Title
Prehistoric Use of the Coso Volcanic Field

ISBN
1-882744-09-8

Authors
Gilreath, Amy J
Hildebrant, William R

Publication Date
1997

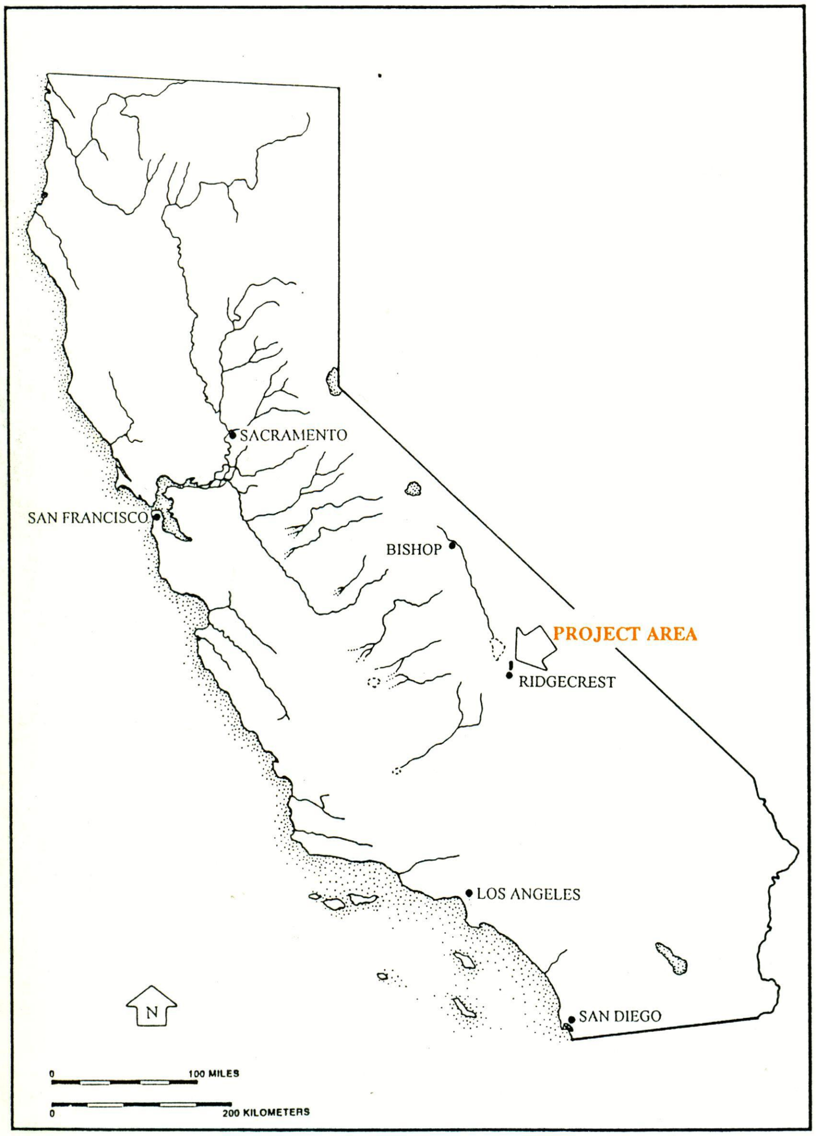
CONTRIBUTIONS OF THE UNIVERSITY OF CALIFORNIA
ARCHAEOLOGICAL RESEARCH FACILITY

NUMBER 56 AUGUST 1997

PREHISTORIC USE OF THE COSO VOLCANIC FIELD

by
AMY J. GILREATH
and
WILLIAM R. HILDEBRANDT

UNIVERSITY OF CALIFORNIA AT BERKELEY



ISBN 1-882744-09-8

PREHISTORIC USE OF THE COSO VOLCANIC FIELD

by
AMY J. GILREATH
and
WILLIAM R. HILDEBRANDT

1997

NUMBER 56
CONTRIBUTIONS OF THE UNIVERSITY OF CALIFORNIA
ARCHAEOLOGICAL RESEARCH FACILITY
BERKELEY

Available open access at:
www.escholarship.org/uc/item/51d4w31p

Library of Congress Catalog Number 97-61421

ISBN 1-882744-09-8

Archaeological Research Facility

University of California at Berkeley

Printed in the United States of America.

PREFACE

CalEnergy, Inc., today operates four geothermal power plants and maintains over 70 supporting wells in the Coso Known Geothermal Resources Area (KGRA) of China Lake Naval Air Weapons Station in southern California. Between 1986 and 1993, the authors directed numerous archaeological studies within the Coso KGRA, to support CalEnergy's efforts to comply with federal and state historic preservation law and policy. Many technical reports of these studies are filed with regulatory agencies. These reports typically are extremely descriptive, very dry, and filled with compliance jargon. Their distribution is, unsurprisingly and mercifully, restricted. Our enduring motivation for writing this monograph was to share the noteworthy results of "compliance archaeology" studies in this fascinating part of the western Great Basin with you, the interested public.

Many preceding studies at Coso helped lay the groundwork for this report, and a brief history of the studies is in order here, identifying the most substantive ones. Cultural studies related to geothermal development at Coso began in the late 1970s with an ethnographic and historic overview of Coso Hot Springs (Iroquois Research Institute 1979). Soon thereafter, Clewlow et al. (1980) conducted a sample survey of the KGRA, providing data necessary to develop a predictive model of site density across variable environmental settings. Numerous small-scale studies were then accomplished as prospective developers began exploratory drilling in the early 1980s. Most of this early work was by Intermountain Research (e.g., Drews and Elston 1983; Elston and Zeier 1984; Elston et al. 1981; Zeier and Elston 1984), and focused on obsidian acquisition patterns across time and space. In the late 1980s and early 1990s, exploration accelerated. The roster of archaeologists working in the KGRA expanded, and is reflected by the number of reports filed, such as Botkin et al. 1987, Cleland et al. 1990, Gilreath and McGuire 1987, Kelly et al. 1989, and W&S Consultants 1985, 1986a, 1986b. Once exploration determined that full-scale geothermal development was viable, small-scale studies were replaced by extensive surveys blanketing over 15,000 acres (Gilreath 1987, 1988; Gilreath and Hildebrandt 1988; Gilreath et al. 1991; Hildebrandt and Gilreath 1988).

CalEnergy's preliminary development plans were then overlaid on archaeology base maps. Where feasible, construction and project designs were redrawn to avoid sites and minimize disturbance to others. In the end, all or portions of 34 prehistoric sites required excavation. This report describes the results of those excavations. Under ideal circumstances, sites might have been chosen for investigation based on a strategy designed to obtain a representative sample of the full range of site types present. Although geothermal development plans in large part determined the sites investigated, we were fortuitous in obtaining robust samples of both quarry and off-quarry sites. The reader interested in individual site reports and/or analytical raw data is directed to a three-volume report by Gilreath and Hildebrandt (1995), filed with the Eastern Information Center of the California Historic Resources File System, of the California State Office of Historic Preservation. Volume I is similar in many ways to the report in hand, but necessarily describes the project within the cultural resources management regulatory framework. Individual site reports are presented in Volume II. Volume III includes analytical raw-data appendices for projectile points, other flaked stone artifacts (e.g., bifaces, cores, flake tools, etc.), ground and battered implements (e.g., handstones, millingstones, cobble tools, etc.), and faunal remains. Excavation unit summaries are also provided, and obsidian sourcing (X-ray fluorescence) and obsidian hydration analyses conclude the appendices.

ACKNOWLEDGMENTS

Completing an archaeological project of this magnitude is quite a challenge. Many people have contributed to the effort, beginning with project planning, continuing through multiple seasons of field work, and concluding with years of analysis and write-up. Carolyn Shepherd (China Lake Naval Air Weapons Station) was a primary player throughout the process. She was instrumental in developing this study and, through determined interactions with numerous parties, made sure we were able to finish the work. Her enduring patience was always welcomed. CalEnergy, who financed the undertaking, also deserves a great deal of credit. Dave McClain and Phil Essner are commended for their efforts to incorporate archaeological concerns into the development process. Greg Halsey, with the help of Jony Homer and Becky Baker, assisted in all aspects of the project, ranging from field logistics to budgetary concerns. Laurie McClenahan (MHA Environmental Consulting, Inc.) and Jean Hopkins (formerly of MHA) developed the environmental documents necessary for our work to go forward; we appreciate their efforts. We also thank Rob Jackson (then of the State Office of Historic Preservation) and Joan Oxendine (Bureau of Land Management) for their assistance during early phases of the project.

Many people participated in the field effort, working hard under a wide range of climatic conditions. We thank Laura Barrett, John Berg, Gary Buck, Kimberly Collins-Roscoe, Jerry Doty, Willie Duddles, Rick Fitzgerald, Mark Giambastiani, David Glover, Leslie Glover, Glenn Gmoser, Larry Hause, Jeff Hall, Jennifer Hider, Liz Honeysett, Cristi Hunter, Mark Hylkema, Marilyn Jasmain, Robert Jobson, Kirk Johnson, Bob Johnson, Debbie Jones, Ed Kaler, Eric Kaufmann, the late Ron King, Jan Lawson, the late James N. Leavitt, Susan McCabe, Kelly McGuire, Pat Mikkelsen, Rochelle Mink, Peter Mundwiller, Jim Nelson, Daryl Noble, Bill Norton, Traci O'Brien, Matt O'Connell, Jill Onken, Rex Palmer, Cindy Park, Bert Rader, Allise Rhode, D. Rogers, James Roscoe, Kristina Roper, Gary Sauer, Barry Scott, Jill Shannon, Bill Slater, Linda Sickler-Hylkema, Bill Stillman, Chris Sublett, Miranda Warburton, Laurie Walsh, Brian Wickstrom, Glen Wilson, and Eric Wohlgemuth.

We are grateful to all involved with analysis and report preparation, including Marguerite Badovinac, Kevin Bell, John Berg, David Boe, Chris Carter, Bill Combs, Jerry Doty, Deborah Dyer, Jelmer Eerkens, Christine Franco, David Glover, Leslie Glover, Carl Hansen, Susan Harris, Jennifer Hider, Liz Honeysett, Cristi Hunter, Kandi Gillespie, Martha Jackson, Eric Kaufmann, Joe Mayeux, Bill Norton, Jessie Piper, Jennifer Richman, Barry Scott, Paul Strader, Krislyn Taite, Nnika Tinney, Sharon Waechter, Patricia Welsh, and Derek Wheeler. We especially appreciate the efforts of Eric Wohlgemuth throughout this project, leading excavation crews, directing laboratory studies, and contributing his ethnobotanical expertise. Finally, we thank Tammara Ekness and Peter Mundwiller for their fine graphics work, and Michael Delacorte for sharing information from ongoing projects.

The authors particularly appreciate Robert Bettinger and William Clewlow, Jr., for their efforts reviewing, editing, and discussing an early draft version. We thank two anonymous peers for the time and attention they paid our revised draft. Comments they provided made us work harder at strengthening certain aspects of this monograph, and we are much obliged for their efforts.

ABSTRACT

Excavations at 34 sites in the Coso Volcanic Field reveal a dynamic history of obsidian use spanning at least 10,000 years. Obsidian is common and abundant throughout the area, both in primary and secondary contexts. Secondary lag deposits are widely distributed due to numerous pyroclastic eruptions that sent obsidian nodules and other debris over much of the local landscape. Primary flows, though less numerous and of more difficult access, have greater quantities of material, often forming thick bands of glass extruded from the sides of rhyolite domes. Dated primarily on the basis of obsidian hydration, analysis of over 90 chronologically discrete assemblages indicates that prior to 2800 B.P., use of the area was largely restricted to generalized, short-term exploitation of lag quarries by groups using an expansive, highly mobile subsistence-settlement system. Beginning around 2800 B.P., but reaching peak proportions between 2300-1275 B.P., a major reorganization in production strategy took place. Lag quarries were essentially ignored, and primary flows were intensively exploited, supplying obsidian to a corresponding proliferation of off-quarry biface manufacturing areas. Increases in production volume were at least partially related to long distance exchange. Contemporaneous parallel increases in Coso obsidian use among consumer populations in the Owens-Rose Valley area, southern Sierra Nevada and, more importantly, several locations in coastal southern California provide evidence of this exchange. Contrary to expectations of some, development of obsidian surpluses for exchange did not correlate with the emergence of sedentary populations and local control of the source. Rather, subsistence-settlement pattern data from surrounding areas indicate that residential mobility remained relatively high, but followed a more regularized schedule, allowing more predictable interactions among neighboring populations.

Local control of the Volcanic Field appears to have occurred for only a short period between ca. 1275-800 B.P., co-occurring with a reduction in settlement mobility region-wide. During this short period, flaked stone production became largely restricted to few primary deposits, even though obsidian consumption continued unimpeded in outlying areas. After 800 B.P., continued decreases in settlement mobility, often accompanied by higher degrees of territoriality, did not lead to an expanded inter-regional exchange system. Instead, production and exchange of Coso obsidian items essentially stopped, and the Volcanic Field was used for subsistence, largely the exploitation in unprecedented proportions of small seeds. Collapse of the Coso production-exchange system is attributed to decreased demand caused by a variety of factors including technological change and a shifting subsistence focus, while increases in territoriality may have inhibited its supply, not only by restricting direct access, but also by increasing the number of exchanges required to move material equivalent distances across the land.

TABLE OF CONTENTS

CONTENTS - Continued

CONTENTS - Continued

LIST OF MAPS

LIST OF FIGURES

CONTENTS - Continued

LIST OF PLATES

LIST OF TABLES

CONTENTS - Continued

CHAPTER 1: INTRODUCTION

This report summarizes recent archaeological excavations in the Coso Volcanic Field, Inyo County, California (Maps 1 and 2). Administered by China Lake Naval Air Weapons Station, the area is characterized by vast deposits of naturally occurring obsidian that were extensively quarried throughout prehistory. It also contains a great underground reservoir of super-heated water, currently evident at active fumaroles. In addition to providing hot springs used by both prehistoric and historic peoples, the reservoir has been developed and generates enough electricity for over 240,000 urban dwellers.

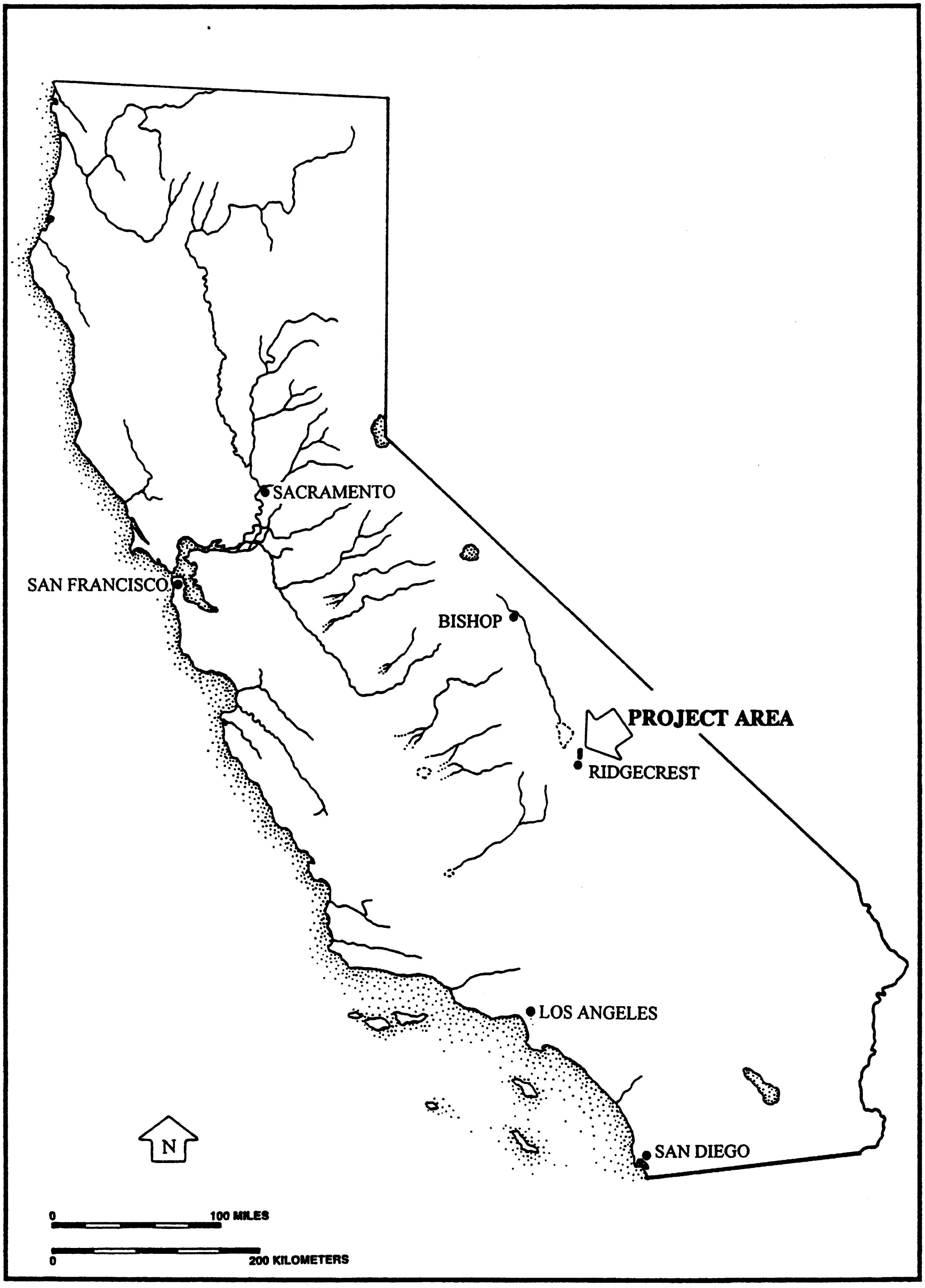
Known sites in the Coso Volcanic Field include about 150 quarry sites, identified as such by the natural presence of workable obsidian, 300 off-quarry sites, and 100 segregated reduction locations. This report presents results of excavations at 34 of 62 prehistoric sites within part of the Coso Volcanic Field (Map 3, Table 1). The sites investigated include 20 quarries and 14 off-quarry sites, but no segregated reduction locations. It is apparent from previous descriptions of these segregated reduction locations, where one or several cobbles were reduced to a few cores and/or bifaces, that the reduction activities at them differed only in intensity, not in kind, from activities carried out at quarry and off-quarry sites. Consequently, their absence in our data base is of minimal importance since it creates little interpretive biases. Of the 11 prehistoric site types identified in the Coso Volcanic Field, our data base includes at least one example of all but one of these types (Table 2). Brief Encampments are the most common type of off-quarry loci in the Volcanic Field; over half of the off-quarry sites we investigated were previously classified to this type (Table 2). Perfunctory Quarries are the most common type of quarry loci; nearly half of the quarries studied here were of this type. In a general sense, then, the sites excavated and described herein, include a variety of site types, with those most prevalent, best represented. Excavations were extensive (435.4 m^3). Combined with surface collection, over 7,500 artifacts and 185,000 pieces of debitage were recovered.

Table 1. Excavated Sites.

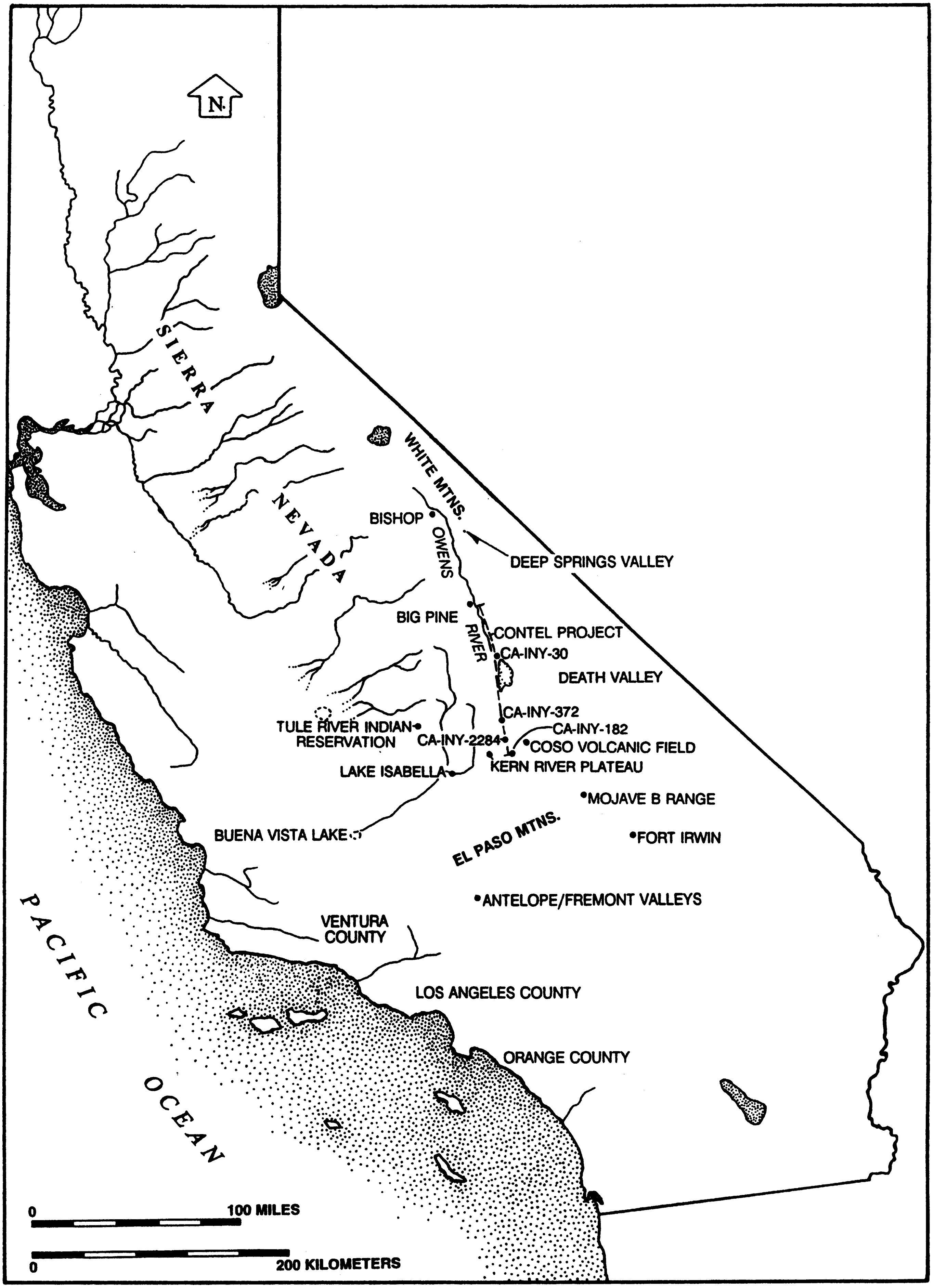
Site Number	Site Number	Site Number
INY-1816	INY-3015	INY-4320
INY-1824 Main	INY-3299	INY-4322/H
INY-1824-B	INY-3300	INY-4324/H
INY-1824-X	INY-3456	INY-4325
INY-1906	INY-4239	INY-4327
INY-1907	INY-4240	INY-4328
INY-1984	INY-4243	INY-4329
INY-2103	INY-4244	INY-4330
INY-2825	INY-4246	INY-4331
INY-2826	INY-4252	INY-4378
INY-3004/3005	INY-4267	
INY-3012	INY-4319	

NOTE: California State Trinomial site designations are employed.

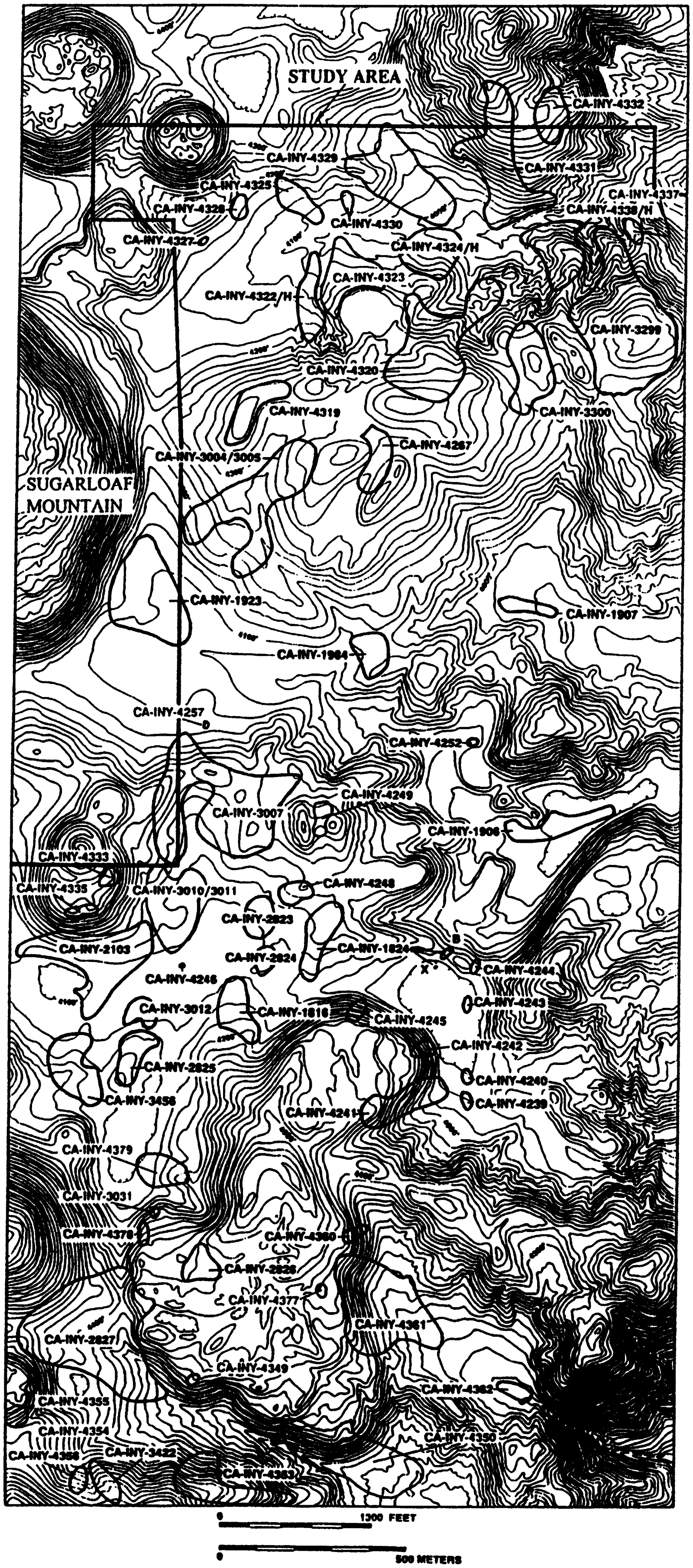
This volume begins with a summary of our research goals, outlining the outstanding issues addressed by the study (Chapter 2). Field and analytical methods follow, summarizing approaches to excavation, artifact classification and sampling, and other procedural matters (Chapter 3). The next five chapters present data directly corresponding to the research issues outlined in Chapter 2. These include a review of critical local and regional environmental variables (Chapter 4), development of a local chronological sequence (Chapter 5), a diachronic accounting of lithic production activities (Chapter 6), and an evaluation of how these activities related to patterns of subsistence and settlement (Chapter 7). Finally, Coso obsidian and its relevance to prehistoric exchange patterns is addressed in Chapter 8, followed by a synthesis of important project findings (Chapter 9).



Map 1. Project Location.



Map 2. Important Project Locations in the Region.



Map 3. Prehistoric Sites in Study Area.

Table 2. Types of Loci Investigated.

	Coso Volcanic Field		Sample Excavated	
	No.	%	No.	%
Quarry Loci/Sites				
Limited Residential Quarry	34	18.6	5	26.3
Perfunctory Quarry	131	71.6	9	47.3
Quarry Location Encampment	13	7.1	3	15.8
Large Lag Quarry	3	1.6	1	5.3
Quarry Milling Zone	2	1.1	1	5.3
Subtotal	183	100.0	19	100.0
Unclassified/Unknown	50	--	2	--
Off-Quarry Loci/Sites				
Brief Encampments	247	69.5	17	56.7
Limited Habitation Encampments	35	9.9	7	23.3
Production Station	11	3.1	2	6.7
Milling Camp	13	3.7	3	10.0
Isolated Feature/Milling Station	49	13.8	1	3.3
Subtotal	355	100.0	30	100.0
Unclassified/Unknown	54	--	1	--
Segregated Reduction Loci	89	--	--	--

NOTE: Many sites contain multiple loci.

CHAPTER 2: RESEARCH ISSUES

The major goal of this project is to monitor the prehistoric production, use, and exchange of Coso obsidian, and determine the relationship of these activities to other socio-economic developments in the region. To achieve this goal, several research problems have been developed. Derived from previous studies in eastern California and similar projects conducted in other parts of the world, these issues reflect current perspectives in hunter-gatherer research as applied to prehistoric use of obsidian-rich environments. The first of four issues considered is the area's environmental productivity, both in terms of hard resources (e.g., obsidian) and soft resources (e.g., food). The second research problem revolves around chronology and determining the age of project sites. Documenting prehistoric lithic exploitation patterns is the third problem domain. The final issue concerns subsistence and settlement practices.

ENVIRONMENTAL PRODUCTIVITY

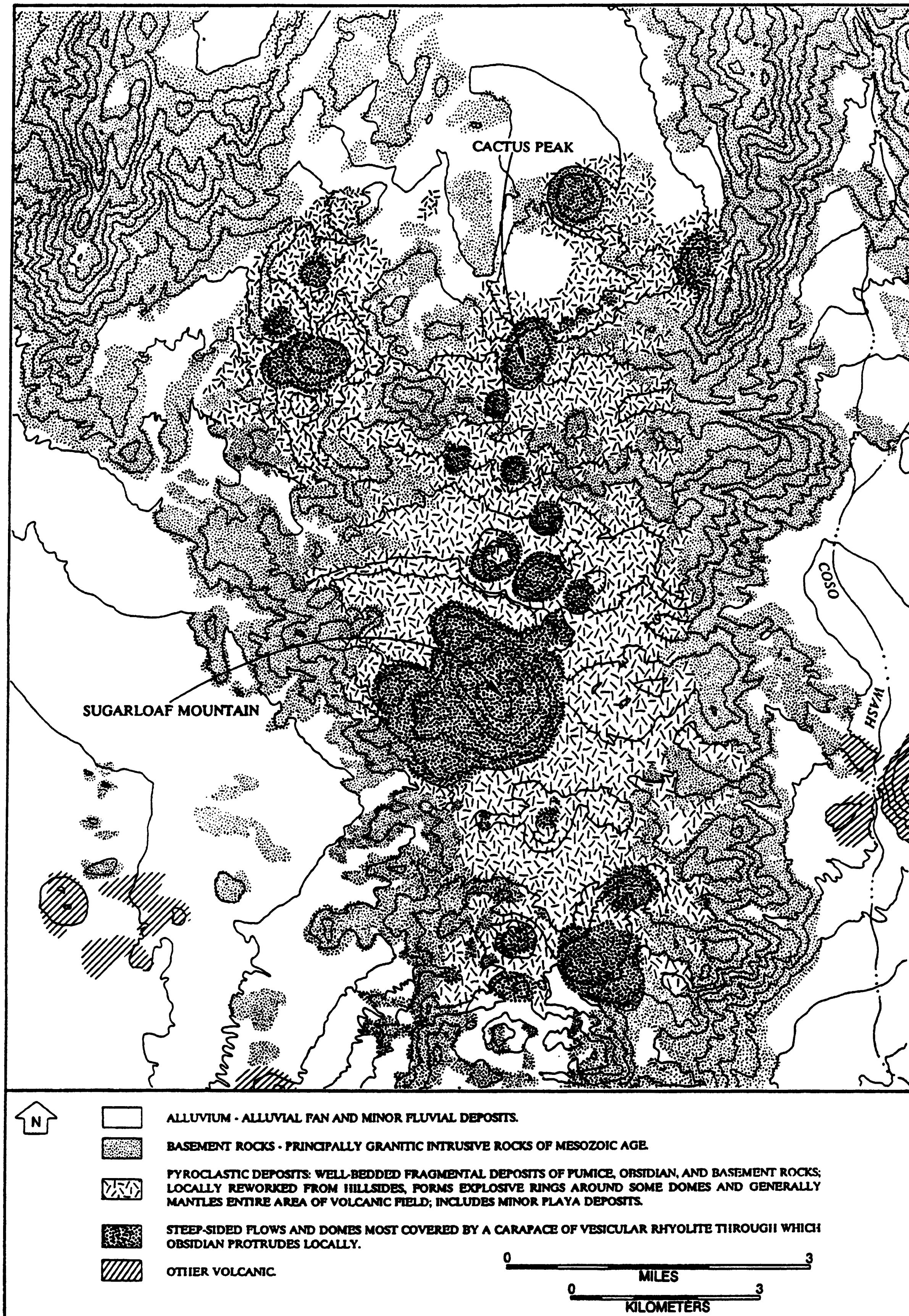
The Coso Volcanic Field lies in the southwestern portion of the Coso Range, east of the Sierra Nevada, south of Owens Valley, west of the Argus Range, and north of Indian Wells Valley (Map 2). It is characterized by numerous explosion craters, rhyolitic domes, debris flows, and pyroclastic deposits, most originating from volcanic events that occurred between 1.5 million and 33,000 years B.P. (Map 4; Duffield et al. 1980). Most of the original basement rock consists of Mesozoic granitics which protrude the more recent volcanic material in the form of sporadic, discontinuous ridge systems. Pyroclastic fallout fills most of the small valleys that have formed between the ridges and domes, creating a landscape that clearly reflects its violent past. Due to the complexity of these multiple volcanic events, many of the valleys have been enclosed, resulting in several small, internally drained playas.

Naturally occurring obsidian is abundantly present throughout the Coso Volcanic Field, and available from a variety of contexts. Survey of approximately 24,000 acres has identified over 150 quarry sites (Gilreath and Hildebrandt 1991). These include several primary outcrops of glass flowing from the sides of steep rhyolitic domes, with high quality obsidian often occurring as large boulders and slabs. Most of these are on Sugarloaf Mountain where many tons of high quality material are still available. The most impressive of this group was originally termed the "Colossal Quarry" by Harrington (1951) and described as:

> More than two miles of ancient diggings, plainly visible along the edge of the bluff! A hillside covered with hundreds of tons of obsidian quarry refuse left by prehistoric workers! It did not seem possible, yet there it was... We stood there in amazement that day ...thinking of the innumerable human hands, the countless generations that must have been required to produce such a result [1951:15].

Secondary quarries occur as obsidian float in major debris flows or in concentrations of air fall sporadically scattered across the land during volcanic eruptions. These quarries are numerous and usually more accessible than the others. They vary from small pockets that could have been played-out during a single visit, to extensive nodule scatters encompassing tens of acres. The amount of useable obsidian in the most extensive secondary deposits, however, seems inconsequential when compared to the amount at extensive primary quarries. These secondary quarries occur on ridgetops, exposed as lag after fine-grained sediments have eroded away (Elston and Zeier 1984). The obsidian ranges from pebbles to cobble-sized fragments reaching 30 cm in diameter. Every major natural obsidian deposit discovered during survey was exploited (i.e., contains chipping debris), but there are many tons of useable obsidian still available both at primary and secondary deposits.

Subsistence resources are less abundant. Owing largely to the rain shadow effect of the Sierra Nevada, precipitation averages only 14 cm (5 in.) per year, with the majority (75%) occurring between December and March (Troxell and Hofman 1954). Convectional thunderstorms originating from the Southwest and Gulf of Mexico provide additional moisture from July through October, however, potential evapotranspiration exceeds annual



Map 4. Geologic Map.

precipitation by a wide margin, resulting in a sparse vegetative cover of Mojave Creosote Bush Scrub, Mojave Mixed Woody Scrub, and Desert Saltbush Scrub (Billings 1951; Leitner and Leitner 1988; Thornthwaite 1948). A wide range of plant and animal resources were exploited within these environmental zones, but their availability varied considerably from one season to the next, and from year-to-year depending on local climatic conditions. To evaluate the importance of these resources, and ultimately determine their influence on long-term strategies of subsistence and settlement, it is first necessary to measure local resource abundance and diversity relative to that of surrounding regions (e.g., the well-watered lands of Owens Valley). This will be accomplished through tracing the distribution of local vegetation communities (Leitner and Leitner 1988) and translating this information into measures of plant and animal productivity. Successful completion of this process requires review of ethnographic accounts of subsistence technology and ecological data concerning seasonal and annual cycles in resource productivity. Much of this work has already been completed by Delacorte (1990) who organized particular habitat zones common to eastern California into seasonally specific resource packages. Combining each package with the most-likely techniques used in their exploitation allows estimates of search, pursuit, and processing costs for each, and ultimately an overall ranking of the various environmental circumstances existing in the region.

CHRONOLOGY

Our ability to place prehistoric sites in their temporal context is prerequisite to developing a use-history for the Volcanic Field. Because we want to know when the area was occupied, if occupational intensity and focus changed through time, and if diachronic variability in obsidian exploitation patterns existed, we want to estimate the age of as many sites as possible. The nature of the prehistoric record within the Volcanic Field is such that only three dating techniques are useful in positing age estimates: radiocarbon assay, cross-dating of diagnostic artifacts, and obsidian hydration.

RADIOCARBON DATES FROM THE VOLCANIC FIELD

Unfortunately, prehistoric cultural deposits containing organic residues are the exception, not the rule, within the Volcanic Field. True midden deposits have accumulated at very few locations, and structural remains are equally rare. Consequently radiocarbon samples are primarily obtained from hearths, roasting pits, and other such comparatively small features. Furthermore, rarely are such features discovered in buried context. An inordinately high percentage of those features excavated in the Volcanic Field could be seen on the ground, suggesting in and of itself that they are fairly recent. Notwithstanding these problems of visibility, an occupational history of the Volcanic Field reliant on the radiocarbon dates would also, in effect, document when specific kinds of activities involving hearth usage occurred, but those episodes need not have been in phase with activities related to stone working.

CROSS-DATING OF DIAGNOSTIC ARTIFACTS FROM THE VOLCANIC FIELD

Prehistoric artifacts from the Volcanic Field most amenable to cross-dating include projectile points, several types of beads, and pottery. Projectile points occur at more sites than either beads or pottery, but only about 150 have been discovered.

Stating what many North American archaeologists before them had come to conclude, Heizer and Hester wrote "projectile points are subject to distinctive morphological variation through time, and these changes have made them extremely important as 'time markers' (the 'historical-index' types of Steward 1954)...no one can deny the value of projectile point types as guides to the chronological ordering of prehistoric cultural development" (1978:153). By compiling lists of radiocarbon dated deposits in the Great Basin where various projectile point types had been recovered, Heizer and Hester reaffirmed that different styles occurred during different intervals, and offered temporal ranges for various commonly recognized types: Pinto, Humboldt, Elko, Rose Spring, Eastgate, Desert Side-notched, and Cottonwood, among others.

In seeking to develop a local chronological sequence for Monitor Valley, Nevada, Thomas (1981) devised a classification scheme for projectile points that relied on a variety of metric attributes. This approach served to remove much of the subjectivity from classifications, and allowed researchers working with different collections to directly compare the morphological characteristics of their points to those found elsewhere. The Monitor Valley projectile point chronological sequence has come to serve as a standard for cross-dating points throughout the Great Basin.

Several years ago, Flenniken and Raymond made the observation that "the contingencies of point manufacture, hafting, use, and rejuvenation create morphological changes that may render questionable use of these morphological typologies as prehistoric cultural markers" (1986:603). In the course of repairing a break, the morphology of the point may change such that the repaired one ill-conforms to the ideal type. This rather plain observation has generated considerable debate (Bettinger et al. 1991; Flenniken and Wilke 1989; Thomas 1986; Wilke and Flenniken 1991) regarding the degree to which reworking is of concern to chronology: is there evidence that prehistoric individuals actually did rework broken points in a fashion that mutes their veracity as chronological markers; are particular types of projectile points more susceptible/amenable to reworking than others? The argument has expanded, since, to question the temporal placement of dart-points (special emphasis given to Elko, Little Lake, Gypsum, and Humboldt series) in the Great Basin, with one side contending that various types are derivatives of one another (changing form during the use-life of the artifact), and that the types are not consecutively occurring temporally diagnostic forms, rather they co-exist in deposits ranging from 8500-1500 B.P. (Flenniken and Wilke 1989). The other side maintains that they are temporally consecutive types that serve as chronological markers (Bettinger et al. 1991).

Data from the Coso Volcanic Field may provide some insight into this issue. The projectile points recovered from the Volcanic Field will be described in a fashion consistent with the Monitor Valley projectile point key (Thomas 1981), and referenced using the point type nomenclature that has developed in the archaeological literature for the region. Hydration rim values recorded on the projectile points will be presented, and used to independently evaluate the temporal significance of morphologically distinct types.

OBSIDIAN HYDRATION DATING IN THE COSO VOLCANIC FIELD

That moisture penetrates volcanic glass at a predictable and, hence, quantifiable rate is at the foundation of obsidian hydration dating. The assumption holds that the hydration rind on a surface of an obsidian flake broken off from the parent mass some 2000 years ago will be consistently wider than the rind on a flake broken from the same piece only 1000 years ago, all else being equal. Since the inception of obsidian hydration studies in North America, Coso glass has commonly been a subject of discussion, resulting in it being one of the most thoroughly investigated obsidians in North America.

Friedman and Smith (1960) were the first to recognize the chronometric potential of obsidian. Their initial study concluded that: (i) "hydration thickness increased as the square root of time, (ii) the rate was independent of relative humidity but increased with temperature, and (iii) the chemical composition of the obsidian appeared to affect the rate" (Friedman and Long 1976:347). Picking up where the initial study left off, and through a series of experiments, Friedman and Long concluded: "it is possible to calculate the hydration rate of a sample from its silica content, refractive index, or chemical index and the knowledge of the effective temperature at which the hydration occurred" (1976:347). These and other potentially key variables have been the focus of many subsequent studies.

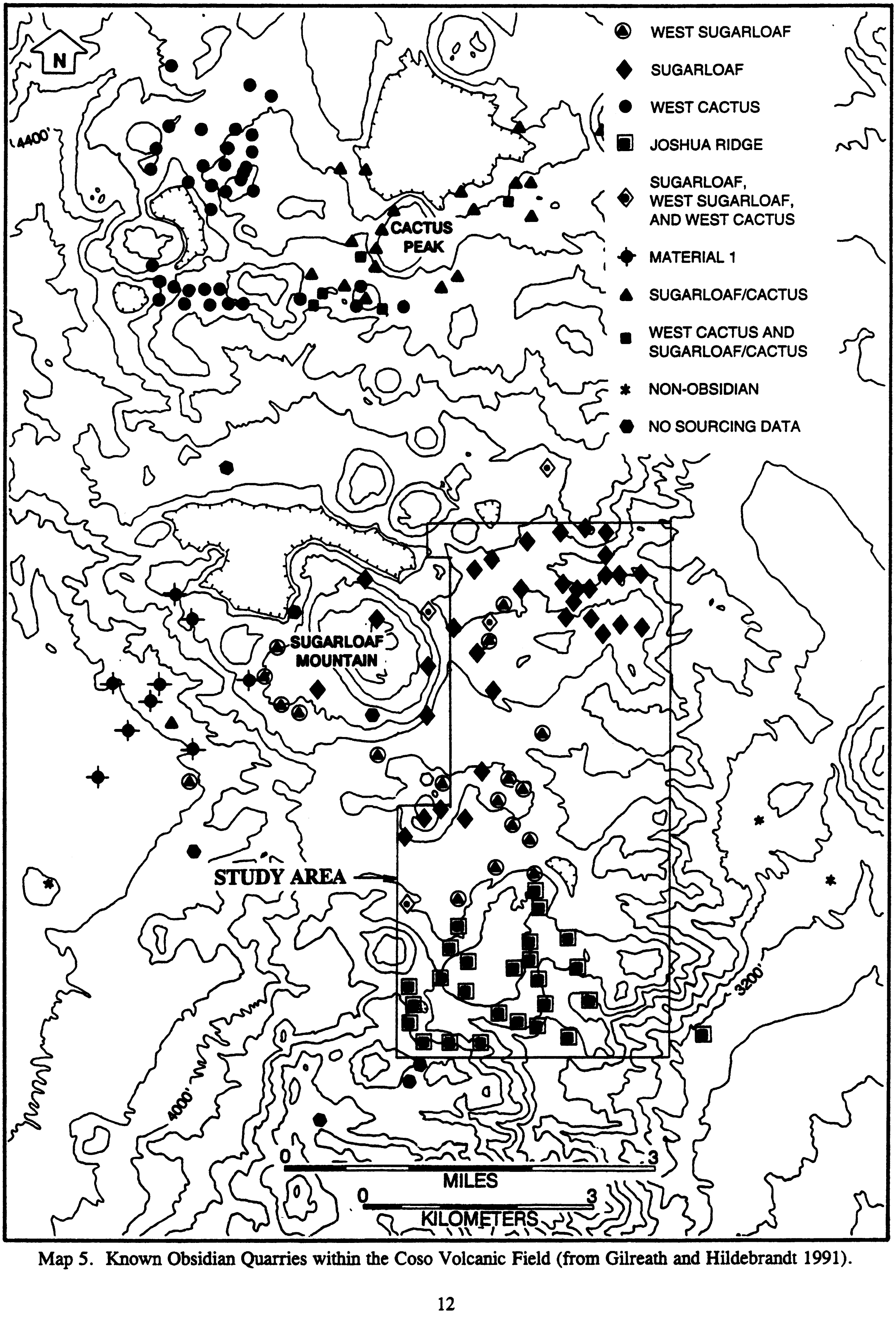
In developing a hydration rate for Coso glass at the source, Zeier and Elston (1984) made pioneering attempts to control for temperature variability, giving consideration to such factors as ambient air temperature, ground surface temperature, slope, exposure, vegetation canopy, and elevation. Their results were far from conclusive regarding many of these conceivably influential factors, but they were able to adequately reaffirm that effective hydration temperature (EHT) greatly influenced hydration rates. Ambrose cells placed in the Sugarloaf Mountain area verified that the EHT was high compared to many other parts of California and the Great Basin, and quite variable within the Volcanic Field.

Hughes (1988) and Ericson (1989) have spent considerable energy examining obsidian geochemical variability within the Volcanic Field. In spite of early geological studies that showed obsidian was available at numerous localities within the field (Bacon et al. 1981, 1982; Duffield and Bacon 1981; Duffield et al. 1980; Lamphere et al. 1975), early archaeological sourcing research was satisfied to recognize "Coso" as geochemically distinct from other major obsidian sources in eastern California and Nevada. Interest in the magnitude of intra-field geochemical variability grew in response to increasing appreciation of the fact that glass from different sources absorbs water at differential rates. To study intra-field variability at Coso, Hughes processed samples from 15 locations, and discriminated four groups based on differing ratios of rubidium (Rb) and zirconium (Zr): West Sugarloaf, Sugarloaf, West Cactus Peak, and Joshua Ridge. Map 5 (taken from Gilreath and Hildebrandt 1991) shows the distribution of recorded obsidian quarries in the Volcanic Field. West Sugarloaf glass occurs in the south-central portion of the project area, and Sugarloaf in the northern half of the project area. West Cactus and Joshua Ridge quarries occur at the northern and southern ends of the Volcanic Field, respectively. Having shown that these four subgroups have different chemical indices (Hughes 1988:Table 4), he concluded that "each of them should hydrate at a slightly different rate" (Hughes 1988:262). Regarding prehistoric exploitation of the obsidian available in the Volcanic Field, his analysis of projectile points found at the Rose Spring (CA-INY-372) and Stahl (CA-INY-182) sites, which are located within 12 km of the Volcanic Field and each other, suggested West Sugarloaf and Sugarloaf deposits were more heavily utilized in prehistoric times than either West Cactus or Joshua Ridge deposits. Sourcing data from the Lubkin Creek site (CA-INY-30 [Basgall and McGuire 1988]) provided additional support for this pattern, with comparatively few West Cactus or Joshua Ridge specimens identified in archaeological materials.

The prevalence of West Sugarloaf and Sugarloaf obsidian in prehistoric sites prompted subsequent hydration and sourcing investigations to concentrate on these two subgroups, largely ignoring West Cactus and Joshua Ridge. In an attempt to independently verify the geochemical distinctiveness of West Sugarloaf and Sugarloaf glass, Bouey (1991) re-analyzed 30 archaeological artifacts that had been previously ascribed to these two subgroups, and found that many rubidium/zirconium ratios fell outside of the 95% confidence intervals Hughes (1988) delimited that distinguished one from the other. Bouey offers two explanations for why his results diverged from Hughes': (1) Hughes' study may have suffered from inadequate sample size (i.e., had Hughes used larger sample sizes and/or more sampling localities, he might have documented more variability and hence greater overlap between the two subgroups); and (2) the geochemical fingerprinting technique is simply not precise enough to render such accurate distinctions. Comparatively simple factors that influence precision include "slight alterations in sample surface configuration and placement" relative to the angle at which the X-ray diffraction beam strikes the artifact or flake's surface (Bouey 1991:309).

We will leave to others the issue as to whether analytical techniques are accurate enough to distinguish true West Sugarloaf glass from true Sugarloaf specimens. However, an important chronological issue remains: does intra-field geochemical variability influence the rate of hydration in a fashion that we need concern ourselves with? Data from the Lubkin Creek site have been summarized (Basgall 1990; Basgall and McGuire 1988) to address this specific question. At that site south of Lone Pine, artifactual specimens of West Sugarloaf and Sugarloaf glass were recovered together in some of the most intact depositional contexts imaginable. In two cases, tool caches were found on the floors of burned prehistoric houses. As Table 3 shows, hydration measures on co-associated West Sugarloaf and Sugarloaf specimens are not significantly different. The data are admittedly meager, but it is unlikely that more robust, inarguably co-associated artifacts will be recovered in the near future. These data suggest that the magnitude of influence that intra-source variability has on hydration rim formations is inconsequential.

On a different tack, Stevenson (1987), and Stevenson and Scheetz (1989), among others (Ericson 1989; Tremaine 1989; Tremaine and Fredrickson 1988) have been examining variability in rim formation processes through induced-hydration experiments. Results of the experiments conducted by Stevenson (1987, 1990) discussed by Cleland (1988, 1989, 1990) raise serious questions about the replicability of induced-hydration experiments. In 1988, Cleland presented hydration rates for Sugarloaf and West Sugarloaf glass based on the results from a liquid bath experiment involving one specimen ascribed to each subgroup. The rate for Sugarloaf was stated as 27.2 μ^2/1000 years and for West Sugarloaf at 38.7 μ^2/1000 years — the latter hydrating 42% faster than the former. This set of experiments was followed by another that attempted to replicate the results using a vapor rather than liquid bath matrix. The vapor matrix experiments resulted in reported rates of 23.3 μ^2/1000 years for Sugarloaf glass and 12.9 μ^2/1000 years for West Sugarloaf glass (Cleland 1989), reversing the order of which subgroup hydrates fastest.



Map 5. Known Obsidian Quarries within the Coso Volcanic Field (from Gilreath and Hildebrandt 1991).

Table 3. Intra-source Hydration Relationships at the Lubkin Creek Site (CA-INY-30), from Basgall 1990.

	West Sugarloaf			Sugarloaf Mountain		
	n	mean hydration (μ)	s.d.	n	mean hydration (μ)	s.d.
Cache 1 (Humboldt Basal-notched Points)	2	5.65	0.21	3	5.70	0.53
Cache 2 (bifacial preforms)	2	5.35	0.35	3	5.30	0.70
Desert Side-notched Points	11	3.45	0.69	1	3.00	--
Cottonwood Triangular Points	9	2.78	0.82	2	3.75	1.06
Humboldt Basal-notched Bifaces	6	5.36	0.50	4	5.45	0.66
Structure 11	8	5.69	0.50	7	5.14	0.67

The profound difference in the liquid bath and vapor matrix experiments results for the West Sugarloaf samples prompted the analyst to remeasure the liquid bath sample, and revise the 38.7 μ^2/1000 years to 10.9 μ^2/1000 years. Depending on the results one prefers, Sugarloaf glass might be hydrating 80% or 161% faster than West Sugarloaf glass. A third set of experiments attempted to replicate results obtained in the vapor matrix tests (Cleland 1990). The single West Sugarloaf and single Sugarloaf sample this time produced results comparable to one another — results that were also similar to that of the West Sugarloaf sample in the first vapor matrix test. Supplemental geochemical analysis of the piece of glass classified as "Sugarloaf" that was used in the liquid bath experiment and the first vapor matrix experiment prompted Cleland (1990) to hypothesize that it derived from a not-previously-identified, fifth, geochemical subgroup in the Volcanic Field. In short, the confusion resulting from the various results reported for liquid bath and vapor matrix experiments on West Sugarloaf and Sugarloaf obsidian, leave us doubtful that these induced-hydration results are replicable. Because of these problems, we do not consider their results relevant to the current project.

Most recently, some glass scientists have turned their attention to inherent moisture content of the toolstone itself as a potential factor influencing hydration rim formation (Knaus and Mazer 1991; Stevenson et al. 1990, 1993). Citing Mazer et al. 1992, Stevenson et al. (1993:371) report "Recent experimental results have shown that the intrinsic water content of an obsidian is the dominant hydration rate-controlling compositional parameter." Analyzing specimens from the four subgroups defined by Hughes (1988), Stevenson et al. (1993) show that nodules of obsidian from lag deposits within the Volcanic Field, in contrast to primary deposits, contain great amounts of water due to the explosive events associated with their deposition. But, the intrinsic water content found within each geochemical subgroup was found to be extremely variable. The authors suggest that this variability may in part account for the numerous Coso rates that have been offered. Like the induced-hydration experiments, the "intrinsic water content" studies are nascent, and, as such, do not influence our interpretation of hydration results.

Continued refinement in interpreting hydration analysis is likely to result from studies such as the induced-hydration experiments and intrinsic water content analyses. It is doubtful, though, that they will radically alter the basic tenet that wider hydration bands result from exposure over longer periods of time, and, all other things being equal, rim formation is slower in a cool depositional environment than in a warm environment. In spite of all the potential sources of variability of Coso hydration, the archaeological record from the western Mojave Desert indicates that Coso hydration rim values and age are strongly correlated (Figure 1). We can glean from the literature 28 pairings of Coso hydration values and radiocarbon dates from the western Mojave Desert (Table 4). Other chronological indicators found in association with these pairings (e.g., projectile points and pottery) provide independent support of each locality's chronological integrity (see Chapter 5, Table 18). These data clearly indicate that wider micron values mean older samples. Confronted with such compelling data, we are not inclined to join the ranks of the hydration nay-sayers. It is clearly our position that Coso glass hydrates at a predictable and quantifiable rate, and that EHT of the area in which sites containing Coso glass occur must be factored into the hydration rate equation. Giving further examination to Figure 1, recognize that southern Owens Valley, where INY-30 (depicted by triangles), and INY-3806/H and INY-3812 (depicted by hexagons) are found, has a lower mean annual temperature than Fort Irwin; and that Rose Valley, where INY-372 occurs, has a mean annual temperature nearer to that of southern Owens Valley than Fort Irwin. Since Fort Irwin has a higher EHT than the other areas,

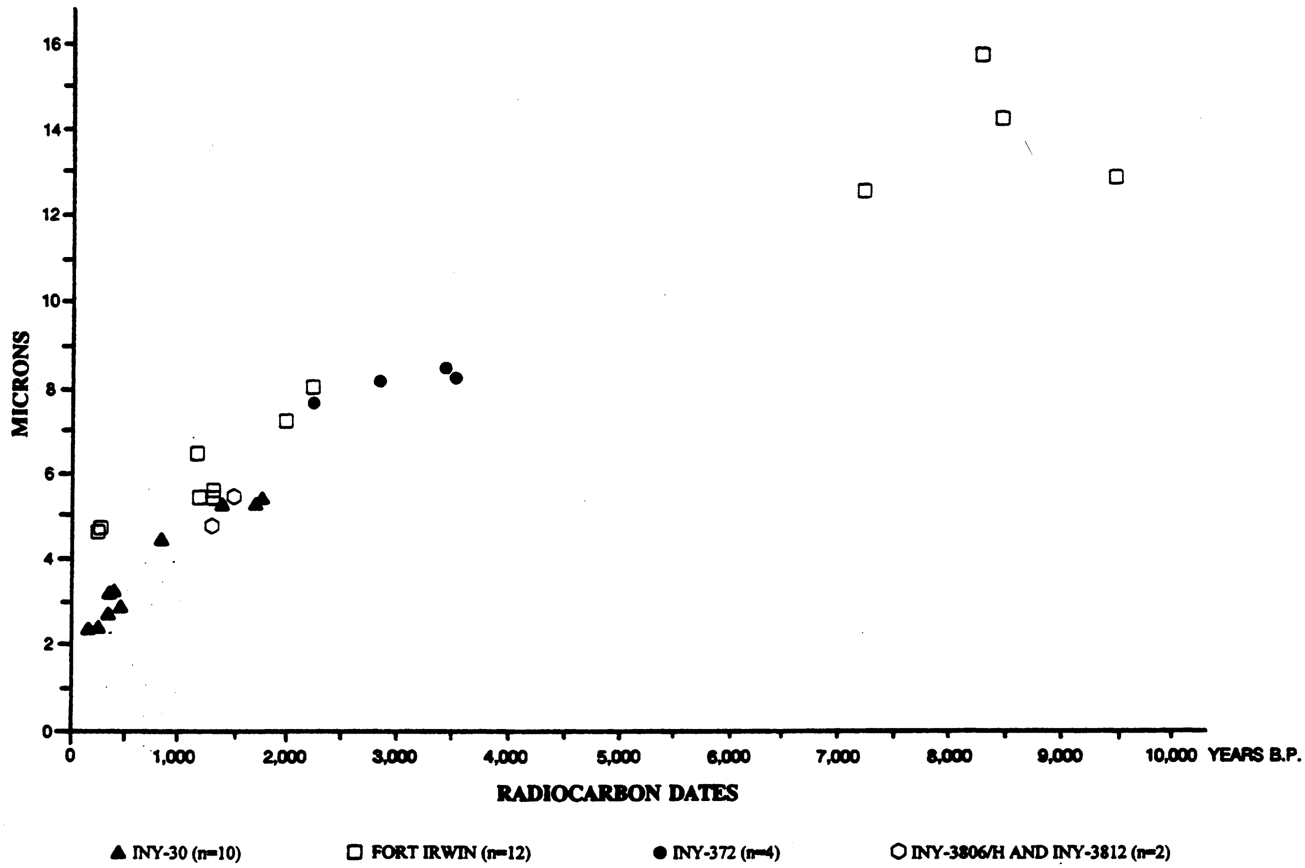


Figure 1. Pairings of Coso Hydration Values and Uncorrected Radiocarbon Dates from the Western Mojave Desert.

Table 4. Pairings of Coso Hydration Values and Uncorrected Radiocarbon Dates from the Western Mojave Desert.

Site	Hydration n	Hydration mean (μ)	Hydration s.d.	Uncorrected Radiocarbon Mean in Years B.P.	Uncorrected Radiocarbon Values in Years B.P.
INY-30	—	2.3	—	180±60	
INY-30	—	2.4	—	270±70	
SBR-4504, L. 5	9	4.6	0.4	275	260±60 and 290±60
SBR-5365	4	4.3	1.1	290±60	
INY-30	—	2.7	—	360	330±60 and 390±90
INY-30	—	3.2	—	390	310±70 and 470±70
INY-30	—	3.2	—	410±80	
INY-30	—	2.9	—	480±60	
INY-30	—	4.4	—	860	760±100 and 960±100
SBR-2659	14	6.4	1.0	1180	1150±200 and 1210±70
SBR-4483, L. 9	26	5.4	0.5	1190±110	
SBR-4449	12	5.4	0.4	1290	1040±150 and 1540±70
SBR-4786	27	5.3	0.8	1310±70	two identical values
INY-3806/H	34	4.4	1.0	1380	1160±90 and 1600±100
INY-30	—	5.2	—	1410	1220±70 and 1600±70
INY-3812	34	5.0	0.8	1470	1340±50 and 1600±60
INY-30	—	5.3	—	1695	1530±80 and 1860±70
INY-30	—	5.4	—	1745	1650±100 and 1840±80
SBR-4786	3	7.2	0.3	2010±70	
INY-372	6	7.6	0.7	2240±145	
SBR-5367	10	7.8	2.7	2240±50	
INY-372	10	7.8	1.1	2900±80	
INY-372	2	8.4	0.0	3520±80	
INY-372	9	8.2	0.2	3580±80	
SBR-4966	96	12.4	3.1	7230	7140±290, 7150±290, and 7400±280
SBR-5250	22	15.4	1.5	8240	8180±150 and 8300±110
SBR-5250	19	14.2	1.6	8410±140	
SBR-4562	40	12.8	2.5	9440	9410±115, and 9470±115

NOTE: All hydration specimens were geochemically identified as "Coso" glass using XRF analysis. Correlations from INY-30 presented in Basgall and McGuire 1988:Table 17 (hydration sample size and standard deviations not presented there); SBR-4562 from Basgall and Hall 1992; SBR-5250 and SBR-5367 from Hall 1992; all other SBR (San Bernardino County) pairings from Gilreath et al. 1987; INY-372 correlations from Drews and Elston (1983), Clewlow et al. (1970), and Ericson (1978); INY-3806/H and -3812 from Delacorte and McGuire 1993.

the hydration band on a piece of Coso obsidian found there is thicker than the band on a specimen of the same age found in Rose Valley. This trend accounts for the Fort Irwin samples shown in Figure 1 to plot higher than pairings from other areas.

In an attempt to bring order to chaos, Basgall (1990) examined the radiocarbon/Coso hydration rim values reported from a variety of depositional contexts. He derived a Coso hydration rate from the 10 radiocarbon/hydration value pairings obtained at the Lubkin Creek Site, and using Lee's (1969) temperature integration equation, he calculated EHT for a variety of contexts throughout the southern third of California, thus allowing different depositional settings with differing EHTs to factor that influence. The EHT correction factor for Haiwee/Coso was determined to be 19.3° C. He concludes that much, if not most, of the variability in Coso glass hydration values documented by many archaeologists — the variability that has spawned more than 15 hydration rates (see Basgall and True 1985; Cleland 1988, 1989, 1990; Drews and Elston 1983; Ericson 1977; Friedman and

Obradovich 1981; Garfinkel and McGuire 1981; Koerper et al. 1986; McGuire et al. 1982; Meighan 1978, 1981; Michels 1983; Stevenson and Scheetz 1989) — can largely be explained by the effective temperature of the environment in which the glass has been deposited. As an outcome of his review, he offers a single hydration rate for Coso glass which factors in the mean annual temperature of the area from which the archaeological sites occur. This rate and the conversion factors for temperature account for the radiocarbon/hydration pairings found at Malibu, Orange County, Fort Irwin, Owens Valley, and the Coso area. The rate he has developed is:

$$\text{LOG } Y = (2.32\ [\text{LOG } (X \times a)]) + 1.50$$

where X is the rim measurement in microns, Y is the date in years before present, and a is the EHT correction factor. The correction factor for Haiwee/Coso is 0.8723, it being slightly warmer than the Lubkin Creek site in southern Owens Valley. In the subsequent chapters (see Chapters 5 and 8), this single rate is applied to the Coso obsidian hydration data from our investigations, and to comparative data obtained from outlying areas.

LITHIC PRODUCTION AND EXCHANGE

As Ericson has so aptly pointed out, "The quarry remains the logical site to begin the study of a stone-tool using culture" (1984:1). This study approaches the Volcanic Field from two points of view. The first objective is to document toolstone manufacturing patterns evident in the procurement zone. Our concern is with answering fairly basic questions: where did production occur; when did exploitation occur, i.e., what is the shape of the production/exploitation curve for Coso obsidian; and what kinds of items in what quantities were produced at Coso? Attempts to place the exploitation of Coso obsidian in a regional context lead us to explore answers as to why Coso obsidian was exploited (for the producer's consumption or for trade); and who was exploiting the quarry (resident populations or visitors).

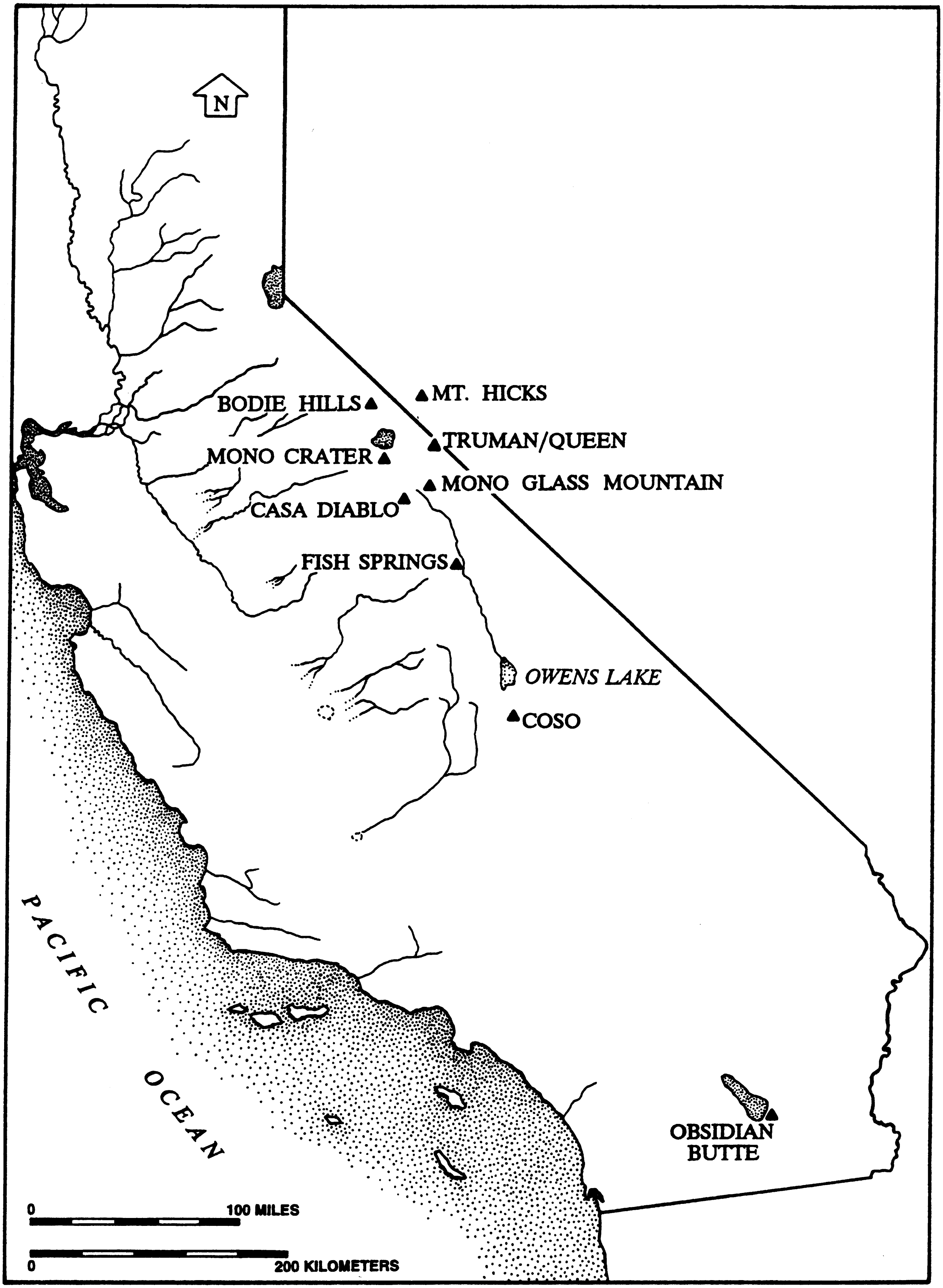
WHAT QUARRY DEPOSITS WERE EXPLOITED

Geological processes have determined the distribution of obsidian deposits, but many factors interacted to determine the degree to which a deposit was used. Chief among them are the quality and abundance of workable stone at a deposit, the deposit's location relative to other desirable resources (e.g., water and food), the ease or difficulty of getting to the deposit (e.g., does it necessitate climbing to the top of a steep rhyolite dome, or excavating a mining pit), and the acuteness of need for stone tools. Both lag and major primary deposits occur within the Coso obsidian procurement zone. Virtually all exposures of workable quality stone were used, even small patches of secondary deposits with comparatively few cobbles. By no means, however, was exploitation so extensive that it approached exhausting the overall supply. When given ready access to both, what factors precipitated the use of lag deposits instead of the seemingly superior primary deposits? We will begin to address this issue by plotting the spatial distribution of lag and primary deposits in the Coso Volcanic Field through time.

