area was grass, especially Indian Rice Grass. The small size and limited resources of the zone are reflected in the number and variability of site types. This zone has only two sites recorded within the survey sample. As might be expected, one site is a milling station consisting of a metate in the middle of the grassy basin floor adjacent to the playa. The other site is a sherd scatter/pot drop. Extrapolating from the results of our random sample, this zone could be projected to have 20 sites per km.^{2} The small size of the vegetation zone, however, makes this measure of little significance. This zone is not included further in our analyses because of its small size, the small sample, and the uniqueness of this vegetation stratum in Joshua Tree.

ANALYSES OF THE DISTRIBUTION OF SITES BY VEGETATION ZONE

The relationships between archaeological sites and vegetation zones provide a number of insights into past cultural ecology. Human adaptation to the California deserts during the past approximately 2,000 years is reflected in the relationships between archaeological sites and vegetation zones within Joshua Tree. The archaeological research described here is based on a stratified random sample with eight vegetation zones serving as the strata. The size of each sample was intended to be proportional to the area of each vegetation zone. The sample units consisted of 0.1 km.^{2} transects. The sample of each vegetation zone was originally intended to total slightly less than one percent of the area encompassed by that vegetation zone. This proportional sampling, however, could not be fully maintained because of time constraints and the difficulties of access to some zones. Consequently, the final samples of the vegetation zones varied from

46 percent to 84 percent of the targeted sample size of slightly less than one percent of each zone. Zone D was eliminated from the sample because of the extremity of the terrain. Zone H was so small that the sample consisted of only two transects. For these reasons, our analyses involve only sites in zones A, B, C, E, F, and G.

The final samples used here comprise less than 0.7 percent of the area of what was then (1991–1993) Joshua Tree National Monument. Since then, additional lands have been added to Joshua Tree, and therefore our actual samples would comprise somewhat less than 0.7 percent of today's Park lands. The small size of the sample from individual vegetation zones ranges from 0.4 percent to 0.7 percent of the area comprising each vegetation zone. However small these samples may be, they are still the best-controlled archaeological samples from Joshua Tree, and can provide a better—and more statistically valid—overview of the distribution of cultural resources in the Park than any other archaeological study to date.

It is apparent from Table 1 that (1) the size of each zone and the frequency of sites per $km.^2$ have little, if any correlation; that (2) sites are not distributed evenly across the landscape; and (3) that there may be environmental factors that are instrumental in determining settlement patterns both within Joshua Tree and in similar landscapes. The largest of the vegetation zones (Zone B, the Creosote Bush Vegetation Association) has only 2.3 sites per $km.^2$, while Zone A (Granite Outcrop/Southern Bench Vegetation Association), one of the smaller zones, has 17.3 sites per $km.^2$, the highest frequency per $km.^2$

Site Frequencies and Vegetation Zones

The variation in the frequency of sites per $km.^2$ of each vegetation zone appears to indicate that the 73 sites that we recorded are unevenly distributed across the landscape. Perhaps a better approach would be to ask the following question. How likely is it that the entire sample of 73 sites came from a population of sites in which there was *no preference* for locating sites in any particular vegetation zone? We can use the chi-square test to statistically answer that question.

The expected frequency of sites in a particular vegetation zone is proportional to the size of that zone. For example, Zone A comprises 10.6 percent of the territory sampled for this project. Therefore, the expected frequency of sites in Zone A is equal to 10.6 percent of 73 (the total number of sites recorded), giving an *expected* site frequency of about 7.7 sites per square kilometer for Zone A. In the Creosote Bush Vegetation Association, Zone B, which included 42.3 percent of the territory sampled, the *expected* frequency of sites per square kilometer is 30.9 ($0.423 \times 73 = 30.9$). These *expected* frequencies may then be compared with the *actual observed* frequencies in constructing a chi-square test. This is a one-variable

Table 1

NUMBER OF SAMPLE TRANSECTS IN EACH OF SIX VEGETATION ZONES WITHIN EACH OF FIVE REGIONS OF JOSHUA TREE NATIONAL PARK; NUMBER OF SITES RECORDED; FREQUENCY OF SITES PER SQUARE KILOMETER; NUMBER OF SITE TYPES

REGIONS	Zone A	Zone B	Zone C	Zone E	Zone F	Zone G	Total
No. of Transects in Queen Valley/Lost Horse	4	7	2	5	6	16	40
No. of Transects in East Pinto Basin	3	9	0	0	0	0	12
No. of Transects in West Pinto Basin	1	22	0	0	0	0	23
No. of Transects in Cottonwood	3	6	0	1	0	7	17
No. of Transects in Covington Flats	0	0	6	3	3	0	12
Transects Completed	11	44	8	9	9	23	104
Transects Targeted Percent Achieved	15/ 73%	95/ 46%	16/ 50%	17/ 53%	11/ 82%	39/ 59%	193/ 54%
Approximate Percent of Zone Surveyed	<0.66	<0.41	<0.45	<0.48	<0.74	<0.53	<0.54
No. of sites recorded	19	10	13	7	6	18	73
No. of sites/transect	1.73	0.23	1.63	0.78	0.67	0.78	1.4
No. of sites/$km.^2$	17.27	2.27	16.25	7.78	6.67	7.78	13.68
No. of site types	9	6	5	4	4	7	12

tabulation—the observed and expected frequencies of sites distributed across six vegetation zones. The results of these calculations are shown Table 2.

Table 2

OBSERVED AND EXPECTED NUMBERS OF SITES FOR CHI-SQUARE TEST

VEGETATION ZONES	km.² Surveyed	Percent of area Surveyed	Expected Frequency of Sites	Observed Frequency of Sites	Contribution to Chi-Square
A. Granitic Outcrop and Southern Bench	1.1	10.6%	7.7	19	16.58
B. Creosote Bush	4.4	42.3%	30.9	10	14.14
C. Oak and Pine Woodland	0.8	7.7%	5.6	13	9.78
E. Blackbush and Burroweed	0.9	8.7%	6.4	7	0.06
F. Joshua Tree	0.9	8.7%	6.4	6	0.03
G. Mojave Yucca	2.3	22.1%	16.1	18	0.22
Total	**10.4**	**100%**	**73**	**73**	**40.81**

Chi-Square = 40.81 $p < .001$ df=5

The chi-square score demonstrates that there is a high probability (greater than 99.9 percent) that the sites are not randomly distributed across the landscape. Impressively, 75.2 percent of the chi-square is accounted for by vegetation zones A and B. With the addition of Zone C, 97.9 percent of the chi-square score is accounted for. This indicates that Zone A and Zone C contain a greater than expected number of sites, whereas Zone B has fewer than expected. In the other three vegetation zones, the numbers observed are close to the expected numbers. This tells us that there is a very high probability that site density varies with vegetation zone, but it tells us nothing about the distribution of different site types or the functions of the sites in a given vegetation zone. Those subjects are addressed below.

Site Types and Vegetation Zones

We argued that the occurrences of the site types are determined by a number of variables. Although we may speculate about reasons for the observed uneven distribution, we must also raise questions concerning the functions of the sites involved. For example, the relatively low plant variability and paucity of water in the Creosote Bush Zone (B) suggests that it would not only have few sites, but that the number of more permanent residential sites would be very small or nonexistent. It is apparent from Table 3 that residential sites are essentially limited to the Granitic Outcrops/Southern Bench, Oak/Pine Woodlands, and Mojave Yucca vegetation zones. The single exception is a rockshelter with an apparent midden deposit and many surface artifacts located within Zone B at the base of the Coxcomb Mountains at the eastern edge of Pinto Basin. This site is near a spring in a locality that is known to have bighorn and probably the increased richness of vegetation that is characteristic of the edge areas of vegetation zones. Residential sites are more likely to be located where there is water and within reach of resources that are productive over a longer period of time.

Table 3

DISTRIBUTION OF SITE TYPES BY VEGETATION ZONES

	VEGETATION ZONES						
Site types	**A**	**B**	**C**	**E**	**F**	**G**	**Total**
Residential	6	1	3	–	–	2	**12**
Camps	1	–	3	–	1	3	**8**
Sparse Artifact Scatter	4	2	–	2	2	3	**13**
Milling Stations	2	1	1	2	2	4	**12**
Lithic Scatter	1	–	3	–	–	2	**6**
Quarry	1	2	–	–	–	–	**3**
Rock Art	–	–	3	–	1	–	**4**
Storage Pits	2	–	–	–	–	–	**2**
Rock Rings	–	–	–	1	–	1	**2**
Sherd Scatter/Pot Drop	1	2	–	2	–	3	**8**
Spirit Stick	1	–	–	–	–	–	**1**
Redeposited Artifacts	–	2	–	–	–	–	**2**
Total	**19**	**10**	**13**	**7**	**6**	**18**	**73**

Eighteen of the twenty residential and camp sites are located in three zones: Zone A (Granitic Outcrops/Southern Bench), Zone C (Oak/Pine Woodland), and Zone G (Mojave Yucca). The sparse artifact scatter that is also considered "residential" in the site typology does not exhibit the same tendency toward clustering in these three zones. Sparse artifact scatter sites consist of a grouping of artifacts that are varied enough that the site cannot be said to be a specialized activity site. However, this site type is identified as a "one-stop domestic site;" i.e., one that is probably not returned to regularly, if at all. Therefore, in the following analysis we group a sparse artifact scatter site with the more specialized activity sites on the basis that it is (1) not as permanent as the other sites in this category, and (2) it does not share the distribution pattern of other domestic sites. The results of a chi-square test of the distribution of the residence versus non-residence sites between two groups of vegetation zones (zones A, C, and G versus zones B, E, and F) are shown in Table 4.

Table 4

CHI-SQUARE TEST ON DISTRIBUTION OF "RESIDENCE" AND "NON-RESIDENCE" SITES

Site types	Group 1 Zones A, C, G	Group 2 Zones B, E, F	Total
Residence, permanent	A1 18/13.699	B1 2/6.301	20
Non-Residence, mobile	A2 32/36.301	B2 21/16.699	53
Total	**50**	**23**	**73**

Cell
A1 1.350
B1 2.936
A2 0.510
B2 1.108
Chi-Square = 5.904
02 > p > .01
df = 1

The differences in the distribution of residence/non-residence site types between the two groups of vegetation zones is significant. There is more than a 98 percent chance that the differences in the distribution of the residential/camp sites between the two groups of vegetation zones reflect differences in the distribution of the site categories in Joshua Tree. The combined contribution of the cells A1 and B1 (residential and camp sites) is over 72 percent of the total chi-square value (4.286 of 5.904). The differences in the distribution of the residential/camp sites between the two vegetation groups are responsible for the high value of the chi-square. This indicates that the residential/camp sites are more numerous in the A, C, and G zones and less numerous in the B, E, and F zones than expected. The non-residential sites are slightly more numerous than expected in the B, E, and F zones and slightly less numerous than expected in the A, C, and G zones, but the differences are probably not significant. Ninety percent of the residential/camp sites are in the A, C, and G zones. The chi-square value indicates it is very unlikely that the distribution of the larger, more permanent sites primarily in the A, C, and G zones is due to vagaries of sampling.

First, we may conclude from these analyses that archaeological sites in Joshua Tree are more concentrated in the Granite Outcrop/Southern Bench Vegetation Association (Zone A) and the Oak-Pine Woodland Vegetation Association (Zone C), and that the Creosote Bush Vegetation Association (Zone B) has the fewest sites per square kilometer. The Blackbush and Burroweed (Zone E), Joshua Tree (Zone F), and Mojave Yucca (Zone G) vegetation associations have site concentrations intermediate between the two extremes.

Second, we conclude that there are functional differences among the sites that seem to be correlated with differences in vegetation zones. The more permanent site types (residential and camp sites) are concentrated in three zones: Zone A, Granitic Outcrop/Southern Bench; Zone C, Oak-Pine Woodland; and Zone G, Mojave Yucca.

Artifact Distribution and Site Functions

The majority of residential and camp sites are in vegetation zones A (Granitic Outcrop/Southern Bench), C (Oak/Pine Woodlands), and G (MojaveYucca). This suggests that these zones were the focus of more intense subsistence activities. In Table 5 the artifact types are presented by vegetation zone. However, since the number of artifacts at any one site is relatively small and to make analytical comparisons more meaningful, we have grouped the recorded artifacts into larger and more generalized "functional" categories (Table 6). Manos and pestles are grouped together as milling tools (but metates and mortars are eliminated from the count because they were not systematically collected due to transport problems). Hammerstones and cores are grouped into a lithic reduction category; projectile points and bifaces are grouped together as cutting tools. Debitage is not included because it is so abundant that it would overshadow all other categories in the chi-square tests that we employed. The five artifacts in the "other" category are eliminated in our statistical analysis.

The artifact counts in the assigned functional categories for chi-square testing are presented in Table 6. The chi-square value is relatively high, but falls just short of 0.05, indicating that there is only a slightly greater than 90 percent chance that the distribution of the artifact categories in the sample is statistically meaningful, rather than a vagary of the sampling.

Table 5

FUNCTIONAL ARTIFACT TYPES BY ZONE

Artifact Type	Zone A	B	C	E	F	G	Total
Projectile Points	10	0	6	0	2	9	**27**
Bifaces	7	1	3	1	2	12	**26**
Unifaces	3	2	2	0	4	2	**13**
Flakes[a]	626	24	262	2	86	212	**1212**
Flakes[b]	25	50	16	4	11	21	**127**
Cores	20	15	10	1	2	10	**58**
Hammerstones	1	1	1	0	1	8	**12**
Nether stones	6	1	0	0	0	17	**24**[c]
Manos	2	1	2	0	2	16	**23**
Pestles	2	0	2	0	0	4	**8**
Other	1	0	1	0	0	3	**5**
Total	**52**	**21**	**27**	**2**	**13**	**81**	**196**

[a] Flakes collected from sites on sample transects. Not included in totals.

[b] Flakes collected as isolates on sample transects. Not included in totals.

[c] Netherstones are under represented by this number because these are the number collected during the survey. Many more were left in the field.

Table 6

COUNTS OF SELECTED ARTIFACT CATEGORIES IN THREE VEGETATION ZONES WITH CHI-SQUARE TEST

Artifact Categories		Vegetation Zones A	C	G	Totals
Projectile Ponts and Bifaces	O E	17 15.792	9 9.024	21 22.184	**47**
Cores and Hammerstones	O E	21 16.800	11 9.600	18 23.600	**50**
Manos and Pestles	O E	4 9.408	4 5.376	20 13.216	**28**
Totals		**42**	**24**	**59**	**125**

A	C	G
0.092	0.000	0.063
1.050	0.204	1.059
3.109	0.352	3.408

4.251 + 0.556 + 4.530 = Chi-Square = 9.337,

$.1 > p > .05$

df = 4

The chi-square score is accounted for primarily by the lithic reduction category (cores and hammerstones) and milling tool category (manos and pestles) in Zone A (Granitic Outcrop/Southern Bench) and Zone G (Mojave Yucca). This reflects a distribution in which the numbers of milling tools are higher than expected in the Mojave Yucca zone and lower than expected in the Granitic Outcrop/Southern Bench zone.[4] The lithic reduction artifacts, on the other hand, are unexpectedly more numerous in the Granitic Outcrop/Southern Bench zone and less numerous in the Mojave Yucca zone. The frequency of the cutting/processing tools was very close to the expected numbers in all three zones.

Sites in all three zones contain evidence for all of the activities discussed here. However, milling activities are more apparent at sites in the Mojave Yucca zone than at sites in other zones, and lithic reduction activities appear to be better represented in sites in the Granitic Outcrop/Southern Bench zone.

Simple observations of the numbers of artifacts from these three zones strongly suggest that there is little difference between the artifact assemblages recovered from the Oak-Pine Woodland (Zone C) and Granitic Outcrop/Southern Bench (Zone A), but that the Mojave Yucca (Zone G) has a somewhat different artifact assemblage, suggesting a stronger emphasis on the collecting and processing of seeds. It is also quite apparent that projectile points and bifaces, when taken as a group, have a distribution that suggests that the taking and processing of animals may have been conducted in all three of these zones with some intensity.

Faunal Remains and Artifact Types

Faunal remains, the bones of the animals in sites, are good indicators of the taking of animals. However, some caution should be used in equating hunting toolkits and animal procurement. Not all animals are taken with "hunting tools" as they are usually defined in the archaeological literature. While the primary hunting tool recognized in the literature is the stone-tipped projectile (e.g., spear, dart, or arrow), not all animals are taken with stone-tipped projectiles. This situation is illustrated by the faunal remains found in the California deserts. Here, the game animals may be grouped into three major categories: (1) large mammals, almost always limited to the local Artiodactyla (bighorn sheep, deer, and antelope); (2) small mammals, primarily lagomorphs and rodents; and (3) reptiles, primarily tortoise and lizard. It is obvious that the weapons used in taking the large mammals would be neither required nor effective in taking the small mammals and reptiles. Although the bow and arrow was sometimes used in taking rabbits, the most effective way of taking the lagomorphs was to drive them into nets where they could be clubbed; this, however, was a group activity. For individual hunting, throwing sticks (sometimes called rabbit sticks) were used in taking jackrabbits, while a hooked stick was used to pull cottontails from their burrows. Other uses of the hooked stick included the extraction of a chuckwalla when it was wedged in a crack in the rocks, or dragging a tortoise from its burrow. Simple traps and snares were used to take rodents, other small mammals, and some reptiles. Tortoises were taken by hand without the use of special tools. Sharp stone knives or flakes were used to butcher most, but not all, of these animals.

The task of obtaining food involved a division of labor that is rarely visible in the archaeological record. Both women and children, however, could take tortoises and other small animals without the use of special tools or the assistance of men. A rabbit drive often involved the whole community or several communities gathered together for this purpose—men, women, and children—all cooperating in the drives. Only the taking of large game appears to have been the province of men alone.

In analyzing the distribution of the faunal remains collected in this study, it is as important to recognize that there was a division of labor, along lines of sex and age, as that there was a division of function among tools. The hunting of Artiodactyla is a process requiring a tool assemblage and personnel different from the tool assemblages and personnel involved in the taking of lagomorphs or reptiles.

Vegetation Zones and Faunal Remains

Anna C. Noah's (2000) analysis of the faunal remains recovered during the Joshua Tree random-sample inventory project is the source for much of the data presented in this section. Table 7 presents the faunal elements by vegetation zone. The faunal sample, however, was collected from the ground surface and has all the shortcomings of any body of surface survey data. First, the data are derived from only 24 sites, or approximately 25 percent of all the sites recorded. Second, only five of the seven vegetation zones are represented among sites with faunal remains; in two of the five represented vegetation zones, there was only a single site that produced faunal remains. Third, only one site (CA-RIV-1950/A-9-2 [Triple House site]) yielded more than 100 faunal elements. Only two vegetation zones, A and G, had sites that, when combined, produced a total of more than 100 elements.

Table 7

DISTRIBUTION OF FAUNAL REMAINS BY VEGETATION ZONE

Vegetation Zones	A	B	C	E	F	G	H	Total
Number of Sites	10	1	5	0	1	7	0	**24**
Number of Elements	2253	6	60	0	5	149	0	**2473**
>50 elements per site	2	0	0	0	0	0	0	**2**
>40 elements per site	8	1	5	0	1	7	0	**22**

The Triple House site produced 2,138 of the 2,253 faunal elements from Zone A (Table 8). This site is differentiated from others by the large quantity of faunal remains present, as well as by its high percentage of sherds of southern pottery types (see Seymour et al. 2000). It appears likely that the Triple House faunal assemblage is unique and is not representative of the faunal assemblages from Joshua Tree as a whole. The purpose of manipulating these data (as seen in the series of tables that follow, Tables 9–12) is to determine if there is any evidence to suggest that differences in faunal assemblages are associated with differences in vegetation zones. The only assemblages that have sufficient numbers of elements for statistical analysis are the combined sites of A (Table 9), C (Table 10), and G (Table 11) vegetation zones. Table 12 presents faunal distributions for zones B and F. But even in these cases, in order to obtain sufficient numbers of faunal elements for analysis, the faunal categories have been reduced to two, (1) lagomorphs, reptiles, and other small animals and (2) Artiodactyla and other large mammals.

Distribution of Faunal Elements in Zone A (Granitic Outcrop/Southern Bench Vegetation)

In an attempt to extract as much information as possible from our faunal data, we compare a composite of the faunal data from the Triple House site (A-9-2) and an adjacent site (A-9-1) with a composite faunal assemblage from all other faunal-bearing sites from Zone A. In doing so, we group units of analysis (i.e., taxa) into more encompassing general categories in order to increase the number of elements in each category for statistical manipulation. For example, we use artiodactyl and

Table 8

DISTRIBUTION OF FAUNAL ELEMENTS FROM SITES IN ZONE A (SOUTHERN BENCH/GRANITIC OUTCROP PLANT ASSOCIATIONS)

Sites	Lagomorph	Small mammal	Artiodactyl	Large mammal	Medium mammal	Aves	Tortoise	?	Total
A-1-1	–	1	–	17	–	–	3	2	**23**
A-3-1	–	–	–	1	2	–	–	–	**3**
A-4-1	2	–	–	–	–	–	–	–	**2**
A-4-2	3	1	1	3	–	–	–	–	**8**
A-4-4	–	1	–	2	–	–	2	2	**7**
A-4-11	1	2	–	8	2	–	36	5	**54**
A-4-12	–	–	–	2	–	–	–	1	**3**
A-4-13	–	–	–	5	–	–	6	2	**13**
Granitic Outcrop Subtotal	**6**	**5**	**1**	**38**	**4**	**–**	**47**	**12**	**113**
A-9-1	–	–	–	1	–	–	–	1	**2**
A-9-2	9	64	12	181	5	–	1,634	233	**2,138**
Southern Bench Subtotal	**9**	**64**	**12**	**182**	**5**	**–**	**1,634**	**234**	**2,140**
Zone A Total	**15**	**69**	**13**	**220**	**9**	**–**	**1,681**	**246**	**2,253**

Table 9

DISTRIBUTION OF FAUNAL ELEMENTS: SUBDIVISIONS *WITHIN* ZONE A (GRANITIC OUTCROP/SOUTHERN BENCH PLANT ASSOCIATIONS) CHI SQUARE TEST

Subdivisions	Lagomorph and Small Mammal		Artiodactyla and Large Mammal		
Sites of Zone A	Observed	Expected	Observed	Expected	Total
Granitic Outcrop A-1-1, A-3-1, A-4-1,-2,-4,-11-13	A1 11	13.249	B1 39	36.751	**50**
Southern Bench A-9-1 and A-9-2	A2 73	70.751	B2 194	196.249	**267**
A-Zone Total	**84**		**233**		**317**

A1 = 0.382 B1 = 0.138
A2 = 0.071 B2 = 0.026
0.453 + 0.164 = Chi-Square = 0.615, .5 > p .2

With df = 1 this Chi-Square Value has a significance of slightly less than 0.5 and the confidence that the samples reflect two different populations of only slightly more than 50%

Table 10

DISTRIBUTION OF FAUNAL ELEMENTS FROM SITES IN ZONE C (OAK AND PINE WOODLANDS PLANT ASSOCIATION)

Sites	Lago-morph	Small Mammal # (%)	Artio-dactyl # (%)	Large Mammal # (%)	Medium Mammal	Aves # (%)	Tortoise # (%)	? # (%)	Total # (%)
C-2-1	–	2	1	7	–	–	–	–	**10 (16.7)**
C-2-5	–	–	–	–	–	–	2	–	**2 (3.3)**
C-2-6	–	–	1	6	–	–	–	–	**7 (11.7)**
C-2-8	–	–	3	21	–	1	1	8	**34 (56.7)**
C-3-1	–	–	1	6	–	–	–	–	**7 (11.7)**
C-Zone Total	–	**2 (3.3)**	**6 (10.0)**	**40 (66.7)**	–	**1 (1.7)**	**3 (5.0)**	**8 (13.3)**	**60 (100)**

lagomorph as categories rather than the more specific taxonomic designations reported by Noah (2000). We do, however, make use of Noah's division of mammals into small, medium, and large categories for elements that could not be identified taxonomically. She defines each as follows:

Small—
ranges from mouse-sized through jackrabbit-sized

Medium—
ranges from fox-sized through coyote-sized; and

Large—
ranges from deer-sized through mountain lion-sized.

Where Noah identified an element as small-medium and medium-large, we have placed them in small and large mammal categories respectively. Unidentified bone is listed but not counted in our calculations below.

Table 11

DISTRIBUTION OF FAUNAL ELEMENTS FROM SITES IN ZONE G (MOJAVE YUCCA VEGETATION ASSOCIATION)

Sites	Lago-morph	Small Mammal #(%)	Artio-dactyl #(%)	Large Mammal #(%)	Medium Mammal #(%)	Aves #(%)	Tortoise #(%)	? #(%)	Total #(%)
G-3-1	–	–	1	–	4	–	–	16	21 (14.2)
G-11-1	–	2	1	25	–	–	3	2	33 (22.3)
G-19-1	2	–	1	2	–	–	–	–	5 (3.4)
G-19-2	–	2	3	18	–	–	3	–	26 (17.6)
G-20-1	–	–	–	–	–	–	2	–	2 (1.4)
G-21-1	1	2	2	15	1	1	1	–	23 (15.5)
G-21-3	–	1	2	13	–	–	2	20	38 (25.7)
G-Zone Total	**3 (2.0)**	**7 (4.7)**	**10 (6.8)**	**73 (49.3)**	**5 (3.4)**	**1 (0.7)**	**11 (7.4)**	**38 (25.7)**	**148 (100)**

Table 12

DISTRIBUTION OF FAUNAL ELEMENTS FROM SITES IN ZONES B AND F (CREOSOTE BUSH AND JOSHUA TREE VEGETATION ASSOCIATIONS)

Sites	Lago-morph	Small Mammal	Artio-dactyl	Large Mammal	Medium Mammal	Aves	Tortoise	?	Total
B-70-2	–	–	–	–	–	–	6	–	**6**
F-6-1	–	1	–	4	–	–	–	–	**5**
Total	–	**1**	–	**4**	–	–	**6**	–	**11**

The samples of faunal remains at the site level are so small that most sites have three or more categories that are not represented. To compensate for the small sample sizes, sites were grouped together on the basis of the vegetation zone in which they were located. Zone A consists of two similar plant communities, Southern Bench and Granitic Outcrop. The Triple House site was one of two sites in the Southern Bench community that produced faunal remains. The Triple House site faunal assemblage contains 1,634 tortoise elements, far more than any other site recorded. This sample is so large that it sets the Triple House site apart from others. Why the number of tortoise elements is so large is unknown; however, when tortoise elements are removed from all the faunal samples from the A Zone, the difference in the assemblage that is accounted for by small mammals is less than 6 percent. With the tortoise remains removed from the samples, a chi-square Test (Table 8) reveals that there is close to a 50 percent chance that the samples from these two areas (Triple House and the adjacent site; other A Zone sites) are not different populations.

There are few differences in faunal remains between the Southern Bench and Granitic Outcrop portions of the sample (Tables 8 and 9). Given this information, it appears that the Triple House site has an unusually large number of desert tortoise elements, but is similar to other Zone A sites in other measurable faunal attributes. Unfortunately, when the sample is trimmed of tortoise, Aves, medium mammals, and unidentified elements, only two categories remain: (1) lagomorph and other small mammals, and (2) Artiodactyla and other large mammals. Even then the Zone C lagomorph and small mammal cell has only two elements.

Distribution of Faunal Elements in Zones C and G

Tables 10 and 11 show relatively meager numbers of elements for zones C and G. Most notable in the data is the percentage of the faunal elements that are those of large mammals. In Zone C, 66.7 percent; in Zone G, 49.3 percent (Tables 10 and 11). In zones B and F (Table 12), faunal elements are so scant that they are not further discussed here.

Comparative Analysis of Faunal Element Distribution and Vegetation Zones

Differences in the game taken is suggested by variations in the faunal assemblages from vegetation zones A, C, and G. Differences in the percentage of small mammals in the samples seem especially significant (Table 13). In Zone A, the lagomorph, reptile, and small mammal elements comprise 26.5 percent of the sample. This is more than twice the percentage (10.8 percent) of lagomorph, reptile, and small mammal elements in the Zone G faunal sample, and more than six times their percentage (4.2 percent) in vegetation zone C. This difference is also demonstrated in the chi-square test on the comparative distribution (Table 14). The distribution of the faunal elements seems to indicate that in vegetation zone A, smaller animals were taken relatively more often and comprised a larger proportion

Table 13

NUMBER AND PERCENTAGE OF SMALL AND LARGE ANIMAL ELEMENTS BY VEGETATION ZONE

Vegetation Zones	Lagomorph, Reptile, and Small Mammals # (%)	Artiodactyla and Large Mammals # (%)	Total # (%)
Zone A, Southern Bench and Granitic Outcrop Associations	84 (26.5)	233 (73.5)	**317 (100)**
Zone C, Oak and Pine Woodland Association	2 (4.2)	46 (95.8)	**48 (100)**
Zone G, Mojave Yucca Association	10 (10.8)	83 (89.2)	**93 (100)**
Total	**96 (21.0)**	**362 (79.0)**	**458 (100)**

Table 14

COMPARISON OF DISTRIBUTIONS OF SMALL AND LARGE ANIMAL ELEMENTS IN ZONE A (SOUTHERN BENCH/GRANITIC OUTCROP), ZONE C (OAK-PINE WOODLAND), AND ZONE G (MOJAVE YUCCA) CHI SQUARE TEST RESULTS

	Small Mammal, Reptiles, and Lagomorph		Large Mammal and Artiodactyla		
Zones	Observed	Expected	Observed	Expected	Total
Zone A, Southern Bench and Granitic Outcrop Associations	A1 84	66.445	B1 233	250.555	**317**
Zone C, Oak-Pine Woodland Association	A2 2	10.061	B2 46	37.939	**48**
Zone G, Mojave Yucca Association	A3 10	19.493	B3 83	73.507	**93**
Total	**96**		**362**		**458**

A1 = 4.638 B1 = 1.230
A2 = 6.459 B2 = 1.713
A3 = 4.623 B3 = 1.226
Total 15.720 + 4.169 = Chi-Square = 19.889

$p < .001$

$df = 2$

Chi-Square of 19.889 with a significance of < .001 indicates a greater than 99.9% chance that the sample of fauna reflects differences in number of faunal elements from vegetation zones A, C, and G.

of the fauna than they did in zones C and G. These numbers suggest that there are some differences in the faunal remains from different vegetation zones.

Another fragment of data that must be considered is the fact that—in many sites dating to the late period of occupation in the Mojave and Colorado deserts—the most common game animals represented in the faunal remains are either lagomorphs or tortoises. At the Triple House site, tortoise is the dominant animal, as judged by the number of elements present. However, if one looks at the other faunal elements in the Triple House site assemblage and at the faunal assemblages from all other vegetation zones, large animal elements account for a far greater percentage of the faunal assemblage than small animal elements. This suggests that there may have been a different dynamic involved in the taking of game within the study area than was common in other areas of the California deserts. Large game may have been more abundant here than in many other areas; perhaps large mammals were hunted seasonally here, and local sites contain more large mammal bones because the animals were processed near where they were killed and only selected parts were removed to more permanent occupation sites.

The case of tortoises. Tortoise elements were very numerous only at the Triple House site in the Southern Bench portion of Zone A; elements numbered 1,634 and comprised 76.4 percent of the faunal assemblage at this site. Elsewhere within Joshua Tree, tortoise makes up a relatively small percentage of the faunal assemblages: 5.0 percent in Zone C (Oak and Pine Woodlands) and 7.4 percent in Zone G (Mojave Yucca). The differences in tortoise-element numbers may reflect differences in tortoise habitat in the various zones and/or cultural differences in the use of tortoises by the indigenous groups of the area, or other factors.

Absence of the smallest animals. Finally, it should be noted that this sample is missing the remains of smaller mammals such as rodents and packrats, as well as those of such reptiles as chuckwalla, other lizards, and snakes. It seems reasonable that the surface collecting of faunal remains introduces a bias toward larger bones that is not as pronounced in collections from excavations in which bones are recovered from screens or are removed by the very careful water screening of midden samples. However, the sample derived from surface collecting during this project demonstrates that Artiodactyla constitute an important component of faunal assemblages in Joshua Tree and that Artiodactyla hunting was an important subsistence activity. Furthermore, the quantity of faunal remains is large enough to indicate that the analysis of faunal assemblages from sites within Joshua Tree can make an important contribution to the study of the prehistoric use of faunal resources.

SUMMARY, GENERALIZATIONS, AND CONCLUSIONS

Our observations indicate that the zones with the most sites were also the zones most preferred for relatively permanent occupation by humans; i.e., Zone A (the Granitic Outcrop/Southern Bench Vegetation Association), with 17.27 sites per km.^{2} and Zone C (the Oak-Pine Woodland Vegetation Association) with 16.27 sites per km.^{2} Zone E (the Blackbush and Burroweed Vegetation Association), Zone F (the Joshua Tree Vegetation Association), and Zone G (the Mojave Yucca Vegetation Association) fall within a narrow range between 6.67 sites per km.^{2} and 7.78 sites per km.^{2} The sparse and arid Zone B (the Creosote Vegetation Association) ranks last with 2.27 sites per km.^{2}

Site-type variability does not appear to correlate with the number of sites per km.^{2} (Table 15). Zone A, the zone with 17.27 sites per km.^{2}, contained 9 of the 12 site types we recognized in the total site sample. Zone G, however, with only 7.78 sites per km.^{2}, contained 7 of the 12 site types. Zone B, with only 2.27 sites per km.^{2}, contained 6 of the 12 site types. Zone C, with 16.25 sites per km.^{2}, contained only 5 of the site types. Zone E and Zone F have 7.78 and 6.67 sites per km.^{2}, respectively, and they each contain only 4 site types.

This distribution suggests that while certain site types are widespread, other site types are more restricted in distribution, and these types are correlated with particular vegetation zones. The distribution of residential and camp sites by vegetation zones (Table 15) shows a concentration in zones A, C, and G, with a single exception in Zone B. This distribution seems to indicate that Zone A, Zone C, and Zone G were preferred for domestic activities, whereas in other areas the sites appear to have been the result of specialized, short-term activities at particular locations on the landscape, or the transitory activities of people passing through the area.

This kind of distribution of site types suggests that different environments within the landscape were used in different ways by indigenous peoples, and that functional differences in the use of these areas may be identified in the artifact assemblages. However, the analysis of the distribution of the small artifact and faunal-remain assemblages from these vegetation zones produced results that, at best, raise questions and are in some respects enigmatic. The samples of artifacts and faunal remains are from surface contexts only. The surfaces of many of these sites have been picked over by tourists and other visitors to the area for over 75 years; many, if not most, artifact and fauna assemblages have been adversely impacted. There can be little doubt that these samples are biased and may have produced incorrect results.

Artifact and faunal assemblages from only three zones are large enough to possibly be worthy of further study. It is not surprising that these are zones A, C, and G, the same zones that contain the majority of residential and camp sites and the greatest number of sites per km.^{2} We have outlined the major problems with these data. The results are presented in a positive manner because they seem at times to contradict accepted interpretations and require further explanation. They raise questions worthy of being investigated.

The distribution of the artifact assemblages from zones A, C, and G indicate that the hunting of large mammals was an important activity in all three, but processing/milling activities (presumably plant processing) were more important in Zone G, the Mojave Yucca Zone, than in the other two. The faunal remains from zones A, C, and G exhibit a similar uneven distribution in the frequency of small animals taken. Zone G (Mojave Yucca) and Zone C (Oak-Pine Woodland) have a lower-than-expected frequency of small animal elements, whereas Zone A (Granitic

Table 15

COMPARISON OF SITES PER SQUARE KILOMETER AND SITE TYPES PER SQUARE KILOMETER DISTRIBUTION OF RESIDENTIAL (1A) AND CAMP (1B) SITE TYPES BY VEGETATION ZONES

	Sites/km.^{2}		Site		Site Types 1a & 1b
Zones	No.	Rank	No.	Rank	Number
A. Granitic Outcrop/Southern Bench	17.27	1	9	1	7
C. Oak-Pine Woodland	16.25	2	5	4	6
G. Mojave Yucca	7.78	3	7	2	5
E. Blackbush and Burroweed	7.78	3	4	5	0
F. Joshua Tree	6.67	5	4	5	0
B. Creosote Bush	2.27	6	6	3	1

Outcrop/Southern Bench) has a larger-than-expected number of small animal elements.

Three vegetation zones have comparable site densities: Zone F (Joshua Tree, with 6.7 sites per km.[2]), Zone G (Mojave Yucca, with 7.8 sites per km.[2]), and Zone E (Blackbush/Burroweed, with 7.8 sites per km.[2]). Zone C (Oak and Pine Woodland) has a significantly higher site density at 16.25 sites per km.[2], as does Zone A (Granitic Outcrop/Southern Bench), with 17.27 sites per km.[2], and Zone H (Playa Margin) with a density[5] of 20.0 sites per km.[2]

It is clear from the numbers presented above that Granitic Outcrop/Southern Bench (Zone A), Oak and Pine Woodland (Zone C), and Mojave Yucca (Zone G) were the vegetation zones of major importance to the inhabitants of Joshua Tree in the late prehistoric period. Taken together, 90 percent (18 of 20) of the residential sites recorded were found in these three vegetation zones. Sites in the other zones were mostly small specialized-activity sites where people did not reside or where they stayed only temporarily when traveling through the region.

The distribution of residential sites strongly suggests that zones A, C, and G were preferred for more permanent living sites; in addition, the diversity of sites in Zone A and Zone G suggests that many activities were conducted relatively close to the domestic sites in these zones. The fewer site types in Zone C (the Oak-Pine Woodland) may indicate that less variable subsistence activities occurred there than in Zone A or Zone G. Zone B (Creosote Bush), while having relatively few sites per km.[2], has a relatively wide diversity of site types; this remains unexplained. We might speculate, however, that the food and water resources of this zone were so scarce that the sites represent people moving through it from one highly-focused subsistence activity to another, leaving evidence of many different subsistence activities.

Zone E (Blackbush and Burroweed) and Zone F (Joshua Tree) have low site-type diversity and low site density. This suggests that important, but limited resources, were found in these zones. Our data indicate that they were occupied less often, and the range of subsistence activities was more limited, than in zones A, C, and G.

The artifact assemblages and faunal remains are very limited and incomplete. The results of their analyses, therefore, must be considered tentative for the reasons that were discussed above. Hunting with projectile technology occurred in the A, C, and G zones, indicating the taking of large mammals. Large mammal remains are surprisingly common in the A, C, and G zones, lending support to this scenario. Processing/milling equipment also occurs in the A, C, and G zones, but is more abundant in Zone G (Mojave Yucca) than in others. Tortoise remains are very abundant at the Triple House site (CA-RIV-1950) in Zone A, but much less so at all other sites.

We conclude that there can be little doubt that the environmental and ecological differences associated with the several vegetation zones played an important role in the location, frequency, variability, and type of human activities across the Joshua Tree landscape in late prehistoric times.

NOTES

1 However, since this was a survey in which virtually no excavation was conducted, archaeological information from the sites is very uneven. The surface collections from a few sites produced relatively large assemblages with significant variability in artifact types, while other sites produced very few artifacts with little variability. The low productivity sites were carefully recorded. When there are several sites with artifacts of limited variability, all containing pottery, and all associated with a topographic feature, they may be grouped together and their combined artifact assemblages considered representative of the late prehistoric/protohistoric period at that given locality. These human activities can be identified as occurring at a given moment in time at a particular location. A site with a single milling stone hardly seems comparable to a single site with a large number of milling stones and little else. Half a dozen small sites, however, each containing one or two milling stones and little else, and in proximity to one another, may be interpreted as representing some repetitive pattern having a relationship to the locality.

2 "Milling" is a generalized term that we apply to processing locations; however, they were not necessarily limited to plant or seed processing. Although the term has become associated with plant processing, we now know that many other substances were processed using bedrock or portable mortars, pestles, metates (or other slab devices), and manos (or other types of handstones). See Note 4 below.

3 Diagnostic means having features enabling the analyst to determine the stage of manufacturing, reshaping, or resharpening involved and/or the type of object the flake was removed from.

4 Although a general assumption is often made that milling is directly associated with pine nuts, acorns, and other seed

resources, studies have shown that meat, as well as non-organic materials, was processed using milling tools (e.g., Kraybill 1977; Schneider and Bruce 2009; Yohe et al. 1991). Future research might explore the question of why milling equipment is more common where Mojave Yucca (Zone G) is the prevalent vegetation type than in the zones where pine and oak are prevalent (Zones A and C).

[5] The Playa Margin, Zone H, is so small in area and the sample so limited that its numbers cannot be considered comparable to those from other zones.