How the exploitation of the Coso quarries articulated with a group's exploitation of other quarries in the region is also of interest. Basgall (1989) presents compelling data that early populations had direct access to many obsidian quarries, e.g., Coso, Fish Springs, Casa Diablo, Queen/Truman/Hicks, and Bodie/Pine Mountain (Map 6), among others, as a consequence of their expansive mobility pattern. Changes in mobility range or pattern would, of course, affect which quarries were visited, as well as how frequently a group would have been able to exploit a particular quarry. Factors such as territoriality and resource control, in combination with population growth, may have significantly determined what quarry locations a group could have exploited, as well as which specific deposits they actually did exploit.

WHEN DID EXPLOITATION OCCUR

As the first step in exploring variables that affect the structure of a lithic production system, one must necessarily determine when the resource was exploited, and assess the changing magnitude of quarrying activities throughout the past. Production curves constructed for Casa Diablo (Hall and Basgall 1994), Bodie Hills (Singer



Map 6. Major Obsidian Sources in Eastern California.

and Ericson 1977), and the Sugarloaf Quarry (Elston and Zeier 1984) are remarkably similar (Figure 2). Each shows one major period of peak production, now commonly placed at roughly 3000-1000 B.P. corresponding with the Newberry and early Haiwee periods, and a major production decline after ca. 1000 B.P. Given the similarities of these three major obsidian quarries with respect to their geographical location (just off-set from the east front of the Sierra Nevada), their shared cultural context (being at the western edge of the Great Basin culture region and across the Sierra divide from foothill and central valley groups), the gross manufacturing activities that occurred there (see below), and their spatial relationship to one another (Map 6), it would be remarkable had their production histories been widely dissimilar.

Considering how different the methods were that derived these production curves, their similarity is even more remarkable. The production curve for Casa Diablo is based on about 2500 hydration specimens mostly from secondary reduction sites located along the west edge of the procurement zone, some of which were used at various periods in the past also as habitation sites. The Bodie Hills hydration profile is built from approximately 100 hydration samples collected from across the quarry zone. The production curve for the Sugarloaf Quarry is based on about 135 hydration rim readings on specimens from four sites in or immediately adjacent to Sugarloaf Mountain. Thus, one can rightfully be concerned with how representative each sample is of the quarrying and production history of these large quarry exploitation zones.

We are not in a position to independently judge the veracity of the production curves for Casa Diablo and Bodie Hills, but we are in a position to re-evaluate the production curve for the Coso Volcanic Field, and certainly such an action is appropriate. Our interest in the spatial and temporal distribution of Coso obsidian, and the relationship between the various aspects of the full lithic exploitation pattern, prompts us to develop separate production curves for the primary quarries, the lag quarries, the numerous off-quarry obsidian reduction sites that exist within the Volcanic Field, as well as major obsidian reduction sites located well outside of the procurement zone.

WHAT WAS BEING PRODUCED AND IN WHAT QUANTITIES

Quarry studies have shown, time and again, that the predominant items manufactured throughout the western United States are bifaces and cores, with the reduction techniques varying in response to time, place, and material constraints.

The obsidian quarries in eastern California are no exception. Studies at and near the Casa Diablo obsidian procurement zone (Adams 1986; Basgall 1983, 1984, 1987; Bettinger 1977; Bouscaren and Wilke 1987; Goldberg et al. 1990; Hall 1983; Jackson 1985; Michels 1965; Mone 1986) consistently show biface production to have been the overwhelmingly predominant activity (Table 5). Unifacially-thinned "bifaces" have recently been identified as a common variant in Casa Diablo biface reduction strategies (Skinner and Ainsworth 1990). Most Casa Diablo studies, however, have been of secondary reduction locations, not locations where workable nodules of Casa Diablo obsidian occur naturally. It is worth noting that only MNO-577 listed in Table 5, is a quarry site and represents the only site in the group where cores outnumber bifaces. Singer and Ericson conclude from their study at Bodie Hills that the quarry deposit "was a single activity site devoted exclusively to the production of bifaces and blades for export" (1977:181). They recognized that "two distinct artifact forms were produced for export: (1) prismatic blades, and (2) partially finished bifaces..." (Singer and Ericson 1977:177-178). The "prismatic blades" might well be functional equivalents to Casa Diablo unifacially thinned bifaces and "Coso" cores as described below. They also note that biface forms shift through time from large bipointed items to medium and small straight or concave-based forms. In addition to identifying the major items of manufacture, they offer some necessarily rough calculations that help us appreciate the magnitude of stone working at Bodie, estimating that 470 million pieces of debitage exist, and figuring "somewhere between 4.79 and 8.62 million bifaces of all shapes and sizes were produced" (Singer and Ericson 1977:185). These figures should be viewed, of course, very cautiously. In an early overview study of quarrying activities at Sugarloaf Mountain, Elston and Zeier found that biface reduction had been the prevalent activity. Referring to all "reduction pieces" as cores, they classify 39% (n=93; Elston and Zeier 1984:104) as bifaces, 34% as irregular polyhedral or cobble/boulder/rhomboidal cores, and a remaining 23% as plano-convex cores, alternatively referred to as "Coso" cores and large flake blanks. "Coso" cores are primarily large flakes that

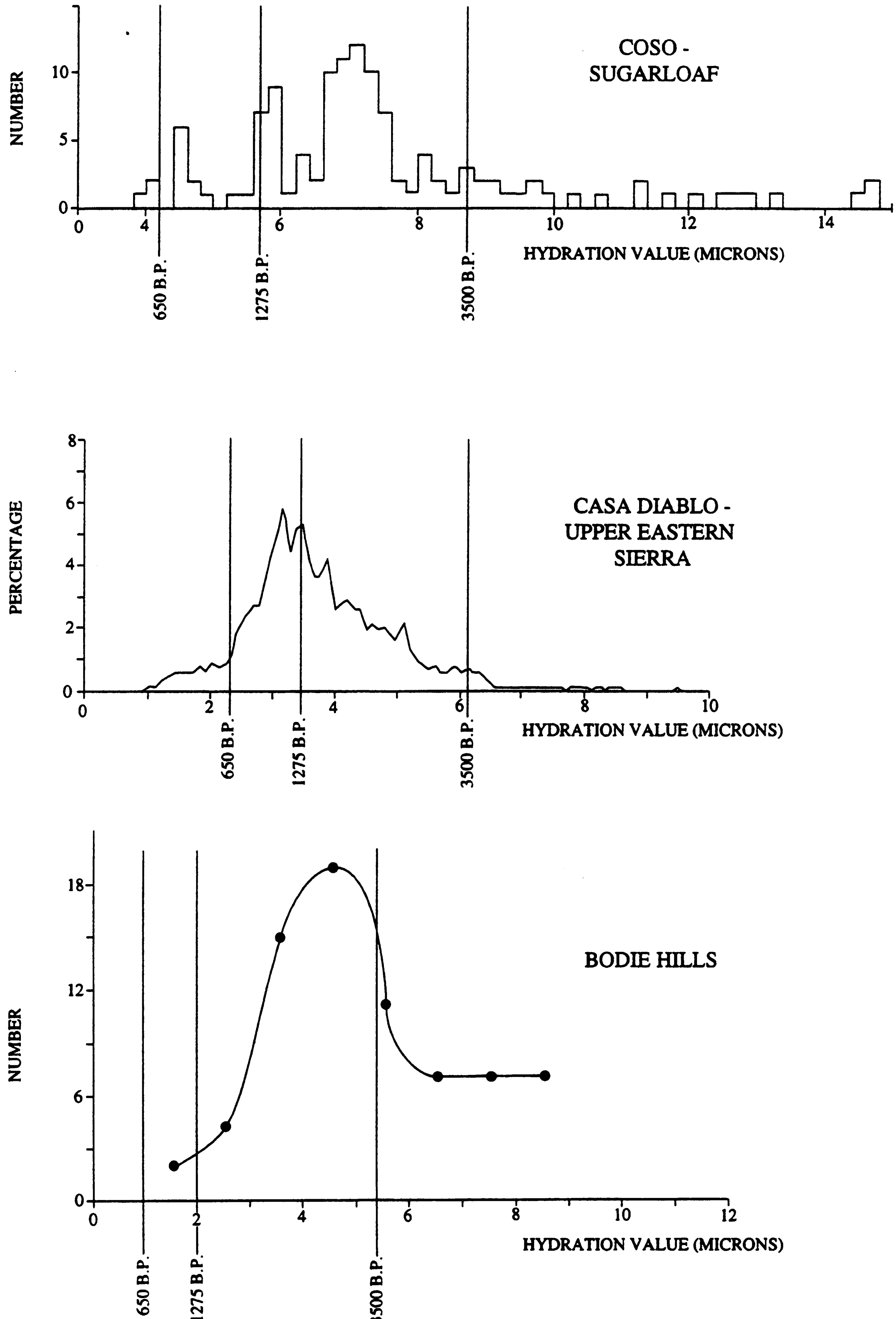


Figure 2. Hydration Profiles for Coso (Elston and Zeier 1984; Basgall 1990), Casa Diablo (Hall and Basgall 1994; Hall 1984), and Bodie Hills (Ericson 1982) Source Areas.

Table 5. Flaked Stone Assemblages from Selected Casa Diablo Sites.

CA-MNO	-529	-561	-574	-577[a]	-578	-833	-1529
Bifaces	35	539	49	25	100	16	176
Cores	56[b]	32	1	33	23	-	5
Other Obsidian Artifacts	524[c]	322[d]	14	7	67	4	97
Debitage (weight)	25,338	32,402	40,521	88,500	121,025	~3,000	(35.2 kg)

NOTE: [a] - only site of this group where obsidian occurs naturally, qualifying it as a quarry. MNO-529 from Basgall 1983; [b] - Basgall offers the following regarding the number of cores: "core fragments...may largely represent shatter resulting from the reduction of large, tabular blanks, and not reflect core reduction at all" (Basgall 1983:64); [c] - includes 508 edge modified flakes of which 336 are from the surface. MNO-561 from Hall 1983; [d] - unifaces (n=224) were not differentiated from edge modified flakes. MNO-574, -577, -578, and -833 from Goldberg et al. 1990; MNO-1529 from Basgall 1984.

have been rudimentarily percussion flaked from one side, in a fashion that would tend to thin the item in cross-section. They consider such items as a variant form affiliated with a biface reduction sequence, and the illustrations they provide certainly indicate that subsequent work would generate regularized, thinned bifaces.

From these prior studies, one can reasonably expect that biface production was the prevalent reduction activity applied to Coso obsidian; that cores might be more prevalent than bifaces at quarry loci, with the former items virtually non-existent at off-quarry reduction locations; and that a unifacially worked variant figures into the early and middle portion of the biface reduction sequence with some frequency. The degrees to which these trends are supported by data from lag quarry deposits, primary quarry deposits, and at off-quarry sites both within and outside of the Coso obsidian procurement zone remains to be documented.

Lithic production analysis has become increasingly concerned with reduction sequences used, the changing techniques applied from one manufacturing stage to the next, and the various forms an artifact assumes during its use-life. With this increasing desire to understand more fully the range of factors that account for the flaked stone tool assemblages found in sites, artifacts as well as debitage have come under greater scrutiny. The earliest studies of North American quarries have emphasized that items found at quarries are largely rejected items and unfinished pieces. Consequently, those assemblages present a quite biased impression of the quantity and kinds of items successfully produced and transported from an area. For that reason, in determining the magnitude and range of stone-tool working that occurred at a location, debitage resulting from both failed and successful reduction events is superior to the artifact assemblage as a basis for study. Flaked stone studies have shown that different stages of the manufacturing process frequently occurred in disjunct locations. It is not uncommon to discover that the kinds of items produced at a site differ from the kinds of items discarded there. Thus, in assessing the relative or absolute frequencies of the kinds of items manufactured of Coso obsidian, it will be necessary to consider how much production occurred at varying locations based on debitage types and quantities, and compare that to the number and kinds of items discarded there.

An additional issue confounding attempts to determine the number of items produced or the amount of stone working that occurred, revolves around the technological shift from dart to arrow-sized points. This shift is well documented to have occurred throughout the United States by at least 1200 B.P. Whether this shift resulted in the production of more or less stone-working debris is debated. Smaller arrow-sized items obviously can be generated from smaller starting forms, thus it is a safe assumption that all things being equal, more arrow-sized points than dart-sized points could be produced from the same amount of toolstone; put another way, the quantity of debris generated from producing 100 arrow-sized points very likely weighs substantially less than the debris generated from producing 100 dart-sized points. Ericson (1982), however, has suggested that a bow hunter needed somewhere on the magnitude of ten times as many arrows as an atlatl hunter. Holding the position that the pre-1000 B.P. production peak at the quarries is a result of eastern Sierran groups producing items for exchange with California groups west of the Sierra, he reasons that the need for more finished tools in later times, compounded by the fact that population levels were substantially higher after adoption of the bow-and-arrow, actually resulted in a late period decline in stone-working at eastern California obsidian quarries.

> ... the primary producers at the sources could not meet the increasing demands for finished items from central California. To meet this increasing demand it appears that the primary producers later changed their technology from biface production to blade-flake production, to outright export of raw materials. ... Most likely the dispersion of the production systems away from the sources is a direct response to the limited manpower available for production under such conditions [Ericson 1982:145-146].

WHY WAS COSO OBSIDIAN EXPLOITED

The sheer quantity of chipping debris and discarded items found at the major obsidian quarries in eastern California has led many to conclude that production far exceeded the needs of resident populations. The western Great Basin, excluding Owens Valley, is thought to have supported moderate to low population densities throughout prehistory. While there is debate as to what those levels were over time, the notion that population densities were higher in much of California west of the Sierran crest throughout most of prehistory meets with little opposition. The market for stone tools west of the Sierran crest is often cited as the impetus for the development of extensive exchange networks. The distribution of Coso glass in prehistoric sites quite far from the source (for example, Ericson 1977; Hughes and True 1985; Jack 1976), and the presence of shell beads originating from the Pacific Ocean or Gulf of Mexico in eastern California prehistoric sites are typically given as evidence that such a system was in operation. Coso glass, for example, has been recovered from prehistoric sites throughout the southern half of California, extending east to the Colorado River, west to the Pacific Ocean, and north to Monterey Bay.

Bettinger (1982a), Bettinger and King (1971), Ericson (1977, 1982), and Singer and Ericson (1977) all assume that eastern California obsidians were traded across the mountains, and have explored the influence that regularized exchange had on the socio-economic complexity of hunter-gatherers, considering alternately sedentism, territoriality, and the like. In an attempt to explain the origin of hunter-gatherer exchange systems, Ericson (1984) proposes a model of population growth which leads to sedentism and increased territoriality, which ultimately leads to a growing need for non-local resources. These conditions are conducive to the development of large-scale exchange systems operating to move important products among different groups.

The issues here revolve around how much Coso obsidian production occurred in excess of the resident population's own needs; and what mechanisms account for the distribution of Coso obsidian throughout southern California. Conceding that Coso obsidian was traded among groups, what does its distribution suggest about the structure of the exchange network: in what forms was it exchanged, in what volume was it exchanged, in what directions did it move, and was craft specialization involved?

Torrence (1986) and Arnold (1987) provide the following list of archaeological indicators of production specialization: (1) very high volume of production materials; (2) identifiable workshops separated from other subsistence/residential areas; (3) distinct pattern in regional distribution, reflecting organized and controlled production and exportation; (4) high technological standardization and high rates of success; (5) control over critical resources; and (6) specialists' tools in certain burials. Further, if specialized production was practiced to produce the exchange commodity, it is argued that the labor investment and the specialists must have been underwritten by others. The degree to which the lithic production patterns documented for Coso support the existence of craft specialization will be examined, after due consideration has been given to the production-for-consumption needs of resident groups.

WHO HAD ACCESS TO COSO OBSIDIAN

Obviously resident populations had direct access to the resources available in the Volcanic Field. Were they, however, single-handedly responsible for the vast amount of stone-working that occurred, or did non-residents also have direct access? Considering this issue for the Casa Diablo quarry, Bouey and Basgall (1984) argue that when quarry production was at its highest level, the socio-political condition of the resident population was not consistent with specialized production and exchange. At the same period of time when production appears to have peaked, the organizational complexity and population level of people in central California (Goldberg et al. 1986;

King 1976; Moratto 1972; Moratto et al. 1978) are considered sufficiently developed to support a regularized trade/exchange system. Consequently, Bouey and Basgall (1984) conclude that groups from the western Sierra traveled to the quarry, where they manufactured the desired items, then transported them back over the Sierra. In this scenario, residents and non-residents were independently both producers and consumers. Bouscaren and Wilke (1987) cite the absence of western Sierran lithic materials and flaked stone tool artifact types in Long Valley, among other patterns, to argue that producers were residents, leading to the tacit conclusions that residents generated the massive amounts of chipping debris, and that Casa Diablo items obtained by western Sierra people were initially fashioned by eastern Sierran people. Goldberg et al. take a third position, suggesting that perhaps "the group using both the east and west side of the Sierra were one and the same, at least during the Middle Horizon" (1990:182-183).

From the above discussions, four main objectives can be distilled regarding the obsidian production patterns of Coso: (1) documenting the shape of the production curve and evaluating how it correlates with the production curves of other eastern California obsidian sources, as well as consumption curves outside the procurement zone; (2) documenting the pattern of obsidian acquisition, and assessing how it correlates with the acquisition patterns modeled for other eastern California obsidian sources; (3) evaluating what the production pattern for Coso obsidian suggests about population growth, territoriality, and mobility patterns; and (4) documenting the distribution of Coso obsidian, and evaluating what it suggests about mechanisms for exchange.

SUBSISTENCE AND SETTLEMENT

As clearly documented by the foregoing discussion, useful inferences regarding obsidian production and exchange cannot be made without considering the range of constraints associated with the larger socio-economic system. At Casa Diablo, for example, Bouey and Basgall (1984) note that many of the requirements connected with specialized obsidian production (e.g., sedentary population controlling the source) were not entirely consistent with the settlement system reconstructed during Newberry period use of the Inyo-Mono region (i.e., high residential mobility). The following discussion summarizes subsistence-settlement pattern models offered for areas surrounding the Coso Volcanic Field, developing the socio-economic context necessary to evaluate the changing role of Coso obsidian in southeastern California prehistory. By virtue of lying at the boundary between the Mojave Desert, Sierra Nevada, Owens Valley, and arid lands to the east (e.g., Death Valley), and the likelihood that prehistoric peoples from these localities visited Coso to some degree or another, subsistence-settlement pattern models developed for these areas are outlined below. Emphasis is placed on research conducted in the northern Mojave Desert and Owens Valley, as these areas have been the primary focus of large-scale subsistence-settlement pattern studies. Important comparative data are also provided from the western Mojave, southern Sierra Nevada, White Mountains, Death and Deep Springs valleys, and the Coso region.

NORTHERN MOJAVE DESERT

Until recently, models of early Holocene adaptations in the northern Mojave Desert have been largely derived from the work of Warren and his colleagues (Warren 1967, 1984, 1986; Warren and Crabtree 1986; Warren et al. 1984). Their sequence begins with the Lake Mohave Period (10,000-7000 B.P.), a temporal interval thought to have been characterized by severe climatic change. Between about 10,000-9000 B.P., Warren argues that temperatures increased, but precipitation remained relatively stable. This climatic regime filled the valleys and basins with streams, marshes, and lakes, and produced vegetation communities that supported abundant populations of artiodactyls. Lake Mohave settlements, subsumed under the more general Western Pluvial Lakes Tradition (Bedwell 1973; Hester 1973), were thought to have been concentrated along lake shores, and produced artifact assemblages reflecting heavy emphasis on hunting; e.g., Lake Mohave and Silver Lake points, leaf-shaped bifaces, large ovate-domed and elongate keeled scrapers, crescents, engraving tools, and only a minor presence of milling equipment.

After 9000 B.P., trends toward increased temperature and aridity intensified, reaching critical proportions between about 8000-7000 B.P. Most lowland lakes and streams became dry, and vegetation communities providing food for larger game animals retracted into a few isolated contexts. In response to increasing aridity, human settlements appear to have been more restricted in space, concentrated in higher elevations where few ephemeral streams and lakes still existed. Correlated with this environmental change was the emergence of the Pinto Basin complex. Rather than representing a new cultural group with a different subsistence focus, the complex was thought to have developed out of a single Lake Mohave-Pinto Basin cultural tradition, with continued emphasis on hunting large game. Support for this interpretation was based on: (1) spatio-temporal overlap of Lake Mohave and Pinto points; (2) the continued use of fine-grained igneous materials for bifacial tools, in contrast to cryptocrystalline materials so prevalent in later cultural complexes; (3) continued reliance on percussion techniques of lithic reduction, also distinctly different from later assemblages where pressure flaking is common; and (4) a dominance of morphologically and functionally similar hunting and animal processing tools (e.g., projectile points, biface "knives", and domed and keeled scrapers).

By 6500-4000 B.P., during the height of the mid-Holocene climatic optimum, the number of clearly defined occupation areas decreased, and most appear at springs. In addition to this settlement location adjustment, domed and keeled scrapers are replaced by flake scrapers and there is an increase in the frequency of handstone and millingstones, the latter indicating a greater reliance on seed collecting and processing. Faunal assemblages indicate that artiodactyls became a negligible component of the overall diet, restricted only to high elevation spring locations. Finally, toward the end of this temporal interval, sites of any kind are difficult to identify, further indicating a substantial decline in human population.

The apparent continuity of a hunting focus in the face of deteriorating climatic conditions, and a corresponding reduction in artiodactyl availability, indicates to Warren (1986) that Pinto Complex people practiced an adaptive strategy that had outlived its viability. Perhaps due to strong cultural values and traditions, attempts by early inhabitants of the Mojave Desert to preserve an adaptive strategy geared toward hunting may have ultimately failed, forcing the near abandonment of the desert during the arid middle Holocene.

According to Warren et al. (1984), productivity of large game increased during the Gypsum Period (4000-1500 B.P.) due to ameliorating mid-Holocene climatic conditions. Large game hunting resumed importance while use of plant resources continued to intensify, the latter reflected by increases in the frequency of milling equipment. The combination of increased environmental productivity and intensification of production systems resulted in population expansion, and a hypothesized shift from the family-based organization of the Pinto period, to multi-family bands. By the end of the Gypsum period, the introduction of the bow and arrow (presumably increasing the efficiency of large game procurement) combined with a period of increased aridity, required even greater reliance on plant and small animal resources. Throughout the Saratoga Springs (1500-800 B.P.) and Shoshonean (800 B.P. - Historic) periods, these changes in subsistence orientation are thought to have caused a reduction in the number of large residential bases and general dispersal of the population into smaller family groups.

More recent work at Fort Irwin (Map 2) by Basgall (1991) and Hall (1992) provides a contrasting view of early Holocene adaptations. Based on an extensive review of paleoenvironmental data, they question long-held assumptions about post-glacial habitats as portrayed by those who support the notion of the Western Pluvial Lakes Tradition. Rather than characterizing the late Pleistocene/early Holocene interval as a time of perennial rivers and lakes, it appears that by ca. 10,000 B.P. surface water in the north-central Mojave Desert was restricted to spring/seep discharge and episodic playa lakes of variable frequency and duration. Vegetation was also somewhat marginal, consisting of desert scrub below 1200-1500 m (3940-4920 ft) and juniper-shrub woodland in higher elevations. By 7000 B.P. the juniper-shrub woodland had retreated to elevations above 1700-1800 m (5580-5900 ft) while the near-modern creosote scrub community was probably in place throughout the area by about 3500 B.P. (Basgall et al. 1988:33-53).

Artifact assemblages from Lake Mohave contexts, like those documented by Warren (1986), include an abundance of bifaces made of fine-grained igneous materials (basalt, rhyolite, and felsite), formed flaked tools of various material types, and only minor frequencies of milling equipment. Rather than viewing bifaces and formed flaked tools as specialized implements used to process large game (butchering, skinning, and hide-scraping), Basgall (1991) argues that most of the former were probably used as cores (many were early stage forms exhibiting very little wear), while the latter apparently served a wide range of functions due to the presence of multiple wear configurations. Although artiodactyls appear to have been exploited when encountered, faunal remains obtained from a variety of sites indicate diversified diet centered on lagomorphs, rodents, and reptiles (not including tortoise). Lake Mohave sites were also found to cross-cut a wider range of non-lacustrine settings, providing further evidence for a more generalized adaptation than traditionally attributed to this interval of time.

Pinto/Little Lake period assemblages recovered by Basgall (1991) and Hall (1992) are broadly similar to those described by Warren. Flaked stone tools and debitage are roughly comparable to the preceding period, showing a continued preference for the use of fine-grained igneous materials. Faunal assemblages also remain the same, emphasizing the exploitation of small game (now including tortoise). In contrast to the Lake Mohave pattern, a sharp increase in the frequency of milling equipment and battered stone implements occurs, suggesting greater reliance on hard seeds. Site location data show continued use of a wide range of habitats, not necessarily adjacent to water. These distributions, coupled with the generalized mix of tools and faunal remains, suggested to Basgall (1991) and Hall (1992) that a relatively broad-based subsistence regime was in place throughout the early and middle Holocene. Furthermore, the presence of highly curated assemblages (i.e., well-worn tools made from exotic materials), indicated a settlement system characterized by a substantial degree of residential mobility.

Gypsum/Newberry period (ca. 3300-1350 B.P.) deposits also contain highly curated assemblages, including a full complement of flaked, ground, and battered stone tools, as well as diversified accumulations of faunal remains composed largely of lagomorphs, tortoises, and artiodactyls (Basgall 1991; Basgall et al. 1988; Hall 1992). In contrast to earlier periods, emphasis on percussive production of igneous tools shifted to the almost exclusive use of cryptocrystalline materials, often modified by pressure retouch — a change accompanied by major increases in the frequency of bifaces and associated debitage. Whereas earlier settlement systems appear to have reused specific locations on a regular basis, creating accumulations of debris within relatively large site areas, most Gypsum/Newberry sites are relatively small, probably indicating a wide-ranging settlement system geared to recurrent, short-term occupation of generalized areas rather than specific locations.

During the Saratoga/Haiwee (ca. 1350-650 B.P.) and Shoshonean/Marana (650 B.P. - Historic) intervals, Fort Irwin data indicate that foraging radii decreased and became more regularized (Basgall 1991; Hall 1992). Evidence of this shift includes a decrease in the frequency of curated tools (local materials dominate all artifact types) and a more regular use of particular locations (sites became slightly bigger and in some cases contained patches of midden). The density of milling equipment continues to increase, taken to reflect intensified use of local plant resources. Faunal remains show a greater diversity of small game, including a higher frequency of tortoise. Production of bifaces and associated debitage decreased substantially, perhaps a response to using bow and arrow technology: because projectile points were no longer the outcome of biface reduction but made from modifying flakes, both flaked stone material needs and the production of debitage were reduced. It was also noted that decreased biface manufacture could have resulted from a reduced need to gear-up for long distance travel (see Kelly 1988).

WESTERN MOJAVE DESERT

In contrast to Fort Irwin, comprehensive subsistence-settlement studies have not been accomplished for the western Mojave. A recent overview by Sutton (1988a) does identify several settlement trends that have interesting implications when viewed from a larger, inter-regional perspective. Lake Mohave and Pinto/Little Lake period materials have rarely been encountered, consisting of a few sites tentatively cross-dated with projectile points and flaked stone assemblages dominated by rhyolite (Glennan 1971). After 3000 B.P. archaeological visibility increases substantially, allowing several inferences regarding settlement structure. Sutton (1988a) identifies large permanently occupied villages supported by numerous special purpose sites, the latter used to exploit specific resources on a part-time basis. Located in the vicinity of Antelope Valley (Map 2), major settlements were often quite large and complex, containing deep middens, cemeteries, structures, and numerous trade items from coastal California (mostly shell beads). This system, fully in place during the Saratoga Springs/Haiwee period, was thought to reflect a transition from an earlier pattern of seasonal transhumance to one characterized by a more sedentary existence made possible, to some degree, by profits obtained from administering the exchange of Coso obsidian for shell beads (Sutton 1988a:77). This general pattern is thought to have persisted until about 300 B.P. when, for reasons unknown, large villages were abandoned.

A similar transition was also encountered by Sutton (1991) in Fremont Valley, just north of Antelope Valley. Prior to 1500 B.P., evidence of occupation was sporadic, limited to a few scattered projectile points and a low number of relatively wide hydration readings. Although less substantial than Antelope Valley settlements, excavations at two Saratoga Springs/Haiwee period residential bases yielded diverse assemblages of artifacts and faunal remains, as well as remnants of structures. The one site for which analysis is complete (CA-KER-2211) contained abundant milling equipment, as well as a faunal assemblage dominated by jack rabbit and, to a lesser degree, tortoise. Similar to his findings in Antelope Valley, occupations in Fremont Valley appear to have extended until around 300 B.P., at which time a shift to an unknown pattern occurred.

Evidence that jack rabbit exploitation was emphasized during Saratoga Springs/Haiwee times has also been found in the El Paso Mountains (Map 2; McGuire et al. 1982). Prior to 1300 B.P., they argued, a broad-based subsistence pattern focused on hunting large ungulates was present. In contrast, components dating between 1300-700 B.P. produced faunal assemblages dominated by jack rabbit. These data, when combined with the abundant presence of milling equipment, appear to reflect a shift to more intensive use of local plant and small game resources in an attempt to mitigate increased human population density — a construct fully consistent with the resource intensification model forwarded by Bettinger and Baumhoff (1982; see below).

OWENS VALLEY

Owens Valley (Map 2) has been the subject of numerous subsistence-settlement studies, the majority conducted by Bettinger (1975, 1977, 1982a, 1989). Except for a few sites, however, data from the Lake Mohave-Little Lake periods are quite sparse and have contributed little to these studies. One exception is the Lubkin Creek Site (CA-INY-30), a large multi-component site just south of Lone Pine (Map 2; Basgall and McGuire 1988). The early assemblage here includes projectile points, bifaces, a variety of formal and informal flake tools, some heavier core-related implements, but no milling equipment. This narrow range of tools, associated with faunal remains that include a relatively high proportion of artiodactyl, appear to represent short-term use of the area by people focused on hunting. One of the most remarkable aspects of the assemblage was its diversity in flaked stone materials. Obsidian from a variety of sources was identified, as well as various cryptocrystalline, quartzitic, basaltic, and other fine-grained igneous materials. Similar to findings at Fort Irwin, these data are thought to reflect a foraging area extending hundreds of kilometers north, east, and probably other undocumented directions from the site (Basgall 1989; Basgall and McGuire 1988).

Although largely consistent with findings from the northern Mojave Desert, the above reconstruction encounters difficulties incorporating results of Harrington's (1957) excavations at the Stahl site (CA-INY-182, Map 2). Excavations here revealed a Little Lake period occupation area consisting of hearths, obsidian caches, graves, and a wide range of flaked and ground stone tools, in addition, perhaps, to "house floors." Most researchers, including Harrington (1957), considered the site a permanent village, an assessment that conflicts with a highly mobile adaptive pattern. In a more recent evaluation of the site, however, Bettinger (1989) argues that it probably functioned as a seasonal base camp regularly occupied by people who traveled over a wide area during other times of the year.

Well-defined Newberry period occupation of the Lubkin Creek site did not occur until around 2000 B.P. Marked by burned structural remains associated with hearths, biface and bone tool caches, a variety of ground and flaked stone tools, and diverse floral and faunal remains, these materials are thought to represent residential use, but only on a seasonal basis. The non-permanent nature of these settlements is also reflected by patterns of flaked stone material acquisition and use. While Coso obsidian is the predominant material, non-local obsidians from Long Valley and areas further north are represented by finished tools (and comparatively little debitage), indicating prior visits to these localities. Unlike the Lake Mohave-Little Lake periods, when foraging radii seem to have encompassed numerous geographic areas, Newberry period data support a more regularized settlement system, where residential bases were occupied seasonally, moving along a north-south trending axis. Regional climatic patterns combined with seasonally specific ecofactual remains suggest a transhumance pattern of summer occupations in northern areas, moving to southern areas during cooler periods of the year (Basgall 1989; Basgall and McGuire 1988). Such an interpretation is largely consistent with Bettinger et al. (1984) findings at CA-INY-2146 (south of Bishop) and Bettinger's (1989) recent evaluation of Newberry period subsistence-settlement patterns, where relatively mobile populations are thought to have focused on a carefully selected suite of plants, and favored the use of large mammals. For this to have been the case, Bettinger (1989) further argues that population levels must have been sufficiently low to allow groups to freely circulate between high quality resource concentrations, making it more advantageous to shift residential locations when local resources diminished, than to remain in place and exploit lower ranking resources.

A major restructuring of these patterns appears to have developed during the Haiwee period, and continued forward until ethnographic contact (Bettinger 1989; Bettinger and Baumhoff 1982). Excavations by Bettinger (1989) at three sites near Big Pine identified a Haiwee period emergence of permanent or semi-permanent lowland villages (characterized by residential structures, bedrock milling features, extensive assemblages of flaked and ground stone tools, and a diverse set of floral and faunal remains), probably supported by upland pinyon camps, and centralized seed production stations. The relationship between these sites suggested to Bettinger that seasonal movements had become spatially confined, resulting in more intensive use of resources within progressively smaller foraging areas. Probably responding to increased population pressure, these trends toward settlement centralization and resource intensification are also reflected by data from CA-INY-30 (Basgall and McGuire 1988). Although Haiwee period use of the Lubkin Creek Site was quite marginal, resource intensification was clearly evident in Marana components by increased exploitation of riparian and lacustrine settings (e.g., shellfish, water fowl, tule seeds), and greater emphasis on pine nut exploitation. Reduced residential mobility was also indicated by decreased flaked stone material diversity, a more even balance between tool and debitage material types, and greater use of expedient, non-curated milling equipment. According to Bettinger (1989), this adaptive shift culminated in Owens Valley during the ethnographic period where inter-village exchange and inherited political authority (i.e., chieftainship) helped maintain an increasingly rigorous degree of territoriality.

SOUTHERN SIERRA NEVADA AND WHITE MOUNTAINS

Excavations in the southern Sierra Nevada (Garfinkel and McGuire 1980; Garfinkel et al. 1984; McGuire 1981), west of the Coso Volcanic Field, have produced results consistent with the resource intensification model proposed by Bettinger and others. Prior to 3500 B.P. (Little Lake period), evidence of human occupation in the southern Sierran uplands (above about 1830 m [6000 ft]) is restricted to a sporadic scatter of projectile points and the infrequent wide obsidian hydration reading. During the Newberry period, use increased to a limited degree, as indicated by the presence of biface reduction locations, hunting camps, and short-term occupations that may have been associated with pinyon exploitation. Late in time (post 1400 B.P.), however, use of the uplands intensified.

> Temporary occupation camps as well as large base camps, with their associated subsistence and habitation activities, appear during this time... The increased amount of vegetal processing equipment associated with these site types affirms the primacy of plant resources, of which pinyon was undoubtedly the most important [McGuire 1981:57].

High in the White Mountains, northeast of Coso (Map 2), Bettinger also encountered late period resource intensification in upland habitats (3050-3810 m [10,000-12,500 ft]). Prior to 1400 B.P., White Mountain uplands are thought to have been used on a relatively short-term basis for hunting (probably bighorn sheep), reflected by sites with hunting blinds, sparse lithic scatters, and debris/tools associated with hunting and butchering animals. Sites after 1400 B.P. contain remains of well-built houses (with circular, multiple-course footings), diverse assemblages of plant and animal procurement and processing tools, as well as debris associated with repair and production of these tools.

> This dramatic shift in alpine land use appears to have been a response to regional population growth that decreased rates of return for lowland subsistence activities to the point where it became cost-effective to use alpine plants and other costly resources (e.g., pinyon, small seeds) previously used casually or ignored altogether [Bettinger 1991:675].

DEATH AND DEEP SPRINGS VALLEYS

Interpretive summaries of Death Valley (Map 2) subsistence-settlement systems by A. Hunt (1960), C. Hunt (1975), and Wallace (1958, 1977) elucidate trends broadly similar to those found elsewhere in eastern California.

Death Valley I (Lake Mohave) assemblages, thought to date between 9000-7000 B.P., include Lake Mohave and Silver Lake projectile points, knives, scrapers, and choppers, but no milling equipment. Most of these sites are located in the lowlands on gravel benches next to active as well as extinct springs, and they seem to represent seasonal, though recurrent, occupancy by mobile people focused on hunting large game (Wallace 1958:11). This was followed by a substantial hiatus — a 2000 year period attributed to the mid-Holocene climatic optimum.

The subsequent Death Valley II/Mesquite Flat Complex dates between 5000-2000 B.P. and has two phases. The earliest phase includes Pinto and Gypsum series points found at small sites that appear to have been temporary camps. Other tools include knives, choppers, scraper-planes, and drills. The later phase is represented by several large occupation sites, many on the edge of dry washes in lowland settings. Elko series projectile points predominate, and are accompanied by expanding-base drills, hammerstones, choppers, scraper-planes, mortars and pestles, and an abundance of large flakes and cores — the latter reflecting an extensive stone working technology. Hunting is considered a primary component of the economy given the abundance of projectile points, knives, and other implements presumably used to slaughter and prepare large game. The presence of mortars and pestles is considered to reflect increased reliance on plant foods, while settlement size implies a fairly large, semi-sedentary population. Wallace (1958) viewed these sites as seasonal gathering areas, from which smaller groups would split-off during other times of the year to hunt and forage elsewhere. Specialized hunting sites found in the uplands potentially represent hunting parties originating from the lowland residential bases. Similar to Warren's work in the northern Mojave, the expansion of population was largely attributed to increased environmental productivity stemming from neoglacial events that took place during this interval (Hunt 1975; Wallace 1958).

Death Valley III (Saratoga Springs) dates between 2000-1000 B.P. and includes Eastgate and Rose Spring points as signature artifacts, a diverse mix of flaked and battered stone tools (e.g., knives, scrapers, drills, hammerstones, choppers), high frequencies of milling equipment (largely manos and metates), and a significant presence of shell beads, bone implements, and pottery sherds of Puebloan origin (Warren 1984). Perhaps in response to increasing aridity, populations appear to have occupied a wider range of habitats, focusing on the use of plant resources more than during previous intervals (Hunt 1975; Wallace 1977).

Death Valley IV (Desert Shoshone) is characterized by "many small and a few rather large settlements... Their living sites are amongst the mesquite-covered dunes, usually some distance from springs or other water sources. Although these were seasonal camps, many appear to have been inhabited recurrently" (Wallace 1958:14). Mesquite camps include fire-affected rock, charcoal, a variety of flaked stone tools (including Cottonwood and Desert Side-notched projectile points), Owens Valley Brown Ware pottery, twined and coiled basketry, *Olivella* beads, abundant milling stones and handstones, as well as a significant presence of long, cylindrical stone pestles, and wooden mortars made from mesquite logs. Upland seasonal camps have also been encountered, many including "storage pits, charcoal filled roasting pits, bedrock milling places and gathering crooks -- all connected with pinyon harvesting" (Wallace 1958:15). This general pattern of seasonal movements from the valley floor up to the mountain slopes appears to have continued into the ethnographic period (Warren 1984:371).

Delacorte's (1990) work in Deep Springs Valley reveals parallel patterns to those of Death Valley, 125 km southeast (Map 2). Newberry period settlement systems included seasonal base camps in the lowlands (characterized by a relatively high density and diversity of ground, battered, and flaked stone tools), as well as short-term seed processing areas (milling equipment concentrations with a lower frequency of flaked stone implements) and hunting camps (largely flaked stone tools and debitage scatters). Similar to Owens Valley reconstructions, the presence of exotic lithic materials are taken to reflect a system with a high degree of residential mobility, with groups using widely spaced base camps, and occupying areas well beyond the bounds of Deep Springs Valley.

> These base camps served as residential hubs from which groups moved to specialized logistical field camps to collect a narrow range of plants and to hunt large game species. This expansive, narrow-spectrum strategy implies little competition between groups (Bettinger and Baumhoff 1982), allowing free access to critical resources [Delacorte 1990:247].

During the Haiwee and Marana periods in Deep Springs Valley, a reorganization of the subsistence-settlement system occurred: Lowland base camps and temporary seed camps continued to be used, while temporary camps used for hunting decreased in importance. Of greater significance was the appearance of three new settlement types: pinyon camps (similar to lowland occupation sites but having a higher frequency of structures), pinyon caches (largely structures), and alpine (summer) occupation sites (diversified assemblage scatters lacking associated structures). The addition of these settlement types indicated that seasonal movements had become spatially confined, increasing the need to exploit a broader range of lower ranked plant and animal species available from a wider range of environments.

COSO REGION

The most comprehensive subsistence-settlement studies of the Coso region to date have been completed by Whitley et al. (1987) and Delacorte (1988). Focusing largely on late Holocene adaptations, Whitley et al. (1987) offer interpretations that contrast significantly with those outlined above. During the Newberry period, settlement organization included "major villages along pluvial Owens River... and the use of various upland environments, as evidenced by multi-function and specialized purpose sites" (Whitley et al. 1987:20). Subsistence pursuits were thought to have been quite general, exploiting a wide range of environments. This adaptive strategy was thought to have persisted into the Haiwee period, differing from the Newberry period only by increases in population as evidenced by the establishment of major villages at a variety of new locations. The Marana period, in contrast, was thought to be marked by a great reduction in the number of sites and the range of environmental zones exploited/occupied. Although changes in subsistence-settlement structure were considered a possible explanation (i.e., land-use shifts reducing archaeological visibility), Whitley et al. (1987:22) hypothesize that "the change was principally one of decreasing population, and that this decrease was in fact very substantial."

Delacorte's (1988) review of an expanded data base produced a different set of interpretations for Coso. Represented by a series of limited habitation sites (including milling equipment, cobble tools, bifaces, and points), the Lake Mohave period was characterized as a highly mobile settlement system focused on the exploitation of plants and animals in predominantly lowland settings. Little Lake habitation areas, particularly those in riparian settings (e.g., the Stahl site), were thought to have been occupied for longer periods. Similar to characterizations of Newberry period adaptations in Owens Valley (see Basgall and McGuire 1988; Bettinger et al. 1984), Delacorte argues that logistically organized upland hunting camps were used in support of lowland residential bases. Newberry period settlement organization was considered similar to the preceding Little Lake system (Delacorte 1988:25-26): "... during the Newberry period groups traveled between a series of lowland occupation sites from which many resources were exploited through use of specialized temporary camps and limited habitation sites."

The Haiwee settlement pattern was thought to differ in several fundamental ways from the Newberry pattern. First, occupation sites appear to have moved away from lowland riparian habitats to the desert scrub communities along valley flanks. Accompanying this shift was a decrease in the number of temporary camps (e.g., logistically organized hunting sites) and, most importantly, the inception of pinyon camps in the uplands. The overall strategy was one of reduced logistical travel, but relatively frequent residential moves over short distances within increasingly smaller territories — a strategy made possible by the exploitation of a wider range of subsistence resources (see Bettinger and Baumhoff 1982). This same basic pattern is thought to have continued into the Marana period, however, the frequency of residential moves appears to have increased later, creating more smaller sites with reduced archaeological visibility. According to Delacorte (1988:30) "The difference between early [*pre-Haiwee*] and late [*Haiwee-Marana*] settlement patterns reflects, therefore, a change in the organization of aboriginal land-use from large, logistically oriented groups to small, residentially mobile groups, not a decrease in population."

DISCUSSION

The foregoing review indicates that subsistence-settlement pattern strategies remained relatively consistent from one area to the next during much of the early Holocene. Beginning in the mid-Holocene, however, interregional variability appears to have progressively increased. As the following discussion seeks to demonstrate, the uniformity of early adaptations is largely due to a subsistence pattern focused on the exploitation of a narrow range of highly ranked resources irrespective of environmental circumstance. Later populations, in contrast, intensified the use of local environments, exploiting a wider range of lower ranked resources, including those regionally restricted in distribution. It follows, therefore, that inter-regional environmental differences had minimal effect on early tool assemblages, while later such differences were amplified, creating greater variability in the archaeological record.

Lake Mohave sites reflect a high degree of residential mobility (indicated by significant tool-debitage disjunctions in the frequency of exotic versus local material types [Basgall 1989, 1991]), minimal use of seed resources (based on the near-absence of milling equipment), and a probable emphasis on hunting large and small game animals (the latter particularly prevalent in the more arid parts of the Mojave Desert). With the possible exception of the Stahl site, Pinto/Little Lake period assemblages are quite similar between areas with respect to patterns of flaked stone material acquisition and use, mobility, and hunting adaptations, but differ from earlier assemblages by virtue of showing an increase in the frequency of milling equipment — a shift probably reflecting a broadening subsistence base in response to declining environmental conditions (Warren 1986). The Stahl site differs from most other Pinto/Little Lake period manifestations by the presence of hearths, graves, and perhaps residential structures, and a diverse assemblage of flaked and ground stone tools, all attributes consistent with a long-term residential base. Rather than reflecting a permanent residential base, however, it seems more likely that mobile populations may have occupied the unique environmental setting of Little Lake more frequently and for longer periods of time than was the case in most other localities (Bettinger 1989).

During the Gypsum/Newberry period, the settlement system remained mobile but appears to have been less expansive and more regularized. This pattern is well-documented in Owens and Deep Springs valleys (Basgall 1991; Basgall and McGuire 1988; Bettinger 1989; Bettinger et al. 1984; Delacorte 1990), and may also have been the case for Death Valley, but it is difficult to determine with the data at hand (Wallace 1958). In contrast to the central Mojave Desert, where numerous short-term occupations were used to exploit a variety of habitat zones, the Owens-Deep Springs areas evidence greater residential stability. In Owens Valley, for example, groups appear to have moved along a north-south axis, establishing a series of seasonal residential bases, probably occupying Long Valley in summer and southern Owens and Rose valleys in winter. These sites appear to have been occupied and re-occupied for substantial periods of time judging from the presence of structures, features, and a variety of resources obtained from vertically distant habitat zones (e.g., pinyon, mountain sheep, and marmots found in lowland sites such as Lubkin Creek). This latter phenomena probably reflects exploitation of upland areas by task-specific groups, a strategy consistent with archaeological data from the southern Sierra (McGuire 1981), White Mountains (Bettinger 1991), and the uplands surrounding Death and Deep Springs valleys (Delacorte 1990; Wallace 1958).

Saratoga Springs/Haiwee and Shoshonean/Marana period adaptations in Owens Valley are characterized by increased sedentism, territoriality, and socio-political complexity, developments made possible by more intensive exploitation of local resources within progressively smaller units of land, as well as more extensive use of upland areas used previously for hunting (Bettinger 1989, 1991; Bettinger and Baumhoff 1982; McGuire 1981). In addition to these subsistence shifts, Bettinger (1982a) and Bettinger and King (1971) argue that the exchange of Fish Springs obsidian was also a primary contributor to the origin of this system, allowing those in control of the source to trade for subsistence resources previously acquired through some form of settlement mobility. Bettinger (1989), however, suggests that other factors, such as increasing population, may also have contributed to the development of this pattern.

Although territorial ranges after the Newberry period appear to have been reduced in all areas considered, permanent or semi-permanent residential bases seem to have emerged only in the far western Mojave (e.g., Antelope Valley [Sutton 1988a]) and perhaps in Owens Valley (Basgall and McGuire 1988; Bettinger 1989). The more arid lands of Deep Springs and Death valleys, as well as much of the Mojave, required numerous short-term residential base camps to exploit a more dispersed set of environmental zones throughout the Haiwee and Marana periods.

Continuation of these inter-regional differences are also found in the ethnographic record. Summaries of subsistence-settlement information collected from the Owens Valley Paiute and Coso Shoshone (Delacorte 1988; Delacorte and McGuire 1993; see also Bettinger 1982b) document several organizational differences between the two groups. Rather than residing in large semi-permanent villages like the Owens Valley Paiute, inhabitants of the Coso region were organized into independent family groups who moved frequently from one resource tract to another. In early spring, when stored resources were exhausted, families moved to well-watered areas such as Haiwee Springs to collect greens. This was also a time when larger groups would occasionally form to conduct rabbit and antelope drives. By May, many families traveled to Owens Lake to gather brine-fly pupae, but soon thereafter dispersed to gather seeds. Seed gathering was initiated in the lowlands, and progressively moved up in elevation during the summer. The Coso Range was a favored locality; however, more distant upland areas were also used if necessary. Trips could also be made to Saline or Panamint valleys to collect mesquite in years when local seed production was below normal. By late summer groups often concentrated in upland areas to gather and store late ripening seeds and prepare for the fall pinyon harvest. The Coso Range was a primary pinyon collection area, but when local crops failed, families would go to the Inyo and Panamint ranges to collect and store the nuts.

After fall harvest and continuing through winter, several families would aggregate in favored lowland settings (e.g., Olancha, Coso Hot Springs, Little Lake) or, in years when pinyon crops were exceptionally productive, smaller groups might choose to winter in the Coso Range closer to their caches of nuts. Alternatively, when local crops were insufficient, families could gather in neighboring uplands, and rely on stored foods and locally available game.

As the foregoing discussions of archaeological and ethnographic data indicate, the Coso Volcanic Field comprised only a small component of several larger subsistence-settlement systems. Nevertheless, by virtue of lying within an environment rich in lithic material, but relatively marginal with respect to subsistence resources, the area provides an excellent opportunity to measure the relative importance of obsidian across a variety of adaptive modes and historic circumstances.

CHAPTER 3: FIELD AND ANALYTICAL METHODS

Extensive excavation was undertaken at 34 sites (Map 3; Table 6). Each locality was systematically surface collected and subjected to a phased excavation strategy. The purpose of this approach was to develop a preliminary evaluation of site/locus structure, followed by extensive excavation focusing on areas identified as potential single component deposits. Potential single component areas were identified in the field as spatially discrete concentrations of material, and typically were confined to areas less than 30-40 m in diameter. This method directed detailed investigations to artifact/debitage concentrations and features; diffuse scatters were less thoroughly sampled.

FIELD METHODS

Two basic field strategies were applied, one in areas with subsurface deposits (usually off-quarry sites), the other where cultural materials were essentially restricted to the surface (usually lag quarries). If subsurface deposits were suspected, fieldwork began by establishing a 15 x 15 m grid, followed by surface collecting all formed tools from the site (e.g., flaked, ground, and battered stone tools, but not debitage), provenienced relative to 3 x 3 m cells. Subsurface distributions were then evaluated by excavating 1 x 1 m selective recovery units usually in the southwest corner of 15 x 15 m quads. Selective recovery units were dug in 10 cm levels, deposits were processed through 1/4" mesh, and all cultural material other than debitage was retained. Debitage densities were monitored by Controlled Volume Samples (CVS) consisting of approximately 10% of a 10 cm level (1 x 1 m unit - 1/4" mesh). This approach was designed to maximize recovery of information related to site structure, in order to decide the placement of subsequent excavation units. Based on these data and surface distributions, control excavation units (CUs) were placed where artifact and debitage concentrations appeared to be present. Control units were also excavated in 10 cm levels with spoils processed through 1/4" or 1/8" mesh. CU-1/4" units were usually 1 x 2 m in size, while CU-1/8" units were typically 1 x 1 m or 0.5 x 1 m. Where cultural material was largely restricted to near-surface contexts, 3 x 3 m surface scrapes were excavated to a depth of 10 cm. Surface scrape matrices were processed using regular combinations of 1/4" and 1/8" mesh.

At lag quarries, because subsurface deposits were usually lacking, a variety of surface collection techniques were used. When such an area was of a manageable size and artifact densities were low, surface collection procedures were the same as those described above, with the additional collection of debitage samples from a 3 x 3 m cell at the corner of each 15 x 15 m quad. When an area was very extensive and artifact densities were very low, debitage and artifacts alike were collected from 3 x 3 m cells placed at constant intervals along widely spaced transects. Interval widths varied from one site to the next in response to the size of the area, the steepness of the terrain, and the perceived density of materials. For areas less than 150 x 250 m (e.g., INY-1816 and INY-1824 Main), sample cells were at 15 m intervals. For even more extensive areas, which usually had even more sparse distributions, 30 m or wider intervals were used (e.g., INY-3200 and INY-3300) and transects were oriented at a right angle to the landform. Temporally diagnostic artifacts or other particularly noteworthy artifacts found outside the sample of surface collection cells were individually collected. When a concentration of materials occurred within an otherwise extensive but sparse quarry, a 15 x 15 m grid was established overlaying the concentration, and all formed tools within the grid were collected (again relative to 3 x 3 m cells). Based on documented surface distributions, areas of further interest were test excavated with 1 x 1 m selective recovery units to verify that subsurface deposits were lacking. Additional excavation was limited to 3 x 3 m surface scrapes overlaying the densest artifact/debitage clusters.

Backhoe trenches were also used on occasion to discover features or significant concentrations of artifacts below ca. 40 cm. As field work continued, it became apparent that subsurface deposits were largely restricted to the upper 50 cm (and rarely extended to 80 cm) and correlated with surface distributions. Backhoe trenches were cut only at INY-4267 and INY-4329, they proved to be of limited utility, and further use was discontinued.

Upon completing excavation, profiles were drawn of representative exposures, and soil samples were collected so that color, consistency, and other characteristics of depositional strata could be examined under laboratory conditions. Grid stakes, fencing, flagging, etc., were then retrieved, and units backfilled to original contours.

Table 6. Materials Recovered from Project Sites.

Site (INY-)	1816	1824 Main	1824-B	1824-X	1906	1907	1984	2103	2825	2826	3004/5	3012	3015	3299	3300	3456	4239	4240	4243
Flaked Stone																			
Biface/Point	-	8	1	-	2	-	2	4	1	5	4	-	1	-	-	-	1	-	-
Biface	52	319	6	8	67	59	123	171	8	44	267	101	11	37	155	71	61	3	18
Core	9	37	2	-	3	-	37	29	5	80	245	15	11	55	424	9	1	-	-
Drill	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Flank Blank	1	15	-	-	3	-	4	6	-	-	18	3	-	1	2	2	3	-	-
Flake Tool	6	46	-	-	13	11	23	40	-	3	57	17	1	10	21	4	6	2	3
Formed Flake Tool	1	-	-	-	-	-	1	1	-	-	5	-	-	1	7	-	-	-	-
Projectile Point	3	5	-	-	2	-	2	8	-	2	8	1	1	-	4	1	2	-	-
Uniface	1	10	-	-	1	-	11	6	-	5	28	1	-	6	9	2	6	1	1
Uniface-B	6	27	2	-	2	1	15	13	-	6	38	4	1	7	27	2	4	-	-
SUBTOTAL	79	467	11	8	93	71	218	279	14	145	670	142	26	117	649	91	84	6	22
Debitage																			
Obsidian	2819	11182	269	927	3694	10348	1377	8872	90	8014	4908	1404	985	3079	3372	4974	9017	2193	368
Non-obsidian	19	41	1	-	40	28	104	41	4	3	35	19	3	-	3	20	67	8	8
Ground and Battered Stone																			
Millingstone	35	10	-	-	56	1	26	51	12	3	28	45	-	1	-	14	2	-	3
Handstone	17	5	-	-	38	3	7	19	3	1	7	23	-	2	-	14	1	-	6
Misc. Ground Stone	6	1	-	-	3	-	1	14	1	-	7	27	-	-	-	-	-	-	-
Mortar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Pestle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Bedrock Mortar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bedrock Slick	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-obsidian Cobble-Core	7	14	-	-	16	12	14	9	4	5	22	16	1	1	7	4	1	1	1
SUBTOTAL	65	30	-	-	116	16	48	93	20	9	64	111	1	4	7	34	4	1	10
Miscellaneous																			
Abrader	-	1	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-
Anvil	2	-	-	-	-	-	-	1	-	-	2	-	-	-	1	-	-	-	-
Bead	-	1	-	-	247	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crystal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Historic	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Incised Stone	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Miscellaneous Shaped Stone	1	-	-	-	2	4	-	-	-	-	1	5	-	-	-	1	-	-	-
Miscellaneous Stone	-	-	-	-	-	-	1	-	2	1	11	-	-	-	-	1	-	-	-
Modified Stone	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Palette	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sherd	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SUBTOTAL	3	2	-	-	253	5	1	2	2	1	15	7	-	-	1	3	-	-	-
Artifact Total	147	499	11	8	462	92	267	374	36	155	749	260	27	121	657	128	88	7	32
Organics																			
Bone	53	3	-	-	209	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Charcoal	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Excavation Summaries (in cubic meters)																			
Selective Recovery 1/4"	6.45	13.10	-	1.20	7.20	4.80	3.70	7.20	3.50	1.30	13.40	9.85	-	1.40	2.80	6.70	5.90	3.40	2.80
Control Unit 1/4"	17.30	12.55	2.60	2.20	7.65	5.00	6.60	7.60	1.00	6.00	6.45	10.60	2.10	3.10	0.80	5.50	4.60	5.80	1.20
Control Unit 1/8"	0.85	1.95	0.10	0.65	1.85	0.55	0.65	0.70	1.20	0.60	1.80	1.75	1.00	1.30	0.72	0.45	0.65	0.55	0.20
TOTAL	24.60	27.60	2.70	4.05	16.7	10.35	10.95	15.50	5.70	7.90	21.65	22.20	3.10	5.80	4.32	12.65	11.15	9.75	4.20

Table 6. Materials Recovered from Project Sites (continued).

Site (INY-)	4244	4246	4252	4267	4319	4320	4322/H	4324/H	4325	4327	4328	4329	4330	4331	4378	TOTAL
Flaked Stone																
Biface/Point	-	-	-	3	1	-	-	-	1	-	1	4	1	-	-	40
Biface	98	26	25	301	109	15	13	90	33	8	70	446	52	18	27	2912
Core	5	2	-	33	157	25	29	93	7	19	73	306	8	15	122	1856
Drill	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2
Flank Blank	5	2	-	14	14	6	-	-	4	-	4	58	-	-	2	167
Flake Tool	16	9	2	45	15	15	7	15	5	2	11	225	4	13	2	649
Formed Flake Tool	-	-	-	6	-	1	-	-	-	1	1	8	-	2	-	35
Projectile Point	2	-	-	5	-	-	-	-	3	-	1	7	2	1	-	60
Uniface	6	1	-	13	15	3	-	5	2	6	13	50	1	4	1	208
Uniface-B	7	-	1	26	24	2	-	13	2	-	11	56	2	1	3	303
SUBTOTAL	139	40	28	446	335	67	49	216	57	36	185	1161	70	54	157	6232
Debitage																
Obsidian	21984	2083	1321	25074	448	474	1229	12195	771	400	610	33715	3314	465	3325	185300
Non-obsidian	-	3	95	173	1	-	-	12	7	3	7	251	36	1	-	1033
Ground and Battered Stone																
Millingstone	-	1	1	56	5	1	-	-	5	-	3	25	3	-	-	387
Handstone	1	1	1	18	-	-	-	-	5	-	-	6	1	-	-	179
Misc. Ground Stone	-	-	-	10	-	-	-	-	-	-	-	2	1	-	-	73
Mortar	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	6
Pestle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Bedrock Mortar	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Bedrock Slick	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	5
Non-obsidian Cobble-Core	-	-	-	14	25*	3	3	4	3	2	6	108	4	3	1	311
SUBTOTAL	1	2	2	106	30	4	3	4	13	2	9	141	9	3	1	963
Miscellaneous																
Abrader	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Anvil	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	7
Bead	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	250
Crystal	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Historic	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	6
Incised Stone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Miscellaneous Shaped Stone	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	19
Miscellaneous Stone	-	-	-	2	1	-	-	-	-	-	-	3	1	-	-	23
Modified Stone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Palette	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Sherd	-	-	-	-	-	-	-	-	-	-	-	41	-	-	-	41
SUBTOTAL	-	-	-	6	1	-	-	1	-	-	-	49	1	-	1	354
Artifact Total	140	42	30	558	366	71	52	221	70	38	194	1351	80	57	159	7549
Organics																
Bone	2	1	-	20	-	-	-	-	-	-	-	21	3	-	-	315
Charcoal	-	-	11	26	-	-	-	-	-	-	-	1	8	-	-	47
Excavation Summaries (in cubic meters)																
Selective Recovery 1/4"	-	0.80	1.90	19.60	6.20	2.10	0.70	2.95	1.40	-	4.90	45.70	11.50	1.50	0.70	194.65
Control Unit 1/4"	10.00	3.70	3.50	18.40	1.60	0.60	2.50	2.85	1.00	3.60	1.90	35.60	14.00	1.20	2.90	212.00
Control Unit 1/8"	0.60	0.63	0.70	0.90	0.80	0.15	0.30	0.70	2.76	0.40	0.30	1.55	0.85	0.15	0.40	28.71
TOTAL	10.60	5.13	6.10	38.90	8.60	2.85	3.50	6.50	5.16	4.00	7.10	82.85	26.35	2.85	4.00	435.36

NOTE: * - includes one obsidian core tool.

ANALYTICAL METHODS

All cultural material was washed and catalogued during fieldwork at a temporary lab at Coso Junction, or soon thereafter at Far Western facilities in Davis, California. Accession numbers were obtained from the Environmental Branch, China Lake Naval Air Weapons Station, and any materials previously collected from project sites were loaned to us for re-analysis and incorporation in this study. Analysis during cataloguing was limited to basic artifact description, saving more sophisticated observations for individuals in charge of particular artifact classes. As the first step of analysis, catalogued artifacts were individually reviewed by the authors (flaked stone by Gilreath, ground and battered stone by Hildebrandt) to verify type and condition ascriptions. Reassignments based on this full review of the collection were incorporated in the master catalogues. Detailed analyses were then implemented. All recovered materials are now curated at the Naval Air Weapons Station. Field notes, field maps, and project photographs accompany the collection. Master catalogues and analysis files exist in both printed versions and as dBASE IV files on computer diskettes.

FLAKED STONE ANALYSIS

Our interest in documenting the flaked stone production history for the Coso Volcanic Field resulted in an analysis structured to emphasize recognition of manufacturing activity, intensity, and technology; and artifact morphology in the context of reduction trajectories. Functional analysis was kept to a minimum, in response to the low number of flaked stone "tools," relative to the extraordinary quantities of cores, blanks, and preforms. For descriptive purposes, artifact size, shape, and condition were stressed. The raw material itself sets upper limits on attainable artifact sizes, may influence the shape of some artifact types, and sometimes is responsible for the broken condition of a specimen (e.g., flaws in the stone, not poor execution on the part of the craftsperson might have caused an item to break). Prehistoric flintknappers' habits, techniques, and objectives are, however, more compelling forces responsible for shaping the artifacts, and creating the archaeological record at Coso.

The following artifact categories were used for flaked stone at the catalogue level: projectile points, biface/points, drills, bifaces, uniface-B's (items reduced like a biface but with modification largely restricted to one face), flake blanks, formed flake tools, simple flake tools, cores, and unifaces. In addition to classifying each artifact by material (obsidian, cryptocrystalline, basalt, etc.), basic measurements were recorded (length, width, thickness, weight) for all analyzed specimens, as well as the condition or portion of the item represented. All projectile points and biface/points were analyzed; analysis of all other flaked artifacts was largely restricted to those occurring in temporally meaningful contexts.

Projectile points are bifacial implements fashioned by pressure flaking and having hafting elements present, denoted by notches, shoulders, and/or a stem. Most can be readily classified according to Thomas' (1981) Great Basin projectile point key; the remaining are large, shouldered forms considered Great Basin Stemmed and various leaf-shaped items. A total of 60 projectile points was recovered (Table 6; see Plates 1-9 in Chapter 5); 112 additional points found during survey in the Volcanic Field supplement the sample. Attributes recorded for all 172 projectile points are those used in Thomas' key.

Non-diagnostic pieces of projectile points were classified as biface/points, of which 40 were recovered (Table 6). In addition to recording the same attributes as those for bifaces, biface/point fragments were subjectively identified as deriving from arrow or dart-sized points, based primarily on size.

Only two of the nearly 6,250 flaked stone items were classified as drills. Both exhibit elongate, bi-convex bits fashioned by bifacially pressure flaking converging edges.

Bifaces exhibit percussion and/or pressure flake removal scars along opposing sides of a continuous margin. Nearly 3000 bifaces were recovered (n=2912, Table 6). Two other artifact categories related to biface production — uniface-B's (n=303) and flake blanks (n=167) — are considered biface-equivalents. The former are typically large flake-based items that were percussion flaked, removing thinning flakes from a single surface. Minor modification sometimes occurs on the original ventral surface, but is confined to a narrow zone around the perimeter, and related to edge and platform preparation. Flake blanks are complete or near complete flakes which were edge trimmed by a series of short percussion flake removals, usually making a triangular form with rounded basal corners. Planar and cross-section views indicate that bifaces and these two variants were systematically rather than haphazardly formed.

The analytical utility of differentiating reduction stages is well established by such works as Callahan (1979), Collins (1975), Crabtree (1973), Frison and Bradley (1980), Muto (1971), Newcomer (1971), and Sharrock (1966). Bifaces, uniface-B's and flake blanks received comparable analysis, starting with classification into five stages based on size, reduction technique, appearance, and quality. Stage 1 items are typically large, very thick items with percussion worked edges rendering an irregular planar form, and extremely sinuous and often discontinuous worked margin. Approximately 60% of the item's margin has been bifacially worked, suggesting its affiliation with a biface reduction trajectory, rather than a flake-production core trajectory. The distinction between Stage 1 bifaces and bifacial cores is admittedly often arbitrary. Modification on Stage 2 items, a term used interchangeably here with bifacial blanks, is also restricted to percussion flaking, but they have less sinuous margins and slightly thinner cross-sections than Stage 1s. At least 80% of the margin has been bifacially modified (for uniface-B's at least 80% of the margin has been unifacially worked), with flake removals having served to effectively thin the item (Figures 3 and 4c). Stage 3 items, also referred to as preforms, are thinner and display more regular, less sinuous, margins than Stage 2s. Evenly spaced, systematically removed percussion flakes have rendered a symmetric, uniformly bi-convex cross-section on the bifaces (Figure 4a-b); plano-convex shapes on uniface-B's; and slightly concave-convex cross-sections on the edge-trimmed flake blanks (Figure 5). Stage 4 items are small, intermittently pressure flaked bifaces, representing either fragmented projectile points or items which broke early during tool finishing activities. Finally, Stage 5 bifaces are extensively pressure flaked fragments of final tool forms such as projectile points and bifacial knives. Margins are heavily flaked, and entire opposing surfaces are completely covered by closely spaced pressure flake removal scars. In addition to classifying bifaces to stage of reduction and condition, a single edge-angle measurement was taken, planar and cross-sectional shape were recorded, and the reason for discard/rejection was assessed. As previously mentioned, high technological standardization and high rates of success have been listed as indicators of production specialization. A high number of bifaces standard in form and shape, combined with manufacturing failure patterns could provide evidence that such specialization occurred at Coso. For the most part, uniface-B's and flake blanks will not be distinguished from true bifaces in discussions that follow, in order to minimize confusion and unnecessarily protracted assemblage characterizations.

For this study, a core is a mass of stone minimally exhibiting two flake removals. At least a portion of the margin from which flakes were removed remains intact, so that direction of removals can be evaluated. This definition served to eliminate the amorphous "core-like" pieces of shatter produced during initial reduction and the naturally fractured chunks of glass common in the Volcanic Field. A total of 1856 cores was recovered (Table 6); they were classified as unidirectional, bidirectional, bifacial (Figure 6a), non-patterned (Figure 6b, d), or cobble/chunk tests (Figure 6c), depending on the orientation of flake removals and worked margins relative to one another. Other attributes recorded include: the basic form of the mass reduced (tabular cobble, globular cobble, angular cobble, flake, piece of shatter), type of cortex evident on the piece, and planar and cross-sectional shape of the object.

Simple flake tools (n=649) are flakes that show minimal amounts of deliberate flaking and/or damage extending along a continuous segment of the perimeter. Edge modification occurs nearly exclusively as microchipping, most commonly unifacial damage, and rarely intrudes more than two or three millimeters from the margin. As a result, edge damage has little changed the size and shape of the originally detached flake (Figure 7a). Analysis included number of edges modified, shape of the modified edge (straight, convex, concave, etc.), length of the modified portion of an edge, type of modification (unifacial/bifacial microchipping, edge grinding), as well as spine-plane and working edge angles. Formed flake tools (n=35) are flake-based tools where edge modification was extensive and deliberate, resulting in reshaping of the originally detached flake. Recorded attributes parallel those for simple flake tools.

Unifaces (n=208) display steep, unidirectional, percussion flake removal scars underlaying a 2-5 mm zone of extensive edge modification (Figure 7b-d). Edge modification, apparently from use, takes the form of non-invasive, percussive edge trimming flakes and/or microchipping. They differ from unidirectional cores in that they tend to display fairly regularized planar shapes, keeled cross-sections, and intentional edge damage; they differ from uniface-B's in that percussion flake removals did not effectively thin the piece, rather they created a steep platform/face juncture.

Flake stone debris lacking post-detachment modification (i.e., no subsequent edge damage or flake removals) was considered debitage. Excavation and surface collection rendered over 185,000 pieces of obsidian debitage, compared to about 1,000 pieces of non-obsidian chipping debris (Table 6). Preliminary review of the collections revealed two major manufacturing trajectories, both largely confined to percussion flaking: biface production and core production. Consequently, flake types developed for debitage classification sought to monitor

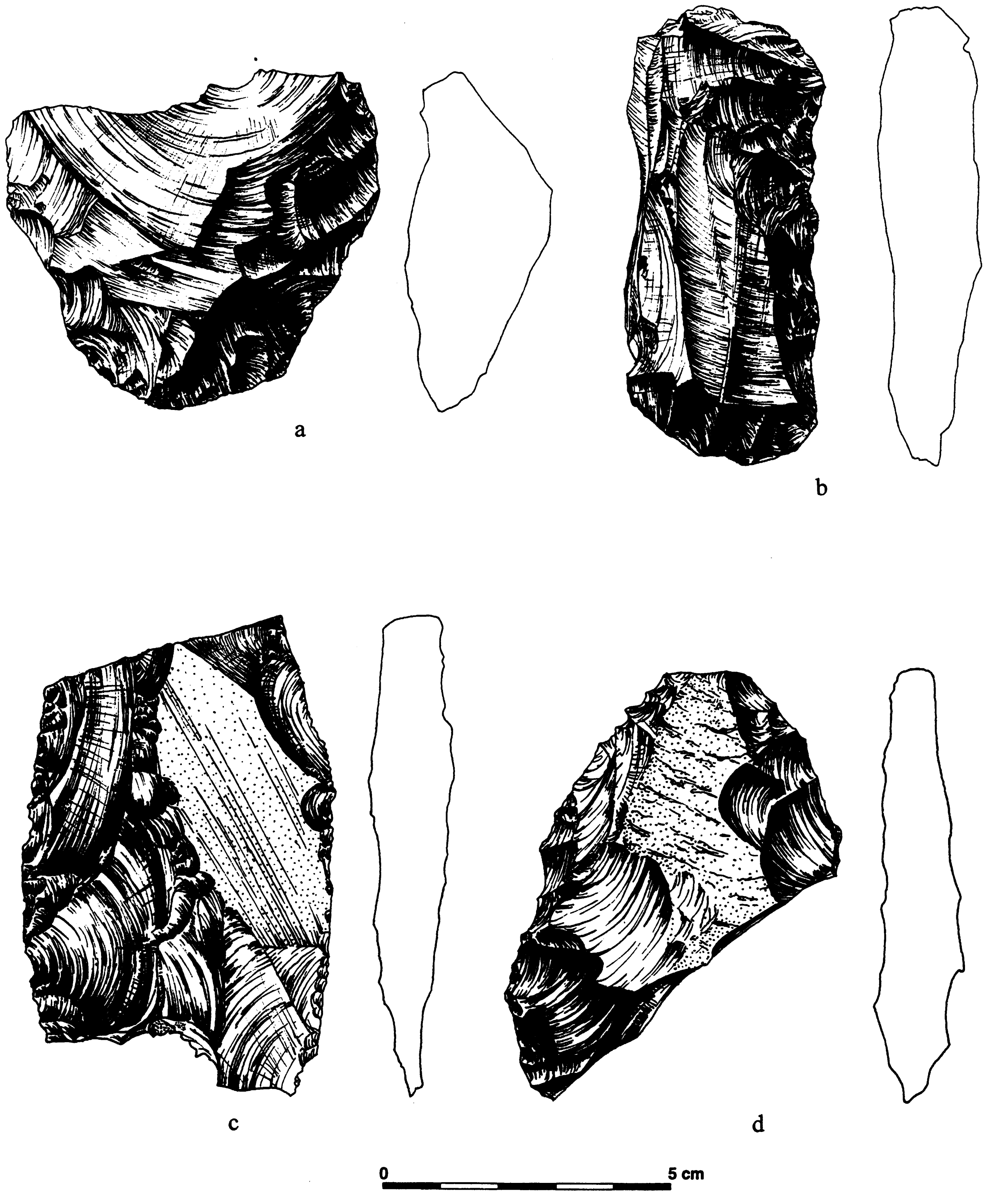


Figure 3. Obsidian Stage 2 Bifaces from INY-3456 (a, b) and INY-4252 (c, d). a. Whole (987-44-104); b. Whole (987-44-216); c. Base (987-93-96); d. End (987-93-68).

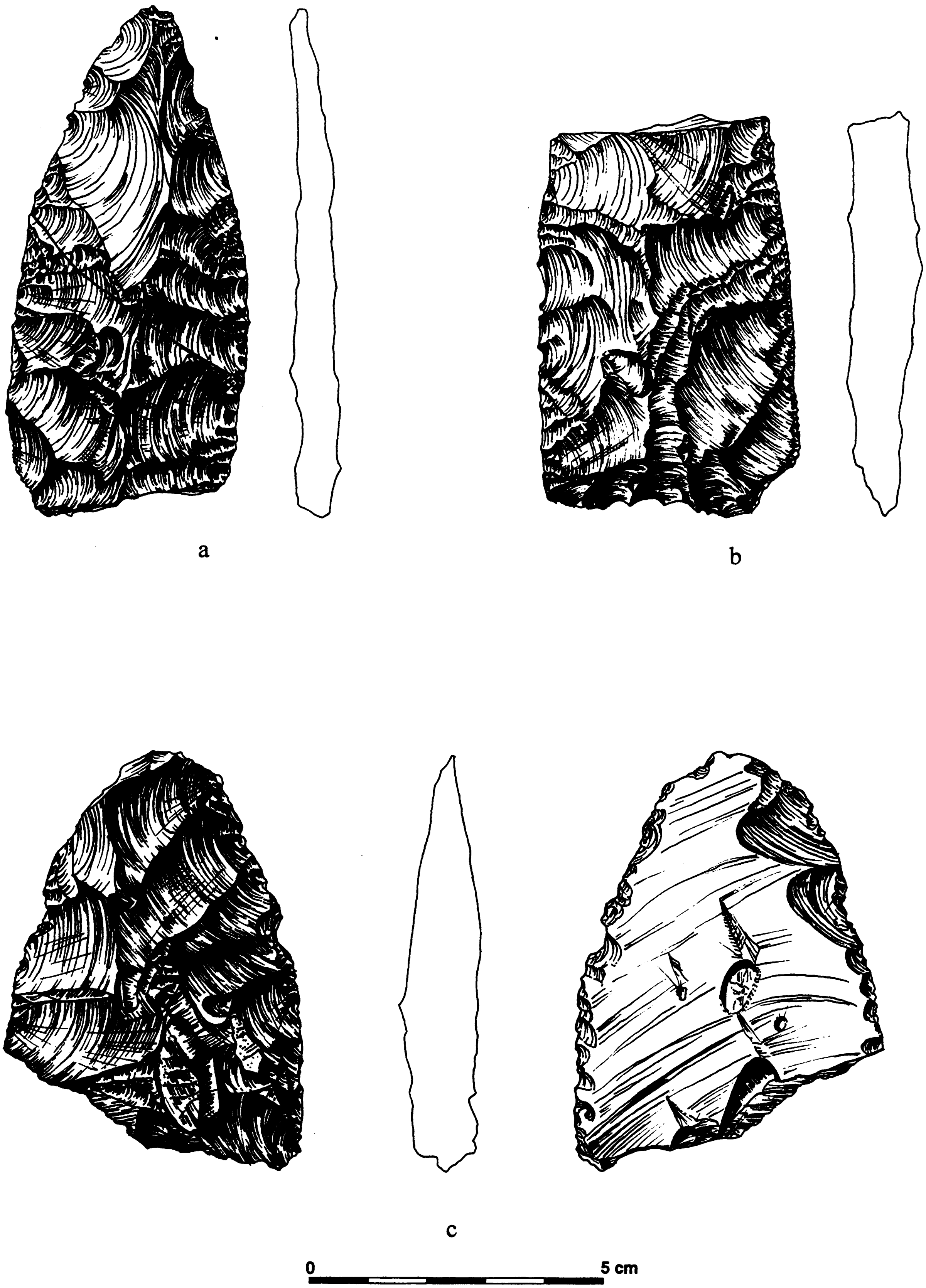


Figure 4. Obsidian Stage 3 Bifaces (a, b) and Stage 2 Uniface-B (c) from INY-4252. a. Complete (987-93-17/89); b. Base (987-93-71); c. End (987-93-7).

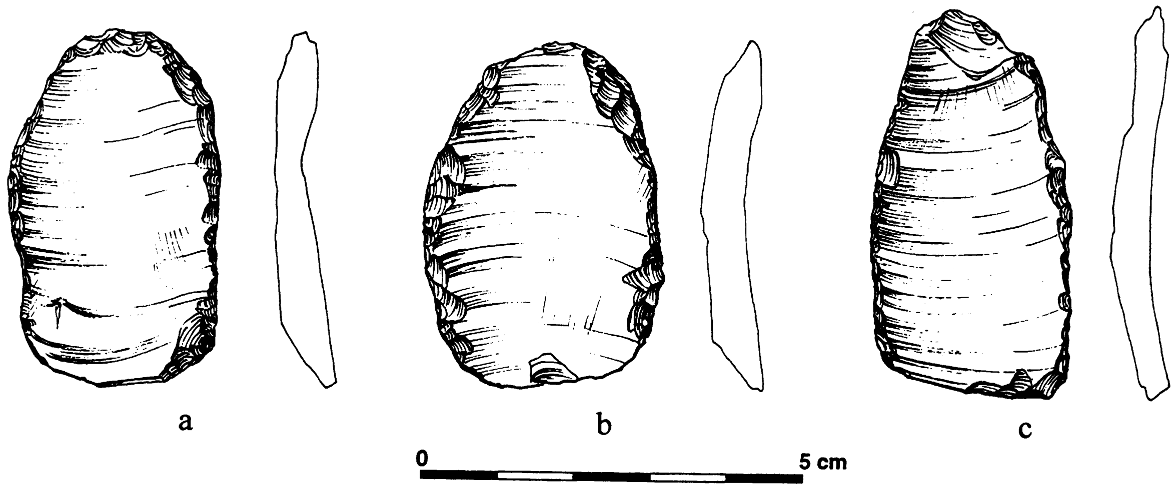


Figure 5. Complete Obsidian Stage 3 Flake Blanks from INY-4239. a. 987-38-93; b. 987-38-111; c. 987-38-172.

the relative importance of these two basic strategies. The initial separation of biface from core/flake percussion reduction debris relied on complexity of the striking platform, platform to dorsal surface angle, complexity and configuration of dorsal surface scars, and flake curvature as distinguishing characteristics. Biface percussion reduction debitage categories include: primary and secondary decortication flakes, and early (large interior flakes which tend to be thick, of variable shapes, and only slightly curved from proximal to distal ends), middle (smaller than early thinning flakes, thinner, and slightly more curved from proximal to distal end, with moderately complex dorsal surfaces), and late stage thinning flakes (thin, regularly shaped biface thinning flakes of uniform size, complex dorsal surface, moderately curved from proximal to distal end, and multi-faceted, sometimes ground striking platforms). Cortical thinning flakes and early interior thinning flakes were subsequently combined as early stage biface reduction debris. Core/flake percussion reduction debitage categories include: primary and secondary decortication flakes, simple interior (displaying two or fewer dorsal arrises), complex interior (displaying three or more dorsal arrises), and rectangular/linear flakes. Other flake types recognized include: angular shatter (angular chunks displaying sufficient flake attributes such as compression rings, hackles, or partial bulbs of force, signifying that they were culturally produced), edge preparation flakes (small [$<$1.5 cm], usually whole percussion flakes), indeterminate percussion flake fragments, pressure flakes, edge preparation/pressure flakes, and indeterminate flake bits.

GROUND AND BATTERED STONE ANALYSIS

Milling equipment is dominated by millingstones (n=387), and handstones (n=179), followed by fewer miscellaneous fragments (n=73), and the rare bedrock slick, mortar, and pestle. These tools were analyzed using methods applied to similar assemblages from Owens Valley and the central Mojave Desert (Basgall and McGuire 1988; Basgall et al. 1988), but modified to some extent to deal with analytical problems unique to our project's goals (see also Fratt and Adams 1993).

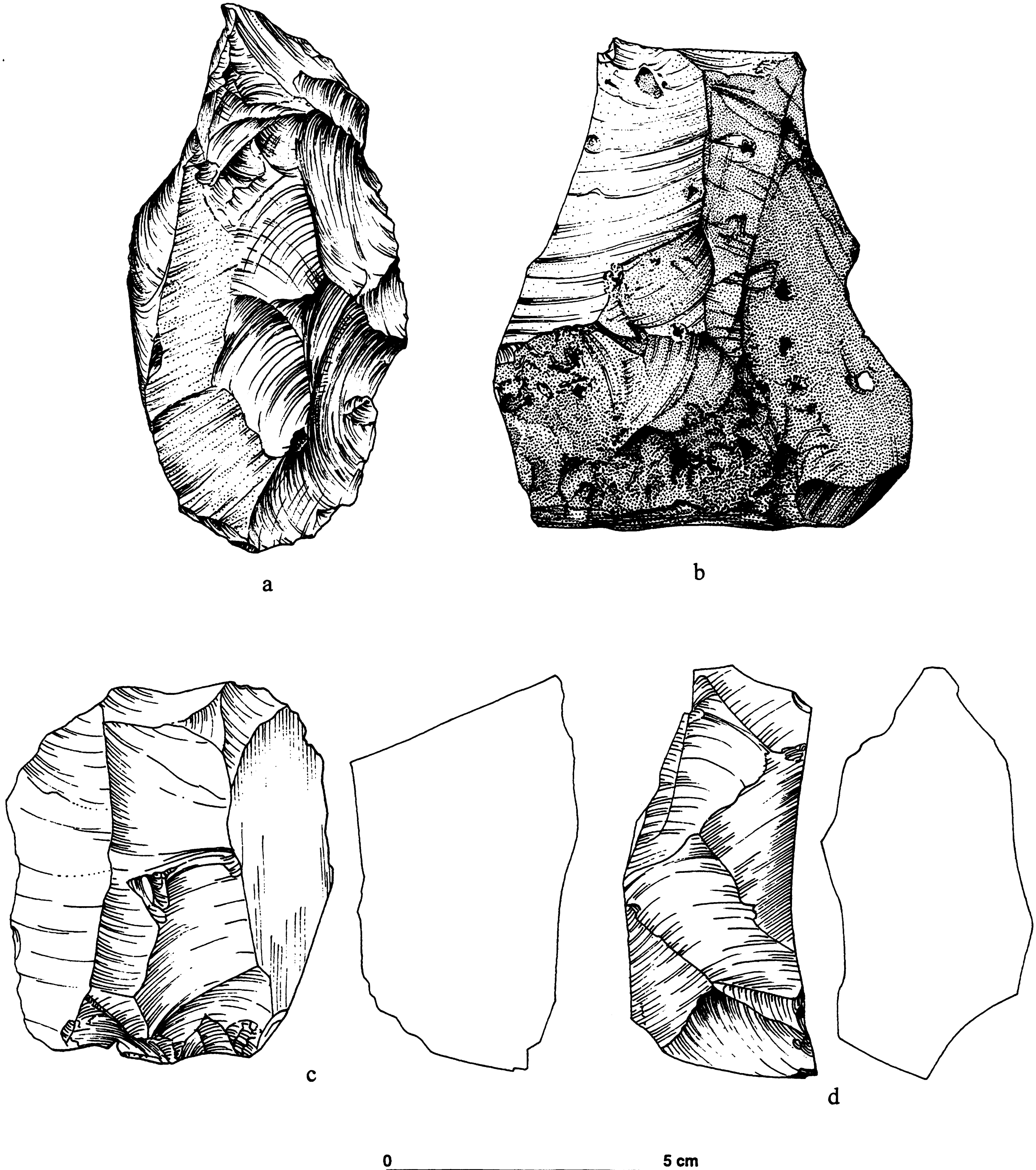


Figure 6. Complete Obsidian Cores from INY-2826 (a, b,); INY-4327 (c); and INY-4319 (d). a. Bifacial (987-29-70); b. Non-patterned (987-29-64); c. Cobble/Chunk Test (987-101-64); d. Non-patterned (987-97-352).

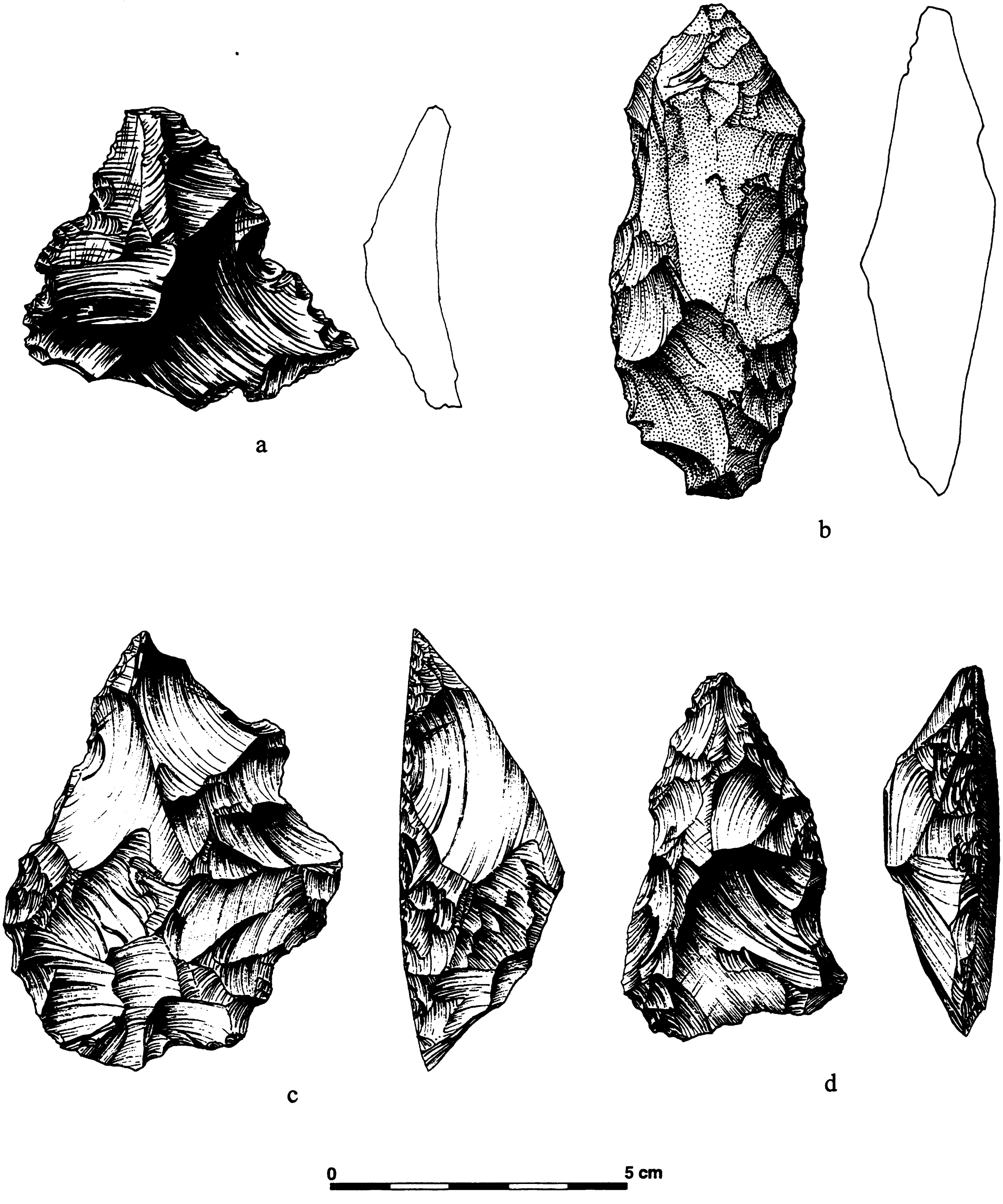


Figure 7. Complete Obsidian Flake Tool from INY-2103 (a), and Unifaces from INY-4267 (b) and INY-4327 (c, d).
a. 987-27-385; b. 987-88-52; c. 987-101-17; d. 987-101-18.

Millingstones

Aboriginal decisions regarding materials used were often influenced by the natural form and consistency of locally available rock. Rock types found only as boulders and cobbles, for example, were rarely selected when a portable, thin slab millingstone was desired. Hardness also influences wear patterns, as softer rocks develop diagnostic wear patterns more quickly than resistant stone. Finally, the presence of exotic rock types (usually in the form of handstones and thin slab millingstones) can also provide information regarding settlement mobility, particularly if the source locality is known. For all of these reasons, material type was the first major attribute used to classify millingstones.

The vast majority of millingstones fall into four basic rock types: rhyolite, granite, basalt, or dike rock. Rhyolite is least resistant of the four, and is common as natural blocks and slabs on the sides of rhyolitic domes. It is quite light and friable, often exhibiting pumice-like qualities. Granitics are much harder, and various forms found in the Volcanic Field include granite, granodiorite, diorite, and gabbro. Local basalts are also relatively hard, and range from boulders to thin slabs. Most of this material is fine-grained, dense, and heavy; however, vesicular basalt occurs in a few nearby areas. Dike rock is a fine-grained material extruded from fissures within the granitic outcrops. Harder than the other three, it routinely occurs as thin tabular pieces.

Once identified by material, millingstones were classified according to maximal thickness. Block millingstones are more than 13.0 cm thick (Figure 10b), and are believed to represent essentially stationary tools. Slab millingstones measure between 6.0-13.0 cm thick, and could reasonably have been transported short distances (Figures 8, 9b, 10a). Thin slabs, those less than 6.0 cm thick, were readily transportable (Figure 9a). In addition to other morphological measures such as length, width, and weight, several important functional attributes were recorded for each worn surface. Surface configuration measures the depth of the working surface, and was recorded as flat (no visible concavity), slightly concave (depth $\leq$ 1.0 cm), concave (depth $>$ 1.0 cm), and irregular/convex. Concave forms rarely achieved depths greater than 2.0 cm; deeply basined millingstones do not occur. Wear type refers to some combination of polish, pecking, and striations, while surface wear attempts to measure how extensive wear has been (smooth/complete, irregular, incipient). Other observations include length and width of the grinding surface, whether the implement was intentionally shaped, the number of worn surfaces, and artifact condition (complete, nearly whole, margin fragment, interior fragment).

Material-specific morphological forms outlined above (i.e., blocks, slabs, and thin slabs of granite, rhyolite, etc.), were cross-tabulated with functional attributes to identify correlations between artifact form, function, duration of use, condition, etc. Patterning among the millingstones, combined with attributes of the larger assemblage (e.g., flaked stone, features, plant remains), contribute to a variety of inferences regarding subsistence-settlement strategies.

Handstones

Handstones were analyzed using an approach similar to that of millingstones. Material types include the four outlined above, plus sandstone. Conceding that any and all handstones are portable, morphological types were not explored. Instead, material type was cross-tabulated with a series of functional attributes including surface configuration (flat, slightly convex, convex, rounded), wear type (polish, pecking, striations), and surface wear (smooth/complete, irregular, incipient). Secondary wear patterns (edge battering, edge flaking, edge grinding) were noted, as was tool condition. On bifacial (and the few trifacial) handstones, each milling surface was recorded separately, including dimensions of the worn area. Representative unifacial and bifacial handstones of granite are shown in Figures 11 and 13, rhyolite ones in Figures 11-13, and a basalt handstone in Figure 12a.

Miscellaneous Ground Stone

Miscellaneous ground stone does not represent a distinct functional class, but rather fragments of either millingstones or handstones too small to classify. Analytical methods, therefore, were essentially equivalent to those applied to millingstones and handstones, recognizing the same material types and functional attributes.

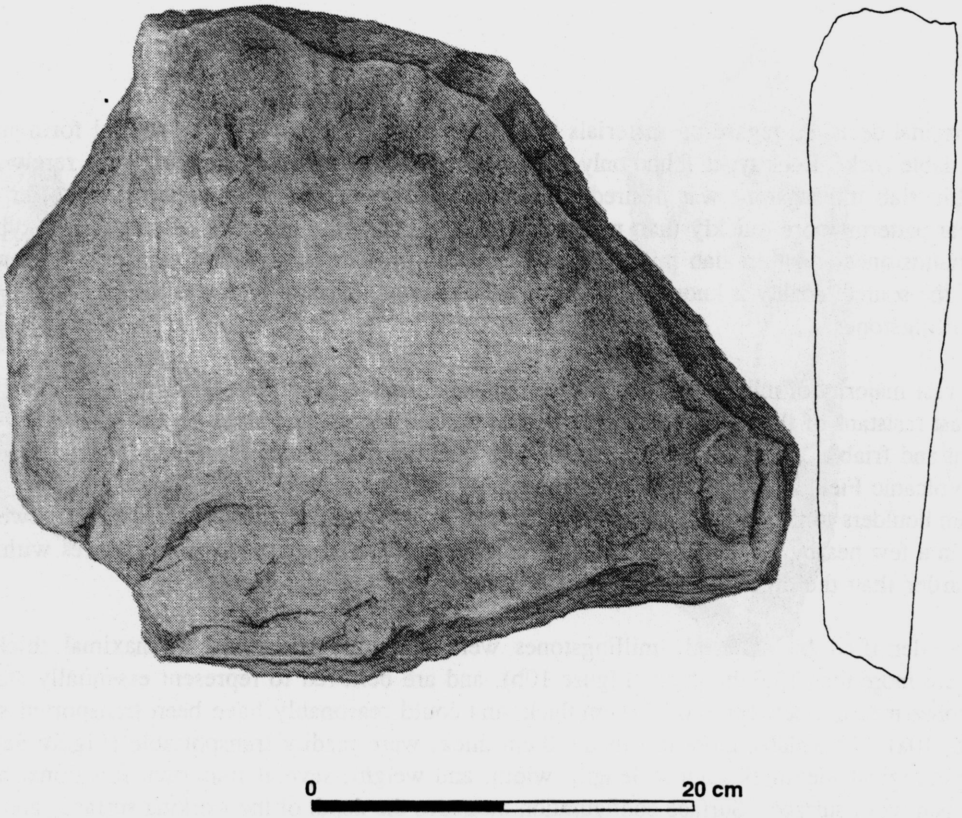


Figure 8. Complete Unifacial Slab of Granite (987-92-1799) with a Planar Surface from INY-4329.

Other Milling Equipment

Other kinds of milling equipment were rare, comprising seven mortars (including one bedrock mortar), one pestle, and a few bedrock slicks. All of these artifacts were recorded using the same basic techniques outlined above.

Non-Obsidian Cobble-Cores

Included in this category are 311 various percussion flaked and/or edge modified cobbles or chunks of non-obsidian material. Some no doubt were hammerstones (e.g., Figure 14d) used by the flintknappers in working obsidian, but many operated as part of the milling assemblage based on context and modification type. Material types parallel those represented in the milling equipment. In addition to basic metrics (length, width, thickness, weight) and condition, we recorded the type and prevalence of use-related damage. Most commonly, edge flaking (Figure 14a), edge battering (Figure 14b), or both (Figure 14c) occur on dike rock or granitic cobbles. Basic shape of the original object (tabular, globular, angular cobble, etc.) was also documented.

MISCELLANEOUS ARTIFACTS

Unusual items are collectively referred to here. Those readily identified as ornaments include 247 glass beads, three shell beads (Figure 15), and perhaps the one piece of incised stone. A single quartz crystal was recovered, as was a thin, lightly surface-worn stone, provisionally identified as a palette. Pebbles or rocks obviously

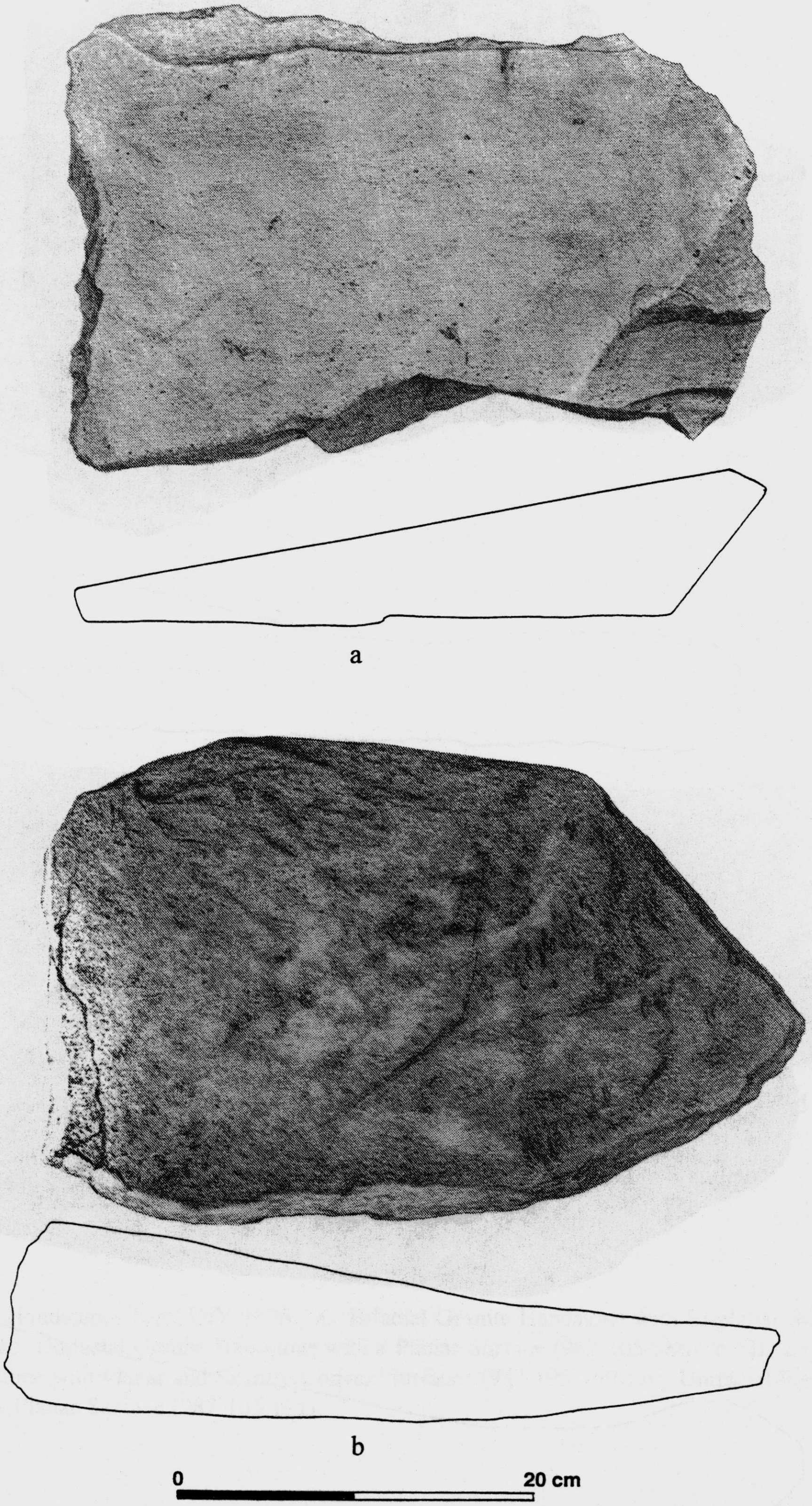


Figure 9. Select Complete Unifacial Granite Millingstones from INY-1906 (a) and INY-1984 (b). a. Thin Slab with a Planar Surface (987-105-131); b. Slab with a Slightly Concave Surface (987-86-27).

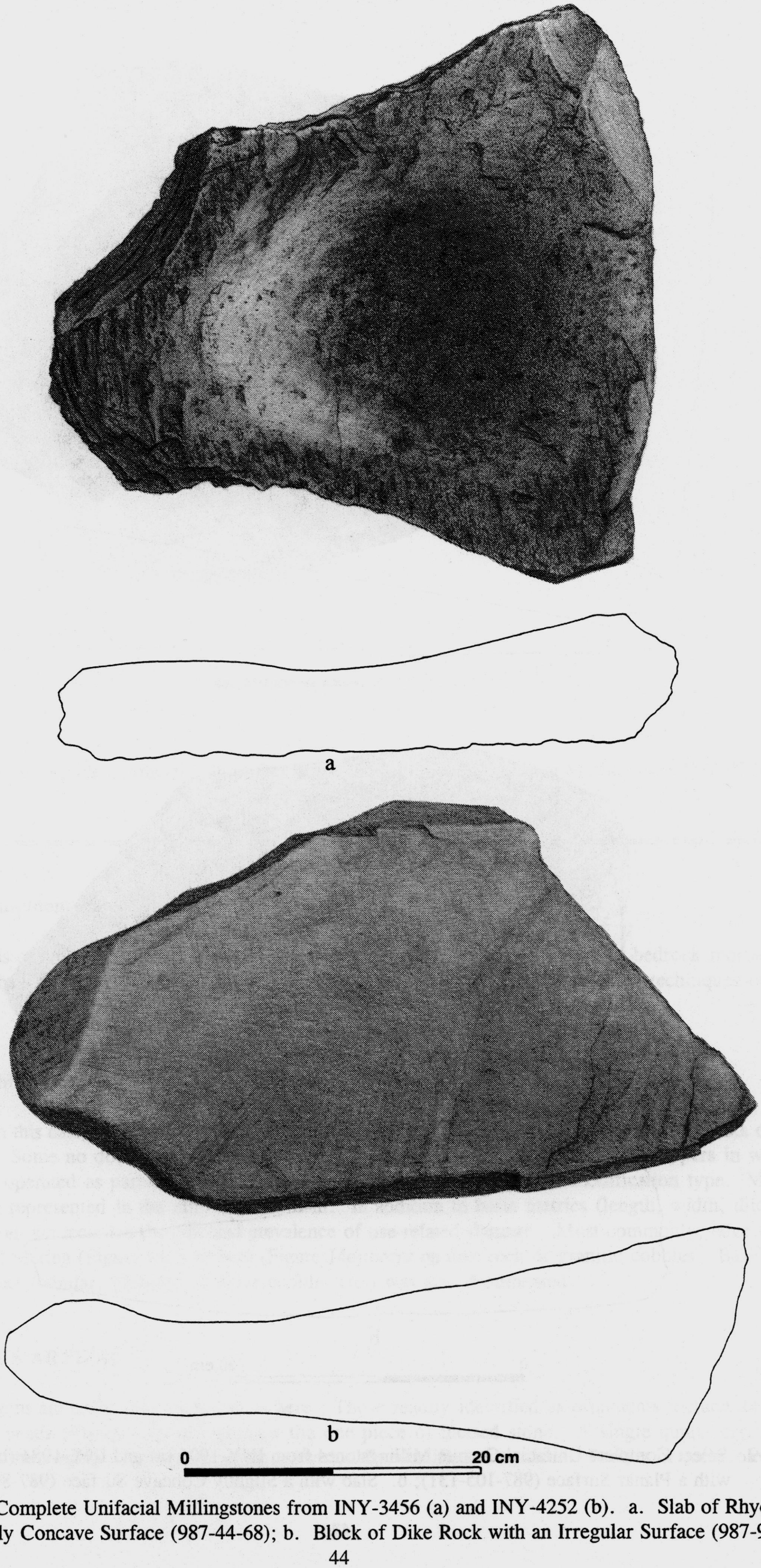


Figure 10. Select Complete Unifacial Millingstones from INY-3456 (a) and INY-4252 (b). a. Slab of Rhyolite with a Deeply Concave Surface (987-44-68); b. Block of Dike Rock with an Irregular Surface (987-93-76).

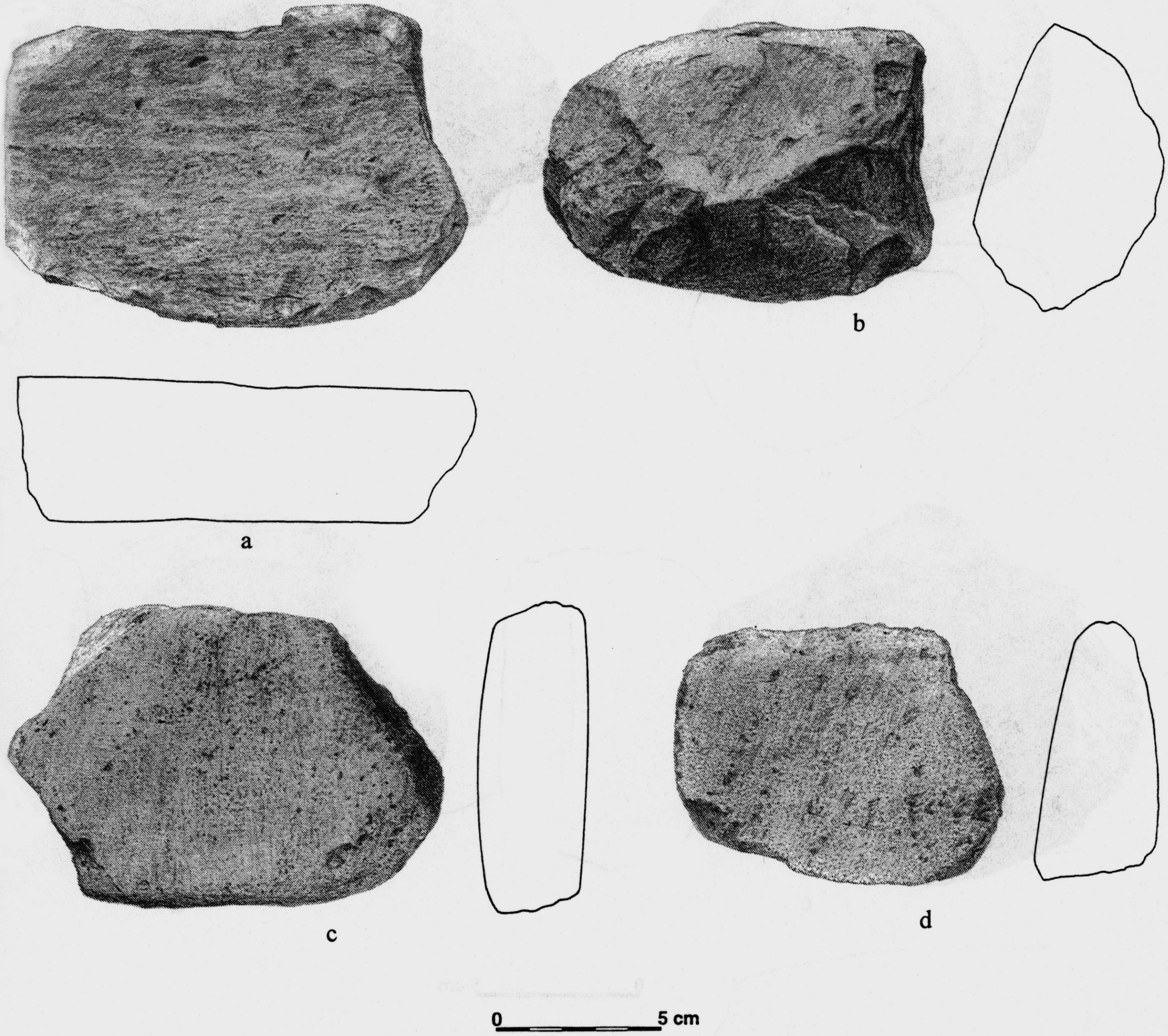


Figure 11. Select Handstones from INY-1906. a. Bifacial Granite Handstone with Bi-planar Surfaces (987-105-165); b. Unifacial Granite Handstone with a Planar Surface (987-105-286); c. Bifacial Granite Handstone with Planar and Slightly Convex Surfaces (987-105-169); d. Unifacial Rhyolite Handstone with a Planar Surface (987-105-171).

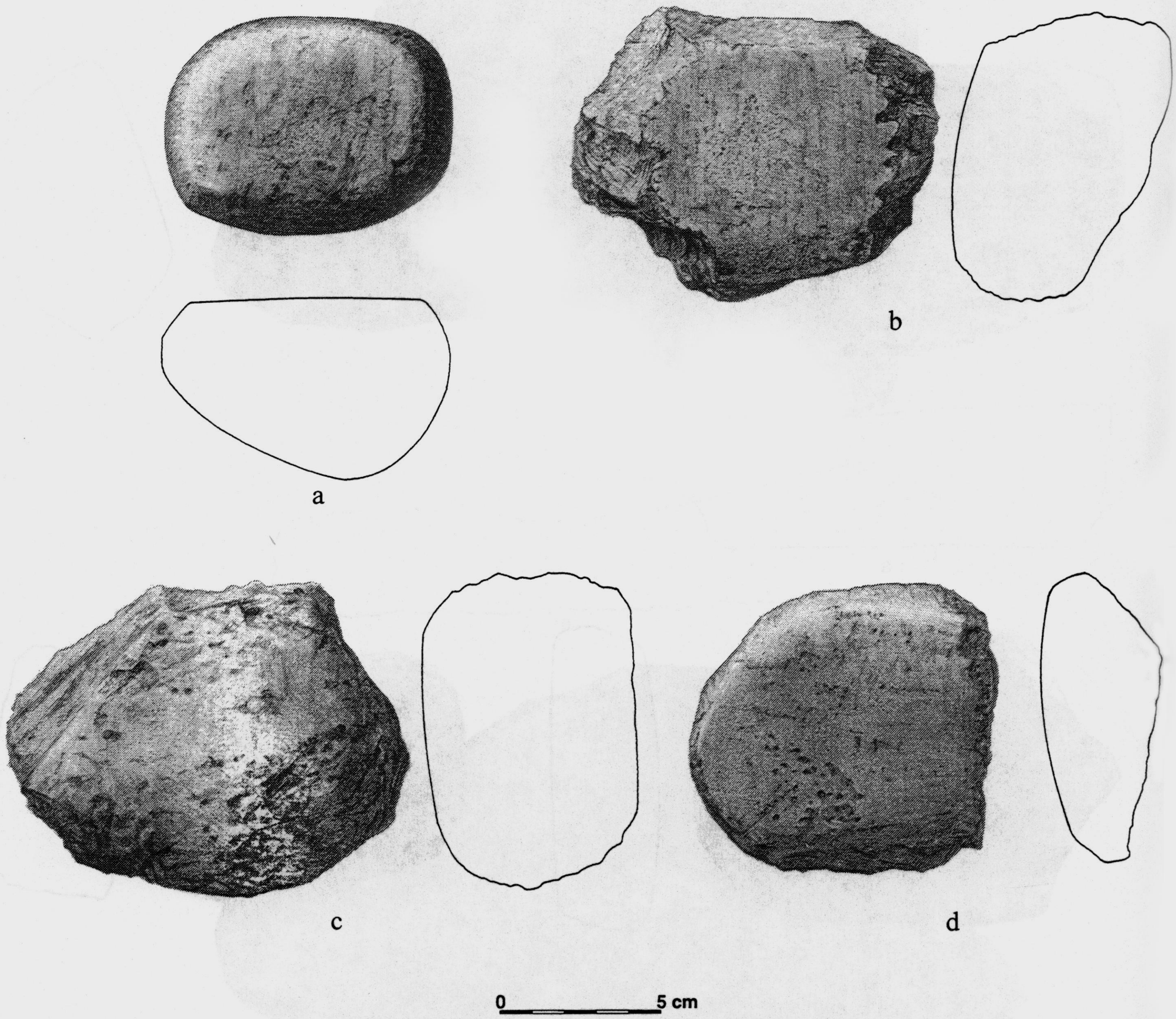


Figure 12. Select Handstones from INY-3012. a. Bifacial Basalt Handstone with Planar and Slightly Convex Surfaces (987-9-116); b. Bifacial Rhyolite Handstone with Slightly Convex Surfaces (987-9-115); c. Bifacial Rhyolite Handstone with Planar and Slightly Convex Surfaces (987-9-236); d. Unifacial Rhyolite Handstone with a Slightly Convex Surface (987-9-227).

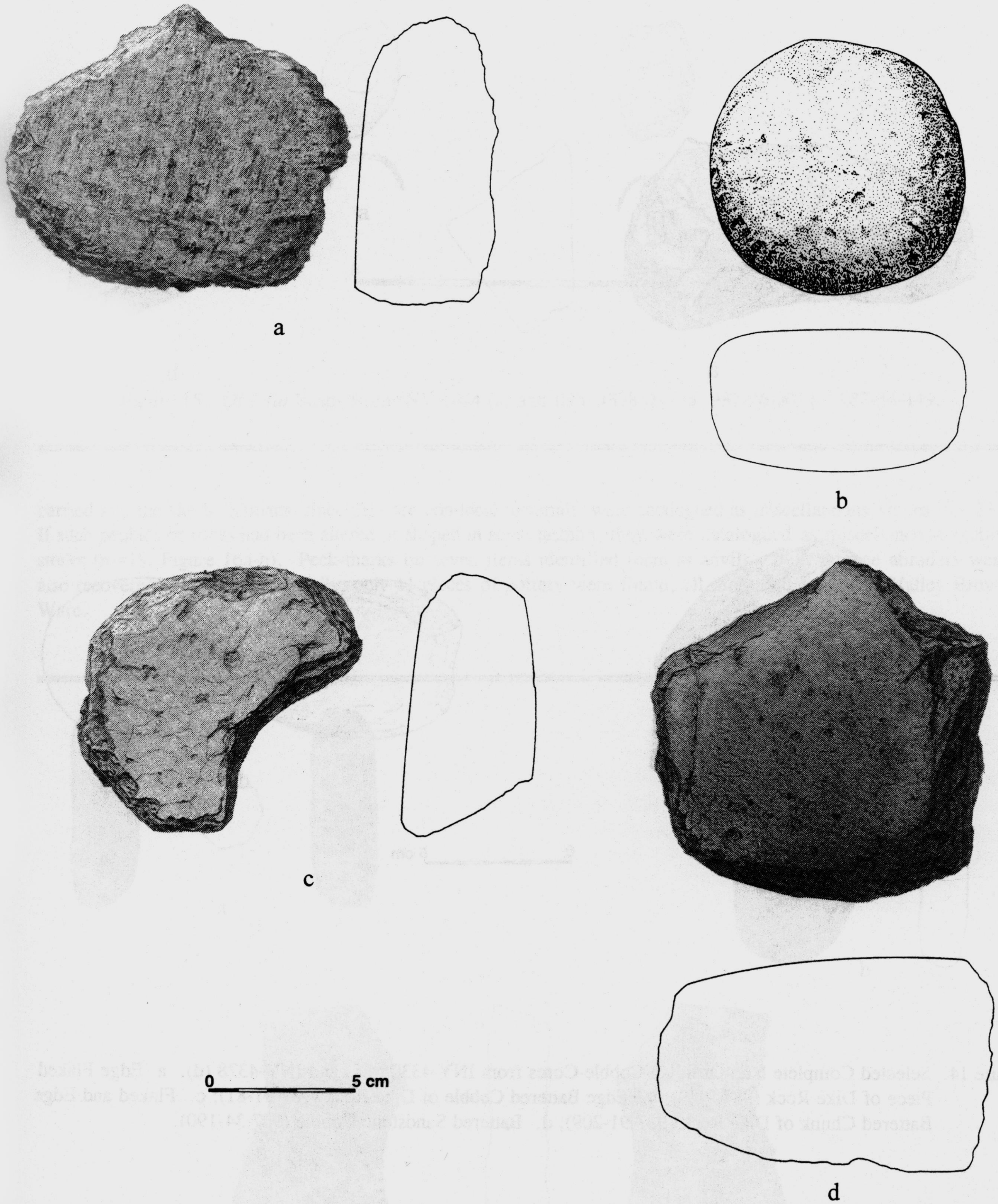


Figure 13. Select Handstones from INY-2103 (a), INY-4244 (b), and INY-4329 (c, d). a. Unifacial Rhyolite Handstone with a Slightly Convex Surface (987-27-370); b. Bifacial Granite Handstone with Slightly Convex Surfaces (987-46-121); c. Bifacial Granite Handstone with Slightly Convex Surfaces (987-92-1525); d. Unifacial Granite Handstone with a Slightly Convex Surface (987-92-1626).

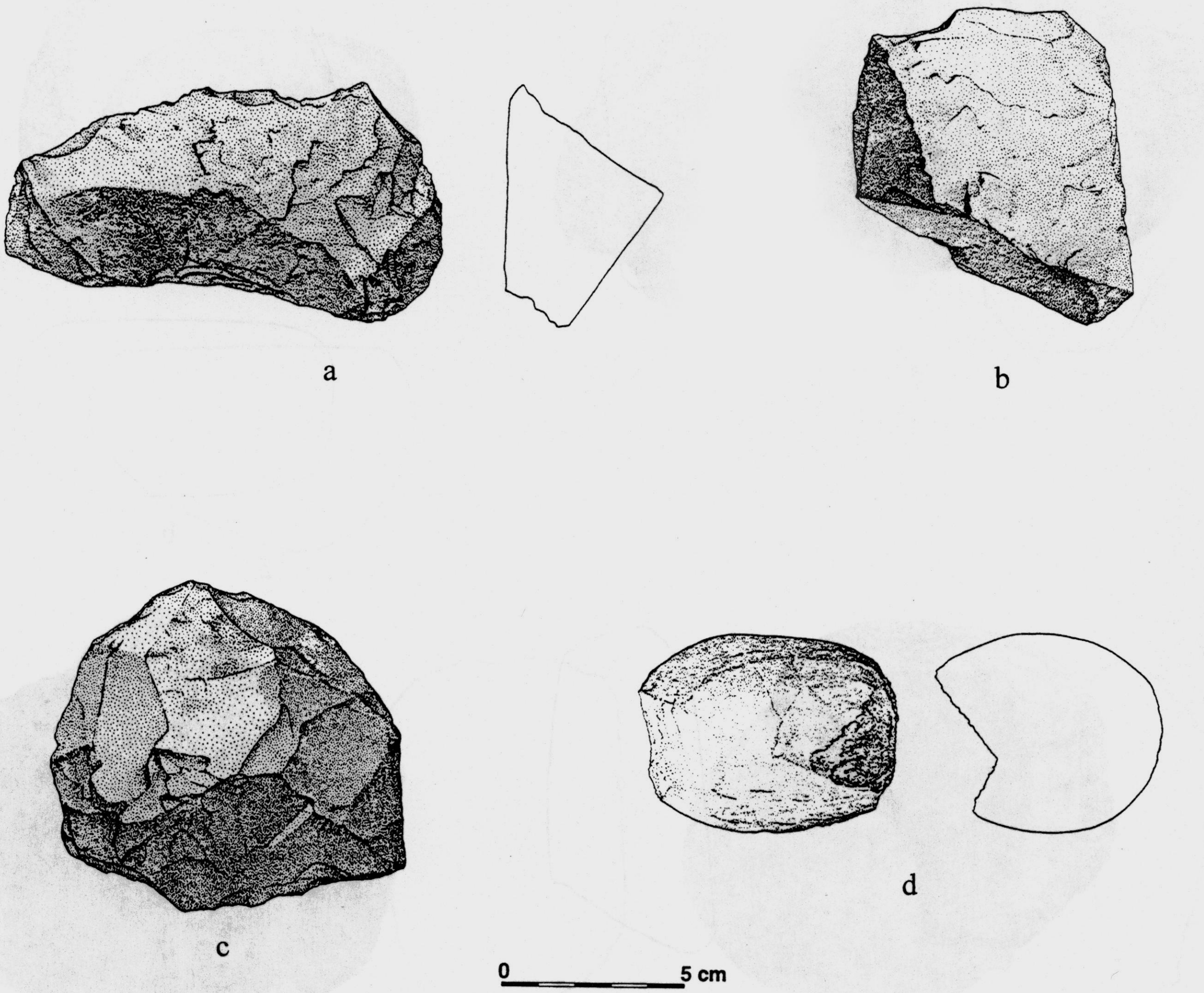


Figure 14. Selected Complete Non-Obsidian Cobble-Cores from INY-4330 (a-c) and INY-4378 (d). a. Edge Flaked Piece of Dike Rock (987-91-9); b. Edge Battered Cobble of Dike Rock (987-91-81); c. Flaked and Edge Battered Chunk of Dike Rock (987-91-209); d. Battered Sandstone Cobble (987-34-190).

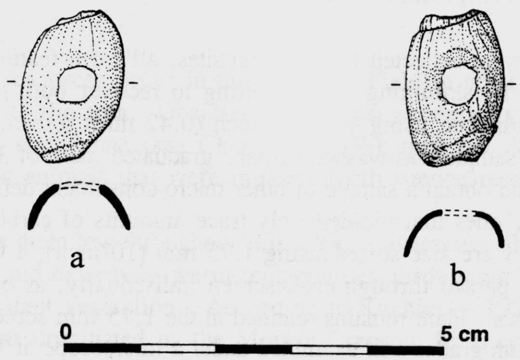


Figure 15. *Olivella* Beads from INY-1824 (a) and INY-4378 (b). a. 987-26-90; b. 987-34-149.

carried into the site by humans, since they are non-local materials, were catalogued as miscellaneous stones (n=23). If such pebbles or rocks had been altered or shaped in some fashion, they were catalogued as miscellaneous shaped stones (n=19; Figure 16a-b). Peck-marks on seven items identified them as anvils. Four pumice abraders were also recovered (Figure 16c). Finally, only 41 pieces of pottery were found, all identified as Owens Valley Brown Ware.

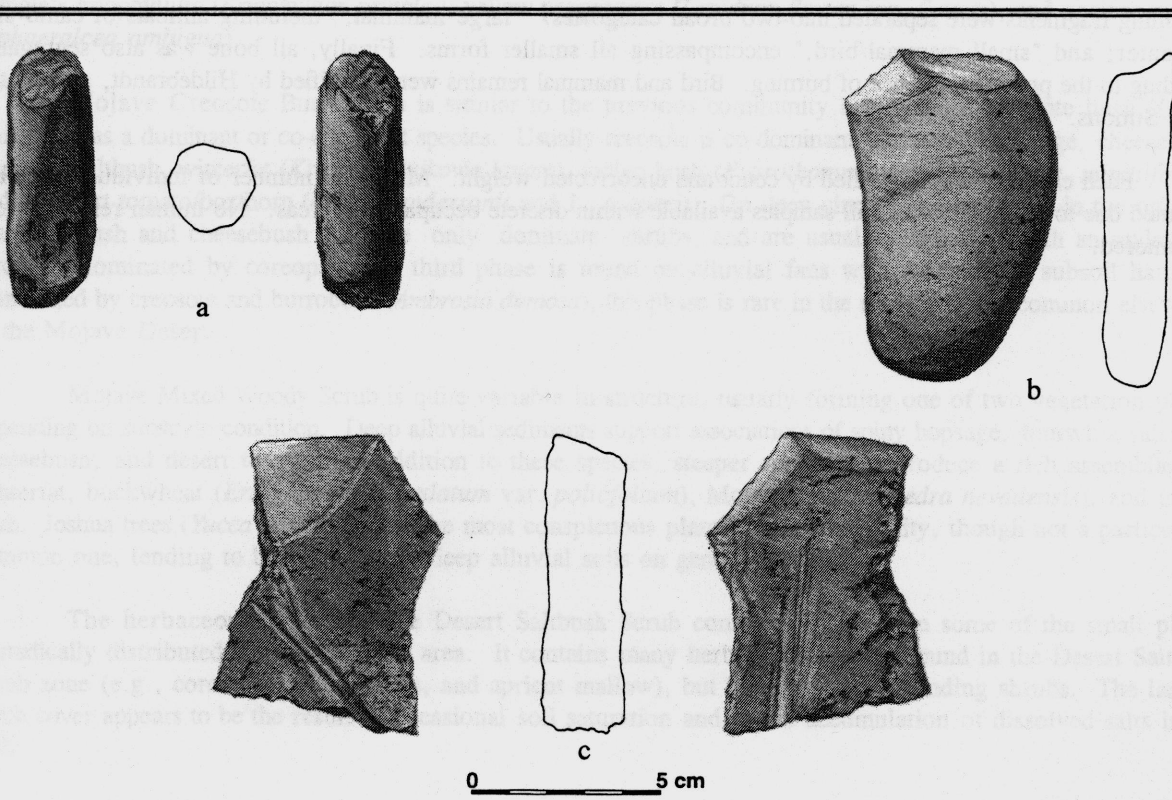


Figure 16. Miscellaneous Artifacts from INY-1907 (a) and INY-3012 (b, c). a. Miscellaneous Shaped Stone of Fine-grained Igneous Material (987-8-784); b. Miscellaneous Shaped Stone of Quartzite (987-9-488); c. Pumice/Rhyolite Abrader (987-9-163).

FLOTATION ANALYSIS (by E. Wohlgemuth)

Eighty-six flotation samples were collected from project sites, all from feature contexts. Each sample was water separated in a large washtub, by skimming and decanting to recover both floating and less buoyant plant remains. Burnt macrofossils were collected using 40 mesh/inch (0.42 mm) screen, and rinsed thoroughly with a fine water spray. The heavy fraction sample was washed through graduated mesh of 3.0 mm and 1.0 mm to recover additional non-floating macrofossils and obtain a sample of other micro-constituent debris. Subsequent analyses were limited to 53 of the original samples; ones that yielded only trace amounts of carbonized material were given no further consideration. Light fractions were size-sorted using 1.75 mm (10/inch), 1.00 mm (16/inch), and 0.7 mm (24/inch) mesh. The materials were passed through each screen individually, as opposed to a nested manner, to minimize damage to the fragile particles. Plant remains retained in the 1.75 mm screen were sorted with the naked eye, while debris in the 1.0 and 0.7 mm grades was examined under a microscope at 10-20X. Seeds were separated from remaining charcoal, and subsequent effort concentrated on identifying seeds to the most specific level possible (i.e., species, genus, family). E. Wohlgemuth and E. Honeysett performed all seed separations and identifications, consulting with specialists at the Seed Identification Laboratory, California Department of Food and Agriculture, Sacramento, for independent verification and identification of particularly troublesome specimens. Flotation sample results are summarized in Chapter 7.

FAUNAL ANALYSIS

In spite of the high volume of site deposit excavated, only 315 pieces of faunal remains were recovered. All vertebrate fauna collected was initially segregated between bone fragments that could be characterized to taxon and element, and those too fragmentary for identification. The identifiable portion was then classified as specifically as possible, using the comparative faunal collections provided by the Department of Anthropology, University of California, Davis. In cases where some degree of segregation was possible, but species-level identifications could not be made, specimens were placed within higher order taxonomic units (e.g., genus, family, order, etc.). Remaining fragments were separated into two broad categories: "large mammal," including animals of canid size or greater; and "small mammal/bird," encompassing all smaller forms. Finally, all bone was also segregated according to the presence/absence of burning. Bird and mammal remains were identified by Hildebrandt, augmented by D. Simons.

Each category was quantified by count and uncorrected weight. Minimum number of individuals was not computed due to the relatively small samples available within discrete occupational areas. No human remains were encountered.

CHAPTER 4: ENVIRONMENTAL PRODUCTIVITY

Several hard and soft natural resources occur in the Volcanic Field in great enough abundance to have attracted prehistoric Native Americans to the area. Obsidian is the most noteworthy hard resource, and we have already discussed its distribution and abundance (see Chapter 2). We turn our attention here to the distribution and availability of those plants and animals that were important subsistence resources.

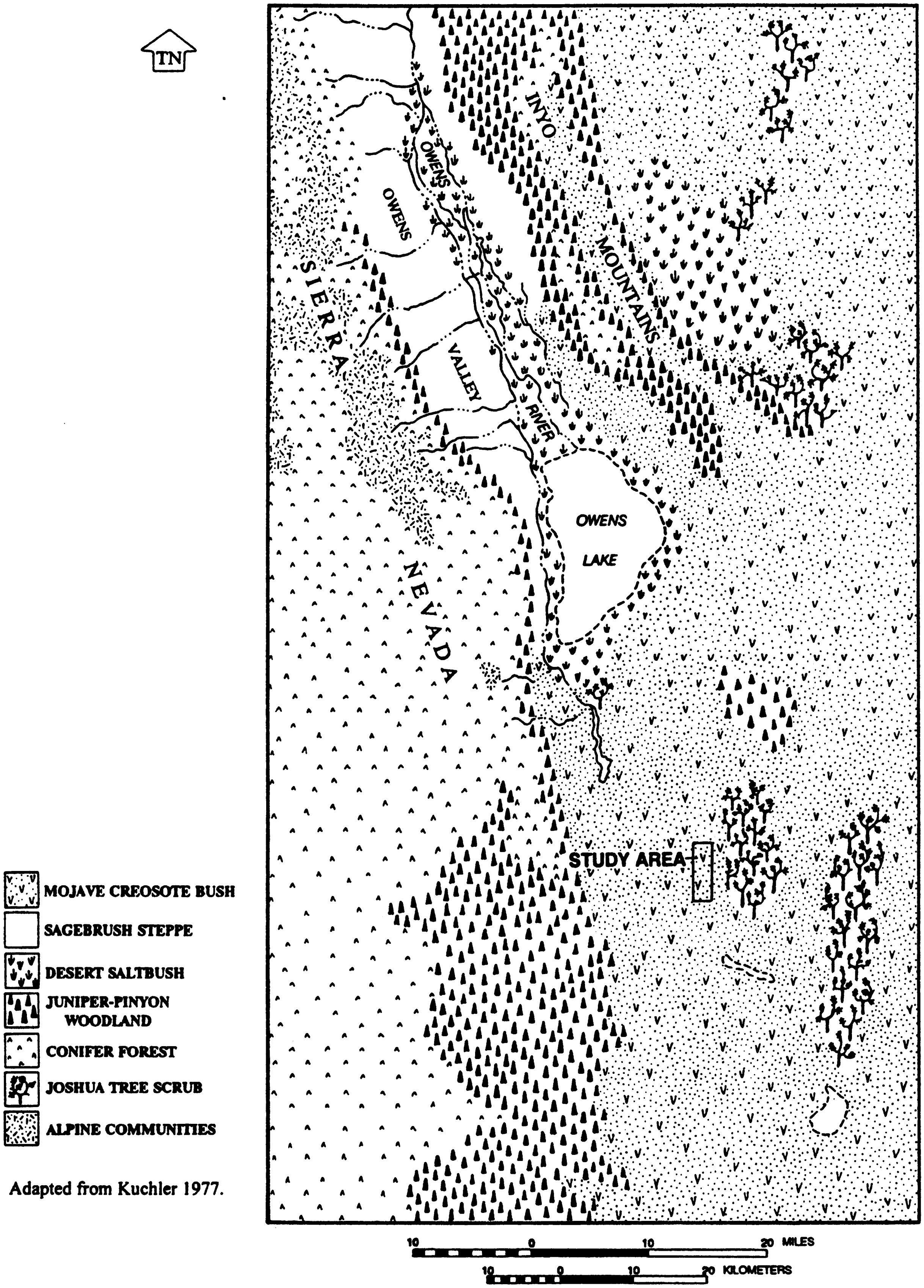
Annual precipitation is quite low throughout this region, averaging about 14 cm, and ranging from 0.5 to 2.0 cm a month. Low rainfall and extremely warm temperatures throughout much of the year (Table 7) combine to produce sparse, drought-resistant vegetation. According to Kuchler's (1977) general vegetative reconstruction (Map 7), the Volcanic Field was dominated by the Mojave Creosote Bush community, an association that covers much of the Mojave Desert to the south and east. Juniper-Pinyon Woodland occurs several kilometers to the west in the southern Sierra, as well as in the higher elevations of the Coso and Argus ranges, north and east. Further north, in Owens Valley, vegetation associations were more diverse. Before the Los Angeles Department of Water and Power Aqueduct was built, the Owens River and its well-watered tributaries were bounded by riparian vegetation. Desert Saltbush covered areas set back from the lake and river margins, and Sagebrush Steppe extended up the valley flanks to the Juniper-Pinyon zones of the Sierra Nevada to the west and the Inyo Mountains to the east.