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High-Altitude Intensification and Settlement in Utah's Pahvant Range

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Recent excavations at Pharo Heights, a residential site in the subalpine region of the Pahvant Range in central Utah, and the dating of a storage feature associated with Pharo Village, a Fremont hamlet at the base of the eastern side of the range, indicate contemporaneous occupations between approximately 1,650 and 500 cal B.P. Combined with survey data suggesting a long period of Archaic hunting along the crest of the Pahvants, this information suggests intensive exploitation and seasonal residential occupation of the high country developed alongside population growth and economic intensification in the lowlands, likely as a way of increasing hunting returns, but probably not as a way of facilitating trade or travel. This interpretation suggests that Fremont farming and hunting intensification were interlinked, a model in accord with both regional and global perspectives identifying economic intensification as the primary impetus for intensive, residential occupation at high altitude.

The subject of why people intensively exploit and live at high elevations is an important one, especially in the Great Basin, which is of course characterized as much by mountain ranges as by basin floors. Though somewhat contentious (see Walsh 2005; and Walsh et al. 2006), most thinking along these lines has it that high mountains (i.e., regions above 2,700 m.) are marginal environments where biotic productivity, growing season, temperature, oftentimes water, and even oxygen are limiting to human occupation (Aldenderfer 2006; Beall 2001). So the question is asked: why would people choose to live for any extended period of time under such circumstances? Recent survey and excavation in Utah's Pahvant Range and a new radiocarbon date on a storage feature associated with Pharo Village, a Fremont hamlet near the base of the northeastern part of the range, provide evidence pointing to an intimate relationship between highland and lowland occupations. This close relationship suggests that increasing population density associated with economic intensification in the lowlands also elicited intensive exploitation of alpine-subalpine settings and the establishment of seasonally-occupied, residential highland camps.

These conclusions are based on a survey of 518 acres along the crest of the Pahvant Range, the excavation of a subalpine residential site known as Pharo Heights, also along this crest, and the dating of a subterranean storage feature associated with Pharo Village, on the valley floor immediately east of the range. This brief paper presents evidence supporting the findings described above. It begins with an overview of the study area's setting, continues with a presentation of field and lab results, explores these results using a GIS settlement pattern analysis, and concludes with a discussion of

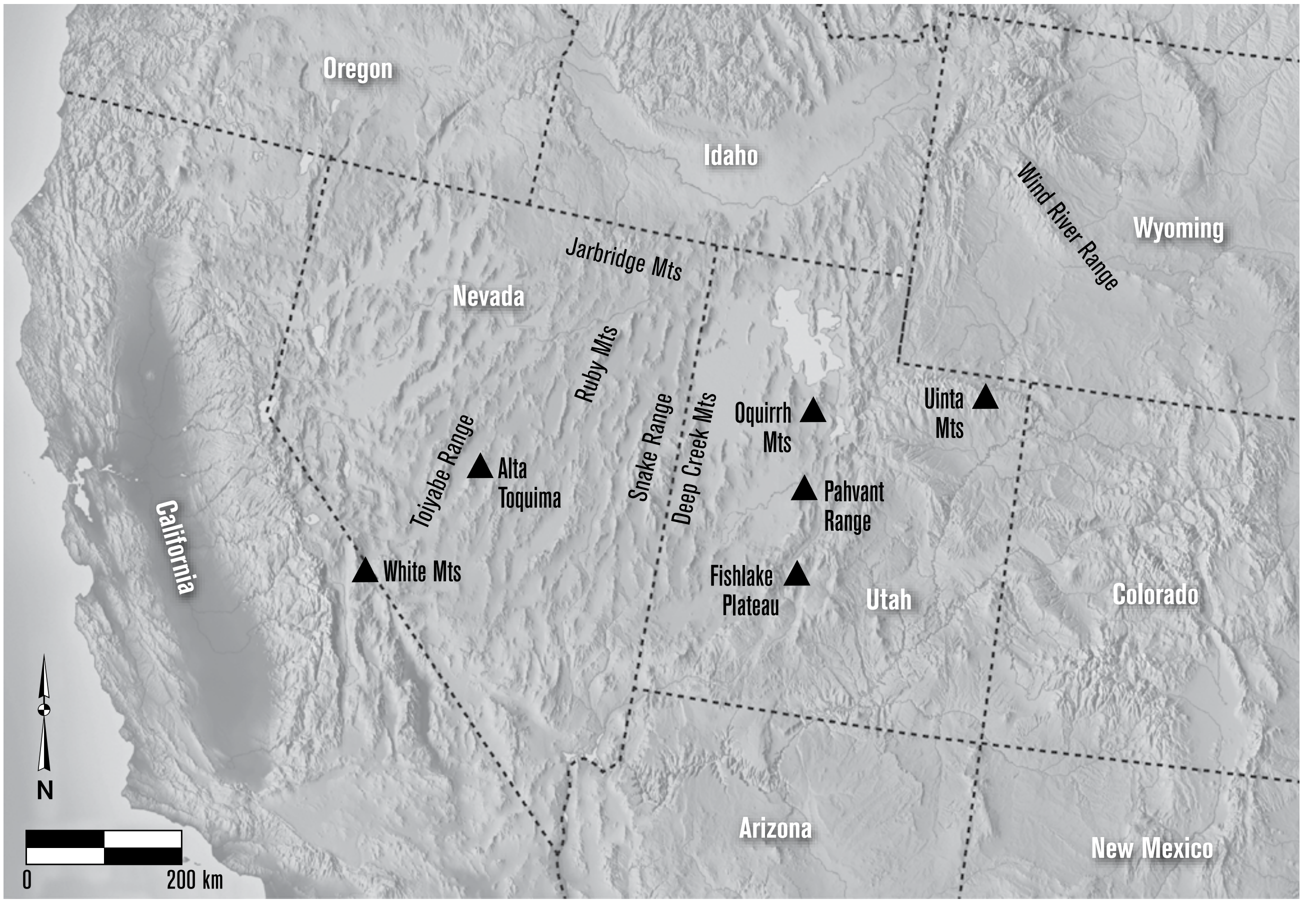

Figure 1. Study area showing Pahvant Range and other high altitude studies mentioned in text.

the relevance of these results to the local and regional archaeological record, particularly as they relate to high-altitude archaeology in and around the Great Basin.

PAHVANT RANGE ARCHAEOLOGY

The Pahvant Range is a relatively short, steep, and narrow (roughly 70 km. long by 15 km. wide) mountain range in central Utah, bounded on the north by the town of Scipio and Scipio Pass, on the west by Fillmore, on the east by Richfield and the Sevier River, and on the south by Interstate 70, Clear Creek Canyon, and the Tushar Mountains (Fig. 1). Like most Great Basin ranges, the Pahvants are a generally north-south trending, fault-block chain composed of sedimentary and metasedimentary rocks like sandstones, quartzites, limestones, and shales. In its northern portion, near Scipio, there are conglomerate cliffs containing, among other larger clasts, toolstone-quality chert nodules. Elevations range from approximately 6,000 ft. (ca. 1,800 m.) in Upper Round Valley at the eastern base of the range to 10,222 ft. (3,116 m.) at Mine Camp Peak. The base of the range is some 800 feet lower on its western side (at ca. 1,600 m.). Biotic distribution conforms to that seen elsewhere in the Great Basin (Grayson 1993), with a sagebrush (*Artemisia* spp.) steppe at the base of the range, a mixed hardwood and coniferous (*Acer-Pinus*) forest between roughly 6,000 and 7,000 ft. (1,800–2,100 m.), coniferous forest (*Pinus-Abies*) and shrublands (mainly *Cercocarpus* and *Prunus* spp.) between 7,000 and 9,000 ft. (2,100–2,743 m.), and a narrow swath of subalpine sagebrush-grasslands above about 9,000 ft. (2,743 m.) that also contains small stands of aspen (*Populus tremuloides*) in the lee of steeper slopes. Deeply incised, steep-sided canyons containing mostly seasonal, but also a few perennial streams (in the northeast, notably Willow and Ivie creeks; Pharo Creek, mapped as intermittent, has continuous flows most years), dissect the range (USGS 2002).

Beyond an initial recording of Fremont mounds along Ivie Creek (not to be confused with the more famous Ivie Creek, which drains Old Woman Plateau some 85 km. to the east) by Elmer Smith in 1936 (Smith 1937) and the occasional Forest Service survey or site evaluation (e.g., Leonard 1993), very few archaeological investigations have been conducted in the northern part of the Pahvant Range. In the south, however, expansion of I-70 through Clear Creek Canyon resulted in particularly substantial, though lower-elevation, investigations (Janetski et al. 1985; 2000; Talbot et al. 1998, 1999, 2000). The exception to this was the University of Utah's excavation of Pharo Village, originally described as a Fremont hamlet extending some 200 m. along the banks of Pharo Creek, at an average elevation of 6,000 ft., in 1967 (Marwitt 1968). The work here was considerable, and was focused on clearing excavations in the site's northeastern locus (a second locus, to the southwest, was test-trenched, but never systematically excavated). Excavations revealed three roughly rectilinear pithouses, six above-ground granaries, two human burials, a dog burial, two "activity areas," and several other features characteristic of Fremont residential sites. Recovered artifacts were more or less typical of the region: Sevier, Snake Valley, and Ivie Creek ceramics, Parowan Basal-notched and other Formative Period projectile points, abundant flaked-stone artifacts and milling tools (including Utah-type metates), worked-bone artifacts, charred corncobs and cornstalks, and animal bone, particularly that of mountain sheep (*Ovis canadensis*) and mule deer (*Odocoileus hemionus*). Based on these findings, Marwitt (1968) interpreted the site as a small, permanent horticultural settlement that supplemented its diet with locally-available large game like sheep and deer. Two radiocarbon dates, one from a structural member in the floor of the first pithouse, the other from a granary, bracket the site occupation between 690±80 and 760±90 rcy B.P. (744–832 and 805–619 cal B.P. at 2 sigma, respectively; all radiocarbon dates in this article were calibrated with CALIB 6.1.1 [Stuiver and Reimer 1993] using the IntCAL09 calibration curve [Reimer et al. 2009]). A third date of 1,490±80 rcy B.P. (1,545–1280 cal B.P. at 2 sigma), from a wood fragment recovered from what was described as the crawlway of the third pithouse, was rejected because it was "incompatible with the archaeological data," probably because it did not correspond to the later (e.g., Ivie Creek Black-on-White) ceramics at the site (Marwitt 1968:5).

FIELD INVESTIGATIONS IN 2009

Within this context, and drawing on previous studies of Fremont mountain adaptations and settlement patterns (e.g., Janetski 1985, 2010; Johnson and Loosle 2002; Knoll 2003; Loosle and Johnson 2000; Talbot and Richens 2004), volunteers from Utah State University's anthropology program set out to investigate high-altitude prehistoric land use in the vicinity of Pharo Village in the summer of 2009. This work consisted of survey along the crest of the range, excavation of a site known as Pharo Heights, and a rather serendipitous sampling and dating of a subterranean storage feature associated with Pharo Village itself.

High-Elevation Survey

The survey portion of the study focused on the subalpine-alpine region of the northern Pahvant Range and was geared towards elucidating high-altitude aboriginal land use and its relationship (if any) to Pharo Village. Operating on this basis, a DEM of the region was queried to identify all areas above 9,100 ft. (2,774 m.), a robust proxy for alpine-subalpine habitats in the region (Grayson 1993), and an 8.5 km. Euclidian buffer was generated around Pharo Village; this is a more-or-less typical central-place foraging radius (Morgan 2008). The intersection of these two polygons resulted in a 6,397-acre parcel representing those areas both above timberline and within 8.5 km. of Pharo Village. Within this area, 518 acres (an 8.1% sample) were intensively surveyed with a crew of five walking 15-meter-wide, line-abreast transects. Findings were few, consisting of the occasional isolate (most often an isolated chert flake) and three archaeological sites. The first two sites are small lithic scatters, with projectile point types ranging in age from Archaic to Late Prehistoric (i.e., one Elko Corner-Notched and one Rosegate Series point, together dating to ca. 4,500–500 B.P.) (Thomas 1981). The third site was Pharo Heights, initially identified by Fishlake National Forest Archaeologist Robert Leonard and described in the succeeding subsection. These findings, admittedly somewhat unremarkable, are commensurate with those from nearly every other surveyed range in the American

West (e.g., Benedict 1975; Canaday 2001; Wright et al. 1980) in that they characterize a low-intensity, sporadic use of the region (mostly for hunting) during the Archaic and latter half of the Holocene.

Pharo Heights

The Pharo Heights site is located at an elevation of 9,465 ft. (2,885 m.) on an exposed north-south trending, low-angle saddle between Pioneer Canyon, which drains toward the town of Holden to the west, and Rock Canyon, a tributary of Pharo Creek, which drops precipitously to the east. The site was initially reported to contain at least ten possible housepit depressions and an extensive artifact scatter of flaked and ground stone artifacts, as well as a small quantity of pottery. A well-travelled, USFS-maintained dirt road passes through the western edge of the site. Cattle regularly graze and vehicles occasionally park or are driven on-site.

The 2009 field investigations consisted of a complete inventory of the site's surface artifact assemblage (using 2-meter-wide, line-abreast transects) and the excavation of ten 50 x 50 cm. shovel probes and one 1 x 1 m. unit (all excavated in 10 cm. arbitrary levels and screened using 1/8" mesh). Excavations were conducted to ascertain the composition of the site's subsurface deposit and to determine the nature of the possible housepit depressions. To this end, four shovel probes and the single unit were excavated in five of the most distinct depressions; the remaining probes were used to judgmentally test other portions of the site, particularly a higher-density artifact scatter near a seep in the northern portion of the site. These excavations identified a mostly-shallow subsurface deposit extending no more than 30 cm. below surface (cmbs.), save in Shovel Probes 6 and 10, which revealed deposits extending to 80 and 60 cmbs., respectively. In general, the site deposit contained a diverse artifact assemblage comprised of groundstone, ceramics, abundant flaked stone, and faunal remains; anthropogenic midden soils were found in the southern portion of the site (Fig. 2).

Features. Site features consisted of eight 3–4 m. diameter, 5–10 cm. deep depressions resembling wickiup or housepit floor features on the site's surface (our investigations could confidently identify only eight of the original 10 noted at the site by Leonard). There were also at least two subsurface features. The first of these was a 4-cm.-thick lens of charcoal-stained soil and fire-cracked rock adjacent to a small sandstone boulder, found 28.5 cmbs. in Shovel Probe 1, excavated in the center of the most obvious possible housepit depression. Carbon samples were recovered from this feature. The second subsurface feature was a discrete 2 to 3-cm.-thick clay lens resembling a compacted house floor found 12 cm. deep in Shovel Probe 8, also excavated within a distinct depression (Fig. 3). Less discrete paraconformities between sandy surface soils and clayey subsurface horizons and indicators of subsurface compaction were identified in an additional two shovel probes. These findings are equivocal, however, given the frequency of cattle grazing and other impacts at the site (which may have compacted surface and subsurface soil horizons) and the fact that house floors associated with ephemeral structures like wickiups are oftentimes difficult to identify, particularly with regard to soil or sediment compaction (Janetski 2010; Metcalf et al. 1993). All together, identified features included at least one hearth, one compacted house (probably a wickiup) floor, and perhaps as many as two other house floors. The remaining depressions showed little or no evidence of use as housepits, though this fact alone does not preclude their use as such, given problems associated with identifying such short-lived residential structures (see also Simms 1989; Stapert 1990; Surovell and Waguespack 2007).

Artifacts. Surface inventory, surface collection, and excavations identified a diverse assemblage composed of a single ceramic sherd, groundstone, and flaked stone (the vertical distribution of artifacts is shown in Table 1). Based especially on the diversity and temporal variability of the projectile point types found in both surface and subsurface contexts, it appears that stratigraphic mixing has occurred, at least in the shallow subsurface deposits that characterize most of the site.

The sherd is gray, with a uniform, fine-grained, quartz temper, suggesting it is a fragment of a Snake Valley grayware vessel (Madsen 1977). Local landowners report that large vessel fragments and complete pots have been collected from the surface of the site over the last 50 years (Dick Probert and Richard Wasden, personal communications 2009). Groundstone consists of seven manos and three milling slab fragments. The manos are all small (long axis mean = 7.2 cm.), single-handed, unifacially or bifacially worn, and made of locally-

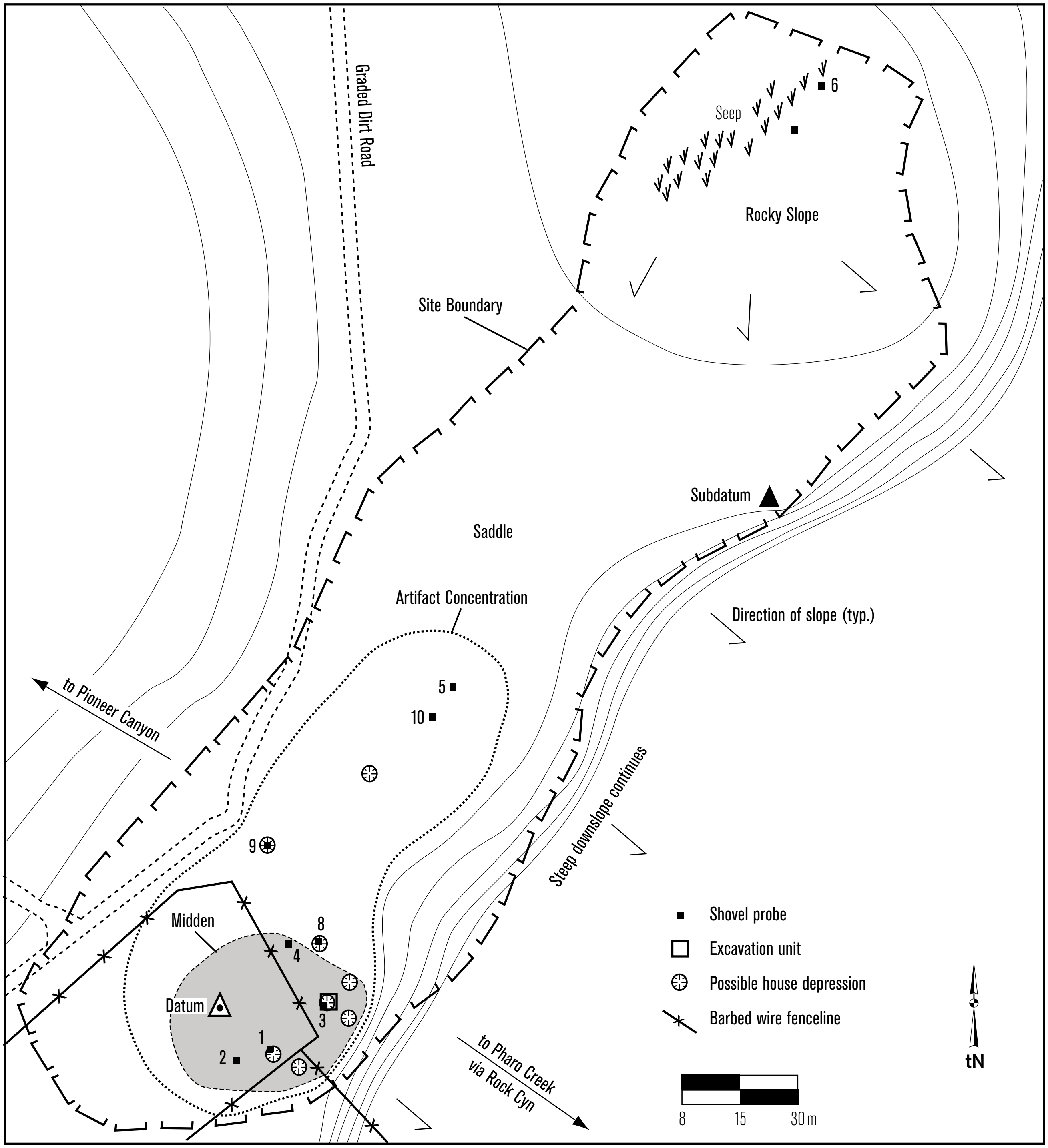

Figure 2. Pharo Heights site map.

available quartzite cobbles. All save one is unshaped. These are somewhat similar to the Archaic manos Schroedl identified at Sudden Shelter (see Jennings et al. 1980), yet clearly represent the expedient use of the abundant, naturally-occurring quartzite cobbles found in and around the site (for a description of expedient groundstone tool attributes, see Madsen and Schmitt 2005:115–119). The three milling slab fragments are likewise lightly-worn milling surfaces developed on locally-available quartzite slabs.

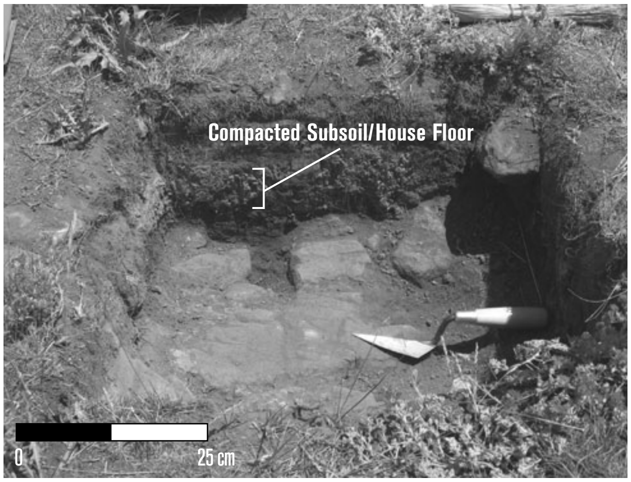

Figure 3. Photograph of possible compacted house floor in Shovel Probe 8.

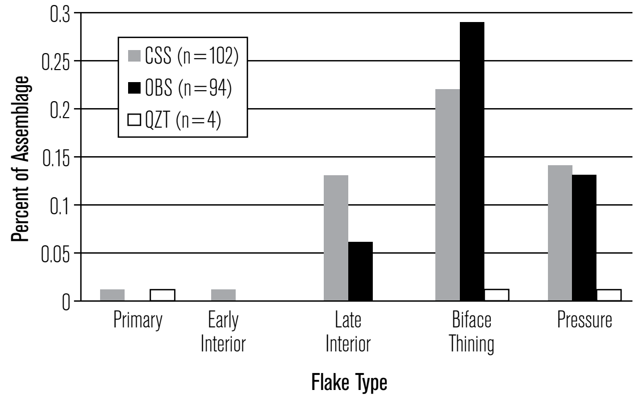

Figure 4. Debitage analysis: Flake type frequencies.

A total of 3,132 pieces of debitage was recovered; 61.6% of the total consisted of chert, 37.8% of obsidian, and less than 1% of quartzite, the latter indicative of testing naturally-occurring cobbles at the site. A random sample of 10 flakes from each of the 10 shovel probes and a second random sample of 100 flakes from the excavation unit (n=200) indicates that the debitage is dominated by small biface-thinning and pressure flakes associated with bifacial tool manufacture and retouch (Fig. 4). An X-ray fluorescence (XRF) analysis of 21 obsidian specimens indicates that roughly 71% of the assemblage is from the Black Rock source and 12% is from the Wild Horse Canyon source, which is not surprising given their location 66 and 88 km., respectively, southwest of the Pahvant Range. A single sample came from an as-yet unidentified source.

Flaked stone tools consist of edge-modified flakes, bifaces, and projectile points. Edge-modified flakes (flakes showing unifacial retouch along one or more margins) consist of two chert, one obsidian, and one quartzite tool. Three obsidian and 25 chert biface fragments were recovered from the site; all save three are mid- to late-stage specimens (i.e., Stages 3–5; Andrefsky 2000:180–181), indicating initial reduction and thinning occurred elsewhere. Importantly, 12 of these bifaces are classed as Stage 5, indicating that they represent finished and perhaps hafted tools or broken projectile points. Nine projectile point fragments were also identified: a heat-treated chert Elko base, an obsidian Nawthis type missing its tip, an obsidian Rose Springs base, an obsidian Cottonwood Triangular missing its tip, a possible crude chert Bull Creek fragment, one unidentifiable chert point tip, and four unidentifiable obsidian point fragments.

Fauna. Faunal remains consist of 590 specimens of mostly fragmentary burnt bone, with a relatively low number of specimens identified to the ordinal level (Table 2) and only 23 specimens confidently identified below the class level (i.e., Mammalia). One specimen was

Table 1

FREQUENCY DISTRIBUTION OF PHARO HEIGHTS ASSEMBLAGE BY ARTIFACT CLASS

	Biface	Core	Debitage	EMF[a]	Faunal Bone	Mano	Milling-slab	Sherd	Proj. Point	Total
Subsurface	6	1	3,132	0	602	1	1	1	3[b]	3,748
Surface	22	5	0[d]	4	1	6	2	0	6[c]	48
Total	28	6	3,132	4	603	7	3	1	9	3,796

[a] Edge modified flake

[b] one Bull Creek, one Elko and one unidentifiable fragment

[c] one Nawthis, one Cottonwood, one Rose Springs and three unidentifiable fragments

[d] debitage not collected from site surface

Table 2

SUMMARY OF TAXA PRESENT IN THE PHARO HEIGHTS FAUNAL ASSEMBLAGE

Taxon	Count
Rodentia	1
Artiodactyla	21
Ovis canadensis	1
Unidentified, size class 2	1
Unidentified, size class 3	20
Unidentified, size class 4	1
Unidentified, size class 5	57
Unidentified, unknown size	488
Total NISP	**23**
Total Unidentified	**567**
Total Specimens	**590**

identified at the species level, a malleolus of mountain sheep (*Ovis canadensis*). An additional 21 specimens of highly fragmented tooth enamel and a single lumbar vertebra centrum fragment were identified as Artiodactyla. The single rodent specimen is a fragmented upper incisor of a Class 2 size animal (approximately the size of *Neotoma* or *Thomomys*). Based on the single specimen, it cannot be determined whether this specimen is intrusive or cultural.

The Pharo Heights faunal assemblage exhibits a high proportion of burning based on the presence of carbonized (charred) and calcined specimens. Excluding specimens with "indeterminate" burning, 194 specimens (35.6%) exhibit some degree of heat exposure. Most burned specimens were calcined (83.0%). No other cultural markers, such as cutmarks, were identified on the remains aside from burning.

The high frequency of burning in the assemblage warrants a brief discussion. Quite a few researchers have suggested that scrap bone may have been added to fires at high elevation sites to help fuel wood fires (Costamagno et al. 2005; Grayson 1991; Grayson and Millar 2008; Thèry-Parisot 2002; Thèry-Parisot et al. 2005). The rate of burning as a whole is lower in the Pharo Heights assemblage than that observed by Grayson (1991) for high elevation sites in the White Mountains, California, where between 50% and 74% of the faunal remains were either charred or calcined. However, between 10% and 68% of the burned bone in the White Mountain alpine assemblages was calcined, which is comparable to the high rate of calcined specimens observed at Pharo Heights. Although it is tempting to interpret this as the result of using bones as fuel (or perhaps simply as discards into cooking fires—see Janetski et al. 2000:78–79), the high rate of burning in the Pharo Heights assemblage may also simply be due to preservation biases.

Dating. The dating of Pharo Heights relies on one AMS date, source-specific obsidian hydration measurements, and diagnostic artifact types. The single AMS date (Beta-26872), on charcoal recovered from the hearth identified in Shovel Probe 1, returned a date of 1,720 ± 40 rcy B.P. (1,713–1,538 cal B.P. at 2 sigma). The taxon of the charcoal was not identified prior to dating. This datum is consistent with a fairly early Formative Period occupation of the site, but could possibly be confounded by an "old wood" problem (Schiffer 1986), though at present only short-lived species grow near the site (i.e., aspen, which lives to a maximum of about 220 years [Fitzgerald 2010]). Obsidian hydration (OH) measurements for 20 source-identified obsidian specimens range from 1.2 to 3.6 microns (Fig. 5). Using the relative temporal framework for these two obsidian sources devised by Seddon (2005), dates range from "confidently Archaic" (n = 2) to "confidently Late Prehistoric" (n = 3), with most dates falling into "Late Prehistoric/Formative" (n = 10) or "confidently Formative" categories (n = 4) (Table 3). Combined, 15 of 20 OH measurements fall into a Formative Period category, skewing towards the younger end of the Formative range. Finally, AMS and OH data are consistent with the almost exclusively Formative Period diagnostic artifacts at the site: Snake Valley grayware pottery arguably dates to between 1,050 and 700 B.P. (Berry 1972); Cottonwood Triangular points generally post-date 650 B.P., Rose Springs points date to between 1,350 and 650 B.P. or perhaps later (Bettinger and Taylor 1974; Garfinkel 2010); Bull Creek points, though more often associated with Ancestral Puebloan sites, date from 900 – 650 B.P. (Holmer and Weder 1980:61; Woods 2009); and Nawthis projectile points date to between 1,150 and 750 years B.P. (Holmer and Weder 1980; Lyndon 2005). The single Elko Eared point, a generally poor temporal marker (but see Lyndon 2005), corresponds to the Archaic to early Formative obsidian hydration dates, arguably between about 3,250

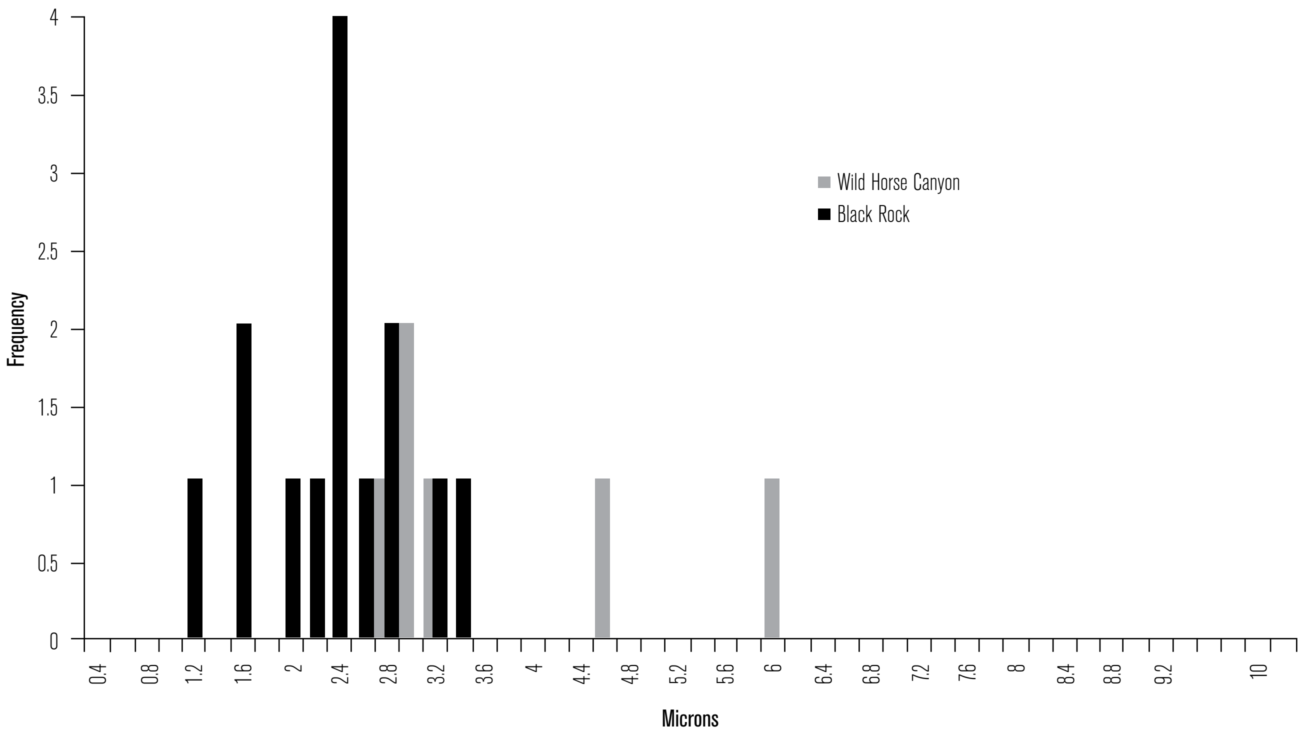

Figure 5. Obsidian hydration histogram by source.

and 1,250 B.P. (O'Connell 1967; Thomas 1981). In any event, chronological data for the site clearly indicate mainly Formative Period occupations, between about 1,650 and 500 cal B.P. (Fig. 6).

Site Summary. Based on the preceding, Pharo Heights appears to be a seasonal residential locus that was likely repeatedly occupied for short spans in the summer and fall when the ridge upon which it is located was snow-free. Features indicate the construction of one to three, and possibly more, wickiups, brush shelters, or other expedient living structures, as well as campfires, particularly in the southern portion of the site. Plant (and possibly small animal) processing is indicated by the relatively abundant groundstone on the site, as well as the small quantity of pottery that could have been used to boil such items. Hunting and animal processing, including but not necessarily limited to mountain sheep, is indicated by projectile points, bifaces, expedient flake tools and artiodactyl bone. Tool manufacture and maintenance is evidenced by the prevalence of biface thinning and pressure flakes in the debitage assemblage. Combined with multiple dating proxies, it appears that the site served as a seasonal residential locus focused on plant procurement, processing, and hunting that was occupied repeatedly, mainly between 1,650 and 500 cal B.P.

Table 3

DISTRIBUTION OF PHARO HEIGHTS OBSIDIAN HYDRATION DATES (SEDDON 2005)

Age	Black Rock	Wild Horse	Total
Confidently Late Prehistoric	3	0	3
Late Prehistoric/Formative	6	4	10
Confidently Formative	4	0	4
Formative/Archaic	1	0	1
Confidently Archaic	0	2	2
Total	**14**	**6**	**20**

Pharo Village

During a visit to Pharo Village, a large sinkhole was identified near what appears to have been the southwestern locus of the site (as described by Marwitt 1968:3), in an area blanketed with chert flakes and sherds (Fig. 7). The sinkhole was roughly 8 m. in diameter, 3 m. deep and had perfectly sectioned an anomalous (for central Utah) slab-lined storage cist. The cist measured

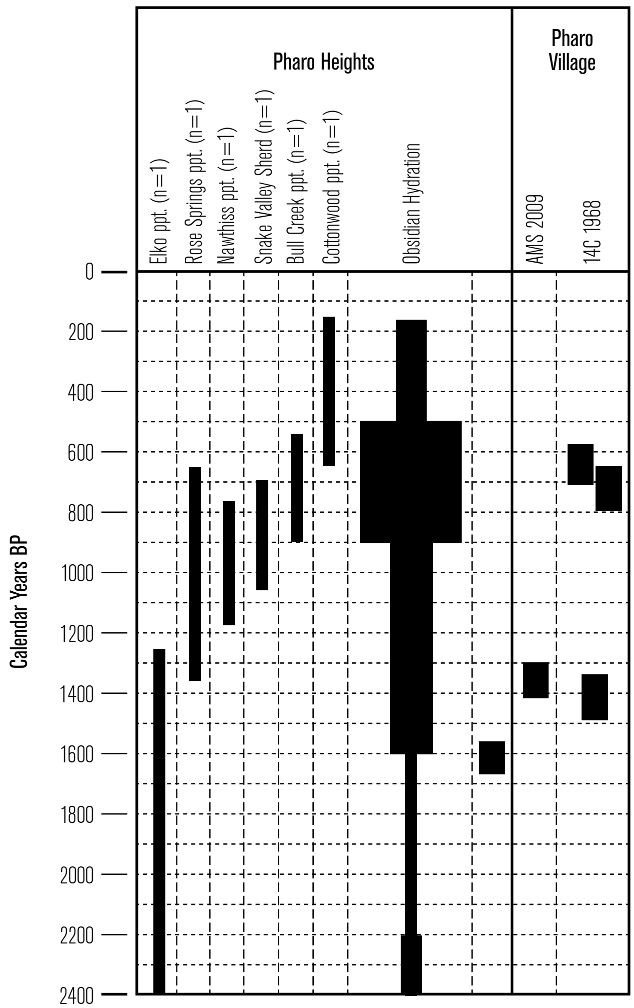

Figure 6. Dating comparison: Pharo Heights : Pharo Village.

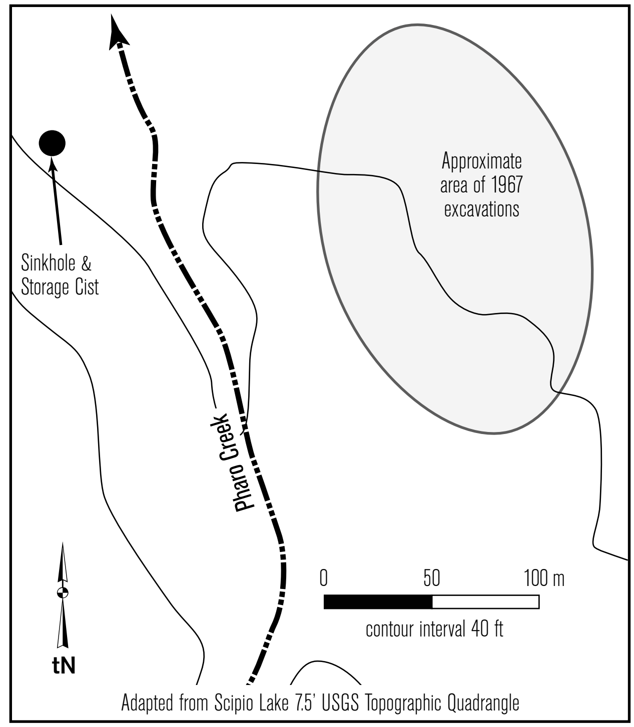

Figure 7. Map showing 1967 Pharo Village excavations and cist sampled in 2009. The exact location and extent of Pharo Village and its two loci are estimated based on written descriptions and an aerial photograph in Marwitt (1968:2) and the site map from the original excavations. Almost no artifacts and no evidence of excavation, however, are present in the location depicted in the figure, though abundant artifacts are present in and around the sampled storage cist.

95 cm. wide by 63 cm. deep, was capped by a 10- to 15-cm.-thick weakly-developed soil, and was filled with cobbles, small boulders, and burned midden soils. A 1- to 2-cm.-thick lens of burned organic material lined the base of the pit (Fig. 8). In an effort to salvage information from the feature, the section was cleaned, mapped and photographed, and carbon samples were collected from the burned base of the pit. A single AMS date (Beta-268171) from carbon collected from the lens at the base of the pit indicates it burned at 1,460 ± 40 rcy B.P. (1,410–1,269 cal B.P. at 2 sigma). This date is consistent with Marwitt's (1968) discarded date of 1,490 rcy B.P. for the third Pharo Village pithouse, suggesting that these earlier dates likely do represent legitimate occupations of the site. All together, dates from Pharo Village indicate either a continuous occupation between about 1,400 and

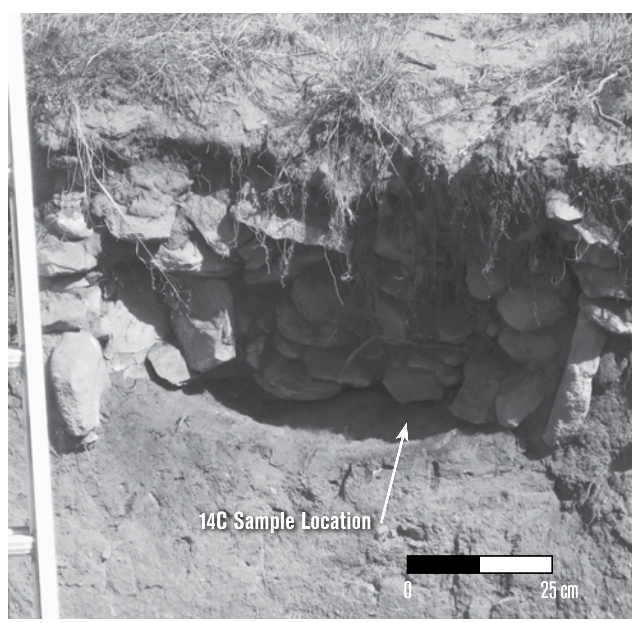

Figure 8. Photograph of sectioned storage feature near Pharo Village.

650 cal B.P. or two separate occupations at either end of this temporal span (Fig. 6).

SYNTHESIS: DATING, SETTLEMENT, AND SUBSISTENCE PATTERNS

The preceding data suggest that the Pharo Village and Pharo Heights sites were occupied roughly between 1,500 and 650 cal B.P. (Fig. 6), during the emplacement and fluorescence of regional Fremont lifeways that were at least partially dependent on maize farming. The geographic and temporal proximity of these sites thus suggests that Pharo Heights was part of a larger settlement system associated at least in part with Pharo Village (and likely associated with Fremont sites near Holden and Fillmore on the west side of the Pahvant Range as well). The question remains, however, as to the role that Pharo Heights played in this system.