Leitner and Leitner (1988) have documented more specific vegetative patterns for the Volcanic Field, and defined four basic plant associations: Desert Saltbush Scrub, Mojave Mixed Woody Scrub, Mojave Creosote Bush Scrub, and an herbaceous subunit of the Desert Saltbush Scrub community (Map 8). The Desert Saltbush Scrub community usually occupies basins and is often dominated by a single species. Fourwing saltbush (*Atriplex canescens*) is dominant in uplands, while allscale (*A. polycarpa*) or shadscale (*A. confertifolia*) are common in lower elevational basins. Associated shrub species include bud sage (*Artemisia spinescens*), spiny hopsage (*Grayia spinosa*), and cheesebush (*Hymenoclea salsola*). The herbaceous layer is more diverse and more responsive to annual variations in rainfall, and often includes coreopsis (*Coreopsis bigelovii*), pincushions (*Chaenactis* spp.), Pringle's eriophyllum (*Eriophyllum pringlei*), yellow peppergrass (*Lepidium flavum* spp. *flavum*), and apricot mallow (*Sphaeralcea ambigua*).

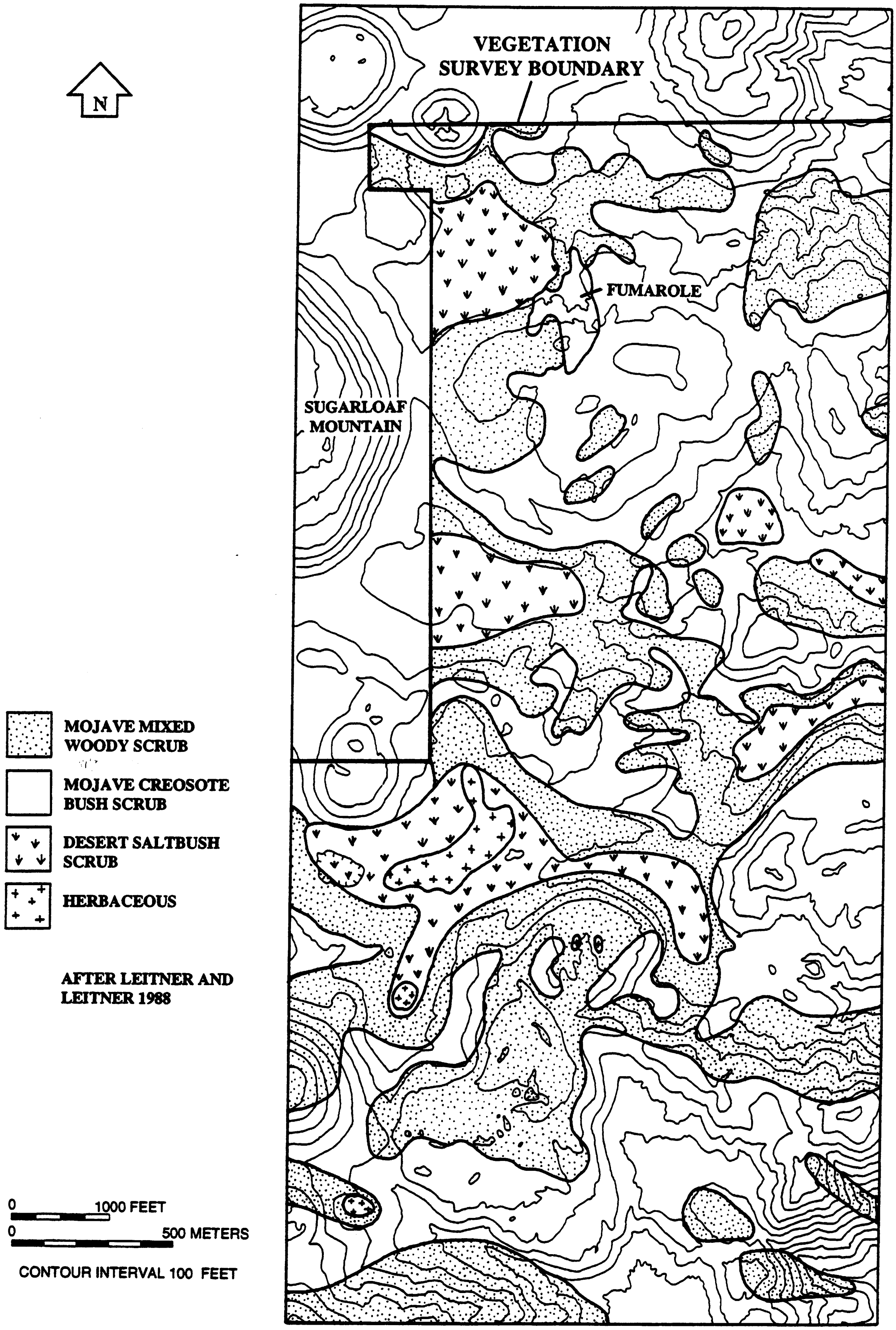
Mojave Creosote Bush Scrub is similar to the previous community but includes creosote bush (*Larrea tridentata*) as a dominant or co-dominant species. Usually creosote is co-dominant with spiny hopsage, cheesebush, fourwing saltbush, winterfat (*Krascheninnikovia lanata*), indigo bush (*Psorothamnus arborescens* var. *minutifolius*), and/or desert tomato/boxthorn (*Lycium andersonii* and *L. cooperi*). On deep cinder or sandy soils in the uplands, creosote bush and cheesebush are the only dominate shrubs, and are usually associated with an understory strongly dominated by coreopsis. A third phase is found on alluvial fans with a cemented subsoil hardpan. Dominated by creosote and burrobush (*Ambrosia dumosa*), this phase is rare in the study area but common elsewhere in the Mojave Desert.

Mojave Mixed Woody Scrub is quite variable in structure, usually forming one of two vegetation phases depending on substrate condition. Deep alluvial sediments support associations of spiny hopsage, fourwing saltbush, cheesebush, and desert tomato. In addition to these species, steeper rocky soils produce a rich assemblage of winterfat, buckwheat (*Eriogonum fasciculatum* var. *poliofolium*), Mormon tea (*Ephedra nevadensis*), and indigo bush. Joshua trees (*Yucca brevifolia*) are the most conspicuous plant in this community, though not a particularly common one, tending to be restricted to deep alluvial soils on gentle slopes.

The herbaceous subunit of the Desert Saltbush Scrub community occurs in some of the small playas sporadically distributed across the study area. It contains many herbaceous species found in the Desert Saltbush Scrub zone (e.g., coreopsis, pincushions, and apricot mallow), but lacks the corresponding shrubs. The lack of shrub cover appears to be the result of occasional soil saturation and/or the accumulation of dissolved salts in the soil.



Map 7. Regional Vegetation.



Map 8. Local Vegetation.

Table 7. Average Monthly and Mean Annual Precipitation and Temperature at Select Locations in the Region.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average monthly and mean annual precipitation (in cm)													
Independence (elev. 1200 m)	2.5	2.0	1.2	0.6	0.5	0.2	0.4	0.4	0.4	0.8	0.9	2.8	12.7
Lone Pine (elev. 1136 m)	3.1	2.6	2.7	0.5	1.0	0.2	0.2	0.4	0.6	1.1	0.3	1.7	14.4
Haiwee (elev. 1146 m)	1.7	2.0	1.7	1.2	0.5	0.5	0.9	0.8	0.5	0.9	1.4	2.0	14.1
Average monthly and mean annual temperature (in °C)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Independence (elev. 1200 m)	4.1	6.2	9.6	13.7	17.7	22.6	25.8	24.6	20.7	14.9	8.9	4.4	14.4
Lone Pine (elev. 1136 m)	4.4	6.7	9.9	13.3	16.3	20.9	23.8	22.4	18.4	13.6	8.7	4.2	13.6
Haiwee (elev. 1146 m)	4.6	7.5	10.3	14.6	19.0	23.4	27.3	36.2	22.1	16.3	10.1	5.4	15.6

PLANT RESOURCES

The above communities provide a variety of subsistence resources that were exploited by local Native American peoples. Following Delacorte (1990), these resources are organized according to shared similarities in seasonal availability and techniques used to exploit them (Table 8). Plants listed derive from ethnographic reviews by Bettinger (1982b), Delacorte (1990), Fowler (1986), Steward (1933, 1938), and Zigmond (1981), cross-referenced with regional and local plant inventories developed by DeDecker (1984) and Leitner and Leitner (1988). Five plant complexes are defined: greens and shoots, roots and tubers, seeds, fruits and berries, and tree crops.

Most greens and shoots were available for a short period of time in spring, providing important food at the end of winter when stored resources were depleted. Most commonly exploited species were those concentrated in moist settings near permanent water (Delacorte 1990). These settings not only produce the highest density and diversity of plants, but also have a growing season prolonged by the availability of water. The study area lacks wetland-adapted plants (e.g., watercress, tule, cattail) and other mesic species, but several dryland species exist (Table 8). Of these, coreopsis is particularly abundant, common in the Desert Saltbush Scrub (including the herbaceous subunit) and Mojave Creosote Bush Scrub communities. Collecting these and other greens required little time and effort, as most were either eaten raw or minimally blanched/leached with boiling water (sometimes extensively to eliminate toxicity), characteristics leaving little evidence of their use in the archaeological record (Delacorte 1990).

Plants with edible roots and tubers include a variety of species adapted to a wide range of habitats (Table 8). As with greens and shoots, wetland species such as cattail, tule, chufa flat sedge, spike-rush, and other moisture dependent taxa (e.g., buttercup, wood brownies), were not available in the Volcanic Field. Four important dryland forms are present (Inyo onion, Sego lily, thistle, and blue dicks), but none is considered a major component of the four plant communities defined. The four taxa present could have been collected year-round with a digging stick, but they are most nutritious after the spring/summer growing season. Subsurface roots and tubers accumulate large reserves of carbohydrates during the growing season that are depleted by growth in the following spring (Delacorte 1990). The difficulty of locating these plants in winter (i.e., the dying back of surface vegetation, and periodic snow cover), indicates most collection was in summer and fall. Many required little or no processing, while others were roasted or pulped to remove edible starch. If the latter techniques were used, archaeological indicators would include hearth/oven features or heavy-duty flaked and battered stone tools (Delacorte 1990).

Table 8. Important Economic Plants of Southeastern California.

Species	Common name	Season of Availability
EDIBLE GREENS AND SHOOTS		
Allium atrorubens	Inyo onion *	April-November
Amsinckia tessellata	Fiddleneck *	March-May
Anisocoma acaulis	Scale bud *	March-May
Caulanthus sp.	Wild cabbage *	March-June
Claytonia perfoliata	Miners' lettuce	April-June
Coreopsis bigelovii	Coreopsis *	March-May
Nasturtium officinale	Watercress	February-November
Phacelia sp.	Phacelia *	March-June
Scirpus nevadensis	Tule	April-July
Stanleya elata	Prince's plume *	April-June
Trifolium wormskioldii	Clover	April-September
Typha domingensis	Cattail	March-May
Yucca brevifolia	Joshua tree *	April-May
EDIBLE ROOTS AND TUBERS		
Allium atrorubens	Inyo onion *	June-November
Calochortus sp.	Sego lily *	June-November
Cirsium sp.	Thistle *	August-December
Cyperus esculentus	Chufa flat sedge	December-May
Dichelostemma capitatum	Blue dicks *	May-November
Eleocharis sp.	Spike-rush	October-April
Fritillaria atropurpurea	Wood brownies	June-November
Lewisia rediviva	Bitterroot	May-November
Ranunculus cymbalaria	Buttercup	July-November
Scirpus nevadensis	Tule	July-April
Typha domingensis	Cattail	July-April
SEEDS: Perennial Grasses		
Agropyron sp.	Wheatgrass	July-September
Agrostis sp.	Bentgrass	July-September
Bromus sp.	Bromegrass *	May-August
Deschampsia sp.	Hairgrass	August-September
Elymus sp.	Wild rye *	July-September
Glyceria striata	Fowl meadow grass	August-September
Hilaria jamesii	Galleta	June-July
Melica imperfecta	Melic grass *	May-June
Muhlenbergia sp.	Scratchgrass	July-October
Oryzopsis sp.	Ricegrass *	May-September
Poa sp.	Bluegrass *	July-August
Sitanion hystrix	Squirreltail *	August-September
Sporobolus sp.	Dropseed	June-October
Stipa speciosa	Needlegrass *	May-July
Trisetum spicatum	—	August-September
SEEDS: Perennial Herbs		
Asclepias sp.	Milkweed *	July-October
Cymopterus sp.	—	May-August
Eriogonum sp.	Buckwheat *	April-December
Juncus balticus	Wire grass	June-September
Polygonum sp.	Smartweed	July-October

Table 8. Important Economic Plants of Southeastern California (continued).

Species	Common Name	Season of Availability
SEEDS: Perennial Herbs (continued)		
Ruppia sp.	Ditch grass	May-August
Scirpus nevadensis	Tule	July-September
Solidago sp.	Goldenrod *	August-October
Stachys albens	Hedge-nettle	June-October
Suaeda torreyana	Seep-weed	June-September
Trifolium wormskioldii	Clover	June-October
Triglochin debilis	Alkali arrow grass	June-October
SEEDS: Annual Grasses and Herbs		
Amaranthus sp.	Pigweed *	August-October
Chenopodium sp.	Goosefoot	July-October
Descurainia sp.	Tansy mustard *	April-September
Eragrostis orcuttiana	Love grass	June-November
Festuca sp.	Fescue *	May-July
Gilia sp.	Gilia	May-July
Helianthus sp.	Sunflower	August-October
Lappula redowskii	Stickseed	May-August
Lepidium sp.	Peppergrass *	April-June
Mentzelia sp.	Blazing star *	May-August
Oenothera sp.	Evening primrose *	July-October
Panicum capillare	Panic grass	August-October
Salvia columbariae	Chia *	May-July
SEEDS: Shrubs		
Artemisia sp.	Sagebrush *	September-November
Atriplex sp.	Saltbush *	July-October
Dalea polyadenia	Nevada Dalea	June-October
Ephedra nevadensis	Mormon tea *	April-May
Haplopappus macronema	Goldenrod	August-October
Sphaeralcea sp.	Globe mallow *	April-July
EDIBLE BERRIES		
Amelanchier utahensis	Service berry	June-July
Lycium andersonii	Desert tomato *	May-June
Opuntia sp.	Prickly pear *	May-July
Physalis hederaefolia	Ground cherry	June-August
Prunus virginiana	Western chokecherry	June-July
Ribes sp.	Currant/gooseberry	July-August
Rosa woodsii	Wild rose	July-September
Sambucus caerulea	Elderberry	July-October
Shepherdia argentea	Buffalo berry	May-June
Vitis arizonica	Canyon grape	July-August
TREES		
Pinus monophylla	Pinyon pine	September-November
Prosopis glandulosa	Mesquite	August-September
Prosopis pubescens	Screw bean	August-September
Quercus chrysolepsis	Canyon live oak	September-November

NOTE: * - present in the Coso Volcanic Field.

Small seeds were obtained from a wide range of grasses, herbs, and shrubs (Table 8). For most of these species, there is only a short interval between when the seeds are ready for harvest and when they are taken by animals or lost on the ground. Successful collection, therefore, required carefully monitoring local stands and quickly harvesting the crop (Delacorte 1990). As discussed in more detail below, full use of these kinds of resources could only be accomplished by people with a thorough knowledge of the distribution and condition of local seed-bearing plants.

Seven of the 15 perennial grasses regularly used in the region are present in the Coso Volcanic Field (Table 8). Five of these seven (ricegrass, bluegrass, squirreltail, needlegrass, and wild rye) are listed by Bettinger (1982b) among the most important producers of perennial grass seed in the larger Inyo-Mono area. These grass seeds were available during summer and processed in various ways. Seeds were either detached from the plants using seed beaters and collected in baskets in the field, or entire plants were cut, bunched, and transported in large baskets to a residential base where seeds were then detached. Following collection, most grasses were winnowed and parched, then ground into a flour, and either eaten immediately or used in stews, gruels, and breads (Steward 1933; Zigmond 1981). Like some herbaceous seed producers, processing these resources often creates rather conspicuous archaeological remains. Seed grinding is evidenced by milling equipment, while fire hearths could indicate parching, particularly if they contain plant macrofossils lost or discarded during processing.

Of the 12 perennial herbs considered regionally important seed producers, only milkweed, buckwheat, and goldenrod are found in the Volcanic Field (Table 8). Annual grasses and herbs are much more abundant, with seven of 13 regionally important species growing here. Two of these, blazing star and chia, are also classified as major, region-wide subsistence resources by Bettinger (1982b). Some of these seed-bearing herbs and annual grasses produce during the spring-summer (buckwheat, tansy mustard, peppergrass, blazing star, chia), while for others seed production begins in summer and extends into fall (milkweed, goldenrod, pigweed, evening primrose). All species were harvested with a seed beater and basket. Most seeds were ground into a flour (some after parching), and some were mixed with water to make a beverage (e.g., buckwheat, tansy mustard, peppergrass, chia). Blazing star was ground into a paste similar to peanut butter (Zigmond 1981).

Seed producing shrubs are also abundant at Coso, represented by four of the six listed regional taxa (Table 8). Each of these four is dominant in at least one of the local plant communities; however, none appears to have been a staple. Sagebrush, due to its bitter taste, was mixed with other materials only during periods of resource stress (Steward 1933), while saltbush, Mormon tea, and globe mallow seed are only mentioned in passing (Irwin 1980; Steward 1933; Zigmond 1981). The latter is particularly abundant in some prehistoric sites (e.g., Crater Middens [cf. Bettinger 1989:287-288]).

Fruit-bearing plants, although relatively numerous in the larger region, are limited at Coso to desert tomato and prickly pear cactus (Table 8). Both species are quite common here, particularly desert tomato which is a major component of the Mojave Mixed Woody Scrub community. Fruit becomes available in late spring and early summer on both plants. Desert tomato was eaten raw, juiced, or pulverized into a paste. Cactus fruit was knocked from the plant with a stick, cooked, then eaten (Zigmond 1981).

Regionally important tree crops include pine nuts, acorns, and mesquite beans. None of these exists in the study area. Pine nuts occur along the southern Sierra and in the Coso and Argus ranges, acorns are confined to the southern Sierra, and mesquite occur deeper in the Mojave Desert to the south and east.

PLANT RESOURCE SUMMARY

Clearly, only a small portion of the plants used regionally by aboriginal peoples existed within the Coso Volcanic Field. Beginning in spring, when a marginal resource base developed in the form of edible greens and shoots, nearby wetland areas such as Owens Valley or Little Lake would have provided a greater abundance and diversity of these plants. With the advent of summer, local resource productivity peaked when seeds from several perennial grasses and other herbaceous plants could be harvested. This was also when roots and tubers, and fruit from a few additional taxa were collected. Although other areas in the region were also at peak production during the same months, the Volcanic Field no doubt attracted a fair number of people on at least a short-term basis. By fall, subsistence productivity was much higher in the nearby mountains (pine nuts and acorns) and in the desert to the east (mesquite beans).

ANIMAL RESOURCES

Economically important animal resources can also be grouped according to similarities in behavior, seasonal distribution, and exploitation techniques. Bettinger (1982b) has proposed six such groups, including pronghorn and jack rabbits, deer and bighorn sheep, small game, insects, waterfowl, and fish.

Pronghorn antelope (*Antilocapra americana*) and jack rabbits (*Lepus californicus*) were common throughout the desert scrub and upper sagebrush areas of eastern California. Because of their excellent eyesight and speed, these animals could not be successfully acquired through stalking or ambush, but were most effectively obtained through communal drives. Pronghorn are predominately a herding animal, the size and density of their aggregations varying according to season. During summer, herds usually are dispersed, due to the wide range of available browse. With the advent of winter, feed becomes more restricted, causing populations to congregate in localized areas of abundance, making them, therefore, more susceptible to communal drives (McClean 1944; Steward 1938). During such drives, animals were usually herded between two brush fences which ultimately converged into a brush and wood corral where they were trapped and dispatched. Jack rabbits were also driven by large groups of people. Rather than brush enclosures, fiber nets were used to form a large semi-circular trap where animals could easily be killed once entangled (Steward 1938). Both pronghorn and jack rabbits were, of course, also taken individually.

Mule deer (*Odocoileous hemionus*) and bighorn sheep (*Ovis canadensis*) are entirely different from pronghorn and jack rabbits with respect to behavior, distribution, and capture techniques used. Deer would have been rarely present in the Volcanic Field, favoring the mountainous areas of the Sierra and, to a lesser extent, the Coso and Argus ranges. Bighorn sheep, on the other hand, have a much greater tolerance for arid environments, allowing them to occupy the rocky slopes of the study area. Preferring rugged country with good visibility, small groups of these animals followed a transhumant pattern, foraging along the mountain-valley interface most of the year, while spending the summer at more productive, higher elevations. Both species were hunted by small groups or by individuals. Bighorn sheep were most commonly obtained by slowly herding a group toward a mountain pass, where a few men in hiding dispatched them with arrows (Irwin 1980). Single animals were stalked by an individual hunter, sometimes using rock decoys to guide animal movement (Irwin 1980; Steward 1933). Bighorn sheep were an important prey from a regional perspective, but of more particular concern for inhabitants of the Coso region, judging from the thousands of sheep petroglyphs that exist here (Grant et al. 1968; Heizer and Baumhoff 1962).

Small game was probably the most plentiful and important quarry in the study area. In addition to cottontail rabbits (*Sylvilagus* sp.), numerous species of rodents were actively pursued, including various squirrels, rats, mice, and chipmunks. These animals were taken using a variety of snares and traps, as were small game birds such as quail (Steward 1933). Desert tortoise and a variety of lizards were also important resources, the latter largely restricted to desert areas to the east and south (Schneider and Everson 1989). Insect larvae were significant in the diet, however, the most important of these (brine fly larvae [*Hydropyrus hians*]) was available only from Owens Lake. Steward (1938:83) makes mention of *piugi* gathering at Little Lake, perhaps using the term to broadly refer to large grubs, larvae, or army worms (cf. Fenega and Fisher 1978, Sutton 1988c), not just Pandora moth larvae. What the grub/larvae available at Little Lake might have been remains unknown. Fish, shellfish, and waterfowl were also non-local, essentially limited to the Owens Valley and Little Lake areas (Steward 1933).

DISCUSSION

Environmental characteristics of the Coso Volcanic Field provide an interesting context for evaluating existing models of prehistoric adaptation. The incredible abundance of high-quality obsidian in the area placed no limitations on the amount of material reduced for personal use, exchange, or any other purpose. Variable intensities of lithic production must therefore be accounted for by changing demand among consumer groups, changes in flaked stone reduction technology, shifts in settlement organization, and the like. Subsistence resources, in contrast, are limited both in an absolute sense, and relative to other areas in the region. Small seeds, rabbits and other small game, and in lesser degree, large game such as pronghorn and bighorn sheep are the only locally available subsistence resources worth mentioning. Conspicuously absent are a wide range of upland (acorns, pine nuts, deer) and lowland (fish, shellfish, brine fly larvae, waterfowl, greens and shoots, roots and tubers) resources — crucial components of the overall subsistence system.

These data correspond quite closely to contrasts observed in the ethnographic records from adjacent geographic contexts (Bettinger 1982b; Delacorte 1990). Whereas the Owens Valley Paiute occupied large semi-permanent villages supported by locally present dryland roots and seeds, as well as temporary camps from which more distant resources such as pine nuts, large and small game, and fish were obtained; the Coso Shoshone system required a higher degree of residential mobility of smaller, independent family groups.

CHAPTER 5: CHRONOMETRICS

Obsidian hydration data provide the prevalent means for assessing the age of archaeological deposits in the Volcanic Field. To date, hydration rim values are available for over 4600 specimens from numerous discrete artifact and debitage concentrations at 381 sites in the Volcanic Field. Nearly 1400 of those rim values are from the 34 excavated sites (Table 9), an additional 2484 come from limited work at some 317 other sites within ca. 15,000 acres in the surrounding vicinity (summarized in Gilreath and Hildebrandt 1991:Appendix D), and the remaining were obtained by other researchers' projects in the Volcanic Field (e.g., Elston and Zeier 1984). Over 900 of the hydration specimens have also received XRF analysis, which identified 99% as Coso glass (359 Sugarloaf, 353 West Sugarloaf, 163 Joshua Ridge, 15 Cactus Peak, and 29 undifferentiated Coso), three as known exotic glasses, and seven as unknown. Given the incredibly low number of non-Coso pieces of obsidian in the XRF sample, non-geochemically sourced hydration specimens are assumed to be of local glass.

A chronological scheme was developed by Gilreath and Hildebrandt (1991) for the Volcanic Field by applying the Coso obsidian hydration rate developed by Basgall (1990), to hydration cluster samples from over 450 individual artifact and debitage concentrations within the Coso Volcanic Field. Single period deposits were identified as those loci with a hydration cluster sample having a coefficient of variation (CV, derived by dividing the standard deviation by the mean value) of 0.25 or less, resulting in the recognition of 138 quarry and 233 off-quarry single period loci (Gilreath and Hildebrandt 1991:Table 18). The temporal distribution of single period quarry and off-quarry loci were graphed (Figure 17), and using breaks or shifts in their frequencies through time, eight periods were defined (Table 10). Deposits at numerous other loci appear to have been generated during multiple periods, but they do not represent magnet locations on the landscape (e.g., areas next to springs), only similar kinds of loci simply overlapping in space. They do not contain different kinds or densities of artifacts or other occupational debris (i.e., they are not villages or substantial occupational sites), and, in fact, including multiple-period loci does little to alter the relative proportions of the quarry and off-quarry loci through time. Period names applied here were chosen with regard to the Bettinger and Taylor (1974) nomenclature. The temporal distribution of loci within the Coso Volcanic Field indicates that during the earliest period, single period off-quarry loci considerably out-number quarry loci. In the subsequent temporal interval the two occur with near-equal frequencies. In the Little Lake period, the number of off-quarry sites changes little from prior intervals, but the frequency of quarry loci rises slightly. The Early Newberry period is marked by a spike in the number of off-quarry loci, with a substantial trough occurring between 3000-2750 B.P. Quarry loci are at maximal frequency during the Middle Newberry period corresponding with a secondary peak in the frequency of off-quarry loci. During the Late Newberry period off-quarry loci are at record numbers, though the number of quarry loci remains relatively constant. A dramatic decline in the frequency of off-quarry single period loci occurring with a concomitant decrease in the number of quarry loci marks the Haiwee interval. Finally, in the Marana period, the number of quarry loci is at a record low, corresponding with comparatively few off-quarry loci. For a hydration-based chronology such as this, we remind the reader that poorly represented periods indicate intervals of minimal obsidian exploitation, and need not necessarily indicate minimal exploitation of other resources in the Volcanic Field.

The initial chronological assessment of deposits at project sites considered depositional context, the horizontal and vertical distribution of cultural materials, the homogeneity of the assemblage from within an area, and other relevant clues of depositional integrity. Discrete concentrations of features and/or cultural debris within a site were treated as potential single period component areas. Hydration samples from those areas and radiocarbon assays from the rare locations containing organic material were forwarded for analysis. Results of the hydration and radiocarbon analyses were used to re-evaluate the hypothesis that materials from that area were deposited during a single period. In interpreting the hydration data, rim values in excess of 24.0 μ were uniformly dismissed from consideration as valid chronological data: the largest reported rim values on projectile points made of Coso glass are 21.1 and 21.5 μ from items in the Volcanic Field, and rims thicker than 30.0 μ are not uncommon on gravelly-looking flakes.

For many areas, available indicators suggested a single period deposit when the hydration sample produced tightly clustered values, associated temporally diagnostic artifacts were consistent with the age-estimate provided by the hydration sample, the deposit was spatially discrete, and horizontal and vertical distributions of material were

Table 9. Chronological Data from Project Sites.

Site INY-	Number of Hydration Samples	Number of Projectile Points	Number of Radiocarbon Assays	Other Chronologically Sensitive Items
1816	37	3	1	
1824 Main	113	5	1	1 shell bead
1824-B	5	-	-	
1824-X	10	-	-	
1906	61	2	2	246 glass beads, 1 shell bead
1907	22	2	1	
1984	55	2	-	
2103	79	8	1	
2825	20	-	-	
2826	37	2	-	
3004/3005	82	8	2	
3012	59	1	-	
3015	11	1	-	
3299	40	-	-	
3300	56	4	-	
3456	38	3	-	
4239	22	2	-	
4240	11	-	-	
4243	13	-	1	
4244	25	2	-	
4246	16	-	-	
4252	14	-	-	
4267	74	5	1	
4319	50	-	-	
4320	48	-	-	
4322/H	29	-	1	
4324/H	26	-	-	1 glass bead
4325	19	3	1	
4327	20	-	-	
4328	28	1	-	
4329	187	6	6	41 sherds
4330	35	2	2	
4331	33	1	-	
4378	20	-	-	1 shell bead
TOTAL	1395	63	20	

uncomplicated. For other areas, chronological data indicated material from more than one period was present, and these areas were handled in a variety of manners depending on the magnitude and nature of the temporal mixing.

In some instances there was a surface or near-surface hearth, usually with milling equipment associated, overlaying a very sparse obsidian debitage scatter. Characteristically, the hearth would provide a radiocarbon date consistent with the Marana period (less than 650 B.P.), while hydration rim values indicated the debitage in the arae was older and of variable age. These hearths with associated milling stations were treated as Marana period component areas, and the sparse, dispersed debitage was excluded as part of their Marana-period assemblage, as it was understood to be background noise. That is, trace amounts of redeposited obsidian debitage often existed where late period hearths were made. In other instances these surface or near-surface milling stations occurred with

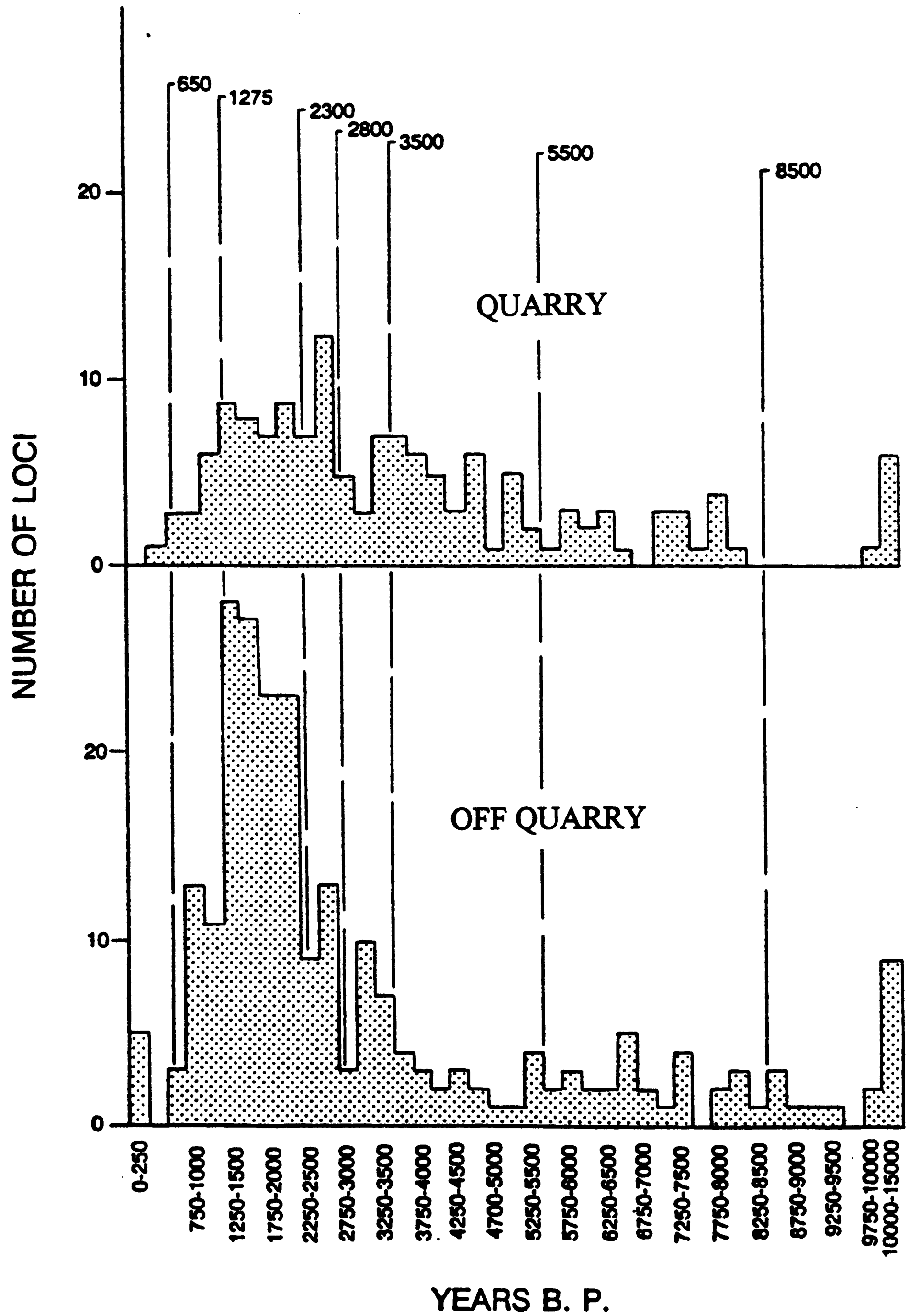


Figure 17. Temporal Distribution of Single Period Loci in 250 Year Increments (from Gilreath and Hildebrandt 1991:56).

Table 10. Chronological Periods for the Coso Volcanic Field.

Bettinger and Taylor 1974		Gilreath and Hildebrandt 1991			
Designation	Interval	Designation	Period	Interval	Coso Glass Hydration Range
Marana	650 B.P.-contact	Marana	VIII	650-200 B.P.	4.2-2.5 μ
Haiwee	1350-650 B.P.	Haiwee	VII	1275-650 B.P.	5.65-4.2 μ
Newberry	3150-1350 B.P.	Late Newberry	VI	2300-1275 B.P.	7.3-5.65 μ
		Middle Newberry	V	2800-2300 B.P.	7.9-7.3 μ
		Early Newberry	IV	3500-2800 B.P.	8.7-7.9 μ
Little Lake	6000-3150 B.P.	Little Lake	III	5500-3500 B.P.	10.6-8.7 μ
Mohave	pre-6000 B.P.	Early	I and II	pre-ca. 5500 B.P.	>10.6 μ

no hearth associated. These milling stations were identical to the Marana-period ones associated with hearths in terms of the condition, type, and other over-all characteristics of the equipment, and in their basic structure. Again, a sparse scatter of obsidian debitage frequently co-occurred that rendered variable pre-Marana age hydration values. These milling stations lacking hearths were cross-dated as Marana period components; the small quantity of obsidian found in their proximity was treated as background noise and excluded from the assemblage inventory.

A different set of problems pertained to dating deposits from the early end of the occupational sequence. Part of the problem relates to the fact that older modified obsidian tends to displays quite variable hydration bands, perhaps as a result of the hydration rim sloughing off, or perhaps simply resulting from the vagaries of time. One line of reasoning indicates that the longer an obsidian artifact has been left in an environment, it is more likely to have fallen subject to events that adversely influenced the constancy of rim development (Rhode 1992). An opposite line of reasoning suggests that rim width variability should diminish not increase with time, because hydration rim development slows down over time, placing greater constraints on the amount of variability possible. Empirical data support the former position. Figure 18 is based on Coso hydration data generated by Gilreath and Hildebrandt (1991), graphing only those loci classified as single period deposits because they produced hydration samples having a CV value of less than .25 (the mean values range from 1.4-20.7 μ, standard deviations ranged between 0.2-3.9). As this figure indicates, the standard deviations associated with cluster samples increase as mean values increase.

The second part of the problem has to do with the overall veracity of Basgall's (1990) Coso hydration rate for the early end of the sequence. The Coso hydration rate developed by Basgall is robust for the past ca. 5500 years, but appears to be less firm for earlier dates. This is not particularly surprising since most radiocarbon age-hydration pairings figuring into the rate formulation post-date 5500 B.P. — an unfortunate reality due to the low-number of early radiocarbon age-hydration pairings available. A second factor relates to the nature of logarithmic rates in general, which produce a Coso curve that begins to flatten out at about 5500 B.P. (see Figure 1). The effect of using a logarithmic rate is such that a 0.1 μ change in the hydration value is amplified with time. For instance, the difference between 4.9 and 5.0 μ calculates to 44 years, while the difference between 14.9 and 15.0 μ equates to 189 years (using the Haiwee EHT correction factor). Because inconsistencies in the actual rim formation process appear to become pronounced with antiquity, and because the Coso hydration rate is perhaps less robust after ca. 5500 B.P., we simply chose to classify deposits with a mean hydration value greater than 10.6 μ and CV values typically less than 0.25 as Early period components, with no finer chronological separation.

A fourth group of potential components corresponds to areas used during two consecutive periods, signaled by hydration values spanning those periods; or during two temporally discrete events, indicated by a bimodal hydration value distribution. In these instances, the assembly was assigned, intact, to both periods.

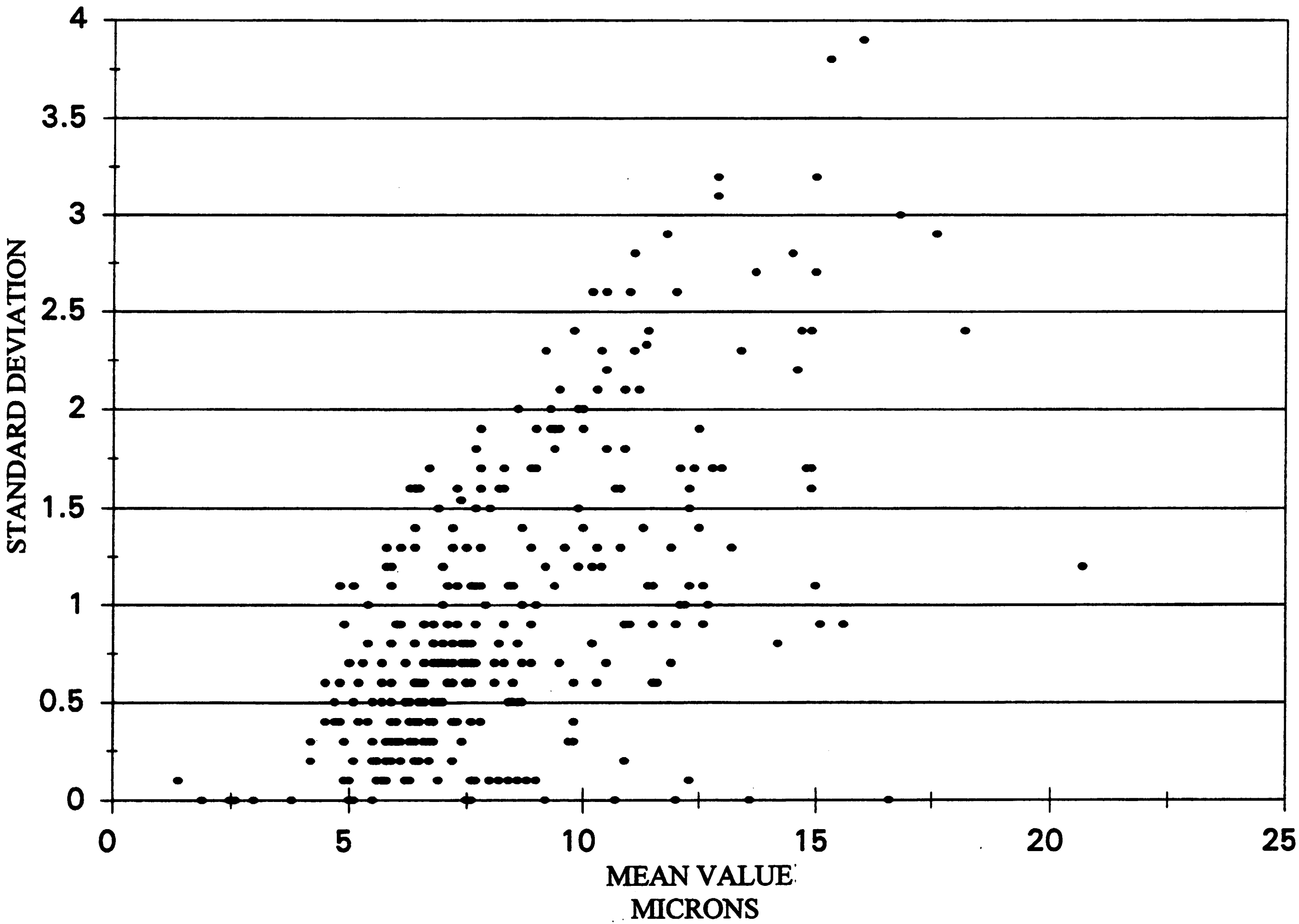


Figure 18. Hydration Data Summary from Single Period Deposits in the Coso Volcanic Field (Adapted from Gilreath and Hildebrandt 1991:Appendix D).

For all remaining areas, diverse hydration rim values on samples were interpreted to mean that materials had accumulated during numerous intervals. Such areas were subsequently considered Residual, since their temporally mixed deposits were of very restricted analytical utility in addressing the questions of interest to us.

The temporal assignment of component areas at project sites is presented in Table 11.

Table 11. Chronometric Summary from Component Areas by Site.

	Hydration Data				Projectile	Uncorrected Radiocarbon	
	n	mean	s.d.	NOE	Points	Age B.P.	Other
Historic							
4322/H B	--	--	--	2	--	modern[a]	--
Marana Period							
1816 C	--	--	--	6	1	160±70	--
1816 D	--	--	--	--	--	--	--
1816 E	--	--	--	--	--	--	--
1816 F	--	--	--	--	--	--	--
1816 G	--	--	--	--	--	--	--
1816 H	--	--	--	--	--	--	--
1906 A	--	--	--	--	--	--	--
1906 E	--	--	--	--	--	--	--
1906 F	--	--	--	5	--	110±70[b]	--
1906 H	7	1.5	0.2	10	2	110±70[b]	glass beads
1984 E	--	--	--	--	--	--	--
2103 D	--	--	--	6	--	370±70	--
2825 B	--	--	--	--	--	--	--
3004/5 G	--	--	--	4	--	110±60	--
3300 D	4	1.3	0.1	--	--	--	--
3456 B	--	--	--	5	--	--	--
4239 B	--	--	--	--	--	--	--
4243 B	--	--	--	--	--	130±80	--
4267 A	--	--	--	--	1	modern[a]	--
4329 A	1	2.2	--	6	--	140±50 and 580±60	--
4329 D	1	3.7	--	9	1	310±50 and 360±50	--
4329 N	--	--	--	5	--	530±60	--
4329 R	--	--	--	3	--	--	--
4329 W	1	3.1	--	7	1	--	sherds
4329 V	--	--	--	--	--	290±50	--
4330 B	--	--	--	4	--	600±50	--
Haiwee Period							
4239 A	23	4.7	0.5	--	2	--	--
4240 (all)	10	5.5	0.1	1	--	--	--
4322/H C	10	4.3	0.3	--	--	--	--
4325 B	--	--	--	4	--	930±80	--
4378 B	10	5.1	1.3	--	--	--	--
3004/5 I[c]	12	11.7	1.9	2	--	860±65	--
3012 C[d]	9	6.5	1.3	--	1	--	--
4329 O[e]	15	9.5	2.9	--	1	--	--

Table 11. Chronometric Summary from Component Areas by Site (continued).

	Hydration Data				Projectile	Uncorrected Radiocarbon	
	n	mean	s.d.	NOE	Points	Age B.P.	Other
Late Newberry Period							
1816 A	12	7.0	0.2	2	1	--	--
1824 Main D	11	6.6	0.6	3	--	--	--
1824 Main F	17	6.3	0.5	6	4	--	--
1824 Main Z	8	5.7	0.5	1	--	--	--
1824-B (all)	5	6.3	0.1	--	--	--	--
1824-X (all)	9	6.6	0.3	1	--	--	--
1906 B	24	6.5	0.1	--	--	--	shell bead
1907 A	15	5.8	0.3	--	--	3080±70	--
1984 A	17	7.0	0.9	1	1	--	--
2103 A	25	7.0	0.8	2	2	--	--
2103 B	13	6.9	0.3	--	--	--	--
2826 B	9	5.9	0.4	--	--	--	--
2826 C	14	6.3	0.4	--	--	--	--
3012 D	4	6.3	0.5	--	--	--	--
3012 E	4	5.7	0.6	--	--	--	--
3456 A	28	7.2	0.7	2	--	--	--
4243 A	9	6.9	0.8	--	--	--	--
4243 C	3	6.7	0.4	--	--	--	--
4244 (all)	24	6.5	0.5	1	2	--	--
4252 (all)	14	5.8	0.5	--	--	--	--
4267 N	8	6.4	1.2	--	--	--	--
4378 A	8	5.8	1.2	2	--	--	shell bead
Middle Newberry Period							
1824 Main J	10	7.6	0.9	--	--	--	--
1824 Main K	4	7.5	0.3	--	--	--	--
1824 Main M	7	7.2	0.1	9	--	2450±90	--
Early Newberry Period							
1824 Main A	8	8.5	0.5	2	--	--	--
1824 Main Y	4	8.6	0.5	1	--	--	--
3004/5 A	13	8.5	1.0	3	6	--	--
4327 A	5	8.7	0.7	--	--	--	--
4329 K	22	8.5	1.1	--	3	--	--
4331 A	6	8.7	1.1	3	--	--	--
1984 B[c]	19	11.2	4.5	--	--	--	--
Little Lake Period							
4319 (all)	9	9.9	1.2	9	--	--	--
4322/H A	2	8.8	1.1	2	--	--	--
4325 A	1	10.6	2.4	1	--	--	--
4330 A	1	8.8	1.8	1	--	3600±280	--
3299 A[c]	3	10.4	2.8	3	--	--	--
4320 C[c]	14	10.6	3.8	1	--	--	--
2103 H[c]	5	10.8	1.3	--	--	--	--

Table 11. Chronometric Summary from Component Areas by Site (continued).

	Hydration Data				Projectile	Uncorrected Radiocarbon	
	n	mean	s.d.	NOE	Points	Age B.P.	Other
Early Period							
1824 Main B	4	11.5	2.5	--	--	--	--
1984 C	5	13.6	2.0	5	--	--	--
1984 D	2	15.8	4.6	--	1	--	--
3004/5 J	9	12.0	1.7	2	--	--	--
3299 B	16	12.5	4.3	2	--	--	--
3300 A	19	11.5	2.8	4	1	--	--
3300 B	19	12.0	3.8	1	--	--	--
4267 M	2	13.0	2.0	2	--	--	--
4320 A	12	11.8	1.8	8	--	--	--
4320 B	7	11.1	1.9	5	--	--	--
4324/H B	14	11.5	2.4	--	--	--	--
4327 C	4	11.8	0.9	--	--	--	--
4329 G	18	11.3	1.7	3	--	--	--
4329 L	6	18.4	2.2	6	--	--	--
4331 B	14	11.9	2.9	4	1	--	--

NOTE: [a] - "modern" reported as a percentage; [b] - also reported as "modern"; [c] - also Early; [d] - also Late Newberry; NOE - number of hydration rim values excluded from mean calculation.

RADIOCARBON ASSAYS

Twenty radiocarbon dates were obtained from project sites (Table 12). All samples were collected from feature contexts through the use of water flotation. Fifteen features from nine sites produced dates corresponding to the Marana period (i.e., <650 years B.P.), including four classified as modern. Obsidian tools and debitage genuinely associated with these features was rare, precluding the potential for a radiocarbon age-hydration pairing. Single features at two sites provided radiocarbon age estimates falling between 1275-650 B.P., corresponding to the Haiwee period. The first, from INY-4325 B, is not associated with an obsidian assemblage; the other, from INY-3004/5 I, is from a rock concentration with an obsidian assemblage occurring in the same general vicinity but evidently not contemporaneous, since hydration data indicate it dates to the Early period (Table 13). The single radiocarbon date obtained from a feature in INY-1907 A produced a radiocarbon date of 3080±780 B.P. The hydration specimens from this area, however, cluster tightly around a mean of 5.8 μ (s.d.=0.3), are comparable for artifacts and debitage alike, and show no appreciable difference with depth. The mean hydration value equates with an age of 1360 B.P., falling at the recent terminus of Late Newberry, and the range in hydration values is so narrow that it suggests the obsidian assemblage dates from a single occupational episode. The vertical distribution of materials here provides additional indication of a single period deposit. Using the Coso hydration rate we have adopted, values in the low eights would be consistent with the radiocarbon date obtained from the INY-1907 feature, and no rims of this magnitude were recorded. While the possibility remains that the feature pre-dates the dense obsidian assemblage-bearing deposit (in effect, making it an isolated feature), they are, in our judgement, more likely to be contemporaneous, which makes the radiocarbon date enigmatic. A better pairing was obtained from INY-1824 Main-M, where radiocarbon and hydration data from a single feature rendered Middle Newberry period dates of 2450±950 B.P. and 2246 B.P., respectively (Table 13). A single feature at INY-4330 A, provided the earliest radiocarbon date for the project, at 3600±280 B.P., corresponding to the magnitude of the associated hydration rim values, allowing temporal assignment to the Little Lake period.

Table 12. Uncorrected Radiocarbon Dates from Project Sites.

Site and Component	Laboratory Number	Catalogue Number	Provenience	cm bs	Flotation Volume (liter)	Radiocarbon Age B.P.	Context
1816 C	Beta-39765	31-286	N30/W25	8-12	7.0	160±70	Feature 2
1824 M	Beta-33258	26-942 26-943	N174/E107	40-60	30.0	2450±90	Feature 1
1906 H	Beta-36258	105-267	N28/W151	0-10	11.5	110±70 Modern	Feature 10
1906 F	Beta-36259	105-393	N78/E335	0-10	22.0	110±70 Modern	Feature 9
1907 A	Beta-36261	87-176 87-177	N18/E38	40-48	9.5	3080±70	Feature 1
2103 D	Beta-39766	27-734 27-735	S56/W18	0-20	24.0	370±70	Feature 1
3004/5 G	Beta-39361	109-917	S360/E49.8	0-10	14.0	110±60	Feature 1
3004/5 I	Beta-36260	109-920	S288/E191	0-10	7.0	860±65	Feature 4
4243 B	Beta-39763	43-51	N34/W69	0-10	6.5	130±80	Feature 1
4267 A	Beta-59992	88-700	S60/W20	0-10	17.5	101.6%±0.6% Modern	Feature 1
4322/H B	Beta-39363	98-87	N84.5/W56.9	10-20	5.0	99.1%±0.7% Modern	Feature 1
4325 B	Beta-39764	102-73 102-69	S17/E80	0-15	12.5	930±80	Feature 2
4329 A	Beta-39360	92-1671	N22/W189.5	10-20	8.0	140±50	Feature 2
4329 A	Beta-39357	92-1950 92-1951	N176/W157	0-30	6.5	580±60	Feature 1 & 1a
4329 V	Beta-39364	92-2437	N122/W57	30-40	9.0	290±50	Feature 17
4329 D	Beta-39358	92-2426	N9/W56 N7/W55	4-20	10.0	310±50	Feature 20
4329 D	Beta-39359	92-1878 92-1879	N74/W83	0-30	19.5	360±50	Feature 6
4329 N	Beta-39356	92-2617 92-2620	S29/W122	8-17	10.0	530±60	Feature 14
4330 B	Beta-39362	91-207	N11/E3	20-30	7.0	600±50	Feature 2
4330 A	Beta-30427	91-234	N11/W5	30-40	5.5	3600±280	Feature 3

Table 13. Radiocarbon and Hydration Pairings from Project Sites.

Site and Component	Radiocarbon Age (B.P. uncorrected)	Hydration Pairing Mean Value	Hydration Rate Equivalent (years B.P.)
1906 H	110±70	1.5	59
3004/5 I	860±65	11.7	6927
1907 A	3080±70	5.8	1360
1824 Main M	2450±90	7.2	2246
4330 A	3600±280	8.8	3577

NOTE: The hydration mean value for each pairing except INY-1907 is calculated with select values excluded (see Table 10).

PROJECTILE POINTS

In total 172 projectile points have been collected from excavations and prior work in the project area: 153 of obsidian and 19 of non-obsidian materials (Table 14). Consistent with the trend reported by Hughes (1988) at the Stahl and Rose Spring sites, and by Basgall and McGuire (1988) at INY-30, West Sugarloaf obsidian tends to be the prevalent Coso material subgroup, followed by substantial quantities of those identified to the Sugarloaf subgroup, but comparatively few of either Joshua Ridge or West Cactus Peak material subgroups. The remaining obsidian points include one each made of Fish Springs, "Queen imposter," and Mono Glass Mountain obsidian; and two have not been geochemically analyzed. Most non-obsidian projectile points are made of basalt (n=10), followed by cryptocrystalline materials (n=8), and one provisionally identified as tuff.

The projectile point assemblage contains examples of each type commonly identified throughout the Great Basin. Organized from what is generally considered most recent to oldest, they include two Desert Side-notched points and 10 Cottonwood Triangular; six Saratoga Spring and 21 Rose Spring; 10 Humboldt Basal-notched, 31 Elko Corner-notched or Eared, and seven Gypsum; 17 Little Lake, 42 Great Basin Stemmed (14 Silver Lake, 22 Lake Mohave, and six undifferentiated); and three Paleoindian style Concave-based points. Those of less certain chronological placement include eight non-basally notched Humboldt points, three Elko Side-notched, and eight leaf-shaped forms. The balance of the assemblage consists of two small notched items (either Desert Side-notched or Rose Spring points), one provisionally classified as a Cottonwood, and one provisionally classified as a Little Lake. Summary metrics for the obsidian points for each type are provided in Table 15; individual point measures are presented in Gilreath and Hildebrandt 1995, Appendix A, Volume III; representative examples are shown in Plates 1-9.

Hydration rim measures were made for all Coso obsidian projectile points (Table 16). As shown in Figure 19, the mean value of the various point styles increases in magnitude from the Desert series, to Saratoga Spring and Rose Spring, to Humboldt Basal-notched, to Elko, and then Gypsum; with Little Lake, Great Basin Stemmed, and Paleoindian points having substantially larger rim values. Using one standard deviation from the mean value, the hydration data indicate very little temporal overlap between Desert series, Rose Spring and Elko series points, with Humboldt Basal-notched temporally falling between Rose Spring and Elko. As shown in Table 17, the hydration rim measures on the majority of the Desert series, Saratoga Spring, Rose Spring and Humboldt Basal-notch items falls within the range identified for the various temporal periods. The hydration range for the Marana period, for example, is identified as $< 4.2\ \mu$, and 69% of the Coso obsidian Desert series points had rim values less than 4.2 μ. In sum, the hydration data for Desert series, Saratoga Spring, Rose Spring, and Humboldt Basal-notched points are consistent with the position held by many Great Basin archaeologists regarding their chronology.

Table 14. Projectile Points by Material Type.

	Coso Obsidian				Exotic Obsidian			UNK.	Non-Obsidian			
Type	WSL	SL	JR	WC	Fish	Qu-Imp	Mono	OBS	Basalt	CCR	Tuff	Total
Desert Side-notched	1	1	-	-	-	-	-	-	-	-	-	2
Cottonwood Triangular	6	2	2	-	-	-	-	-	-	-	-	10
Saratoga Spring	3	2	1	-	-	-	-	-	-	-	-	6
Rose Spring	16	3	-	1	-	-	-	1	-	-	-	21
Humboldt Basal-notched	7	-	2	-	-	-	-	-	1	-	-	10
Other Humboldt	3	3	2	-	-	-	-	-	-	-	-	8
Elko Corner-notched and Eared	11	10[a]	3	4	-	-	-	-	-	3	-	31
Gypsum	1	2	1	-	1	-	-	-	-	1	1	7
Elko Side-notched	2	-	1	-	-	-	-	-	-	-	-	3
Little Lake	4	8	1	1	-	-	-	-	2	1	-	17
Great Basin Stemmed												
Silver Lake	5	3[a]	-	-	-	-	-	-	5	1	-	14
Lake Mohave	7	5	2	3	-	1	1	1	1	1	-	22
Other Stemmed	3	1	1	-	-	-	-	-	1	-	-	6
Concave-based	-	-	1	1	-	-	-	-	-	1	-	3
Others												
Leaf	5	2	1	-	-	-	-	-	-	-	-	8
DSN/RS?	1	1	-	-	-	-	-	-	-	-	-	2
Cottonwood?	1	-	-	-	-	-	-	-	-	-	-	1
Little Lake?	1	-	-	-	-	-	-	-	-	-	-	1
TOTAL	77	43	18	10	1	1	1	2	10	8	1	172

NOTE: WSL - West Sugarloaf; SL - Sugarloaf; JR - Joshua Ridge; WC - West Cactus; Fish - Fish Springs; Qu-Imp - Queen Imposter; Mono - Mono Glass Mountain; UNK - not sourced; CCR - Cryptocrystalline; DSN/RS? - Desert Side-notched/Rose Spring?; [a] - includes one unknown, probably Sugarloaf.

The hydration data provide little comfort, however, to those who hold that Great Basin Stemmed points pre-date Little Lake/Pinto series points, and even less comfort to those who contend that the Little Lake/Pinto points largely pre-date Elko points. Rather, the hydration data indicate that in the Volcanic Field, these three point styles were contemporaneous for a long period of time. The chronological significance of Elko points throughout the Great Basin is controversial, and the fact remains that many who key their projectile points through the Monitor Valley scheme, often apply some measure of subjectivity when deciding if an item is referenced as an Elko or Little Lake. It is not uncommon that objective application and strict conformity with the key would require classification into one category, but subjectivity over-rules such assignment. Researchers' familiarity with the material culture in the area where they work allows them to recognize the less than perfect examples, and those pieces are often given provisional classification, referred to as "atypical" or "aberrant," often described as non-conforming because of the crudeness of craftsmanship. Consequently, and not infrequently, these irregular items are placed in a category other than that to which they keyed.

Elko and Little Lake points from the Volcanic Field raised all of these concerns. Subjectively there was considerable overlap in their appearance, size, and quality of craftsmanship, and they appeared to represent a continuum rather than two readily distinguishable styles. For that reason, it came as no surprise to learn that their hydration rim values indicated considerable temporal overlap (Figure 19). Sorted by hydration values, however, it became apparent that Elko points with a maximal thickness less than 6.5 mm routinely displayed quite narrow

Table 15. Summary Metrics of Obsidian Projectile Points.

	ML	AL	MW	TH	WT	BW	NW	PSA	DSA	NOA	STL
Desert Side-notched (n=2)											
n	-	-	2	2	-	2	2	2	2	2	NA
mean	-	-	14.3	3.0	-	14.3	7.6	159.5	228.0	68.5	NA
s.d.	-	-	2.8	0.2	-	2.8	0.1	0.5	2.0	1.5	NA
max.	-	-	17.2	3.3	-	17.2	7.7	160.0	230.0	70.0	NA
min.	-	-	11.5	2.8	-	11.5	7.5	159.0	226.0	67.0	NA
Cottonwood (n=10)											
n	6	6	8	10	5	7	NA	NA	NA	NA	NA
mean	26.1	24.0	13.4	3.2	0.6	11.8	NA	NA	NA	NA	NA
s.d.	8.7	8.0	2.6	0.5	0.2	2.7	NA	NA	NA	NA	NA
max.	39.3	36.6	17.2	4.0	0.9	15.0	NA	NA	NA	NA	NA
min.	15.8	15.0	9.7	2.1	0.3	7.5	NA	NA	NA	NA	NA
Saratoga Spring (n=6)											
n	4	4	6	6	4	5	NA	NA	NA	NA	NA
mean	39.1	39.0	19.2	4.8	2.5	19.1	NA	NA	NA	NA	NA
s.d.	10.6	10.7	4.3	1.1	1.3	4.7	NA	NA	NA	NA	NA
max.	56.7	56.7	25.2	7.1	4.7	25.2	NA	NA	NA	NA	NA
min.	30.6	30.6	12.3	3.7	1.4	12.3	NA	NA	NA	NA	NA
Rose Spring (n=21)											
n	10	10	18	21	10	15	20	NA	NA	NA	15
mean	29.5	28.3	15.9	4.0	1.2	8.4	7.9	NA	NA	NA	4.9
s.d.	5.4	4.3	2.3	0.7	0.3	2.5	2.1	NA	NA	NA	1.0
max.	37.4	37.4	22.0	5.9	1.8	14.5	10.1	NA	NA	NA	6.7
min.	22.2	22.2	12.7	2.6	0.8	7.0	5.8	NA	NA	NA	2.7
Humboldt Basal-notched (n=9)											
n	2	2	6	9	2	6	NA	NA	NA	NA	NA
mean	63.8	56.4	29.8	8.2	16.3	28.2	NA	NA	NA	NA	NA
s.d.	10.2	11.4	3.7	1.7	6.4	23.6	NA	NA	NA	NA	NA
max.	73.9	67.8	36.2	11.2	22.7	80.0	NA	NA	NA	NA	NA
min.	53.6	45.0	25.7	5.6	13.8	13.2	NA	NA	NA	NA	NA
Elko Corner-notched and Eared (n=28)											
n	14	14	22	28	12	18	25	25	26	24	26
mean	48.3	46.2	28.7	6.1	7.4	21.0	15.1	126.8	169.7	43.2	8.7
s.d.	8.9	8.1	4.3	1.5	3.4	4.8	3.1	15.9	16.8	22.0	2.0
max.	59.1	59.1	36.0	10.5	12.4	30.7	21.2	150.0	210.0	110.0	12.7
min.	28.6	28.6	20.7	4.0	2.7	11.2	9.9	95.0	140.0	12.0	5.2
Gypsum (n=5)											
n	1	1	5	5	1	2	5	5	5	5	4
mean	47.2	47.2	24.7	5.6	5.3	10.0	11.6	63.8	167.6	103.8	7.3
s.d.	0.0	0.0	3.8	0.9	0.0	1.6	2.0	8.1	21.7	26.2	1.4
max.	47.2	47.2	29.6	7.0	5.3	11.6	14.0	80.0	190.0	130.0	9.7
min.	47.2	47.2	17.8	4.5	5.3	8.4	8.9	59.0	135.0	70.0	6.3
Elko Side-notched (n=3)											
n	1	1	3	3	-	1	3	3	3	3	3
mean	50.4	42.0	22.9	6.5	-	20.9	14.5	149.7	201.7	52.0	113.3
s.d.	0.0	0.0	1.2	0.8	-	0.0	2.2	3.7	23.9	27.0	141.5
max.	50.4	42.0	24.0	7.6	-	20.9	16.8	154.0	235.0	90.0	313.4
min.	50.4	42.0	21.2	5.6	-	20.9	11.6	145.0	180.0	30.0	10.0
Little Lake (n=14)											
n	10	10	14	14	10	13	14	14	14	14	14
mean	40.3	37.8	28.6	8.4	7.8	19.6	19.2	100.0	196.5	96.5	12.1
s.d.	6.4	6.1	4.3	1.3	3.6	5.1	3.8	7.8	21.8	22.1	3.5
max.	51.5	47.8	37.0	10.6	15.4	26.8	25.9	112.0	220.0	125.0	21.5
min.	29.9	28.1	20.8	5.8	3.7	8.4	10.7	85.0	143.0	50.0	6.8

Table 15. Summary Metrics of Obsidian Projectile Points (continued).

	ML	AL	MW	TH	WT	BW	NW	PSA	DSA	NOA	STL
Great Basin Stemmed- Silver Lake Variant (n=8)											
n	6	6	7	8	7	8	8	NA	8	NA	8
mean	40.3	40.1	25.1	7.3	6.3	16.8	17.1	NA	215.6	NA	12.1
s.d.	8.7	8.8	1.8	0.8	2.2	7.2	4.3	NA	9.2	NA	2.2
max.	56.5	56.5	27.4	8.6	10.3	24.5	21.9	NA	230.0	NA	16.6
min.	27.8	27.4	21.7	6.5	3.3	1.4	7.4	NA	200.0	NA	9.0
Great Basin Stemmed- Lake Mohave Variant (n=20)											
n	7	7	15	18	9	6	11	NA	10	NA	10
mean	45.9	45.9	28.8	7.8	9.9	19.9	23.5	NA	210.4	NA	24.9
s.d.	6.4	6.4	3.3	1.3	2.2	2.9	2.2	NA	22.2	NA	8.2
max.	59.3	26.3	36.4	10.0	13.6	23.0	26.4	NA	243.0	NA	43.0
min.	40.0	40.0	23.3	4.9	7.0	16.0	19.0	NA	176.0	NA	17.6

NOTE: NA - not applicable; ML - maximum length; AL - axial length; MW - maximum width; TH - thickness; WT - weight; BW - basal width; NW - neck width; PSA - proximal shoulder angle; DSA - distal shoulder angle; NOA - notch opening angle; STL - stem length; all measurements in mm.

Table 16. Hydration Data Summary of Coso Obsidian Projectile Points from the Volcanic Field.

	n	mean	s.d.	Rim Values
Desert Series	12	3.0	1.2	1.3, 1.5, 1.9, 2.1, 2.8, 2.8, 2.9, 3.0, 3.8, 4.3, 4.5, 4.7, (6.7)
Rose Spring	20	5.2	0.8	(~2.5), 3.6, 4.2, 4.4, 4.5, 4.7, 4.8, 4.8, 4.9, 5.0, 5.2, 5.3, 5.3, 5.3, 5.6, 5.7, 5.8, 5.8, 6.2, 6.3, 6.9
Saratoga Spring	6	4.8	0.8	4.2, 4.3, 4.3, 4.8, 4.9, 6.3
Elko <6.5 mm thick	12	7.4	1.0	6.0, 6.6, 6.8, 6.9, 6.9, 7.0, 7.3, 7.6, 7.6, 8.1 9.1, 9.3, (11.6, 16.2, DH, DH)
Elko ≥6.5 mm thick	8	12.3	3.3	(6.2), 8.7, 9.4, 10.7, 11.1, 12.2, 12.5, 14.9, 18.9, (DH)
Elko Side-notched	2	8.6	1.3	7.6, 9.5, (DH)
Humboldt Basal-Notched	8	6.3	1.0	(2.3), 4.8, 5.7, 5.7, 5.9, 6.0, 6.8, 7.5, 7.7
Gypsum	4	10.1	2.5	7.9, 8.0, 12.1, 12.4
Little Lake/Pinto	12	14.2	4.3	(6.1), 9.1, 9.5, 9.5, 10.6, 11.2, 13.6, 14.3, 15.0, 17.7, 18.3, ~19.5, ~21.5, (DH, VW)
Great Basin Stemmed	21	12.9	2.7	(5.5), 8.7, 8.9, 9.4, 9.9, 10.3, ~11.0, 11.1, 11.5, 11.6, 12.5, 12.9, 13.1, 13.6, 14.2, 14.2, 14.3, 15.2, 15.6, 16.7, 17.5, ~17.8, (DH, DH, DH, DH, DH, VW)
Concave-Base	2	17.3	5.4	13.4, 21.1
Leaf-shaped	6	11.1	4.0	(4.7), 7.5, 8.7, 8.7, 9.7, 14.0, 17.9

NOTE: ( ) - value not included in calculations; DH - diffuse hydration; VW - variable width; ~ - approximate measure.

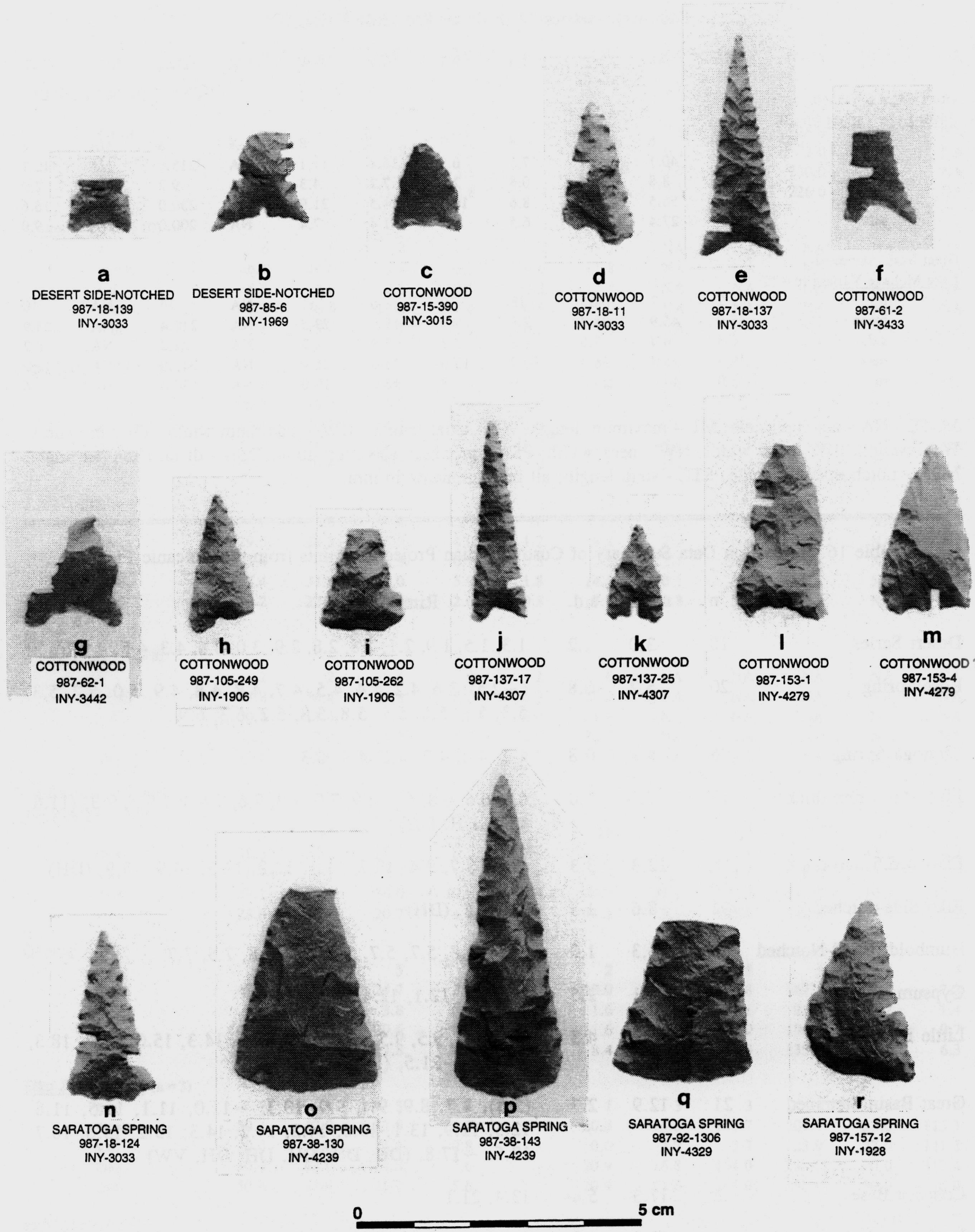


Plate 1. Desert Side-notched (a,b), Cottonwood (c-m), and Saratoga Spring (n-r) Projectile Points.

Plate 2. Rose Spring Projectile Points.

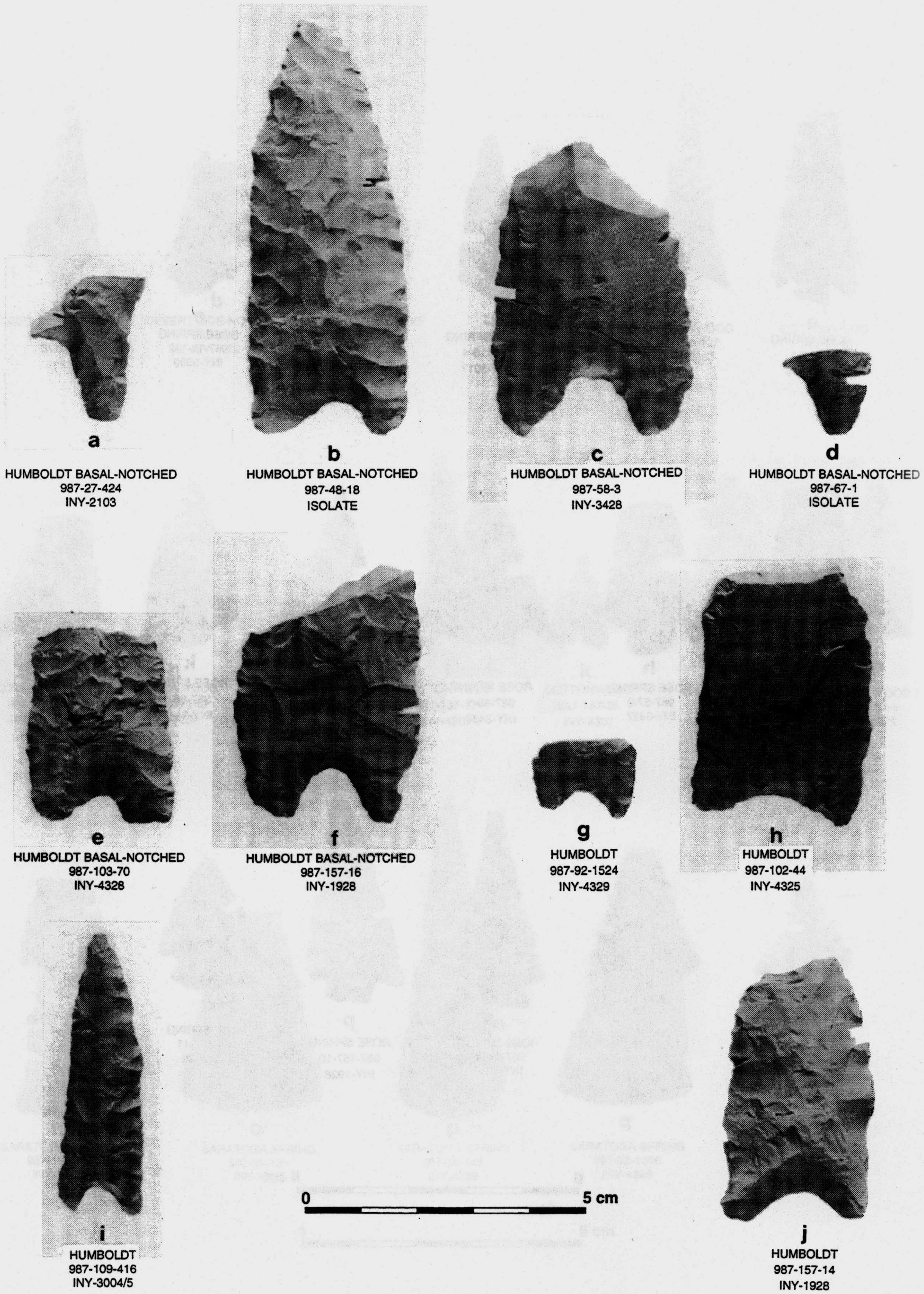


Plate 3. Humboldt Basal-notched (a-f) and Undifferentiated Humboldt (g-j) Projectile Points.

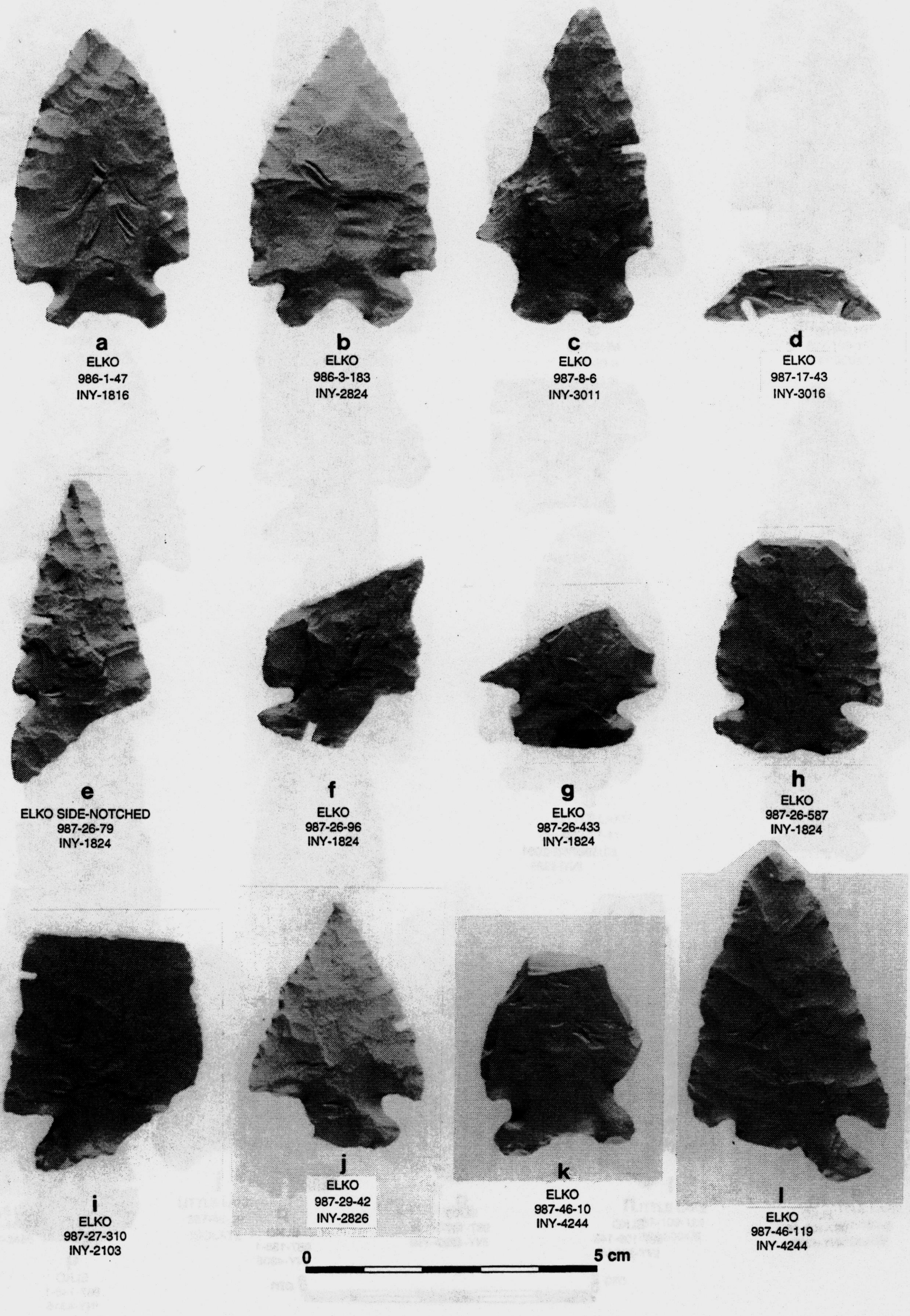


Plate 4. Elko Series Projectile Points.

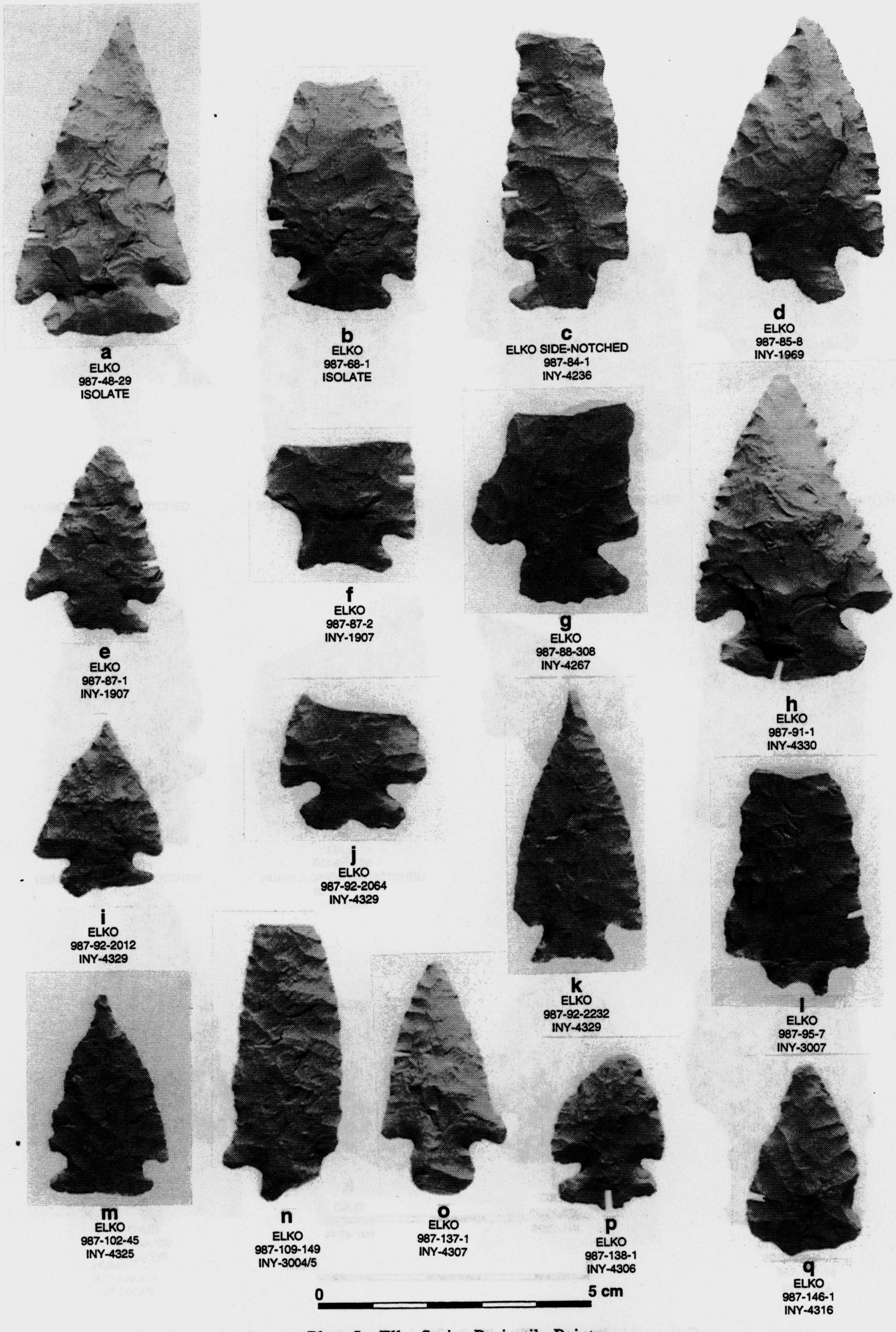


Plate 5. Elko Series Projectile Points.

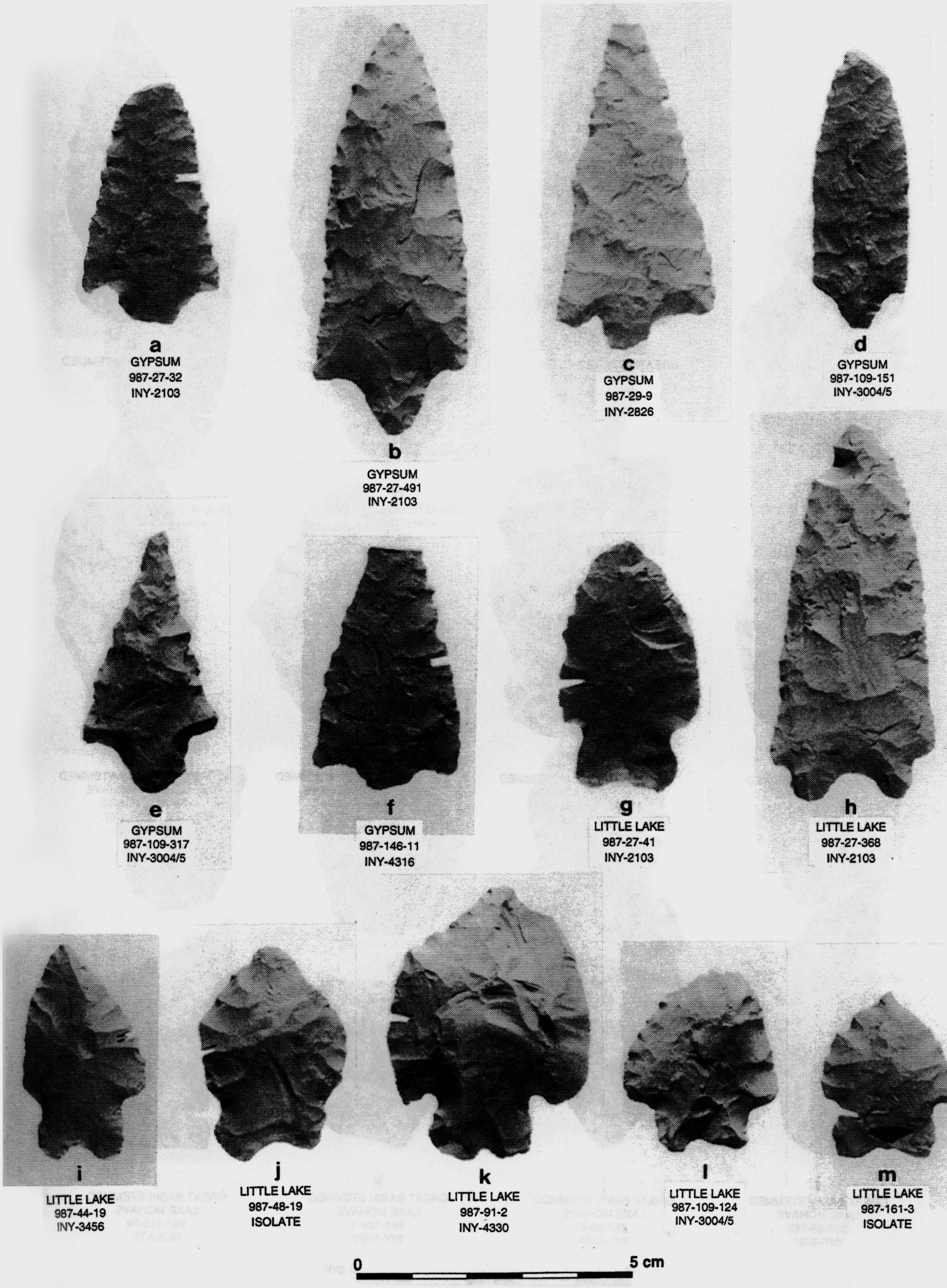


Plate 6. Gypsum (a-f) and Little Lake (g-m) Series Projectile Points.

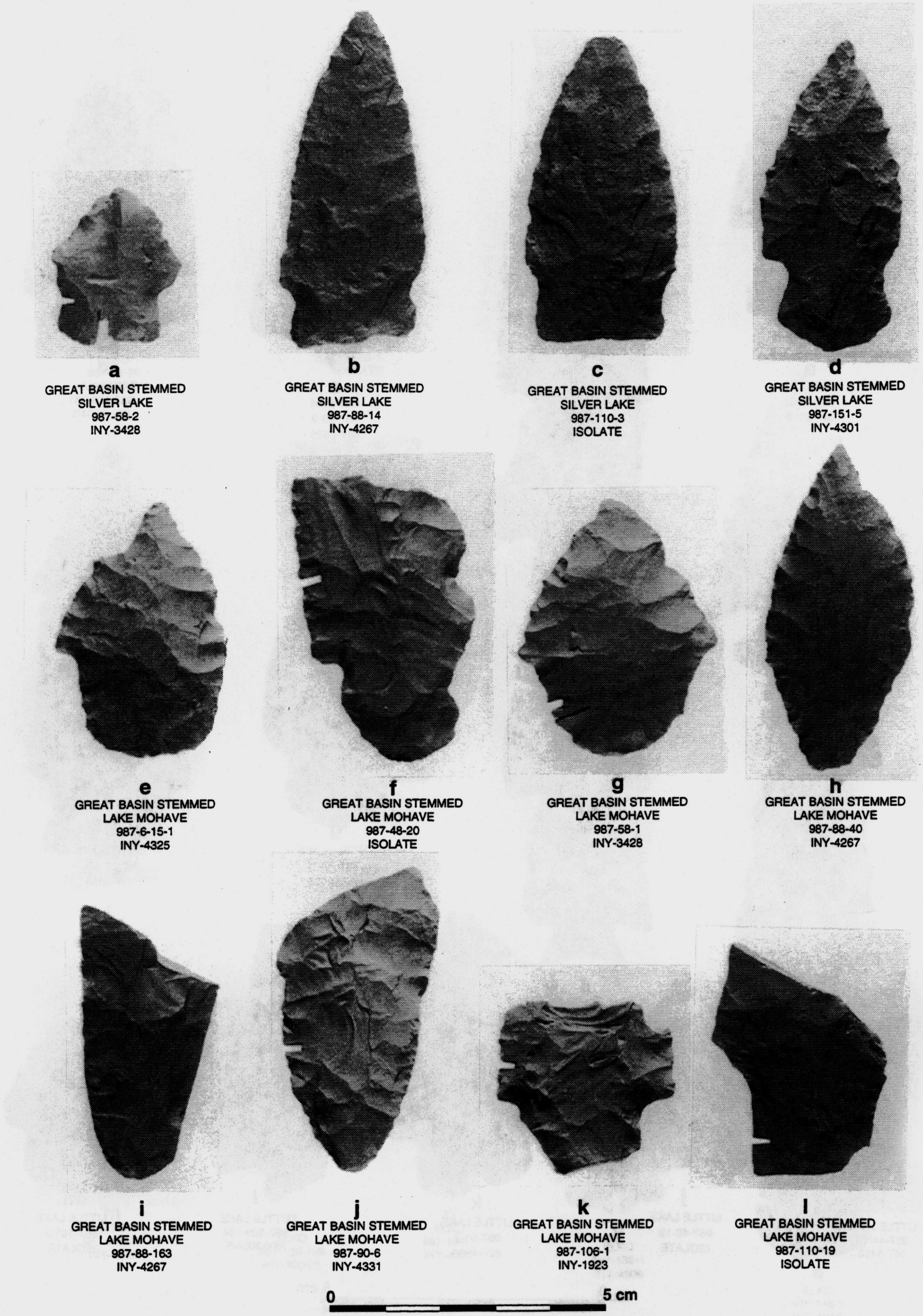


Plate 7. Silver Lake (a-d) and Lake Mohave (e-l) Variants of Great Basin Stemmed Projectile Points.

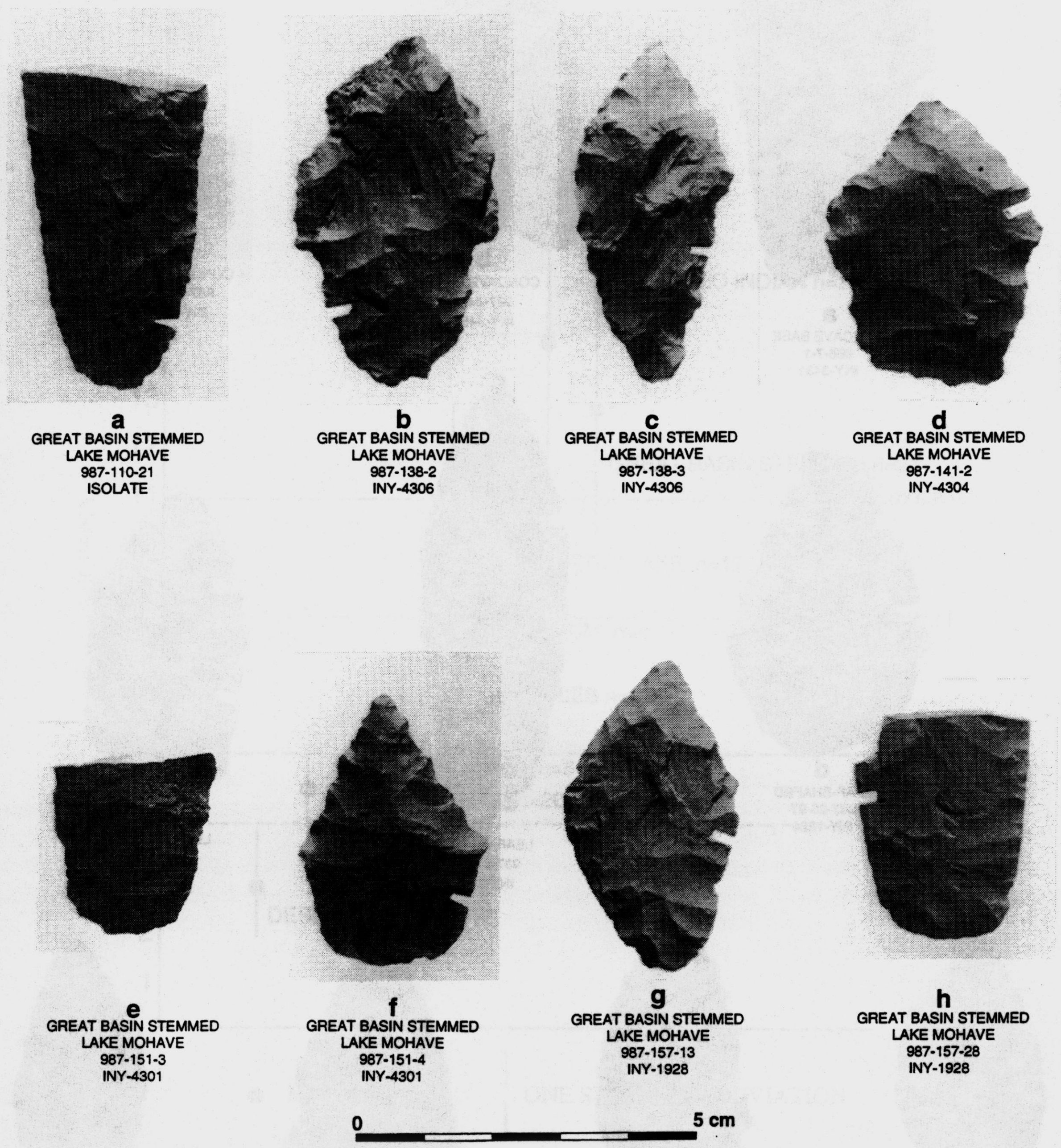


Plate 8. Lake Mohave Variants of Great Basin Stemmed Projectile Points.

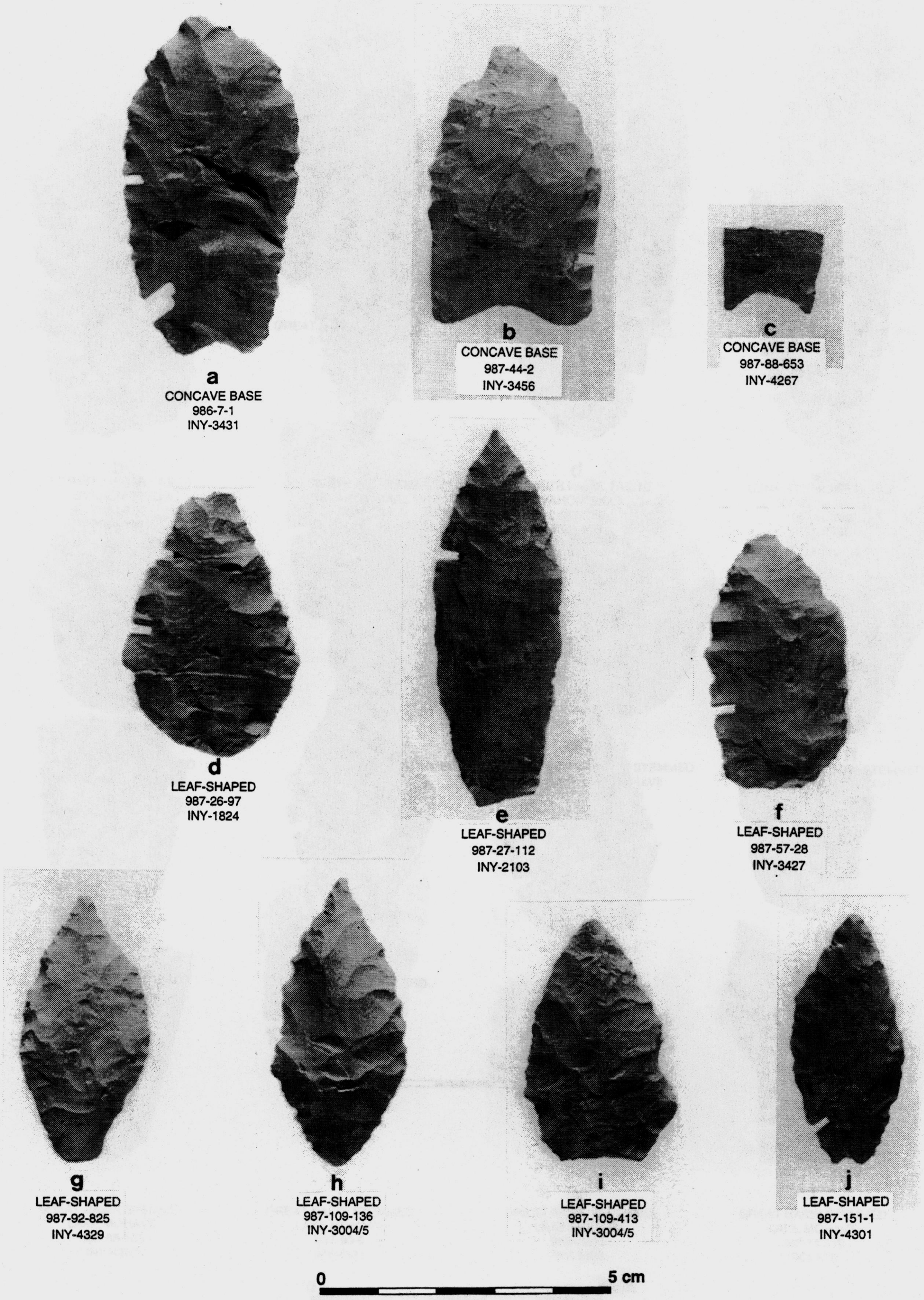


Plate 9. Concave-based (a-c) and Leaf-shaped (d-j) Projectile Points.

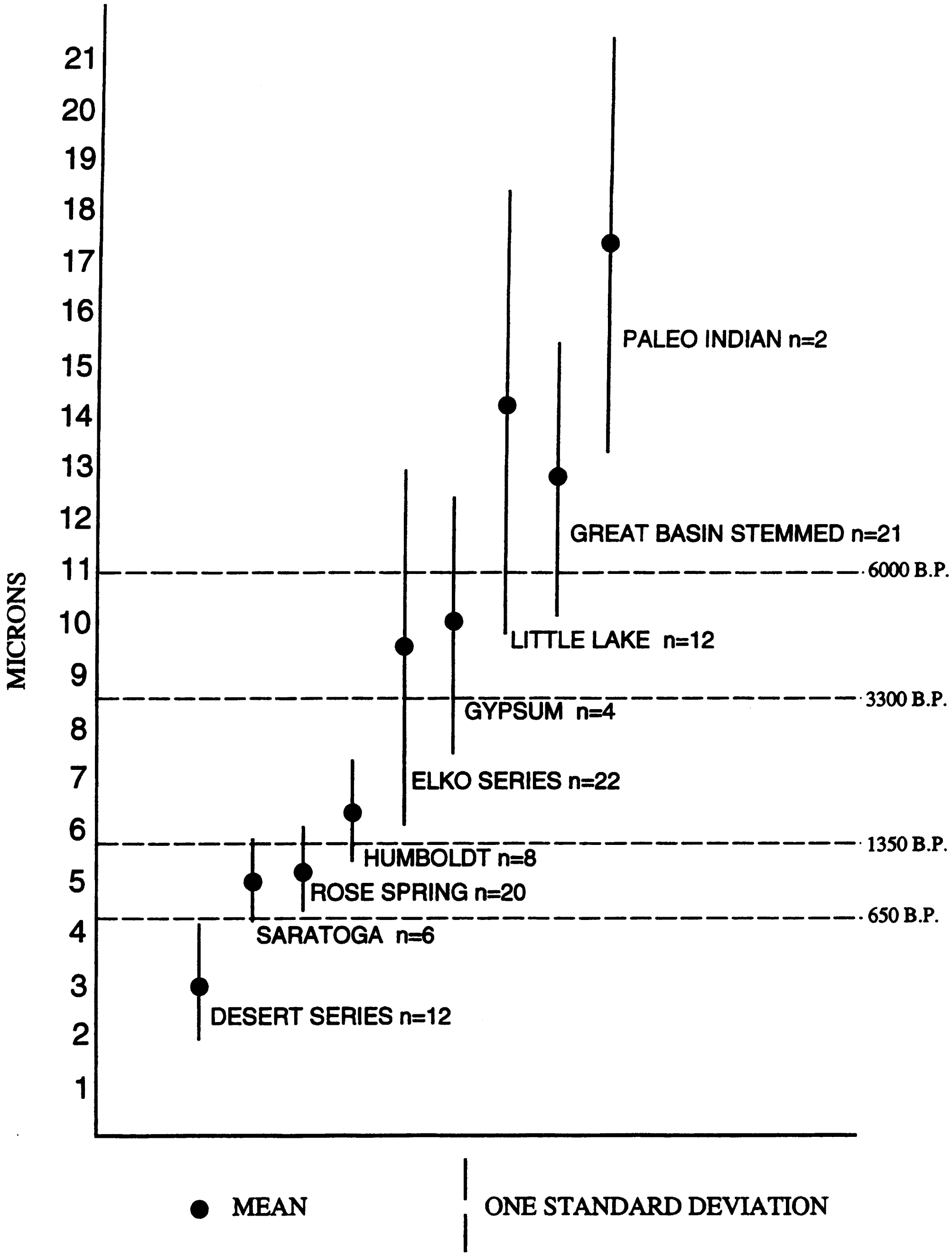


Figure 19. Coso Obsidian Hydration Values on Projectile Points from the Volcanic Field.

Table 17. Frequencies of Coso Obsidian Projectile Points by Type and Period.

Period	Coso Hyd. Range (μ)	Desert Series	Saratoga Spring	Rose Spring	Humboldt Basal-notch	Elko		Gypsum Contracting	Elko Side-notch	Little Lake	Great Basin Stemmed	Total
						Thin	Thick					
Marana	< 4.2	9	-	3	1	-	-	-	-	-	-	13
Haiwee	4.2-5.65	3	5	12	1	-	-	-	-	-	1	22
Late Newberry	5.65-7.3	1	1	6	5	7	1	-	-	1	-	22
Middle Newberry	7.3-7.9	-	-	-	2	2	-	1	1	-	-	6
Early Newberry	7.9-8.7	-	-	-	-	1	1	1	-	-	1	4
Little Lake	8.7-10.6	-	-	-	-	2	1	-	1	4	4	12
Early	> 10.6	-	-	-	-	2	6	2	-	8	16	34
Total		13	6	21	9	14	9	4	2	13	22	113

hydration rim bands, while those with a maximal thickness equal to or exceeding 6.5 mm showed a strong tendency to display substantially wider hydration bands, quite comparable with the Little Lake points. Further, as shown in Figure 20 and Table 16, the temporal overlap of Thin Elko points compared to either Thick Elko or Little Lake points, using one standard deviation from the sample mean, is minimal. Thin Elko points are concluded to have a restrictive temporal range, calculating to ca. 3200-1700 B.P. (using one standard deviation) using Basgall's Coso hydration rate, which makes them a good chronological indicator. On the basis of this attribute, 71% of the Thin Elko points fall within our Late, Middle, and Early Newberry periods, collectively; while 77% of the Thick Elko points fall within our Little Lake and Early periods. It is worth noting, too, that the hydration rim values on Thick Elko and Little Lake points from the Volcanic Field are comparable to values reported for a large sample of points from the Stahl site (Figure 20), included in that sample here are "Corner-notched, tangs visible, notched base" (Meighan 1981:Figure 1a-l), "Notched stem, open sides" (Meighan 1981:Figure 2c-t), and "Side notches, slightly concave base without basal notch" (Meighan 1981:Figure 3a-d) variants. The Thick Elko and Little Lake points from the Volcanic Field, however, on average have a higher mean hydration value than comparable forms at the Stahl Site (Figure 20).

To this point we have shown that hydration data from Desert Side-notched/Cottonwood, Saratoga Spring/Rose Spring, Humboldt Basal-notched, and Thin Elko points from the Volcanic Field correlate well with the chronological scheme for the project area; and are largely consistent with the point sequence applied throughout the western Great Basin. Our data suggest, however, that Thick Elko, Little Lake, and Great Basin Stemmed points were used contemporaneously throughout the Little Lake and Early periods. The range in values for each of these latter three types is quite large, paralleling the characteristic of the cluster samples from Early period deposits (compare Figure 18). The higher incidence of immeasurably diffuse hydration (DH) and variable width (VW) bands on Great Basin Stemmed points (recorded on 21%), compared to their lower incidence on Thick Elko (15%) and Little Lake (13%) points might signify the greater antiquity of Great Basin Stemmed points, but this is at present only conjecture. Alternatively, one could argue that hydration rims have poor chronological resolution at this early date. Only two Coso obsidian Paleoindian concave-based points have been recovered, precluding assessment of the temporal span, though both had quite wide hydration rim bands (13.4 and 21.2 μ).

Table 18 is presented to underscore the importance of Effective Hydration Temperature (EHT) on the rim formation rate of Coso glass. Rim values recorded on Coso projectile points from six other projects in the western Great Basin are summarized here; geochemical XRF analysis has been conducted on all specimens included in this tabulation. Fort Irwin, located north of Barstow, CA, currently has the highest EHT factor, having a mean annual temperature higher than the other areas. The Kern Plateau, at the south end of the Sierra Nevada Range, has the lowest EHT factor, being substantially cooler than the other areas listed. The Lubkin Creek site (INY-30), approximately six km south of Lone Pine, has an EHT value intermediate to Fort Irwin and the Kern Plateau, while the EHT in the Volcanic Field and the Stahl Site at Little Lake are likely to be quite similar, falling between the values for INY-30 and Fort Irwin. Contel project sites are adjacent to U.S. Highway 395 between Big Pine and Little Lake, through Owens and Rose valleys (Delacorte and McGuire 1993), indicating that the EHT value from the north end is comparable to that for INY-30, while the EHT for the south end is similar to the Volcanic Field and the Stahl Site. Put simply, listed from high to low EHT values (hot to cold) the areas are: Fort Irwin, the

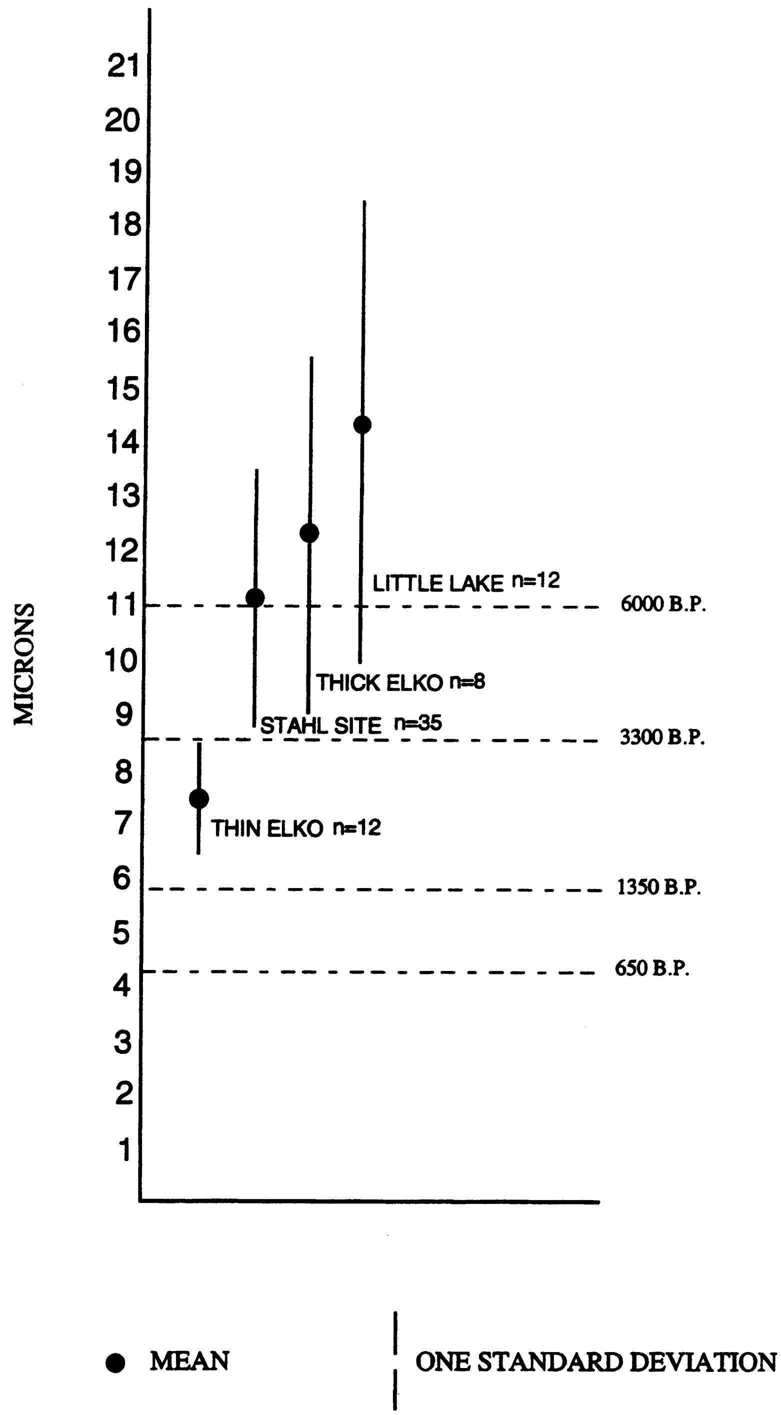


Figure 20. Coso Obsidian Hydration Values on Elko and Little Lake Points (Stahl Site Sample Based on Meighan 1981; All Others are from the Volcanic Field).

Table 18. Hydration Data on Coso Obsidian Projectile Points from Various Projects.

	n	mean (μ)	s.d.	range (μ)
Desert Series				
Fort Irwin	5	3.2	1.5	1.5-5.0
Coso	12	3.0	1.2	1.3-4.7
Stahl Site	2	3.2	2.1	1.7-4.6
Contel[b]	12	3.1	1.9	1.3-5.9
INY-30[c]	44	3.0	0.9	0.7-5.2
Kern Plateau	40	2.0	0.7	1.0-4.7
Rosegate Series				
Fort Irwin[a]	6	4.7	1.1	3.5-6.1
Coso	20	5.2	0.8	3.6-6.9
Contel[b]	11	5.1	1.2	4.0-7.9
INY-30[c]	13	4.1	0.8	2.6-5.4
Kern Plateau	20	2.8	0.8	1.0-4.0
Humboldt Basal-notched				
Fort Irwin	(none)			
Coso	8	6.3	1.0	4.8-7.7
Contel	2	6.2	0.4	5.9-6.5
INY-30	12	5.5	0.7	4.7-6.9
Kern Plateau[d]	d	d	d	d
Elko Series: Thin < 6.5 mm maximal thickness; thick are ≥ 6.5 mm maximal thickness.				
thin - Coso	12	7.4	1.0	6.0-9.3
thin - Contel	3	7.1	1.3	6.3-8.6
thin - INY-30	2	6.6	0.4	6.3-6.8
thin - Kern Plateau	2	5.4	1.5	4.3-6.4
thick - Coso	8	12.3	3.3	8.7-18.9
thick - Contel	2	8.1	0.2	7.9-8.2
thick - INY-30	(none)			
thick - Kern Plateau	(none)			
Little Lake/Pinto/ Gatecliff Split-stem Series				
Fort Irwin[a]	4	12.5	1.5	11.1-14.1
Coso	12	14.2	4.3	9.1-21.5
Stahl Site	35	11.1	2.5	8.1-17.3
INY-30	1	14.0	-	-
Kern Plateau	2	9.9	1.1	9.1-10.7
Great Basin Stemmed				
Fort Irwin	11	13.3	2.5	10.0-16.9
Coso	21	12.9	2.7	8.7-17.8
INY-30 (Lake Mohave)	1	11.8	-	-
Concave-based				
Coso	2	17.25	5.4	13.4-21.1

NOTE: Fort Irwin data derived from Basgall 1991:51; [a] - excluded a value of 2.7 for a Rosegate and 5.4 and 16.8 values for Pinto items. Stahl site data derived from Meighan 1981; Desert series items correspond to Meighan 1981:Figure 4h and j, Little Lake/Pinto/Gatecliff items correspond to Meighan 1981:Figure 1a-l, Figure 2c-t, and Figure 3a-d. Contel data derived from Delacorte and McGuire 1993; [b] - excluded values of 7.2 and 7.3 from Desert series items, and a value of 9.4 on a Rose Spring item. INY-30 data derived from Basgall and McGuire 1988; [c] - excluded multiple rim values of 5.8/8.5 and 5.2/9.3 on two Desert series items, and multiple rim values of 2.6/7.0/7.5 on a Rose Spring item; [d] - Kern Plateau data was intentionally omitted because of confusion surrounding Sierran Concave-base forms.

Volcanic Field, and Stahl site; the Contel project area; INY-30; and the Kern Plateau. Though the mean hydration values from one area to the next for any particular series do not perfectly correspond to the temperature gradient, the trend is strongly supported. Where similar point styles are represented at both Fort Irwin and the Kern Plateau, the sample from the latter area consistently produced a narrower mean hydration rim value than was recorded for the Fort Irwin sample — the magnitude of the difference increasing from 1.2 μ for the Desert series samples, to 1.9 μ for the Rosegate series, and to 2.6 μ for the Little Lake/Pinto/Gatecliff Split-stem series. Comparing samples from the Volcanic Field to INY-30, samples from the latter environment, with the exception of the Desert series, have consistently lower mean values than the corresponding sample from the Volcanic Field, generally averaging between 0.8 to 1.2 μ narrower.

As indicated in Tables 11 and 19, projectile points were recovered from comparatively few component areas. Had temporal assignment relied on projectile points *very* few areas (only 18) would have been dated; and a high proportion of those would likely have been considered multi-period accumulations (Table 19). Only two of the six points from Marana period deposits are Desert series forms, the remainder are Rose Spring, Great Basin Stemmed (Silver Lake variant), Humboldt Concave-base, and an undifferentiated arrow-sized fragment. Ten of the 19 points recovered from Newberry components are styles *other* than Gypsum or Thin Elko: two Thick Elkos, three Little Lake, one Great Basin Stemmed, three leaf-shaped points, and a Humboldt Concave-base. On the other hand, Desert series points are always from deposits concluded to be Marana period; four of the five Rose Spring/Saratoga Spring points are from Haiwee period deposits; both Gypsum and all Thin Elkos are from Newberry period deposits; and three of five Great Basin Stemmed items are from Early deposits. In sum, projectile points are not common in the Volcanic Field, but hydration data from them corroborate the temporal placement of the point types.

OTHER TEMPORALLY DIAGNOSTIC ITEMS

The remaining temporally diagnostic items recovered from project sites are limited to *Olivella* shell beads found singly at three sites, a single glass trade bead at one site and nearly 250 from another site, and comparatively few Owens Valley Brown Ware sherds at another (Table 9).

Each of the *Olivella* beads is a complete split specimen, two of which are punched, the other drilled. These are classified as Types C2 or Types D1a (Bennyhoff and Hughes 1987), and are tentatively dated to the Late Middle and Late prehistoric intervals in the Great Basin, though their chronological significance is weakly documented. One of both variants was collected from Late Newberry period deposits, reinforcing the temporal placement for Type C2, but suggesting that Type D1a beads occur during the "Middle" period.

Three varieties of glass trade beads were recovered, the most numerous (n=27) being blue monochrome, multi-sided tubular beads with chopped ends (Class Dtum Type 1c, Ross 1993:Appendix V). This type is fairly common throughout the Desert West in protohistoric and early historic times. By comparison, only a few of those commonly and erroneously referred to as "Russian" trade beads were recovered; these being similar to the previous type, but having ground facets (n=15; Class Dtum Type 1f, Ross 1993:Appendix V). The final variety corresponds to Ross' (1993:Appendix V) Class Dtfp Type IVa; they are small red-on-white cylinders shaped with a hot-tumble finish (n=10). This latter type has also been referred to as "cornaline d'Aleppo" or "Hudson's Bay Company" beads (e.g., Jenkins 1975; Mille 1975). The first variety described above generally dates to the early to mid-1800s; the second variety is slightly more recent, typically post-dating 1860; and the final variety is dated ca. 1820-1860. All of the trade beads at INY-1906 are from a Marana component area (H) where a very recent radiocarbon date was obtained, as were Desert series points, and quite narrow hydration rims.

All 41 pieces of pottery were recovered from INY-4329. They consist of six rim fragments, 34 wall fragments, and one basal fragment deriving from Owens Valley Brown Ware vessels. Regional data suggest that this pottery is a comparatively late phenomenon, dating within the past 700 years (Basgall and McGuire 1988; Bettinger 1989). To date, moderate quantities of Owens Valley Brown Ware pottery have been found at only a few other sites in and adjacent to the Volcanic Field (fewer than 20 pieces each from 13 sites, and over 200 pieces from one site on Coso Wash). Thirty-one of the pieces from INY-4329 were recovered from Marana-age Component W, where an arrow-sized projectile point was also collected, and a single hydration rim value of 3.1 was obtained, lending additional support to this late temporal placement. The remainder are from a residual area (E), adjacent to Component D, another Marana-age deposit identified at the site.

Table 19. Diagnostic Projectile Points in Components.

	Desert Series	Rose Spring/and Saratoga Spring	Humboldt Basal-notched	Gypsum	Thin Elko	Thick Elko	Little Lake	Great Basin Stemmed	Other	Total
<u>Marana</u>										
1816 C	-	1	-	-	-	-	-	-	-	1
1906 H	2	-	-	-	-	-	-	-	-	2
4267 A	-	-	-	-	-	-	-	1	-	1
4329 D	-	-	-	-	-	-	-	-	1	1
4329 W	-	-	-	-	-	-	-	-	1	1
subtotal	2	1	-	-	-	-	-	1	2	6
<u>Haiwee</u>										
3012 C[a]	-	1	-	-	-	-	-	-	-	1
4239 A	-	2	-	-	-	-	-	-	-	2
4329 O	-	1	-	-	-	-	-	-	-	1
subtotal	-	4	-	-	-	-	-	-	-	4
<u>Late Newberry</u>										
1816 A	-	-	-	-	-	-	1	-	-	1
1824 Main F	-	-	-	-	2	1	-	-	1	4
1984 A	-	-	-	-	-	-	-	1	-	1
2103 A	-	-	-	1	-	-	1	-	-	2
4244 (all)	-	-	-	-	1	1	-	-	-	2
subtotal	-	-	-	1	3	2	2	1	1	10
<u>Early Newberry</u>										
3004/5 A	-	-	-	1	1	-	1	-	3	6
4329 K	-	-	-	-	3	-	-	-	-	3
subtotal	-	-	-	1	4	-	1	-	3	9
<u>Early</u>										
1984 D	-	-	-	-	-	-	-	1	-	1
3300 A	-	-	-	-	-	-	-	1	-	1
4331 B	-	-	-	-	-	-	-	1	-	1
subtotal	-	-	-	-	-	-	-	3	-	3
TOTAL	2	5	-	2	7	3	2	5	6	32

SUMMARY

Investigations at the 34 sites led to the discovery of 21 spatially discrete Early period concentrations of material at 12 sites; seven Little Lake period component areas at as many sites, seven Early Newberry period components at six sites, three Middle Newberry components at one site; 23 Late Newberry period concentrations at 16 sites, eight Haiwee period components at as many sites, and 26 Marana period component areas at 13 sites (Table 11). Of the 6232 flaked stone artifacts recovered from project sites, 3594 are within component areas, as are 359 of the 652 pieces of ground stone, 155 of the 311 cobble-cores, three of the four abraders, five of seven anvils, 31 of 41 sherds, all but two of the beads, and the single incised stone. In the subsequent chapters, assemblage characterizations for the different time periods are based on the artifacts found in these well-dated deposits.

CHAPTER 6: LITHIC PRODUCTION PATTERNS

This chapter presents period-specific flaked stone assemblage characterizations, organized from early to most recent. Because reduction activities greatly differed between quarry and off-quarry locations, they are considered separately within each period. We have also focused on attributes shared by components of the same age (Table 11), rather than seeking out variability between them. For this reason, emphasis is given to composite assemblages created by combining materials across contemporaneous component areas. The chapter concludes with a discussion of diachronic trends in obsidian exploitation practices in the Volcanic Field.

EARLY PERIOD QUARRY ASSEMBLAGES

Early period areas occur primarily at lag quarries (n=16), of which three (INY-2103H, -3299A, -4320C) contain materials from both Little Lake and Early period occupations, while one (INY-3004/5I) contains an Early flaked stone assemblage associated with a Haiwee period ground and battered stone assemblage (Table 20). The combined chipped stone assemblage is dominated by cores (52.2%), with bifaces (inclusive of uniface-B's and flake blanks) making a significant secondary contribution (37.4%). Other artifacts occur in persistently low frequencies, including flake tools (5.7%), unifaces (3.5%), and formed flake tools and projectile points (<1.0% each).

Cores. Cores are the "type" artifact of Early period quarries, found at nearly every Early lag quarry, but particularly abundant at INY-3300. Similarly high proportions of bifacial, non-patterned, and unidirectionally flaked cores were recovered, with a substantial number of bidirectional specimens also found (Table 20). The vast majority (85.9%) were discarded whole. Size differs little between these (Table 21), indicating that one core form does not give way to another with subsequent reduction, excluding cobble/chunk tests. Whole cobble/chunks tests have an average weight of 218.4 g, while average weight of the other forms ranges from 137.7 to 188.5 g. Wide-shouldered slightly outnumber triangular shapes among bidirectional and non-patterned cores, while the reverse is true among unidirectional cores. The two shapes are equally represented among bifacial cores; blocky-rectangular shapes are best represented among non-patterned cores.

Bifaces. Bifaces were recovered from nearly each Early lag quarry (Table 20). Stage 2 forms are most numerous in virtually every one of these contexts, accounting for 72.4% of all bifaces. Stage 1 bifaces follow at 14.7%, and Stage 3 at 11.3%. As indicated in Table 22, size tends to decrease as reduction increases, with Stage 1s averaging 78 x 52 x 25 mm (86.9 g), and Stage 2s 73 x 48 x 19 mm (64.2 g). Stage 3s are longer, but narrower and thinner than preceding forms, averaging 83 x 45 x 15 mm. Over half of the bifaces discarded at the lag quarries are whole (54.7%), most frequent among Stage 1s (79.7%) and declining to 45.1% among Stage 3s (Table 23). Most whole bifaces are wide-shouldered (33.9%) and triangular (29.1%) shaped; the most common cause for discard is a poor cross-section (divots or high-spots, 32.9%), followed by human error during manufacture (31.4%), and structural flaws in the stone (18.0%, Table 23).

Projectile Points and Biface/Points. The remaining bifacial implements are limited to a few projectile points and a biface/point fragment. Single projectile points were found in only three of 16 Early lag quarry deposits (Table 20). Each is an Early type. The point from INY-1984D is a complete basalt Silver Lake; the one from INY-3300A is a complete Lake Mohave made of cryptocrystalline material; and the one from INY-4331B is a proximal fragment of a Lake Mohave (Plate 7j) made of Sugarloaf obsidian. The single biface/point is a medial fragment of an intermittently pressure-flaked obsidian specimen from INY-3004/5I.

Unifaces. A low number of unifaces occurred at the majority of the Early lag quarries, with a total of 44 recovered (Table 20). Averaging 67 x 48 x 20 mm (69.0 g), the unifaces are comparable in size to discarded Stage 2 bifaces from the same contexts (compare Tables 22 and 24), and like the bifaces, they are mostly discarded whole (79.5%). Rather than representing a desired separate artifact type, the size, condition, and shape of the unifaces suggest they represent a particular kind of failure in the biface production trajectory that resulted from using striking angles too steep to effectively thin the base implement. Consequently, the blank remained unsuitably thick, and surmounting this problem to produce a regularized cross-section would have required reducing the item's length and/or width to a degree apparently judged unsuitable.

Table 20. Assemblage Inventories in Early Period Components.

	1824 B QL	1984 C QL	1984 D QL	2103 H* QL	3004/5 I* QL	3004/5 J QL	3299 A* QL	3299 B QL	3300 A QL	3300 B QL	4320 A QL	4320 B QL	4320 C* QL	4327 C QL	4329 G QL	4331 B QL	Subtotal QL	1984 B* OQ	4267 M OQ	4324/H-B OQ	4329 L OQ	4329 O* OQ	Subtotal OQ
Flaked Stone																							
Bifaces, Uniface-B's, and Flake Blanks																							
Stage 1	-	-	-	-	-	3	7	-	12	6	1	-	2	1	32	5	69	-	1	3	-	2	6
Stage 2	7	3	-	-	11	24	24	6	86	50	8	2	6	2	103	7	339	43	21	19	2	15	100
Stage 3	2	-	1	-	4	15	3	1	13	6	-	-	2	-	5	1	53	23	2	27	2	6	60
Stage 4	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	2	-	-	1	-	-	1
Stage 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeterminate	-	-	-	-	-	-	-	1	-	-	-	-	2	-	2	-	5	2	-	-	1	1	4
Not Analyzed	2	-	-	-	-	-	-	-	1	3	-	-	-	-	3	-	9	-	2	-	-	-	2
Subtotal	11	3	1	-	15	43	34	8	113	65	9	2	12	3	145	13	477	68	26	50	5	24	173
Projectile Points and Biface/Points	-	-	1	-	1	-	-	-	1	-	-	-	-	-	-	1	4	2	-	-	-	A	2
Cores																							
Non-patterned	-	5	-	-	3	6	8	6	37	27	1	1	5	-	24	-	123	3	1	2	-	3	9
Unidirectional	-	1	-	-	1	12	9	4	44	33	-	-	1	-	12	1	118	1	3	1	-	3	8
Bidirectional	1	-	-	-	2	12	9	2	23	19	4	-	1	1	14	2	90	2	3	2	-	2	9
Bifacial	2	3	-	1	3	22	10	3	35	23	3	-	3	3	13	3	127	3	4	-	-	2	9
Other	-	-	-	-	-	5	1	-	6	4	2	1	-	1	18	1	39	-	-	1	-	4	5
Not Analyzed	-	-	-	-	-	2	-	-	81	84	-	-	-	-	1	-	168	-	-	-	2	-	2
Subtotal	3	9	-	1	9	59	37	15	226	190	10	2	10	5	82	7	665	9	11	6	2	14	42
Flake Tools	-	-	1	-	4	8	2	4	8	10	11	3	-	1	10	10	72	10	-	13	5	22	50
Unifaces	-	2	-	-	1	4	4	2	2	7	-	1	1	-	18	2	44	4	2	2	3	1	12
Formed Flake Tools	-	-	-	-	-	2	1	-	3	4	-	-	-	-	1	1	12	-	-	-	-	-	-
Drills	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Debitage (¼"/m³)	101	48	17	405	230	505	435	1095	565	408	93	NS	60	111	1011	84		138	NS	2346	498	740	
Ground and Battered Stone																							
Millingstones																							
Thin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-	5
Slab	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	6	1	-	-	-	7
Block	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Not Analyzed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Subtotal	2	-	-	-	A	-	-	1	-	-	-	-	-	-	-	-	3	10	3	-	-	-	13
Handstones																							
Bifacial	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Unifacial	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	2	-	-	-	-	A	-
Subtotal	-	-	-	1	A	-	1	1	-	-	-	-	-	-	-	-	3	-	-	-	-	A	-
Mortars	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pestles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Ground Stone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cobble-Core Tools	-	1	6	1	-	-	-	1	6	1	1	-	2	-	13	3	35	4	1	1	5	4	15
Anvils	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Materials																							
Features	-	-	3	-	A	-	-	-	1	1	-	-	-	-	1	-	6	-	-	-	-	-	-
Beads	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sherds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Incised Stone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Miscellaneous Stone	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	1	1
Modified Stone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pebble	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bone	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	1
Seeds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTE: * - dual period assignments (see Table 10); QL - lag quarry; OQ - Off-quarry; A - items assigned to Haiwee component; NS - no sample.

Table 21. Summary Metrics of Cores in Early Period Components.

	Lag Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Bifacial	127					9				
length	99	87	18	170	47	8	64	9	74	45
width	119	60	13	110	28	9	42	9	61	32
thickness	125	31	8	68	19	9	26	6	40	18
weight	93	142.9	106.4	976.7	22.9	8	68.2	32.4	144.4	40.9
edge angle	127	69	13	100	40	9	71	11	80	45
Bidirectional	90					9				
length	77	79	15	132	52	7	62	14	83	39
width	89	56	12	98	34	9	46	8	62	35
thickness	89	34	11	78	13	9	27	7	37	16
weight	77	151.0	117.4	686.0	41.4	7	87.1	38.0	155.4	44.6
edge angle	90	72	14	120	50	9	76	6	85	65
Non-patterned	123					9				
length	122	81	19	150	45	9	66	16	89	42
width	122	56	14	109	32	9	45	8	58	35
thickness	122	41	13	83	16	9	34	6	44	25
weight	119	188.5	173.5	1171.9	34.8	9	101.0	36.2	142.0	39.3
edge angle	123	76	13	110	40	9	80	19	110	50
Unidirectional	118					8				
length	12	80	15	133	43	5	63	7	74	55
width	9	57	12	100	26	5	53	7	62	44
thickness	110	33	9	68	17	7	28	8	42	14
weight	100	137.7	85.7	562.8	37.8	5	91.8	41.0	173.2	65.6
edge angle	118	68	14	105	40	8	61	16	80	40
Cobble and Chunk Test	39					5				
length	39	77	24	152	41	5	81	28	136	61
width	39	59	21	150	29	5	49	19	86	33
thickness	39	42	14	96	18	5	39	21	81	22
weight	38	218.4	326.5	2009.0	30.6	5	232.4	308.2	847.5	51.0
edge angle	39	79	15	115	45	5	71	7	80	60
Not analyzed	167					-				
Grand Total	664					42				

NOTE: length, width, thickness in mm; weight in grams.

Formed Flake Tools. Formed flake tools occur in very low frequencies at about one-third of the Early quarries (Table 20). This artifact type is, however, primarily restricted to Early period quarries. Of the 15 recovered from component areas, 12 were from Early lag quarries, and only three from later contexts. Averaging 61 x 50 x 16 mm, the formed flake tools at the Early lag quarries typically have modification along two or three steeply shaped edges (worked edge angles average 85.8°) and the majority (n=9) are whole. The shape of edges used shows little patterning, with a few examples of each with straight, convex, and concave-shaped worked edges.

Table 22. Summary Metrics of Bifaces, Uniface-B's and Flake Blanks in Early Period Components.

Lag Quarries

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
<u>Stage 1</u>	63					1					5				
length	49	78	16	133	50	1	85	-	-	-	5	81	17	106	63
width	61	52	9	75	36	1	57	-	-	-	5	58	15	86	42
thickness	63	25	6	44	14	1	28	-	-	-	5	25	4	30	20
weight	49	86.9	39.8	204.5	29.7	1	111.4	-	-	-	5	107.1	76.3	256.2	51.6
edge angle	63	62	14	90	40	1	75	-	-	-	5	52	8	60	40
<u>Stage 2</u>	265					59					15				
length	127	73	13	104	46	38	71	12	93	50	11	75	22	139	43
width	231	48	10	76	10	54	51	11	77	31	15	52	14	92	28
thickness	251	19	5	36	8	58	20	4	28	11	15	19	6	30	11
weight	124	64.2	28.5	174.1	15.5	38	64.8	27.9	132.8	16.8	12	69.5	80.7	329.3	12.5
edge angle	264	56	13	90	30	59	64	10	80	40	15	51	11	70	35
<u>Stage 3</u>	46					6					1				
length	20	83	21	146	53	3	63	14	81	47	1	90	-	-	-
width	44	45	12	76	28	6	53	8	63	40	1	57	-	-	-
thickness	45	15	7	32	5	6	15	3	20	12	1	19	-	-	-
weight	-	-	-	-	-	2	44.0	18.2	62.6	25.9	1	88.7	-	-	-
edge angle	46	45	10	70	25	6	56	11	70	40	1	40	-	-	-
<u>Stage 4</u>	2														
width	2	34	1	35	33										
thickness	2	11	2	12	9										
edge angle	2	40	-	40	40										
Other	3					-					2				
Not analyzed	7					2					-				
Grand Total	386					68					23				

Off-Quarry Contexts

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
<u>Stage 1</u>	6														
length	4	84	7	94	75										
width	5	40	10	49	21										
thickness	6	19	7	29	8										
weight	4	86.3	38.8	141.5	31.9										
edge angle	6	63	13	80	40										
<u>Stage 2</u>	84					13					3				
length	32	63	11	89	37	6	65	16	90	37	2	55	3	58	52
width	70	43	10	70	37	13	47	13	87	32	3	55	4	60	50
thickness	82	14	4	26	7	13	16	4	23	9	3	21	3	25	19
weight	29	39.7	20.0	101.0	16.1	5	51.7	23.9	97.1	30.4	2	41.7	0.9	42.6	40.7
edge angle	84	54	15	80	6	13	57	9	75	45	3	62	5	65	55
<u>Stage 3</u>	55					2					3				
length	6	53	8	61	38	-	-	-	-	-	2	57	5	62	52
width	46	40	10	59	16	2	41	3	43	38	3	31	2	33	29
thickness	55	9	3	23	4	2	8	1	8	7	3	7	1	7	6
weight	4	16.2	6.3	24.8	8.9	-	-	-	-	-	2	10.7	0.7	11.4	10.0
edge angle	55	36	7	55	25	2	33	3	35	30	3	30	-	30	30
<u>Stage 4</u>	1														
width	1	31	-	-	-										
thickness	1	9	-	-	-										
edge angle	1	25	-	-	-										
Other	4					-					-				
Not analyzed	2					-					-				
Grand Total	152					15					6				

NOTE: length, width, thickness in mm.; weight in grams.