To address this question, a pair of GIS-based analyses was developed to assess the costs and benefits of living at Pharo Heights in terms of two hypotheses explaining its relationship to Pharo Village: (1) that it facilitated trade and travel over the Pahvant Range; and (2) that it increased the overall efficiency of high altitude resource exploitation. In the first case, passes through alpine-subalpine regions often served as trade and travel corridors for regional hunter-gatherer groups, with hunting sometimes playing a subsidiary role in determining high-altitude settlement patterns (e.g., Morgan 2009a:389). Pharo Heights' location at a pass providing access to canyons draining to both the west and east superficially conforms to expectations derived from this hypothesis, especially given the abundance of obsidian from sources to the west and Pharo Village's location east of the site—the site provides access to both. To assess the possibility that Pharo Heights served as a camp geared mainly to facilitating travel from Pharo Village over the crest of the Pahvant Range to obtain or trade for local obsidians west of the range, paths were developed using the least-cost path extension in ArcGIS 9.3 to model the most economical routes of travel between Pharo Village and the Wild Horse and Black Rock obsidian sources (the obsidian source locations were modeled as single points by averaging the latitude and longitude for each subsource recorded by Northwest Research Obsidian Studies Laboratory [NROSL 2011]). This extension identifies the lowest-cost route of travel between points, determined by the cumulative cost of traveling through the cells in a raster separating these points (Conolly and Lake 2006:252–256; Surface-Evans and White 2012; but see Kanter 2012). Costs are based on the z-values (a measure of impedance) in a cost-surface raster, in this case an unweighted slope model derived from a 30 m. DEM of the study area (see ESRI 2001 for an explanation of the ArcGIS least-cost paths function). As shown in Figure 9, paths follow the current configuration of modern highways in the area, over Scipio Pass at the northern end of the Pahvant Range. This indicates that transit over the range via Pharo Heights provides a less economical way to access these quarries, and that (at least in terms of obsidian toolstone procurement) Pharo Heights was not primarily associated with facilitating this type of resource acquisition.

An extraction of plant and animal resources is certainly indicated by the faunal, groundstone, and flaked stone assemblages of Pharo Heights, but the way these subsistence activities articulated with those at Pharo Village is unclear. Operating on the assumption that artiodactyl, and in particular, sheep hunting was an economically-important activity associated with both the Pharo Heights and Pharo Village occupations (an interpretation bolstered by the artiodactyl remains and hunting equipment at each site, as well as the regional data showing long-range alpine hunting in subalpine-alpine locales [Knoll 2003; McGuire et al. 2007]), a GIS-based central-place transport analysis (see Morgan 2009b) was developed to model return rates for hunting mountain sheep when operating from each of these sites.

First, seven hypothetical sheep-hunting locales were generated by identifying subalpine regions with low slopes (i.e., <5 degrees) that currently have open exposure and abundant grasses available during the summer for grazers like mountain sheep. Within these areas, seven random points were generated and plotted using the "generate random points in polygon" tool in Hawth's Utilities for ArcGIS (Beyer 2007). Least-cost paths were then developed between both Pharo Village and Pharo Heights and these hypothetical hunting locales, and their distances measured and tabulated (Fig. 10). The costs of traveling over each path were then derived by multiplying the length of each

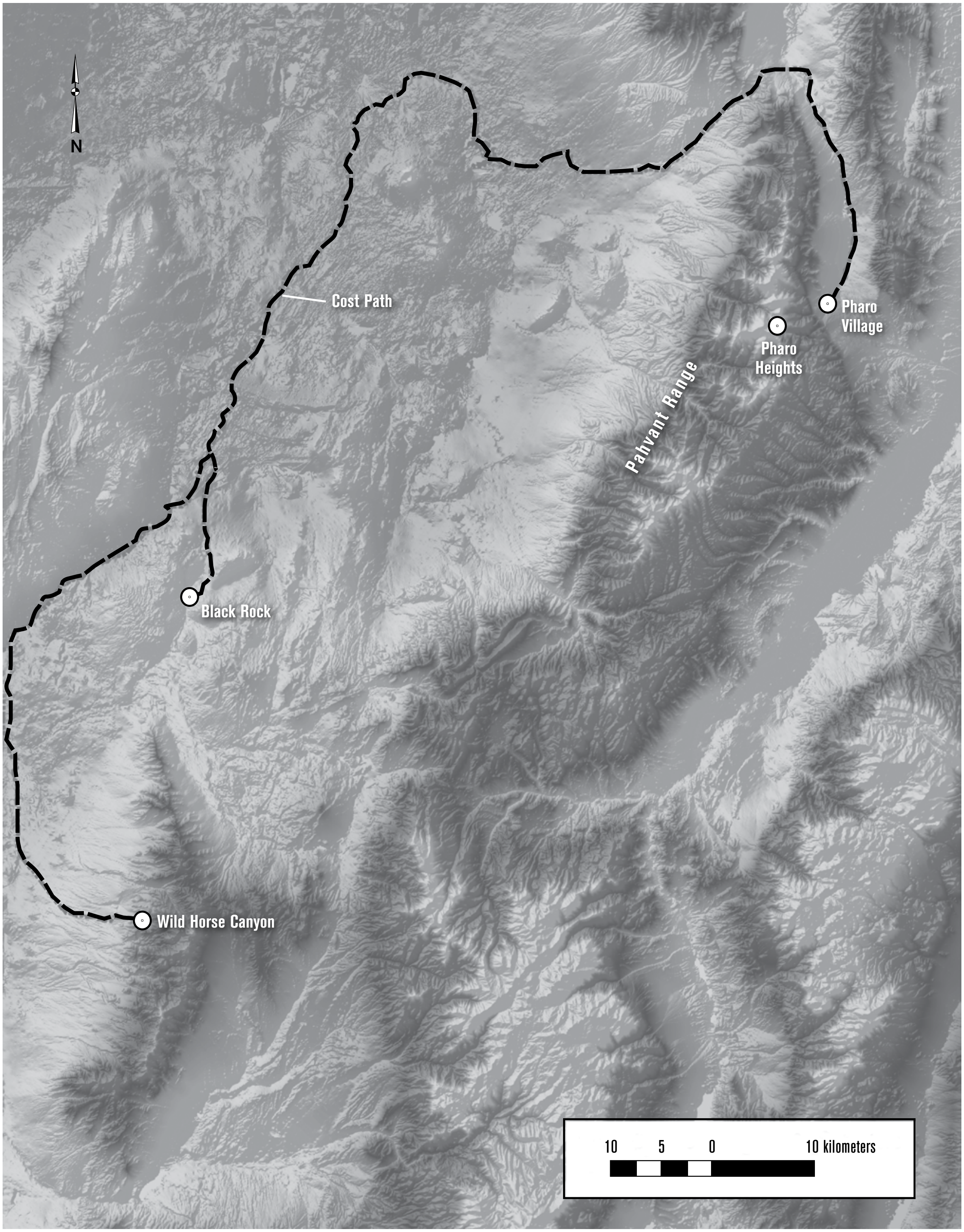

Figure 9. Map showing least-cost paths from Pharo Village to Black Rock and Wild Horse quarries.

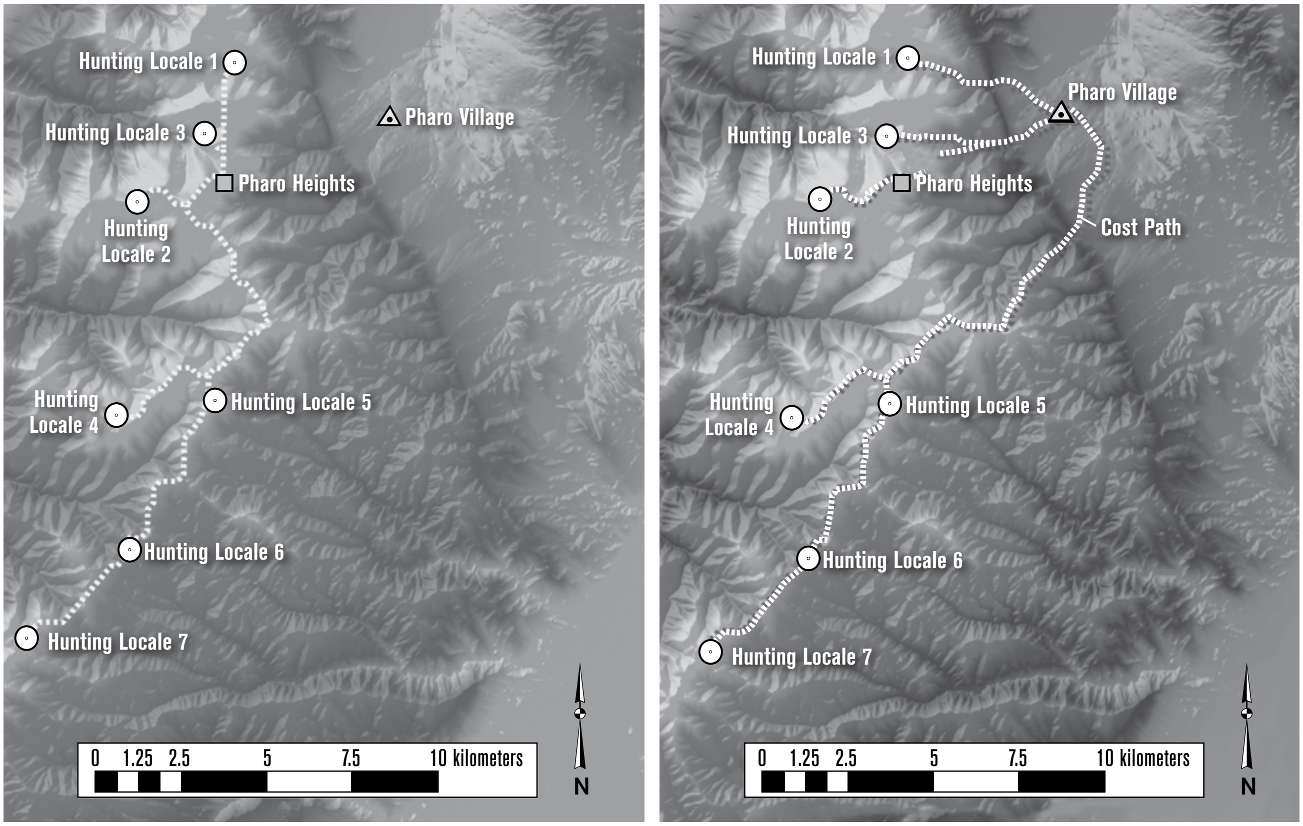

Figure 10. Map showing least-cost paths from hypothetical hunting locales to Pharo Heights (left) and Pharo Village (right).

path (in kilometers) by the average costs (110 kcal./km.) of unburdened travel for the trip leaving each site and adding this to the average costs (140 kcal./km.) of burdened travel (at 34 kg., the capacity of a typical burden basket) for the return trip to each site following a successful hunting foray (Bettinger et al. 1997; Jones and Madsen 1989; McGuire et al. 2007). Though caloric costs increase at higher elevations, especially for unacclimatized people, the difference in elevation between Pharo Village and Pharo Heights is relatively small (ca. 1,000 m.), and the crest of the Pahvants, at 2,885 m., is only about 180 m. above the point where elevation begins to substantively affect human physiological processes (Beall 2001), meaning that though the caloric costs used in this analysis may slightly underestimate actual costs of working at elevation, they would be roughly equivalent at both the eastern base and the crest of the range. Combined, these data result in a total travel and transport cost for hunting at each location. The average search (6,000 kcal.) and handling (126 kcal.) costs for 34 kg. of meat (McGuire et al. 2007:363) were then added to these data to arrive at a total cost for hunting and transporting sheep from and to each site, respectively. These data were then subtracted from the overall gross caloric benefit (42,900 kcal.) contained in 34 kg. of meat (Simms 1987; Zeanah 2000) to arrive at a return rate for each path and an average return rate, taking into account travel and transport costs from each site (Table 4).

The results of this analysis are not surprising, with return rates for hunting from Pharo Heights being 2,640 kcal. greater, on average, than from Pharo Village, this resulting from the average 5.28 km. greater distance to Pharo Village from the seven hypothetical grazer (sheep) hunting locales (the return rate mean differences are significant [$t = -9.95$; $\alpha = 0.5$; $p = 0.0000594$; $df = 6$]) (Fig. 11). The strength of these differences is of course more than just statistically significant, in that they represent enough additional calories to feed an average hunter-gatherer for a day or more (Kelly 1995:102). The returns on long-range hunting from Pharo Village are, however, certainly high enough to provide an incentive

Table 4

MOUNTAIN SHEEP HUNTING RETURN COMPARISON: PHARO VILLAGE VS. PHARO HEIGHTS

Hunting Locale	Distance (km.)	Out Trip Cost (kcal)[a]	In Trip Cost (kcal)[b]	Total Trip Cost (kcal)	Total Cost (kcal)[c]	Return (kcal)[d]
Pharo Village						
1	5.50	604.68	769.59	1,374.26	8,874.53	34,025.47
3	6.41	705.56	897.99	1,603.55	9,333.11	33,566.89
2	9.76	1,073.58	1,366.37	2,439.95	11,005.90	31,894.10
5	14.22	1,564.16	1,990.74	3,554.90	13,235.80	29,664.20
4	17.00	1,869.94	2,379.93	4,249.87	14,625.75	28,274.25
6	20.02	2,202.61	2,803.33	5,005.94	16,137.88	26,762.12
7	24.48	2,692.41	3,426.70	6,119.11	18,364.23	24,535.77
					Pharo Village Avg. Return	29,817.55
Pharo Heights						
1	5.50	604.68	769.59	1,374.26	8,874.53	34,025.47
1	3.27	359.90	458.06	817.96	7,761.93	35,138.07
2	3.28	360.79	459.19	819.97	7,765.95	35,134.05
3	1.27	139.90	178.06	317.96	6,761.93	36,138.07
4	11.27	1,239.82	1,577.95	2,817.77	11,761.53	31,138.47
5	8.29	912.03	1,160.76	2,072.79	10,271.58	32,628.42
6	14.30	1,572.49	2,001.35	3,573.83	13,273.67	29,626.33
7	18.75	2,062.28	2,624.72	4,687.01	15,500.01	27,399.99
					Pharo Village Avg. Return	32,457.63

[a] Distance x 110 kcal/km.

[b] Distance x 140 kcal/km.

[c] Total trip cost + combined search & handling costs (6126 kcal)

[d] Total cost – 42,900 kcal/34 kg. load

for this behavior as well, a finding similar to that of McGuire et al. (2007), who modeled similar behaviors in the eastern Sierra Nevada. This observation helps to explain the mountain sheep remains found by Marwitt at Pharo Village (1968). More importantly, this analysis indicates that living in a seasonal base camp at Pharo Heights would have increased returns on high-altitude logistical hunting by approximately 8% when compared to returns from operating out of Pharo Village. Further, it supports the idea that Pharo Heights served as a seasonal residential base camp occupied by Pharo Village residents who focused to a large degree on logistical sheep hunting in the highlands, an interpretation corroborated by the Snake Valley grayware ceramics and the admittedly somewhat spotty sheep remains found at Pharo Heights.

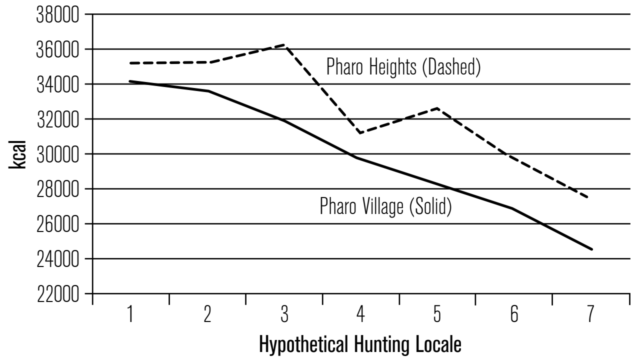

Figure 11. Hypothetical return rate comparison: Pharo Village : Pharo Heights.

GREAT BASIN AND FREMONT HIGH ALTITUDE ADAPTATIONS

The preceding interpretations have significant implications with regard to regional high-altitude prehistoric adaptations, both across the Great Basin and (more specifically) in the case of the Fremont. In the Great Basin, the most important studies of high-altitude adaptations are Canaday's (1997) surveys of the alpine regions of five high ranges in the central Great Basin, Thomas' (1982, 1994) work in the Toquima Range in south-central Nevada, and Bettinger's (1991) work in the White Mountains above Owens Valley, on the California-Nevada border; the latter two have been adequately summarized elsewhere (Bettinger 1996, 2008; Grayson 1993:261–269). Canaday's surveys in the Toiyabe and Snake ranges and in the Ruby, Jarbridge, and Deep Creek mountains focused specifically on determining aboriginal alpine land-use patterns. He found very few sites in a rather large survey, but did find numerous stacked-rock features that he interpreted as being used as hunting blinds, an interpretation consistent with Thomas' (1982) in the Toquima Range. Using regional projectile point chronologies to control for time, he concluded that most of the alpine Great Basin had been used sporadically for hunting since the middle Holocene, a pattern generally consistent with hunting in high elevation areas worldwide (Aldenderfer 2006), in the Sierra Nevada (Stevens 2005), and in the Rocky Mountains (e.g., Benedict 1975, 1992; Wright et al. 1980). Not surprisingly, this pattern also corresponds to the Archaic hunting pattern identified during survey in the Pahvant Range, as well as in several other Utah mountain ranges (DeBloois 1983).

Contrasting with this are data from the Toquima Range and the White Mountains, where alpine villages containing rock-ringed houses and substantial middens were investigated through the 1980s and early 1990s. The gist of these studies is that by approximately 1,100 years ago at Alta Toquima, and probably a bit later at the 13 residential sites Bettinger identified in the White Mountains, a long-lived logistical alpine hunting pattern similar to that identified by Canaday gave way to a residential pattern focused on house construction, intensive plant food gathering and processing (often of foodstuffs transported from the lowlands; e.g., Scharf 2009), and an increased reliance on hunting smaller-bodied game (Grayson 1991). Bettinger attributes this shift to a population increase causing resource stress in the Owens Valley, a phenomenon he argues was associated with the migration of Numic speakers with an intensive, seed-based economic focus into the region between about 1,000 and 600 B.P. (Bettinger and Baumhoff 1982). Basing her case on floral remains from Midway, one of the White Mountains alpine villages, Scharf (2009) reiterates Bettinger's population-based argument. Thomas (1994) is far more equivocal, arguing that Numic expansion (see Lamb 1958; Morgan 2010; Sutton 1987) is irrelevant to the patterns he identified at Alta Toquima. Needless to say, the topic is contentious but important as it draws attention to at least two possible explanations for the development of alpine residential adaptive patterns. Based on the dating at Alta Toquima, the effects of medieval warming between approximately 1,300 and 650 B.P. may have either made high altitudes more amenable to human occupation, or made surrounding valleys so resource-stressed that high mountains became attractive refugia for human populations. Alternatively, as Bettinger argues with regard to the White Mountains, population increases and resource stress may have brought about more intensive and even residential use of alpine ecozones.

Though residential villages like those found at Alta Toquima or the White Mountains have not been discovered in Utah (but see Adams 2010; Morgan et al. 2011; and Wingerson 2009 regarding high-altitude villages in Wyoming), there is substantial evidence for an intensified (including residential) use of subalpine-alpine settings akin to that seen at Pharo Heights during the Formative. For instance, at 7,840 ft. in the Oquirrh Mountains southwest of Salt Lake City, Janetski (1985) argues that use of a hunting camp intensified concomitantly with Fremont foraging and horticultural intensification in the valley below (see also Janetski 1997). He identifies a similar pattern at two sites near 9,000 ft. on the Fishlake Plateau, with site use switching to a residential focus and more intensive exploitive patterns between about 1,700 and 700 B.P. (Janetski 2010). In eastern Utah, in the high elevations of the Uinta Mountains, Watkins (2000) used groundstone residue analysis and radiocarbon dates to argue that the alpine processing of wild plants intensified between approximately 3,700 and 700 years ago. This interpretation corresponds well with Knoll's (2003) argument that high-elevation residential structures at nearly 11,000 ft. in the Uinta Mountains served as seasonally-occupied central places geared mainly towards increasing returns on Fremont logistical sheep hunting between approximately 1,600 and 1,300 B.P. Likewise, these results agree to some degree with Nash's (2011) assertion that transport and reliance on stored corn increased returns on Fremont high-elevation sheep hunting in this same range. The degree to which a reliance on either gathered or transported plant foods sustained and perhaps reduced risks (e.g., Morgan 2009a; Scharf 2009) associated with high altitude occupation and hunting in the Pahvant Range remains to be seen, but evidence of storage in both the Sierra Nevada (Morgan 2012) and the Uinta Mountains (Johnson and Loosle 2002; Loosle and Johnson 2000) indicates that such behaviors may indeed have played critical roles in regional high-altitude adaptive patterns. In any event, there is fairly abundant evidence for the increased exploitation and seasonal residential use of subalpine and alpine settings in at least four of Utah's mountain ranges between about 1,700 and 700 B.P. (but see Janetski et al. 2005, and Simms 1979), a pattern closely corresponding in time to the fluorescence of diverse Fremont lifeways (Madsen and Simms 1998), but also to the climatic and environmental changes associated with the Medieval Climatic Anomaly (Bradley et al. 2003; Fisher 2010).

These patterns, of course, correspond to the one identified in the Pahvant Range, where what appears to have been a long period of Archaic Period hunting gave way to high-altitude residential use, likely as a way of increasing hunting returns, approximately 1,500 – 650 B.P. Because of the contemporaneity of increasingly intensive high-altitude residential use across Utah and the central Great Basin (though not necessarily in eastern California), it might be tempting to attribute high-altitude intensification to the effects of medieval warming. But at least in the eastern Great Basin, two lines of evidence suggest otherwise. First, though droughts and their effects were no doubt felt throughout the greater Southwest during this time (Jones et al. 1999), this period also marks the most intensive residential occupations on valley floors, alluvial fans, and ridges emanating from the base of Utah's mountain ranges (Janetski et al. 2000; Reed 2005; Talbot et al. 1998; Talbot and Wilde 1989). If medieval droughts were limiting lowland occupations and encouraging highland ones, it would be expected that valleys would be abandoned, or at least less intensively occupied, while the highlands would witness more intensive occupations perhaps akin to those identified in the Uintas, the Pahvants, and the Fishlake Plateau. This was clearly not the case.

Second, concomitant intensification in lowland and highland settings would be expected if population was the impetus driving changes in settlement pattern. In the Fremont case, this might appear counterintuitive given the forager-farmer continuum model developed in various permutations by Madsen and Simms (Madsen 1982, 1989; Madsen and Simms 1998; Simms 1986). Despite a multitude of adaptive choices, interpretations of this model often see Fremont adaptive decision-making as essentially an either/or question—either one farms *or* one forages, depending on ecological-adaptive circumstances, but one may do one or the other repeatedly over the course of one's life. But the choice can also be inclusive rather than dichotomous—to solve population-resource imbalances, one hunts, gathers, *and* farms, which is the essence of the concept of intensification when using the diet breadth model (Macarthur and Pianka 1966), where low-ranking items are added to the subsistence base as diet expands, but higher-ranking items (in the Great Basin, large prey items like sheep and deer) never drop out of the diet, but are just as intensively pursued as before (outside the parameters of the model, perhaps even more so). This does not necessarily preclude evidence for decreasing hunting returns due to human overpredation during the Formative (Janetski 1997; Ugan 2005; but see Whitaker 2009); in fact this might be exactly what one might expect as both hunting and farming become more intensive and human pressure on both natural and modified environmental productivity increases.

This is the pattern identified in Upper Round Valley and the Pahvant Range. The Fremont hamlet of Pharo Village was established sometime around 1,400 cal B.P. Milling tools and corncobs indicate maize farming was an essential part of the subsistence economy here, while sheep and deer bone indicate hunting was important as well. Nearly the same pattern is evident some 1,000 m. (3,400 ft.) higher in elevation at Pharo Heights, where a seasonal residential base was established that likely featured expedient residential structures whose inhabitants relied on processed foodstuffs and locally-available artiodactyls like mountain sheep. High-altitude residential use here thus appears intrinsically linked to agricultural intensification in the valley below, a pattern consistent with those seen in several of Utah's other mountain ranges during this same period of time. Ultimately these lowland-highland settlement dynamics suggest economic intensification drove the development of eastern Great Basin high-altitude residential patterns; it remains to be seen whether such an assertion holds for the remainder of the Intermountain West.

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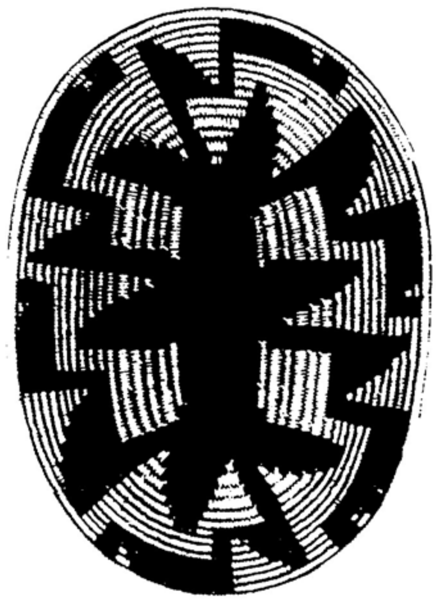

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Chemical Composition, Mineralogy, and Physical Structure of Pigments on Arrow and Dart Fragments from Gypsum Cave, Nevada

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Pigments preserved on arrow and dart weaponry fragments from Gypsum Cave, Nevada, were analyzed by laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), X-Ray diffraction (XRD), and electron microprobe (EM) to determine their chemical composition, mineralogy, and physical structure. Results show that a variety of minerals were used to produce the green, red, pink, brown and black pigments. Although variation in composition and mineralogy suggests some degree of experimentation, similarities in the pigments suggest the application of standardized recipes for certain colors. Pigments applied to the more ancient darts are systematically different for cane vs. wooden implements, despite the finding that cane and wooden fragments were often used as fitting parts of the same composite weapon. For example, greens applied to darts are based on malachite while greens applied to cane are based on green earth minerals. The smaller sample of arrows shows many similarities to the more ancient darts, suggesting the transmission of information about pigmenting was fairly conservative over thousands of years in the southwest Great Basin, but does not show the same wood-cane dichotomy.

While the ethnographic record suggests pigment was widespread in the ancient Great Basin of North America, archaeological examples and studies of such pigments are relatively few. Examples of pigment are represented primarily by pictographs from rock art sites and special decorated items from well-preserved deposits. Usually these items are described and evaluated for their artistic merits; for example, the discussion may focus on how the specific colors were used within the image and on the possible emic meanings of the resulting imagery (e.g., Whitley 1998). Detailed studies of the composition of ancient pigments in the Great Basin are less common (however, see Koski et al. 1973; McKee and Thomas 1973; Whitley and Dorn 1984; further afield in California, see Backes 2004; Scott and Hyder 1993).

In the present paper we describe the physical structure, chemical composition, and mineralogy of pigments preserved on ancient hunting weaponry from Gypsum Cave, Nevada. While our goals are descriptive in nature, we consider the anthropological significance of the results as well.

GYPSUM CAVE, NEVADA

Gypsum Cave (26CK5) is a limestone solution cave about 20 km. northwest of the Colorado River and 30 km. east of downtown Las Vegas, Nevada (Fig. 1). Mark Harrington of the Southwest Museum (in Los Angeles) directed excavations of the cave deposits in the late 1920s and early 1930s, resulting in the removal of the majority

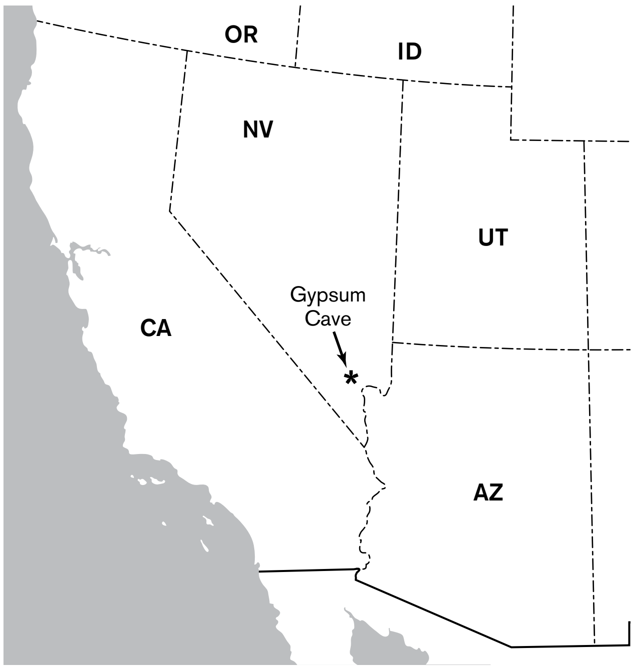

Figure 1. Map of western United States, showing location of Gypsum Cave.

of the sediments. Excavation methods were typical of those in practice in the early part of the twentieth century. Sediments were generally removed according to stratigraphic levels within particular rooms of the cave, but were not screened prior to disposal. Diagnostic artifacts were removed as they were encountered and bagged for transport back to the museum. The excavations produced a wide range of materials, including a robust collection of decorated and undecorated dart and arrow shaft fragments (Harrington 1933).

The cave is widely known for its well-preserved paleontological (e.g., Poinar et al. 2008) and archaeological (e.g., Harrington 1933) remains. Artifacts and ecofacts recovered from Gypsum Cave played an important role in the "early man" debates in American archaeology during the 1940s and 1950s. For example, Harrington recovered dart fragments in stratigraphic layers reported to be below layers of dung from extinct ground sloth (*Nothrotheriops shastensis*). Later radiocarbon dating of those weaponry fragments by Heizer and Berger (1970) showed them to be much younger, ca. 2,500–3,000 B.P., than the Pleistocene age suggested by their stratigraphic position relative to the sloth dung.

A limited excavation of the cave was undertaken recently by Far Western Anthropological Research Group. This work sought to expose and re-evaluate Harrington's stratigraphic levels (see Gilreath 2009); it also included recataloging and re-analysing the existing collections. That work included the pigment study reported here. We employed laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), X-Ray diffraction (XRD), and electron microprobe (EM) analyses to examine the mineralogical and structural nature of the pigmenting materials, to examine variation across different weapons types and ages, and to document variation within particular colors. In addition, a sample of items was directly dated by radiocarbon means.

PIGMENT SAMPLE

The sample for this study consists of 33 painted weaponry fragments, listed in Table 1. The analyzed sample accounts for nearly half (46%) of all the painted dart and arrow fragments identified in the Harrington collection. Based on the presence of a nock (e.g., Fig. 2A) or other diagnostic elements, four of these artifacts were determined to represent fragments of arrows. Three (75%) were fashioned from cane (likely *Phragmites* sp.), while one was made out of wood. All four arrow fragments in this study contain only a single color, although other arrow fragments in the Gypsum Cave collection contain multiple colors on the same piece. Colors represented in the arrow sample include black and red (see Table 1). Based on their recorded stratigraphic position within the cave and associations with radiocarbon-dated items, these arrows are believed to date to between 400 and 700 years ago.

Based largely on size (i.e., diameter of 8 mm. or greater), 28 of the remaining 29 pieces were classified as dart fragments (the final sample was too small to classify into a particular weaponry category). Direct AMS dates recently obtained by Gilreath (2009) on eight of these fragments suggest that they were used between 3,200 and 3,800 radiocarbon years ago (1,370–2,340 cal B.C.); they are listed in Table 2. Only nine of the dart fragments were fashioned from cane (32%), while 19 were made out of wood. As well, over half of the dart pigment samples we analyzed display more than one color, with red and green being most common, often in combination, followed by black, brown, and pink. Decorations often consist of lines arranged in various geometric patterns,

Table 1

WEAPONRY FRAGMENTS, PIGMENTS PRESENT, AND ANALYSES UNDERTAKEN IN THIS STUDY

			Colors Present					Analyses			
Cat# 6F-	Weapon	Material	Rd	Gr	Bl	Br	Pi	LA-ICP-MS	XRD	EM	^{14}C
193	Arrow	Wood			X			X	X		
42	Arrow	Cane	X					X			
802	Arrow	Cane	X					X			
805	Arrow	Cane	X					X			
82B	Dart	Wood	X	X		X		X			
113	Dart	Wood	X	X				X	X	X	X
147	Dart	Wood			X			X		X	
164A	Dart	Wood	X					X			
331	Dart	Wood		X				X	X		
428	Dart	Wood		X		X		X	X		
474	Dart	Wood	X					X		X	
484	Dart	Wood	X					X			
591	Dart	Wood	X	X				X	X	X	X
601A	Dart	Wood	X					X	X	X	
610	Dart	Wood				X		X			
627	Dart	Wood	X		X			X			
702C	Dart	Wood	X		X			X			
766A	Dart	Wood	X					X			
929	Dart	Wood				X		X			X
946	Dart	Wood				X		X		X	
993B	Dart	Wood	X					X			
1040	Dart	Wood				X		X		X	X
1042	Dart	Wood				X		X			X
241A	Dart	Cane				X		X			
397	Dart	Cane		X			X	X			X
398	Dart	Cane		X				X			X
430	Dart	Cane		X				X			X
480	Dart	Cane		X			X	X		X	
634B	Dart	Cane		X				X		X	
751	Dart	Cane	X	X				X			
754	Dart	Cane	X		X			X		X	
994	Dart	Cane		X				X			
342A	Unkn.	Cane	X					X		X	

Notes: Cat# = Catalog number; Cal BP range = Calibrated age range at 2-sigma deviation. Rd = Red; Gr = Green; Bl = Black; Br = Brown; Pi = Pink.

although occasionally large sections of the shaft were homogenously covered in pigment. Figure 2F shows such a specimen with green, red, and black pigments.

We classified the pigments into five different color categories based on our subjective visual assessments. These colors include red, green, black, brown, and pink. There was some variability in these colors; for example, greens varied between deep green and pale green and browns tended to transition between true brown and a darker black-brown. Part of this variation is related to the density of the pigment itself; pigments applied in thick coatings tended to be darker than pigments that were only thinly painted on the weapon. For example, Figure 2D shows a dart fragment with brown pigments arranged in a non-linear pattern, where the color varies greatly depending on the thickness of the pigment. As an initial means to organize the analyses, the Results section below is organized according to our initial and subjective color classification.

With regard to the density of pigments, it is also relevant to note that application style varied greatly across the 33 weaponry fragments. Occasionally pigments were applied in thick coatings that clearly rested on the exterior of the original wooden or cane surface (as in both Figs. 2C and 2F). These pigments appear to have been more viscous when applied and served to completely coat the original wood or cane surface. On other specimens (as in Figs. 2D and 2E), the pigments appear to have been applied in a watery state and were absorbed *into* the cane or wood, and acted more like a dye than a paint. On such examples, the exterior surface of the wood or cane is still visible but is transformed in color. In such cases, the LA-ICP-MS analyses are likely to include a combination of both pigment and substrate, as both had to be ablated simultaneously, and it was not possible to apply XRD to these samples. Finally, in some cases it appeared that the "pigments" visible on the surface of the weapon might actually have been a precipitate leached out of string or some other substance that was originally wrapped around the surface of the item. Such pigments, then, were probably not intentionally applied but are secondary compounds that were deposited on the cane or wood surface after a more fragile material such as string decayed. We did not include such apparent precipitates in the analyses below.

METHODS

All pigment samples were analyzed using instrumentation at U.C. Davis. All 33 pigments were analyzed by LA-ICP-MS. However, due to sample quality (especially size) and instrument availability, not every sample was analyzed by

Figure 2. Pigmented arrow (A–B) and dart (C–F) fragments from Gypsum Cave (composite photo by Jelmer W. Eerkins).

Table 2

RADIOCARBON DATES ON WEAPONS FROM GYPSUM CAVE INCLUDED IN THIS STUDY

Cat #	Weapon	Material	BETA #	$\delta^{13}C/^{12}C$	^{14}C BP	Cal BP range
113	Dart	Wood	228748	−24.0	3,760 ± 50	3,975–4,292
591	Dart	Wood	228753	−24.0	3,740 ± 50	3,929–4,243
929	Dart	Wood	228755	−25.9	3,180 ± 50	3,267–3,555
1040	Dart	Wood	228756	−22.0	3,640 ± 40	3,856–4,084
1042	Dart	Wood	228757	−24.4	3,740 ± 50	3,929–4,243
397	Dart	Cane	228750	−22.3	3,550 ± 40	3,707–3,964
398	Dart	Cane	228751	−21.9	3,730 ± 40	3,934–4,230
430	Dart	Cane	228752	−23.4	3,540 ± 40	3,700–3,957

Note: All analyses by AMS and performed by Beta Analytic. Cat# = Catalog number; Cal BP range = Calibrated age range at 2-sigma deviation. See Gilreath 2009:50–51 for additional information about these artifacts and radiocarbon results.

XRD and EM (see Table 1). Where possible, we tried to analyze at least one sample from each color group using all three techniques.

LA-ICP-MS Methods

The ICP-MS is an Agilent 7500a quadrupole instrument coupled to a NewWave 213 nm. laser, which was set at 20 Hz repetition rate and 25% power. For each unique pigment color on each weapon fragment, five spots approximately 160 microns in diameter were selected and ablated with the laser. Each spot was pre-ablated for five seconds to remove surface contaminants (followed by a delay to remove any geochemical "memory" of possible surface contaminants) and then ablated for 60 additional seconds. The ablated material was transported from the sample chamber by a helium carrier gas into the ICP-MS where the counts of isotopes for 26 different elements were made. For most samples we also analyzed a section of the weapon that had not been modified by the application of a pigment (again, measuring five spots). This allowed us to compare modified vs. unmodified sections and to evaluate the compositional effects of coloring.

With the exception of very small weaponry samples which were analyzed whole, small slivers of cane or wood with pigment were removed from the weapon. Slivers had to be removed to fit the specimens into the LA-ICP-MS sample chamber (~20 cm.^{2}). Slivers were attached to a glass slide with an adhesive and placed within the analysis chamber for analysis, with approximately 30–40 slivers per glass slide.

Unfortunately, it was not possible to analyze geochemically similar (i.e., matrix matched) standards, and therefore—as is common in LA-ICP-MS work—raw counts measured by the mass spectrometer could not be converted to absolute concentrations of elements (e.g., ppm. scale). Rather, we rely on the ratio of raw counts of a particular element to an internal standard, which is assumed to be constant across samples. For this study we chose potassium (K) as our internal standard. However, we also examined ratios of other elements directly to one another to characterize the pigment samples. The list of the remaining 25 elements includes common ones such as sodium (Na), calcium (Ca), and sulfur (S), metals such as iron (Fe), lead (Pb), and copper (Cu), and rare earth and high field strength elements such as molybdenum (Mo), lanthanum (La) and zirconium (Zr). Occasionally, an aberrant reading for an element was encountered in one of the five ablation spots, or after subtracting the background, a negative value resulted for an element. We removed these aberrant readings from the analysis, and averaged the remaining spots.

XRD Methods

Six pigment samples were analyzed by XRD (see Table 1) to help establish mineralogy for samples analyzed by LA-ICP-MS. A larger sample would have been ideal, but in most cases there was not enough pigment material (or we felt uncomfortable removing so much pigment) to analyze by XRD. Samples were run on a Scintag XDS-2000 diffractometer in the Materials Sciences department at U.C. Davis. Samples were scanned across 120 degrees for 40 minutes. The resulting scans were compared by computer to a large database of reference mineralogical samples (within the Materials Data Incorporated JADE® program).

EM Methods

Eleven samples received EM analysis (see Table 1). Samples were mounted in epoxy and then sectioned using a Beuhler Isomet low-speed saw in such a way that the interface between cane or wood and pigment was exposed in cross section. The samples were then polished and coated with a conductive layer of carbon. EM allows us to examine the chemical composition of small sections of pigment, much smaller than the 160-micron spot size of the LA-ICP-MS. In many cases we were able to analyze individual grains within the pigment body. The numerical results, however, are more qualitative than LA-ICP-MS. In addition, EM allows us to examine the physical structure of individual pigments; i.e., whether they are coarse-grained or fine-grained, and whether particles are rounded or angular. We can also estimate the thickness of the pigment layer applied to the underlying substrate.