Table 23. Summary Attributes of Bifaces in Early Period Components.

	Percent Whole							
	Stage 1	Stage 2	Stage 3	Stage 4	Indeterminate	All	N	Total
Lag Quarries	79.7	51.0	45.1	-	20.0	54.7	254	468
Off-Quarry Contexts	66.7	36.0	10.0	-	-	26.9	46	171

	Shape of Whole Bifaces							
	Triangular	Wide Shouldered	Rounded Elongate	Rectangular	Circular	Irregular	Total %	Total N
Lag Quarries	29.1	33.9	13.0	13.0	1.6	9.4	100.0	254
Off-Quarry Contexts	32.6	23.9	10.9	10.9	2.2	19.6	100.0	46

	Cause of Rejection							
	Human Error	Outrepasse	Structural Flaw	Cross-Section	Poor Planar Shape	Unknown	Total %	Total N
Lag Quarries	31.4	6.0	18.0	32.9	3.6	8.1	100.0	468
Off-Quarry Contexts	54.4	7.0	19.3	8.2	5.8	5.3	100.0	171

Simple Flake Tools. Simple flake tools were recovered from 75% of the Early lag quarries, but never in much abundance (Table 20). The majority (n=61, 84.7%) of simple flake tools at Early lag quarries are whole. They typically display modification along one or two edges that usually are straight (36.1%) or convex-shaped (40.3%). Their low frequency, the high percentage found whole, and the unimpressive degree of wear on them, combine to suggest that most are edge-damaged flakes rather than functional tools.

Table 24. Summary Metrics of Unifaces in Early Period Components.

	Lag Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
	44					12				
length	24	67	14	89	39	5	64	8	76	51
width	32	48	14	79	23	7	43	7	56	35
thickness	35	20	6	37	10	8	20	3	25	16
weight	24	69.0	47.3	198.0	13.1	5	50.0	8.2	55.9	34.1

NOTE: length, width, thickness in mm.; weight in grams.

Debitage. The intensity of stone tool manufacture varies greatly from one Early period lag quarry to the next, with minimal and maximal subsurface debitage densities of 17 and 1095/m^3 (CU-1/4"), respectively (Table 20). At all but one Early period lag quarry, core manufacturing debris is either equal to or more common than biface manufacturing debris. The degree to which core production prevails varies between component areas, but the combined average of core/flake debris and angular shatter accounts for 78.4% of the diagnostic percussion debitage (Table 25). Cortical flakes typically make up at least half of the diagnostic core-production debris, followed by simple interior flakes. The low frequency of complex and other interior percussion flake types signals minimal concern with dressing cores, and little intent to produce cores of much sophisticated form. The small amount of

Table 25. Debitage Summary Data for Early Period Components.

	Sample					% Biface	% Core	%	Biface Reduction			Core Reduction			
	Surf.	1/4"	1/8"	Total	% Diag.	Reduct.	Reduct.	Shatter	Early	Middle	Late	Cort.	S.Int.	C.Int.	Other
Lag Quarries															
1824 B	-	89	47	136	35.3	75.0	25.0	--	13.9	55.6	30.6	16.7	66.7	8.3	8.3
1984 C	-	43	22	65	38.5	8.0	60.0	32.0	50.0	50.0	--	40.0	60.0	--	--
1984 D	-	10	--	10	20.0	50.0	50.0	--	100.0	--	--	100.0	--	--	--
2103 H	-	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3004/5 I	-	15	201	216	18.5	30.0	42.5	27.5	8.3	66.7	25.0	58.8	29.4	11.8	--
3004/5 J	-	203	82	285	46.0	9.2	64.1	26.7	25.0	75.0	--	55.9	15.5	22.6	6.0
3299 A	-	469	119	588	72.3	2.6	40.5	56.9	45.5	36.4	18.2	56.4	34.9	7.6	1.2
3299 B	-	438	808	1246	59.1	6.4	71.2	22.4	55.3	36.2	8.5	71.5	19.1	9.2	0.2
3300 A	-	226	632	858	57.9	8.7	63.8	27.5	32.6	53.5	14.0	64.6	28.4	5.0	1.9
3300 B	-	167	99	266	48.2	3.1	58.6	38.3	50.0	50.0	--	46.7	44.0	5.3	4.0
4320 A	-	37	12	49	75.0	25.0	52.8	22.2	44.4	55.6	--	47.4	15.8	10.5	26.3
4320 B	-	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4320 C	-	12	1	13	100.0	23.1	30.8	46.1	33.3	--	66.7	25.0	25.0	25.0	25.0
4327 C	-	100	13	113	47.8	25.9	66.7	7.4	7.1	78.6	14.3	19.4	58.3	19.4	2.8
4329 G	-	810	530	1340	39.3	5.1	60.1	34.8	64.5	32.3	3.2	75.0	11.3	12.6	1.1
4331 B	-	83	15	98	36.7	30.6	58.3	11.1	18.2	27.3	54.5	61.9	28.6	--	9.5
Off-Quarry Contexts															
1984 B	-	352	84	436	49.8	46.5	47.0	6.4	12.9	43.6	43.6	21.6	36.3	19.6	22.5
4267 M	287	--	--	287	64.1	59.2	31.5	9.2	31.3	62.4	6.4	53.5	24.1	22.4	--
4324/H B	-	--	3313	3313	16.3	75.9	18.1	5.9	7.8	46.9	45.2	27.5	28.6	22.4	21.4
4329 L	-	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4329 O	-	1167	80	1247	41.9	73.8	21.2	5.0	14.5	72.3	13.2	64.8	19.8	12.6	2.7

NOTE: Surf. - surface; Diag. - diagnostic; Reduct. - reduction; Cort. - cortical; S.Int. - simple interior; C.Int. - complex interior.

biface manufacture that took place at Early period lag quarries typically represents earlier stages of manufacture. Late outnumber early and middle stage thinning flakes at only two component areas — both being areas with minimal debitage samples.

EARLY PERIOD OFF-QUARRY ASSEMBLAGES

Five Early period components are in off-quarry contexts (Table 20), and two of these contain a mixture of artifacts dating from other periods: Early and Early Newberry period materials are mixed together at INY-1984B, Early and Haiwee period chipped stone are mixed together at INY-4329O. In contrast to Early quarries, the flaked stone assemblage from off-quarry components is dominated by bifaces (62.0% including uniface-B's and flake blanks) followed distantly by flake tools and cores (17.9% and 15.0%, respectively, Table 20). Unifaces and point fragments are rare.

Bifaces. Bifaces were recovered from each of the five Early off-quarry components (Table 20). The cumulative biface assemblage is dominated by Stage 2 specimens (58.5%), but unlike the Early quarries, Stage 1 items are rare (3.5%), and Stage 3 items occur in significant quantities (35.1%). Comparatively few whole bifaces were discarded at secondary reduction locations (26.9%, Table 23), made up mostly of Stage 1s and 2s. Whole bifaces tend to be triangular (32.6%) or wide-shouldered shapes (23.9%, Table 23). Over half (54.4%) were discarded due to human error during manufacture, followed distantly by structural flaws (19.3%). Bifaces from secondary reduction locations are considerably smaller than their counterparts at lag quarries. Whole Stage 2 bifaces at the early lag deposits, for example, weigh on average 64.2 g, while ones in Early off-quarry contexts average 39.7 g (Table 22).

Projectile Points and Biface/Points. Projectile points and biface/point fragments are rare in Early period off-quarry components. INY-4329O produced a nearly complete Saratoga Spring point made of Coso obsidian (Plate 1q), clearly associated with later use of the site. Both biface/point fragments were found at INY-1984B: one is a cryptocrystalline distal tip weighing 8.3 g, showing a slight shoulder indicating it probably derived from a stemmed projectile point; the other is a medial fragment, weighing 4.0 g, of an apparent dart-sized obsidian point.

Unifaces. A few unifaces occurred in each Early off-quarry component (Table 20). These artifacts are similar in size to co-associated Stage 2 bifaces, averaging 64 x 43 x 20 mm, with an average weight of 50.0 g (Table 24). Some 42% of the unifaces are whole, presumably discarded due to an inability to effectively thin the base item.

Cores. Cores are much less abundant at Early period off-quarry components than at Early period quarries. However, the relative proportions of various core types is similar between the two contexts, with near equal amounts of bifacial, bidirectional, non-patterned and unidirectional cores found (Table 20). The majority (81.0%) were discarded whole. Cobble/chunk tests are the largest form, averaging 232.4 g; others are much smaller, averaging 68.2-101.0 g, depending on type (Table 21). The ones from off-quarry components are roughly half the weight of those at the Early period quarries (Table 21), and the more extensive reduction has altered them such that near equal amounts of triangular, rhomboidal, and rounded-elongate forms occur.

Simple Flake Tools. Simple flake tools are present at all but one of the Early off-quarry components. About two-thirds (n=34, 68.0%) of these are whole (Table 26). Typically they display one or two modified edges, most commonly straight (38.0%) or convex-shaped (36.0%).

Debitage. Debitage densities in Early period off-quarry component areas are about three times as high as at the quarries. Densities are, however, just as variable, ranging from 138 to 2346 pieces/m^3 (CU-1/4"; Table 20). Site INY-4324/H-B produced the extraordinarily high density; however, densities at the three other loci with subsurface samples are $\leq$ 740 pieces/m^3. In these contexts, biface production tends to be only slightly more prevalent than core reduction, accounting anywhere from 46.5% to 75.9% of the diagnostic percussion debris (Table 25). At two components, middle and late stage thinning flakes are equally represented, and at the other two, middle stage thinning flakes heavily dominate. Debitage from core production typically contains a fairly high amount of complex interior flakes (between 12.6-22.4% of the diagnostic debris), and in two locations, rectangular flakes are particularly abundant, constituting about 22% of the core-reduction debris. The high incidence of interior and rectangular percussion flakes suggests the occasional use of a fairly systematic (i.e., patterned) reduction strategy and a preference for linear flakes. In general, a variety of reduction strategies are represented in Early period off-quarry components, with biface and core-reduction activities well represented. Bifacial blanks and preforms were both produced with some frequency, while the cores imported from the lag quarries were worked into more patterned forms at contemporaneous off-quarry locations.

EARLY PERIOD DISCUSSION

Early period occupations occur primarily at lag quarries typically having low quantities of stone, which were worked in moderate levels. A wide assortment of artifacts types were made at these components, with about 50% cores and 38% bifaces, and small quantities of unifaces, flake tools, projectile points, and formed flake tools. Formed flake tools occur nearly exclusively in Early period lag quarries. Cores are of similar size regardless of form, and near equal quantities of bifacial, non-patterned, and unidirectional ones occur. Stage 2 forms dominate the bifaces (72%), with substantially fewer but near equal numbers of earlier and later stage items. Debitage reflects emphases on initial reduction, and core over biface manufacture. Of the few associated projectile points, two of the four are of non-local materials. A high percentage of the artifacts were discarded whole (86% cores, 85% flake tools, 80% unifaces, and 54% bifaces), in roughed-out forms judged unacceptable for one reason or another.

In moving to the Early period off-quarry components, reduction activities shift to an emphasis on bifaces. This is reflected in the artifact assemblages as well as the debitage samples. Bifaces account for 62.0% of the artifacts, with flake tools making a secondary contribution at 17.9%, and cores ranking third (15.0%). The majority of bifaces are blanks (Stage 2, 58.5%) followed by preforms (Stage 3, 35.1%), and the blanks average about half to two-thirds the size of their quarry counterparts. About 75% of the bifaces are fragmented, also reflective of their

Table 26. Summary Attributes of Simple Flake Tools at Off-Quarry Contexts by Period.

Period	Total	Number Whole	Number of Modified Edges	Average Number of Modified Edges
Early	50	34	70	1.4
Little Lake	4	2	5	1.3
Early Newberry	26	18	33	1.3
Middle Newberry	12	8	16	1.3
Late Newberry	79	48	123	1.6
Haiwee	11	6	16	1.5
Marana	5	2	6	1.2

Period	Modified Edge Shape						Total
	Straight	Convex	Concave	Spokeshave	Beaked	S-Shaped	
Early	19	18	6	2	1	4	50
Little Lake	1	2	-	-	-	1	4
Early Newberry	7	11	2	-	-	6	26
Middle Newberry	5	5	1	-	-	1	12
Late Newberry	32	25	9	4	6	3	79
Haiwee	6	3	-	-	2	-	11
Marana	1	1	2	-	-	1	5

Period	N	Average Metrics				
		Length	Width	Thickness	Weight	Edge Angle (°)
Early	34	52	39	10	23.6	35
Little Lake	2	53	33	5	7.1	28
Early Newberry	18	59	41	12	31.1	36
Middle Newberry	8	45	41	8	11.4	29
Late Newberry	48	50	39	9	24.6	31
Haiwee	6	54	39	7	12.3	40
Marana	2	58	39	8	16.6	37

Period	N	Average Length of Modified Edges by Shape					
		Straight	Convex	Concave	Spokeshave	Beaked	S-Shaped
Early	50	28	38	33	8	7	41
Little Lake	4	24	-	-	-	-	35
Early Newberry	26	39	42	43	-	-	49
Middle Newberry	12	22	44	-	-	-	42
Late Newberry	79	33	43	30	12	37	45
Haiwee	11	29	19	-	-	30	-
Marana	5	29	-	31	-	-	51

NOTE: Length, width, and thickness in mm.; weight in grams.

more advanced state of reduction. Cores are few in number, but like the quarries, near equal numbers of assorted types exist, and a high proportion (81%) were discarded whole. They are, however, smaller than those at quarries, at about half their weight. Debitage is also indicative of the cores more advanced state of reduction, with a definite preference shown for linear, blade-like flakes. High proportions of flake tools (68.0%) were discarded whole, showing no inclination to curate such tools in this obsidian rich zone. A few projectile points and unifaces complete the flaked stone assemblage.

LITTLE LAKE PERIOD QUARRY ASSEMBLAGES

Little Lake period component areas tend to occur at lag quarries (Table 27). Five Little Lake period lag quarries exist, of which three contain Early period materials intermixed. Their combined flaked stone assemblages contain a high proportion of cores (48.2%) and bifaces (43.3%, inclusive of uniface-B's and flake blanks), while flake tools, unifaces, and formed flake tools contribute no more than 5% each. Site INY-4319 yielded a more substantial assemblage than the other four locations, and in large part the following characterizations conform to this component.

Cores. Variable quantities of cores were recovered from each of the five components (Table 27). All core forms are well represented with bifacial and unidirectional cores slightly more numerous than bidirectional or non-patterned ones. Size differs little between these four forms, with the average weight of whole ones per class ranging from 153.0 to 189.8 g (Table 28). Cobble/chunk tests are, not surprisingly, much larger, averaging 610.2 g. Triangular and wide-shouldered shapes are most common, though other forms are well represented.

Bifaces. Bifaces are relatively common at four of the Little Lake quarries (Table 27). Most are Stage 2 (67.5%) followed by Stage 1 (21.5%), then Stage 3 (11.0%) forms. Slight reductions in all dimensions and edge angle acuteness track through the reduction stages. Stage 1s average 80 x 51 x 23 mm (80.8 g); Stage 2s 76 x 47 x 18 mm (63.8 g); and Stage 3s average 40 mm wide and 9 mm thick (Table 29). A high proportion are whole (Table 30), most frequent among Stage 1s (80.5%), declining to 45.5% among Stage 3s. Most whole bifaces are triangular (34.7%) or wide-shouldered (28.2%). The most common reason for discard is human error (31.7%) or poor cross-section (23.1%), though 25.6% displayed no apparent reason for discard (i.e., it was not obvious why reduction was discontinued on many of the whole ones).

Projectile Points and Biface/Points. Only one biface/point was found at one Little Lake quarry, a squared-off base of a large (11.3 g), broad-bladed (35 mm) pressure-worked fragment. Workmanship, robustness, and general shape suggest affinity with Paleoindian points. Hydration analysis recorded an immeasurably diffuse hydration band.

Unifaces. Only one of the five Little Lake lag quarries had a sizeable number of unifaces, and few were found at two others (Table 27). These items appear to be rejected, unifacially worked items intended as Stage 2 bifaces. All but one of the 20 unifaces are whole, and they generally match the size of co-associated Stage 2 uniface-B's (compare Tables 29 and 31): Stage 2 uniface-B's average 23 mm thick, unifaces average 25 mm thick. The high incidence of discarded whole unifaces, many with poor cross-sections, suggests that a formidable error prompted discard early in the manufacturing sequence.

Formed Flake Tools. The single obsidian formed flake tool from one Little Lake lag quarry is whole, measures 84 x 42 x 17 mm, and has a working edge angle of 86°. It has two convex-shaped working edges, each about 50 mm long.

Simple Flake Tools. Simple flake tools are present at three Little Lake quarries, but only in an appreciable number at one (Table 27). Nearly 95% are whole. Modified edges are primarily convex (77.8%), and typically only one edge per tool is modified. The low frequency of simple flake tools at Little Lake lag quarries, the high proportion found whole, and the minimal extent of edge attrition indicate that they are probably naturally damaged flakes.

Table 27. Assemblage Inventories in Little Lake Period Components.

	2103 H* QL	3299 A* QL	4319 QL	4320 C* QL	4322/H A QL	Subtotal QL	4325 A OQ	4330A OQ	Subtotal OQ
Flaked Stone									
Bifaces, Uniface-B's, and Flake Blanks									
Stage 1	-	7	30	2	4	43	-	1	1
Stage 2	-	24	102	6	3	135	2	31	33
Stage 3	-	3	15	2	2	22	3	9	12
Stage 4	-	-	-	-	-	-	-	-	-
Stage 5	-	-	-	-	-	-	-	-	-
Indeterminate	-	-	-	2	-	2	-	-	-
Subtotal	-	34	147	12	9	202	5	41	46
Projectile Points and Biface/Points	-	-	1	-	-	1	-	1	1
Cores									
Non-Patterned	-	8	17	5	4	34	-	1	1
Unidirectional	-	9	28	1	4	42	1	-	1
Bidirectional	-	9	18	1	4	32	-	2	2
Bifacial	1	10	21	3	8	43	-	1	1
Other	-	1	10	-	-	11	-	1	1
Not Analyzed	-	-	63	-	-	63	-	-	-
Subtotal	1	37	157	10	20	225	1	5	6
Flake Tools	-	2	15	-	1	18	-	4	4
Unifaces	-	4	15	1	-	20	1	1	2
Formed Flake Tools	-	1	-	-	-	1	-	-	-
Drills	-	-	-	-	-	-	-	-	-
Debitage (¼"/m^3)	405	435	111	60	34		20	239	
Ground and Battered Stone									
Millingstones									
Thin	-	-	-	-	-	-	-	-	-
Slab	-	-	5	-	-	5	A	-	-
Block	-	-	-	-	-	-	-	-	-
Subtotal	-	-	5	-	-	5	A	-	-
Handstones									
Bifacial	1	-	-	-	-	1	-	-	-
Unifacial	-	1	-	-	-	1	-	-	-
Subtotal	1	1	-	-	-	2	A	-	-
Mortars	-	-	-	-	-	-	-	-	-
Pestles	-	-	-	-	-	-	-	-	-
Misc. Ground Stone	-	-	-	-	-	-	-	-	-
Cobble-Core Tools	1	-	25	2	1	29	-	-	-
Anvils	-	-	-	-	-	-	-	-	-
Other Materials									
Features	-	-	-	-	-	-	-	1	1
Beads	-	-	-	-	-	-	-	-	-
Sherds	-	-	-	-	-	-	-	-	-
Incised Stone	-	-	-	-	-	-	-	-	-
Miscellaneous Stone	-	-	1	-	-	1	-	-	-
Modified Stone	-	-	-	-	-	-	-	-	-
Pebble	-	-	-	-	-	-	-	-	-
Bone	-	3	-	-	-	3	-	3	3
Seeds	-	-	-	-	-	-	-	-	-

NOTE: * - dual period assignments (see Table 10); QL - lag quarry; OQ - Off-quarry; A - one item each reassigned to Residual.

Table 28. Summary Metrics of Cores in Little Lake Period Components.

	Lag Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Bifacial	43					1				
length	35	90	19	164	61	-	-	-	-	-
width	43	60	13	99	28	1	57	-	-	-
thickness	42	32	7	60	23	1	23	-	-	-
weight	33	153.0	105.8	675.4	22.9	-	-	-	-	-
edge angle	43	76	12	100	50	1	65	-	-	-
Bidirectional	32					2				
length	30	82	17	114	57	2	85	1	86	84
width	32	59	12	105	44	2	61	-	61	61
thickness	32	33	11	67	18	2	31	1	31	30
weight	30	154.8	126.6	749.5	53.1	2	150.8	6.5	157.3	144.3
edge angle	32	75	16	105	55	2	83	3	85	80
Non-patterned	34					1				
length	32	87	23	158	52	-	-	-	-	-
width	33	58	12	95	35	-	-	-	-	-
thickness	33	40	10	70	27	1	17	-	-	-
weight	32	189.8	129.7	599.5	48.7	-	-	-	-	-
edge angle	34	83	15	110	50	1	85	-	-	-
Unidirectional	42					1				
length	38	86	22	153	51	-	-	-	-	-
width	41	59	14	100	31	1	88	-	-	-
thickness	41	33	9	68	18	1	25	-	-	-
weight	38	162.6	130.8	803.4	42.8	-	-	-	-	-
edge angle	42	75	13	105	40	1	60	-	-	-
Cobble and Chunk Test	11					1				
length	11	105	27	165	66	-	-	-	-	-
width	11	73	25	109	31	-	-	-	-	-
thickness	11	55	23	103	13	1	(33)	-	-	-
weight	10	610.2	560.3	1941.5	38.0	-	-	-	-	-
edge angle	11	89	15	110	70	1	100	-	-	-
Not analyzed	63					-				
Grand Total	225					6				

NOTE: length, width, thickness in mm.; weight in grams.

Debitage. Debitage densities suggest that comparatively little stone-tool reduction occurred at any Little Lake period lag quarry. Subsurface densities (CU-1/4") average only 209 pieces/m^3, and never exceed 435 pieces/m^3 (Table 27). Core reduction is the prevalent activity at each component, with core/flake debris and angular shatter combining to account for no less than 76.9% of the diagnostic percussion debris at each (Table 32). Where adequate samples were recovered, more than half of the core reduction flakes are cortical pieces, and complex and other interior flakes are minimally represented. Of the small quantity of biface reduction debris, decreasing quantities of early reduction flakes, middle stage thinning flakes, and late stage thinning flakes are present. Typically though, late stage thinning flakes still account for between 12.2-25.0% of the biface reduction debris, indicating all biface percussion reduction stages occurred.

Table 29. Summary Metrics of Bifaces, Uniface-B's and Flake Blanks in Little Lake Period Components.

Lag Quarries

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	39					4									
length	30	80	10	103	54	4	71	50	187	64					
width	36	51	8	68	38	4	56	7	66	46					
thickness	37	23	5	37	13	4	23	3	27	20					
weight	29	80.8	21.5	137.6	42.4	4	84.0	21.7	120.3	63.5					
edge angle	37	59	9	75	45	4	48	6	55	40					
Stage 2	105					23					7				
length	53	76	13	100	38	17	102	17	124	51	6	71	19	100	43
width	98	47	10	72	23	19	54	10	76	29	7	48	11	60	28
thickness	105	18	5	36	9	21	23	6	33	9	7	17	5	26	9
weight	55	63.8	29.8	133.4	18.0	17	91.1	45.1	196.4	18.0	6	55.2	43.7	143.7	12.5
edge angle	105	51	9	80	30	21	58	12	85	40	7	43	12	65	30
Stage 3	11					2					9				
length	1	71	-	-	-	1	83	-	-	-	8	72	11	90	54
width	11	40	9	54	28	2	59	10	68	49	9	42	12	57	16
thickness	11	9	1	12	7	2	17	3	20	14	9	14	3	19	9
weight	1	33.8	-	-	-	1	62.6	-	-	-	8	41.7	20.7	88.7	14.8
edge angle	11	33	3	40	30	2	43	3	45	40	9	38	3	45	35
Other	-					-					2				
Grand Total	155					29					18				

Off-Quarry Contexts

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	1														
width	1	71	-	-	-										
thickness	1	27	-	-	-										
edge angle	1	50	-	-	-										
Stage 2	31					1					1				
length	2	66	3	68	63	1	94	-	-	-	1	106	-	-	-
width	15	50	8	64	36	1	46	-	-	-	1	90	-	-	-
thickness	31	14	4	24	6	1	26	-	-	-	1	23	-	-	-
weight	2	70.2	2.3	72.4	67.9	1	97.8	-	-	-	1	173.7	-	-	-
edge angle	31	39	7	55	25	1	65	-	-	-	1	45	-	-	-
Stage 3	12														
width	7	41	10	60	31										
thickness	12	9	2	11	5										
edge angle	12	31	4	40	25										
Grand Total	44					1					1				

NOTE: length, width, thickness in mm.; weight in grams.

LITTLE LAKE PERIOD OFF-QUARRY ASSEMBLAGES

Only two Little Lake period off-quarry components were identified, and one of these (INY-4330A) produced nearly 90% of their combined flaked stone assemblage (Table 27). Bifaces strongly dominate (78.0%), followed distantly by cores (10.2%) and flake tools (6.8%).

Bifaces. Some 71.7% of the bifaces are Stage 2s, followed by 26.1% Stage 3s. Only one of the 46 bifaces is a Stage 1; only four are whole. Given the fragmented condition of bifaces found in these contexts, little can be inferred about their size or preferred morphologies. More than two-thirds of the bifaces were discarded due to human error during manufacture, followed distantly by structural flaws (19.6%; Table 30).

Table 30. Summary Attributes of Bifaces in Little Lake Period Components.

	Percent Whole							
	Stage 1	Stage 2	Stage 3	Stage 4	Indeterminate	All	N	Total
Lag Quarries	80.5	59.3	45.5	-	100.0	62.3	124	199
Off-Quarry Contexts	-	12.1	-	-	-	8.7	4	46

	Shape of Whole Bifaces							
	Triangular	Wide Shouldered	Rounded Elongate	Rectangular	Circular	Irregular	Total %	Total N
Lag Quarries	34.7	28.2	17.7	10.5	1.6	7.3	100.0	124
Off-Quarry Contexts	-	50.0	50.0	-	-	-	100.0	4

	Cause of Rejection							
	Human Error	Outrepasse	Structural Flaw	Cross-Section	Poor Planar Shape	Unknown	Total %	Total N
Lag Quarries	31.7	1.0	12.6	23.1	6.0	25.6	100.0	199
Off-Quarry Contexts	69.6	8.7	19.6	-	2.2	-	100.0	46

Projectile Points and Biface/Points. Only one biface/point fragment was found at one Little Lake off-quarry component. It is a distal tip too small (0.9 g) to determine whether it is part of a dart or arrow-sized point.

Unifaces. One uniface was recovered from each Little Lake off-quarry context. Their low frequency is consistent with the notion that they are early stage manufacturing rejects. The one uniface that was whole is comparable in weight to the one whole uniface-B from these two areas (95.0 g and 97.8 g, respectively, compare Tables 31 and 29).

Table 31. Summary Metrics of Unifaces in Little Lake Period Components.

	Lag Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
	20					2				
length	19	83	14	117	59	2	64	7	70	57
width	20	50	8	68	37	1	61	-	-	-
thickness	20	25	6	37	15	1	11	-	-	-
weight	19	93.3	38.6	185.7	43.6	1	95.0	-	-	-

NOTE: length, width, thickness in mm.; weight in grams.

Cores. The six cores recovered from the two component areas represent all types (Table 27). Most are fragmented, but the two whole ones are similar in size to their quarry counterparts (Table 28), suggesting they were discarded in much the same condition as they entered the site. In light of the quantity of cores produced at Little Lake period lag quarries, their absence in contemporaneous off-quarry contexts is particularly noteworthy, suggesting that many cores were transported outside of the Volcanic Field for consumption/use elsewhere.

Table 32. Debitage Summary Data for Little Lake Period Components.

	Sample					% Biface	% Core	%	Biface Reduction			Core Reduction			
	Surf.	1/4"	1/8"	Total	% Diag.	Reduct.	Reduct.	Shatter	Early	Middle	Late	Cort.	S.Int.	C.Int.	Other
Lag Quarries															
2103 H	-	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3299 A	-	469	119	588	72.3	2.6	40.5	56.9	45.5	36.4	18.2	56.4	34.9	7.6	1.2
4319 all	-	184	159	343	60.3	19.8	42.0	38.2	60.9	26.8	12.2	62.1	12.6	18.4	6.9
4320 C	-	12	1	13	100.0	23.1	30.8	46.1	33.3	–	66.7	25.0	25.0	25.0	25.0
4322/H A	-	62	33	95	35.8	11.8	32.3	55.9	50.0	25.0	25.0	81.9	18.2	–	–
Off-Quarry Contexts															
4325 A	-	–	20	20	5.0	100.0	–	–	100.0	–	–	–	–	–	–
4330 A	-	672	414	1086	33.3	90.4	6.6	3.0	15.9	37.3	46.8	62.5	12.5	8.3	16.7

NOTE: Surf. - surface; Diag. - diagnostic; Reduct. - reduction; Cort. - cortical; S.Int. - simple interior; C.Int. - complex interior.

Flake Tools. Only four flake tools were recovered from Little Lake period off-quarry components. The two whole ones average 53 x 33 x 5 mm (7.1 g; Table 26). Modified edge shape varies, with convex, straight, and s-shaped edges represented.

Debitage. Debitage densities were low at both Little Lake period off-quarry contexts, equaling 20 pieces/m^3 at one and 239/m^3 (CU-1/4") at the other. Only INY-4330A yielded a subsurface debitage sample large enough to warrant consideration, and here, 90.4% of the diagnostic pieces were from biface manufacture, with only 9.6% identified as core-reduction flakes or shatter (Table 32). Of the biface production debris, late stage thinning flakes are most abundant (46.8%), with decreasing quantities of middle (37.3%) and early stage (15.9%) thinning flakes recovered. While the proportions of bifaces by reduction stage indicate bifacial blank manufacture was prevalent, the debitage profile clearly indicates preform (Stage 3) manufacture was of greater incidence. Core reduction, whether measured by the number of cores or the relative proportion of core-reduction debitage, is poorly represented.

LITTLE LAKE PERIOD DISCUSSION

Patterns established in the Early period continue essentially unchanged through the Little Lake period. Occupations occur primarily at lag quarries; assorted core forms dominate their assemblages, followed by early stage bifaces; and high proportions of both are whole rejects. Debitage profiles are consistent with this emphasis on initial reduction of the lag cobbles into cores and Stage 1 and 2 bifaces. In moving to off-quarry contexts, reduction emphases shift to biface blank and preform manufacture. Small quantities of flake tools, unifaces, projectile points, biface/points, and formed flake tools occur intermittently at both the quarry and off-quarry components. Cores are noticeably absent in off-quarry contexts, and core-reduction debris is also poorly represented, indicating that most cores were carried out of the Volcanic Field in the form made at the quarries.

EARLY NEWBERRY PERIOD QUARRY ASSEMBLAGES

Of the seven Early Newberry components, four occur at lag quarries (Table 33). These four quarries generated a collection dominated by bifaces (53.0%), followed distantly by cores (18.1%), and flake tools (14.1%). Our characterization of Early Newberry quarries largely derives from materials at INY-3004/5A, which yielded 70.5% of the combined flaked stone artifact assemblage. The three other components offered comparatively meager assemblages.

Cores. Cores are surprisingly scarce at Early Newberry lag quarries, with only small quantities at each component (Table 33). Of the 27 cores, unidirectional and non-patterned forms co-dominate at 33.3% each.

Bifacial, bidirectional, and non-patterned forms are similar in size, averaging between about 160-170 g (Table 34), while unidirectional ones are narrower and thinner, and, therefore, considerably lighter, averaging 110.0 g. Unidirectional cores generally take rounded-elongate shapes, while non-patterned ones are irregularly shaped.

Table 33. Assemblage Inventories in Early Newberry Period Components.

	1824 Main A QL	3004/5 A QL	4327 A QL	4331 A QL	Subtotal QL	1824 Main Y OQ	1984 B* OQ	4329 K OQ	Subtotal OQ
Flaked Stone									
Bifaces, Uniface-B's, and Flake Blanks									
Stage 1	-	-	-	2	2	-	-	8	8
Stage 2	6	23	1	4	34	-	43	54	97
Stage 3	-	34	-	-	34	-	23	34	57
Stage 4	-	3	-	-	3	-	-	-	-
Stage 5	-	-	-	-	-	-	-	-	-
Indeterminate	1	-	-	-	1	-	2	22	24
Not Analyzed	1	4	-	-	5	-	-	1	1
Subtotal	8	64	1	6	79	-	68	119	187
Projectile Points and Biface/Points	-	7	-	-	7	-	2	3	5
Cores									
Non-Patterned	2	1	-	6	9	-	3	-	3
Unidirectional	2	6	1	-	9	-	1	1	2
Bidirectional	1	1	1	1	4	-	2	2	4
Bifacial	1	1	1	1	4	-	3	2	5
Other	-	1	-	-	1	-	-	6	6
Subtotal	6	10	3	8	27	-	9	11	20
Flake Tools	-	18	-	3	21	1	10	15	26
Unifaces	3	5	3	2	13	-	4	2	6
Formed Flake Tools	-	1	-	1	2	-	-	-	-
Drills	-	-	-	-	-	-	-	-	-
Debitage (¼"/m³)	135	540	23	45		NS	138	4129	
Ground and Battered Stone									
Millingstones									
Thin	-	4	-	-	4	-	4	1	5
Slab	-	2	-	-	2	-	6	-	6
Block	-	-	-	-	-	-	-	-	-
Subtotal	-	6	-	-	6	-	10	1	11
Handstones									
Bifacial	-	-	-	-	-	-	-	-	-
Unifacial	-	2	-	-	2	-	-	-	-
Subtotal	-	2	-	-	2	-	-	-	-
Mortars	-	-	-	-	-	-	-	-	-
Pestles	-	-	-	-	-	-	-	-	-
Miscellaneous Ground Stone	-	5	-	-	5	-	-	2	2
Cobble-Core Tools	5	2	2	-	9	-	4	8	12
Anvils	-	-	-	-	-	-	-	-	-
Other Materials									
Features	-	-	-	-	-	-	-	-	-
Beads	-	-	-	-	-	-	-	-	-
Sherds	-	-	-	-	-	-	-	-	-
Incised Stone	-	-	-	-	-	-	-	-	-
Miscellaneous Stone	-	9	-	-	9	-	-	-	-
Modified Stone	-	-	-	-	-	-	-	-	-
Pebble	-	-	-	-	-	-	-	-	-
Bone	-	-	-	-	-	-	1	2	3

NOTE: * - dual period assignments (see Table 10); QL - lag quarry; OQ - off-quarry; NS - no sample.

Table 34. Summary Metrics of Cores in Early Newberry Period Components.

	Lag Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Bifacial	4					5				
length	2	112	1	113	111	4	61	10	71	45
width	4	63	7	72	53	5	47	7	57	37
thickness	4	34	15	58	19	5	26	3	30	22
weight	1	168.7	-	-	-	4	65.7	15.9	89.6	49.7
edge angle	4	66	10	80	55	5	54	11	71	41
Bidirectional	4					4				
length	2	88	8	96	80	2	76	4	80	72
width	4	67	12	76	46	4	48	8	55	35
thickness	4	33	13	49	17	4	28	9	40	16
weight	2	158.6	24.8	183.3	133.8	1	83.6	-	-	-
edge angle	4	69	16	85	45	4	64	15	80	40
Non-patterned	9					3				
length	9	79	14	109	62	3	58	7	68	50
width	9	61	12	80	42	3	46	6	55	40
thickness	9	41	8	50	28	3	38	5	44	33
weight	8	172.4	51.7	178.3	114.2	3	102.7	28.1	142.0	78.2
edge angle	9	76	13	95	55	3	83	17	95	60
Unidirectional	9					2				
length	7	84	12	104	70	1	39	-	-	-
width	9	51	10	65	29	1	32	-	-	-
thickness	9	28	4	34	21	2	32	-	-	-
weight	7	110.0	45.9	180.5	45.0	1	46.2	-	-	-
edge angle	9	74	8	90	60	2	70	-	-	-
Cobble and Chunk Test	1					6				
length	1	88	-	-	-	5	73	13	93	55
width	1	65	-	-	-	5	60	15	88	44
thickness	11	51	-	-	-	6	36	9	48	21
weight	1	354.4	-	-	-	5	173.9	82.5	318.3	68.3
edge angle	1	95	-	-	-	6	64	5	70	55
Grand Total	27					20				

NOTE: length, width, thickness in mm.; weight in grams.

Bifaces. Bifaces occurred at each of the four components, and are especially numerous at INY-3004/5A (Table 33). Stage 2 and Stage 3 bifaces co-dominate at 46.0% each. It should be noted, however, that only Stage 1s and 2s occur at three component areas, and all Stage 3s occur at INY-3004/5A. As indicated in Table 35, size decreases as reduction stage increases, with whole Stage 2s averaging 79 x 42 x 15 mm (61.0 g), and Stage 3s 59 x 34 x 11 mm (22.1 g). Overall, 20.5% of the bifaces were discarded whole (Table 36), and of these, rounded-elongate (36.8%) and triangular shapes (21.1%) are most frequent. Discard of nearly two-thirds of the bifaces is ascribed to human error during manufacture.

Projectile Points and Biface/Points. The six projectile points and one biface/point recovered from Early Newberry lag quarries all came from INY-3004/5A. The points represent a variety of types, including one each Gypsum (Plate 6d), Elko (Plate 5n), Humboldt (Plate 3i), and Little Lake (Plate 6l); and two leaf-shaped (Plate

Table 35. Summary Metrics of Bifaces, Uniface-B's and Flake Blanks in Early Newberry Period Components.

Lag Quarries

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	2														
length	1	107	-	-	-										
width	2	58	6	63	52										
thickness	2	29	2	31	28										
weight	1	149.7	-	-	-										
edge angle	2	63	3	65	60										
Stage 2	29					4					1				
length	6	79	14	101	60	3	81	17	96	58	-	-	-	-	-
width	22	42	9	55	20	4	51	5	59	45	1	42	-	-	-
thickness	23	15	5	25	9	4	17	5	24	12	1	15	-	-	-
weight	6	61.0	26.0	111.1	34.7	3	79.8	40.5	134.3	37.3	-	-	-	-	-
edge angle	29	51	15	75	25	4	64	18	90	45	1	40	-	-	-
Stage 3	34														
length	10	59	15	94	40										
width	31	34	7	52	18										
thickness	33	11	3	18	6										
weight	8	22.1	7.5	38.2	14.2										
edge angle	34	42	14	75	35										
Stage 4	3														
length	1	55	-	-	-										
width	3	26	1	26	25										
thickness	3	10	1	11	8										
weight	1	12.4	-	-	-										
edge angle	3	50	12	65	35										
Other	1					-					-				
Not analyzed	4					1					-				
Grand Total	73					5					1				

Off-Quarry Contexts

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	5										3				
length	1	114	-	-	-						2	67	6	72	61
width	4	57	7	63	47						3	58	10	72	48
thickness	5	21	4	26	15						3	25	4	28	20
weight	1	157.2	-	-	-						3	88.0	38.7	141.7	51.8
edge angle	5	74	16	90	45						3	47	2	50	45
Stage 2	89					6					2				
length	20	66	13	89	37	3	56	14	72	37	2	74	4	78	70
width	62	49	12	80	31	6	49	17	87	34	2	47	12	59	35
thickness	76	14	4	28	8	6	17	3	23	13	2	15	4	19	11
weight	18	48.8	23.7	103.6	17.0	2	36.5	6.1	42.6	30.4	2	45.2	26.4	71.6	18.8
edge angle	89	53	13	80	30	6	53	7	65	45	2	35	5	40	30
Stage 3	54					2					1				
length	7	64	15	95	52	-	-	-	-	-	1	62	-	-	-
width	46	46	11	85	25	2	47	9	56	38	1	29	-	-	-
thickness	51	9	2	15	3	2	9	1	10	8	1	6	-	-	-
weight	6	27.4	13.5	54.9	14.9	-	-	-	-	-	1	11.4	-	-	-
edge angle	54	36	7	55	25	2	33	3	35	30	1	30	-	-	-
Other	24					-					-				
Not analyzed	-					-					1				
Grand Total	172					8					7				

NOTE: length, width, thickness in mm.; weight in grams.

Table 36. Summary Attributes of Bifaces in Early Newberry Period Components.

	Percent Whole							
	Stage 1	Stage 2	Stage 3	Stage 4	Indeterminate	All	N	Total
Lag Quarries	50.0	26.5	23.5	33.3	-	20.5	16	78
Off-Quarry Contexts	50.0	22.7	12.3	-	-	17.7	33	186

	Shape of Whole Bifaces							
	Triangular	Wide Shouldered	Rounded Elongate	Rectangular	Circular	Irregular	Total %	Total N
Lag Quarries	21.1	15.8	36.8	15.8	-	10.5	100.0	19
Off-Quarry Contexts	27.3	24.2	6.1	18.2	6.1	18.2	100.0	33

	Cause of Rejection							
	Human Error	Outrepasse	Structural Flaw	Cross-Section	Poor Planar Shape	Unknown	Total %	Total N
Lag Quarries	65.4	11.5	2.6	7.7	1.3	11.5	100.0	78
Off-Quarry Contexts	56.5	11.3	18.3	6.5	2.7	4.8	100.0	186

9h and 9i). Each is whole or nearly complete. The Elko was geochemically identified as an "unknown" obsidian; the rest have been ascribed to various Coso subgroups. Hydration rim values on the Coso specimens range from 7.9 to ~15.5 μ; however, rim values on five of the six items range from 7.9-9.7 μ, suggesting that the "unknown" might simply be made from an aberrant piece of Coso glass. The single biface/point fragment at 3.9 g, is a distal tip of a dart-sized point.

Unifaces. A few unifaces occurred at each Early Newberry period lag quarry (Table 33). They account for 8.7% of the cumulative flaked stone assemblage — the highest value they obtain in any period or context. Six of the 13 unifaces are whole. Averaging 59 x 44 x 18 mm (45.0 g. Table 37), they are intermediate in size to co-associated Stage 2 and 3 bifaces. They are also substantially smaller than the unifaces recovered from lag quarries used in other time periods. These factors combine to suggest that Early Newberry unifaces were functionally separate from the biface reduction trajectory.

Formed Flake Tools. One formed flake tool was found in each of two Early Newberry lag quarries (Table 33). Both are broken (18.5 g and 34.8 g), and have steep (85-90°) working edges. One has a single convex-shaped modified edge, the other has two straight worked edges.

Table 37. Summary Metrics of Unifaces in Early Newberry Period Components.

	Lag Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
	13					6				
length	6	59	10	74	42	2	58	7	64	51
width	8	44	10	60	31	3	46	9	56	35
thickness	10	18	6	29	10	4	19	3	23	16
weight	6	45.0	27.1	81.8	9.0	2	42.2	8.1	50.3	34.1

NOTE: length, width, thickness in mm.; weight in grams.

Simple Flake Tools. In contrast to earlier lag quarries, flake tools are well represented at Early Newberry lag quarries, and they also tend to be more extensively modified. The average number of worked edges per piece is two. Shaped margins are most commonly straight (33.3%), followed by convex (28.7%) and concave (23.8%). As in preceding periods, a very high proportion (81.0%) are whole. The high number of worked edges per tool and the diversity of their edge shapes suggest that edge attrition is quite likely the result of use-related damage. All but three were recovered from INY-3004/5A, which in combination with other characteristics suggest use more as a campsite than as a lag quarry.

Debitage. Debitage densities are quite low at three of the four Early Newberry lag quarry components ($\leq$ 135/m^3, CU-1/4"), suggesting that comparatively little stone-tool reduction occurred at these locations (Table 33). Core-reduction flakes and shatter strongly dominate the debitage samples at these three components, accounting for 81.4% or more of the diagnostic debris (Table 38), with cortical flakes and simple interior percussion flakes constituting half or more of the core-manufacturing debris. At the same three components, the less-well represented biface manufacturing debitage is dominated by early stage removals. The debitage profile at INY-3004/5A is distinct from the other three Early Newberry lag quarries. Over three-fourths (76.4%) of the diagnostic percussion debris here is from biface manufacture, and three-quarters of this is middle stage removals. While the debitage profile indicates Stage 2 bifacial blanks were predominately worked, Stage 3 bifaces (n=34) are half again as numerous as Stage 2s (n=23). In sum, discarded preform fragments are overly represented at this atypical component.

Table 38. Debitage Summary Data for Early Newberry Period Components.

	Sample					% Biface	% Core	%	Biface Reduction			Core Reduction			
	Surf.	1/4"	1/8"	Total	% Diag.	Reduct.	Reduct.	Shatter	Early	Middle	Late	Cort.	S.Int.	C.Int.	Other
Lag Quarries															
1824 Main A	-	95	86	181	48.6	9.1	71.6	19.3	97.5	12.5	--	55.6	19.0	20.6	4.8
3004/5 A	-	496	585	1081	20.8	76.4	18.7	4.9	15.7	75.0	9.3	50.0	33.3	2.4	14.3
4327 A	21	1	17	39	51.3	5.0	60.0	35.0	100.0	--	--	25.0	25.0	16.7	33.3
4331 A	-	100	9	109	84.4	18.5	78.2	3.2	53.0	41.2	5.9	58.3	29.2	9.7	2.8
Off-Quarry Contexts															
1824 Main Y	-	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1984 B	-	352	84	436	49.8	46.5	47.0	6.4	12.9	43.6	43.6	21.6	36.3	19.6	22.5
4329 K	-	--	1010	1013	19.1	85.6	8.2	6.2	19.3	40.4	40.4	43.8	37.5	18.8	0.0

NOTE: Surf. - surface; Diag. - diagnostic; Reduct. - reduction; Cort. - cortical; S.Int. - simple interior; C.Int. - complex interior.

EARLY NEWBERRY PERIOD OFF-QUARRY ASSEMBLAGES

The flaked stone assemblage from the three Early Newberry off-quarry components is strongly dominated by bifaces (76.6%), with substantially fewer flake tools (10.7%), and cores (8.2%; Table 33). One of these components contains a mixture of both Early Newberry and Early period material.

Bifaces. Robust samples of bifaces were recovered from two of the three Early Newberry period off-quarry components (Table 33). Stage 2 specimens dominate their cumulative assemblage (52.2%), followed by a substantial amount of Stage 3s (30.7%). The number of unclassifiable percussion worked biface fragments (i.e., small margin fragments) is, however, substantial, at 12.9%, indicating the highly fragmented condition of these bifaces. As elsewhere, size decreases as biface reduction stage increases (Table 35). The Stage 1 and 2 bifaces at the Early Newberry off-quarry components tend to be slightly smaller than those at the quarries, but the Stage 3 preforms are longer, wider, and thinner than those from Early Newberry period quarries, averaging 64 x 46 x 9 mm (27.4 g). Comparatively few bifaces (17.7%) were discarded whole at non-quarry components, and most of these are Stage 1s and 2s (Table 36). Manufacturing breaks are most frequently the reason for rejection (56.5%), followed by structural flaws (18.3%, Table 36). Triangular (27.3%) and wide-shouldered (20.2%) shapes are prevalent on the whole items, though rectangular and irregular shapes are well-represented (18.2% each), indicating little preference was given to particular morphologies.

Projectile Points and Biface/Points. All three projectile points in Early Newberry off-quarry components derive from INY-4329K, and are Thin Elko points: a whole one of cryptocrystalline material (Plate 5i), a whole one of Joshua Ridge glass (Plate 5k), and a proximal fragment made of West Cactus obsidian (Plate 5j). Both biface/points are from INY-1984B, an area identified as containing a mixture of both Early and Early Newberry period materials, and have been described above with the Early off-quarry assemblage.

Cores. A modest number of cores was recovered from two of the three Early Newberry off-quarry components, though all core forms are represented (Table 33). Surprisingly, cobble/chunk tests are more numerous than any other core type; all of these, however, derive from INY-4329K, which is contiguous to a lag quarry. Regardless of type, the cores from these contexts are about half the weight of their quarry counterparts (Table 34); yet about 70% are whole. Approximately one-third of the whole cores are blocky rectangular shapes, fewer are triangular, and wide-shouldered forms are rare.

Unifaces. The six unifaces recovered from two Early Newberry off-quarry components differ little from those found at the lag quarries, and presumably served the same function. They average 58 x 46 x 19 mm (42.2 g, Table 37), and two-thirds are whole.

Simple Flake Tools. Flake tools occurred at each of the three Early Newberry off-quarry components, cumulatively constituting 10.7% of their flaked stone assemblage (Table 33). Some 69.2% are whole, and typically one or two edges are modified per tool. They are large flakes (averaging 59 x 41 x 12 mm, 31.1 g), with fairly extensive portions of their edges modified. Convex (42.3%), straight (26.9%), and s-shaped (23.1%) used edges are all well represented, and use-wear commonly covers a 35-45 mm stretch of an edge (Table 26).

Debitage. Only two of the three Early Newberry off-quarry components produced subsurface debitage samples, and their characteristics are quite different from one another. Debitage occurs in very low densities at INY-1984B, recorded at 138 pieces/m^3, and about half results from biface manufacture, with half being core reduction debris or shatter. Among the biface reduction debitage, similar proportions of middle and late stage thinning flakes were recovered, with little indication of early stage removals (Table 38). Among the core reduction debitage, high proportions of all four major flake categories are represented: cortical, simple interior, complex interior, and rectangular interior flakes — indicative of a variety of core forms, some reduced to fairly advanced states. This site is immediately adjacent to a lag deposit, and the incidence of core-reduction debris at INY-1984B reflects quarrying of this nearby deposit.

Component INY-4329K yielded the highest debitage density of any off-quarry component, regardless of period, at 4129 pieces/m^3. Typical of off-quarry components, a very high proportion of the debitage (85.6%) is from biface manufacture. Among the biface reduction debris, similar high proportions of middle and late stage thinning flakes are represented (40.4% each), with less early stage reduction (19.3%). The small quantity of core-reduction debitage consists of high proportions of cortical and simple interior flakes, indicative of initial reduction.

EARLY NEWBERRY PERIOD DISCUSSION

Increasing disinterest in lag quarries and greater differentiation between site types denote subtle shifts in the land-use patterns from earlier periods. Fewer lag quarries exist than in earlier times, and three of the four studied have diminished flaked stone assemblages, containing fairly equal quantities of cores and bifaces. Their debitage profiles remain consistent with lag deposit quarrying, documenting an emphasis on initial reduction and core manufacture, and less biface manufacture, most of which is early stage reduction. The lag quarry with the richest assemblage, however, displays characteristics typical of earlier off-quarry occupations — i.e., quarrying activities are poorly represented. Bifaces overwhelmingly outnumber cores at this component, late staged bifaces are the single most numerous artifact type, and flake tools are well represented. The associated debitage reaffirms the prevalence of biface manufacture and low quantity of initial reduction at INY-3004/5A. Considering these four components together, fewer cores were manufactured at Early Newberry lag quarries compared to earlier lag quarries; nonetheless, they remain highly variable in form (though bifacial ones are less common) and comparable in size.

Off-quarry components also show some differentiation between them. Their assemblages are similar, being dominated by bifaces (mostly Stage 2s and very few Stage 1s), with cores slightly less common than flake tools. However, debitage profiles are dissimilar to one another: at one, core and biface manufacture are nearly equally represented; at the other, middle and late stage biface manufacture predominates.

Aside from these slight shifts, flaked stone patterns for the Early Newberry are similar to earlier periods: initial reduction tends to occur at lag quarries, shifting to an emphasis on biface manufacture at off-quarry contexts; the size of artifact types diminishes in shifting from the quarry to off-quarry contexts, and no particular morphology dominates core or biface forms. Further, there is no appreciable change in the size of artifact types from one period to the next, indicating that comparable lag deposits continued to be used to produce the same kinds of artifacts.

MIDDLE NEWBERRY PERIOD OFF-QUARRY ASSEMBLAGES

Only three Middle Newberry components were identified. Each corresponds to a different off-quarry portion of one site, INY-1824 Main. The flaked stone assemblage at each is dominated by bifaces, collectively accounting for 87.1% of all flaked stone tools (Table 39). A few flake tools occurred at each, and they account for 8.6% of the composite assemblage (Table 39). Only one or two cores, unifaces, and biface/points were recovered.

Bifaces. Each of the three components yielded a robust biface sample, but the profile of that sample differs between them. Stage 2s are dominant at one, Stage 3s are dominant at another, and nearly equal amounts of Stage 2s and 3s were recovered from the third. However, fragments of indeterminate stage account for 22.3%, indicative of the bifaces' highly fragmented condition. Only three of the 122 bifaces are whole (precluding meaningful size-estimates [Table 40]), the remainder consisting mostly of margin (57%) and end fragments (20%). Two of the whole ones are rectangular shaped and the third is wide-shouldered. Compared to earlier or later periods, the proportion broken and discarded due to human error is high, and the proportion discarded due to structural flaws is low (Table 41).

Projectile Points and Biface/Points. The single biface/point, from INY-1824 J, is a mid-section weighing 3.2 g, with a maximal width of 28 mm. Overall size indicates it likely is part of a dart-sized point.

Cores. Both cores in the Middle Newberry off-quarry assemblage are from the same component, and both are whole. One is unidirectionally flaked and measures 81 x 55 x 37 mm (108.6 g). The other is a cobble/chunk test measuring 70 x 59 x 21 mm (84.7 g).

Unifaces. Unifaces are as uncommon as cores, and both are from the same component (Table 39). One is a margin fragment; the other is whole, measuring 85 x 47 x 28 mm (89.8 g).

Simple Flake Tools. A few flake tools were found in each of the three components (Table 39). Two-thirds of the flake tools are whole, and edge modification occurs primarily on straight or convex-shaped edges (Table 26). By comparison to flake tools in off-quarry components dating to other periods, they tend to be small, but are otherwise undistinguished.

Debitage. Debitage densities range widely between these three loci, attaining minimal and maximal values of 283 to 1022 pieces/m^3 (CU-1/4", Table 39). Regardless of the varying intensity of stone working between areas, their debitage profiles are remarkably similar, with biface reduction accounting for 96-97% of the diagnostic percussion debris (Table 42). Middle stage thinning tends to be the best represented activity, accounting for 44-51% of the diagnostic biface percussion debris, with late stage thinning debris only slightly less abundant, contributing a remaining 30-47%. Overall debitage profiles are quite consistent with artifact assemblages, reflecting intermediate and late stage percussion biface working and little else.

Table 39. Assemblage Inventories in Middle Newberry Period Components.

	1824 Main J OQ	1824 Main K OQ	1824 Main M OQ	Total
Flaked Stone				
Bifaces, Uniface-B's and Flake Blanks				
Stage 1	2	-	-	2
Stage 2	29	15	4	48
Stage 3	21	14	9	44
Indeterminate	9	9	9	27
Not Analyzed	-	-	1	1
Subtotal	61	38	23	122
Projectile Points and Biface/Points	1	-	-	1
Cores				
Unidirectional	-	1	-	1
Other	-	1	-	1
Subtotal	-	2	-	2
Flake Tools	3	5	4	12
Unifaces	2	-	-	2
Debitage (1/4" m^3)	1022	283	616	
Ground and Battered Stone				
Handstones				
Unifacial	-	1	-	1
Subtotal	-	1	-	1
Other Materials				
Features	-	-	1	1
Seeds	-	-	55	55

NOTE: OQ - off-quarry.

MIDDLE NEWBERRY PERIOD DISCUSSION

The diminishing interest in lag quarry deposits that started in the Early Newberry period appears to have continued in the Middle Newberry period. Of the numerous quarries investigated, none was identified as a Middle Newberry period accumulation. Instead, several discrete flaked stone accumulations within a single off-quarry site document flaked stone reduction activities during this interval. Each of these components is quite similar to one another. Their assemblages are dominated by Stage 2 and/or 3 bifaces, of which nearly all broke during manufacture. Associated debitage is consistent with this near-exclusive focus on bifacial blank and preform manufacture.

LATE NEWBERRY PERIOD PRIMARY QUARRY ASSEMBLAGES

A major shift in toolstone procurement practices occurred in this period, with primary outcrops serving as quarries instead of lag deposits. Of the numerous lag quarries investigated, *none* was identified as Late Newberry

Table 40. Summary Metrics of Bifaces, Uniface-B's and Flake Blanks in Middle Newberry Period Components.

Off-Quarry Contexts

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	2														
edge angle	2	73	3	75	70										
Stage 2	46					1					1				
length	1	73	-	-	-	-	-	-	-	-	-	-	-	-	-
width	23	53	18	112	27	1	68	-	-	-	1	53	-	-	-
thickness	38	12	5	23	4	1	17	-	-	-	1	24	-	-	-
weight	1	84.0	-	-	-	-	-	-	-	-	-	-	-	-	-
edge angle	46	45	14	90	25	1	40	-	-	-	1	55	-	-	-
Stage 3	38					5					1				
length	1	67	-	-	-	-	-	-	-	-	1	55	-	-	-
width	26	45	10	64	22	1	45	-	-	-	1	30	-	-	-
thickness	37	8	2	14	5	5	10	3	14	7	1	14	-	-	-
weight	1	22.0	-	-	-	-	-	-	-	-	1	21.3	-	-	-
edge angle	38	36	7	55	25	5	33	5	40	25	1	60	-	-	-
Other	25					2					-				
Not analyzed	1					-					-				
Grand Total	112					8					2				

NOTE: length, width, and thickness in mm.; weight in grams.

Table 41. Summary Attributes of Bifaces in Middle Newberry Period Components.

	Percent Whole							
	Stage 1	Stage 2	Stage 3	Stage 4	Indeterminate	All	N	Total
Off-Quarry Contexts	-	2.1	4.5	-	-	2.5	3	121

	Shape of Whole Bifaces							
	Triangular	Wide Shouldered	Rounded Elongate	Rectangular	Circular	Irregular	Total %	Total N
Off-Quarry Contexts	-	33.3	-	66.7	-	-	100.0	3

	Cause of Rejection							
	Human Error	Outrepasse	Structural Flaw	Cross-Section	Poor Planar Shape	Unknown	Total %	Total N
Off-Quarry Contexts	79.3	6.6	12.4	0.8	0.8	-	100.0	121

Table 42. Debitage Summary Data for Middle Newberry Period Components.

	Sample								Biface Reduction			Core Reduction			
	Surf.	1/4"	1/8"	Total	% Diag.	% Biface Reduct.	% Core Reduct.	% Shatter	Early	Middle	Late	Cort.	S.Int.	C.Int.	Other
Off-Quarry Contexts															
1824 Main J	-	433	407	840	28.2	95.8	0.8	3.4	25.1	44.5	30.4	--	--	50.0	50.0
1824 Main K	-	149	--	149	34.2	96.0	3.9	--	8.1	51.0	40.8	50.0	50.0	--	--
1824 Main M	-	796	670	1466	26.9	97.0	2.0	1.0	7.3	45.3	47.4	12.5	12.5	37.5	37.5

NOTE: Surf. - surface; Diag. - diagnostic; Reduct. - reduction; Cort. - cortical; S.Int. - simple interior; C.Int. - complex interior.

in age; instead, two primary outcrops of Joshua Ridge glass were identified, both heavily exploited during the Late Newberry period. Cores dominate their combined assemblage (63.5%), followed by bifaces (34.0%), with two flake tools and two unifaces completing the flaked stone assemblage (Table 43).

Cores. Cores dominate the flaked stone assemblage at both Late Newberry primary quarries. Non-patterned and bifacially flaked forms are most abundant, accounting for 37.9% and 27.6%, respectively, with unidirectional and bidirectional forms contributing an additional 13.8% and 11.5% (Table 43). Roughly 60% of the cores are whole. Cobble/chunk tests are, not surprisingly, the largest of the forms, averaging 330.2 g, followed by non-pattered ones, averaging 238.9 g (Table 44). Prevalent shapes include blocky rectangular, triangular and wide-shouldered forms, which occur in near equal frequencies.

Bifaces. Bifaces occur at both primary quarries, but are particularly well represented at INY-2826C (Table 43). Most are Stage 2s (58.5%) followed by Stage 1s (26.4%). As indicated in Table 45, bifaces from these primary quarries are large, and size diminishes as reduction stage increases: Stage 1s average 101 x 65 x 25 mm (136.9 g); Stage 2s 96 x 56 x 21 mm (110.1 g). As a comparison of Tables 44 and 45 shows, Stage 1s are only slightly lighter weight than bifacial cores, yet dimensional relationships are similar, indicating that the former developed out of the latter: both bifacial cores and Stage 1 bifaces are about half again as long as they are wide, and width is about two and a half times greater than thickness. Only about one-fourth of the bifaces discarded at the Late Newberry primary quarries are whole (26.4%); and triangular and wide-shouldered forms predominate at 50.0% and 35.7%, respectively (Table 46). Human error during manufacture accounts for the discard of 62.3%, followed distantly by those with irregular cross-sections (13.2%, Table 46). Structural flaws account for only 11.3% of the discards, indicative of the high quality of obsidian at these outcrops, compared to lag deposits.

Unifaces and Flake Tools. Two unifaces were recovered at one primary quarry. Both are whole, but one is small at 41.3 g, while the other is comparable in size to the unidirectional cores, at 145.4 g (Table 47). One simple flake tool was found at each of the components; and they, too are whole. Each displays damage on a single margin: a notched or spokeshave-like edge on the heavier item weighing 147.7 g, and a convex-shaped edge on the other weighing 84.3 g. The few unifaces likely are aberrant unidirectional cores rather than a functionally distinct tool; the few flake tools, judging from their large size, probably are damaged flakes rather than tools.

Debitage. A high quantity of debitage occurred at one Late Newberry primary quarry (570/m^3), and an extraordinarily high quantity (4832/m^3) occurred at the other, indicating large volumes of stone were reduced. The debitage profiles are remarkably similar for the two components (Table 48), suggesting uniformity in the manner with which the quarries were exploited: about 75% of the diagnostic percussion debris is core reduction flakes or angular shatter, and 25% is from biface reduction. Of the core-reduction debris, cortical flakes are most abundant (about 50-60%), followed by high proportions of simple interior flakes (23-31%). The biface reduction debris consists of about 48% early, 35% middle, and 17% late stage thinning flakes. The debitage profiles are generally consistent with the co-associated artifact assemblages: initial reduction activities were dominant, and the resulting cores remained large; fewer bifaces were made than cores, and Stage 1 and 2 forms predominated.

LATE NEWBERRY PERIOD OFF-QUARRY ASSEMBLAGES

Late Newberry off-quarry components are prolific in the project area, and rarely occur at localities used earlier or later. Twenty of the 21 investigated contain *only* Late Newberry period materials; the exception, INY-3012C, contains a mixture of both Haiwee and Late Newberry period materials. Bifaces are plentiful in virtually each context, and account for 81.5% of the cumulative flaked stone assemblage from all such areas (Table 43). Flake tools make a distant secondary contribution, at 10.0% of the assemblage. No other flaked stone artifact type contributes more than 4.2% to the cumulative assemblage.

Table 43. Assemblage Inventories in Late Newberry Period Components.

	2826 C QP	4378 A QP	Subtotal QP	1816 A OQ	1824 Main D OQ	1824 Main F OQ	1824 Main Z OQ	1824-B OQ	1824-X OQ	1906 B OQ	1907 A OQ	1984 A OQ	2103 A OQ	2103 B OQ	2826 B OQ	3012 C* OQ	3012 D OQ	3012 E OQ	3456 A OQ	4243 A OQ	4243 C OQ	4244 OQ	4252 OQ	4267 N OQ	Subtotal OQ
Flaked Stone																									
Bifaces, Uniface-B's, and Flake Blanks																									
Stage 1	10	4	14	3	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	4	-	-	10
Stage 2	25	6	31	24	20	25	-	4	6	15	21	10	34	26	-	6	-	4	34	7	-	75	9	1	321
Stage 3	7	-	7	19	12	19	-	3	1	12	24	9	16	10	-	5	6	4	27	3	3	20	15	3	211
Stage 4	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	1	-	-	-	1	-	5
Stage 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeterminate	1	-	1	-	4	11	-	1	1	3	6	1	13	5	-	1	-	-	8	1	-	11	1	-	67
Not Analyzed	-	-	-	-	-	5	-	-	-	-	-	-	23	-	-	-	-	-	-	-	-	-	-	-	28
Subtotal	43	10	53	46	36	61	-	8	8	30	52	21	88	41	-	12	7	8	70	11	3	110	26	4	642
Projectile Points and Biface/Points	-	-	-	1	-	6	-	1	-	-	-	1	4	1	-	1	-	-	-	-	-	2	-	-	17
Cores																									
Non-Patterned	25	8	33	1	-	1	-	2	-	1	-	-	2	-	-	1	-	-	2	-	-	1	-	-	11
Unidirectional	4	8	12	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	3
Bidirectional	6	4	10	-	2	1	-	-	-	1	-	-	2	-	2	-	-	-	-	-	-	2	-	-	10
Bifacial	23	1	24	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	2	-	-	2	-	-	7
Other	1	7	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2
Not Analyzed	-	12	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal	59	40	99	2	2	2	-	2	-	2	-	-	6	-	5	1	-	-	6	-	-	5	-	-	33
Flake Tools	1	1	2	2	3	9	-	-	-	6	9	6	11	2	1	3	1	3	3	2	-	16	2	-	79
Unifaces	2	-	2	-	-	1	-	-	-	-	-	-	3	3	1	-	-	-	2	-	-	6	-	-	16
Formed Flake Tools	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drills	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Debitage (¼"/m³)	4832	570		490	1033	805	290	79	226	366	1534	318	537	780	97	333	965	379	690	433	260	1496	245	NS	
Ground and Battered Stone																									
Millingstones																									
Thin	-	-	-	-	-	1	-	-	-	-	-	-	3	1	-	4	-	-	-	-	-	-	-	-	9
Slab	-	-	-	-	-	-	-	-	-	-	1	2	1	-	-	2	-	-	3	-	-	-	-	-	9
Block	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	1	-	-	-	-	1	-	5
Indeterminate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Subtotal	-	-	-	-	-	1	-	-	-	-	1	2	4	3	-	7	1	1	3	-	-	-	1	-	24
Handstones																									
Bifacial	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	2	-	-	-	1	1	-	6
Unifacial	-	-	-	1	-	1	-	-	-	-	2	-	3	2	-	6	-	-	-	-	-	-	-	-	15
Subtotal	-	-	-	1	-	1	-	-	-	-	3	-	3	2	-	6	1	2	-	-	-	1	1	-	21
Mortars	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pestles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Ground Stone	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	10	1	-	-	-	-	-	-	-	14
Cobble-Core Tools	5	-	5	1	-	-	-	-	-	-	6	-	2	-	-	5	1	-	-	-	-	-	-	-	15
Anvils	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Abraders	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	3
Other Materials																									
Features	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Beads	-	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Sherds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Incised Stone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Miscellaneous Stone	-	-	-	1	-	-	-	-	-	-	3	-	-	-	-	-	1	-	-	-	-	-	-	-	5
Modified Stone	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Pebble	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bone	-	-	-	-	-	-	-	-	-	2	1	1	-	-	-	-	-	-	-	-	-	2	-	-	6

NOTE: * - Dual period assignments (see Table 10); QP - primary quarry; OQ - off-quarry; NS - no sample.