Mineral constituents of the pigments were analyzed using a Cameca SX100 electron microprobe located in the Department of Geology at the University of California, Davis. During analyses, accelerating potential was 15 kV, beam current was 20-30 nanoamps, and beam diameter was roughly one micron. Due to the fine mineral grain sizes and the instability of wood under the electron beam, only qualitative evaluation of mineral compositions was attempted via an examination of energy dispersive spectra (EDS). We attempted to analyze between 10 and 20 grains by EDS on each sample. In some cases, the identification of mineral species was tentative, particularly when the pigment contained a polycrystalline aggregate in which the size of some grains was less than the beam diameter. Additionally, a backscattered electron (BSE) image was produced for the section surfaces of all 11 samples.

RESULTS

Table 3 shows the LA-ICP-MS data for the pigment and organic substrate for all samples. The most obvious signal in the data concerns the difference between the pigments and the unmodified cane or wood substrate. Figure 3 plots the first two components of a principal components analysis (PCA) on the natural log values for elements (as ratios against K). In Figure 3, each point represents a distinct pigment color or substrate from a weapon, and is the average of the five spots ablated.

The first component, which accounts for 79% of the variation in the data set, neatly separates cane and wood substrates from pigments, with four exceptions. The exceptions include a red and a green pigment (artifacts 993B and 994, respectively) that group on the edge of the substrates, and a cane and wood substrate (artifacts 430 and 766A, respectively) that group on the edge of or within the distribution of pigments. The former red and green pigments were both thinly applied on artifacts that were poorly-preserved, and did not cover the entire surface. In fact, the red was initially questioned as a true pigment, but inspection by microscope suggested it was indeed a pigment. It is possible that our five-second pre-ablation removed much of the actual pigment on these two artifacts, and that the subsequent analysis consists primarily of substrate material. On the other hand, it is unclear why the two anomalous substrates are grouping

Table 3

LA-ICP-MS DATA RELATIVE TO K (INTERNAL STANDARD)

Cat#	Weapon	Color	Na	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Cu	Zn	Rb	Sr	Y	Zr	Mo	Sn	Sb	Ba	La	Ce	Pb
Multiplier			$x10^{1}$	$x10^{3}$	$x10^{2}$	$x10^{4}$	$x10^{3}$	$x10^{4}$	$x10^{3}$	$x10^{4}$	$x10^{5}$	$x10^{3}$	$x10^{3}$	$x10^{4}$	$x10^{2}$	$x10^{4}$	$x10^{4}$	$x10^{3}$	$x10^{5}$	$x10^{4}$	$x10^{5}$	$x10^{4}$	$x10^{4}$	$x10^{3}$	$x10^{4}$	$x10^{4}$	$x10^{2}$
994	arrow	green	0.88	0.97	0.09	2.06	0.12	0.12	0.34	0.16	0.36	0.37	0.92	0.12	0.06	0.28	0.73	0.26	0.03	0.05	0.03	0.00	0.00	0.04	0.00	0.00	0.03
82B	dart	green	1.51	7.23	1.35	1.71	1.00	0.42	1.09	4.56	2.05	2.85	4.18	104.80	690.81	5.37	0.85	2.56	2.79	0.24	1.50	0.33	0.33	0.36	0.19	0.44	2.64
113	dart	green	1.62	3.07	1.01	3.25	0.80	0.42	1.41	1.45	1.12	1.70	1.41	8.69	313.53	3.79	0.76	0.82	1.99	0.20	1.80	0.78	0.45	0.86	0.19	0.34	1.03
331	dart	green	3.64	11.46	3.94	2.70	2.67	1.01	4.20	5.07	1.91	6.46	2.17	11.58	1,423.00	37.42	1.35	4.00	4.30	0.94	0.82	3.82	0.17	0.84	0.48	0.83	11.96
397	dart	green	0.49	5.45	1.41	1.90	1.40	1.59	1.64	4.10	0.76	8.37	6.86	2.45	0.07	0.36	5.89	1.60	1.67	0.55	0.20	0.03	0.02	0.11	0.29	0.52	0.11
398	dart	green	0.51	6.38	1.27	4.45	0.64	0.43	1.77	0.85	0.41	2.66	2.01	1.31	0.11	2.10	0.82	1.46	1.30	0.38	0.22	1.38	0.07	0.18	0.19	0.46	0.56
428	dart	green	11.60	35.95	0.92	1.06	3.87	0.78	0.35	4.68	2.09	7.28	1.31	344.11	1,203.70	9.66	0.37	14.22	4.72	0.11	0.33	0.14	0.04	0.14	0.12	0.41	1.80
430	dart	green	0.52	3.91	1.95	2.98	0.72	1.09	2.12	1.13	1.13	10.41	10.84	2.30	0.27	6.25	9.04	1.67	4.42	0.47	0.07	0.47	0.23	0.57	0.26	0.87	1.41
480	dart	green	0.19	3.12	0.96	3.54	0.54	0.42	2.01	0.97	0.49	1.32	7.14	1.85	0.27	1.30	13.06	0.45	0.79	0.46	0.05	0.20	0.03	0.11	0.13	0.24	0.27
591	dart	green	0.39	4.88	1.27	2.83	1.66	0.67	2.24	2.42	0.99	3.60	2.75	16.00	696.68	24.62	1.31	2.47	4.21	0.54	1.30	2.40	1.92	0.41	0.30	0.52	1.60
634B	dart	green	0.41	4.05	2.70	2.29	1.03	0.88	10.61	2.46	1.32	5.64	9.05	1.39	0.11	1.53	3.64	1.28	2.72	1.37	0.93	0.39	0.24	0.25	0.63	1.07	0.95
751	dart	green	0.30	3.33	0.86	1.01	0.29	1.81	2.49	5.71	0.58	2.52	8.37	2.98	0.11	0.65	7.63	0.32	0.73	0.75	0.02	0.06	0.05	0.06	0.09	0.16	0.25
42	arrow	red	0.53	9.21	3.27	9.81	0.98	1.71	2.03	4.30	1.58	5.53	38.18	4.30	1.20	11.09	2.88	2.72	5.40	0.55	2.32	1.40	1.06	0.69	2.89	2.36	4.86
802	arrow	red	0.50	4.85	4.67	1.54	1.37	1.91	2.79	5.93	3.28	8.94	31.50	5.77	0.97	5.56	1.57	2.82	2.97	0.72	1.36	2.38	0.65	0.51	0.71	0.98	1.25
805	arrow	red	0.36	6.50	4.59	1.79	2.60	1.34	3.48	5.92	5.17	4.15	21.20	1.85	0.37	4.36	2.80	7.24	7.45	1.43	1.02	0.30	0.13	0.54	1.29	2.14	1.24
82B	dart	red	0.45	3.28	2.71	2.11	0.89	1.81	1.96	16.16	2.92	5.76	65.55	1.85	17.27	4.34	1.23	2.02	22.18	2.02	1.42	0.53	4.29	0.75	1.62	2.10	3.05
113	dart	red	1.72	13.12	9.81	5.30	3.04	3.82	5.69	1.92	1.88	7.02	9.00	2.84	13.78	1.13	2.07	5.80	6.21	0.71	1.30	0.14	0.05	0.89	1.93	4.46	0.74
164A	dart	red	1.32	7.25	5.13	5.02	1.14	1.57	10.37	1.35	6.26	5.08	3.86	3.85	4.49	211.71	1.30	4.22	3.86	3.13	0.17	7.15	0.41	2.20	0.35	0.67	7.01
474	dart	red	2.23	5.45	2.91	4.95	1.37	0.84	3.31	1.46	1.01	6.60	17.30	3.76	0.66	5.57	1.20	1.94	2.05	0.49	2.71	1.92	0.08	0.34	0.41	1.12	2.53
484	dart	red	0.97	13.75	6.15	10.79	3.63	2.50	9.44	2.98	5.99	10.98	6.96	4.90	7.28	11.71	3.02	10.99	7.13	1.36	0.69	4.43	0.17	1.55	1.10	2.86	2.44
591	dart	red	0.33	7.70	3.71	4.44	1.43	0.82	3.12	1.54	2.28	7.31	41.32	2.84	23.39	12.20	1.90	3.12	2.90	0.75	6.55	7.08	0.10	0.34	0.41	1.14	2.50
601A	dart	red	2.99	10.96	4.79	1.28	1.42	1.43	3.88	3.11	1.21	8.91	18.42	2.34	0.32	2.55	2.56	2.09	3.29	1.10	1.06	0.38	0.05	0.36	0.50	1.16	2.11
627	dart	red	0.57	5.66	2.24	2.35	1.86	0.69	1.57	5.98	2.79	4.93	17.37	3.64	1.24	9.28	1.44	3.00	2.81	0.34	2.94	1.86	0.26	0.74	0.44	0.68	6.62
702C	dart	red	1.16	6.81	3.63	4.35	2.14	1.65	4.69	2.42	1.15	6.90	30.69	2.36	1.55	26.66	2.25	2.95	4.38	0.72	1.92	1.35	3.74	0.48	0.64	1.49	4.99
751	dart	red	1.71	8.18	0.84	3.11	0.85	0.61	2.18	0.92	0.25	2.93	1.26	0.98	0.17	2.23	0.96	1.00	1.04	0.30	0.23	0.12	0.05	0.13	0.05	0.35	0.99
754	dart	red	3.00	9.40	5.88	7.29	4.89	2.58	10.63	5.69	6.07	15.70	6.14	7.29	4.19	11.89	8.27	4.62	6.13	1.68	0.30	1.35	0.35	2.18	1.02	2.10	4.73
766A	dart	red	3.40	10.11	10.34	5.14	6.75	3.34	14.90	5.45	5.63	8.61	39.06	5.45	3.02	3.82	5.00	19.20	8.88	1.50	5.26	0.99	1.81	2.75	1.53	3.43	4.13
993B	dart	red	4.05	41.64	0.32	0.92	0.41	0.06	0.17	0.20	0.20	0.60	0.16	0.62	0.04	0.90	0.25	1.61	0.30	0.03	0.76	0.02	0.00	0.03	0.03	0.10	0.13
342A	unk.	red	0.44	6.08	2.79	4.33	1.78	0.96	2.81	13.79	2.85	4.67	103.90	8.50	0.42	3.94	2.07	4.46	2.17	0.80	1.68	0.12	1.21	4.77	0.36	0.65	0.79
397	dart	pink	1.35	3.55	4.15	3.32	1.30	1.17	2.56	1.51	0.54	5.85	14.38	1.13	0.09	0.37	2.30	2.98	2.81	1.21	0.74	0.07	0.07	0.51	0.52	1.04	0.37
480	dart	pink	0.65	3.50	7.99	4.99	1.03	4.53	7.50	1.42	0.54	4.42	12.40	12.04	34.50	4.03	10.83	1.15	19.76	33.89	3.59	1.44	1.53	0.55	0.37	1.15	1.92
241A	arrow	brown	0.55	5.47	2.59	2.90	1.27	0.80	1.93	1.01	1.07	3.97	1.85	1.52	0.18	1.81	1.11	2.22	2.94	0.76	0.12	0.26	0.02	0.33	0.31	0.80	0.34
82B	dart	brown	0.84	3.53	2.43	2.40	0.86	1.43	5.37	11.32	2.01	6.30	43.24	2.82	19.10	9.88	1.34	2.09	18.78	3.36	0.83	0.96	3.30	1.25	1.19	1.27	1.99
428	dart	brown	2.15	10.05	3.19	5.51	3.69	1.31	3.92	2.78	2.12	6.56	4.41	11.19	45.40	13.40	2.32	5.05	4.86	0.60	0.27	8.52	0.11	1.25	0.78	1.15	7.09
610	dart	brown	0.35	8.69	6.89	1.81	1.91	1.57	3.63	1.80	1.34	5.22	4.27	1.90	0.34	4.98	3.85	2.95	7.21	0.85	0.14	0.34	0.07	0.49	0.60	1.55	0.66
929	dart	brown	0.11	4.62	0.72	11.72	2.07	0.20	0.53	0.30	1.20	1.04	0.78	0.68	0.50	3.62	0.52	5.85	0.49	0.08	0.06	17.75	0.05	0.16	0.09	0.20	0.48

Table 3 (Continued)

LA-ICP-MS DATA RELATIVE TO K (INTERNAL STANDARD)

Cat#	Weapon	Color	Na	Mg	Al	S	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Cu	Zn	Rb	Sr	Y	Zr	Mo	Sn	Sb	Ba	La	Ce	Pb
Multiplier			x10^1	x10^3	x10^2	x10^4	x10^3	x10^4	x10^3	x10^4	x10^5	x10^3	x10^3	x10^4	x10^2	x10^4	x10^4	x10^3	x10^5	x10^4	x10^5	x10^4	x10^4	x10^3	x10^4	x10^4	x10^2
946	dart	brown	0.51	19.80	4.92	3.65	1.97	1.43	3.57	2.27	1.44	12.67	10.65	2.35	0.38	8.46	2.54	4.00	3.26	0.65	0.57	43.92	0.04	0.86	0.54	1.48	1.95
1040	dart	brown	2.16	7.57	6.04	7.08	2.58	2.71	9.28	3.34	3.90	9.52	20.55	5.85	1.58	37.02	6.40	7.67	6.29	1.16	0.63	406.50	1.59	2.54	1.32	4.24	4.73
1042	dart	brown	1.47	16.57	13.64	5.98	3.99	2.76	13.08	6.29	5.52	25.84	11.48	9.50	4.66	11.80	8.56	6.51	9.65	1.04	0.65	6.18	0.81	3.20	1.65	3.66	4.81
147	dart	black	2.21	7.20	5.65	7.82	2.25	1.72	3.96	2.71	3.94	8.17	5.05	4.92	39.91	41.44	3.83	3.87	5.27	1.69	0.44	5.71	0.35	0.62	1.16	2.20	34.94
193	arrow	black	2.06	3.98	1.26	3.55	0.81	0.45	2.83	1.51	0.10	388.2	1.65	1.39	1.24	1.27	1.05	3.78	1.68	0.25	2.06	0.06	0.04	1.58	0.26	0.50	14.82
627	dart	black	0.69	5.06	0.92	3.06	1.52	0.30	0.81	0.77	2.06	3.30	4.86	1.10	0.65	3.89	1.05	3.05	0.83	0.19	0.50	2.33	0.11	0.28	0.14	0.44	2.09
702C	dart	black	1.05	9.62	2.55	5.06	1.12	0.67	1.69	0.94	0.67	3.55	4.44	1.65	51.25	2.72	1.31	2.10	2.60	0.34	0.64	0.14	0.04	0.27	0.32	0.68	0.34
754	dart	black	1.35	4.88	3.08	9.31	2.24	2.04	3.35	1.75	0.88	4.66	10.20	1.88	0.19	2.73	6.62	4.95	3.80	0.73	0.43	0.33	0.29	0.62	0.45	1.09	0.87
42	arrow	cane	0.77	2.87	0.01	0.88	0.10	0.01	0.02	0.04	0.25	0.23	0.03	0.12	0.03	0.14	0.96	0.43	0.05	0.01	0.58	0.00	0.00	0.01	0.01	0.01	0.02
193	arrow	wood	1.33	0.58	0.02	1.19	0.02	0.01	0.02	0.01	0.14	0.62	0.02	0.03	0.03	0.11	0.35	0.22	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.00
241	arrow	cane	0.24	0.12	0.00	0.22	0.01	0.00	0.00	0.00	0.06	0.35	0.00	0.03	0.01	0.03	0.37	0.03	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
802	arrow	cane	0.24	1.41	0.01	0.26	0.05	0.02	0.39	0.01	0.23	0.25	0.01	0.02	0.04	0.32	0.68	0.11	0.00	0.09	0.04	0.01	0.00	0.01	0.00	0.00	0.00
805	arrow	cane	0.45	0.33	0.00	0.44	0.01	0.01	0.00	0.01	0.14	0.08	0.00	0.08	0.02	0.12	0.48	0.04	0.01	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
994	arrow	cane	1.05	0.97	0.00	0.37	0.17	0.00	0.02	0.01	0.66	0.35	0.02	0.03	0.00	0.01	0.44	0.42	0.00	0.00	0.02	0.00	0.00	0.12	0.00	0.00	0.00
82B	dart	wood	0.83	1.03	0.00	0.70	0.11	0.01	0.02	0.00	0.27	0.27	0.02	0.07	0.27	0.57	0.28	1.23	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.06
113	dart	wood	4.60	3.82	0.11	1.19	0.28	0.06	0.09	0.04	0.32	0.98	0.16	0.21	2.23	2.95	0.45	0.81	0.08	0.01	0.08	0.03	0.01	0.05	0.05	0.04	0.08
147	dart	wood	1.68	0.82	0.00	0.60	0.20	0.01	0.00	0.00	0.41	0.63	0.00	0.06	0.02	0.18	0.35	1.19	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
164A	dart	wood	2.22	1.12	0.02	0.72	0.18	0.03	0.40	0.01	0.28	0.36	0.04	0.05	0.08	2.62	0.26	0.91	0.10	0.07	0.01	0.09	0.00	0.01	0.01	0.01	0.31
331	dart	wood	9.37	1.26	0.02	0.37	0.20	0.01	0.17	0.00	0.27	0.15	0.04	0.02	0.21	0.45	0.21	0.62	0.01	0.02	0.00	0.03	0.00	0.03	0.00	0.00	0.05
397	dart	cane	4.46	1.02	0.01	1.40	0.07	0.01	0.01	0.00	0.19	0.53	0.03	0.03	0.02	0.12	0.20	0.33	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01
398	dart	cane	5.52	0.82	0.05	1.14	0.08	0.03	0.08	0.03	0.39	2.34	0.09	0.12	0.04	0.34	0.89	0.17	0.10	0.03	0.09	0.01	0.00	0.05	0.01	0.03	0.02
430	dart	cane	13.24	10.69	5.54	5.62	4.51	2.11	10.75	5.00	1.67	20.15	8.39	16.33	0.54	4.53	3.83	7.29	6.55	6.91	0.55	1.80	0.06	0.81	1.04	2.39	3.11
480	dart	cane	1.26	2.39	0.00	0.35	0.14	0.00	0.03	0.01	0.34	0.87	0.02	0.01	0.02	0.16	0.61	0.50	0.01	0.01	0.02	0.00	0.00	0.14	0.00	0.00	0.00
484	dart	wood	4.58	0.37	0.01	0.30	0.08	0.00	0.06	0.00	0.12	0.25	0.01	0.05	0.06	0.22	0.17	0.28	0.01	0.02	0.00	0.01	0.00	0.02	0.00	0.00	0.03
601A	dart	wood	6.51	0.70	0.01	0.53	0.17	0.04	0.13	0.01	0.53	0.25	0.03	0.07	0.07	0.22	0.24	0.72	0.01	0.02	0.00	0.01	0.00	0.03	0.00	0.00	0.02
610	dart	wood	0.86	1.86	0.26	2.29	0.33	0.10	0.15	0.14	0.30	1.05	0.22	0.28	0.03	0.24	0.62	0.59	0.33	0.04	0.09	0.01	0.01	0.80	0.05	0.07	0.08
627	dart	wood	0.35	0.59	0.05	1.41	0.23	0.00	0.06	0.16	0.81	0.61	1.07	0.30	0.22	0.54	0.78	1.01	0.20	0.00	0.27	0.00	0.03	0.03	0.11	0.08	0.12
634B	dart	cane	3.16	2.67	0.40	0.86	0.28	0.18	1.91	0.48	0.88	1.23	1.77	0.24	0.04	0.58	1.22	0.44	0.47	0.23	0.06	0.17	0.10	0.09	0.06	0.22	0.22
702C	dart	wood	2.18	1.21	0.00	0.28	0.16	0.01	0.00	0.00	0.26	0.23	0.01	0.03	0.02	0.48	0.68	0.58	0.01	0.00	0.00	0.01	0.00	0.07	0.00	0.00	0.08
766A	dart	wood	11.18	7.47	0.31	9.96	7.28	0.21	0.31	0.94	0.59	6.53	0.28	3.71	5.30	0.46	0.27	13.29	1.64	0.35	2.98	0.00	0.00	0.10	0.15	0.69	0.02
929	dart	wood	0.18	1.20	0.00	0.21	0.16	0.00	0.00	0.00	0.06	0.03	0.00	0.00	0.01	0.02	0.27	0.19	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
993B	dart	wood	3.44	14.00	0.03	0.75	0.41	0.06	0.17	0.20	0.20	0.60	0.16	0.62	0.04	0.90	0.25	1.61	0.30	0.03	0.76	0.02	0.00	0.03	0.03	0.10	0.13
1040	dart	wood	22.83	2.90	0.03	1.58	0.46	0.01	0.06	0.03	0.80	0.31	0.02	0.53	0.15	0.98	0.17	1.25	0.01	0.02	0.01	0.02	0.00	0.05	0.00	0.00	0.17
342A	unk.	cane	0.49	1.70	0.02	0.45	0.91	0.03	14.30	0.07	0.13	0.81	0.11	0.22	0.07	0.61	1.93	1.00	0.14	0.11	0.23	0.02	0.00	0.04	0.03	0.05	0.02

Notes: unk. = unknown. “Multiplier” indicates the number that the reported ratio in the table should be multiplied by to arrive at the true ratio of that element against K.

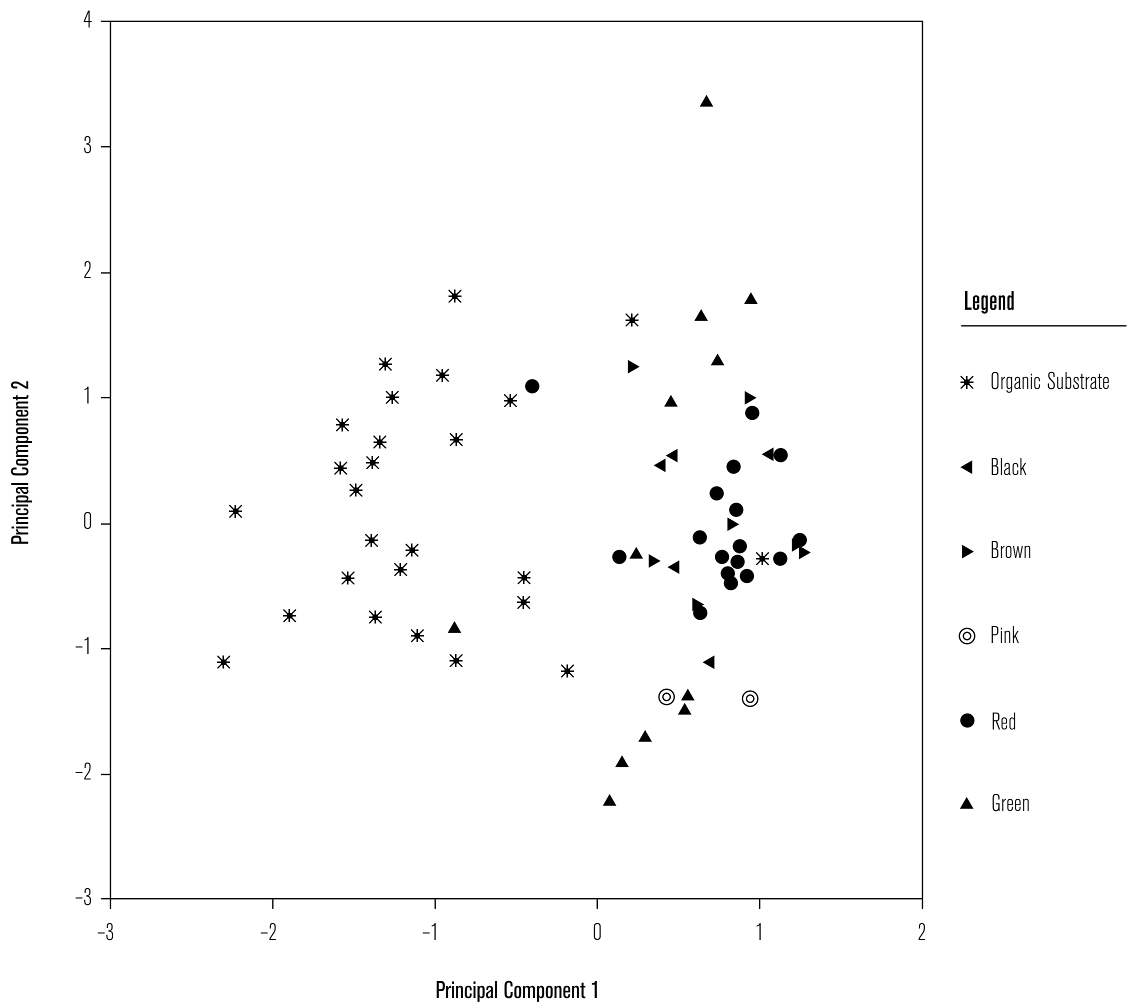

Figure 3. PCA of LA-ICP-MS data, showing separation of wood and cane substrates versus pigments.

with the pigments. One possibility is that pigments on these artifacts penetrated more deeply into the organic substrate, although there is no obvious discoloration to the wood and cane substrate in these cases.

Relative to K, Na was the only element that was consistently higher in the unmodified cane or wood. Most other elements were present in much higher abundance in the pigments than in the organic substrate (up to 10,000 times higher in some cases), particularly transition (Cu, Fe, Mn, Zn) and other metals (Al, Sn, Pb). Indeed, a bivariate plot of almost any of these elements produces essentially the same plot as that from the PCA, with the cane and wood substrates falling well below the pigments. This suggests that many of the pigments derive from metal-bearing minerals and that those minerals did not contain Na as a major constituent. On the other hand, there is some overlap between organic substrates and pigments for some of the alkaline earth metals and some non-metals (e.g., S, Mg, and Ba), especially for green pigments. There are no obvious elemental differences between the cane and wood substrates. Importantly, these analyses show the geochemical signature for an organic substrate relative to a pigment.

It is possible that LA-ICP-MS analyses on some of the pigments included a small component of organic substrate as part of the ablation process. This may be especially true for thin pigment washes where the pigment may have penetrated the substrate, as discussed above for artifacts 430 and 766A. EM images for 11 artifacts do not suggest such penetration was extensive. However, by focusing our subsequent pigment analyses on the ratios of elements that are extremely low in the substrates, we can minimize the potential effects of any substrate interaction. Having separated organic substrates from pigments, we now focus our attention on the pigments only. The sections below summarize the significant findings by color.

For samples examined by EM, Table 4 characterizes pigments based on their physical appearances in BSE images as either coarse-, medium- or fine-grained. We measured the maximum diameter of grains within the pigment as well. Table 4 also reports tentative mineralogy based on EDS analyses on particular grains within the pigment matrix, showing the more common constituents.

Green

Green has the most striking elemental distinctions of the analyzed pigment colors. In total, we analyzed 12 artifacts with green pigment: seven cane and five wood darts (no arrows). Four of these were also subjected to XRD and four to EM analysis (two of the four received both analyses). Figure 4 plots Cu/K and Rb/Sc, highlighting

Table 4

PIGMENT TEXTURE AND MINERALOGY AS RECONSTRUCTED FROM EM BSE IMAGES AND EDS ANALYSES OF PARTICULAR SPOTS

Cat #	Color	Texture	Max. Diam.	Reconstructed Mineralogy based on EDS
113	Green	Coarse	75	Malachite, Plagioclase, Alkali Feldspar, Calcite, Apatite
147	Black	Coarse	60	Cu-Sulfate, Cuprite, Quartz, Alumina-Silicate
474	Red	Fine	<5	n/a
591	Green	Coarse	80	Malachite, Dolomite, Quartz, Plagioclase
591	Red	Coarse	40	Hematite, Cuprite
601A	Red	Fine	<5	Iron oxide, Al-Na Rich Silicate
946	Brown	Fine	5	Iron oxide, Silicate, Carbonate
1040	Brown	Medium	25	Fe Rich Alumina-Silicate
480	Green	Fine	10	Fe-K-Na-Mg-Ca Rich Alumina-Silicate, Quartz
634B	Green	Fine	<5	Fe-K-Na-Mg-Ca Rich Alumina-Silicate, Quartz
754	Black	Fine	<5	Fe-K Rich Silicate, Plagioclase, Alkali Feldspar
342A	Red	Fine	10	Iron oxide, Quartz, Alumina-Silicate

Notes: Cat # = Catalog number; Max. Diam. = Maximum observed diameter of inclusions within pigment; Apparent Mineralogy = Interpretation of mineralogy, in decreasing order of importance within pigment. For artifact 474 we did not perform EDS.

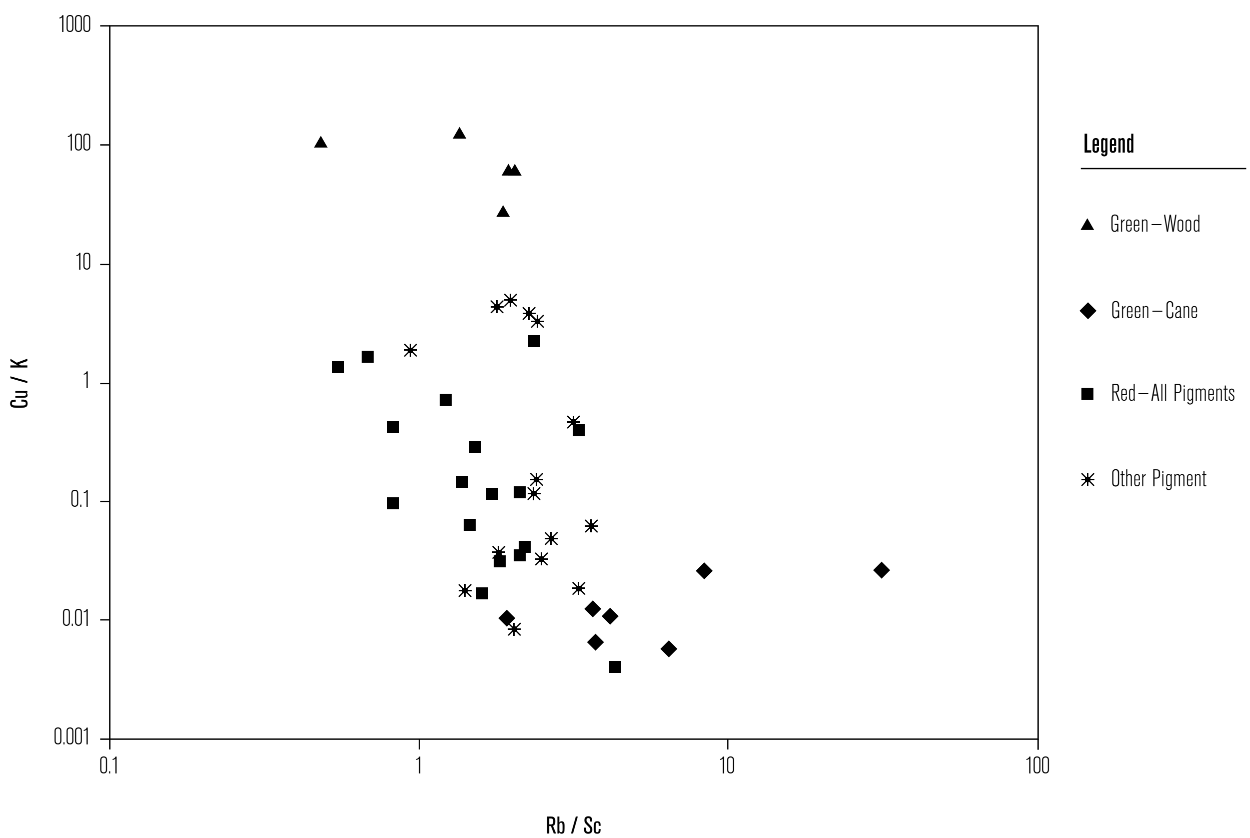

Figure 4. Relative abundances of Cu and Ti (LA-ICP-MS analysis) showing two groups of greens.

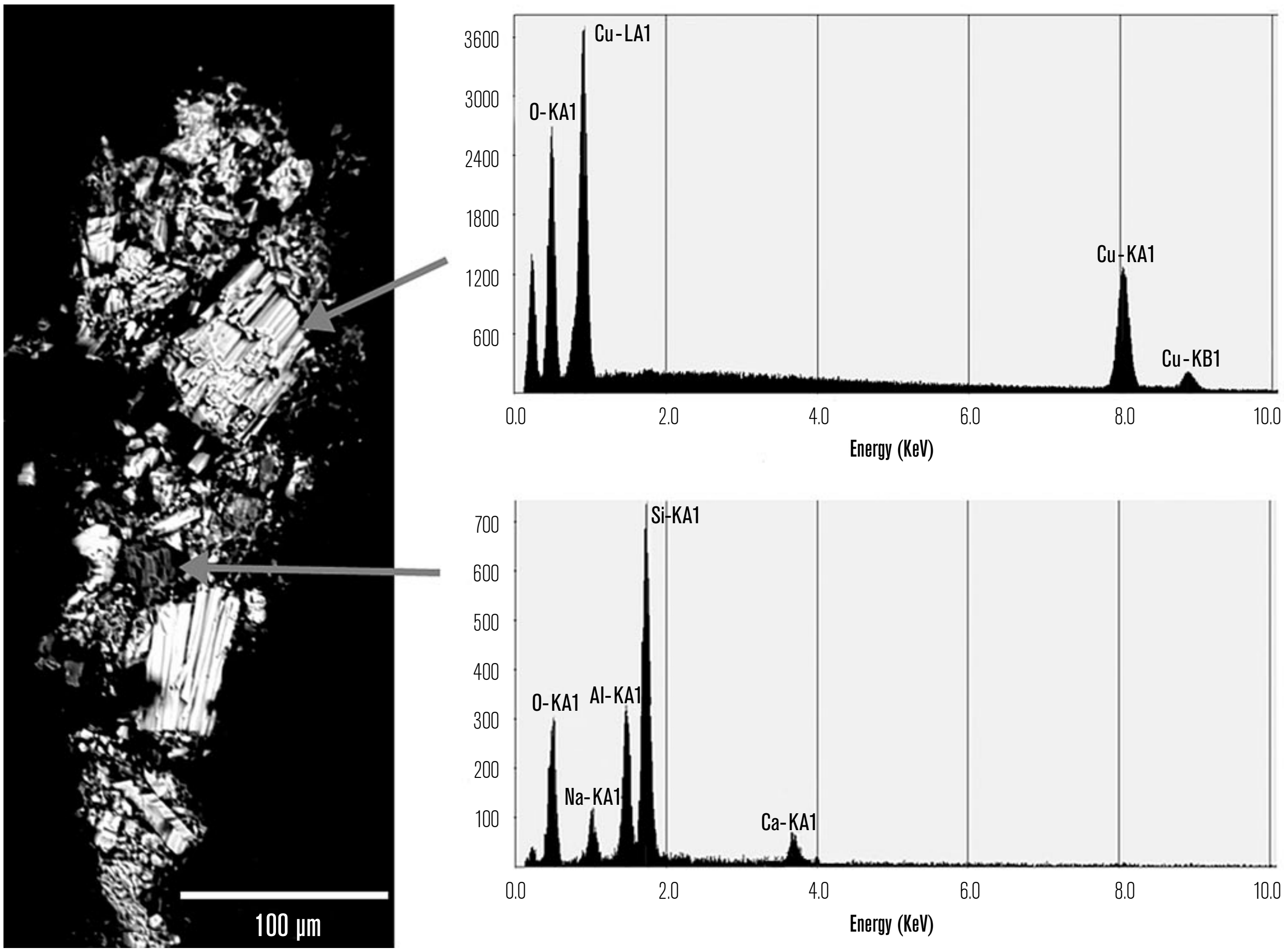

Figure 5. BSE image of sample 113 and associated EDS scans at two locations. Note cleavage and fracturing pattern of the upper copper-rich mineral, consistent with malachite. We interpret the lower mineral as plagioclase feldspar.

green colors versus other pigments. As seen, green pigments clearly divide into two groups, a high-Cu group and a low-Cu group. Copper comprises between 75% and 90% of the ICP-MS element raw counts for the high Cu group, and is 10 to 10,000 times higher than in other samples. These pigments are displayed as triangles in the upper part of Figure 4 and are notably elevated in Na, Co, Pb, and Zn as well.

Interestingly, this division into high and low Cu also neatly divides the sample by substrate type. All greens on wood implements belong to the high-Cu group, with Cu levels nearly 1,000 times higher than in the low-Cu group, which are all on cane and are plotted as diamonds in the lower part of the graph. These greens on cane have even lower Cu values than other pigments. A compositional difference between pigments used on wooden versus cane darts is a trend that repeats in other colors.

XRD and EM-EDS analyses on two high-Cu pigments indicate that the copper-bearing mineral is malachite ($Cu_2[(OH)_2|CO_3]$). For example, Figure 5 shows a back-scattered electron (BSE) scan of a small section of the green pigment on artifact 113, with insets showing EM-EDS analyses at two spots. Contrast is increased to highlight the physical structure of the pigment. The organic substrate lies on the left side of the pigment, but is not visible due to low brightness. The upper EDS scan shows our analysis of a copper-rich inclusion in the pigment, with peaks for copper, oxygen and carbon, consistent with the chemistry of malachite. Cleavage and fracturing patterns are also similar to a malachite standard we examined by EM. The lower EDS spectrum represents a mineral that is completely embedded within the malachite and displays lower brightness, and hence, includes elements with

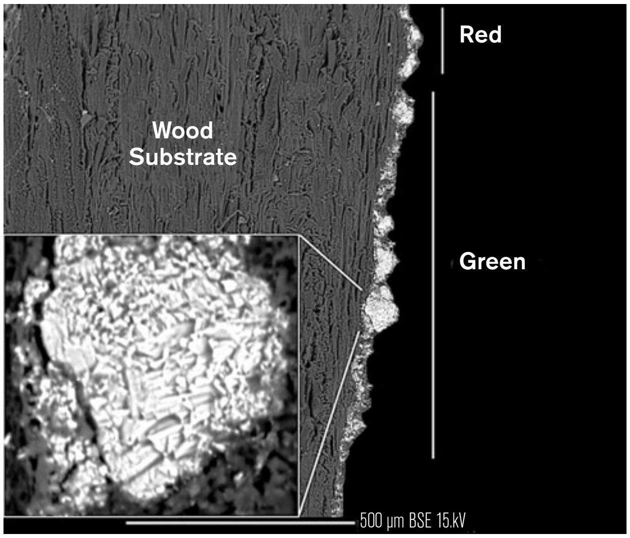

Figure 6. BSE image of sample 591 showing green malachite-based pigment; inset shows large aggregate of malachite grains. Note coarse-grained nature of pigment layer.

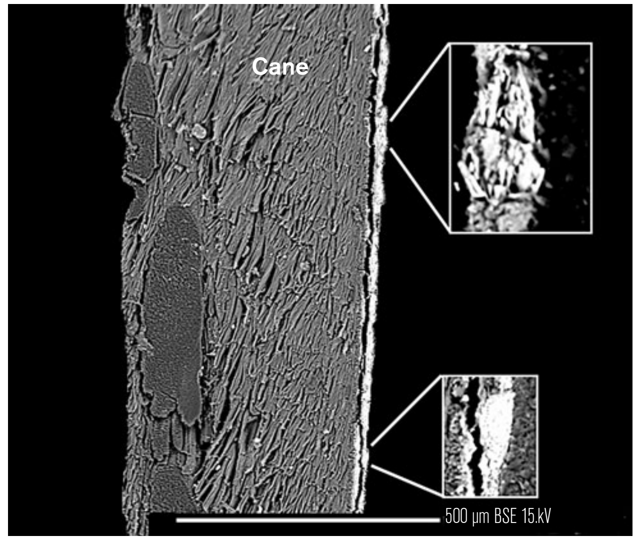

Figure 7. BSE image of non-cuprous green, with insets of hornblende (upper) and celadonite (lower) grains (sample 480). Note fine-grained nature of pigment.

lower atomic number than the malachite. Relative peak heights for Na, Ca, Al, Si, and O suggest the presence of plagioclase feldspar. Summing the bright pixels within the pigment, we estimate that over 65% of this pigment is made up of malachite. Malachite was used widely as a source of green pigment by artisans around the globe, including in California and Nevada (Campbell 2007:44).

Figure 6 shows a BSE image of the green from sample 591. The woody structure of the weapon appears on the left side of the image, while the pigment appears as the brighter vertical line through the center. The inset is zoomed in on one of the larger aggregates of malachite grains. The BSE image reveals poorly sorted and sub-rounded to sub-angular grains with a maximum diameter of well over 50 microns; it is thus a very coarse pigment. The thickness of the pigment across the wooden substrate is also highly variable. For this artifact, XRD and EM-EDS analysis revealed the presence of malachite, with minor amounts of quartz (SiO_2), calcite ($CaCO_3$), gypsum ($Ca[SO_4]\ 2H_2O$), and apatite ($Ca_5(PO_4)_3(F,Cl,OH)$), as well as alkali ($(K,Na)AlSi_3O_8$) and plagioclase ($(Na,Ca)(Al,Si)_4O_8$) feldspars. As discussed below, these minerals are present within some, but not all, of the other pigments. It is unclear if they were intentionally added or not (as, for example, a component in an extender or inorganic clay-based binder). Alternatively, they may be contaminants (as, for example, naturally-occurring minerals within the cave sediments). EM images show these minerals are often deep within the pigment, suggesting the former.