Table 44. Summary Metrics of Cores in Late Newberry Period Components.

	Primary Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Bifacial	24					7				
length	15	95	16	127	73	4	98	19	119	66
width	20	67	14	108	51	7	57	13	81	38
thickness	20	29	7	42	18	7	37	7	45	28
weight	15	166.6	61.3	276.6	66.2	4	232.2	132.9	445.2	79.7
edge angle	24	79	8	95	60	7	74	7	80	60
Bidirectional	10					10				
length	5	97	18	127	76	6	83	21	120	59
width	9	66	15	96	43	7	50	12	75	37
thickness	9	28	8	44	15	7	32	14	60	18
weight	4	152.8	60.8	253.2	93.4	5	134.0	107.6	327.7	35.1
edge angle	10	80	13	110	55	10	71	7	85	60
Non-patterned	33					11				
length	30	102	18	144	71	8	83	20	119	54
width	33	71	16	128	48	10	62	21	93	21
thickness	33	36	12	84	19	11	33	10	48	19
weight	27	238.9	102.8	509.7	73.6	8	215.8	171.3	553.3	62.2
edge angle	33	78	14	110	55	11	77	15	100	50
Unidirectional	12					3				
length	10	107	19	146	85	3	51	6	57	43
width	11	70	15	109	53	3	49	3	51	45
thickness	12	30	6	41	22	3	31	10	43	20
weight	9	190.2	54.7	280.0	115.4	3	78.9	27.9	114.3	46.3
edge angle	12	75	12	100	60	3	67	12	75	50
Cobble and Chunk Test	8					2				
length	7	84	22	121	63	2	76	8	84	68
width	8	64	19	99	31	2	65	2	67	63
thickness	8	48	21	93	31	2	48	5	52	43
weight	6	330.2	220.9	640.2	87.9	2	272.1	89.2	361.3	182.9
edge angle	8	78	19	105	55	2	93	3	95	90
Not analyzed	12					-				
Grand Total	99					33				

NOTE: length, width, thickness in mm.; weight in grams.

Bifaces. The impressive quantity of bifaces recovered from Late Newberry off-quarry components make them the "type" artifact for this period. Bifaces dominate the flaked stone assemblage at 19 of the 21 components, and are absent at only two (Table 43). Stage 2s are most numerous at the majority of the components, constituting 52.3% of the bifaces, overall. An additional one-third (34.4%) are Stage 3s, while 10.9% are too fragmented for classification, and Stage 1s account for merely 1.6%. Size and edge angle decrease as reduction stage increases, with Stage 1s averaging 93 x 52 x 21 mm (98.3 g), Stage 2s 74 x 47 x 13 mm (56.0 g), and Stage 3s 65 x 41 x 9 mm (17.8 g); and they are much smaller than their counterparts from contemporaneous primary quarries (Table 45). Only 9.0% of these bifaces were discarded whole (Table 46), but among these, triangular forms dominate at 41.8%, followed by wide-shouldered ones (21.8%), though a variety of other shapes are well represented. Two-thirds (66.5%) of the bifaces were discarded due to human error during manufacture, augmented by 10.6% outrepasse fractures, with structural flaws accounting for 14.9% of the remainder.

Table 45. Summary Metrics of Bifaces, Uniface-B's, and Flake Blanks in Late Newberry Period Components.

Primary Quarries

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	13					1									
length	5	101	21	135	73	-	-	-	-	-					
width	13	65	7	74	47	1	60	-	-	-					
thickness	13	25	5	35	17	1	21	-	-	-					
weight	5	136.9	61.4	242.3	64.7	-	-	-	-	-					
edge angle	13	59	10	75	45	1	60	-	-	-					
Stage 2	30					1									
length	8	96	9	118	86	1	133	-	-	-					
width	24	56	10	79	41	1	79	-	-	-					
thickness	30	21	6	37	11	1	26	-	-	-					
weight	8	110.1	33.5	187.6	62.0	1	230.0	-	-	-					
edge angle	30	53	12	75	35	1	35	-	-	-					
Stage 3	6					1									
width	5	46	6	54	39	1	50	-	-	-					
thickness	6	12	3	17	10	1	11	-	-	-					
edge angle	6	37	4	40	31	1	40	-	-	-					
Other	-					1									
Grand Total	49					4									

Off-Quarry Contexts

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	9					1									
length	2	93	26	118	67	-	-	-	-	-					
width	4	52	10	63	36	1	134	-	-	-					
thickness	8	21	4	27	14	1	27	-	-	-					
weight	2	98.3	60.7	159.0	37.6	-	-	-	-	-					
edge angle	8	59	16	90	40	1	60	-	-	-					
Stage 2	298					18					5				
length	24	74	17	103	41	3	89	6	98	84	5	60	13	78	41
width	174	47	14	98	17	14	56	18	92	28	5	48	17	70	26
thickness	273	13	4	26	5	18	16	5	30	90	5	18	5	24	9
weight	23	56.0	25.4	119.5	12.6	3	65.4	42.5	123.1	21.9	5	50.6	33.3	101.2	9.1
edge angle	298	46	11	80	30	18	46	8	60	30	5	49	7	60	40
Stage 3	182					12					17				
length	8	65	15	92	41	2	54	-	54	54	7	52	13	72	35
width	148	41	11	84	18	11	46	16	77	23	17	36	14	70	21
thickness	179	9	3	18	4	12	11	5	20	4	17	9	4	20	5
weight	9	17.8	5.5	28.4	9.1	2	26.9	9.7	36.6	17.2	8	12.3	8.9	34.2	5.0
edge angle	180	37	8	60	25	12	37	7	50	25	17	33	5	45	25
Stage 4	5														
length	2	65	7	71	58										
width	5	38	8	53	30										
thickness	5	7	3	11	3										
weight	2	29.5	5.3	34.8	24.3										
edge angle	5	31	5	40	25										
Other	60					5					2				
Not analyzed	28					-					-				
Grand Total	582					36					24				

NOTE: length, width, thickness in mm.; weight in grams.

Table 46. Summary Attributes of Bifaces in Late Newberry Period Components.

	Percent Whole							
	Stage 1	Stage 2	Stage 3	Stage 4	Indeterminate	All	N	Total
Primary Quarries	35.7	29.0	-	-	-	26.4	14	53
Off-Quarry Contexts	22.2	9.7	9.1	40.0	1.5	9.0	55	611

	Shape of Whole Bifaces							
	Triangular	Wide Shouldered	Rounded Elongate	Rectangular	Circular	Irregular	Total %	Total N
Primary Quarries	50.0	35.7	14.3	-	-	-	100.0	14
Off-Quarry Contexts	41.8	21.8	14.5	12.7	5.5	3.6	100.0	55

	Cause of Rejection							
	Human Error	Outrepasse	Structural Flaw	Cross-Section	Poor Planar Shape	Unknown	Total %	Total N
Primary Quarries	62.3	3.8	11.3	13.2	-	9.4	100.0	53
Off-Quarry Contexts	66.5	10.6	14.9	2.6	0.8	4.6	100.0	611

Projectile Points and Biface/Points. Eight of the 21 components contained a few projectile points and/or biface/point fragments (Table 43). Of the 11 points, six are Elkos (three Thin and three Thick variants), while the others include a Rose Spring, Gypsum, Little Lake, Great Basin Stemmed, and leaf-shaped forms (Table 49). The Gypsum and Little Lake points are both made of cryptocrystalline materials; the remainder are West Sugarloaf (n=7) or Sugarloaf (n=2) obsidian. Only two points are whole: one Elko and the Gypsum. Three of the six biface/point fragments are of sufficient size to infer they derive from dart-sized points, one other appears to be the distal tip of a drill, and the remaining two are too fragmented to determine if they derived from dart or arrow-sized implements (Table 49).

Unifaces. Only a few unifaces occurred at six of the Late Newberry off-quarry components (Table 43). Twelve of the 16 unifaces are fragmented; the few whole ones average 91.9 g, making them nearly twice the weight of associated Stage 2 and 3 bifaces (compare Tables 45 and 47). The highly fragmented condition of the unifaces, and their low frequency (2.0 % of the cumulative flaked stone assemblage) suggest that they represent uncommon, cast-off functional tools.

Table 47. Summary Metrics of Unifaces in Late Newberry Period Components.

	Primary Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
	2					16				
length	2	74	27	100	47	4	73	14	90	54
width	2	52	10	61	42	5	47	10	60	31
thickness	2	34	6	40	28	10	15	10	36	5
weight	2	93.3	52.1	145.4	41.3	4	91.9	54.4	171.3	33.0

NOTE: length, width, thickness in mm.; weight in grams.

Table 48. Debitage Summary Data for Late Newberry Period Components.

	Sample					% Biface	% Core	%	Biface Reduction			Core Reduction			
	Surf.	1/4"	1/8"	Total	% Diag.	Reduct.	Reduct.	Shatter	Early	Middle	Late	Cort.	S.Int.	C.Int.	Other
Primary Quarries															
2826 C	-	--	1966	1966	24.7	26.2	54.2	19.6	47.2	34.6	18.1	51.0	31.2	12.9	4.9
4378 A	-	784	315	1099	38.8	23.6	48.4	27.9	48.5	34.7	16.8	63.3	22.7	10.6	3.4
Off-Quarry Contexts															
1816 A	-	614	521	1135	32.0	92.0	6.6	1.4	7.2	70.4	22.5	33.3	33.3	12.5	20.8
1824 Main D	-	666	527	1193	25.8	89.0	7.8	3.2	12.4	71.5	16.1	25.0	33.3	29.2	12.5
1824 Main F	-	268	859	1127	28.1	91.8	6.6	1.6	15.1	52.9	32.0	28.6	33.3	23.8	14.3
1824 Main Z	-	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1824-B all	-	206	22	228	33.3	77.6	18.4	3.9	18.7	40.7	40.7	50.0	701	14.3	28.6
1824-X all	-	531	356	887	29.5	87.0	10.7	2.3	7.5	39.0	53.5	21.4	46.4	10.7	21.4
1906 B	-	605	848	1453	26.3	92.4	5.0	2.6	16.7	43.9	39.4	31.6	31.6	10.5	26.3
1907 A	-	--	1211	1211	21.8	97.3	0.7	1.9	3.5	27.2	69.3	--	--	50.0	50.0
1984 A	-	684	133	817	40.9	89.2	8.7	2.1	6.3	48.7	45.0	6.8	44.8	13.8	34.5
2103 A	-	525	743	1268	26.5	95.2	2.1	2.7	10.0	42.8	47.2	--	42.9	14.3	42.9
2103 B	-	765	322	1087	33.4	94.8	4.1	1.1	16.5	48.3	35.2	43.5	26.1	17.4	13.0
2826 B	-	215	43	258	41.9	15.7	73.1	11.1	41.1	58.8	--	63.3	21.5	11.4	3.8
3012 C	-	276	--	276	37.7	83.6	12.5	3.8	--	32.2	67.8	30.8	23.1	38.5	7.7
3012 D	-	193	--	193	28.5	96.4	--	3.6	5.7	73.6	20.8	--	--	--	--
3012 E	-	328	--	328	45.1	99.3	0.7	--	2.1	40.8	57.1	--	100.0	--	--
3456 A	-	--	1059	1059	14.6	88.4	4.5	7.1	10.2	48.2	41.6	14.3	14.3	14.3	57.1
4243 A	-	175	70	245	17.6	81.2	12.5	6.2	15.4	61.5	23.1	66.7	33.7	--	--
4243 C	-	78	13	91	20.9	78.9	15.8	5.3	6.7	20.0	73.3	33.3	33.3	--	33.3
4244 all	-	--	2341	2341	81.6	93.2	6.8	--	9.0	41.0	50.0	30.8	53.8	--	15.4
4252 all	-	389	408	797	25.1	95.5	2.5	2.0	7.8	30.9	61.3	60.0	--	--	40.0
4267 N	45	--	--	45	62.2	96.4	3.6	--	22.2	74.1	3.7	100.0	--	--	--

NOTE: Surf. - surface; Diag. - diagnostic; Reduct. - reduction; Cort. - cortical; S.Int. - simple interior; C.Int. - complex interior.

Cores. A few cores occurred at about half of the Late Newberry off-quarry components (Table 43). In spite of the low number, all core forms are represented, with non-patterned and bidirectional ones co-dominating (33.3% and 30.3%, respectively). Two-thirds of the cores (66.7%) were discarded whole — a proportion slightly higher than occurred at the primary quarries. In general, they are only slightly smaller (i.e., lighter) than comparable items at the primary quarries (Table 44), suggesting that the few at off-quarry localities were discarded in much the same form as they entered the site.

Table 49. Projectile Points and Biface/Points from Late Newberry Off-Quarry Components.

	Component								
	1816 A	1824 Main F	1824-B	1984 A	2103 A	2103 B	3012 C	4244	Total
Rose Spring	--	--	--	--	--	--	1	--	1
Gypsum	--	--	--	--	1	--	--	--	1
Elko	1	3	--	--	--	--	--	2	6
Little Lake	--	--	--	--	1	--	--	--	1
Great Basin Stemmed	--	--	--	1	--	--	--	--	1
Leaf Shaped	--	1	--	--	--	--	--	--	1
Dart-sized	--	--	1	--	1	1	--	--	3
Drill	--	1	--	--	--	--	--	--	1
Indeterminate	--	1	--	--	1	--	--	--	2
Total	1	6	1	1	4	1	1	2	17

Simple Flake Tools. A small quantity of flake tools occur in the majority (76.2%) of the Late Newberry off-quarry components (Table 43), and they are the second most-numerous artifact in the composite assemblage. Over half (60.8%) of the 79 implements are whole. Usually two or one modified edge exists per tool, and that edge has microchipping extending, on average, along 33 mm of a straight edge, or along 43 mm of a convex-shaped edge (Table 26). In comparison to those in earlier or later components, these flake tools are more extensively modified, as indicated by the average number of worked edges per tool.

Drill. Only one drill was found within a component area, and that item is from INY-2103A. It is an 8.0 mm thick percussion flake that was bifacially pressure flaked along two parallel margins. Portions of the drill tip and proximal end have broken by snap fracture. Maximal dimensions of the fragment are 38 x 31 mm, with the bi-convex bit measuring 15 x 11 x 7 mm.

Debitage. Debitage densities vary considerably from one component to the next, but generally are moderate to high, ranging from 100-500 pieces/m^3 at half of the components, between 500-100/m^3 at five, and in excess of 1000/m^3 at three (Table 43). Biface reduction is the near exclusive activity represented at all but one of these components. The debitage profile at INY-2826B is atypical from all other Late Newberry off-quarry components, with 84.3% of the diagnostic percussion debitage identified as core production debris or shatter. This site, however, is within 30 m of a primary quarry, and the debitage is reflective of this. Excluding this one component, biface reduction debris accounts on average for 90.4% of the diagnostic percussion debris at the Late Newberry off-quarry components, and never less than 77.6% (Table 48).

Debitage profiles at these components readily separate into two groups: those where early through late stage thinning activities are fairly well represented (n= 9), and those where either middle *or* late stage thinning debris predominates (n=10). At five components in this latter group, middle stage thinning debris constitutes anywhere between 61.5-74.1% of the bifacing debitage; while at the other five, late stage thinning flakes account for 57.1-73.3% of the bifacing debitage. The repeated occurrence of locations with high quantities of debitage from narrowly focused reduction activities is without precedent in earlier periods, and is indicative of a different, more highly structured, organizational strategy than was applied earlier. The reduction sequence was being segmented, and different segments were occurring at different locations. Debitage profiles clearly show this spatial differentiation in biface reduction activities; however, the biface samples do not, since Stage 2 bifaces are most common in nearly every context. This reconfirms the notion that debitage profiles are more reliable indicators of on-site reduction activities than artifact assemblage composition.

LATE NEWBERRY PERIOD DISCUSSION

By the Late Newberry period, quarrying has shifted to primary outcrops, where large volumes of obsidian were reduced, lag quarries having fallen completely into disuse. Items manufactured at the quarries are primarily non-patterned cores, bifacial cores, and triangular biface blanks, and items made at these outcrops are generally bigger than those from lag quarries. In contrast to earlier lag quarries, flake tools and unifaces are extremely rare, further reflective of a narrowing in product manufacture and seemingly an exclusive preoccupation with quarrying. Concomitant with this shift to primary outcrops, the number of off-quarry, secondary reduction, components rises dramatically, further documenting the increased magnitude of stone tool manufacture. Reduction activities in off-quarry contexts are increasingly restricted to bifacial blank and preform manufacture, frequently undertaken at separate locations, indicating a more highly organized technological strategy than was practiced earlier. The plethora of these off-quarry biface manufacturing stations is reflected in Figure 17, accounting for the dramatic bulge in the Coso cumulative hydration curve between 2300-1275 B.P.

HAIWEE PERIOD PRIMARY QUARRY ASSEMBLAGES

Of the eight Haiwee period components, one occurs at a primary quarry, two at lag quarries, and five in off-quarry locations (Table 50). The flaked stone assemblage at the single primary quarry is dominated by cores (77.2%), followed distantly by bifaces (21.8%). A single flake tool completes the assemblage; no projectile points or unifaces were recovered.

Table 50. Assemblage Inventories in Haiwee Period Components.

	4378 B QP	3004/5 I* QL	4322/H C QL	Subtotal QL	3012 C* OQ	4239 A OQ	4240 OQ	4325 B OQ	4329 O* OQ	Subtotal OQ
Flaked Stone										
Bifaces, Uniface-B's, and Flake Blanks										
Stage 1	5	-	-	-	-	1	-	-	A	1
Stage 2	17	A	1	1	6	7	3	-	A	16
Stage 3	-	A	-	-	5	48	-	-	A	53
Stage 4	-	-	-	-	-	7	-	-	-	7
Indeterminate	-	-	-	-	1	-	-	-	A	1
Subtotal	22	A	1	1	12	63	3	-	A	78
Projectile Points and Biface/Points	-	A	-	-	1	3	-	-	1	5
Cores										
Non-Patterned	15	A	-	-	1	-	-	-	A	1
Unidirectional	6	A	2	2	-	-	-	-	A	-
Bidirectional	6	A	1	1	-	-	-	-	A	-
Bifacial	2	A	1	1	-	-	-	-	A	-
Other	20	-	-	-	-	1	-	-	A	1
Not Analyzed	29	-	-	-	-	-	-	-	-	-
Subtotal	78	A	4	4	1	1	-	-	A	2
Flake Tools	1	A	6	6	3	6	2	-	A	11
Unifaces	-	A	-	-	-	6	1	-	A	7
Debitage (¼"/m³)	932	A	2047		333	1698	273	57	A	
Ground and Battered Stone										
Millingstones										
Thin	-	1	-	1	4	-	-	-	-	4
Slab	-	9	-	9	2	-	-	-	-	2
Block	-	2	-	2	-	-	-	-	-	-
Indeterminate	-	-	-	-	1	-	-	-	-	1
Subtotal	-	12	-	12	7	-	-	-	-	7
Handstones										
Bifacial	-	1	-	1	-	-	-	-	-	-
Unifacial	-	-	-	-	6	-	-	-	1	7
Subtotal	-	1	-	1	6	-	-	-	1	7
Misc. Ground Stone	-	-	-	-	10	-	-	-	-	10
Cobble-Core Tools	1	-	-	-	5	-	1	-	4	10
Anvils	-	1	-	1	-	-	-	-	-	-
Abraders	-	-	-	-	2	-	-	-	-	2
Other Materials										
Features	-	1	-	1	-	-	-	2	-	2
Miscellaneous Stone	-	-	-	-	-	-	-	-	1	1

NOTE: * - Dual period assignments (see Table 10); QP - primary quarry; QL - lag quarry; OQ - off-quarry; A - items assigned to Early Component.

Cores. Most cores at the Haiwee primary quarry are cobble/chunk tests and non-patterned, with comparatively few examples of other forms (Table 50). As average weight indicates, the cores tend to be large, often weighing between ¼ to ½ kg (Table 51), averaging much larger than ones in pre-Haiwee period quarries.

Table 51. Summary Metrics of Cores in Haiwee Period Components.

	Primary Quarries					Lag Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Bifacial	2					1									
length	1	112	-	-	-	1	111	-	-	-					
width	2	67	15	82	52	1	50	-	-	-					
thickness	2	50	15	55	25	1	32	-	-	-					
weight	1	383.6	-	-	-	1	180.7	-	-	-					
edge angle	2	95	5	100	90	1	60	-	-	-					
Bidirectional	6					1									
length	5	94	19	123	63	1	74	-	-	-					
width	6	74	11	86	57	1	58	-	-	-					
thickness	6	41	14	72	32	1	22	-	-	-					
weight	4	216.9	169.3	460.6	22.5	1	89.5	-	-	-					
edge angle	6	84	15	105	65	1	75	-	-	-					
Non-Patterned	15										1				
length	15	113	26	190	86						1	70	-	-	-
width	15	77	12	107	59						1	50	-	-	-
thickness	14	42	8	55	29						1	39	-	-	-
weight	14	355.2	264.6	1282.0	189.4						1	146.6	-	-	-
edge angle	15	82	16	16	110						1	90	-	-	-
Unidirectional	6					2									
length	2	117	11	128	106	2	80	2	82	78					
width	3	79	3	83	76	2	48	10	58	38					
thickness	5	35	10	44	20	2	35	4	39	31					
weight	2	283.4	22.8	306.1	260.6	2	135.6	52.1	187.7	83.4					
edge angle	6	81	12	100	65	2	73	3	75	70					
Cobble and Chunk Test	20										1				
length	20	102	19	140	70						1	89	-	-	-
width	20	79	15	111	46						1	56	-	-	-
thickness	20	59	16	93	39						1	44	-	-	-
weight	20	491.3	312.8	1241.8	160.8						1	244.0	-	-	-
edge angle	20	91	14	110	65						1	85	-	-	-
Not analyzed	29					-					-				
Grand Total	78					4					2				

NOTE: length, width, thickness in mm.; weight in grams.

Some 83.7% are whole, and planar shapes are generally blocky rectangular, rhomboidal, and triangular. Form and size indicate they generally received minimal reduction; however, debitage presents a slightly different picture.

Bifaces. Bifaces at the Haiwee period primary quarry are Stage 2s (77.3%), or Stage 1s (22.7%). Bifaces, like the cores, are extremely large, with whole ones averaging nearly 200 g (Table 52), regardless of reduction stage, making them nearly three times as heavy as bifaces at earlier lag quarries, and more than half again the weight of those from Late Newberry primary quarries. About 40% of the bifaces are whole, being more prevalent among discarded Stage 1s than Stage 2s (Table 53). Half of the whole bifaces are wide-shouldered forms, and fewer are rounded-elongate, triangular, or irregular. Human error during manufacture is the most common reason for discard (31.8%) followed by structural flaws in the stone (22.7%).

Simple Flake Tools. The single flake tool is 91 x 70 x 32 mm (149.3 g), and displays two unifacially microchipped straight edges.

Debitage. Debitage occurs in high densities at this primary quarry, recorded at 932 pieces/m^3. About 85% of the diagnostic debitage is core reduction debris or shatter, with only 14.4% attributed to biface manufacture (Table 54). Core reduction debitage consists of 34.7% cortical flakes, 37.1% simple interior flakes and 23.5%

Table 52. Summary Metrics of Bifaces, Uniface-B's, and Flake Blanks in Haiwee Period Components.

Primary Quarries

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	3										2				
length	2	92	9	101	83						1	117	-	-	-
width	3	68	6	72	59						2	73	6	78	67
thickness	3	36	2	39	34						2	22	2	24	20
weight	2	198.9	50.7	249.7	148.2						1	150.2	-	-	-
edge angle	3	48	6	55	40						2	53	3	55	50
Stage 2	15					2									
length	6	107	18	129	84	1	97	-	-	-					
width	11	66	12	79	43	2	54	4	58	50					
thickness	15	26	7	40	15	2	18	2	20	16					
weight	5	195.7	82.1	314.8	93.9	1	124.4	-	-	-					
edge angle	15	51	15	75	25	2	55	5	60	50					
Grand Total	18					2					2				

Off-Quarry Contexts

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 1	1														
thickness	1	17	-	-	-										
edge angle	1	35	-	-	-										
Stage 2	16														
length	1	70	-	-	-										
width	8	45	11	62	29										
thickness	16	15	7	39	8										
weight	1	37.5	-	-	-										
edge angle	16	47	9	60	30										
Stage 3	49					1					3				
length	2	47	6	52	41	-	-	-	-	-	3	48	3	51	45
width	17	37	10	61	18	1	50	-	-	-	3	30	2	33	28
thickness	49	8	3	19	4	1	12	-	-	-	3	6	1	6	5
weight	2	11.3	2.2	13.4	9.1	-	-	-	-	-	3	8.5	1.3	10.4	7.6
edge angle	49	34	6	50	25	1	40	-	-	-	3	27	2	30	25
Stage 4	7														
width	3	31	5	37	26										
thickness	7	7	2	10	5										
edge angle	7	33	4	40	30										
Other	1					-					-				
Grand Total	74					1					3				

NOTE: length, width, thickness in mm.; weight in grams.

complex interior flakes. The relatively high proportion of complex interior flakes suggests greater concern for core shape than is indicated by the size and shape of the cores. The small amount of biface production debris represents all stages of manufacture, with middle stage thinning flakes most abundant (46.7%), and early (28.9%) slightly outnumbering late stage thinning flakes (24.4%). This, too, is at odds with the artifact assemblage, since no Stage 3 bifaces were recovered.

HAIWEE PERIOD LAG QUARRY ASSEMBLAGES

Two Haiwee period components were identified at lag quarry deposits (Table 50), but hydration data indicate that the flaked stone assemblage at only one (INY-4322/H-C) actually dates to the Haiwee period. This component is a small (5 m in diameter) chipping station within a lag deposit. Only flaked stone occurred here, and the assemblage was limited to one biface, four cores, six flake tools, and a high density debitage concentration.

Table 53. Summary Attributes of Bifaces in Haiwee Period Components.

	Percent Whole							
	Stage 1	Stage 2	Stage 3	Stage 4	Indeterminate	All	N	Total
Primary Quarries	60.0	35.3	-	-	-	40.9	9	22
Lag Quarries	-	-	-	-	-	-	-	1
Off-Quarry Contexts	-	6.3	9.4	-	-	7.7	6	78

	Shape of Whole Bifaces							
	Triangular	Wide Shouldered	Rounded Elongate	Rectangular	Circular	Irregular	Total %	Total N
Primary Quarries	12.5	50.0	25.0	-	-	12.5	100.0	8
Lag Quarries	-	-	-	-	-	-	-	-
Off-Quarry Contexts	33.3	33.3	33.3	-	-	-	100.0	6

	Cause of Rejection							
	Human Error	Outrepasse	Structural Flaw	Cross-Section	Poor Planar Shape	Unknown	Total %	Total N
Primary Quarries	31.8	9.1	22.7	13.6	9.1	13.6	100.0	22
Lag Quarries	100.0	-	-	-	-	-	100.0	1
Off-Quarry Contexts	59.0	15.4	16.7	1.3	-	7.7	100.0	78

Artifacts. The biface is a Stage 2 end fragment. The four cores include two unidirectional and single bifacial and bidirectional specimens. Each is whole, and they tend to be small, individually weighing between 83.4-187.7 g (Table 51). Two are wide-shouldered in plan-view, one is rhomboidal, and one blocky rectangular. Four of six flake tools are whole and quite large, averaging 63 x 42 x 15 mm (55.6 g). Of the modified edges, six are convex-shaped and two straight. Modification extends an average of 47 mm along the convex edges, but only 19 mm along straight edges.

Table 54. Debitage Summary Data for Haiwee Period Components.

	Sample					% Biface	% Core	%	Biface Reduction			Core Reduction			
	Surf.	1/4"	1/8"	Total	% Diag.	Reduct.	Reduct.	Shatter	Early	Middle	Late	Cort.	S.Int.	C.Int.	Other
Primary Quarries															
4378 B	-	744	283	1027	30.5	14.4	54.3	31.3	28.9	46.7	24.4	34.7	37.1	23.5	4.7
Lag Quarries															
4322/H C	-	614	305	919	32.1	22.8	56.2	21.0	43.3	44.8	11.9	25.3	33.1	36.1	5.4
Off-Quarry Contexts															
3012 C	-	276	--	276	37.7	83.6	12.5	3.8	--	32.2	67.8	30.8	23.1	38.5	7.7
4239 A	-	--	983	983	20.7	98.0	2.0	--	19.3	40.4	40.0	43.8	37.5	18.8	--
4240 all	-	887	547	1434	26.0	87.0	10.0	3.2	22.2	43.3	34.4	43.2	48.6	8.1	--
4325 B	-	--	139	139	19.4	92.5	7.4	--	12.0	40.0	48.0	--	50.0	--	50.0

NOTE: Surf. - surface; Diag. - diagnostic; Reduct. - reduction; Cort. - cortical; S.Int. - simple interior; C.Int. - complex interior.

Debitage. Debitage density is high (2047/m^3), and most diagnostic pieces are core production debris (56.2%) or shatter (21.0%). Only 22.8% is from biface production (Table 54). Of the core production debitage, complex and simple interior flakes occur with equally high frequencies (36.1% and 33.1%, respectively), outnumbering cortical debris (25.3%). The debitage profile suggests cores were the prevalent artifact made here, and that they were not haphazardly reduced: this is consistent with the artifact assemblage. Early and middle stage thinning flakes co-dominate the biface reduction debitage, indicative of Stage 2, bifacial blank, manufacture.

HAIWEE PERIOD OFF-QUARRY ASSEMBLAGES

Five Haiwee period components occurred in off-quarry contexts (Table 50). Three of these contain exclusively Haiwee period materials; Late Newberry and Haiwee period materials are commingled at INY-3012C; the flaked stone assemblage at INY-4329O dates predominately to the Early period, with one projectile point and the ground and battered stone assemblage ascribed to the Haiwee period. The cumulative Haiwee period flaked stone assemblage from these components is dominated by bifaces (75.7%), followed distantly by flake tools (10.7%). Unifaces and projectile points occur in moderate frequencies, at 6.8% and 4.9%, respectively. Cores are rare.

Bifaces. Bifaces occur at three of the components, and are particularly abundant at INY-4239A (Table 50). The vast majority of the bifaces are Stage 3s (68.8%) followed by Stage 2s (20.8%, Table 50); this is a marked change from earlier off-quarry assemblages, where Stage 3s typically constitute only one-third or less of the bifaces, and Stage 2s predominate. As a further distinction, pressure-worked bifaces (Stage 4s) are well-represented, accounting for 9.1% of the biface sample; in earlier off-quarry assemblages, they account for less than 1%. Very few (7.7%) of the discarded bifaces are whole, but they appear comparable in size to those in earlier off-quarry components, with Stage 2s averaging 45 mm wide and 15 mm thick, and Stage 3s 37 mm wide and 8 mm thick (Table 52). Three shapes are equally represented in the small sample of whole bifaces: triangular, wide-shouldered, and rounded-elongate. Human error during manufacture is identified as the reason for discard of 59.0% of the bifaces, supplemented by an additional 15.4% with outrepasse fractures. Structural flaws are evident on 16.7% (Table 53).

Projectile Points and Biface/Points. Three Haiwee period off-quarry components contained one or a few projectile points or non-diagnostic fragments of points (Table 50). The four points include three Saratoga Spring (Plates 1o, 1p, 1q), and one Rose Spring (Plate 2b). Each is made of Coso glass, and rim measures range between 3.0-4.9 μ. The one biface/point is an unfinished basal fragment of a Saratoga Spring. The point types are consistent with the Haiwee period, as are the hydration rim values obtained on them.

Cores. One core was recovered from each of two Haiwee period off-quarry components (Table 50). Each is whole: one is non-patterned, wide-shouldered, and weighs 146.6 g; the other is a circular cobble/chunk test, weighing 244.6 g.

Unifaces. Unifaces are present at two of the components, and six of the seven were found at INY-4239A (Table 50). Each is a small margin fragment, and most weigh less than 5.0 g (Table 55). It is conceivable that some are actually unidirectional core or uniface-B fragments, rather than true unifaces; but their fragmented condition precludes such classification.

Table 55. Summary Metrics of Unifaces in Haiwee Period Components.

	Off-Quarry Contexts				
	n	mean	s.d.	max.	min.
	7				
length*	7	34	13	53	18
width*	7	19	6	30	11
thickness*	6	8	3	12	5
weight*	7	4.5	4.2	13.8	1.3

NOTE: length, width and thickness in mm.; weight in grams;
* - all measurements incomplete.

Simple Flake Tools. Several flake tools occurred at each of three Haiwee period off-quarry components (Table 50). Six are whole; five are fragmented. The whole ones are moderate in size, averaging 54 x 39 x 7 mm (12.3 g; Table 26). Typically one or two worked edges are present, mostly commonly straight (54.5%) or convex-shaped (27.3%). The few remaining have beaked projections 26-33 mm long.

Debitage. Debitage densities vary greatly from one component to the next, ranging from 57 to 1698/m^3 (Table 50). Though the intensity of reduction varies, the nature of the reduction activities is similar between components. Some 90.3% of the diagnostic percussion debris, on average, is attributed to biface production, with minimal amounts of shatter or core-reduction debris (Table 54). Biface reduction at two of the components is narrowly focused on late stage thinning, while all reduction stages are fairly well represented at the other two loci.

HAIWEE PERIOD DISCUSSION

Quarrying remains concentrated at primary outcrops during this period, however, the focus of manufacture shifts to producing relatively more, and larger, non-patterned cores than in the preceding Late Newberry period, and comparatively less, but larger, bifaces. Lag deposits completely ignored in the Late Newberry period are of some small interest in the Haiwee. There appear, however, to be very few of these Haiwee period lag deposits. The frequency of secondary reduction components, so common in the Late Newberry period, decreases significantly in the Haiwee period. At these fewer off-quarry components, like the primary quarries, biface reduction continued to more advanced stages, with preforms substantially better represented than in prior intervals, and pressure-worked bifaces make their most significant contribution ever. As in earlier times, there is little evidence of further core reduction at off-quarry locations, indicating many cores were taken from quarries to distant sites.

MARANA PERIOD LAG QUARRY ASSEMBLAGES

A total of 26 Marana period components was identified at 13 sites (Table 56). Only two of these were at lag quarries, and only one (INY-3300 D) has flaked stone associated. The flaked stone at this component represents a single reduction event where a few cobbles were processed. All materials occurred within a 3 x 3 m area, and the assemblage is limited to a whole Stage 2 biface (92 x 42 x 29 mm, 92.3 g), two non-patterned and two unidirectional cores, 15 pieces of percussion debitage, and the anvil on which the obsidian cobbles were worked.

The cores are whole and fairly large, ranging from 121.1-370.2 g (Table 57). Blocky-rectangular, triangular, and circular shapes are all represented. Nine pieces of debitage are from core reduction (six cortical and three simple interior flakes); the six remaining flakes are from biface reduction.

MARANA PERIOD OFF-QUARRY ASSEMBLAGES

Twenty-four Marana period off-quarry components were identified (Table 56). Many of these were identified as late deposits based on radiocarbon dates obtained from features; hydration data indicated that the flaked stone assemblage at eight of the 24 components was not genuinely associated with late period use. Consequently, the flaked stone from these areas has been excluded from the Marana period composite assemblage. The flaked stone assemblage from the 16 remaining areas is incredibly meager: 14 bifaces, seven cores, five flake tools, four projectile points, and one biface/point fragment (Table 56). Debitage is similarly sparse, never exceeding 100 pieces/m^3 (CU-1/4") at the few locations with subsurface deposits. Extremely limited amounts of flaked stone is the most noteworthy characteristic that these Marana period off-quarry components share.

Bifaces. A few bifaces occurred at only seven Marana components with flaked stone. Of the 14, half are Stage 2s, half are Stage 3s (Table 58). The two whole Stage 2s are dissimilar: one is 76 x 71 x 24 mm (103.8 g), the other 46 x 36 x 9 mm (14.8 g). Three Stage 3s are whole, each a flake blank variant, and they average 45 x 28 x 7 mm (8.4 g). Of the whole ones, two each are triangular and wide-shouldered, one is circular. Human error during manufacture accounts for the discard of 50.0%; the whole ones display no apparent flaws; (Table 59).

Table 56. Assemblage Inventories in Marana Period Components.

	1984 E QL	3300 D QL	Subtotal QL	1816 C OQ	1816 D OQ	1816 E OQ	1816 F OQ	1816 G OQ	1816 H OQ	1906 A OQ	1906 E OQ	1906 F OQ	1906 H OQ	2103 D OQ	2825 B OQ	3004/5 G OQ	3456 B OQ	4239 B OQ	4243 B OQ	4267 A OQ	4329 A OQ	4329 D OQ	4329 N OQ	4329 R OQ	4329 V OQ	4329 W OQ	4330 B OQ	Subtotal OQ
Flaked Stone																												
Bifaces, Uniface-B's, and Flake Blanks																												
Stage 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	A	-	-	-	A	-	-
Stage 2	-	1	1	-	-	2	-	-	3	-	-	-	-	1	-	-	1	-	-	A	A	A	A	-	-	A	A	7
Stage 3	-	-	-	1	-	-	2	-	1	-	-	-	3	-	-	-	-	-	-	A	-	-	A	-	-	A	A	7
Stage 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stage 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeterminate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-
Not Analyzed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal	-	1	1	1	-	2	2	-	4	-	-	-	3	1	-	-	1	-	-	A	A	A	A	-	-	A	A	14
Projectile Points and Biface/Points	-	-	-	1	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	A	-	A	-	-	-	1	-	5
Cores																												
Non-Patterned	-	2	2	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	A	A	A	A	-	-	-	-	2
Unidirectional	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	A	A	A	A	-	-	-	-	1
Bidirectional	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	A	-	A	-	-	-	-	2
Bifacial	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	1
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	A	A	A	-	-	-	-	A	1
Not Analyzed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-	-
Subtotal	-	4	4	-	1	1	-	1	1	-	-	-	-	-	-	-	3	-	-	A	A	A	A	-	-	-	A	7
Flake Tools	-	-	-	-	-	-	1	-	-	-	-	1	2	-	-	-	1	-	-	A	A	A	-	A	-	A	-	5
Unifaces	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-
Formed Flake Tools	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drills	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Debitage (¼"/m³)	9	NS				42*				NS	NS	68	34	38	NS	95	90	<1	5	A	A	A	A	A	A	A	A	
Ground and Battered Stone																												
Millingstones																												
Thin	-	-	-	2	-	1	3	-	3	-	1	-	8	2	-	-	-	-	-	2	1	-	-	-	-	-	-	23
Slab	-	-	-	2	2	6	-	1	3	3	-	4	10	7	3	2	6	-	2	21	3	5	-	-	-	1	-	81
Block	4	-	4	3	2	-	-	1	-	2	-	3	2	-	3	-	4	2	-	2	2	1	-	-	-	-	2	29
Indeterminate	1	-	1	-	1	-	-	-	1	-	-	-	1	-	-	-	-	-	-	6	-	(5[b])	-	-	-	-	-	9
Subtotal	5	-	5	7	5	7	3	2	7	5	1	7	21	9	6	2	10	2	2	31	6	6	-	-	-	1	2	142
Handstones																												
Bifacial	-	-	-	-	-	2	-	-	1	2	2	-	3	-	-	-	2	-	-	1	-	1	-	-	-	-	-	14
Unifacial	1	-	1	7	-	-	-	3	1	2	6	-	10	-	-	-	12	1	2	5	2	-	-	-	-	1	-	52
Subtotal	1	-	1	7	-	2	-	3	2	4	8	-	13	-	-	-	14	1	2	6	2	1	-	-	-	1	-	66
Mortars	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	3
Pestles	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Misc. Ground Stone	-	-	-	1	1	-	1	-	3	-	-	-	3	5	-	-	-	-	-	1	-	-	-	-	-	-	1	16
Cobble-Core Tools	2	-	2	-	1	-	1	1	1	-	-	-	4	1	-	-	4	-	-	4	9	4	1	-	-	-	3	34
Anvils	-	1	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Bedrock Slick/Mortars	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	3[a]	-	-	-	-	-	-	-	6
Other Materials																												
Features	1	1	2	1	-	1	-	-	-	-	1	1	4	1	-	3	-	-	2	5	5	7	2	1	1	-	2	37
Beads	-	-	-	-	-	-	-	-	-	-	-	-	246	-	-	-	-	-	-	-	-	-	-	-	-	-	-	246
Sherds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31	-	31
Incised Stone	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Miscellaneous Stone	-	-	-	-	1	-	-	-	-	-	1	-	1	-	-	-	2	-	-	2	1	-	-	-	-	-	-	8
Modified Stone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pebble	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bone	-	-	-	53	-	-	-	-	-	-	-	48	158	-	-	-	-	-	-	14	4	6	5	-	-	1	-	289
Seeds	-	-	-	44	-	-	-	-	-	-	-	77	110	-	-	-	-	-	>5500	1	-	8	-	-	-	-	-	>5740

NOTE: QL - lag quarry contexts; OQ - off-quarry contexts; A - hydration data where available indicates obsidian assemblage predates the Marana period; * - debitage sample for INY-1816 components C, D, E, F, G, and H; NS - no sample ; [a] - one bedrock mortar not collected; [b] - five indeterminate millingstone fragments fit to the above six items.

Table 57. Summary Metrics of Cores in Marana Period Components.

	Lag Quarries					Off-Quarry Contexts				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Bifacial						1				
length						1	53	-	-	-
width						1	50	-	-	-
thickness						1	20	-	-	-
weight						1	54.1	-	-	-
edge angle						1	50	-	-	-
Bidirectional						2				
length						1	88	-	-	-
width						2	78	10	87	68
thickness						2	54	-	-	-
weight						1	276.8	-	-	-
edge angle						2	93	3	95	90
Non-patterned	2					2				
length	2	92	13	105	79	2	57	3	59	54
width	2	70	5	75	65	2	44	12	56	32
thickness	2	54	10	63	44	2	29	4	33	25
weight	2	329.9	40.2	370.2	289.7	2	55.0	0.3	55.3	54.6
edge angle	2	80	-	80	80	2	80	20	100	60
Unidirectional	2					1				
length	2	81	6	86	75	-				
width	2	74	12	85	62	1	47	-	-	-
thickness	2	37	7	44	30	1	57	-	-	-
weight	2	180.2	59.1	239.3	121.1	1	130.9	-	-	-
edge angle	2	60	-	60	60	1	85	-	-	-
Cobble and Chunk Test						1				
length						1	114	-	-	-
width						1	51	-	-	-
thickness						1	54	-	-	-
weight						1	287.4	-	-	-
edge angle						1	110	-	-	-
Grand Total	4					7				

NOTE: length, width, thickness in mm.; weight in grams.

Projectile Points. Though projectile points were recovered from five Marana period components, the association appears genuine only at INY-1816C, -1906H, and -4329W. The point from INY-1816C (Plate 2f) is a whole Rose Spring made of Coso glass; the ones from INY-1906H include two nearly whole Cottonwoods made of Coso obsidian (Plate 1h and i) and the distal tip of an arrow-sized point; the one from INY-4329W is the proximal fragment of an arrow-sized point.

Cores. Three or fewer cores occurred at only five components with Marana-age flaked stone; nonetheless, they include one or two examples of each core type (Table 56). One is broken, and the whole ones range from 54.1-287.4 g (Table 57); no particular shape dominates.

Table 58. Summary Metrics of Bifaces, Uniface-B's, and Flake Blanks in Marana Period Components.

Off-Quarry Contexts

	Bifaces					Uniface-B's					Flake Blanks				
	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.	n	mean	s.d.	max.	min.
Stage 2	7														
length	2	61	15	76	46										
width	6	54	14	71	36										
thickness	7	17	5	24	9										
weight	2	59.2	44.5	103.8	14.8										
edge angle	7	49	10	65	40										
Stage 3	2					1					4				
length	-	-	-	-	-	-	-	-	-	-	3	45	4	50	40
width	2	48	1	49	47	-	-	-	-	-	4	27	6	36	22
thickness	2	10	2	12	8	1	11	-	-	-	4	6	2	8	4
weight	-	-	-	-	-	-	-	-	-	-	3	8.4	2.6	11.7	5.4
edge angle	2	38	3	40	35	1	40	-	-	-	4	26	2	30	25
Grand Total	9					1					4				

NOTE: length, width, thickness in mm.; weight in grams.

Simple Flake Tools. One or two flake tools occurred at four components with Marana period flaked stone (Table 56). Three are broken; the two whole ones average 58 x 39 x 8 mm (16.6 g, Table 26). They typically display unifacial microchipping on just one edge, with edge shape highly variable (two concave, one straight, one convex, and one s-shaped).

Table 59. Summary Attributes of Bifaces in Marana Period Components.

	Percent Whole							
	Stage 1	Stage 2	Stage 3	Stage 4	Indeterminate	All	N	Total
Lag Quarries	-	100.0	-	-	-	100.0	1	1
Off-Quarry Contexts	-	28.6	42.9	-	-	35.7	5	14

	Shape of Whole Bifaces							
	Triangular	Wide Shouldered	Rounded Elongate	Rectangular	Circular	Irregular	Total %	Total N
Lag Quarries	-	-	-	100.0	-	-	100.0	1
Off-Quarry Contexts	40.0	40.0	-	-	20.0	-	100.0	5

	Cause of Rejection							
	Human Error	Outrepasse	Structural Flaw	Cross-Section	Poor Planar Shape	Unknown	Total %	Total N
Lag Quarries	-	-	-	100.0	-	-	100.0	1
Off-Quarry Contexts	50.0	7.1	7.1	7.1	-	28.6	100.0	14

Debitage. Only trace amounts of Marana-age debitage exist at these components, with the maximal subsurface debitage density recorded at merely 95 piece/m^3 (Table 56). No debitage occurred at several Marana components, and the small amount from the several Marana components at INY-1816 (C-H) are combined into one sample, resulting in six useful samples (Table 60). The debitage in each is a mixture of core reduction flakes,

Table 60. Debitage Summary Data for Marana Period Components.

	Sample					% Biface	% Core	%	Biface Reduction			Core Reduction			
	Surf.	1/4"	1/8"	Total	% Diag.	Reduct.	Reduct.	Shatter	Early	Middle	Late	Cort.	S.Int.	C.Int.	Other
Off-Quarry Contexts															
1816 C-H	-	147	54	201	64.7	23.0	54.0	23.0	–	66.7	33.3	28.6	57.1	14.3	–
1906 A	-	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1906 E	-	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1906 F	-	28	25	53	45.3	87.5	12.5	–	–	28.6	71.4	–	–	66.7	33.3
1906 H	-	39	79	118	6.7	25.0	25.0	50.0	–	–	100.0	100.0	–	–	–
2103 D	-	30	49	79	25.3	–	50.0	50.0	–	–	–	–	100.0	–	–
2825 B	-	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3004/5 G	-	114	125	239	21.8	52.0	35.0	13.4	29.6	44.4	25.9	27.8	55.6	5.6	11.1
3456 B	-	53	–	53	18.9	50.0	30.0	20.0	40.0	–	60.0	33.3	33.3	33.3	–
4239 B	-	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4243 B	-	1	3	4	–	–	–	–	–	–	–	–	–	–	–

NOTE: Surf. - surface; Diag. - diagnostic; Reduct. - reduction; Cort. - cortical; S.Int. - simple interior; C.Int. - complex interior.

shatter, and biface reduction flakes. No one reduction strategy nor flake type is particularly well represented, giving the overall impression that the little flintknapping that occurred was aimed at selective flake removal from cores as well as bifaces.

MARANA PERIOD DISCUSSION

In contrast to all earlier periods, stone tool reduction is poorly represented in all Marana period deposits, regardless of context. No Marana-age quarries were identified, whether lag deposits or primary outcrops, and the quantity of late-period chipped stone in off-quarry contexts is meager. The small quantities of late-period debitage that occur are reflective of core and biface manufacture with neither strategy well represented, suggestive of a perfunctory, comparatively loosely structured flaked stone technology. In short, the vast obsidian resources of the Coso Volcanic Field are largely ignored during the Marana period. Nonetheless, Marana period components are well-represented, indicating that late-period occupation revolved around exploiting other available resources, such as small game and seeds.

DISCUSSION

Two fundamental flaked stone assemblage patterns persist through time in the Volcanic Field: in all periods, cores are virtually always more abundant than bifaces at quarries while bifaces virtually always outnumber all other flaked stone tools in off-quarry contexts, and chipped stone tools directly linked to subsistence pursuits rather than stone tool production are uncommon. Several equally compelling diachronic changes also exist. First, exploitation shifted from lag deposits to primary outcrops in the Late Newberry period, but essentially stopped after the Haiwee period. Second, the shift to primary deposit exploitation in the Late Newberry period coincides with a major increase in the number of secondary reduction locations in the Volcanic Field; however, such locations are few in number during the Haiwee period, indicating that secondary reduction activities took place at sites located outside the Volcanic Field during this interval. Third, the intensity of stone tool reduction, whether gauged by the number of sites, debitage densities, artifact densities, or other indices, fluctuated greatly through time, though all indices indicate that production peaked during the Late Newberry period. Finally, production activities emphasized different artifact forms at different episodes in the past: cores and bifaces of diverse morphology were commonly made items in pre-Late Newberry times, Late Newberry items were primarily bifacial cores and (triangular) bifaces, and in the Haiwee period, more and larger non-patterned cores were manufactured at the quarries, with bifaces also being larger, while in off-quarry contexts, bifaces occurring tend to be worked to a more advanced reduction stage than earlier.

TOOLSTONE WORKING PRACTICES AT COSO QUARRIES

Data accumulated indicate that lag quarries nearly exclusively pre-date the Late Newberry period. The intensity of production activities at these deposits is highly variable, directly linked to the quantity of workable stone at any one pocket. Though never impressive, the intensity of reduction was highest in the Early period, and decreased dramatically into the Early Newberry period (Table 61). At virtually all lag quarries, no strong preference was given to one form of core over another, rather a variety were fashioned that differed little from one another in size. Discarded bifaces make a strong secondary contribution to these assemblages, and production most commonly terminated with blanks rather than preforms. Debitage profiles are generally consistent with the assemblages. Core production debris and shatter combined to account, on average for more than 85% of the diagnostic percussion debitage across Early (excluding INY-1824 Main B), Little Lake, and Early Newberry lag quarries. Low proportions of complex or other types of interior flakes, combined with high proportions of cortical and simple interior flakes reflect loose standards and minimal concern for sophisticated core forms. Bifacial debitage typically constitutes < 20% of the diagnostic percussion debris, and mostly results from early reduction; yet bifaces make up about 40% of the flaked stone assemblages. This apparent incongruity is largely explained by discard patterning with rejection tending to occur early in the manufacturing sequence, prompting many bifaces to be jettisoned whole (54.5% of the Early and 62.3% of the Little Lake period bifaces) at lag quarries. Irregular cross-sections prompted discard of many, and structural flaws are also well represented. While the high incidence of structural flaws speaks best to the variable quality of the obsidian at lag deposits, the frequency of thick irregular profiles suggest that craftsmen were often ineffective at thinning the pieces. Lack of familiarity with the knapping properties of this material may account for this discard pattern.

Table 61. Subsurface Debitage Densities by Period and Context (CU-1/4" m^3).

	n	mean	s.d.	max.	min.
Lag Quarries					
Early	15	344.5	341.4	1095.0	17.0
Little Lake	5	209.0	194.9	405.0	34.0
Early Newberry[a]	3	67.7	59.3	135.0	23.0
Primary Quarries					
Late Newberry	2	2701.0	3013.7	4832.0	570.0
Haiwee	1	932.0	-	-	-
Off-Quarries					
Early	4	930.5	975.5	2346.0	138.0
Little Lake	2	129.5	154.9	239.0	20.0
Early Newberry	2	2133.5	2822.1	4129.0	138.0
Middle Newberry	3	640.3	370.1	1022.0	283.0
Late Newberry	20	567.8	420.4	1534.0	79.0
Haiwee	4	590.3	748.0	1698.0	57.0
Marana	16	245.1	250.9	700.0	<1.0

NOTE: [a] omitted one aberrant component (INY-3004/5A) with 540/m^3.

Primary quarries were mined during the Late Newberry and Haiwee periods, and intensity of production was quite high (Table 61). Two-to-three times as many cores as bifaces were discarded at these locations, and the cores are larger and less variable in form than those at earlier lag quarries: Late Newberry cores tend to be non-patterned or bifacial, Haiwee ones usually cobble/chunk tests or non-patterned. Bifaces, too, are larger than those at earlier lag quarries, this being particularly true in the Haiwee period, and production commonly terminated with blanks rather than preforms. There is some indication that triangular forms were favored in the Late Newberry period, while wide-shouldered ones were preferred in the Haiwee period. Debitage profiles are generally consistent with the primary quarry assemblages: core reduction debris and shatter is prevalent, while only 15-25% of the diagnostic percussion debitage is from biface manufacture (mostly middle stage thinning debris). The different prevailing core types in Late Newberry and Haiwee period quarries is reflected in the debitage: complex interior flakes are much better represented in the Haiwee period, signaling the manufacture of some bigger, and better dressed, or more prepared cores.

There is virtually no evidence of Marana period quarrying. The only definitive Marana quarrying event discerned corresponds to a feature where about three nodules were worked on an anvil (INY-3300D).

TOOLSTONE WORKING PRACTICES IN OFF-QUARRY CONTEXTS

In moving to off-quarry contexts, reduction activities strongly shift to biface manufacture. The majority of off-quarry stone reduction components date to the Late Newberry period, but in all periods bifaces are the most abundant artifact type, and flake tools are always found in secondary frequencies.

In pre-Late Newberry off-quarry contexts, bifaces outnumber cores by about seven to one. Debitage profiles reconfirm the focus on biface reduction, with nearly three-quarters of the diagnostic percussion debris the result of biface thinning (78.8%, s.d.=20.1%), supplemented by core reduction. Just over half of the bifaces are blanks (53.1%) and a third are preforms (33.0%); debitage from all percussion thinning stages is well represented, and tends to co-occur.

Off-quarry, secondary reduction, workshops proliferate in the Late Newberry period, and reduction is much more narrowly focused on biface manufacture than in preceding periods. Bifaces outnumber cores by about twenty to one, and biface thinning flakes account on average for 90.5% (s.d.=6.4%, excluding one aberrant component) of the diagnostic percussion debris. Overall, the relative proportion of blanks and preforms is unchanged from earlier, but significant differentiation occurs in the reduction activities between component areas. At five components, for example, middle stage thinning flakes constitute more than 60% of the biface debris, at four others late stage flakes constitute more than 60%, and at 10 others, middle and late stage debris are both well represented, showing continuity with the earlier pattern. The preference for triangular-shaped bifaces, suggested by primary quarry data, is better substantiated in the contemporaneous secondary reduction workshops.

In the Haiwee period the use of secondary reduction workshops in the Volcanic Field declines significantly, those activities taking place instead at more distant sites. As a further distinction from the Late Newberry period, at the comparatively few off-quarry workshops, bifaces were worked to more advanced states: about 10% are pressure-worked and two-thirds are preforms, blanks decrease to 20.5%. There is little evidence to suggest a continued preference for triangular forms, but whether wide-shouldered forms gained precedence or forms became more variable is undetermined. The differentiation in reduction activities documented at Late Newberry off-quarry components appears to continue into the Haiwee period: late stage thinning debris heavily predominates at one component, though all percussion thinning stages are well represented at others.

Marana period off-quarry contexts, though numerous, contain very little chipped stone, showing considerable disregard for the vast obsidian deposits at Coso. A modicum of core/flake reduction and biface reduction debris is present, and neither clearly dominates. The low quantities of chipped stone and various artifact and debitage types suggest the lack of an established reduction pattern, and the use instead, of ad hoc, selective flake removal from bifaces and cores.

CHAPTER 7: SUBSISTENCE-SETTLEMENT PATTERNS

Ethnographic reviews by Bettinger (1982b), Delacorte (1990), Fowler (1986), Steward (1933, 1938), and Zigmond (1981) identify five complexes of economic plants commonly used by the aboriginal inhabitants of eastern California (see Chapter 4). These include greens and shoots, roots and tubers, seeds, fruits and berries, and tree crops. Animal resources have also been combined into a series of complexes (Bettinger 1982b), including pronghorn and jack rabbits, deer and bighorn sheep, small game, insects, waterfowl, and fish. Of these, small seeds, rabbits and other small game, and low densities of pronghorn and bighorn sheep were present within the Coso Volcanic Field. Upland foods such as acorn, pine nuts, and deer, as well as resources from the lowlands such as fish, shellfish, brine fly larvae, waterfowl, greens and shoots, and roots/tubers were either scarce or absent.

As clearly illustrated in the previous chapter, acquisition of Coso obsidian was important during much of the past. During the Early (pre-5500 B.P.) and Little Lake (5500-3500 B.P.) periods, obsidian procurement strategies focused on lag deposits; during the Newberry periods (3500-1275 B.P.), the intensity of production increased, and shifted to primary outcrops and numerous off-quarry secondary reduction locations. Haiwee period (1275-650 B.P.) exploitation was almost exclusively restricted to the very highest quality primary quarries, and secondary reduction activities are confined to those outcrops or took place outside the Volcanic Field. By the Marana period (post 650 B.P.), production virtually came to a stand-still, shown by the lack of Marana period quarries (either lag or primary) and reinforced by the lack of chipping debris in Marana period off-quarry deposits.

The goal of this chapter is to evaluate the changing relationship between patterns of lithic production and subsistence. During certain periods of time, for example, use of local plants and animals may have been directly tied to patterns of obsidian acquisition (i.e., subsistence pursuits were incidental to lithic production) while during others, the pull of particular subsistence resources may have taken priority over the production of stone tools. By monitoring the changing interplay between these two, several diachronic trends in local land use will be identified, trends that can ultimately be used to evaluate the more comprehensive models of regional subsistence-settlement pattern change presented earlier (see Chapter 2).

ARTIFACT AND FEATURE INVENTORIES

The archaeological analysis of subsistence is organized by temporal period (from early to recent), maintaining the distinction between quarries and off-quarry contexts. General descriptions of period-specific artifact assemblages, features, and floral/faunal remains are reviewed, and provide the data necessary to identify shifts in local resource procurement strategies over time. Once identified, these trends will be further elucidated through a more detailed analysis of those data sets most responsible for the changes observed.

EARLY PERIOD

Of the 21 Early period components, 15 have temporally discrete assemblages, three are mixtures of Early and Little Lake occupations, two contain Haiwee period residues, and one has Early Newberry period materials commingled (Table 20). In the case of the Little Lake and Early Newberry mixes, no artifacts or features can be easily segregated and assigned to one or the other period; as a result, their assemblages are assigned unaltered to both. The mixed Haiwee period material, in contrast, can be confidently identified: INY-3004/5I had a concentration of fire-affected rock radiocarbon dated at 860 $\pm$ 65 B.P. surrounded by an assemblage of milling equipment, overlaying an Early period lag quarry; INY-4329O had a Saratoga Spring projectile point and a few flakes overlaying a much more extensive Early period accumulation. The feature and milling equipment from INY-3004/5I are excluded from the Early assemblage, as is the projectile point at INY-4329O.

Sixteen of the 21 Early components are at lag quarries. Half of these have more cores than bifaces, and all have high relative frequencies of early stage bifaces (i.e., Stage 1-2 bifaces are more numerous than Stage 3-5 forms). These trends are clearly illustrated by the combined quarry sample, in which cores outnumber bifaces (including biface equivalents, biface/points, and projectile points) by 665 (58.0%) to 481 (42.0%), and early stage forms (Stage 1 and 2) comprise 88.1% of the typable bifaces, with the remaining 11.9% being Stage 3-5s.

Subsistence-related tools are quite rare at Early quarries. Ground stone is limited to three millingstones and three handstones. Non-obsidian cobble-cores are more frequently present, found in 10 of the 16 components, but typically in low numbers. Overall, they occur at a frequency of about one per every 33 cores and bifaces. Most are made from durable materials (e.g., granite and dike rock), and appear to have been used as hammerstones for quarry reduction. There are only three projectile points, but flake tools (both simple [n=72] and formed [n=12]) are more abundant, present at 12 components, but many of these were probably edge damaged by something other than use (e.g., trampling). In any case, they make-up a rather minor part (6.6%) of the flaked stone assemblage.

Six features were encountered at Early period lag quarries. Feature 1 at INY-3300A consists of a cleared circle measuring 3.0 m in diameter, surrounded by a concentration of obsidian nodules, chipping debris, and larger granitic boulders. Excavation and surface collection produced three cores, a non-obsidian cobble-core, one uniface-B, one flake tool, and a fair amount of debitage. At INY-3300B, Feature 3 was a concentration of chipping debris (and one uniface) found within a natural enclosure of granitic bedrock. Feature 8 at INY-4329G was a discontinuous circle of large rocks (30-40 cm in maximum dimension) roughly 150 cm in diameter. Several rocks overlaid one another, indicating that they probably were originally stacked three to four courses high. Excavation yielded no artifacts, charcoal, or charred seeds. Although far from certain, its overall character seems to indicate it is recent (perhaps historic). The final three Early period features were discovered at INY-1984D (Features 1, 2, and 3). All three were rock rings with outside diameters ranging from 3.5-5.5 m, cleared interiors measuring between 2.0-2.5 m across, and perimeters built with numerous granitic stones (10-50 cm in maximal dimension). Excavations and surface collections both within and outside of these constructs produced two non-obsidian cobble-cores and a minimal amount of obsidian debitage. Embedded in old deflated sediments, all three features appear to represent remnants of ancient temporary structures.

In contrast to the Early quarries, the five off-quarry components have more bifaces (n=175, 80.6%) than cores (n=42; 19.4%) and a higher percentage of the bifaces are Stage 3-5 forms (36.5%). With the exception of INY-1984B, milling equipment remains rare, limited to three millingstones at one component. Although 10 millingstones were recovered from the former component, this location has a mixture of materials from the Early Newberry period, opening to question the true chronological placement of these materials. Non-obsidian cobble-cores occur in low numbers at every Early off-quarry context, found at a frequency of about one per every 14 cores and bifaces. Like those at the quarries, they were probably also used for stone working. Flake tools, (all simple flake tools), comprise a much larger portion of the combined flaked stone assemblage (17.9%), and many were, no doubt, actually used as tools. Midden, features, floral remains, and faunal remains were absent or near-absent in all Early off-quarry components.

In summary, Early period assemblages contain little in the way of subsistence-related tools, and virtually no floral and faunal remains. Both quarry and off-quarry locations were evidently used to process locally available obsidian, and little more. It appears people visited the Volcanic Field for the primary purpose of obtaining lithic material, most of which was processed at the lag quarries prior to departure or, in some cases, areas nearby. Some subsistence activity no doubt occurred at the latter, but this was minimal judging from the lack of residue left behind.

LITTLE LAKE PERIOD

There are seven Little Lake period components (Table 27), and three have Early period materials intermixed. Like in the Early period, lag quarry outnumber off-quarry components (five to two), however, the difference in their relative proportions is less pronounced. Quarry assemblages have slightly more cores than bifaces (225 to 203, 52.7% to 47.3%), and Stage 1-2 bifaces outnumber Stage 3-5 bifaces (178 to 22, 89.0% to 11.0%) Also similar to the Early quarries, non-obsidian cobble-cores (mostly hammerstones) are present in most contexts. They are particularly abundant at INY-4319 where 25 were found.

Milling equipment includes five millingstones and two handstones. The former were found in a cluster along the edge of INY-4319 and represent a specialized processing area that is perhaps chronologically unrelated to the remainder of the site. The handstones were found singly at INY-2103H and INY-3299A, and also provide little evidence for Little Lake period seed processing within these contexts. Flake tools (simple and formed), the only other artifacts possibly with subsistence-related use, are rare (n=19, 4.1% of the flaked stone assemblage), and probably damaged in ways other than by use (see Early period discussion).

The two Little Lake off-quarry components contain many more bifaces than cores (47 to 6, 88.7% to 11.3%), and higher frequencies of Stage 3-5 (n=12, 26.1%) relative to Stage 1-2 bifaces (n=34, 73.9%) than at the quarries. Non-obsidian cobble-cores are absent, which is consistent with their suggested quarry connection. There is no milling equipment, and flake tools are extremely rare (restricted to four simple specimens from INY-4330A). The only feature (at INY-4330A) is a subsurface hearth that yielded 25 flakes, several pieces of charcoal, but no charred seeds. Direct evidence of subsistence activities was limited to three small bone fragments (probably rabbit), also from INY-4330A.

The relative mix of Little Lake quarry to off-quarry components, and the structure and composition of assemblages in off-quarry locations, indicate a land-use system like that of the Early period. Lacking midden, significant floral and faunal remains, as well as a meaningful number of tools associated with subsistence activities, Little Lake period quarry and off-quarry components seem to represent short-term occupations by people primarily concerned with working the obsidian lag deposits, showing little or no interest in exploiting local subsistence resources.

EARLY NEWBERRY PERIOD

The increase in off-quarry relative to quarry components hinted at in the Little Lake period is quite evident in the Early Newberry interval, as three off-quarry and four quarry components were encountered (Table 33). This trend is strengthened further, if INY-3004/5A is disregarded as a lag quarry for its aberrant characteristics (see Chapter 6). The three remaining quarries differ from earlier assemblages in that bifaces are as common as cores (15 to 17, 46.9% to 53.1%), though the bifaces themselves still remain predominantly early stage forms. Cobble-cores are present at two of the three components, flake tools are minimally represented, and milling equipment is absent altogether.