The non-cuprous green pigments on cane implements have a very different composition and structure (Fig. 7). These greens are lighter in color, unlike the darker and more vibrant greens produced by the malachite-based pigments. EM-BSE images show the pigments to be much finer-grained, with maximum particle size under 15 microns, and they were applied more evenly in thickness across the cane surface. LA-ICP-MS data indicate that relative to the other pigments, these greens have elevated levels of Na, Fe, and Rb. EM-EDS data suggest that the major mineral in these pigments is a green earth (or *terre verte*), likely either glauconite ($(K, Na)(Fe, Al, Mg)(Al,Si)Si_3O_{10}\bullet(OH)_2$) or celadonite ($K(Mg,Fe^{2+})(Fe^{3+}, Al)(Si_4O_{10}\bullet(OH)_2)$). Glauconite is a soft green mineral characteristic of marine depositional environments of the continental shelf (Rieder et al. 1998), and has been reported as being present in deposits less than 10 km. to the west of Gypsum Cave (Rowland et al. 1990), while celadonite is typically associated with altered basalts, and is also available in southern Nevada. Compositionally, these two minerals are similar. Green earth is reported as a green pigmenting agent in California (Campbell 2007; Scott et al. 2002) and elsewhere (e.g., Wainwright et al. 2009). EM-EDS data also indicate the presence of quartz, hornblende, alkali feldspars, and possibly clay

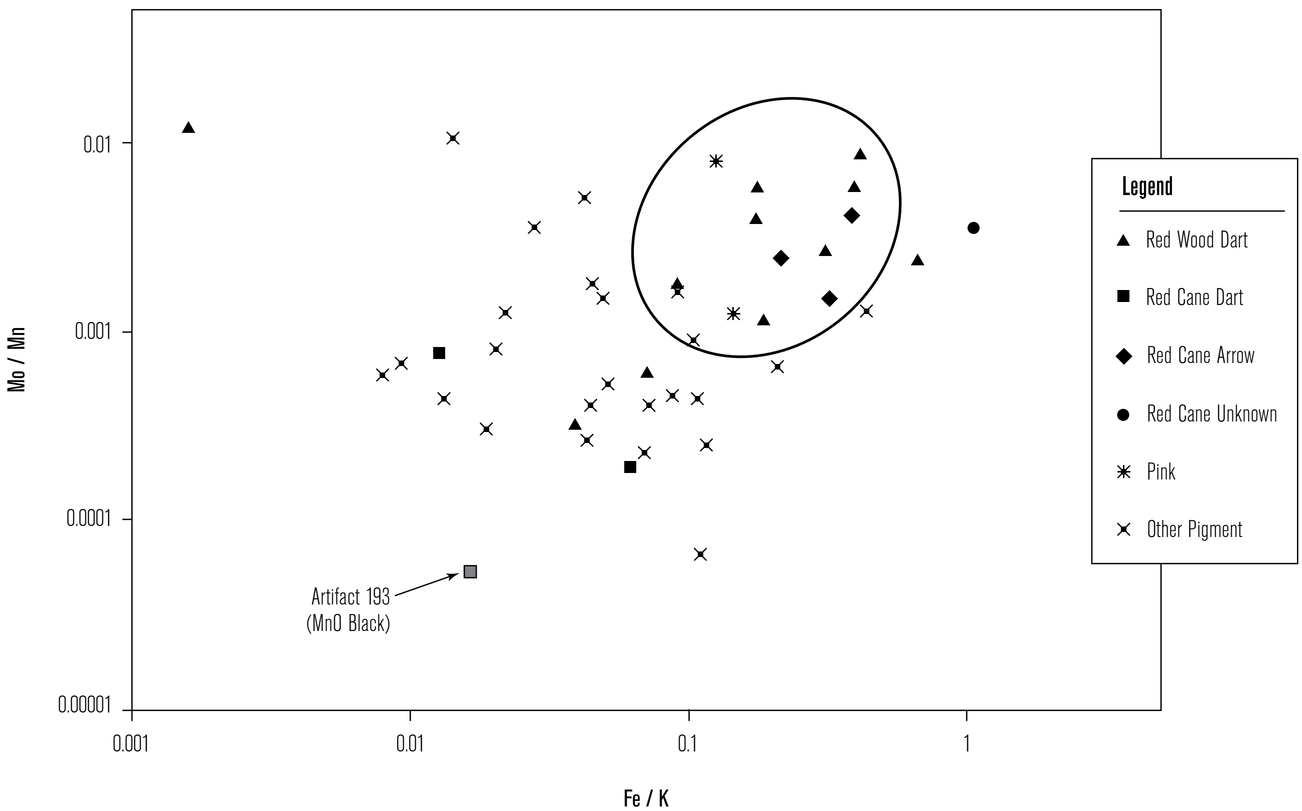

Figure 8. Relative abundances of Fe and Rb/Sr (LA-ICP-MS analysis) highlighting red and pink pigments.

minerals within this matrix, but not the presence of calcite, gypsum, or apatite, as in the cuprous greens.

Red

Red pigments from 17 samples were analyzed by LA-ICP-MS, including three cane arrows, two cane darts, one cane artifact of unknown weaponry type, and eleven wooden darts. Three of these were also subjected to both XRD and EM analyses, while three others received only EM analysis. As shown in Figure 8, the majority of the red pigments tend to have higher levels of Fe, and in artifacts with the highest values, accounts for 25–75% of the raw LA-ICP-MS counts. Red pigments also have elevated levels of Mo, which, although at concentrations about 4-5 magnitudes lower, covaries strongly with Fe in the red pigments.

XRD analysis on two of the high-iron pigments (591 and 601A) indicates large quantities of hematite (Fe_2O_3); again, a common component of red pigments worldwide (e.g., Bordignon et al. 2007; Clottes 1993; Hernanz et al. 2008), including in western North America (Scott and Hyder 1993; Striova et al. 2006; Wallace 1947). The XRD scans also indicate the presence of minor quantities of quartz, calcite, dolomite ($CaMg(CO_3)_2$), ankerite ($CaFe(CO_3)_2$), and a trace of gypsum. EM-EDS analysis of one of these two specimens (601A) and another high-Fe red (342A) corroborates the XRD results. Based on these results and similar overall geochemistry, we believe that most of the reds can be grouped into a single pigment recipe based on hematite, with additional minerals either naturally co-occurring within the hematite source, intentionally added, or incorporated post-depositionally (i.e., contamination from surrounding soil or formed by chemical alteration of the original pigments). We have highlighted this group with an overlying ellipse (not calculated statistically, but merely to draw attention to the association). The two pink pigments also fall into this general ellipse based on Fe and Mo, but are different in other ways (see below).

Five red pigments do *not* fall into the high Fe and Mo category, including three wooden darts and all cane darts. One of these wood dart samples (993B) is isolated in the

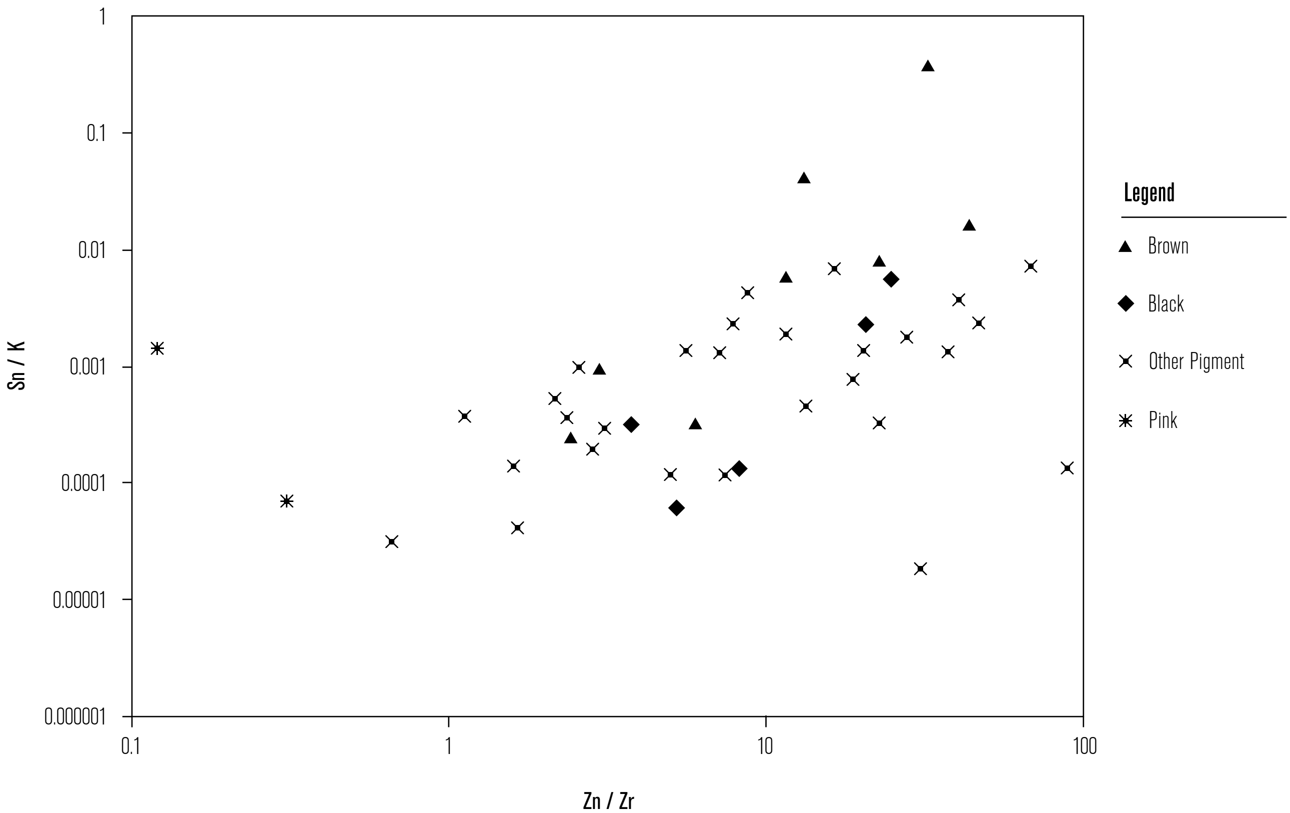

Figure 9. Relative abundance of Sn and Zr (LA-ICP-MS analysis) highlighting brown and pink pigments.

upper left of Figure 8 and was mentioned previously as having an organic substrate-like signature. This sample, then, may not actually represent a pigment but instead a substrate. The remaining two wood darts (164A, 484), and both cane darts (751, 754), are depleted in both Fe and Mo, and are unlike the other red pigments. Among the wooden dart samples, 164A was also distinctive for Zn, displaying concentrations nearly 50 times higher than any other pigment, along with elevated levels of Sn, Zr, and Ti. Unfortunately, we were unable to analyze the sample using either XRD or EM.

As in the green pigments, red cane dart pigments stand out as unique from the wooden dart reds. In addition to being low in Fe and Mo, the red pigments on cane darts are chemically unique in terms of other elements or element ratios as well, such as Na (high), Rb/Sr (high), Zn (low), and Al/Ca (low). This suggests that a distinctive mineralogical recipe characterized the reds applied to cane darts and that this recipe was unlike the red pigments applied to the cane arrows later in time. Differences in Rb/Sr ratios may relate to the general geological age of the materials in the pigment, as one isotope of Rb (^{87}Rb) decays to ^{87}Sr over time, but additional isotopic analyses are necessary to verify this.

Pink

Two artifacts analyzed by LA-ICP-MS had pigments identified as pink rather than red due to their lighter color; both involved cane darts. One of these was subjected to further EM analysis. For the most part, these pigments are compositionally similar to the red ones, displaying elevated levels of Fe and Zr, and higher levels of Pb and Mo. However, both have much lower levels of Cr and Zn. The pink pigments are shown on the left side of Figure 9, which plots Zn/Zr against Sn/K.

Indeed, one of the pink pigments (480) displayed elevated Rb/Sr, Co and Cu, and extremely elevated levels of Zr, approximately 50–100 times the levels seen in all other pigment samples. Zr was consistently higher in all five ablated spots in this sample, suggesting this result is not the product of the laser hitting a stray zircon grain, but that Zr is found throughout the pigment.

EM-EDS analysis of this sample showed a very fine grained structure, but did not disclose the presence of any zircon or other high-zirconium minerals. Instead, quartz, calcite and a mixture of aluminum-rich silicate minerals were observed. We believe its color is the result of mixing a fine-grained red ochre (hematite) with a light-colored clay mineral rich in Zr. Unfortunately, we were not able to perform XRD on this sample to confirm this mineralogical signature.

Brown

Eight pigments were identified as brown in color, ranging from lighter brown to black-brown. These include seven pigments derived from wooden dart shafts and a single pigment on a cane dart. LA-ICP-MS analyses revealed that, relative to other pigments, browns tend to have higher abundances of Sn and Zn (as seen in Fig. 9), and to a lesser degree elevated Ba, Ca, and Sr, and depleted Na. One of the high Sn samples also had highly elevated levels of Zr. However, this was due to one anomalous ablation spot (of five total spots), suggesting the laser may have hit a stray zircon crystal at this location during the analysis. We eliminated this spot from the analysis and averaged the remaining four spots to derive elemental values.

Two brown samples were analyzed by EM, and a third was analyzed by XRD. Of the former, both revealed a thin and fine-grained layer of paint over a wooden substrate. Tin- or zinc-bearing minerals were not evident in either sample. EM-EDS analysis suggested the presence of iron oxides, alkali feldspars, albite, and clay minerals, generally rich in varying mixtures of Fe, Ca, and Mg, in addition to silicon (Si) and Al. We believe the brown colors derive mainly from the addition of a light-colored clay mineral paste to a black base pigmenting agent, perhaps an iron oxide such as limonite with elevated levels of Sn and Zn, and/or a thinner application of a more finely-ground black pigment over a wooden substrate.

Black

Five pigments were classified as black and were analyzed by LA-ICP-MS. The samples analyzed included pigments on one wooden arrow, three wooden darts, and one cane dart. The wooden arrow was analyzed by XRD, and one wooden and one cane dart was analyzed by EM.

Compared to other colors, black pigments were the most variable in chemical composition. The wooden arrow (193) was clearly unlike the others, especially in the relative abundance of Mn, which accounted for 22% of the raw element counts and was over 100 times higher than in any other sample. This artifact is highlighted in the lower left side of Figure 8. XRD analyses on this sample revealed (not surprisingly) the presence of manganese oxide, as well as manganese hydroxides and oxyhydroxides. The presence of hydroxides and oxyhydroxides of manganese ores may indicate a natural decomposition of the Mn minerals into other states, or may alternatively indicate that a Mn compound was treated using heat and water, perhaps during preparation of the paint mixture, before its application to the arrow fragment. Mn oxides were not detected in any of the other pigments from Gypsum Cave. Prehistorically, Mn oxides were used in many places around the globe for black colors (e.g., Clottes 1993; Edwards et al. 1999; Striova et al. 2006). Mn oxide is also reported to have been used by various California groups in the Mojave Desert and San Diego areas to the west of Gypsum Cave (Campbell 2007:73).

Black pigments on two of the three remaining items (all wooden darts) are characterized by levels of Cu that are not as high as the malachite-based greens, but are much higher than any other non-green sample. EM-EDS analysis on one of these (147) revealed the presence of a coarse-grained cuprite (Cu_2O) and a copper-sulfate ($CuSO_4$; likely chalcanthite, $CuSO_4{\cdot}5H_2O$), confirming the source of the elevated Cu level. These minerals likely contribute to the black color. In addition, quartz, calcite, dolomite, kaolinite ($Al_2Si_2O_5(OH)_4$), and tremolite ($Ca_2Mg_5Si_8O_{22}(OH)_2$) are present as indicated by the EM-EDS analysis of this specimen. The third wooden dart contains high levels of Ca and medium levels of Fe, but is not otherwise especially distinctive in chemical composition. XRD analysis on this latter sample showed the presence of feldspars, as well as gypsum, not only in its natural state, but also as bassanite ($2CaSO_4{\cdot}0.5H_2O$), a mineral that can be formed by heating gypsum (and thereby partially dehydrating it). This may be a charcoal-based pigment mixed with a gypsum-bassanite binder and perhaps an iron-bearing mineral.

Finally, relative to other black pigments, pigment from the cane artifact (754) is especially elevated for Ca and Fe. The EM-BSE image (Fig. 10) revealed a fine-grained paint, while EM-EDS suggested the presence of both alkali and plagioclase feldspars, mixed in a paste of Fe-K-Mg-Al-bearing silicates. Figure 10 highlights a concentration of one of these Fe-rich silicate mixtures. We suggest that these Fe-bearing minerals are producing the black color in this pigment.

DISCUSSION

The combined analyses reveal that the pigments from Gypsum Cave were produced from a variety of different minerals. None of the five subjectively-defined colors was characterized by a homogenous/standardized compositional or mineralogical recipe. This indicates that the individuals who used Gypsum Cave exploited a wide range of minerals and blended them in varying amounts to create the palate of colors seen in the weaponry fragments recovered during the archaeological investigations.

The largest pattern in the study is within the green pigments, which strongly divide along a malachite-on-wood and green earth-on-cane line. A similar but weaker pattern exists among the red pigments, where again the reds applied to wooden darts have signatures with elevated Fe and Mo that are distinctive from those placed on cane darts. Although there is only one black applied to a cane dart, it too is different than the black pigments on wooden darts, while brown pigments were not applied to cane darts and pink pigments were applied only to cane darts. Thus, the types of paints applied to wooden darts were different in both mineralogy and chemical composition from those applied to cane darts.

Radiocarbon dating indicates that the wooden and cane darts were in use at the same time. The correlation between substrate type and pigment recipes for the darts raises a number of interesting questions; foremost among them is whether they are part of a single assemblage used by one cultural group, or if they effectively represent two separate assemblages, possibly the result of different groups from different regions making use of the cave.

As at Gypsum Cave, a number of other caves in the region dating to the same time period contain comingled wooden and cane dart fragments, including Pintwater Cave (Buck and DuBarton 1994), Black Dog Cave (Winslow and Blair 2003), Firebrand Cave (Blair and Winslow 2006), and Newberry Cave (Davis and Smith 1981). This suggests that cane and wood were commonly used concurrently. Furthermore, various pieces of cane and wood recovered from Gypsum Cave suggest that these pieces may have been used as part of the same composite tool. At minimum, a dart consists of a mainshaft (of either wood or cane) with one cupped end that fits on an atlatl spur, and a stone-tipped foreshaft that fits on the opposite end of the mainshaft, comprising a two-piece dart. However, pieces from Gypsum Cave show that darts with three or more parts, including one or more midshaft tube couplers, were also commonly used. Such couplers come with female-female, female-male, and male-male ends, and were made from both cane and wood. These sections were used in combination to build a complete dart of the desired length, much as a pipefitter builds a line to the desired shape and length from various fittings. This suggests that cane and wood went together and that the assemblage from Gypsum Cave was used by one cultural group. Furthermore, combining wood and cane into a single weapons system was a region-wide phenomenon.

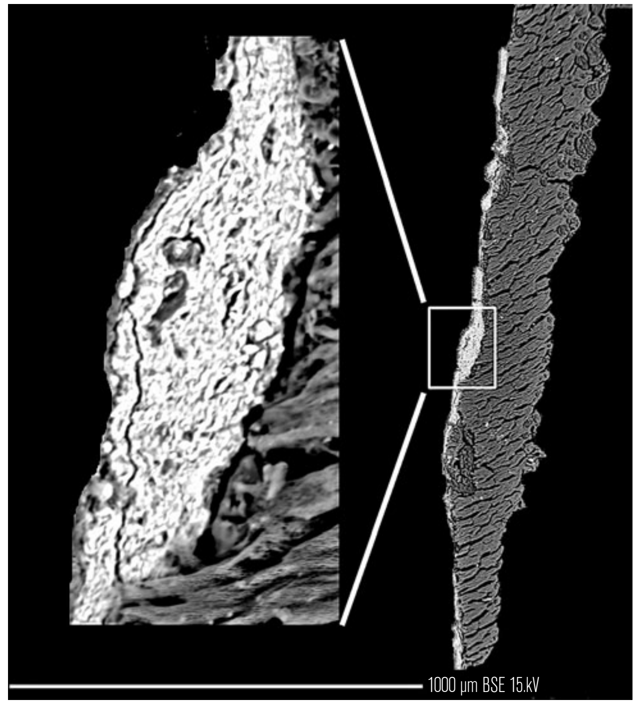

Figure 10. BSE image of black pigment on artifact 754, with inset highlighting Fe-rich silicate mixture.

Yet we are still left to wonder about the behavioral significance behind using one suite of pigment recipes for cane and another suite for wooden weaponry. Several possible explanations come to mind. Perhaps the group using Gypsum Cave had a residential mobility pattern that gave them access to diverse material in the course of their rounds. Thus, cane *Phragmites* and the pigment materials applied to it may have come from one region, while the arrowweed used for the wooden weaponry (Wigand 2009) and the pigment materials applied to it came from another. This might be tested by using Sr-isotope analysis on the substrate, for example, to see if the cane and wood grew in different regions (e.g., English et al. 2001, Reynolds et al. 2005). However, the finding that the reds on arrows are most similar to many of the reds on darts does not fit comfortably with this explanation. Alternatively, perhaps the group using the cave earlier in time obtained part of their dart weaponry assemblage through trade, acquiring painted cane segments that were fabricated in a different region, for example.

On the other hand, practical, or even religious and/or traditional beliefs, might be at the root of some of this behavior. Practically speaking, perhaps malachite did not adhere well to the smooth, waxy surface of cane, and in order to achieve the desired color effect, different recipes using green earth were followed, depending upon whether they were to be applied to cane or to wood. While this may explain patterns in the greens, it does not explain patterns in the reds. Again, recipes for the reds for cane and wooden darts are dissimilar, but cane arrows group with many of the wooden darts.

Concerning religious and/or traditional beliefs, it is a fact that—throughout the world—many cultures attach particular significant to different colors. Contemporary Native American groups in the Great Basin, American Southwest, and along the Colorado River impart symbolic importance to specific colors. The complexity of color symbolism among the Hopi is particularly well developed and has been widely reported, with red, for example, being associated with a particular direction, a particular tree used for building material, particular places in the traditional landscape, a particular bird used in ritual, a particular flower associated with girls, and so forth (Hieb 1979). For the Chemehuevi, Laird (1976:101) reported that different colors of corn were associated with different clans of the dead. Furst (2008:52–55) has reviewed appropriate uses and restrictions concerning different paint colors among the Mojave people, even noting that the "Mojaves lacked a source of red pigment and bartered for it with their Walapai neighbors, who found it at Red Mountain in their own lands," while black paint, "perhaps manganese rock" may have been directly obtained by them from a "place south of Topok they called Black Mountain" (2008:54, citing Devereaux 1949:111). In addition, Applegate (1979) has discussed the significance of colors for the Luiseño, where certain colors were considered dual opposites (e.g., red and black) and were associated with sex, cardinal directions, and other concepts. Technological experiments and additional analyses on pigments from other nearby caves would help to address some of these possibilities.

We also noted that some pigments were particularly coarse in texture. For example, all the malachite-based pigments contained large aggregate clasts of malachite. Campbell (2007:77) reports that some minerals are more vibrant in color when left in a coarse state. In particular, malachite becomes less saturated in color with decreasing average particle size. This may explain why malachite-based greens only appear on wooden implements. If coarse-grained pigment pastes do not adhere well to cane surfaces, malachite may not have been an option for getting green pigments on such a medium, and green earths may have been a substitute.

Within particular colors, especially within the reds, there was evidence of significant and patterned variation in the geochemistry of the pigments. Thus, there appear to be at least two different red "recipes," varying especially in their iron and manganese content. Likewise, several brown pigments had elevated levels of Sn, one pink pigment displayed notably high Zr, one black was based on manganese oxide and another on cuprite, and one red appears to contain a zinc-based compound. Why such variation exists within the sample of pigments is not known, but may indicate different pigmenting traditions, different raw material availability for artisans, experimentation with different minerals, or attempts to produce different shades or lusters of particular colors. Additional research, especially utilizing a larger sample size, will be necessary to begin addressing these issues.

At the same time, while there was significant mineralogical and geochemical variation within particular colors, there were no systematic differences detected by weapon type (e.g., dart vs. arrow). This suggests there was some degree of continuity in pigment recipes over time, though our sample of arrows is small (n=4).

CONCLUSIONS

This paper presents a first step towards understanding pigment use in the southwestern Great Basin by describing, geochemically and physically, the composition of prehistoric pigments. The analyses confirmed notions proposed in previous studies of pigments (e.g., Campbell 2007; Scott et al. 2002), such as the suggestion that malachite and green earths (e.g., glauconite, celadonite) were used to produce greens, and hematite was used to produce reds.

Documenting pigment composition is important, but ultimately we are interested in how these pigments can inform us anthropologically about ancient human behavior in the region. In this regard, the study demonstrated that interesting patterning existed within colors and between color and substrate type, but produced more questions than it answered. For example, analyses revealed the presence of many other non-pigmenting minerals within the paint, such as quartz, feldspar, gypsum, and various alumina-silicate minerals. It is unclear whether these were contaminants from sediments within the cave or were intentionally added to the pigments. EM data suggest that many of these minerals are deeply embedded within the pigment matrix, and do not occur just on surfaces as would be expected of a contaminant. This suggests an intentional addition, perhaps as an extender or binder of some sort, but additional analyses are necessary.

In the future, we hope to undertake similar studies with other weaponry in the southwestern Great Basin. For example, weapons with pigments have been reported in Firebrand Cave (Blair and Winslow 2006) less than 30 km. to the east of Gypsum Cave, and from Newberry Cave (Davis and Smith 1981) in the Mojave Desert of California. Such studies would place the Gypsum Cave pigments in a better geographic and cultural context, and provide greater behavioral meaning for pigment production and use in the desert west of North America. As well, we hope to (or hope others will) undertake parallel studies documenting the nature and location of potential sources for the different minerals used by ancient artisans; such data would be especially informative about issues concerning ancient mobility practices.

ACKNOWLEDMENTS

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GC-MS and Attribute Analysis of Intermountain Brownware from the Southern Great Basin of North America

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Intermountain Brownware pottery refers to a utilitarian ware made by late prehistoric to early historic period hunter-gatherers of southern Nevada, western Utah, and northern Arizona. The pottery, which is confined to jar forms, is typically described as thick and poorly made, but a systematic characterization of Intermountain Brownware sherds has been lacking. This paper seeks to remedy that situation. Residue and attribute analyses were undertaken on a sample of sherds to investigate the production technology, performance characteristics, and function of the vessels. We conclude that the vessels were used for boiling seeds, and that while their performance attributes may not have been ideal for this purpose, they were a necessary outcome of the production constraints imposed by the mobile lifestyle of their makers.

Across the world and throughout time, the use of ceramics has been strongly correlated with sedentary and agriculturally-based societies (Arnold 1985:109, 120). Despite this strong correlation, archaeological and ethnographic data indicate that the producers of Intermountain Brownware pottery were neither sedentary nor full-time agriculturalists (Firor 1994:6, 60; Walling et al. 1986:25; Westfall et al. 1987:9). These wares instead appear to have been produced and utilized by non-agricultural, seasonally-mobile populations adapted to the diverse landscape and sparse resources of the Great Basin and Colorado Plateau.

Intermountain Brownware pottery is typically described as a crudely made ceramic characterized by thick walls and coarse temper (Baldwin 1942; Pippin 1986:9; Tuohy 1986:3). It occurs most frequently in the form of conical jars, though globular pots with rounded bases are also known (Janetski 1990:57). Despite these generalizations, a systematic characterization of these ceramics has been lacking. This paper seeks to correct this oversight. Specifically, we present the results of both attribute and residue analyses of Intermountain Brownware sherds in order to define their physical characteristics and to evaluate what those characteristics tell us about the manufacturing technology, performance characteristics, and function of these wares. We conclude with a discussion of why the producers of Intermountain Brownware ceramics might have elected to manufacture them in the manner that they did.

BACKGROUND

Intermountain Brownware ceramics are found in southern Utah, northern Arizona, and southern Nevada in archaeological contexts dating from the late prehistoric (i.e., mid- to late-1200s) to the early historic (late 1800s) period. The region where they are found is essentially equivalent to the aboriginal territory of the Southern Paiute (Fig. 1), and indeed another term for these ceramics is Southern Paiute Utility Ware. However, because we cannot be certain that all producers of Intermountain Brownware were Paiute, we

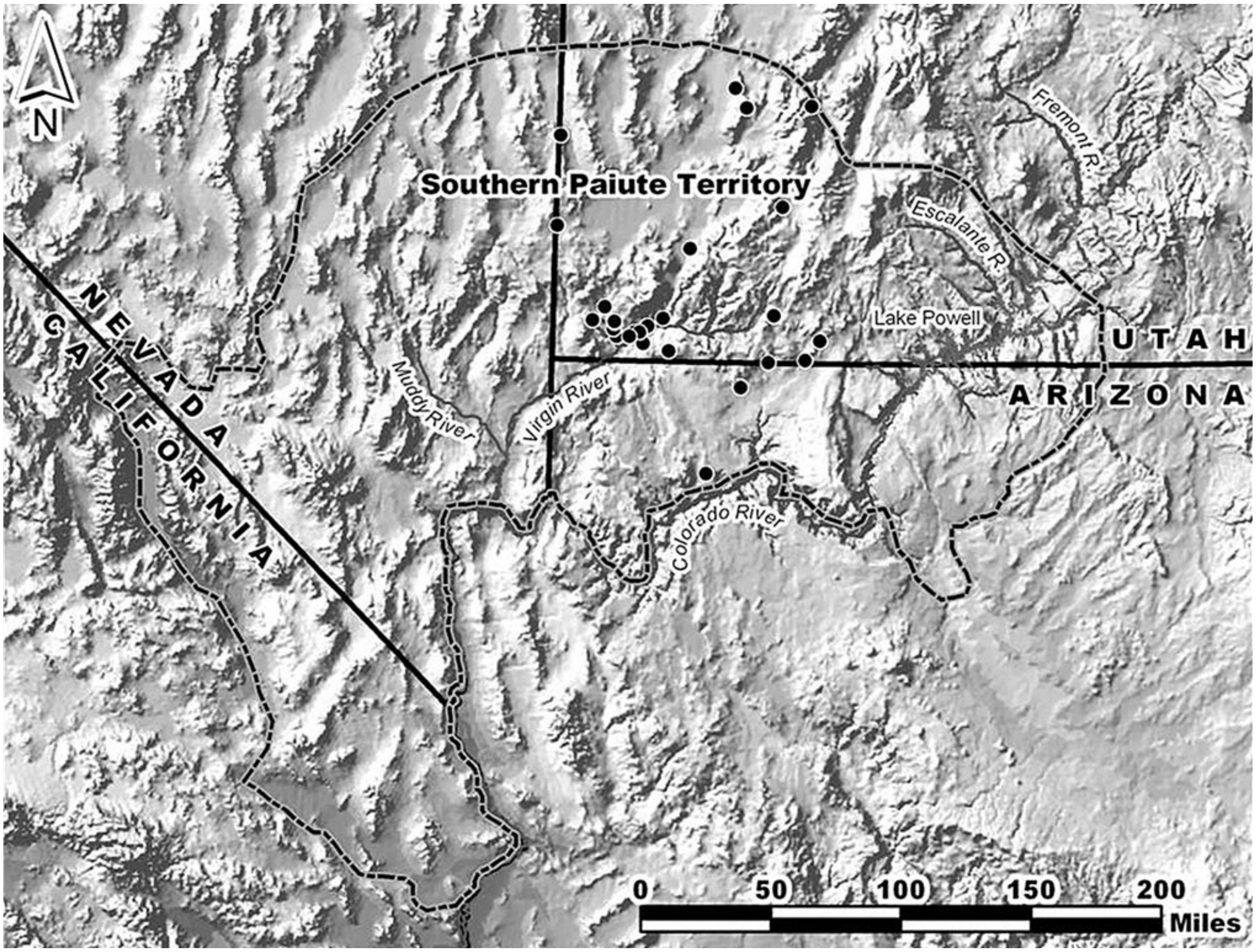

Figure 1. Map of Southern Paiute ancestral territory (after Kelly 1976).

have elected to use the term Intermountain Brownware in this paper.

Intermountain Brownware is one of three basic brownwares produced by Great Basin tribes; the other two are Shoshoni Brownware and Owens Valley Brownware (Tuohy 1990). All three wares were produced by groups of people with settlement patterns that ranged from highly residentially-mobile hunting and gathering to nearly sedentary horticulture. In addition to the brown wares mentioned above, some gray ware ceramics, associated with the Fremont Culture, were produced in the northeastern portion of the Great Basin.

ENVIRONMENTAL CONTEXT

The area where Intermountain Brownware is found contains diverse landscapes. Encompassing portions of both the Great Basin and the Colorado Plateau, the region has not only desert landscapes but also high mountains and wide valleys, broad plateaus, and river-cut canyons. Within this large area are a variety of ecozones containing a diversity of plant and animal species that could have been exploited for food by the indigenous people. In the lowland areas, grass seeds could have been collected in the summer, and in the fall and winter pine nuts and large game could have been procured in upland areas. Other resources, such as agave and rabbits, would have been available year-round.

DESCRIPTIONS OF INTERMOUNTAIN BROWNWARE

Our knowledge of Intermountain Brownware ceramics comes from two sources: historic documents and the

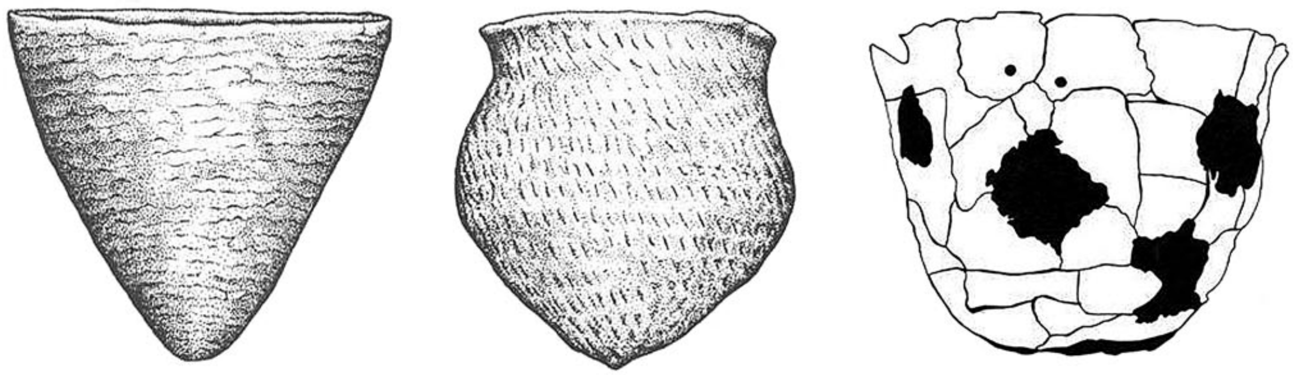

Figure 2. Intermountain Brownware vessel forms.

archaeological record. During the early historic period, the Southern Paiute produced pottery identical to that identified at archaeological sites as Intermountain Brownware. Ethnographic accounts (Kelly 1976:77; Kelly and Fowler 1986:375–377; Lowie 1924:225; Sapir 1992:801) describe this Southern Paiute pottery as a brown, thick-walled, and sand-tempered ceramic, with the most commonly mentioned form being the conical vessel. According to Lowie's (1924:22) consultants, this shape enabled the users to place the vessels directly in the ground and build fires up around them. A few consultants referred to the use of flat-bottomed vessels as well (Kelly 1964:77; see Figure 2 for an illustration of ethnographic brownwares from the Great Basin). In all of the historic accounts the pottery is described as being used for cooking purposes. Observers reported seeing the pots sitting directly in the fire (Fremont 1845:263; Hafen and Hafen 1954:188; Brooks 1972:44, 54) and being used for the "boiling and stewing of horse beef" (Fremont 1845:263) or "pottage" (presumably referring to a mush or a gruel; Brooks 1972:44). Kaibab Paiute consultants interviewed by Isabel Kelly in 1932 recalled that the ceramic vessels were used to cook a mush containing such ingredients as sunflower seeds, pine nuts, and pumpkins (Kelly 1976:42). It is likely that pottery production had waned significantly by the early 1900s due to the migration of American settlers to the western U.S. and the introduction of the technologies they brought with them. Pots and other tools were quickly replaced by metal implements such as Dutch ovens (Fowler and Fowler 1971:105).

Intermountain Brownware ceramics were first recognized as a distinct type by Baldwin (1942), who labeled them Southern Paiute Utility Ware. Baldwin described the ceramics as having a very coarse texture and a crumbly fracture, and occurring as deep bowls, tall narrow jars, and large jars with very wide mouths (Fig. 2). Both the bowls and the jars were said to have pointed or semi-pointed bases and to be "more or less conical in form." The thickness of the vessel walls was described as averaging 5 mm. for the bowls and 6 mm. for the jars (Baldwin 1950). More recent observations (Moffit et al. 1978:4; Pippin 1986; Tuohy 1986, 1990:57–59) have mirrored those made by Baldwin.

DATA ANALYSIS

Sampling Methods

In order to investigate the production technology, performance characteristics, and functions of Intermountain Brownware ceramics, 154 sherds were selected for study. These sherds, which were obtained from collections housed at the Southern Utah University Archaeological Archives and the Grand Canyon Staircase-Escalante National Monument, were derived from thirty-three sites and two non-site locations (see Fig. 1). They were recovered from settings ranging from 2,835 to 6,900 feet above sea level, in locations that can be broadly assigned to two ecological zones. At lower elevations, brushy vegetation such as creosote, sage brush, and rabbit brush predominate, whereas the higher elevations are characterized by pinyon-juniper woodland settings. Approximately 80% of the 130 sherds for which environmental information was available came from lowland settings, while 20% came from upland zones. All of the sherds were recovered from surface contexts. (For additional information on the proveniences of the sherds, see Betenson 2005.)

The 154 sherds included 100 body sherds, 52 rim sherds, and 2 refitted conical bases. A standardized suite of attributes was recorded on all 154 sherds, while residue analysis was conducted on 32 sherds.

Attribute Analysis

The attributes recorded and discussed in this paper included (a) thickness, (b) hardness, (c) the presence of sooting, (d) rim shape and diameter, and (e) the maximum size and degree of sorting of the temper particles. All of the attribute analyses were conducted by the senior author.

Thickness measurements, taken with digital calipers to the nearest millimeter, were recorded for all sherds. Three points were taken on body sherds, and the resulting measurements were averaged to obtain one average thickness measurement per sherd. For rim sherds, a single measurement was taken just below the rim.

Hardness was calculated using the Mohs hardness test. This test measures the resistance of the sherd to being scratched by one of ten standard minerals, each of which is ranked on a scale of one (being the softest) through ten (being the hardest). Each sherd was scratched on both its interior and exterior surface and its hardness score recorded as a range, with the lower number representing the hardest mineral that did not scratch the surface and the upper number representing the softest mineral that could scratch the surface. For example, a sherd having a hardness score of 5–6 means that the sherd surface was not scratched by apatite (ranked 5), but was scratched by feldspar (ranked 6).

The presence or absence of sooting was recorded for each sherd. Sooting was recognizable as a lustrous, finely cracked, blackened coating on the sherd (Hally 1983:8).

Rim shape was recorded as straight, inverted, or everted. Rim diameter, measured to the nearest centimeter, was obtained by fitting the curve of the rim to a diameter measurement template. The measurement of rim diameter was restricted to those sherds for which at least five percent of the arc was present.

To categorize the temper inclusions, the paste of each sherd was examined under a binocular microscope. The size of the maximum temper particle was recorded to the nearest 0.1 cm., and the degree of sorting was recorded using Orton et al.'s (1993:239) ranked system of very poor, poor, fair, good, and very good. The ranking was based on the subjective assessment of how evenly the aplastic inclusions were distributed within the paste.

Residue Analysis

Residue analysis was performed by the chemopyrolysis of ground pottery samples. Chemolysis can be defined as the thermally-induced decomposition and derivitization of complex organic materials. The chemolysis process involves simultaneous pyrolysis processes and chemical reactions. Chemopyrolysis is performed by ballistically heating ground sherd samples that have been mixed with excess tetramethylammonium hydroxide to pyrolysis temperatures (400 to 600°C). The tetramethylammonium hydroxide serves two purposes. First, it causes the saponification and decomposition of biomolecules such as lipids, lignin, carbohydrates, and protein into lower molecular weight fatty acids, phenols, sugars, furans, and other products. The polar functional groups on these molecules are then methylated by the tetramethyl ammonium cation, producing volatile and semi-volatile compounds (methyl ethers and esters) that are suitable for gas chromatographic separation and analysis. For this project, the chemopyrolysis products were analyzed using Gas Chromatography-Mass Spectrometry (GC-MS). The majority of the identified products were lipids, or fats contained in plant and animal residues, that were extracted from pores in the pottery fabric. Lipids present in foods fill pore spaces of unslipped ceramics during cooking, processing, transporting, or storage (Eerkens 2001:92). Pyrolysis or chemopyrolysis is performed in an inert helium atmosphere. During chemopyrolysis, volatile products are delivered by helium flow to the gas chromatograph. These compounds are then fractionated by gas chromatography as a result of their differential retention on a coated capillary column and differences in volatility. The fractionated effluent from the gas chromatograph is delivered to the mass spectrometer through a heated transfer oven, where the chemopyrolysis products are detected by electron impact mass spectrometry (Leute 1987:136; Varmuza et al. 2005). The electron impact of organic analytes creates positively-charged parent ions that subsequently fragment in a characteristic fashion, producing daughter ions of different mass that can be separated and detected by the mass spectrometer (Leute 1987:135; McLafferty 1973). These mass spectra can be used to identify the various decomposition products through a comparison with the spectra in a National Institute of Standards and Technology (NIST) mass spectrum library that is accessed by the mass spectrometer software.

Thirty-three residue samples were analyzed. These included 32 samples taken from the sherd fabric, and one sample taken from residue found adhering to one of the sherd surfaces. To obtain the samples from the sherd interiors, a 1 x 1 cm. sample was removed from each sherd using a Dremmel tool. The surface of each sample was then removed to a depth of approximately 1 cm. using a Dremmel sander attachment. The sanded sherd was handled with sterile tweezers while a small amount of methanol was poured over all surfaces. The saturated sherd was then put under a fume hood to speed evaporation of the methanol. The methanol was used to rinse away contaminants present in the lab or that resulted from handling.

After the methanol evaporated and the sherd appeared dry, it was placed inside a sterile porcelain mortar. The mortar and pestle were washed with hot water and alkaline soap between each experiment to eliminate any residues that might have accumulated during the preparation of each sherd for analysis. The sherd was then pulverized into a fine powder with the pestle. Each powder sample was placed inside a plastic specimen container that was labeled for subsequent identification.

The residue analysis was performed with a Varian 3400 gas chromatograph with a splitless injector, coupled to a Varian Saturn 3 ion-trap mass spectrometer via a heated transfer oven. A fused high temperature silica column (Supelco EC-5) was used for all analyses. Helium was used as the carrier gas. The column head pressure was adjusted to 10 psi at 40°C with ultra high-purity helium. The GC column temperature program was as follows: The initial column temperature was held at 40°C for 4 minutes after sample introduction. The column temperature was then raised at 10 °C min-1 to 250°C, and then 20°C min–1 to 280°C. The column was held at 280°C for 15 minutes before cooling to 40°C. A CDS Pyroprobe 2000 with a CDS Model 1500 interface was used in conjunction with the mass spectrometer to perform chemolysis on the samples. A portion of the sample (approximately 10–20 mg.) was packed into a 2 mm. diameter quartz tube and held in place with quartz wool. A 10 µL portion of tetramethylammonium hydroxide (25% in methanol) was added using a syringe and placed into the pyrolysis probe. The sample was heated for 30 seconds at 80°C to remove the methanol. The probe was inserted into the CDS Model 1500 interface and then ballistically heated to 500°C for 20 seconds to effect chemolysis. The chemolysis products were then swept from the quartz tube into the GC using helium as the carrier gas (Nemr 2004:29, 35; Steinberg et al. 2009:342–343). The remainder of the sample was stored in the specimen container so that it could be used in further trials if necessary.

RESULTS

Attribute Analysis

Manufacturing Technology. The results of the attribute analysis are summarized in Table 1. The physical characteristics observed in the ceramic collection suggest that the vessels were expediently produced yet carefully fired. Expedient production is indicated by the paste characteristics. The fact that most sherds contained very poorly- to poorly-sorted inclusions indicates that they were not well mixed prior to the formation of the vessel, and the size of the inclusions suggests that little effort was

Table 1

SUMMARY OF THE RESULTS OF THE ATTRIBUTE ANALYSIS

Attribute	Sample	Results
Thickness		
Body sherds	All sherds (n=154)	$\bar{x}$=7.30; s=1.17
Rim sherds	All rim sherds (n=53)	$\bar{x}$=5.63; s=1.15
Hardness		
Interior surface	All sherds (n=154)	Median=4–5; Range=2–3 to 7–8
Exterior surface	All sherds (n=154)	Median=4–5; Range=2–3 to 7–8
Sooting	All sherds (n=154)	Present on 10.4% of sherds
Rim Form and Size		
Shape	All rim sherds (n=53)	86% are straight; 14% are slightly everted
Diameter	All rims with >5% of arc present (n=16)	$\bar{x}$=26.0; s=3.8
Aplastic Inclusions		
Degree of sorting	All sherds (n=154)	Very poor=44.3%; Poor=39.6%; Fair=14.3%; Good=1.9%
Maximum size	All sherds (n=154)	$\bar{x}$=1.20; s=.5

made to remove large grains. Expedient production is also reflected in the vessel shapes. The high frequency of straight rims suggests that most of the sherds come from conical vessels having straight sides and unrestricted openings, such as those shown in Figure 2 (left and center). The everted rims are believed to have come from the smaller, globular vessels (Fig. 2, right). Compared to the rounded cooking pots commonly associated with fully sedentary, agriculturally-based societies, these shapes could have been formed relatively quickly since they do not require intermediate drying stages in the building up of the wall.

Despite the lack of time invested in preparing the pastes and shaping the vessels, care seems to have been taken in their firing. The median score of the sherds on the Mohs hardness test was a 4–5, with two-thirds of the sherds falling between either 4–5 or 5–6 (Table 2). These scores are higher than expected, since non-kiln fired ceramics typically score in the 3 to 5 range on the Mohs hardness scale (Rice 1987:356). To aid in the interpretation of these scores, hardness measurements were also obtained for several pieces of Puebloan pottery (Hansen 2002). The ceramics used for the comparison were recovered from two sites in southern Nevada; both sites yielded both Puebloan and Intermountain Brownware ceramics, and sherds of each type were analyzed. To minimize variability between observers, the senior author conducted all of the hardness measurements. The results of these analyses are presented in Table 2. The data show that the Intermountain Brownware sherds used in this study (from southwestern Utah and northwestern Arizona) are fairly hard relative to both the Intermountain Brownware sherds and the Puebloan sherds from southern Nevada. Because hardness is related to firing temperature, these data suggest that the brownwares examined in this study were fired at temperatures comparable to or perhaps even higher than those used to fire the Puebloan wares.

Table 2

RESULTS OF MOHS HARDNESS TESTS, COMPARING INTERMOUNTAIN BROWNWARE AND PUEBLOAN CERAMICS[a]

	Ceramics Used in Present Study	Ceramics from Southern Nevada Sites	
Results of Mohs Hardness Test	Intermountain Brownware (n = 54)	Intermountain Brownware (n = 30)	Puebloan (n = 30)
2 – 3	–	60.0%	23.3%
3 – 4	13.0%	33.3%	36.7%
4 – 5	42.2%	3.3%	30.0%
5 – 6	24.7%	–	3.3%
6 – 7	9.2%	3.3%	23.3%
7 – 8	11.0%	–	–

[a] Measurements refer to those taken on the exterior of the sherds

Performance Attributes. The physical characteristics of the sherds allow us to make inferences about the performance attributes of the whole vessels. The thick walls would have slowed the transmission of heat and the open orifices would have facilitated heat loss through escaping steam. Therefore, the heating efficiency of the Intermountain Brownware vessels would have been poor. Furthermore, the thick walls would have made the vessels susceptible to developing cracks due to thermal stress, which can result when a cooking pot is subjected to repeated heating cycles. Despite these drawbacks, the vessel attributes also offered several performance advantages. The large openings would have minimized boiling-over during cooking and facilitated easy access to the vessel contents, and the conical bases would have made it easy to prop up the vessels in cooking fires. Finally, the thick walls and relatively hard pastes would have resulted in strong vessels having relatively high impact resistance.

Function. Only one recorded attribute, sooting, directly attests to how the vessels were used. Sooting was present on 10.4% of the sherds, indicating that at least some of the vessels were used over an open fire. Experiments by Hally (1983) have shown that two types of soot deposits result from this type of use. Near the base of the pot, where the vessel is in direct contact with the fire, deposits of solid carbon accumulate. These deposits can easily be removed by rubbing. In contrast, higher up on the vessel where the pot is exposed to less heat, soot deposits permanently adhere and cannot be rubbed away once the pot has cooled. The presence of soot deposits on some, though not all, of the sherds suggests that the Intermountain Brownware vessels represented in this study were used over open fires, with soot permanently adhering to only some areas of the pots. Since all of the sherds were recovered from the surface, any impermanent carbon deposits that may have accumulated were probably removed by rain and other weathering processes.

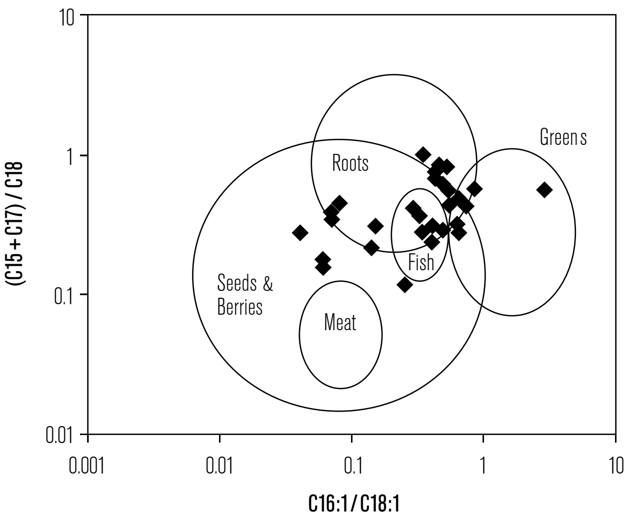

Figure 3. GC-MS results of ratios (C15 +C17)/C18 and C16:1/C18.1.

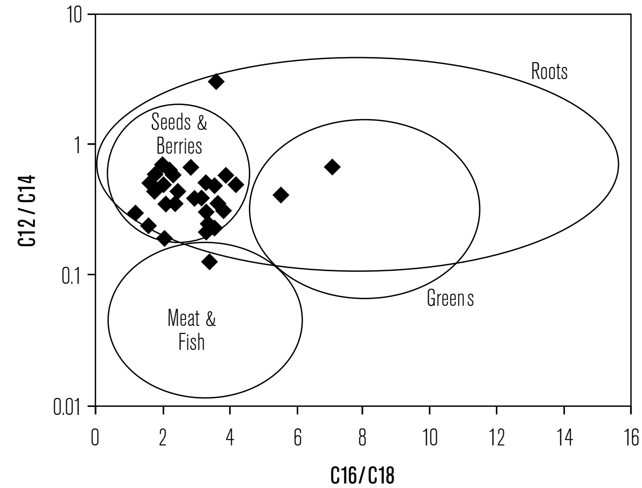

Figure 4. GC-MS results of ratios C12:0/C14:0 and C16:0/C18:0.

Residue Analysis

High concentrations of fatty acids were found in every analyzed residue sample, suggesting that foods had either been cooked or stored in all of the ceramics. The most common fatty acids observed were the medium-chained ones (those ranging from C12–C18:1), though lower concentrations of both short-chained and long-chained fatty acids were also present (see Betenson 2005 for the data). No cholesterol was present in any of the samples.

The interpretation of the residues follows the procedure outlined by Eerkens (2005). That procedure relies on a comparison of ratios of various fatty acids to distinguish meat, fish, roots, greens, seeds and nuts, and berries. The gas chromotograms indicate that our samples contained elevated levels of C16:0, C18:0, and C18:1. High C16 and C18 levels with low levels of C12 and C14, in conjunction with the absence of cholesterol, is evidence that this collection of ceramics had not been used to process, cook, or store meat (Eerkens 2001:102). Biplots of the fatty acid ratios obtained in our study graphically illustrate the similarity of our ratios with those obtained from the experimental analysis of seeds and berries (Figs. 3 and 4).

DISCUSSION

The results of the attribute and residue analyses support the interpretation that the vessels represented in our sample functioned as cooking containers. The large, open orifices would have made them unsuitable for storage (Smith 1983), and the conical bases would have made them difficult to use as serving containers. These physical characteristics, combined with the identification of residues in all of the sherds subjected to GC-MS analysis, suggest that the vessels were used for cooking.

Clues as to the cooking techniques used are provided by the vessel forms and sooting patterns. The conical bases imply that the vessels were embedded in the heat source, and the low proportion (10.4%) of sooted sherds points to the use of hot flames rather than coals. Consistent with the findings reported by Hally (1983) and discussed above, experiments conducted by Skibo (1992:157–162) indicate that soot will not accumulate when a vessel's walls are exposed to temperatures greater than 400°C. Such temperatures are not achieved with coals, but can be achieved with open fires. Therefore, we interpret the sooting patterns found in our sample as indicating use over an open fire, so that soot accumulation was limited to the upper areas of the vessels where the heat was less intense. This type of cooking would be suitable for a short-term boiling of foods but not for long-term simmering, since it would be difficult to control the temperature of the contents and loss of water through evaporation would be high.

However, the attributes of the vessels were not ideal even for short-term boiling. As discussed above, the thick walls would have inhibited the transmission of heat, and—most importantly—have increased the pot's susceptibility to thermal shock. That susceptibility would have been worsened by the presence of the large sand inclusions left in the pastes. Finally, the loss of heat through the large orifices would have further increased the heating inefficiency of the vessels, and required more attention from the cook (since the contents could boil dry), than if the vessel had a restricted opening.

If the attributes of the ceramics cannot be explained by the functional needs associated with the finished vessel, what does explain them? We argue that the thick walls and the conical, open shape of the vessels were a by-product of the mobile lifestyle practiced by the makers of the Intermountain Brownware ceramics. This lifestyle would have presented at least two obstacles to pottery production. First, time constraints would have made it difficult to complete all of the steps that may be required to make a high-quality vessel. The manufacture of a well-made pot can take up to several weeks (Arnold 1985), and as Eerkens (2008:309) has noted, the hunting and gathering lifestyle of the Great Basin populations may have required them to move before all of the desired stages could be completed. Additionally, time conflicts caused by the need to gather food may have limited the amount of time that women could spend on making pottery (Eerkens 2008:310).

A second challenge facing the Great Basin potters may have been a lack of knowledge and skill. Although Intermountain Brownware ceramics were part of the material culture of the study region, they clearly represented a fairly minor part. Unlike the more sedentary farming groups found in adjacent areas, the makers of the Intermountain Brownware pottery appear to have used ceramics only for cooking, and only in limited amounts. This limited use would have meant that each potter made only a few vessels per year. The manufacturing of a high quality vessel is not easy, and the thin-walled, restricted-orifice, rounded vessel is one of the hardest shapes to master. Additionally, it requires the use of highly plastic clays, which may not always be immediately available. For sedentary peoples who make and use pots on a regular basis, information about appropriate clay sources is passed down through the generations, and the necessary skills are acquired through the substantial time that is spent potting. For the hunters and gatherers of the Great Basin, however, limited pottery production may have precluded the development of the specialized skills and knowledge needed to make these types of vessels.

The thick-walled, conical-shaped vessels represented by Intermountain Brownware may be interpreted as a compromise between the need for ceramic cooking vessels and the need to find a vessel shape that could be quickly and easily manufactured. Compared to more typical thin-walled, rounded cooking vessels, the thick-walled, open ones require little skill to manufacture, can be quickly formed, and can be produced using less-than-ideal pastes. Therefore, we argue that the thick walls found in these ceramics occur not because they were particularly desired, but because they were the predictable result of using clays that had not been thoroughly prepared (i.e., through the removal of large sand particles and/or through the grinding and aging of the clays). A comparison of the average thickness of the sherds with the degree of sorting observed (Table 3) provides some support for this interpretation. These data show that the thickness of the sherds tends to be inversely correlated with the degree of sorting, suggesting that thicker walls are manufactured when less time is spent preparing the clays.

Despite the expedient nature of the paste preparation and the shaping of the vessels, the hardness test results indicate that they were fired at temperatures similar to those used for other low-fired terra-cotta pottery. This is not particularly surprising, since time constraints are less relevant during the firing stage of pottery production. Even very brief fires can result in well fired pots, as indicated by the short (less than 20 minutes) firings used by some Puebloan potters (Shepard 1956:87, Table 3). Thus, firing would have imposed few costs on the Intermountain Brownware producers, but it would

Table 3

AVERAGE SHERD THICKNESS[a] BY DEGREE OF SORTING

Degree of Sorting	Number (mm.)	Mean (mm.)	Standard Deviation (mm.)
Very Poor	68	7.4	1.1
Poor	61	7.1	0.7
Fair	20	7.2	1.1
Good	3	6.4	0.4

[a] Rim and base sherds are excluded from this table

have imparted substantial advantages in the increased heating efficiency and durability of the finished product.

CONCLUSIONS

Our results suggest that the Intermountain Brownware vessels included in this study were used to cook foods; specifically, they were used for short-term boiling over an intense heat. These findings are consistent with observations described in the ethnographic literature. They differ from the ethnographic data, however, in that no evidence was found to indicate that meat was ever cooked in the vessels. Instead, the GC-MS data suggest that they were used to cook seeds, reinforcing the results reported by Eerkens (2001, 2005) in the Great Basin and by Tuohy (1990) in central and western Nevada.

It is unclear why our results differ from the cooking patterns described ethnographically. One possibility is that meat *had* been cooked in the vessels, but that the resulting cholesterol residues either were not preserved or were not detected by the GC-MS analysis. A second possibility is that the encroachment of settlers into Southern Paiute territory during the historic period altered indigenous subsistence practices. The archaeological record suggests that in the western Great Basin the use of pottery was largely confined to lowland settings, where vessels were presumably cached and re-used on a seasonal basis (Eerkens 2008). A similar strategy may have been used in the study region discussed here, since 80% of our analyzed samples were recovered from lowland settings. The hunters and gatherers of the Great Basin are believed to have used these areas in the spring and summer to harvest grass seeds and other lowland resources. Because the subsistence practices during this season would have been focused on seed collecting rather than hunting, the lack of meat residues in the pottery may simply reflect this seasonal focus. During the historic period, the Paiutes lost access to many of these lowland areas, which may have resulted in a shift in their seasonal subsistence activities and cooking practices.

Nevertheless, the attributes of the Intermountain Brownware vessels would have made them adequate for cooking seeds. The evidence suggests that the pots were placed in a hot fire during cooking, which would have caused the contents to come to a rapid boil. As others have argued (Eerkens 2005:96; Reid 1990), this type of rapid boiling works well for processing carbohydrate-rich foods such as seeds. Although the open orifices would have contributed to a loss of heat and water during cooking, they would have also allowed the cooks to easily monitor and stir the contents, an important consideration to keeping the liquid from boiling dry.

Although Intermountain Brownware vessels were not the most efficient pots, their shortcomings were likely less problematic to the people who used them than they would have been to the agricultural people of adjacent areas. The pots would have had poor resistance to thermal shock, but given the limited amount of time that they were placed over a fire, this may not have been an important consideration. In comparison to the historic Puebloan peoples, whose preparation of corn and beans required that vessels be used for several hours every day (Kobayashi 1996:307), the time spent boiling seeds was quite short. Under these circumstances, the increased durability imparted by the thicker pot walls may even have offset the drawbacks of the decreased thermal stress resistance.

This paper adds to a growing body of recent literature on the use of ceramics by mobile or semi-sedentary hunters and gatherers (Bright and Ugan 1999; Dean and Heath 1990; Eerkens 2002a, 2002b, 2003, 2005, 2008; Frink and Harry 2008; Harry and Frink 2009; Harry, Frink, Charest, et al. 2009; Harry, Frink, Swink, et al. 2009; Reid 1989, 1990; Simms and Bright 1997). Our results suggest that—as is the case with the pottery of other hunter-gatherers—the key to understanding the technology of Intermountain Brownware may lie less in its intended use than in the production challenges faced by the people who produced it.

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REPORTS

Wima Chert: ~12,000 Years of Lithic Resource Use on California's Northern Channel Islands

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On the Northern Channel Islands, artifacts made from Wima chert, a previously undocumented siliceous rock extensively used by Native Americans to make stone tools, have been found in archaeological sites dating from ~12,000 years ago to historic times. Ranging from true cherts to siliceous shales, Wima clasts appear to be derived from concretions eroding from bedrock outcrops in the Monterey Formation, as well as from cobbles found in modern and ancient beach and alluvial deposits. Unlike the mostly translucent Tuqan, Cico, and Santa Cruz Island cherts, Wima cherts are opaque, with colors ranging from brown, reddish-brown, and yellowish-brown to white, gray, greenish-gray, and black. Some of these colors overlap with those of Franciscan cherts from the mainland, but Wima cherts do not appear to attain the purity, luster, or redder and greener hues found in high-quality Franciscan cherts. A few Paleocoastal projectile points and crescents were made from Wima chert, but the lower quality of most clasts appears to have restricted their use primarily to the production of expedient core and flake tools. Nonetheless, archaeologists should be careful in identifying the source of chipped stone artifacts from Northern Channel Island sites made from opaque cherts with these colors and characteristics..

On California's Northern Channel Islands (NCI), the trade, control, and production of chipped stone raw materials have long been of interest to archaeologists. Since the late nineteenth century, the islands were thought to be largely devoid of local chert sources, except for Santa Cruz Island (SCRI) outcrops heavily used in the Late Holocene by the Island Chumash for the intensive production of microblades used to make Olivella shell beads (e.g., Arnold 1987, 2001; Glassow 1980; Hudson and Blackburn 1987:29; Kennett 2005; King 1976; Perry and Jazwa 2010; Pletka 2001; Rick et al. 2008; Schumacher 1877). For decades, archaeologists assumed that SCRI chert was the only source of high-quality toolstone on the NCI, with artifacts made from other high-grade cherts or chalcedonies (i.e., Monterey or Franciscan cherts) imported from mainland sources. In the past 15 years, however, research on San Miguel Island has shown that high-quality Cico and Tuqan (Monterey) cherts were locally available and had been widely used by island residents for at least 12,000 years (Erlandson et al. 1997, 2008, 2011). A lower quality chalcedonic chert source has also been identified in both geological and archaeological contexts on Anacapa Island (Rick 2006). These discoveries suggest that archaeologists working on the NCI and adjacent mainland should be careful in analyzing and interpreting raw material types found in archaeological sites.

In this paper, we report another distinctive type of chert widely used by Channel Islanders for millennia. Called Wima chert after one variant of the Chumash name for Santa Rosa Island (a.k.a., Wi'ma, Wimal, Uima; see Applegate 1975; Glassow et al. 2010:3.9; King 1975:174), artifacts made from it have recently been identified in NCI archaeological sites ranging in age from ~12,000 years ago (cal B.P.) to the early historic period. Here, we provide some geographic and archaeological background to contextualize our study before summarizing what we currently know about the geological origins and distribution of Wima

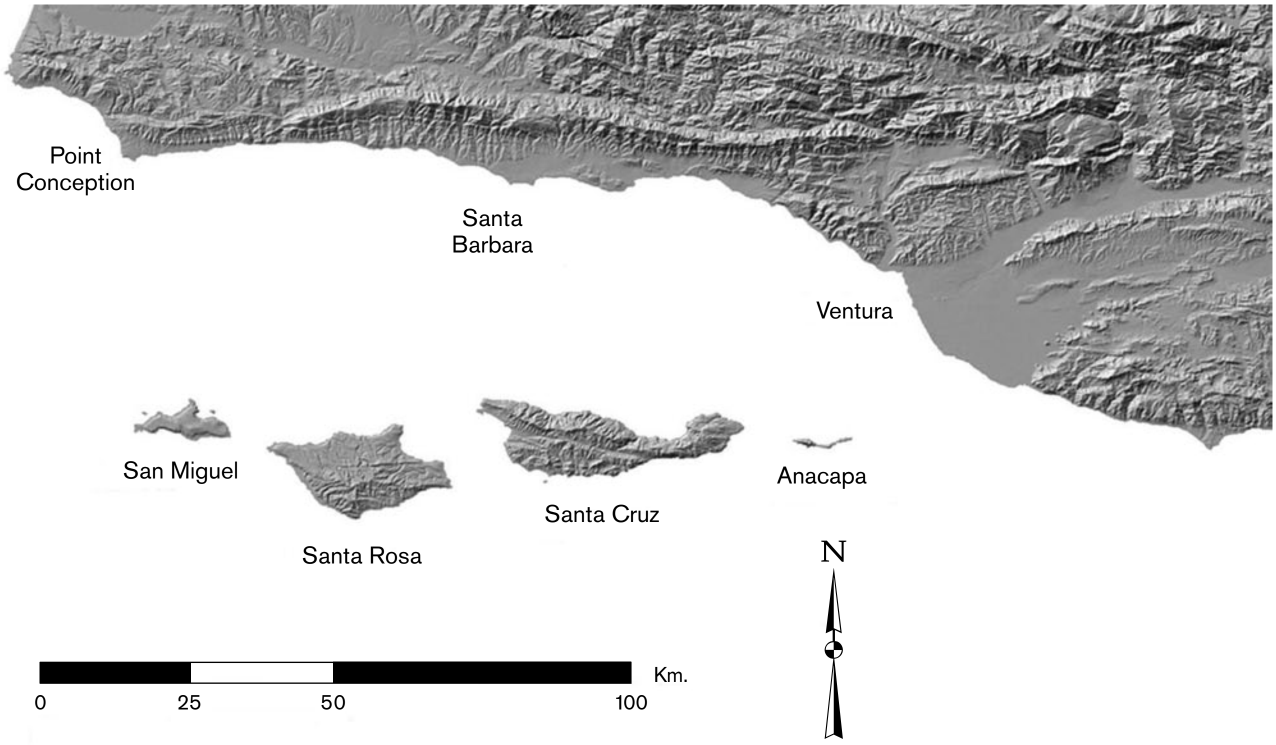

Figure 1. Map of the Santa Barbara Channel region.

chert. We describe the physical characteristics of Wima chert, as well as the temporal and spatial distribution of Wima chert artifacts found in archaeological sites on the NCI. In concluding, we discuss the implications for understanding the deep history of lithic resource use by Channel Islanders and the archaeological study of exchange between the Island Chumash and their mainland neighbors.

DEFINING WIMA CHERT

Background

Located 44 km. off the Santa Barbara Coast (Fig. 1), Santa Rosa Island is the second largest of the four Northern Channel Islands at 24 km. long, 16 km. wide, and ~217 $km.^2$ in land area. Despite its substantial size, Santa Rosa Island is just a remnant of the much larger Santarosae Island that united all four NCI from the Last Glacial Maximum (LGM) until about 9,000 to 10,000 years ago (Orr 1968; Porcasi et al. 1999). Since the LGM, Kennett et al. (2008:2530) have estimated that roughly 75 percent of Santarosae's land area—primarily lowland habitats—has been lost to postglacial sea level rise (Fig. 2). This marine transgression appears to have submerged sources of chert and other minerals that once were available on land. Evidence for this comes from the occurrence of Tuqan chert on San Miguel and Santa Rosa islands, where no bedrock outcrops have been found but where cobbles occur in raised Pleistocene beach deposits and in alluvium containing reworked marine cobbles (Erlandson et al. 2008). Since a great deal of San Miguel and Santa Rosa is now covered by dunes and alluvium, it is also possible that bedrock exposures of tool-quality cherts may exist above sea level.

Today, the Santa Rosa Island landscape consists of a mountainous core with maximum elevations reaching 484 m., surrounded by a series of raised marine terraces separated by steep escarpments that mark ancient shorelines and sea cliffs (Schoenherr et al. 1999:275). The island is composed primarily of Late Cretaceous, Tertiary, and Quaternary rocks of marine and volcanic origin (see Norris 2003:64; Weaver 1969). From east to west, the island is bisected by the Santa Rosa Island fault (Dibblee and Ehrenspeck 2002:118), with broad marine terraces to the north but higher and more rugged topography

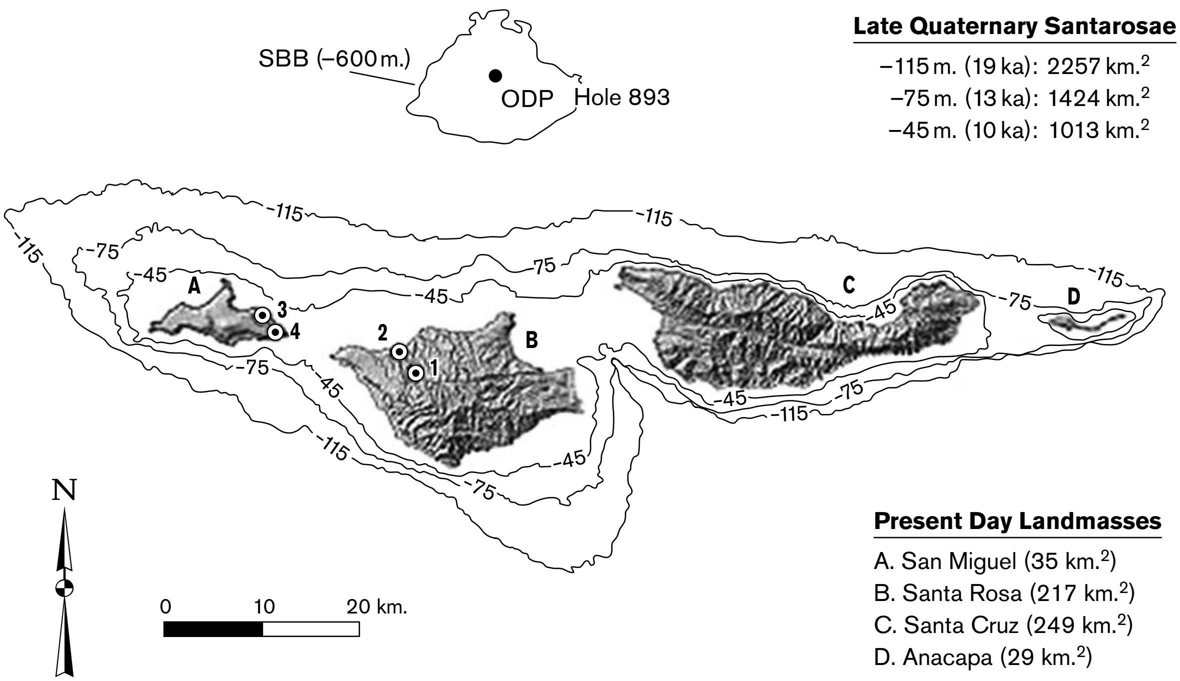

Figure 2. Map of the Northern Channel Islands today and the approximate extent of paleoshorelines from the Last Glacial Maximum to ~ 10,000 cal B.P. (adapted from Kennett et al. 2008).

to the south of the fault. As noted above, parts of the island contain extensive alluvium and sand dunes, both ancient and modern, which obscure the bedrock geology, except where it is exposed in sea cliffs, canyon walls, and other escarpments. Considerable geological work has been done on Santa Rosa Island (e.g., Dibblee and Ehrenspeck 1998, 2002; Dibblee et al. 1998; Orr 1967; Weaver 1969; Weigand 1998), but such studies rarely provide the level of detail required by archaeologists to identify specific rock outcrops used by prehistoric peoples. The large size, ruggedness, and remoteness of the island make a comprehensive geoarchaeological survey for toolstone sources on the island a long-term project that will take years to complete.

For most of the twentieth century, Santa Rosa Island was privately owned, and access for archaeological research was limited. The most extensive program of archaeological work on the island was conducted by Phil Orr of the Santa Barbara Museum of Natural History, who worked extensively on the islands from the 1940s to the 1960s. After 10 years of survey and excavation focused primarily on Santa Rosa Island's northwest coast, Orr (1956:78) stated that "no good native material for making chipped stone implements occurs on the island." Twelve years later, in describing the evidence for a Pleistocene occupation of Santa Rosa, Orr (1968:57) was more ambiguous, stating that the island contains "no natural gravel beds, flint, or obsidian deposits suitable for the making of chipped stone tools," but that a "native rock which has been used for tools is a semi-consolidated yellow to gray chert that forms the most abundant artifacts of the Pleistocene and also occurs in the Recent Indian middens." In a subsequent passage, Orr (1968:58) noted that "[o]ccasionally a piece of water-worn chert occurs which chips readily into a chopper or scraper, though the material is quite soft.... It is this material which forms the greatest number of recognizable artifacts; others are the several igneous or metamorphic chips, the amorphous minerals occurring only as chips, and two pieces of limestone. None of these rocks occur naturally on the Island and they could only have arrived there by being carried by man."

From these quotes it appears that Orr initially believed that no quality cherts or other toolstone existed on Santa Rosa Island, but that he may have later recognized that a soft and semi-consolidated yellow or gray siliceous shale/

chert was found locally on Santa Rosa Island. However, his descriptions are limited, vague, and ambiguous, and include a later comment that none of the described rock types occur naturally on the island. Although he clearly understood that the geography of Santa Rosa Island had changed dramatically since the late Pleistocene, he did not mention the possibility that quality toolstone outcrops might once have been available on the now submerged lowlands of Santarosae. As his excavations were focused primarily on the northwest coast of Santa Rosa, where Wima chert artifacts seem to be found in lesser quantities, Orr may not have grasped the local abundance and full range of quality and colors represented in Wima chert and higher-grade siliceous shales.

Origins and Distribution of Wima Chert

Since Santa Rosa Island was incorporated into Channel Islands National Park in 1986, a wider range of archaeological surveys and excavations has been conducted (see Glassow et al. 2010; Erlandson et al. 2011; Johnson et al. 2002; Kennett 2005; Rick 2009). For the past 10 years, we have been investigating a series of sites spanning the past 12,000 years to document the nature of settlement and subsistence patterns, and the technological and ecological changes that have occurred on the island through time (e.g., Erlandson et al. 2011; Rick 2009; Rick et al. 2005). Many of these sites have produced chipped stone artifacts made from local metavolcanic and quartzite cobbles, Cico or Tuqan cherts from island sources, bladelets that appear to be made from Santa Cruz Island cherts, and smaller quantities of materials such as obsidian, Franciscan chert, and fused shale generally believed to have been imported from mainland sources. In documenting these raw material types, we have also noted the presence of numerous cores, large flake tools, tool-making debris, and occasional formal tools made from opaque cherts that clearly differ from documented Channel Island chert sources. The characteristics of Wima chert are described in greater detail below, but its opacity, lower silica content, and range of colors are easily distinguished from the distinctively purer and darker Tuqan (Monterey) cherts and the typically translucent Cico and Santa Cruz Island cherts or chalcedonies.

Wima chert artifacts have been found in archaeological sites widely distributed on Santa Rosa Island, from the west to the east ends and on the north and south coasts. Wima cherts appear to be associated with or derived from the Miocene Monterey Formation, which has been mapped by geologists as occurring in extensive and widely scattered exposures on Santa Rosa, including substantial outcrops near the west end of the island but in even larger areas in the southeast quadrant of the island (Dibblee and Ehrenspeck 1998, 2002:118; Dibblee et al. 1998; Norris 2003:64). So far, we have only been able to directly examine a small percentage of the geological exposures of the Monterey Formation on Santa Rosa Island.

During 2004-2006 surveys of Old Ranch Canyon on southeast Santa Rosa, Rick (2009:25) noted the presence of small and heavily weathered bedrock exposures of granular, low quality, opaque cherts in tan and yellowish colors. Artifacts of similar materials were found in nearby sites dated to the Middle Holocene (Wolff et al. 2007). In 2008, Erlandson and Rick found Wima chert artifacts in a wider array of colors (red, brown, buff, etc.) in two Paleocoastal sites located on the bluffs overlooking the southwest coast of Santa Rosa Island, one of them located in the vicinity of Miocene Monterey shale outcrops that contained *in situ* beds of siliceous shale similar to the lower quality Wima artifacts. In 2010, we noted numerous artifacts made from higher quality Wima cherts in archaeological sites in the vicinity of Skunk Point on southeastern Santa Rosa Island, suggesting that geological sources of Wima chert may be present in the area. We found numerous cores and large flake tools made from Wima chert, for instance, in dated Early and Middle Holocene sites (SRI-666, SRI-667) located in this area. This led to a broader search of local beaches and raised marine terraces in the Bechers Bay and Skunk Point areas, many of which were covered by dune deposits, alluvium, or thick vegetation that limited visibility. Nonetheless, our geoarchaeological reconnaissance identified an extensive cobble sheet behind the beach near the south end of Bechers Bay (Southeast Anchorage) that contained cobbles of Wima chert. Eroding exposures of Monterey shale bedrock nearby also had *in situ* concretions of siliceous or cherty shales (Rick 2009:25). Raised Last Interglacial beach deposits in the area also contained cobbles of siliceous shale and Wima chert that fractured conchoidally. Whole Wima chert cobbles observed in these modern or ancient beach deposits were up to 15 cm. in diameter.

Since we first became aware of this distinctive type of tool-quality chert and cherty shale, we have also found artifacts made from Wima cherts and siliceous shales in archaeological sites dated to the Terminal Pleistocene, Late Holocene, and early Historic periods, including sites distributed from the western to the eastern ends of the island, as well as the north and south coasts (Table 1). A few Wima chert artifacts have also been identified in Paleocoastal sites at Cardwell Bluffs on eastern San Miguel Island, which was still connected to Santa Rosa (or Santarosae) during the Terminal Pleistocene. Radiocarbon dating of these sites documents a history of human use of Wima chert on Santa Rosa and San Miguel islands for at least 12,000 years and suggests that its use on Santa Rosa Island was extensive. If bedrock exposures or submerged beach deposits containing Wima clasts are located off the east coast of Santa Rosa, we might also expect to find Wima chert artifacts in archaeological sites on western Santa Cruz Island.

Not surprisingly, archaeological examples of Wima chert tend to be of higher quality than the cobbles or bedrock exposures we have found in geological sources, especially those artifacts made or struck from stream or beach-rolled cobbles. This may be related to a combination of geological and cultural factors. First, it may result from the greater resistance to erosion of higher quality siliceous rocks on high-energy cobble beaches, where softer siliceous shales are less likely to be preserved. Subjecting chert clasts to the high-energy wave action of island beaches also tends to destroy those cobbles containing numerous internal fractures, resulting in beach cobbles that are relatively pure and malleable, with well-developed conchoidal fracture. The higher quality of archaeological samples may also be the result of the selection of the harder and purer chert cobbles by Native Americans for transport back to their villages, campsites, and workshops. Finally, the higher quality of archaeological samples may be due to the systematic application of thermal pretreatment to some Wima chert artifacts. Controlled heat treatment experiments at the University of Oregon suggest that the quality of Wima chert is enhanced by exposure to temperatures of 350 to 400 degrees C.

Physical Characteristics of Wima Chert

Because the significance of Wima chert was only recognized recently, there is still much to be learned about its distribution in Channel Island archaeological sites, as well as in modern and ancient beach and alluvial deposits. What can be said at this point is that Wima cherts are opaque rather than translucent, and that they range from cherts to high-grade siliceous shales

Table 1

THE AGE AND CONTEXT OF WIMA CHERT ARTIFACTS IDENTIFIED IN NORTHERN CHANNEL ISLAND SITES

Sites Number	Age (cal B.P.)	Artifacts and Context
CA-SRI-85	Historic/Late Holocene	Wima flakes observed in 2010 on surface around house pits.
CA-SRI-2	1,000–Historic	Wima flakes found in excavation units.
CA-SRI-209	5,300–4,200	Wima flakes from surface and excavation units.
CA-SRI-192	5,930–2,300	Flakes and flake tools found on surface and in bulk sample.
CA-SRI-191	6,100–4,200	Flakes, cores, and flake tools eroded on surface.
CA-SRI-667	~6,600–4,400	Numerous cores and flakes found in multicomponent site.
CA-SRI-61	7,000–2,800	Numerous cores, flakes, and flake tools on eroded surfaces.
CA-SRI-77	7,600–7,300	Flakes and cores in buried Early Holocene shell midden.
CA-SRI-687	7,700–7,500	Flakes and flake tools on surface of deflated site and midden.
CA-SRI-666	8,250–7,800	Numerous cores and flakes on surface; debitage in bulk samples.
CA-SRI-26	~11,600	Flakes and a crescent found in situ in buried Paleocoastal midden.
CA-SRI-512	~11,700	Flakes found in situ in buried Paleocoastal midden.
CA-SMI-678	~12,100–11,400	Channel Island Barbed point made from Wima chert.
CA-SMI-701	~11,700	Cores and flakes of Wima chert present on deflated surface of multi-component site, associated with Amol points and crescents.

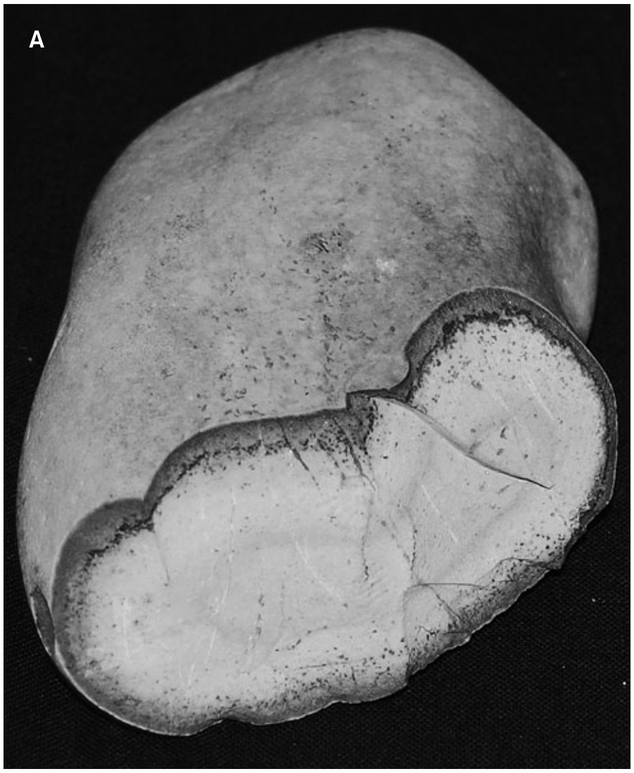

Figure 3. Photographs of (A) Wima chert cobble (WG-01) and (B) microscopic (x20) view of distinctive micro-inclusions in a Wima chert matrix (photos by N. Jew).

with Mohs hardness values ranging from 7 to 6. They come in a variety of colors, with brown, reddish-brown, and yellowish-brown varieties dominant, but white, gray, grayish-green, olive, and black specimens have been observed in geological or archaeological samples (Table 2). Archaeological specimens suggest that the full range of Wima cherts may have come from a mixture of cobble deposits and bedrock outcrops, as many (but not all) cores and large flakes or chunks contain cobble cortex. As is the case with island Cico and Tuqan cherts, many of the cobble cores made from Wima chert have a weathering rind with a different color than the interior (Fig. 3A).

A careful examination of numerous geological and archaeological specimens also shows that Wima cherts often have distinctive micro-inclusions or pits (Fig. 3B). These are barely visible to the naked eye, but they can be readily observed under low-power magnification with a hand-lens or microscope. In many cases, the inclusions are spherical and darker than the matrix. In others the contents of the inclusions seem to have decayed, leaving tiny craters, pits, or voids in the rock matrix. More research is needed to identify whether these dark inclusions are organic or crystalline (or both) in nature, but they did not react to HCl or heat that would destroy carbonates and many organics. Although the micro-pits and inclusions do not appear to significantly interfere with the suitability of Wima chert for fashioning artifacts, they may contribute to a slightly greater granularity of the matrix that may have limited its use for manufacturing projectile points and other formal chipped stone artifacts. We have found a few Paleocoastal projectile points or crescents made from Wima chert (see Erlandson et al. 2011, Fig. 3, in center of far right column), but the lesser quality of most clasts appears to restrict their use primarily to the production of expedient core and flake tools.

Controlled lab experiments on geological samples and study of a Paleocoastal artifact assemblage from CA-SRI-512 suggest that geological samples of Wima chert respond to thermal treatment, and that Paleocoastal peoples intentionally heat-treated Wima chert on Santarosae. Geological samples covered in sand and gradually heated to temperature peaks of 350-400 degrees C exhibited redder hues, increased luster, and improved brittleness and malleability than unheated control samples. If Wima cherts were regularly heat-treated by the Island Chumash, archaeological specimens may have higher frequencies of reddish hues and lustrous surfaces than those found in geological contexts. Even after heat-treatment, however, Wima cherts tend to be less glossy or lustrous than Tuqan, Cico, or Santa Cruz Island cherts, which all appear to have a higher silica content.

Table 2

COLOR AND OTHER CHARACTERISTICS IN GEOLOGICAL AND ARCHAEOLOGICAL SAMPLES OF WIMA CHERT

Catalog #	Locality (CA-)	Sample Type	Munsell Color (Primary)	Munsell Color (Secondary)	Other Features
WG-01	Bechers/Skunk Pt.	Geological	10YR 8/3.5: very pale brown	2.5Y 8/4: pale yellow	black inclusions
WG-02	Bechers-Skunk Pt.	Geological	10YR 5/1.5: gray/grayish brown	2.5Y 3/N: very dark gray	pitted depressions
WG-03	Bechers-Skunk Pt.	Geological	2.5YR 2.5/N: black	–	–
WG-04	Bechers-Skunk Pt.	Geological	10R 3/1: dark reddish gray	7.5YR 5/N:- gray	–
WG-05	Bechers-Skunk Pt.	Geological	2.5Y 3/N: very dark gray	2.5Y 2/N: black	pitted depressions
WG-06	Bechers-Skunk Pt.	Geological	10YR 3/4: dark yellowish brown	10YR 7/4: very pale brown	black inclusions
WG-07	Bechers-Skunk Pt.	Geological	10YR 5/3: brown	2.5Y 7/2: light gray	black inclusions
WG-09	SRI-706	Surface: flake	5YR 6/3.5: light reddish brown	10R 4/2.5: weak red	black inclusions
WG-10	SRI-161	Surface: flake	2.5Y 3/N: very dark gray	–	–
WG-11	SRI-161	Surface: flake	10YR 6/2: light brownish gray	–	black inclusions, pits
WG-12	SRI-161	Surface: flake	5YR 4/4: reddish brown	–	black inclusions
WG-13	SRI-161	Surface: flake	10YR 5/2: grayish brown	10YR 4/1: dark gray	black inclusions, pits
WG-14	SRI-161	Surface: flake	2.5Y 7/4: pale yellow	5Y 6/1.5: gray/light olive gray	black inclusions, pits
WG-16	SRI-161	Surface: flake	2.5YR 5/5: reddish brown/red	10R 5/6: red	black inclusions, pits
WG-18	SRI-161	Surface: flake	2.5Y 6/N: gray	–	black inclusions
666-01	SRI-666E	Surface: debitage	2.5YR 3/N: very dark gray	–	black inclusions, pits
666-02	SRI-666E	Surface: flake tool	5YR 6/3: light reddish brown	5YR 8/1: white	black inclusions, pits
666-04	SRI-666E	Surface: biface	10YR 8/4: very pale brown	2.5Y 5/N: gray	black inclusions, pits
666-06	SRI-666E	Surface: uniface	10YR 8/1: white	10YR 6/6: brownish yellow	black inclusions
666-09	SRI-666E	Surface: debitage	5YR 5/2 : reddish gray	2.5YR 7/2: light gray	black inclusions, pits
666-11	SRI-666E	Surface: uniface	7.5YR 7/2: pinkish gray	10YR 7/2: light gray	black inclusions
666-21	SRI-666M	Surface: flake tool	5YR 5/1: gray	7.5YR 5/4: brown	micro-inclusions
666-23	SRI-666M	Surface: flake tool	10YR 7/2: light gray	10YR 6/4: light yellow brown	micro-inclusions
666-24	SRI-666M	Surface: uniface	5YR 4/1: dark gray	2.5Y 7/4: pale yellow	micro-inclusions, pits
666-26	SRI-666M	Surface: uniface	10YR 6/2: light brownish gray	10YR 7/2: light gray	pitted depressions
666-29	SRI-666	Surface: drill	5Y 5/2.5: olive gray/olive	–	micro-inclusions
666-30	SRI-666	Surface: drill	5Y 5/3: olive	–	micro-inclusions
666-31	SRI-666	Surface: flake tool	7.5YR 4/2: brown/dark brown	–	micro-inclusions
666-33	SRI-666	Surface: uniface	10YR 5/3: brown	10YR 7/3: very pale brown	micro-inclusions, pits
666-34	SRI-666	Surface: flake tool	10YR 6/3: pale brown	7.5YR 5/4: brown	micro-inclusions, pits
666-35	SRI-512	Surface: biface	5Y 6/3.5: pale olive	–	micro-inclusions, pits
512-09	SRI-512	Surface: CIB point	10YR 5/1: dark gray	–	micro-inclusions, pits
512-295c1	SRI-512	Surface: debris	5YR 6/3: light reddish brown	–	pitted depressions
512-295c3	SRI-512	Surface: debris	5YR 6/2: pinkish gray	5YR 5/3: reddish brown	black inclusions
512-295c4	SRI-512	Surface: debris	2.5Y 8/3: white/pale yellow	5YR 3/1: very dark gray	pitted depressions
512-306a	SRI-512	Surface: debris	10R 2.5/2: very dusky red	–	pitted depressions
512-316b	SRI-512	U1/0–10 cm.: debris	7.5YR 4/N: dark gray	10R 4/2: weak red	micro-inclusions, pits
512-323a1	SRI-512	U3/0–10 cm.: flake	5YR 5/4: reddish brown	5YR 5/2: reddish gray	micro-inclusions, pits
512-331d1	SRI-512	U3 level 2: flake	5YR 4/2: dark reddish gray	–	micro-inclusions
512-331d2	SRI-512	U3 level 2: flake	10YR 6/4: light yellowish brown	10YR 5/4: yellowish brown	micro-inclusions
512-331d3	SRI-512	U3 level 2: flake	10YR 7/3: very pale brown	–	micro-inclusions
512-343c3	SRI-512	U3 level 3: flake	2.5Y 4/2: dark grayish brown	–	micro-inclusions, pits
512-458a1	SRI-512	U2/10–20 cm.: flake	7.5YR 3/2: dark brown	–	pitted depressions
512-497a1	SRI-512	U5/level 3: debris	10YR 6/2: light brownish gray	7.5YR 4/2: brown/dark brown	–
512-497a2	SRI-512	U5/level 3: flake	10R 5/2: weak red	2.5YR 4/2: weak red	micro-inclusions
512-497a3	SRI-512	U5/level 3: flake	7.5YR 8/2: pinkish white	–	pitted depressions
512-508	SRI-512	Surface: flake tool	5YR 5/2: reddish gray	10R 4/3: weak red	pitted depressions
512-511a2	SRI-512	U5/level 2: debris	5YR 3/1: very dark gray	5YR 4/2: dark reddish gray	micro-inclusions, pits
512-511a3	SRI-512	U5/level 3: flake	2.5YR 4/2: weak red	–	micro-inclusions, pits

DISCUSSION AND CONCLUSIONS

Although a great deal is known about Channel Island resources and exchange prior to historic times (see Arnold 2004; King 1976; Rick et al. 2001), fundamental research is still needed on the distribution and nature of major mineral commodities used by the Chumash and their ancestors in the Santa Barbara Channel (Erlandson and Braje 2008) and southern California areas. In the last 15 years, four previously undocumented sources of chert have been identified on the NCI (Erlandson et al. 1997, 2008; Rick 2006), including Wima chert. In our view, the systematic inventory of mineral sources on the islands has been inhibited by an uncritical acceptance of fragmentary ethnohistoric records collected in the late nineteenth and early twentieth centuries as fully representative of the deeper past, despite the fact that most of these accounts were collected more than a century after Island Chumash villages and trade routes were abandoned. Another problem is the tendency for scholars, including ourselves, to uncritically accept and repeat earlier statements based on partial archaeological knowledge, even though we have been trained as scientists to test hypotheses and question our existing assumptions.

Our documentation of Wima chert, along with its long-term and relatively widespread human use on western Santarosae Island, broadens the availability of technologically important mineral resources on the NCI, further undermining the notion that they were marginal human habitats compared to the adjacent mainland. At this point, artifacts made from Wima chert cobbles have been identified primarily in Santa Rosa Island sites dating from the Terminal Pleistocene to historic times, demonstrating that such chert was widely used by island residents for at least 12,000 years. As we have become aware of the full range of variability in Wima cherts, however, we have found additional examples in Paleocoastal sites on eastern San Miguel Island, and it seems likely that Wima chert artifacts will also be identified in some Santa Cruz Island sites. Further research is clearly needed to fully understand both the geological and archaeological distributions of Wima chert.

The quality of Wima chert, as does that of other island and mainland cherts, varies significantly, ranging from that of true cherts to higher-grade siliceous shales. In general, the quality of Wima chert does not seem to match the finer varieties of Cico, Franciscan, Monterey, SCRI, or Tuqan cherts from the Santa Barbara Channel region. As a result, it appears that Wima chert was used primarily to make expedient core and flake tools. A few Channel Island Barbed points and crescents made from Wima chert suggest that it was sometimes used to make more formal artifact types, probably after being heat-treated. Nonetheless, the generally lower quality of Wima chert clasts suggests that its use would be more limited on San Miguel and Santa Cruz islands where consistently higher quality cherts were available. These same factors suggest that Wima chert artifacts should only rarely be found in archaeological sites along the mainland coast, where high quality Franciscan and Monterey cherts were available.

Addressing such issues may be complicated by the fact that the macroscopic appearance of some artifacts made from Wima chert is similar to Franciscan chert varieties generally believed to come from mainland sources in the Santa Ynez Valley or along the Santa Barbara Coast. Further study is needed to determine the full range of overlap between Wima and Franciscan cherts, and whether such variations can be distinguished macroscopically, microscopically, or geochemically, especially when a cobble cortex is not present. Because there are Sespe Formation rocks on Santa Rosa Island—which on the mainland contain cobbles of Franciscan chert—further reconnaissance is also needed to be certain that island artifacts made from Franciscan chert were not made locally. Until such studies can be completed, the visual overlap between many artifacts made from island and mainland cherts suggests that archaeologists working in Chumash territory should be cautious in identifying the sources of many chert artifacts and in reconstructing ancient exchange and mobility patterns.

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A Place Called *Sa'aqtik'oy*

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The historic occupation at Sa'aqtik'oy *(Saticoy) in Ventura County, Alta California, represented an important settlement for local Chumash people after they departed from Mission San Buenaventura. Most of the land associated with* Sa'aqtik'oy *has been developed, and the majority of the cultural resources and sediments have been destroyed. We incorporate data from site reports, interviews, and collections to reconstruct the history of human occupation at this culturally and historically important location. The four sites recorded for this locality (CA-VEN-31 [56-000031], CA-VEN-32 [56-000032], CA-VEN-33 [56-000033] and CA-VEN-34 [56-000034]) had significant occupations from the early Holocene to the present.* Sa'aqtik'oy*, therefore, represents one of the oldest settlements recorded for the region. Our work highlights the importance of working with curated collections and site records to glean further information and better interpret the historic and prehistoric settlements in California.*

Saticoy, an unincorporated community located in Ventura County, California, is located near freshwater springs on a river terrace above the Santa Clara River, approximately 13 kilometers upriver from the coast (Fig. 1). Just west of South Mountain, this locality was ideal for subsistence purposes as well as interregional contact. Both inland and coastal areas were accessible via travel along the Santa Clara River, and travel to the southeast provided access to additional interior regions (e.g., Conejo Valley, Simi Valley) via the Oxnard Plain and the Little Simi Valley. The historic site of *Sa'atiqk'oy*, from which modern Saticoy derives its name, was situated approximately 600 m. from the Santa Clara River.

After the secularization of the missions in 1834, local Chumash people resettled in Saticoy. The use of a local Chumash placename suggests that the Chumash resided at this location before secularization. The importance of the *Sa'aqtik'oy* settlement grew over time; in 1869 it was the location of the last known major Ventureño Chumash fiesta held by Pomposa, a female chief, elected due to her connections to the village of *Muwu* (Hudson et al. 1977:31). Although several large Oxnard Plain villages are mentioned in Mission San Buenaventura baptismal records (see Perry and Delaney-Rivera 2011 for a discussion), *Sa'aqtik'oy* is not one of them. This discrepancy suggests that the settlement was a secondary one when—during the Mission Period—the Spanish noted the Chumash occupation of the area. Although the Chumash use of the settlement is well documented historically, our work demonstrates that the occupation was one of great antiquity.

In the research reported here, we first outline the known settlement and activities in the *Sa'aqtik'oy* area from the nineteenth century to the present. We then summarize the artifact-related documentation, archaeological fieldwork, and analyses undertaken during the last 50 years, and present our preliminary results of the further analyses of the unique artifacts and curated collections that were undertaken as a part of this project. We conclude that the available evidence suggests that the site was occupied from the early Holocene to the present.

SA'AQTIK'OY TO SATICOY

By 1782, *Sa'aqtik'oy* and the surrounding area in Ventura County had experienced contact with individuals from the Spanish empire. Mission San Buenaventura, located ca. 13 kilometers from Saticoy, was the ninth and final mission founded personally by Padre Junipero Serra; it was officially dedicated on Easter Sunday 1782, although the church building was not completed until 1809. Mission records from this time do not list *Sa'aqtik'oy* as a "village of origin" for mission neophytes. This lack of written notation in the baptismal records suggests that either *Sa'aqtik'oy* was not occupied in the 1780's, or that the settlement may have been a small, secondary village, used during food-gathering cycles. Chumash seasonal settlement shifts were both noted by Spanish explorers

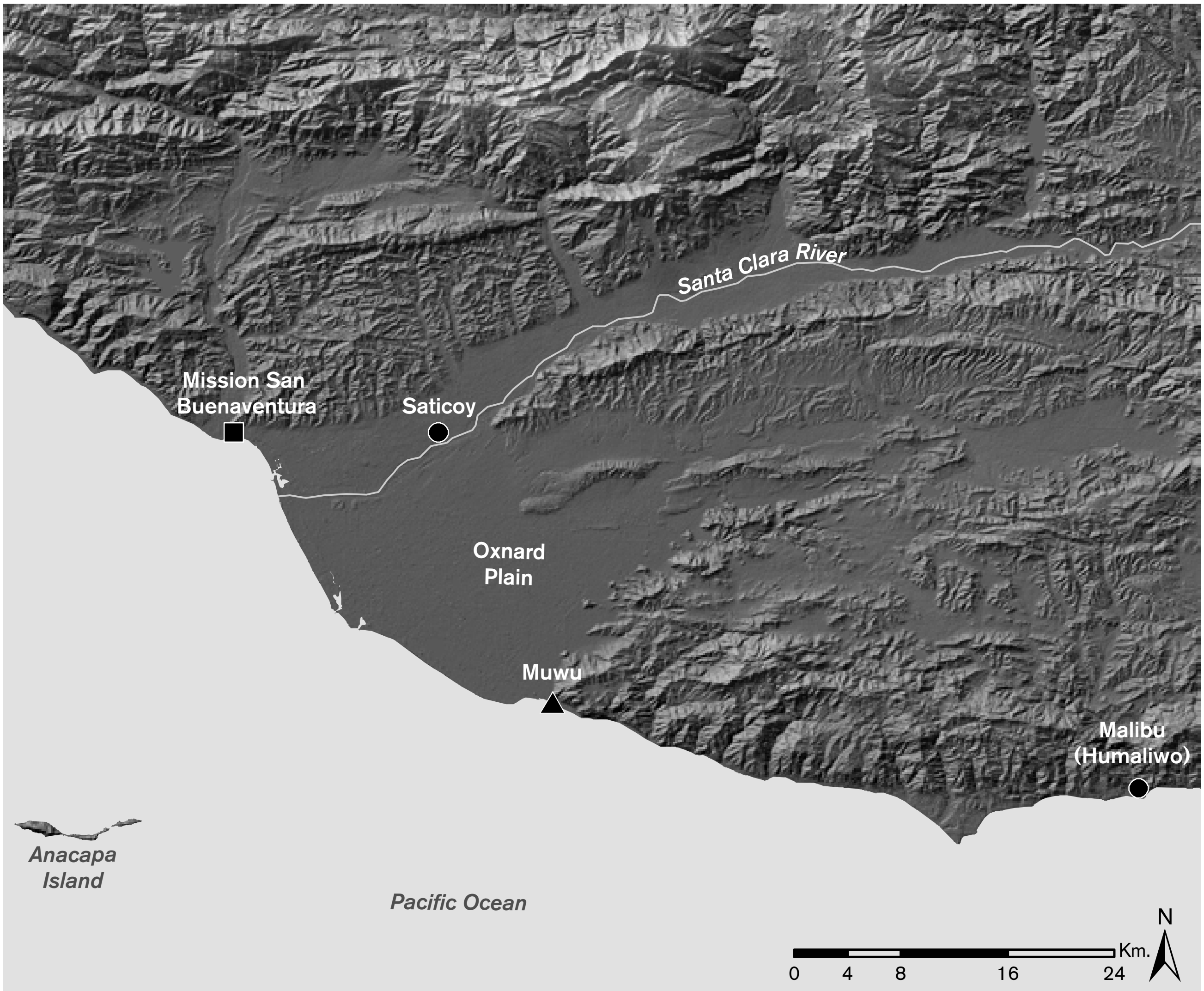

Figure 1. Detailed map of the region indicating archaeological sites and cities discussed in the text.

who passed through the area and recorded in the notes of early missionaries (Kennett 2005; Lopez 1995; Maki and Carbone 1998).

The Acts of Secularization of 1834 released the mission lands from the control of the Catholic Church and ended church control of the Chumash population. Following secularization, a group of Chumash people, led by Luis Francisco, relocated to the general area of the rancheria of *Sa'aqtik'oy* (Lopez 1995). Evidence of this historic period of occupation comes in the form of burials with historic artifacts reportedly found within the prehistoric cemetery, as well as from the ethnographic notes of John P. Harrington (Lopez 1995). This location may have been an important one to the historic-era Chumash, as they returned to this location after secularization, and they also held the last known Ventureño fiesta at this location in 1869 (see below).

The mid-1800s were turbulent years in California history, and land tenure and property claims over the *Sa'aqtik'oy* area both shifted and overlapped substantially. In 1840, Governor Juan B. Alvarado granted Miguel Jimero Casarin the 17,733.33-acre *Rancho Santa Paula y Saticoy*. The rancheria of *Sa'aqtik'oy* was located within the land grant. Inhabitants of California also experienced an influx of immigrants from Europe and China, the California Gold Rush, and the Mexican American War. The 1860 Census indicates that 43 individuals identified as "Indians" were then living in Saticoy in close proximity to the prehistoric site of *Sa'aqtik'oy*. Also in 1860, "Moses Wells purchased from the Chumash, the springs which were contained within a 150-acre parcel made up mostly of boggy cienaga" (Lopez 1995:7). This 150-acre parcel included the physical location of the rancheria of *Sa'aqtik'oy*, as well as its satellite elements.

In 1869, illustrating the importance of *Sa'aqtik'oy*, Pomposa held the last known Ventureño Chumash fiesta in Saticoy, at or near the location of the rancheria of *Sa'aqtik'oy*. This fiesta was recorded by John P. Harrington and recalled by Fernando Librado *Kitsepawit*, who attended the fiesta (Hudson et al. 1977:91–93). All in attendance knew that this was to be the last large gathering, "…the last celebration that would ever take place..." (Hudson et al. 1977:93). A sacred enclosure or *siyilik* was erected that was reported to be approximately 7.6 m. in length and had walls at least 1.8 m. in height. The ceremonies lasted for five days, and included dancing, singing, whistle playing, speeches, and banquets (Gamble 2008; Hudson et al. 1977). By 1880, most of the *Sa'aqtik'oy* population was either deceased, or had moved to "Indian Town," a Chumash enclave within the city of San Buenaventura (Lopez 1985). The land continued to be occupied, but the rancheria of S*a'aqtik'oy* had ceased to be a Chumash village; the area was now farmland (Lopez 1985; Maki and Carbone 1998).

Attilio Vanoni became the single largest landowner in the Saticoy area in 1916 when he purchased 117 acres of land from the Pacific Improvement Company. Rancho Attilio, as Vanoni called his ranch, included the prehistoric settlement of *Sa'aqtik'oy*. The story of the prehistory of this area remained unknown from an archaeological perspective until 1933, when the Vanoni family shifted their agricultural activities from row-crop farming to orchard (Lopez 1995; 2004). The grading associated with these agricultural pursuits disturbed archaeological materials and brought them to the surface.

Although access to the rancheria of *Sa'aqtik'oy* was limited and many families moved to "Indian Town," several Chumash families remained in Saticoy, the unincorporated settlement that grew up adjacent to the rancheria of *Sa'aqtik'oy*. The present Saticoy remains one of the few places in Ventura County with a continued Chumash presence. Today several Chumash families continue to reside there and interact with each other as a cultural community.

ARCHAEOLOGICAL RESEARCH AT *SA'AQTIK'OY*

The Vanoni family unearthed a large cache of millingstones while laying pipelines in 1933. Most of these artifacts were donated to the Ventura County Pioneer Museum, although the family retained a number to display at their ranch. Many of the donated millingstones were eventually lost (Lopez 1985). In the mid-1950's, the Vanoni family again changed their agricultural pursuits, converting the walnut orchards to citrus and avocado trees. The process of re-contouring the land for the orchards revealed additional artifacts. The archaeological investigation of this location began at this time, and continued for the next fifty years.

While grading the property, the Vanoni family leveled a mound that was approximately 91 m. by 91 m. in size (roughly the size of a football field) and approximately 90 cm. high. Charles Rozaire, at the time a graduate student studying archaeology at UCLA, was notified that work at Rancho Attilio was unearthing large numbers of Native American artifacts. He was granted permission to examine the artifacts recovered during grading. Rozaire was only able to examine the materials on the weekends, when he reviewed what the Vanoni family reported to have been unearthed during the week. Although no formal excavations took place, Rozaire examined the area, recovered and documented artifacts, interviewed the landowners, and identified four specific archaeological loci on the property on the basis of his own observations and others' reports: CA-VEN-31(56-000031), CA-VEN-32 (56-000032), CA-VEN-33(56-000033), and CA-VEN-34(56-000034) (Lopez 1995). Although given individual trinomials, these loci represent a single multi-component site, and we refer to this entire area as *Sa'aqtik'oy*.

These four sites were recorded with the Archaeological Site Survey in 1955. VEN-31, roughly an acre in size, was the settlement of prehistoric *Sa'aqtik'oy*. Rozaire was unaware of the village name at this time, and he believed that the site had been almost completely destroyed. He documented many artifacts from the site, including "projectile points, scrapers, blades, drills, manos, metates, mortars, pestles, shell beads and awls" (Maki and Carbone 1998).

Rozaire (Maki and Carbone 1998: B 2-1) concluded that VEN-32 was a cemetery mound, as reported by the Vanoni family. The mound covered approximately 2.5 acres. "[F]our burials and scattered bones, as well as manos, metates, pestles, mortars, bowls, two tubular steatite objects, disk beads and arrowheads" were reportedly disturbed during ranching activities (Maki and Carbone 1998). Rozaire made no additional comments about this site, although he did indicate that most of the soil from the mound was moved to cover the area of VEN-31; the remainder of the soil was spread around the Rancho Attilio property.

VEN-33 and -34 were the locations of the millingstone caches revealed in 1933 and 1955. Rozaire reported that the ground stone artifacts recovered by the Vanoni family in the 1930's included metates (48 whole, 16 fragments), manos (n=6), bowls (n=6), pestles (n=14), and stone balls (n=3). According to Maki and Carbone (1998), the artifacts from VEN-34 noted by Rozaire included sandstone balls, pestles (n=7), manos (n=37), metates (n=158 whole, 67 fragments), and several unmodified pieces of rock of unusual size and shape. During the later grading, another millingstone cache was revealed "...while bulldozing to level the land for a citrus grove" (Maki and Carbone 1998:B 2–11). Confirmation of the two millingstone caches came in a personal interview that Lopez (1987) had with Mr. Ives Vanoni, who stated that VEN-33 and VEN-34 were similar in that they consisted of a small area filled with multiple levels of millingstones.

Development of the land in the immediate vicinity of Rancho Attilio began in the late 1970s, and development continued for the next thirty years. Phase I archaeological surveys undertaken in the area adjacent to Rancho Attilio by Robert Lopez in 1978 resulted in a "negative declaration" for archaeology. An additional nine Phase I archaeological surveys undertaken within a one-mile radius of Rancho Attilio also reported "negative declarations" for archaeology for these adjacent areas (see Lopez 1995 for a list of specific reports). Altogether, this body of work suggests that the archaeological resources in this area were most likely confined to the Vanoni property (Lopez 1995:1).

The Vanoni ranch (Rancho Attilio) and the rancheria of *Sa'aqtik'oy* can therefore be considered spatially conterminous. Robert Lopez interviewed Charles Rozaire in 1985 to better assess the archaeological components at the Vanoni property. That interview indicated that the stratigraphy at the rancheria of *Sa'aqtik'oy* was severely disturbed and that artifact provenience was unclear. Rozaire's information about the metate caches was intriguing, as it suggested that the occupation of the site might extend earlier in time than previously believed (see below).

Robert Lopez, among others, continued archaeological investigations at Rancho Attilio as part of the environmental impact report process for the land associated with the prehistoric and historic rancheria of *Sa'aqtik'oy* (e.g., Lopez 1985, 1986, 1987). In 1985, Lopez undertook a surface survey of VEN-33 and 34. There were no visible surface signs of archaeological resources at VEN-33, but VEN-34 did show visible indications of archaeological resources in the form of broken artifacts and subsistence refuse (Lopez 1985).

Lopez conducted a Phase II archaeological testing of the same area in 1986. That work included the excavation of six 1x1 m. units. Prehistoric materials were recovered at varying depths from five of the six units, including shell, bone, various flakes, a drill, projectile points, cores, beads, an otolith, and ochre (Lopez 1986). Finally, in 1987, Lopez conducted an overall archaeological assessment of Rancho Attilio for Wittenberg-Livingston, the new owners, an assessment that included personal interviews with Charles Rozaire and Ives Vanoni.

In 1998, additional Phase I archaeological work was undertaken by Maki and Carbonne at VEN-31, -32, -33, and -34 in preparation for land development. The highest density of cultural material was found on top of and in the levee and terrace slopes. The materials observed included shell, bone (both bird and small mammal), and chipped lithic material, including quartzite, basalt, steatite, and fused shale (Maki and Carbonne 1998).

In 1999, Maki and Romani undertook extended Phase I and limited Phase II excavations to determine if intact stratigraphy was present below the surface. They conducted surface collections of VEN-31 and -32, and carried out a subsurface testing program at VEN-33 and -34. In total, 16 trenches averaging 60 cm. wide and 2 m. long were excavated. The artifacts recovered comprise a part of Catalog C (discussed below). Trench 15A contained the *in situ* remains of a small adult female under 35 years of age (Maki and Romani 1999).

Lopez and students from Moorpark College undertook a data and salvage recovery program in two areas of VEN-31 and -32 (Lopez 1999). The archaeological materials retrieved are included in Catalog D (discussed below); they consisted of beads, projectile points, ground stone, shell, and bone (Lopez 1999). Finally, in 2003 Lopez and his colleagues, including a Native American monitor, undertook salvage collections and excavations while monitoring the land grading of the 67-acre property (Lopez 2004). During the monitoring they followed the movement of thirteen Catepillar 637C graders, recovering artifacts as they were exposed. In one instance, three stone effigies (discussed below) were excavated *in situ*. The list of materials collected comprise Catalog E; they include beads, projectile points, metates, manos, mortars, pestles, cores, flakes, bone, shell, and several unusual artifacts (discussed below). (Additional information on the archaeological investigations at Rancho Attilio can be found in Clericuzio 2010.)

Today, the entire area associated with *Sa'aqtik'oy* (VEN-31, -32, -33, -34) has been developed, with the archaeological components built on, removed, or covered with fill. To summarize, the area known most recently as Rancho Attilio currently includes a housing development with approximately 400 residences (VEN-34), a veterans' home (VEN-33), a Native American Veterans' memorial (VEN-31 and -32), and the Chumash Preservation site (VEN-31 and -32). The land associated with the Chumash Preservation site has not been developed, as this represents remnant occupational and mortuary materials associated with VEN-31 and -32, the village and cemetery of *Sa'aqtik'oy*. The materials are now safely buried under six meters of fill, and the approximately six-acre parcel has been donated to the Ventureño-Barbareño Band of Mission Indians. Finally, the Vanoni family has retained 2.7 acres of the property that contains the family homestead and that continues to be used by the family.

Although the site of *Sa'aqtik'oy* is no longer accessible for archaeological research, the work undertaken by Charles Rozaire and Robert Lopez (among others), in addition to studies of the curated artifact collections, can still contribute valuable information about these archaeological loci and permit an assessment of the timing and activities associated with the Chumash occupation at *Sa'aqtik'oy*.

ARTIFACT ANALYSIS

The archaeological evidence examined for this project is found in five data sets, dubbed catalogs, that were created over five decades of artifact collection, documentation, and examination at VEN-31, -32, -33 and -34 (Table 1). Catalogs A and B are, in essence, lists compiled from statements made by the Vanoni family to Charles Rozaire. The artifacts listed could not be analyzed because they have been lost, but the data supplement our interpretations of the *Sa'aqtik'oy* site. The artifacts in Catalog C were recovered during salvage excavations that were carried out to determine if the site was intact at a greater depth. The artifacts in Catalog D represent a surface salvage

Table 1

REPORTS AND ARTIFACT COLLECTIONS UTILIZED IN THIS STUDY

Data Set	Materials and Information
Catalog A	1930s artifact lists, reported to Charles Rozaire; based on Vanoni family reports to him; information limited to CA-VEN-33. Artifacts have not been formally analyzed and remain in private collections or lost.
Catalog B	1955 artifact lists, reported to Charles Rozaire, based on his fieldwork and Vanoni reports. Artifacts have not been formally analyzed and remain in private collections or lost.
Catalog C	Artifacts collected by Maki and Romani (1999). Curated at the Santa Barbara Natural History Museum and with the Ventura County Archaeological Society collections.
Catalog D	Artifacts collected during Moorpark College Data Recovery Program (Lopez 1999). Curated with the Ventura County Archaeological Society collections.
Catalog E	Artifacts collected during Lopez' archaeological monitoring in 2003. Curated with the Ventura County Archaeological Society collections.

collection, while Catalog E artifacts were collected during the monitoring that occurred in conjunction with the initial grading of the area prior to development.

The goal of this analysis is to determine the chronology of occupation at the village of *Sa'aqtik'oy* using the artifacts recovered at the site. Although our artifact analysis is based on materials from disturbed stratigraphic contexts, an examination of temporally-diagnostic artifacts permits the establishment of a chronology of site occupation. Our study focuses on projectile points, shell and stone beads, and ground stone artifacts (metates, manos, mortars, pestles, and effigies/charmstones). These items frequently lend themselves to chronological sequencing through a comparison with morphologically-similar artifacts from southern California sites of documented age. Other archaeological materials (e.g., botanical remains, tarring pebbles, and bowl fragments) are represented in these data sets, but are not included in our analysis.

A preliminary note on chronology is necessary before we begin our discussion of artifacts and temporal designations. The published analyses of the temporally-diagnostic artifacts we discuss are based upon the local chronological scheme originally defined by King (1990). His chronology involves the following approximate dates: Early Period 5,500–600 B.C., Middle Period 600 B.C.–A.D. 1150, and Late Period A.D. 1150–1804. While a more general Holocene-based chronology might be preferable, since results could be applied to a broader area, radiometric analyses have not been undertaken as a part of this study. For this reason, we use the regional chronological terms in our discussion, but include the approximate Holocene designations as well. In particular, the timing of the Millingstone Horizon has not been well defined for this region. For our purposes, the Millingstone Horizon roughly approximates the Early Period (Ex, Ey, and possibly portions of Ez) as defined by King (1990), although other archaeologists place the end of the Millingstone Horizon at about 5,000 cal B.C. (Glassow et. al 2007), and some suggest that it lies deeper in time (as early as 7,000 B.C; see below).

Beads

Catalogs B-E indicate that 508 shell and stone beads were recovered from *Sa'aqtik'oy*, although Catalog B beads were never formally analyzed (Table 2). This number represents only a very small fraction of the beads thought to have been collected at this location, as it was widely known to and visited by local residents. Clericuzio analyzed a 10% sample of the beads reported in catalogs C, D, and E (see Clericuzio 2010) to assess the bead types assigned by the catalogs' creators. Additionally, six glass 'trade' beads are recorded in catalogs B and D. The bead collections from these four catalogs suggest that the *Sa'aqtik'oy* site was occupied, at least intermittently, from the early Holocene (Millingstone Horizon) to the 1800s.

Table 2

SUMMARY OF BEAD DATA FROM CATALOGS A–E

	Columella	Barrel	Spiral Lopped	Tube	Cup	Disk	Sidewall	Quantity
Olivella	1	3	7	0	129	1	261	**402**
Tivela	0	0	0	0	0	1	0	**1**
Mytilus	0	0	0	0	0	25	0	**25**
Clam	0	0	0	2	0	6	0	**8**
Haliotis	0	0	0	0	0	7	0	**7**
Steatite	0	4	0	6	0	39	0	**49**
Serpentine	0	4	0	2	0	2	0	**8**
Unknown	0	1	2	1	0	4	0	**8**
Total	**1**	**12**	**9**	**11**	**129**	**85**	**261**	**508**

The bead data suggest a tentative chronology, though it is not conclusive, as many bead styles were in use over multiple time periods. Three *Olivella biplicata* barrel beads and two serpentine tube beads point to an Early Period occupation (primarily Middle Holocene). Seven *Olivella biplicata* spire-lopped beads, at least one of which is an oblique spire-lopped, suggest that the site was in use during the Early to Middle Period transition (ca. 600 B.C.). The majority of the beads (n=261) are classified as *Olivella biplicata* wall (saucer) beads, which were most popular during the Middle Period, while the second largest group of beads (n=129), *Olivella biplicata* cup beads, were first manufactured during the Late Period (late Holocene, after A.D. 1150). Further, one small *Columella* bead was identified, which was in use towards the end of the Late Period (Bennyhoff and Hughes 1987; King 1990).

Projectile Points

The projectile point chronology in the Santa Barbara Channel follows trends similar to those seen in other parts of California; we outline Glassow's summary

(1996:Figure 2.3) below. The earliest points commonly reported for the coastal region are side-notched dart points dating to approximately 5,000 B.P. Contracting-stem dart points were in use from approximately 4,000 to 1,500 B.P., while small foliate, concave- and convex-based (leaf shaped) arrow points appear at varying times after 1,500 B.P. and 700 B. P., respectively.

Catalogs B-E indicate that 232 projectile points were identified during the 50-year retrieval period. Projectile points were not identified in Catalog A, and the Catalog B points (from VEN-31 and -32) were never formally analyzed. The projectile point assemblage listed in catalogs C, D, and E support the conclusion that a wide time span of habitation is represented at *Sa'aqtik'oy,* including the Early, Middle and Late Period (Table 3).

An Early and/or Middle Period (Middle Holocene) occupation is suggested by five shouldered and five stemmed projectile points. Seven notched points are indicative of the Middle Period, while the 32 concave and 29 convex points could be indicative of the late Middle Period or Late Period. The majority of projectile points were manufactured from chert (n=137) and Grimes Canyon fused shale (n=88). Most of the raw materials (chert, Grimes Canyon fused shale, and chalcedony) are available locally. The one exception involves the tip of a flaked tool made from obsidian.

Ground Stone

Ground stone items frequently lend themselves to chronological sequencing based on established dates of morphologically-similar artifacts from southern California sites of documented age. In the Santa Barbara Channel region in particular, mortar morphology can be used as a chronological marker. The earliest mortars have little exterior shaping (e.g., at CA-SBA-53, the Aerophysics site; Harrison and Harrison 1966). Later in time, the morphology shifts to a shaped globular form, and after approximately 1,000 B.C. archaeologists document the appearance of shaped "flowerpot" mortars (Glassow 1996:Figure 2.3).

The catalogs indicate that 719 pieces of ground stone were recovered from VEN-31-, -32, -33, and -34 (Table 4). Catalog A (VEN-33) listed metates, manos, mortars, and pestles, as well as additional types of ground stone. These items were from the ground stone caches reported during the 1931 shift in agricultural production. The Vanoni family donated the majority of the ground stone artifacts from the caches to the Ventura County Pioneer Museum, although a portion of the collections were retained by the family. Neither set of ground stone artifacts was formally analyzed, and today they have been either lost or remain in private collections.

The caches represent one of the most intriguing aspects of this site. The caches were reported to Rozaire as being organized in layers within a restricted area. A systematic excavation could have noted the association of placement. Unfortunately, the ground stone caches were never systematically documented by professional

Table 3

PROJECTILE POINT FORMS FROM CATALOGS C, D, AND E

	Raw Material				
Form	Grimes Canyon Fused Shale	Chert	Chalcedony	Obsidian	Quantity
Convex	21	7	1	0	**29**
Concave	4	26	2	0	**32**
Shouldered	1	3	1	0	**5**
Stemmed	1	4	0	0	**5**
Notched	3	3	1	0	**7**
Mid-section	23	46	1	0	**70**
Tip	26	34	0	1	**61**
Fragment	9	14	0	0	**23**
Total	**88**	**137**	**6**	**1**	**232**

Table 4

GROUND STONE INVENTORY FROM CA-VEN-31. -32, -33, AND -34

	Artifact Type				
Form	Metate	Mano	Mortar	Pestle	Quantity
Slab	23	0	0	0	**23**
Basin	14	0	0	0	**14**
Complete	206	43	6	38	**293**
Uniface	0	74	0	0	**74**
Biface	0	132	0	2	**134**
Triface	0	7	0	0	**7**
Cobble	0	0	6	0	**6**
Hopper	0	0	3	0	**3**
Mid	0	0	0	2	**2**
Base	0	0	0	16	**16**
Fragment	88	34	4	21	**147**
Total	**331**	**290**	**19**	**79**	**719**

archaeologists. The possibility of encountering at least one more of these caches was a motivating factor behind all subsequent archaeological exploration on this property (R. Lopez, personal communication 2010).

Catalog B listed metates, manos, and pestles, in addition to other artifacts (a second millingstone cache was associated with VEN-34). These items were recovered when the Vanoni family converted the agricultural land in the 1950s, and they were never formally analyzed or cataloged. Furthermore, during the monitoring operations associated with Catalog E, only complete or nearly complete ground stone pieces were collected. The remaining fragmentary pieces were redeposited in a deep pit at the Chumash Preservation Site, which includes the remnant sediments and the artifacts associated with VEN-31 and VEN-32. Although some detailed data are missing, these artifacts and notes provide additional support for our archaeological interpretations.

The ground stone collection from catalogs A-E are consistent with the projectile point data and support the interpretation that the occupation at *Sa'aqtik'oy* began at least by the beginning of the Early Period (about 5,500 B.C.), and possibly as early as 7,000 B.C. (see discussion of unusual artifacts below). Occupation continued through the Middle Period and into the Late Period.

The catalogs report 243 metates, which were categorized as complete (n=206), slab (n=23), and basin (n=14). Most of the complete metates were noted in catalogs A and B; a formal analysis did not occur, hence the lack of form designation. An additional 88 metate fragments were noted. The 290 manos reported in the catalogs were categorized as uniface (n=74), biface (n=132), or triface (n=7), with 43 simply listed as complete. Sandstone, a locally available material, was the manufacturing material for all but three of the manos and metates. The high number of metates, as well as the caching behavior, is suggestive of an early occupation, possibly as early as 5,000 B.C.

Mortars (n=19) were only reported in catalogs C, D, and E. The three unshaped mortars, three globular mortars, and three "flowerpot" mortars, as well as the various fragments, were all produced from sandstone. Seventy-nine pestles were reported in the five catalogs. The 21 pestles from catalogs A and B were never formally analyzed, and are now lost or in private collections. The pestle information in catalogs C, D, and E is more detailed: complete (n=38), biface (n=2), midsections (n=2), base sections (n=16), and fragments (n=21). All of the pestles cataloged were made of sandstone. Mortars and pestles became more common through time as acorn utilization increased, and together these artifacts suggest a Middle and/or Late Period occupation (ca. last 2,500 years).

Special and Unique Artifacts

In addition to the more functional artifacts described above, eleven special and unique artifacts have been identified as a part of this study: one stone pendant, five bone whistle fragments, one charmstone/plummet, and four stone effigies. All of these artifacts are associated with Catalog E, and are from the professional salvage excavations completed in 2003. The most interesting and unique of the artifacts recovered from *Sa'aqtik'oy* are three (probable) turtle effigies (Lopez 2004). Furthermore, most of these artifacts suggest an Early Period occupation at the site.

The turtles (Fig. 2) are made of a dark, rich green serpentine and are three-dimensional pieces of carved art. These turtles were found together on the third and oldest terrace of the Santa Clara River, in what had been the village of *Sa'aqtik'oy*, slightly west of VEN-34. The three effigies range in length from 15.5 cm. to 23 cm. Each has a pattern of carved lumps or bumps on its back. The largest has 36 bumps, the mid-size has 16 bumps, and the smallest has 20 bumps. All three turtles have the same design on the front, with a smooth and polished "underside," although the largest effigy has a fault/fissure on the back. The turtles were excavated *in situ*, with the turtles' carved bumpy side on top. The two larger effigies were sitting over the smaller one, and according to the excavators, the turtle effigies appear to have been intentionally set in place, not randomly tossed onto the terrace (G. Higgins, personal communication, 2010). They may have even been placed in water, as they were located in an area of heavy clay. According to Lopez, water was the preferred place to discard powerful objects in order to control or minimize their power (R. Lopez, personal communication, 2012; also see Blackburn 1975:85–6). The smallest effigy has a highly polished and colored depression where it may have been repeatedly employed as a handheld charm.

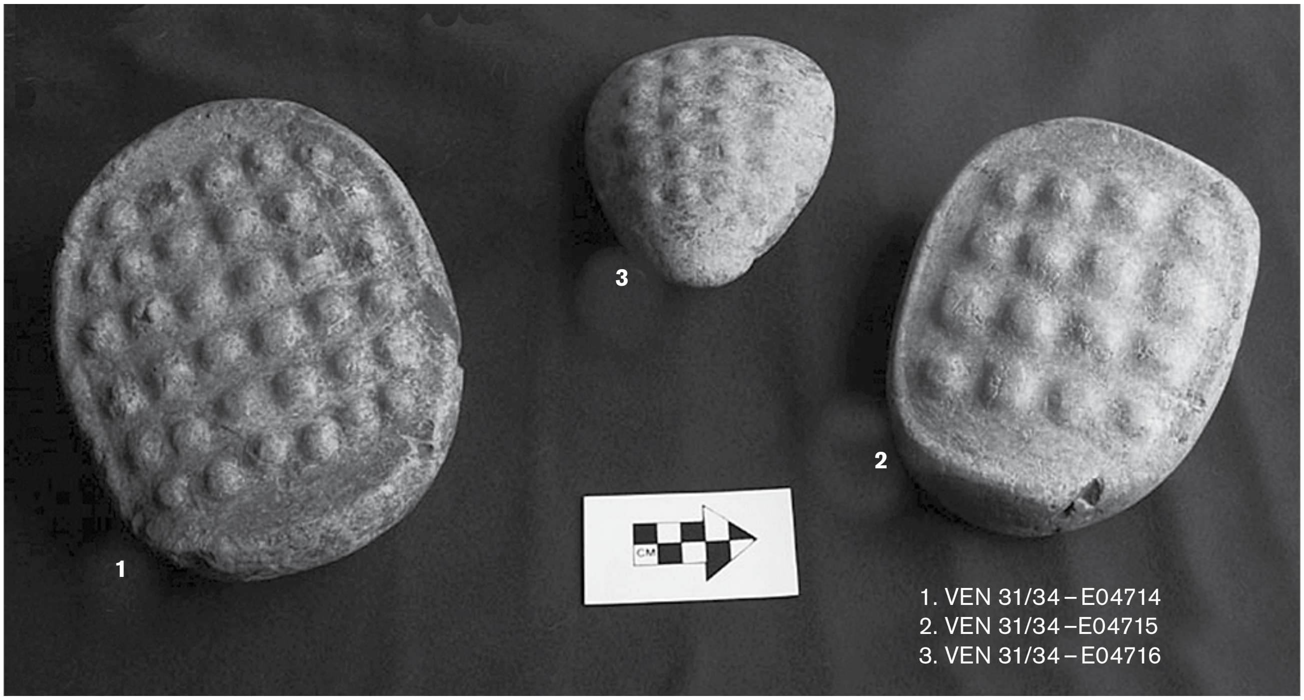

Figure 2. Turtle effigies recovered during the 2003 monitoring excavation.

The fourth stone effigy recovered from *Sa'aqtik'oy* was a three-dimensional, two-headed fish effigy (Fig. 3). The effigy was manufactured from smooth, polished sandstone, and it has an incised mouth visible at both tapered ends. The artifact has a length of 13.2 cm. and a maximum width of 3.2 cm. Also recovered was a quartzite plummet/charmstone which was incised on one end and tapered on the other. The charmstone measures 10 cm. in length and 3.5 cm. in width. The final stone ornament was a highly polished and only slightly damaged steatite disk pendant. Finally, substantial fragments of five individual bone whistles were also identified and recovered, but were not analyzed for this project.

DISCUSSION AND CONCLUSIONS

Since the apparent abandonment of the village in the mid-1800s, use of the land associated with the prehistoric village of *Sa'aqtik'oy* (VEN-31, -32, -33 and -34) has included agriculture (row crops and orchards), a housing development, a U.S. Veterans' retirement center and memorial, a Native American veterans' memorial, and the Chumash Preservation site.

These varied activities, especially those involving land grading and earth moving, have greatly altered the integrity of the archaeological materials and their context. As a result, the stratigraphy of the site has been disturbed, and the main locus of habitation (VEN-31) and the mortuary site (VEN-32) have been buried under six meters of soil (Lopez 1995). However, a detailed analysis of the artifact catalogs, personal interviews, and site reports demonstrates that this location has been occupied at least intermittently from the Early Holocene to the present. Utilizing chronologically-diagnostic salvaged artifacts, we can create a timeline of land use by the Chumash.

Historic documents such as census records, glass trade beads, and ethnohistoric interviews together indicate that *Sa'aqtik'oy* was occupied by the Chumash people during the historic period. Furthermore, this evidence suggests the importance of the location to the historic Chumash. *Sa'aqtik'oy*, which probably means "sheltered from the wind" in Ventureño Chumash (Applegate 1974), was resettled after the secularization of Mission San Buenaventura in 1834. It also served as the general location of the last Ventureño Chumash fiesta, sponsored by Pomposa, in 1869 (Hudson et al. 1977:91–93). Our work demonstrates that this location was occupied by the Chumash for thousands of years prior to that historic event.

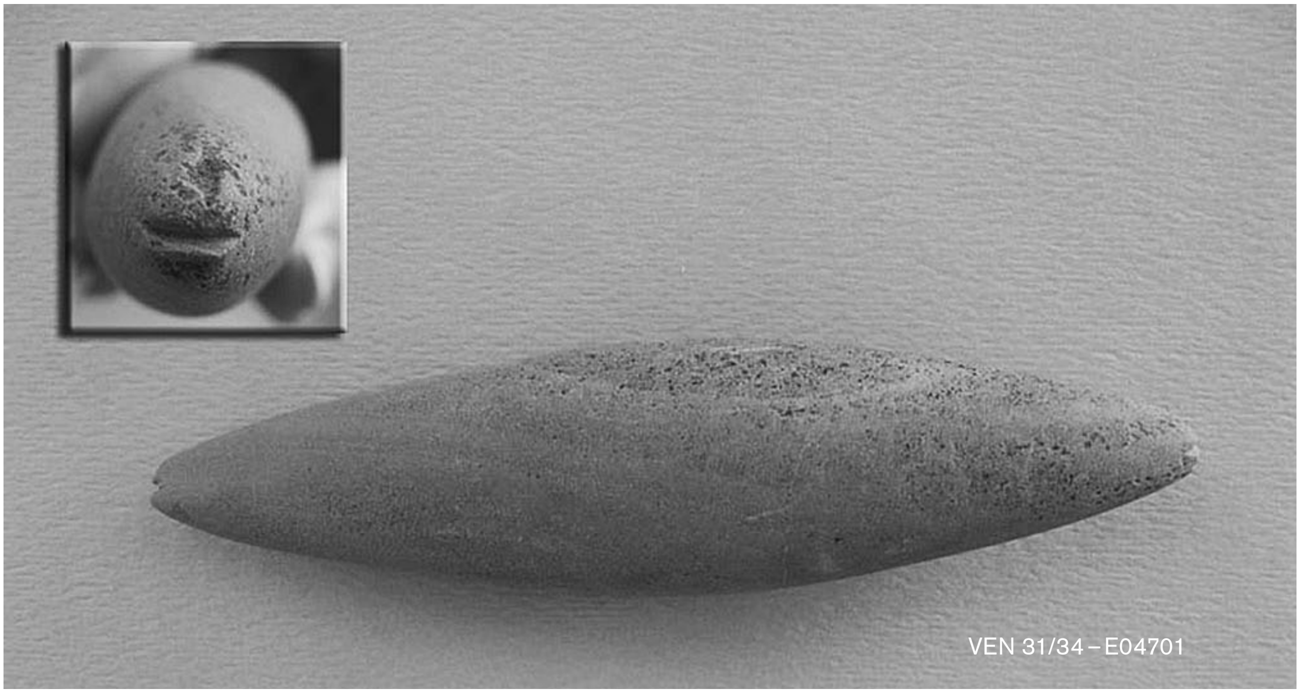

Figure 3. Fish effigy recovered during 2003 monitoring excavation. The effigy is 13.2 cm. long and 3.2 cm. wide.

The artifact assemblage described above provides support for the proposition that *Sa'aqtik'oy* was occupied by the Chumash during the Late Period (Late Holocene). The large number of *Olivella biplicata* cup beads, and the convex and concave projectile points, all support a Late Period habitation at the *Sa'aqtik'oy* site. The mortars and pestles found at the site also give credence to a Late Period site occupation.

The examination of the catalog lists, as well as the detailed analysis of a sample of the artifacts, also suggests a significant Middle Period (Late Holocene) occupation, bolstered primarily by the 261 *Olivella biplicata* wall (saucer) beads and the notched projectile points. Temporal assignments based on the mortar and pestle data are more equivocal, although the shaped "flowerpot" mortars do suggest a Middle and/or Late Period occupation. The steatite disk pendant is similar to those described by Chester King (1990), which he assigns to the Middle Period.

Most interesting, and unexpected, were the variety of artifacts which suggest a relatively early occupation at *Sa'aqtik'oy.* In addition to the few early beads and projectile point styles noted above, the large numbers of cached metates (n=331) and manos (n=290) recovered support this conclusion. These datasets, especially when they involve caches, suggest an Early Period/Millingstone Horizon occupation. A perusal of the literature has not revealed many excavated metate caches from southern California, although Pritchard-Parker does note one for Hemet (1993), and McGuire and Hildebrandt provide a list of Millingstone Horizon sites with significant numbers of milling stones (McGuire and Hildebrandt 1994). Another ground stone item frequently identified in caches from southern California sites are cogged stones, which also appear to date to the Millingstone Horizon/ Early Period (Koerper et al. 2006).

The Browne site, CA-VEN-150, provides an interesting comparison to *Sa'aqtik'oy*. According to Greenwood (1969), this site is dated to the early Millingstone Horizon. Excavators recovered over 200 complete and fragmentary metates. Interestingly, the VEN-150 collections also include two three-dimensional effigies, purported to be frogs. These effigies are made of diorite, and are described as "sculptures in-the-round..." and as "a thoroughly sophisticated work of art..." (Greenwood 1969:46). The two effigies are of different sizes (the larger is a "frog" effigy, and the smaller a "tadpole" effigy), which would tend to suggest an adult-child relationship. Additionally, the tadpole effigy has a polished depression on the back side, suggesting that it might have been a handheld charm.

Although representations of different fauna, this adult-child relationship in three dimensional art is also reflected at *Sa'aqtik'oy* in the stone turtle effigies. The stone turtle effigies also seem to reflect adult and child sizes; in this particular case, the larger ones were placed above,"protecting" the smaller one. Additionally, the smaller stone turtle effigy also has a polished depression on the back side, suggesting use as a handheld charm.

Fitzgerald and Corey have considered the distribution and chronology of the zoomorphic effigies and representational artworks recovered from archaeological contexts in southern California, and suggest that these items were used far earlier than has been previously supposed (2009:192). They acknowledge the difficulty in assigning a temporal range to many of these zoomorphoic artifacts. Given the possible 7,740 cal B.C. date for a fish effigy from the Cross Creek site in San Luis Obispo County (Fitzgerald and Corey 2009:192), and a minimal date of ca. 1,540 cal B.C. for the Browne site "frog and tadpole effigies" (Fitzgerald and Corey 2009:198), they make a compelling argument that three-dimensional art in southern California occurred in the Early Period, and possibly much earlier. Unfortunately, the lack of shellfish and other datable materials from the Browne site, as well as the disturbed stratigraphy at *Sa'aqtik'oy*, do not permit their use as sources of dates from secure contexts. Interpretations of the time depth associated with these three-dimensional zoomorphic figures from coastal south-central California thus remain somewhat speculative.

Two additional Millingstone Horizon sites recorded in coastal Ventura County are CA-VEN-1 (Wallace 1954) and CA-VEN-100 (West 1979). VEN-1 is a multi-component site located on the coast, whereas site VEN-100 is located in an interior valley near the coast that drains to the Pacific Ocean. West (1979:13) indicates that "Area 1 fits the Millingstone Horizon cultural assemblages as defined by Wallace...." Both VEN-150 and VEN-100 are located at higher elevations, and VEN-1 is situated on the coast. *Sa'aqtik'oy* is located on the Oxnard Plain in close proximity to the Santa Clara River, 13 kilometers inland from the coast. This location may make sense, however, if the plants processed using the large numbers of manos and metates grew along this section of the Oxnard Plain. The people of the Millingstone Horizon likely occupied a variety of sites in different locations, but most have been covered by sediments or destroyed in the intervening years. Many Millingstone Horizon sites recognized by archaeologists today are situated at higher elevations with good viewsheds, or in coastal locations. The archaeological sample, therefore, is likely skewed with regard to site location and activities. *Sa'aqtik'oy* may represent another type of site, and thus can also shed light on the people that lived during this difficult-to-define temporal period.

We cannot determine the intensity of occupation at *Sa'aqtik'oy* given the lack of stratigraphic controls, and further research "on the ground" is impossible given the destruction and filling of the site. However, through the analysis of archaeological reports, fieldworker interviews, and artifacts, important details can still be gleaned from these sources. We propose that *Sa'aqtik'oy* was occupied, at least intermittently, from the earliest part of the Early Period (equivalent to the Millingstone Horizon) to the present. The *Sa'aqtik'oy* artifact assemblage, when compared to the artifact collections obtained from verifiable early Holocene sites, supports the proposition that *Sa'aqtik'oy* is one of the oldest settlements on the Oxnard Plain.

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A Chipped Stone Crescent from Simi Valley, Ventura County, California

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A chipped stone crescent, reportedly from Simi Valley, was recently identified in the anthropological collections of the University of Oregon's Museum of Natural and Cultural History. The small lunate crescent, donated to the university in 1952 by archaeologist Joel L. Shiner, appears to have been made from a gray Temblor Range chert. The well-preserved Simi Valley specimen, similar to non-eccentric crescents found in stratified contexts on Santa Rosa Island dated to ~11,750 cal B.P., is one of the few known from Ventura County.

Chipped stone crescents, among the more enigmatic artifacts from North America's Far West, have long been of interest as temporal markers of the Early Holocene (see Beck and Jones 2010; Fenenga 2010; Frederickson and Grossman 1977; Justice 2002; Tadlock 1966). Meighan and Haynes (1970) used obsidian hydration to propose that crescents had an even greater antiquity in California, with some Borax Lake specimens appearing to be roughly contemporary with fluted points. Usually found in sites near ancient lake, wetland, or coastal settings, crescents have often been interpreted as transverse projectile points used in hunting waterfowl (Erlandson and Braje 2008; Tadlock 1966). For Great Basin crescents, however, Mitchell et al. (1977) warned that variation in morphology and breakage patterns may suggest a more complex range of functions. The wide distribution and morphological diversity in crescent types—including classic lunate specimens and several eccentric varieties—also suggest that crescents were used for several millennia and that their function varied through space and time (see Fenenga 2010; Jertberg 1978; Mohr and Fenenga 2010). In California, some eccentric crescents, for instance, have been interpreted as zoomorphic effigies or fetishes (Koerper and Farmer 1987; Ruth 1937) which may have been reused by Late Holocene peoples (Erlandson 2011).

Several hundred crescents have been reported from the California coast over the years (see Davis et al. 2010; Fenenga 2010; Jertberg 1978, 1986; Jones 1956; Mohr and Fenenga 2010), more than half of which come from the Channel Islands. Until recently, relatively few of these crescents had detailed provenience data or temporal control. Recent research on the Northern Channel Islands has shed some light on the context and chronology of chipped stone crescents along the California Coast. Erlandson (2005) reported the first island crescent from a stratified context, a nearly complete specimen found eroding from the sea cliff at Daisy Cave (CA-SMI-261) and embedded in a stratum dated between ~10,200 and 8,600 cal B.P. Erlandson and Braje (2008) also described five crescents from the surface of CA-SMI-679 on eastern San Miguel island, where nearby shell midden deposits have been dated to ~12,000 cal B.P. (Erlandson et al. 2011). Recent research on Santa Rosa Island has also documented lunate crescents associated with hundreds of bird bones in a deeply buried paleosol at CA-SRI-512 that is dated between about 11,900 and 11,500 cal B.P. (Erlandson et al. 2011).

CRESCENTS AND MUSEUM COLLECTIONS

Numerous crescents from California and the Great Basin exist in museums around the United States and elsewhere in the world, with the best known examples in large museums such as the Smithsonian Institution, the American Museum of Natural History, the Southwest Museum, and others (see Justice 2002; Mohr and Fenenga 2010). Erlandson (2011) recently noted that crescents are also found in local or regional museums, where many may lie undiscovered and undocumented. My experience at the University of Oregon (U. O.) Museum of Natural and Cultural History (MNCH) confirms this, inasmuch as two crescents from small California collections were unexpectedly found in a search of documents and drawers that took less than one hour.

One of these small collections was donated to the MNCH by Joel L. Shiner in 1952. Shiner was an archaeologist who was born in Texas, earned a B.A. in anthropology from UCLA in 1948 and a Ph.D. from the University of Arizona in 1955. He then worked for the National Park Service for several years before joining

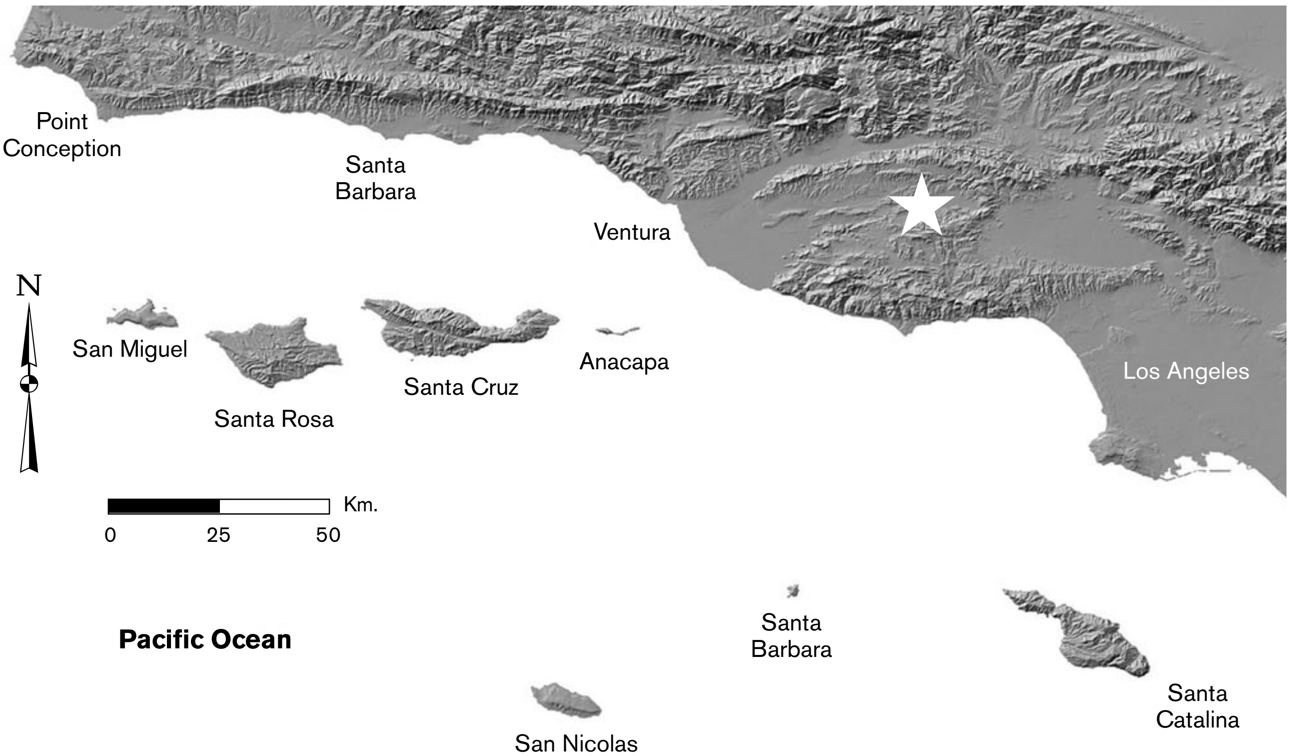

Figure 1. Map of the Santa Barbara Channel region showing the approximate location of Simi Valley (star).

the faculty of Southern Methodist University in 1960 (Wetherington 1989). During the 1950s, Shiner worked in the Pacific Northwest as an acting field director with the River Basin Surveys of the Smithsonian Institution. At this time, Shiner may have come into contact with Luther Cressman, chairman of the University of Oregon's Anthropology Department and director of its Museum of Natural History (now known as the MNCH), who was involved in the Smithsonian's River Basin Surveys. Presumably, the donation of Shiner's California artifacts to the U. O. was the result of his contacts with Cressman or other museum staff members.

The MNCH's Shiner Collection contains six artifacts from southeastern California, including a large stemmed point from the Lake Mojave area and five small arrow points attributed to the Owens Valley area. It also contains 14 artifacts identified in museum notes as coming from Chumash territory in Ventura County's Simi Valley. The Simi Valley (Fig. 1) is near the boundary of ethnographic Gabrielino (a.k.a. Tongva) territory (Johnson 2006), however, and Shiner (1949) himself described excavations at a Simi Valley site that he attributed to a Fernandeño occupation. The Simi Valley collection Shiner donated to the U. O. appears to be unrelated to those excavations and has no specific provenience. It includes eight shell beads (one mussel disc, two cupped, four lipped, and one wall bead made from *Olivella*), an asphaltum basketry impression, a large bone awl made from a deer metapodial, a wooden stick with two fire-making hearth concavities, a small leaf-shaped chert point, a small triangular obsidian point, and one chipped stone crescent. Except for the crescent, most of these artifacts are probably of Late Holocene age, which raises the possibility that the crescent may have been an older artifact reused by later Chumash or Tongva people.

THE SIMI VALLEY CRESCENT

The Simi Valley crescent is a complete lunate specimen, between a quarter-moon and a half-moon in plan view, and lacks the pronounced serrations, notches, or legs typical of eccentric crescents from California (Fig. 2). Relatively small, thin, and bilaterally symmetrical, the Simi Valley crescent is 1.89 cm. long, 3.07 cm. wide, a maximum of 0.47 cm. thick, and weighs just 2.56 g.

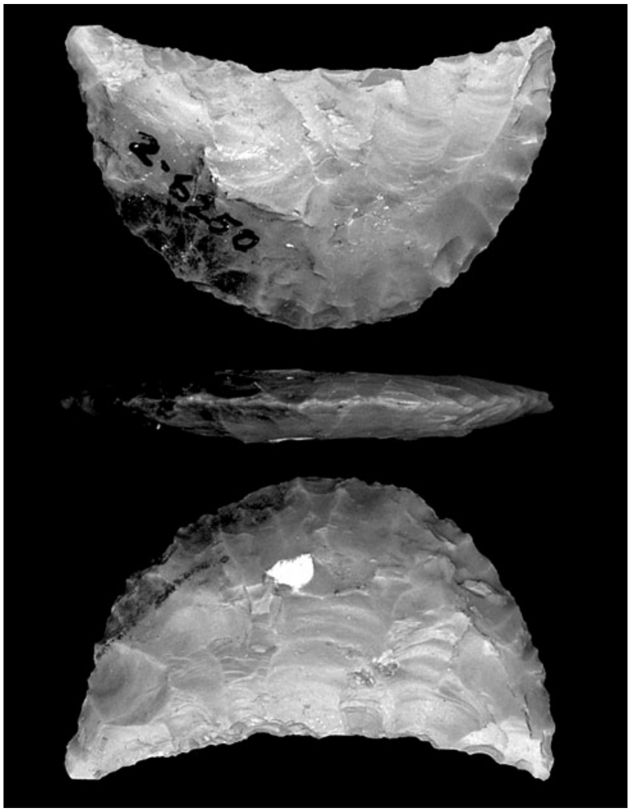

Figure 2. Composite digital scans of the Simi Valley crescent, showing both faces and a cross-section of the artifact. Note traces of hafting residue on the left portions of the convex edge of crescent and small spot of white cortex on lower image (by Keith Hamm).

In cross-section, the crescent is very flat and slightly thinner (0.44 cm.) along the midline, possibly to facilitate hafting. Almost completely flaked on both sides through a combination of percussion and pressure flaking, the crescent has just one small spot of cortex on one face. It was made from an opaque gray (10YR 5.5/1) chert visually similar to cherts from the Temblor Range located between the Carrizo Plain and the southern San Joaquin Valley area in western Kern and eastern San Luis Obispo counties (see Elliot 1966; Hudson and Blackburn 1987:29). Temblor Range chert outcrops, found in uplifted Monterey Formation rocks (Elliott 1966), often contain thin plates of gray chert with white cortex.

The relatively high degree of finish and bilateral symmetry suggest that the Simi Valley crescent was a finished artifact rather than a preform. Unlike many specimens found in surface contexts in California and the Great Basin, this crescent shows no sign of abrasion from eolian sandblasting, stream transport, or other post-depositional damage. The convex edge of the crescent, in fact, appears to retain remnants of a dark residue (asphaltum?) that is probably related to hafting.

Typologically, the crescent appears similar to Tadlock's (1966:663) Type I crescent and Mohr's Type 3 crescent (concavoconvex lunate; Hopkins 2010:65; Mohr and Fenenga 2010:108-109). Lunate crescents, the most common varieties found in California's interior regions and on the Northern Channel Islands (Mohr and Fenenga 2010), are very similar to the non-eccentric crescents found throughout much of the Great Basin and the Columbia Plateau regions, where they are strongly associated with lakes, marshes, and other wetland habitats (Tadlock 1966).

DISCUSSION AND CONCLUSIONS

The Simi Valley crescent is one of the few specimens known from Ventura County. Although not firmly dated, its morphology is consistent with lunate crescents found on Santa Rosa Island that date between about 11,800 and 11,500 cal B.P. (Erlandson et al. 2011). The fact that several other artifacts in the Shiner collection from the Simi Valley area appear likely to date to the Late Holocene, however, suggests the possibility that the Simi Valley crescent could have been an old artifact recycled by Chumash or Tongva people. This has been suggested elsewhere for zoomorphic crescents (Erlandson 2011; Fenenga 2010:38), but not to my knowledge for lunate crescents. According to Hudson and Underhay (1978:75–77), however, the Chumash considered the moon to be a female deity intermediate in power between the sun and earth; they closely monitored the phases of the moon and conducted prayers and ceremonies during the new (crescent) moon seeking "good health and good fortune," and used the crescent form as a symbol of the moon on ritual sunsticks. If the remnants of mastic found on just one side of the convex edge of the Simi Valley crescent are complete, they might suggest that this crescent—although probably of ancient manufacture—was hafted obliquely and reused for symbolic and ritual purposes by later Chumash peoples.

Considering that several early Milling Stone sites have been identified in the general area (e.g., CA-VEN-1, VEN-294, and VEN-853; see Erlandson 1994:228), it is equally possible (and perhaps more likely) that the Simi Valley crescent was collected from a site containing an Early Holocene or Terminal Pleistocene component. Similar lunate crescents have also been found in early sites scattered across the Far West—from the Pacific Northwest, through most of California and the Great Basin, and into northern Baja California (see Mohr and Fenenga 2010; Smith 2008; Tadlock 1966). The wide distribution of these artifacts argues for broad cultural links between early coastal and interior peoples in the Far West (see Beck and Jones 2010; Erlandson and Braje 2008). As early chronological markers and evidence for adaptive similarities and information exchange among early coastal and interior peoples of the Far West, it makes sense to carefully track the distribution of lunate and other crescents in Native North America. Given their broad geographic range and established antiquity, it would seem appropriate to include lunate crescents in continental digital archives such as the Paleoindian Database of the Americas (Anderson et al. 2010; see http://pidba.utk.edu/main.htm).

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REVIEWS

Grave Matters: Excavating California's Buried Past

Tony Platt
Berkeley: Heyday Books, 2011.
256 pp., 42 images and maps, bibliography, index, $18.95 (paper).

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Tony Platt's *Grave Matters: Excavating California's Buried Past* accomplishes many tasks that are frequently incompatible in the hands of other, less skilled writers and scholars. Platt has written a highly readable, engaging, and accessible account of several intertwined strands of history focusing on Humboldt County in northern California. His complex narrative is a thoroughgoing, critical analysis of both white settler colonialism in Humboldt County specifically and in California generally, as well as of the development of anthropological and archaeological scholarship with respect to the native peoples of California. This is an excellent and important book, particularly for the many readers (both academic and non-academic) who know very little about California's colonial history in the late nineteenth and early twentieth centuries. That so few know very much about these aspects of California's history says a great deal about the 'success' of the state's educational system, of dominant ideas in the popular media, and of scholars and scholarship in obstructing critical questioning about the colonization of western North America.

As I read the book, I tracked four thematic strands that Platt develops through an ongoing and focused attention on an extraordinary place, the Big Lagoon area of the Humboldt coast. Platt became a part-time resident of Big Lagoon in the late 1970s, and during his life there gained a deep appreciation for the Yurok, the native people whose ancestors have inhabited that region for a very long time. In his first two chapters, Platt provides a narrative homage to many things Yurok, written from the perspective of his decades-long association with the Big Lagoon area, and from the many affectionate memories of the place derived from his own life and the lives of his family members.

While Platt is evoking the unique beauty and ecological diversity of Big Lagoon, in the middle chapters of the book he also provides a vivid account of the history of white genocide inflicted on the native peoples of California, again with a focus upon the Humboldt region. Platt makes excellent use of native accounts of the war waged against them, and in this way acts as a conduit for native voices, rather than imposing his own perspectives. He cites the important historical works written by native scholars in the region that detail the campaigns waged against them; he also confronts official silence concerning the genocide, a silence that once dominated widely-accepted historical accounts of California's history. Platt cites these dominant histories to underscore how efforts to eliminate the native presence in California during the bloodshed of the nineteenth century was followed in the twentieth century by a campaign to erase that presence from the printed page that was just as determined.

Having followed the trail of genocide in Humboldt County, a chronicle that includes the grisly events of 1860 when hundreds of Wiyot Indians were massacred on Indian Island in Humboldt Bay, Platt then describes Native American activism during the twentieth century that responded to the desecration of graves and human remains and defended native ancestors and sacred places. The last three chapters of his book offer a concise and cautiously optimistic overview of the politics of native cultural reawakening in both Humboldt County and elsewhere in California, organized around the defense of native heritage. These chapters would be extremely instructive and useful for both upper-level undergraduate classes in anthropology and for first-year theory classes for graduate students in both archaeology and cultural anthropology.

Throughout the entire book, the themes of genocide, desecration of Native American graves and heritage, and native activism for the protection of that heritage, play out against a deeper backdrop of critical analysis that constitutes the fourth theme of Platt's book. I think this may be one of the book's most important contributions. Platt shows in detail that both anthropology and archaeology participated in depredations against Native American living and dead in the state of California—particularly against the dead. In an even-handed, nuanced, and careful manner, Platt describes the involvement of very well known—indeed central—figures in the development and growth of the Department of Anthropology at the University of California, Berkeley, in archaeological and ethnological research that was neither planned nor carried out with the interests or values of California Indian communities in mind—to say the least. These figures included Alfred Kroeber, Robert Heizer, and Edward Gifford. Platt is very mindful of the complexity of these anthropologists' careers, and how they—particularly Heizer, but to a certain extent Kroeber as well—were also critical of their own role in the disenfranchisement and erasure of Native Californian peoples, and later realigned with efforts at rectifying past wrongs. While this tale of anthropology's association with the destruction of California Indian peoples is well told, Platt also points out that the establishment of archaeology and anthropology as academic disciplines, particularly at Berkeley, but no doubt elsewhere as well, involved a deep complicity between academics on the one hand, and amateur archaeologists on the other. Amateur excavators were on the front lines of the destruction of Native American graves and sacred sites. Indeed, Platt's narrative reveals just how close the relationship between the professionals and the amateurs was for many years. Once again, the site of the massacre on Indian Island was ground zero for the most extreme forms of genocidal conduct towards native peoples in Humboldt County, as both amateur and academic excavations plundered the final resting places of the Wiyot victims.

I highly recommend this book for classroom use at both the undergraduate and graduate levels. It is also a very useful tool for raising the consciousness of the general public both in California and elsewhere about the historical and contemporary experiences of native peoples in this state.

All Indians Do Not Live in Teepees (Or Casinos)

Catherine C. Robbins

Lincoln and London: University of Nebraska Press, 2011, 385 pp., 24 b/w illustrations, 1 map, $26.95 (paper).

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Get beyond the cutesy title and you'll find a book that wants to be taken seriously.

Independent journalist Catherine Robbins is to be commended for taking on what most anthropologists shun: an assessment of the current state of Native American politics, economics, and culture. Later this year, we will get the results of the first United Nations' investigation of American compliance with standards embodied in the U.N. Declaration on the Rights of Indigenous Peoples. Some of the same subject matter is covered in *All Indians*, an exploration of "contemporary American Indians and how modernity and a restorative vision of the past have generated a new energy among them."

All Indians is written in a brisk, readable style and is framed around detailed vignettes of everyday life. By aiming her book at uninformed "non-Indians" who think of Native Americans as either getting fat off casinos or being stuck in the uncivilized past, Robbins sets the intellectual bar pretty low. But despite her disclaimer that "readers might find that information is sometimes wanting or insufficient," footnotes and a bibliographic essay promise something more than anthro-lite.

It's an ambitious book, organized into self-contained chapters on the status of post-NAGPRA repatriation; the place of homelands in the native imagination; the social and personal ravages of inequality; battles over science and cultural beliefs; sovereignty and gaming issues; and cultural renewal in ceremonies, music, and the arts. Robbins' ground-level reporting on a repatriation ceremony in Pecos, the annual Gathering of Nations in Albuquerque, the art scene in Santa Fe, and hybrid Christmas ceremonies in San Felipe Pueblo is sharply observed, textured, and evocative.

Robbins doesn't shy away from such disturbing topics as historical injustice, harrowing poverty, alcohol and sexual abuse, high dropout and suicide rates, alarming health problems, and "hard evidence of despair." But that's not her main focus. There's a persistently hopeful thread running through the book, emphasizing a "spirit of collaboration across Indian country" and the renewal of Native Americans as "weavers of their destiny."

The author's insistence on wanting to tell a positive story sometimes gets in the way of offering a more complicated and contradictory analysis. For example, she focuses on NAGPRA as a means of cultural recovery, and sidesteps how the promising legislation has become mired in bureaucratic wrangling and is a source of immense frustration to tribes and native communities. Similarly, Robbins welcomes the Smithsonian's National Museum of the American Indian as a high point in "Native cultural expression," but minimizes its failure to adequately deal with the destruction by disease, warfare, massacres, starvation, and humiliation experienced by three-quarters of the indigenous peoples of the continent.

The book opens with a map of the United States that gives an impression that Robbins' scope is far ranging. But *All Indians* primarily focuses on the Southwest, especially New Mexico, the site of the author's home for many years. Here, writing from personal experiences, she has a sure-footed feel for place and people. However, when the book moves on to other regions and national issues, it loses traction.