Even though the aberrant quarry, INY-3004/5A, is at an obsidian lag deposit, it has characteristics like earlier off-quarry components. The assemblage contains more bifaces (n=71, 87.7%) than cores (n=10, 12.3%), and a much higher frequency of Stage 3-5 bifaces (n=37, 61.7%) relative to Stage 1-2 forms (n=23, 38.3%). Further, milling equipment is more numerous than cores, the former including six millingstones, two handstones, and five miscellaneous ground stone fragments. This is the earliest assemblage in which projectile points are significantly represented (n=7, 6.7% of the flaked stone assemblage), while the frequency of flake tools (n=19, 18.1% of the flaked stone assemblage) is comparable to off-quarry components used in other periods.

Only two of the three off-quarry components produced significant numbers of tools. Both yielded many more bifaces than cores (192 to 20, 90.6% to 9.4%) and a relatively high proportion of Stage 3-5 bifaces (n=57, 35.2%) compared to Stage 1-2 bifaces (n=105, 64.8%), but neither trend to the degree noted at INY-3004/5A. Milling equipment is abundant at INY-1984B, but only marginally present at INY-4329K. Other subsistence-related tools include several projectile points (n=5, 2.1% of the flaked stone assemblage) and a moderate frequency of flake tools (n=26, 10.7% of the flaked stone assemblage).

Although the scarcity of midden, features, and faunal and floral remains indicates lack of occupation, the frequency of off-quarry related materials shows more diverse use than in earlier times. More time was spent in the area producing biface blanks and opportunistically exploiting local seed resources when available.

MIDDLE NEWBERRY PERIOD

There are only three Middle Newberry off-quarry components (Table 39), but they provide evidence that activities were shifting from lag quarry exploitation to off-quarry biface reduction stations. Quarries are entirely absent; cores essentially disappear (n=2, 1.4% of the flaked stone assemblage); non-obsidian cobble-cores, consistently present at older lag quarries, are also lacking. Bifaces, however, are common, and Stage 3-5s (n=44, 46.8%) occur in frequencies roughly comparable to Stage 1-2s (n=50, 53.2%).

Subsistence-related tools are limited to a single handstone and a few simple flake tools (the latter equaling only 8.6% of the flaked stone assemblage). The single feature (Feature 1, INY-1824 Main-M) is a subsurface pit that contained several large fire-affected rocks, obsidian debitage, and moderate amounts of charcoal. Flotation analysis of three sediment samples (totaling 44 liters) produced seeds of several important economic plants (e.g., ricegrass, blazing star, desert tomato, and tansy mustard), but no faunal remains. No tools were found within the feature fill, but several bifaces were scattered nearby.

As in the Early Newberry period, the presence of plant remains and other traces of subsistence-related items suggest that visits to the Volcanic Field in this interval included a wider range of activities than during the Early and Little Lake periods. Most of what was found, however, reflects a continuing focus on biface production. It appears likely, therefore, that subsistence activities occurring on these trips were opportunistic and secondary.

LATE NEWBERRY PERIOD

Specialized off-quarry biface production peaks during the Late Newberry period. Of the 23 components (only one with temporally mixed material — INY-3012C, containing both Haiwee and Late Newberry debris), only two are quarries (Table 43). Both are targeted obsidian seams exposed on the steep flanks of Joshua Ridge. Cores outnumber bifaces at both locations, but in closer proportions at INY-2826C (59 cores to 43 bifaces) than at INY-4378A (40 cores to 10 bifaces). A significant number of the cores are bifacially worked. Stage 1-2 bifaces are strongly dominant at both locations (n=45, 86.5% of the typable bifaces). Other than this, they contain large quantities of debitage, a handful of non-obsidian cobble-cores, but little else.

Outside quarries, cores are either absent or minimally present, but bifaces are plentiful, dominating cores 659 to 33 (95.2% to 4.8%). At 17 of the 21 off-quarry components, Stage 3-5 bifaces (n=169, 47.9%) are about as numerous as Stage 1-2s (n=184, 52.1%). At the four remaining components, (INY-1824-X, -2103A, -2103B, and -4244), stage frequencies tend to mimic those at contemporaneous quarries, with early (n=147, 75.8%) more abundant than later stage bifaces (n=47, 24.2%). INY-2103A and B are within 200 m of extensive obsidian lag deposits, helping to account for this quarry-like trait; however, INY-1824-X and -4244 are at least 400 m from the nearest quarry, and remain enigmatic in this regard. Non-obsidian cobble-cores occur at only five Late Newberry off-quarry components, such tools continuing to be associated with quarries and high quantities of cores. Each of these five components, however, also contains milling equipment, suggesting cobble-cores were used here in subsistence-related tasks.

Milling equipment is found in small quantities at over half of the Late Newberry off-quarry components (12 of 21); only four locations (INY-1907A, -2103A, -2103B, and -3012C) yielded four or more pieces. Together these four components account for 69.5% (41 of 59) of all Late Newberry off-quarry milling equipment, and 13 of the 15 (86.7%) non-obsidian cobble-cores. Many of the ground and battered implements, however, come from INY-3012C — the one component with co-occurring Haiwee period material. Projectile points are rare (n=17, 2.2% of the flaked stone assemblage), as are flake tools (n=79, 10.0% of the flaked stone assemblage). There is only one Late Newberry feature: a small hearth at INY-1907A that produced charcoal and fire-affected rocks, but no artifacts, seeds, or faunal remains.

In contrast to short-term exploitation of lag quarries, which characterizes earlier periods, Late Newberry quarrying shifted to primary deposits, and numerous secondary biface production areas were established, many associated with a modicum of subsistence-related implements. Some of these secondary reduction components display evidence of a fair amount of seed processing (i.e., milling gear); however, none shows signs of long-term occupation or intensified use of local subsistence resources.

HAIWEE PERIOD

In striking contrast to periods immediately before (Late Newberry) and after (Marana), Haiwee occupations are quite scarce: only eight Haiwee components were encountered (compared to 23 Newberry and 26 Marana). Of these, only two produced substantial assemblages of unequivocal age (Table 50): INY-4378B is a primary quarry on Joshua Ridge containing mostly cores and early stage bifaces; INY-4239A is an off-quarry biface production area showing the highest relative frequency of Stage 3-5 bifaces relative to Stage 1-2s (55 to 8, 87.3% to 12.7%) of any component area. Except for a few flake tools, subsistence-related artifacts are lacking at both.

Other Haiwee components include a small concentration of lag quarry debris at INY-4322/H-C (one biface, four cores, and six flake tools), a small off-quarry flaked stone production area at INY-4240 (seven artifacts), and two surficial hearths with no artifact associations (but radiocarbon dated at 930 ± 80 B.P.) at INY-4325B. The final three components are temporally mixed and include a problematic milling assemblage that may actually be Late Newberry (at INY-3012C, see above), a concentration of fire-affected rock radiocarbon dated at 860 ± 65 B.P. associated with milling equipment overlaying an Early period lag quarry (at INY-3004/5I), and a Saratoga Spring projectile point associated with a few pieces of debitage over a much more extensive assemblage dating to the Early period (at INY-4329O).

These data duplicate the Late Newberry pattern in which toolstone was obtained from primary quarries, and attention was given to only the largest and most productive exposures. In contrast to the Late Newberry period, though, secondary reduction locations are uncommon; instead, reduction was largely confined to quarries, or to encampments located a goodly distance outside the project area. Use of the Volcanic Field for subsistence is much reduced relative to the Late Newberry period, and visits focused narrowly on obsidian procurement.

MARANA PERIOD

By the Marana period, there is little or no evidence of either primary or secondary reduction of Coso obsidian (Table 56). With the exception of one small production feature consisting of an anvil, four cores, five large flakes, a biface, and a small quantity of debitage (INY-3300D), quarries and off-quarry biface production areas are absent from the record. Instead of the rich obsidian deposits, subsistence resources (primarily small seeds) take priority for the first and only time.

Numerous component areas were identified containing clusters of milling equipment and little/no flaked stone tools or debitage. Fortunately, several of these milling components had hearths that could be radiocarbon dated, and 12 of 13 produced Marana period dates. Attempts to date Marana period components with hydration generally failed because obsidian played such a small role during this temporal interval. The small amount of flaked stone co-occurring with these milling clusters (with or without hearths) often produced older and dispersed hydration values — a situation caused by the presence of background debris originating from earlier flaked stone production in nearby areas. Due to the regularity in this pattern, similar concentrations of hearths and/or milling equipment not directly dated have been assigned to the Marana period. This method of component assignment, although surely quite accurate, creates problems in that the criteria used to identify the component (clustered milling equipment sometimes with hearths) are the same as those that distinguish Marana land-use patterns from earlier ones. The consistency of the radiocarbon results, however, demonstrates that this is appropriate, given that the approach was necessitated by a major discontinuity in the archaeological record.

Milling equipment is present at 22 of the 26 Marana period components. At the four remaining, three were essentially isolated features (INY-4329N, -4329R, -4329V) and one was the small obsidian production feature mentioned above (INY-3300D). Again, hydration data suggest the flaked stone assemblages at INY-4267A, -4329A, D, N, R, V, and W; and -4330B date to earlier periods, while the remaining Marana components either lack flaked stone or have a very modest, genuinely associated, flaked stone assemblage (Table 56). Millingstones are the dominant artifact form recovered (found at 22 locations), followed by fewer handstones in more restricted distribution (present at 15 components), non-obsidian cobble-cores (13 components), hearths (16 components), and very little else. Despite the increased interest in the local subsistence base, the limited range of materials recovered (i.e., the absence of well-developed middens and lack of diversified artifact assemblages) suggests the vast majority of component areas were used for *very* short periods of time. There is one exception to this pattern: INY-1906H produced a large assemblage of milling equipment (21 millingstones, 13 handstones, three miscellaneous ground stone fragments), two projectile points, a probable arrow point fragment, a few flake tools and blanks, four non-obsidian cobble-cores, four hearths, and nearly 250 glass beads. Occupation here was clearly more intensive than at other Marana components.

Marana period features are abundant and show a great deal of structural and functional variability not represented earlier. At INY-4329, for example, nine of 16 features are highly formalized rock-lined hearths (Figure 21). These hearths are about 1.0 m in diameter and no more than 30 cm deep, with perimeters formed by several large rocks, and interiors lined with smaller, burned rocks. Charcoal is concentrated in and under the interior stones, and most have an exterior, contiguous pile of small, burned rocks. In spite of a large quantity of charcoal, flotation samples (a total of 86.0 liters of sediment from nine hearths) produced only four seeds. Although milling equipment is present in nearly all Marana components, it was rarely in direct association with this type of hearth. Given that most small seed resources available at Coso were winnowed, parched, and ground into flour prior to being cooked, the lack of milling gear and charred plant remains probably indicates that these features were designed to heat cooking stones for foods previously processed elsewhere. This interpretation is also supported by the small size of the stones and the fact that many were found in piles outside the hearth, probably reflecting their discard after completing the task at hand.

An entirely different situation was encountered at INY-1906 (Figure 22). Most features here were initially identified as millingstone clusters, but subsequent excavations regularly exposed charcoal concentrations rich in plant macrofossils. For example, Feature 9 was a surface concentration of six millingstones associated with a near-surface, thin, charcoal stain less than 1.0 m in diameter. Excavations yielded debitage and one flake tool, and a 22 liter flotation sample contained 27 chia, 24 blazing star, eight ricegrass, four goosefoot, two Borage family, and two unidentifiable seeds. The flotation sample also produced 40 pieces of bone (36 burnt), most from rabbit-sized and smaller animals. These data clearly indicate that the full range of processing and consumption activities occurred in these contexts.

Environmental contrasts correlate with differences in feature structure and the presence/absence of floral remains (Table 62). Formal hearths, like those at INY-4329, occur exclusively in non-playa environments, produce virtually no seeds, and are rarely directly associated with milling equipment. When found near playas, informal hearths and hearths/structures (e.g., rock scatters 1.5-3.0 m in diameter; see Gilreath and Hildebrandt 1995, Volume II Site Reports [INY-3004/5 Component G]) usually produce milling equipment and seeds. When found away from playas, informal hearths never produce significant quantities of seeds, though milling equipment is present on occasion. Additional evidence for the importance of playa habitats are simple clusters of milling equipment. They are primarily associated with playas, and often have small midden smears containing charred floral remains.

Table 62. Marana Period Features.

	Playa Associated			Non-Playa Associated			
	Number	Milling Equipment Present	Plant Remains Present[b]	Number	Milling Equipment Present	Plant Remains Present[b]	Total
Formal Hearths[a]	-	-	-	9	1	-	9
Informal Hearths	2	2	2	16	4	-	18
Hearths/Structures	2	2	2	-	-	-	2
Milling Clusters	6	6	2	2	2	-	8
Total	10	10	6	27	7	-	37

NOTE: [a] - Circular rock rings with internal rock-lined pits (see INY-4329 in Gilreath and Hildebrandt 1995, Volume II); [b] - Includes only features with $\geq$ five seeds.

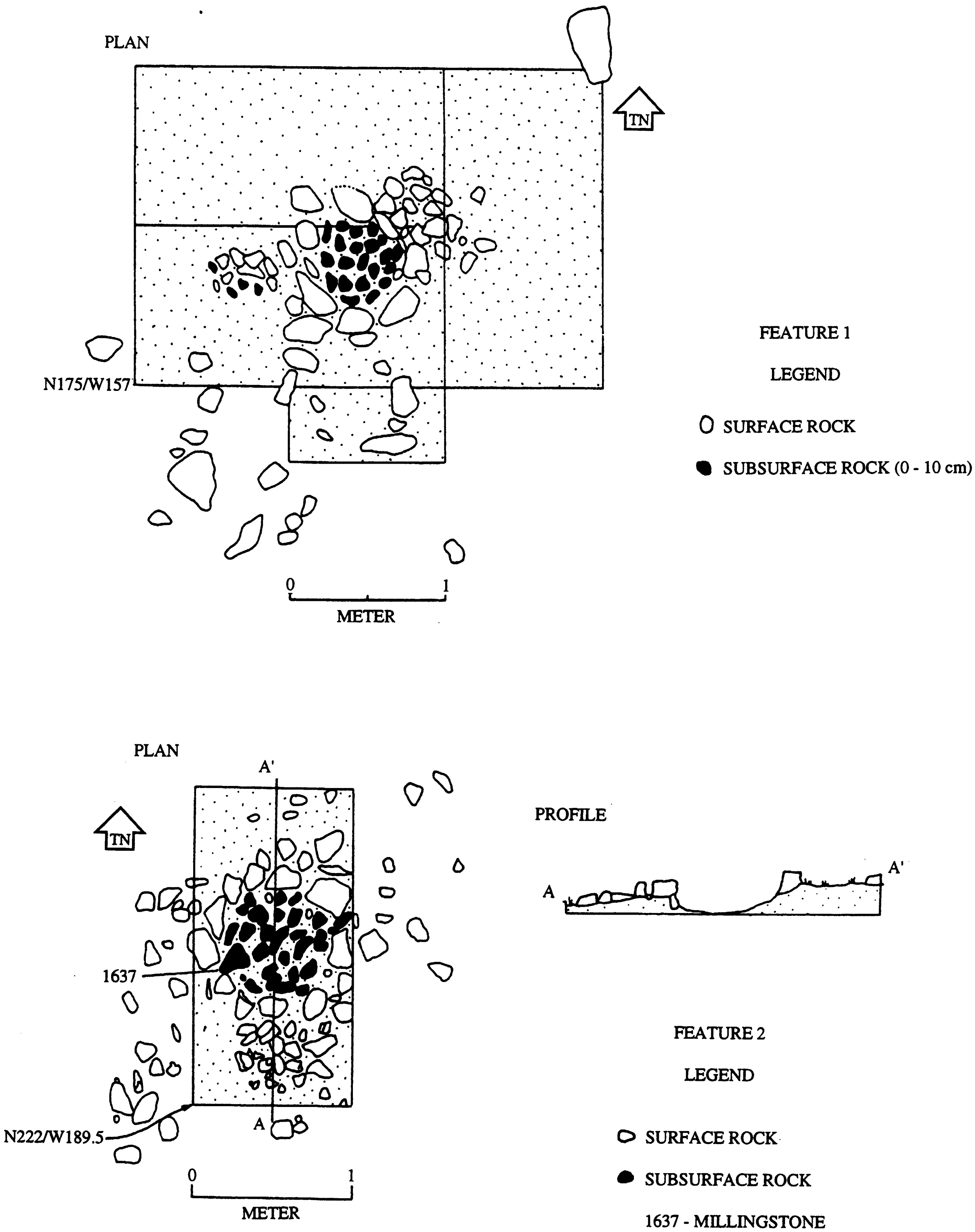
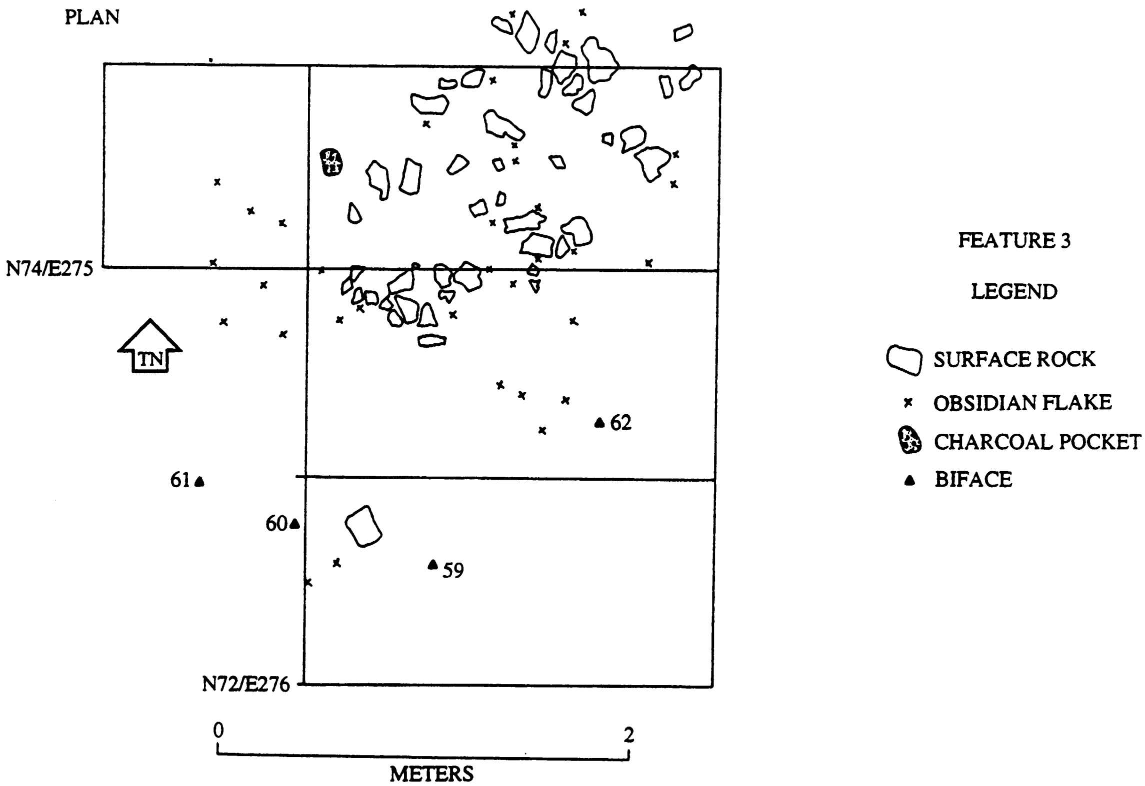


Figure 21. Formalized Rock-lined Hearths at INY-4329, Locus 1.



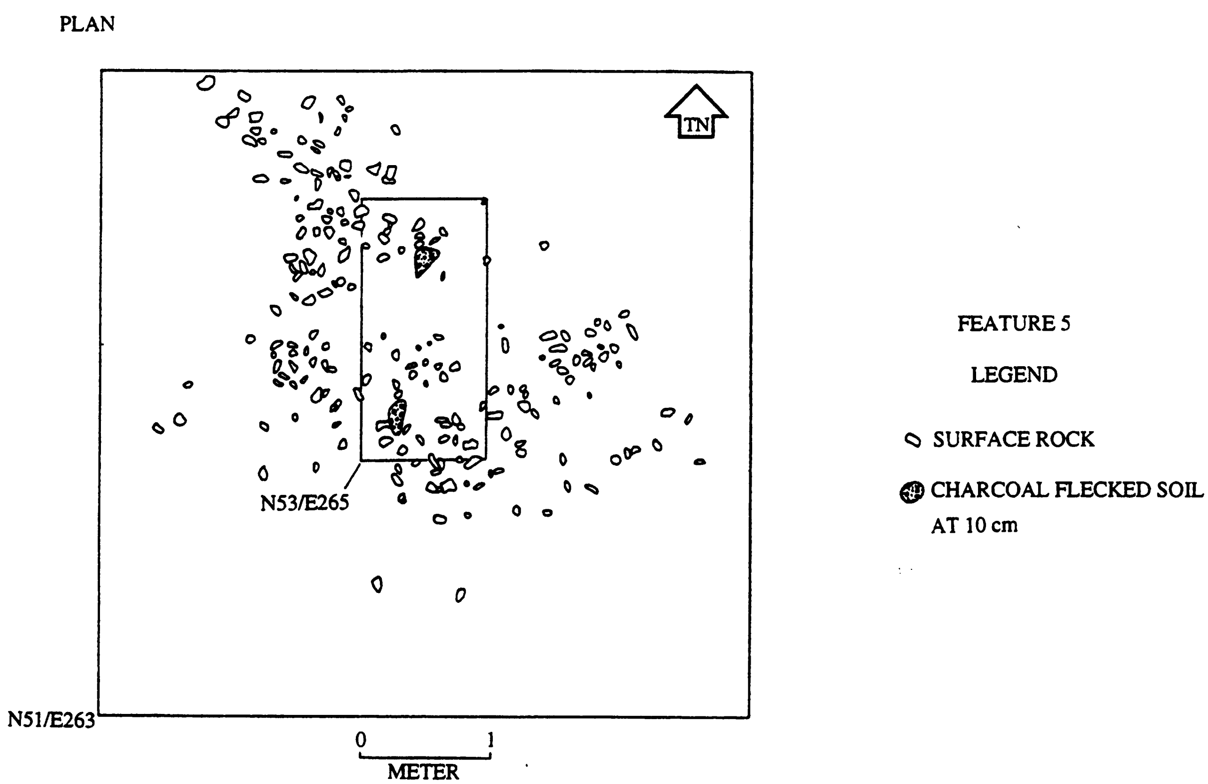


Figure 22. Informal Hearths at INY-1906, Locus 2.

Faunal remains also correlate with playa association and feature type. Only two Marana components yielded appreciable quantities of non-intrusive bone (INY-1816C and -1906H). Both are playa-associated components with features containing substantial quantities of seeds.

SUBSISTENCE-SETTLEMENT SUMMARY

The following section provides supporting evidence for the land-use pattern shifts outlined above, through tracking spatio-temporal changes in assemblage composition. Focusing largely on ground and battered stone tools, and floral and faunal remains, these data suggest several local changes in subsistence orientation. These changes are evaluated with regard to larger regional trends as outlined in Chapter 2.

DIACHRONIC TRENDS

Major shifts in the prehistoric use of the Volcanic Field are clearly illustrated by combining the chronologically segregated assemblages into four simple groups: quarries (lag and primary), off-quarry areas where assemblages are dominated by biface production, off-quarry milling areas, and "other" areas characterized by the presence of features or pottery sherds, but little else (Table 63). Early and Little Lake period components reflect short-term use of lag quarries and little exploitation of local subsistence resources. Of the 28 Early and Little Lake components, 75.0% are lag quarries, 25.0% are biface production areas; milling dominated assemblages are entirely absent. The emphasis on quarrying is further documented by the abundance of cores (Table 64). Marginal use of subsistence resources is evident in the low frequency of milling equipment, and by the near absence of hearths (Table 65), floral remains, and faunal remains.

Table 63. Frequency Distribution of Component Types Across Time.

Period	Quarry	Off-Quarry Biface Dominant	Off-Quarry Milling Dominant	Other[a]	Total
Early	16	5	-	-	21
Little Lake	5	2	-	-	7
Early/Middle Newberry	4	6	-	-	10
Late Newberry	2	20	1	-	23
Haiwee	2	3	3[b]	-	8
Marana	2	-	19	5	26
Total	31	36	23	5	95

NOTE: [a] - Features or sherds dominant; [b] - INY-3004/5I included here.

The combined Early Newberry and Middle Newberry components show a dramatic increase in the frequency of biface production areas relative to quarries, and a minor increase in the use of subsistence resources. Biface production components outnumber quarries (60.0% to 40.0%, Table 63), and the combined assemblage includes many more bifaces than cores (Table 64). The frequency of milling equipment relative to bifaces and cores increases to 5.7%, and the presence of some plant macrofossils indicate an increase in the use of seeds (see Feature 1 at INY-1824 Main-M). However, subsistence pursuits probably remained of secondary importance, judging from the absence or near-absence of milling-dominated assemblages, midden, faunal remains, and, except for INY-1824 Main-M, features, and floral remains.

Table 64. Frequency Distribution of Selected Artifacts Across Time.

Period	Cores	Bifaces	Milling Equipment	Total
Early	707	656	19	1382
Little Lake	231	250	7	488
Early/Middle Newberry	49	401	27	477
Late Newberry	132	712	59	903
Haiwee	84	106	37	227
Marana	11	20	234	265
Total	1214	2145	383	3742

NOTE: Projectile points and biface/points are included in the bifaces.

Off-quarry biface production components reach peak frequencies during the Late Newberry period (Table 63). The two quarries are both primary deposits, signaling the end of extensive lag deposit use, and the earliest milling dominated assemblage was encountered. The overall assemblage produced many more bifaces than cores (Table 64), and the frequency of milling equipment relative to bifaces and cores is slightly higher than in earlier periods (6.5%). Floral and faunal remains, features, and midden, however, still point to rather short-term specialized use.

Table 65. Frequency Distribution of Feature Types Across Time.

	Early	Little Lake	Early/Middle Newberry	Late Newberry	Haiwee	Marana	Total
Rock Rings	4[a]	-	-	-	-	-	4
Flaked Stone Concentration	1	-	-	-	-	1[c]	2
Hearths	-	1	1	1	3	29	35
Milling Clusters	-	-	-	-	-	8	8
Other	1[b]	-	-	-	-	1	2
Total	6	1	1	1	3	39	51

NOTE: [a] - includes a cleared circle at INY-3300A; [b] - Rock feature probably of historic origin; [c] - Chipped stone feature.

In the subsequent Haiwee period, quarrying is largely confined to major primary outcrops, but secondary reduction locations decline radically in number, indicating a much more restrictive land-use pattern than in the prior interval — one in which secondary reduction occurs in areas other than the Volcanic Field. Since many of the Late Newberry period secondary reduction locations display a modicum of subsistence-related activities, the decreased number of this type of component signals a decline in local subsistence exploitation in the Haiwee period. The minor increase in the number of off-quarry milling assemblage-dominated locations from the Late Newberry (n=1) to the Haiwee period (n=3) is not great enough to off-set this pattern. However, the relative increase in milling equipment (from 6.5% in the Late Newberry period to 16.3% in the Haiwee period, Table 64) foreshadows the Marana period pattern.

The Marana period is characterized by intensive use of local subsistence resources and virtual disregard for obsidian deposits. Quarries represent only 7.7% of the Marana period components (Table 63), biface production sites are entirely absent, while milling-dominated locations (73.1%) and isolated features (19.2%) flourish. Milling equipment dominates the tool assemblage (88.3%, Table 64). Features (Table 65), faunal remains, and plant macrofossils are at their highest; furthermore, several midden pockets exist, albeit in few locations (e.g., INY-1906H). Nonetheless, occupations still appear to have been short-term, focused on the exploitation of small seeds and, to a lesser extent, small mammals — a pattern entirely consistent with the local resource base (see below).

SPATIAL DISTRIBUTIONS

The spatial distribution of these components also reflects the diachronic shifts in land-use patterns outlined above. The vast majority of Early and Little Lake period components are in the northern half of the study area, associated with the obsidian lag deposits that occupy much of the rugged lands east of Sugarloaf Mountain (Map 9). The Early Newberry and Middle Newberry components (Map 10), occur at both lag quarries in the north (INY-4331, -4327, and -3004/5), and biface production/subsistence-oriented occupations in the central and southern portions of the study area (INY-1824 Main and -1984). All Middle Newberry components are in off-quarry contexts, compared to only three (42.9%) of the Early Newberry components. In contrast to earlier patterns, most Late Newberry components are in the southern half of the project area (Map 11), primarily around the edges of lowlands, or concentrated at primary deposits of Joshua Ridge obsidian.

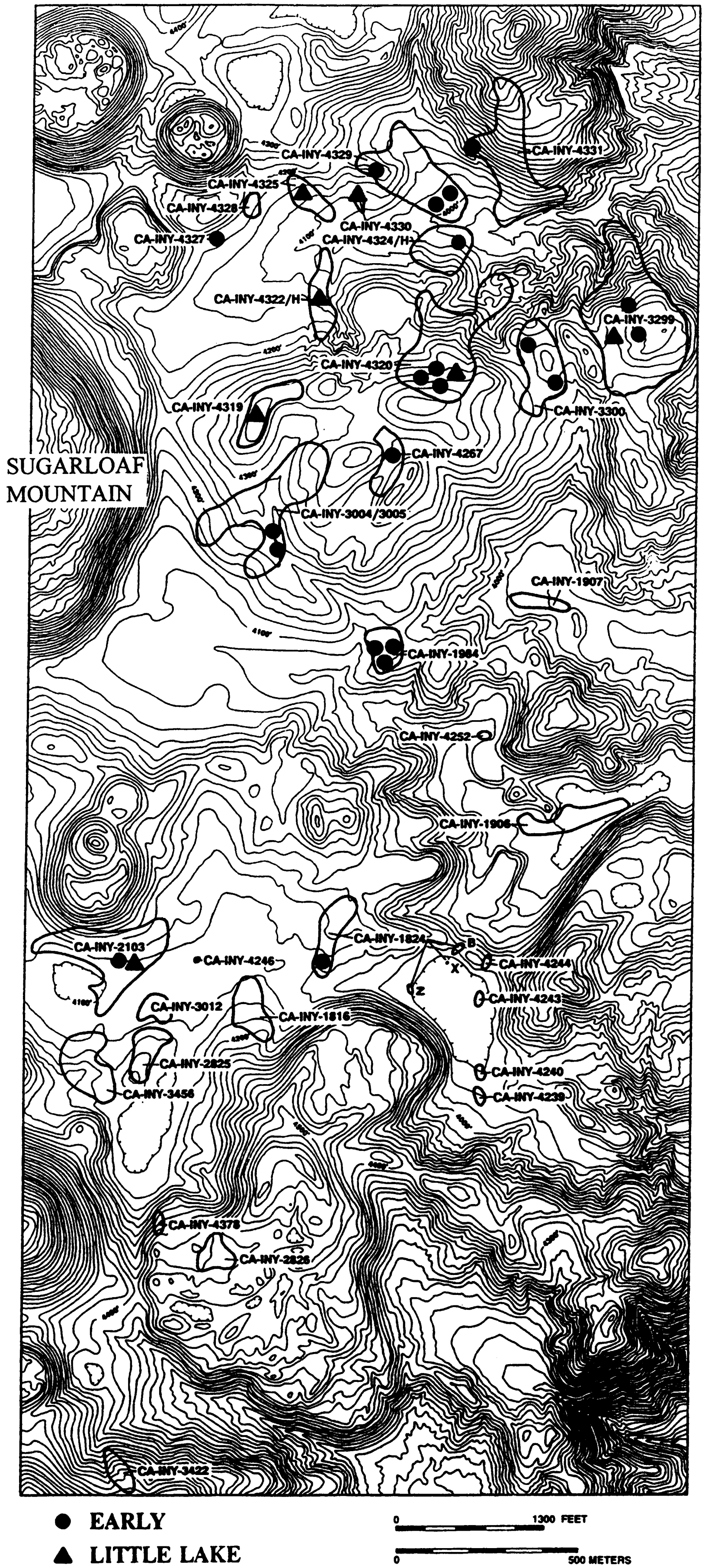
Intensification of seed use is clearly illustrated by the distribution of Marana and, to a lesser degree, Haiwee period components (Map 12). In addition to being concentrated along playa edges in the south, like in the Late Newberry period, feature/milling equipment concentrations are found among lag deposits in the north. The expansion of these types of components into areas not associated with playas indicates increasing use of more marginal areas, and provides further evidence of late period subsistence resource intensification.

GROUND AND BATTERED STONE ASSEMBLAGES

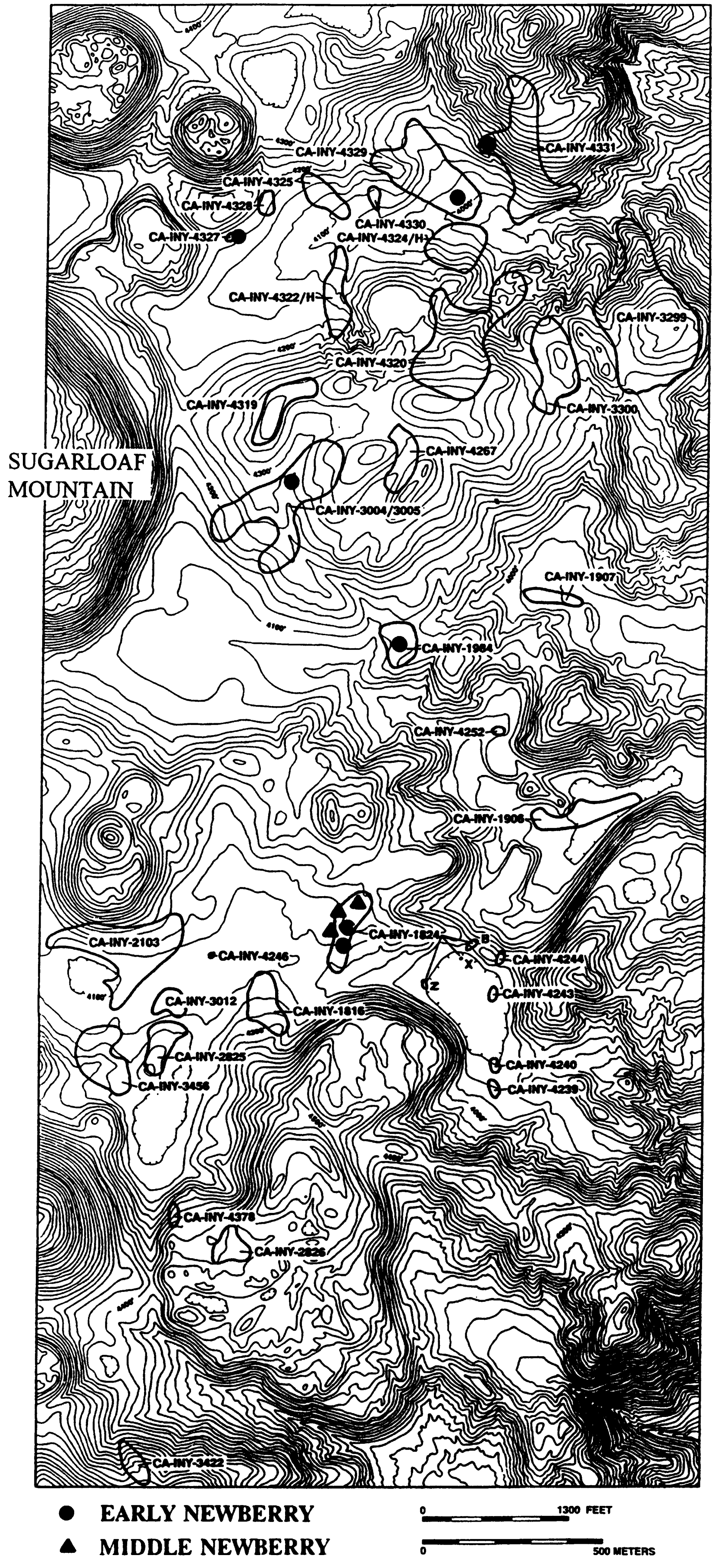
Milling equipment at Coso is summarized first without regard to chronology to familiarize the reader with the kinds of rock used, the kinds of equipment present, and the general forms of that equipment. Temporal patterns are then identified. Millingstones are discussed first, followed by handstones, and then non-obsidian cobble-cores.

Millingstones

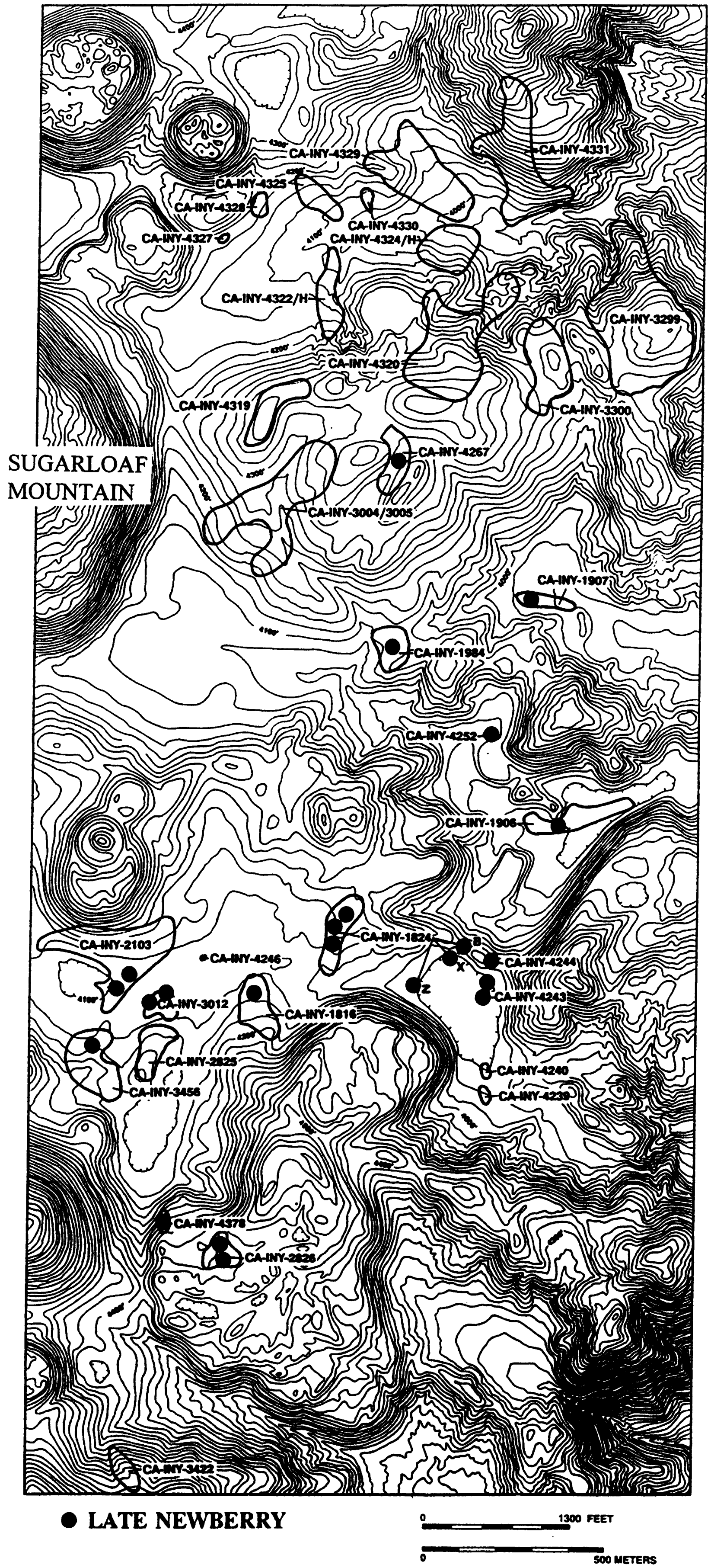
Nearly all milling equipment at Coso derived from local granite and rhyolite, the latter considerably softer and more susceptible to wear than the former. Consequently, strong relationships exist between material type, degree of wear, and millingstone thickness. Considering all granitic and rhyolite millingstones recovered, we see, first, that most ground surfaces on granitic implements are flat/irregular (75.2%; Table 66), followed distantly by slightly concave surfaces (18.8%, defined as $\leq$1.0 cm deep), then deeply concave surfaces (6.0%, defined as >1.0 cm deep). Rhyolite millingstones display a much higher incidence of slightly concave (52.1%) and deeply concave worn surfaces (18.6%), with flat/irregular surfaces reduced to secondary frequency (29.3%). For both materials, the depth of the ground surface correlates with artifact thickness. Of the granitic millingstones, blocks have the highest frequency of slightly or deeply concave surfaces (32.5%), followed by slabs (23.5%), then thin slabs (13.6%). This same trend exists among the rhyolitic millingstones: blocks have the highest frequency of deeply worn surfaces (33.3%), then slabs (20.6%), and, finally, thin slabs (7.3%). Wear type also correlates with material type and thickness (Table 67): simple polish tends to co-occur with flat/irregular wear, while deeper surfaces have a higher frequency of pecking with polish; polish in combination with pecking and striations is most prevalent on concave surfaces, particularly on rhyolite millingstones. In short, an equal amount of use is likely to produce both a deeper milling surface and more extensive wear patterns on a rhyolitic millingstone than on a granitic one. The point here is that different wear patterns on granite and rhyolite millingstones are not necessarily the result of different functions, but of inherent properties of the stone.



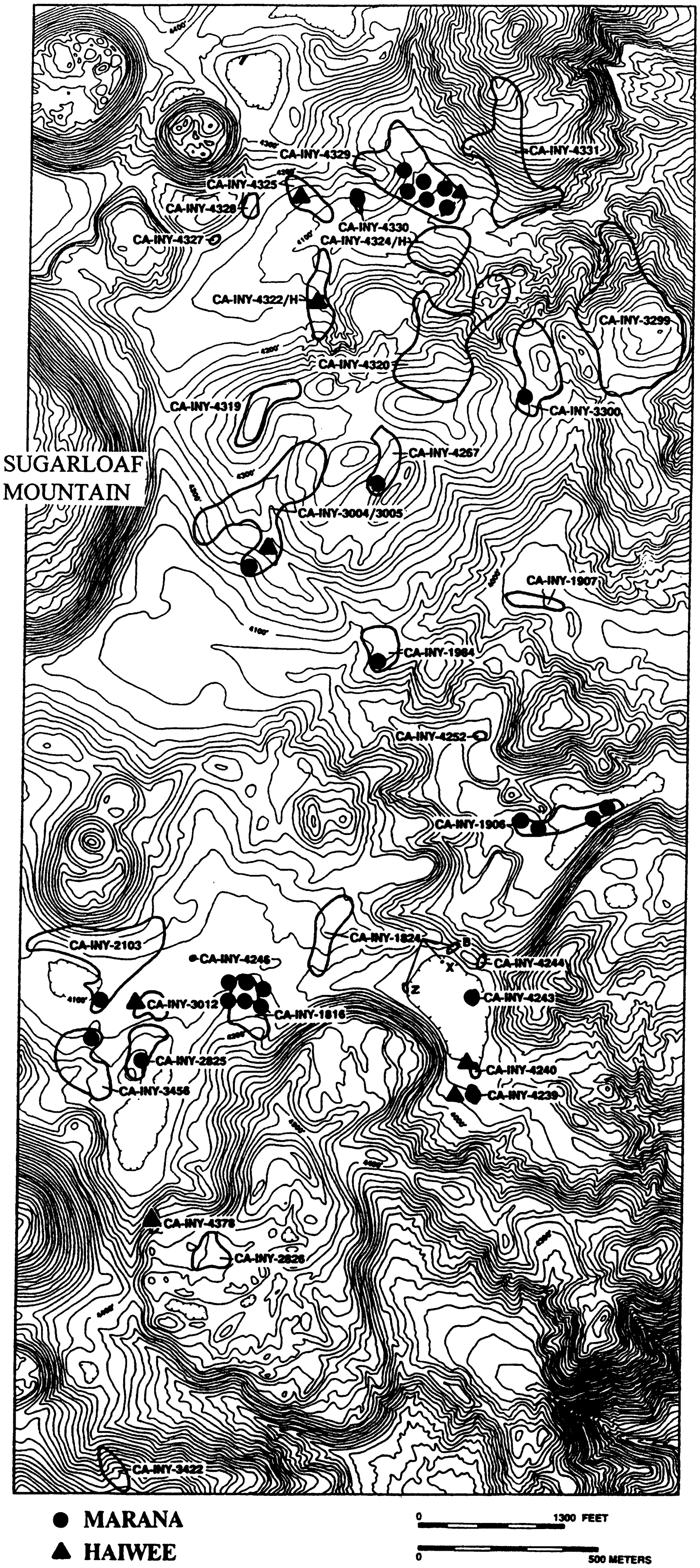
Map 9. Distribution of Early and Little Lake Period Components.



Map 10. Distribution of Early Newberry and Middle Newberry Period Components.



Map 11. Distribution of Late Newberry Period Components.



Map 12. Distribution of Haiwee and Marana Period Components.

Table 66. Millingstone Surface Configuration by Form.

	Thin	Slab	Block	Total
Granite				
Flat/Irregular	19	42	27	88
Slightly Concave	1	10	11	22
Deeply Concave	2	3	2	7
Total	22	55	40	117
Rhyolite				
Flat/Irregular	24	35	4	63
Slightly Concave	27	73	12	112
Deeply Concave	4	28	8	40
Total	55	136	24	215

Bifacial millingstones are rare irrespective of material (Table 68), accounting for 9.5% of the granitic and 15.8% of the rhyolitic ones, and their frequency changes little according to artifact form. Among bifacial rhyolitic millingstones, primary sides (the one side with the heaviest wear) show a stronger tendency to be more deeply worn (31.4% are deeply concave, 60.0% are slightly concave; Table 69) than is the case on the unifacial ones (15.7% deeply concave, 50.5% slightly concave), while the depth of wear on the secondary sides parallels that of the unifacial tools. Granite millingstones, in contrast, show equal frequencies of concave surfaces on bifacial (primary side) and unifacial forms, with flat/irregular surfaces prevalent on unifacial millingstones, as well as both sides of bifacial ones. These trends further suggest that concave surfaces developed from use rather than purposeful construction; otherwise, the apparent "discard" of a concave milling surface by using the opposite face would not have been as common as it was.

Table 67. Millingstone Surface Configuration by Wear Type.

	Polish	Polish, Pecking	Polish, Pecking, Striations	Total
Granite				
Flat/Irregular	89	13	4	106
Slightly Concave	10	14	-	24
Deeply Concave	3	4	-	7
Total	102	31	4	137
Rhyolite				
Flat/Irregular	68	10	3	81
Slightly Concave	89	46	5	140
Deeply Concave	19	25	2	46
Total	176	81	10	267

Other millingstone assemblage traits document diachronic trends suggestive of changing patterns of mobility and increasing intensification of plant resources. Basgall et al. (1988) have found that millingstone portability indices

Table 68. Millingstone Form by Bifacial and Unifacial Wear.

	Thin	Slab	Block	Total
Granite				
Biface	3	5	3	11
Uniface	18	50	37	105
Total	21	55	40	116
Rhyolite				
Biface	8	24	2	34
Uniface	47	112	22	181
Total	55	136	24	215

seem to monitor differing degrees of residential mobility (see Chapter 2). In their Fort Irwin study, for example, thin slab millingstones exhibiting heavy wear were often associated with expansive settlement systems, probably indicating that the thin slabs were used and carried for extended periods of time. In partial contrast to the trends documented by Basgall et al. (1988), at Coso thin slabs are scarce, and they tend to have flat surfaces. As indicated in Table 70, the use of thin slabs (less than 6.0 cm thick) decreases dramatically through time, and blocks (greater than 13.0 cm thick) are in greatest use during the Marana period. Thin slabs account for 33.3% of the Early millingstones, rise to their highest at 52.9% in the Early/Middle Newberry period, and decline in subsequent periods to 39.1% in the Late Newberry, 27.8% in the Haiwee, and 17.6% in the Marana period. Block millingstones outnumber thin slabs only in the Marana period, but it is the thicker millingstones that have heavier, i.e. relatively deeper, wear. Given the increasing prevalence of thick millingstones late in time, and the tendency for deeper wear surfaces to occur on thicker millingstones, it follows that wear depth should also show an increase over time, and data bear this out (Table 71). Among the rhyolite sample, the frequency of pre-Marana millingstones with slightly or deeply concave surfaces figures to 58.1% (ranging from 41.6% to 75.0% depending on period) compared to 71.6% of the Marana rhyolite millingstones. Granitic millingstones adhere to this pattern, but due to material hardness, the difference is less evident — 18.2% of the pre-Marana ones are slightly or deeply concave, compared to 25.4% of the Marana ones.

Table 69. Millingstone Surface Configuration by Bifacial and Unifacial Wear.

	Flat/Irregular	Slightly Concave	Deeply Concave	Total
Granite				
Uniface	83	22	6	111
Biface Primary	10	2	1	13
Biface Secondary	13	-	-	13
Total	106	24	7	137
Rhyolite				
Uniface	67	100	31	198
Biface Primary	3	21	11	35
Biface Secondary	11	19	4	34
Total	81	140	46	267

Table 70. Millingstone Attributes Across Time.

	Early	Little Lake	Early/Middle Newberry	Late Newberry	Haiwee	Marana	Total
Granite							
Thin	4	-	5	2	1	4	16
Slab	2	-	2	3	-	33	40
Block	1	-	-	1	-	21	23
Total	7	-	7	6	1	58	79
Rhyolite							
Thin	1	-	4	7	4	17	33
Slab	7	5	6	4	11	46	79
Block	-	-	-	2	2	7	11
Total	8	5	10	13	17	70	123
Dike							
Thin	-	-	-	-	-	2	2
Slab	-	-	-	1	-	6	7
Block	-	-	-	2	-	-	2
Total	-	-	-	3	-	8	11
Basalt							
Thin	-	-	-	-	-	2	2
Slab	-	-	-	1	-	2	3
Block	-	-	-	-	-	2	2
Total	-	-	-	1	-	6	7
All							
Thin	5	-	9	9	5	25	53
Slab	9	5	8	9	11	87	129
Block	1	-	-	5	2	30	38
Total	15	5	17	23	18	142	220

NOTE: Indeterminate types not included.

Two possible explanations for the divergent Fort Irwin and Coso patterns readily come to mind. First, the two ends of the spectrum could represent separate functions. For example, thin-flat millingstones could have been carried to distant seed patches for light hulling (producing little wear), while thick concave forms could have been placed near residential bases where more intensive pounding and grinding took place. Because there appears to have been a progressive change in the mix of millingstone forms used over time at Coso, it appears more likely that differences in wear might have simply resulted from longer or shorter durations of use. Rather than pecking a surface to purposefully create a concavity, a millingstone used for an extended period of time would have required pecking to sharpen a surface smoothed over by heavy use. If this were the case, thinner objects may have been broken relatively early in their use-life, often prior to developing roughed-up concave surfaces. Partial support for this notion is gained through an assessment of fragment type according to artifact form (Table 72). Some 75.0% of the rhyolite blocks are whole or nearly whole, compared to 19.1% of the slabs and 5.5% of the thin slabs. This general trend applies to the granitic sample, though the tendency for overall completeness is higher due to granite's superior strength compared to rhyolite: 87.5% of the granite blocks are whole or nearly whole, compared to 76.4% slabs, but only 27.3% of the granitic thin slabs.

Table 71. Millingstone Surface Configuration Across Time.

	Early	Little Lake	Early/Middle Newberry	Late Newberry	Haiwee	Marana	Total
Granite							
Flat/Irregular	6	-	7	4	1	47	65
Slightly Concave	1	-	1	1	-	14	17
Deeply Concave	-	-	-	1	-	2	3
Total	7	-	8	6	1	63	85
Rhyolite							
Flat/Irregular	4	2	7	5	8	25	51
Slightly Concave	2	6	1	6	6	50	71
Deeply Concave	4	-	4	3	4	13	28
Total	10	8	12	14	18	88	150
All							
Flat/Irregular	10	2	14	9	9	72	116
Slightly Concave	3	6	2	7	6	64	88
Deeply Concave	4	-	4	4	4	15	31
Total	17	8	20	20	19	151	235

NOTE: Other materials not included.

Although few Coso millingstones show clear evidence of long-term curation, there seems to be a tendency for pre-Marana peoples to select objects suitable for at least short-term transport. Such a strategy is consistent with an opportunistic approach to seed gathering whereby portable millingstones easily carried but prone to breakage were moved to ripening seed patches, and used with little concern for reuse in the future. The Marana pattern, in contrast, is characterized by a more focused approach to seed gathering, reflected by numerous clusters of milling equipment distributed across the landscape. In several instances, block millingstones were moved to known areas of high productivity, as if individuals were fully anticipating return visits to the same location. Despite the greater short-term effort required to transport block millingstones, it was apparently considered a worthwhile endeavor by people heavily dependent on seeds.

Table 72. Millingstone Form by Condition.

	Thin	Slab	Block	Total
Granite				
Whole	4	31	30	65
Near Whole	2	11	5	18
Margin	7	12	4	23
Interior	9	1	1	11
Total	22	55	40	117
Rhyolite				
Whole	1	15	11	27
Near Whole	2	11	7	20
Margin	28	76	5	109
Interior	24	34	1	59
Total	55	136	24	215

Handstones

Like the millingstones, rhyolite and granite are the prevalent materials for handstones, but basalt makes an increased contribution (Table 73). The frequency of bifacial wear appears dependent on material type, showing a consistent increase from rhyolite (13.4%) to granite (26.3%), and finally basalt (54.2%). Chronological change in these relationships is difficult to measure due to the small number of items from any particular time period (Table 74). Comparisons between Marana and pre-Marana assemblages, however, show relatively even frequencies of bifacial items (21.2% and 22.9%, combined material types), as well as the same rough mix of the three material types.

Table 73. Handstone Wear by Material Type.

	Granite	Rhyolite	Basalt	Total
Flat				
Polish	22	29	6	57
Polish, pecking, striations	2	4	-	6
Total	24	33	6	63
Slightly Convex				
Polish	30	44	10	84
Polish, pecking, striations	6	18	7	31
Total	36	62	17	115
Convex				
Polish	7	4	2	13
Polish, pecking, striations	1	4	2	7
Total	8	8	4	20
Rounded				
Polish	4	5	4	13
Polish, pecking, striations	-	-	2	2
Total	4	5	6	15
Uniface	42	84	11	137
Biface	15	13	13	41
Total	57	97	24	178

Most rhyolite and granitic handstones have slightly convex and flat grinding surfaces, followed by fewer with convex or rounded faces (Table 73). Basalt handstones follow the same pattern but have a higher frequency of rounded surfaces. Simple polish is the dominant wear type, followed by some combination of polish, pecking, and/or striations (multiple wear types were collapsed into a single category to increase sample size). Wear other than just polish occurs less frequently on granitic than on other types of handstones, probably due to its hardness. Secondary wear is much more prevalent on basalt and granitic handstones than rhyolitic ones, with edge grinding and battering observed more frequently than edge flaking (Table 75). Basalt and rhyolitic handstones rarely were formally shaped, while this phenomenon is slightly more common on granitic ones. Finally, whole or nearly whole handstones are common regardless of material type.

Table 74. Frequency of Unifacial and Bifacial Handstones Across Time.

	Early	Little Lake	Early/Middle Newberry	Late Newberry	Haiwee	Marana	Total
Granite							
Uniface	2	1	1	5	1	21	31
Biface	1	1	-	2	-	7	11
Total	3	2	1	7	1	28	42
Rhyolite							
Uniface	-	-	2	9	6	27	44
Biface	-	-	-	2	-	6	8
Total	-	-	2	11	6	33	52
Basalt							
Uniface	-	-	-	-	-	4	4
Biface	-	-	-	1	1	1	3
Total	-	-	-	1	1	5	7
All							
Uniface	2	1	3	14	7	52	79
Biface	1	1	-	5	1	14	22
Total	3	2	3	19	8	66	101

NOTE: Other materials not included.

Table 75. Handstone Shaping, Secondary Wear, and Condition by Material Type.

	Granite	Rhyolite	Basalt	Total
Shaping				
Shaped	8	3	2	13
Unshaped	42	89	20	151
Total	50	92	22	164
Secondary Wear				
Edge Batter	5	-	4	9
Edge Flaking	5	-	-	5
Edge Grinding	9	8	4	21
None	36	84	14	134
Total	55	92	22	169
Fragment Type				
Whole	33	57	16	106
Near Whole	12	15	1	28
Margin	8	19	3	30
End	4	2	2	8
Total	57	93	22	172

NOTE: Indeterminate objects and other materials not included.

The correlation between surface configuration and wear type remains the most important pattern documented. Flat handstones almost always have simple polish, perhaps used primarily on flat millingstones. When working surfaces become more convex, also corresponding to the millingstone data, more rigorous grinding is reflected by the presence of striations and pecking (Table 73). This trend is most evident on basalt and rhyolite items.

Given that millingstone wear depth increased during the Marana period, one might expect a corresponding increase in the frequency of convex handstones, but this is true for only some material types (Table 76). Marana granitic handstones show more convex surfaces than pre-Marana ones, (67.7% to 58.8%), but the opposite is true for rhyolite handstones (55.3% to 68.2%). These data, when combined with observed similarities in material selection and bifacial use over time (see Table 74), suggest little change in handstone function over time. Notwithstanding differences in overall abundance, and sampling problems associated with pre-Marana assemblages, it appears that basalt and granitic handstones were used (and presumably curated) for longer periods of time than rhyolitic ones, no doubt indicating a greater preference for these material types (see Bostwick and Burton 1993). The former commonly exhibit bifacial wear, secondary damage and, in the case of granite, formal shaping. Rhyolite handstones rarely showed these attributes, the material is more friable but more easily shaped, characteristics favoring more expedient, casual use.

Table 76. Handstone Surface Configuration Across Time.

	Early	Little Lake	Early/Middle Newberry	Late Newberry	Haiwee	Marana	Total
Granite							
Flat	1	1	1	4	-	10	17
Slight Convex	-	-	-	4	1	19	24
Convex	3	2	-	-	-	2	7
Total	4	3	1	8	1	31	48
Rhyolite							
Flat	-	-	-	5	2	17	24
Slight Convex	-	-	2	9	4	19	34
Convex	-	-	-	-	-	2	2
Total	-	-	2	14	6	38	60
Basalt							
Flat	-	-	-	1	-	-	1
Slight Convex	-	-	-	1	1	5	7
Convex	-	-	-	-	-	-	-
Total	-	-	-	2	1	5	8

NOTE: Rounded and indeterminate specimens not included.

Non-Obsidian Cobble-Cores

Cobble-cores were recovered in most contexts, but the majority came from Early and Little Lake period lag quarries, and Marana period milling stations. Given the lack of plant processing in the former contexts, and the lack of stone working in the latter, a good deal of functional variability is expected to exist in this artifact class. These implements likely were used as hammerstones in flaked stone manufacture at the early lag quarries, and for processing vegetal material and fashioning and/or maintaining milling equipment during the late period. These divergent uses should be apparent by differing proportions of the types of rock selected, and by the types of use-related wear present.

The mix of materials used for cobble-cores differs markedly from the milling equipment, and evidently corresponded with the need for tools more resistant to fracture. Granite (47.1%) and dike rock (40.7%) occur in high quantities, followed by basalt (5.8%), with few of rhyolite or assorted other materials (Table 77). Basalt, though not abundant, must have been a favored material, given that such pieces were probably carried into the study area, while other material types could be locally obtained. Tracking the distribution of material types across time reveals the persistence of granite and dike rock in all but Late Newberry contexts. Granite and dike rock occur in similar high proportions in the Early and Little Lake components combined, at 46.8% and 44.3% respectively; while granite cobble-cores become more abundant than dike rock ones in Marana contexts (53.8% and 38.5%, respectively). It is also noteworthy that basalt is largely restricted to stone working contexts, while granite and dike rock are found in all settings, suggesting various uses throughout time.

Table 77. Non-Obsidian Cobble-Core Material Types Across Time.

	Early	Little Lake	Early/Middle Newberry	Late Newberry	Haiwee	Marana	Total
Granite	30	7	9	7	7	21	81
Rhyolite	-	-	-	4	1	2	7
Basalt	4	-	1	4	-	1	10
Dike Rock	16	19	11	6	3	15	70
Other	-	3	-	-	1	-	4
Total	50	29	21	21	12	39	172

The changing functional role of these tools can be monitored in part by intensity (i.e., heavy, equivocal, no wear), and types of use-wear over time (Table 78). Early period deposits show a disproportionately high frequency of items with little or no observable wear (74.0%), while Marana period contexts have a much lower frequency of these items (29.7%). Intervening time periods show variable relationships, some of which are dependent on material, but about 40% of dike rock and granite cobble-cores in the Little Lake through Haiwee periods have heavy wear. Irrespective of time, basalt cobble-cores rarely have equivocal or no wear (20.0%), reflecting a higher degree of tool curation.

Analysis of the implements with heavy use-related wear indicates that the vast majority of granitic tools in pre-Haiwee period deposits exhibit battering (83.3%, Table 79). Only 53.8% of the combined Haiwee-Marana sample have this type of damage, most of the balance displaying grinding. The same pattern holds for dike rock cobble-cores, with battering dominant until Late Newberry times, at which point, edge flaking and grinding gain importance.

These data indicate that non-obsidian cobble-cores were composed of materials purposefully chosen for durability. Those in relatively early settings are usually at lag quarries and appear to have been used as hammers for working the obsidian. Beginning in Late Newberry times, but reaching peak proportions during the Marana period, non-obsidian cobble-cores show more variable patterns of use: heavy wear is found on a greater number of objects (reflecting more intensive use?), and the incidence of grinding and edge flaking document activities not associated with the reduction of obsidian, but with vegetal processing.

FLORAL REMAINS

Of the 12 components with identifiable floral remains (see Tables 20, 39, and 56), only six produced five or more seeds (Table 80), one from a Middle Newberry feature and five from Marana period features. Of the five economic plant complexes defined for eastern California (greens and shoots, roots and tubers, seeds, fruits and

Table 78. Non-Obsidian Cobble-Core Wear Intensity Across Time.

	Early	Little Lake	Early/Middle Newberry	Late Newberry	Haiwee	Marana	Total
Granite							
Heavy	7	3	3	5	1	12	31
Equivocal	5	3	1	-	1	2	12
None	18	1	5	2	5	7	38
Total	30	7	9	7	7	21	81
Dike Rock							
Heavy	5	9	2	3	1	13	33
Equivocal	-	4	3	1	-	-	8
None	11	6	6	2	2	2	29
Total	16	19	11	6	3	15	70
Basalt							
Heavy	1	-	-	4	-	1	6
Equivocal	-	-	-	-	-	-	-
None	3	-	1	-	-	-	4
Total	4	-	1	4	-	1	10

berries, and tree crops), only small seeds and one fruit/berry taxon (desert tomato) were recovered. Notwithstanding problems associated with archaeological visibility (e.g., greens and shoots not preserving in the archaeological record), these findings are entirely consistent with the environmental conditions of the Volcanic Field.

Table 79. Non-Obsidian Cobble-Core Wear Type Across Time.

	Early	Little Lake	Early/Middle Newberry	Late Newberry	Haiwee	Marana	Total
Granite							
Battering	6	3	3	3	-	7	22
Edge Flaking	-	-	-	1	-	-	1
Grinding	-	-	-	1	1	4	6
Other	1	-	-	-	-	1	2
Total	7	3	3	5	1	12	31
Dike Rock							
Battering	4	8	2	-	-	8	22
Edge Flaking	-	1	-	2	-	3	6
Grinding	1	-	-	1	1	2	5
Total	5	9	2	3	1	13	33

Seasonal availability of most of these foods ranges from spring through summer, while some extend into the fall (Figure 23). Season-specific estimates can be offered from some individual features by considering the

Table 80. Plant Macrofossils from Select Features.

	Middle Newberry	Marana					
	1824 Main M F-1	4243 B F-1/2	1816 C F-2	1906 F F-9	1906 H F-11	1906 H F-10	Total
Grasses							
Oryzopsis sp. (Ricegrass)	9	>5500	22	8	-	-	>5539
Stipa sp. (Needlegrass)	-	1	-	-	-	-	1
Poaceae (Grass Family)	2	2	2	-	5	-	11
Herbs							
Boraginaceae (Borage Family)	8	-	-	2	9	1	20
Chenopodium sp. (Goosefoot)	-	20	-	4	-	-	24
Descurainia sp. (Tansy mustard)	2	2	-	-	10	-	14
Mentzelia sp. (Blazing star)	9	7	2	24	80	2	124
Salvia columbariae (Chia)	-	-	3	27	-	-	30
Shrubs							
Malvaceae (Mallow Family)	-	1	3	-	-	-	4
Berries							
Lycium sp. (Desert tomato)	11	-	6	-	-	-	17
Unknown	14	7	6	2	-	3	32
Total	55	>5540	44	67	104	6	>5816

combination of taxa recovered. Two Marana period features (Feature 1/2 at INY-4243B and Feature 9 at INY-1906F), for example, had a co-occurrence of ricegrass, goosefoot, and blazing star seeds, but no desert tomato. Summer use is suggested, assuming they were collected together or at the same time. Feature 1 at INY-1824 Main-M and Feature 2 at INY-1816C, in contrast, both contain desert tomato in addition to ricegrass and other small herbaceous seeds (not including goosefoot), probably indicating late spring/early summer use. The other features, lacking either desert tomato or goosefoot, probably represent spring/summer collection.

All seeds recovered are mentioned in local ethnobotanical studies, particularly ricegrass, blazing star, chia, tansy mustard, and desert tomato. As discussed in Chapter 4, ricegrass seeds were either detached from the plants with seed beaters and baskets at individual seed patches, or separated after the entire plants had been cut and transported to a base camp. Following collection, most grasses were winnowed and parched, and then ground into flour and eaten with no further preparation, or used in stews, gruels, and breads (Delacorte 1990; Zigmond 1981). Blazing star, chia, and tansy mustard were collected with a seed beater and basket, and after parching and grinding, chia and tansy mustard were mixed with water into a beverage, while blazing star was turned into a paste like peanut butter (Zigmond 1981). Desert tomato fruit was eaten raw, squeezed for juice, or pulverized into a paste.

The plant remains provide additional support for the idea that local seed exploitation increased in the late period, but little can be said about the nature of pre-Marana seed exploitation patterns, given the limited data available. Judging from the mix of resources recovered from the one Middle Newberry sample, it appears that at least some plants used during the Marana period were also used earlier. The difference between pre-Marana and Marana period strategies, however, is probably one of opportunistic gathering earlier in time (i.e., if seeds were ripe when obsidian deposits were being exploited, they were harvested) as opposed to the Marana period approach where local crops were carefully monitored and maximally exploited. The former approach is consistent with the Middle Newberry assemblage which shows a high frequency of desert tomato which is available early in the year (cooler) and requires little processing. Given the single sample at our disposal, such an interpretation is, however, largely conjecture.

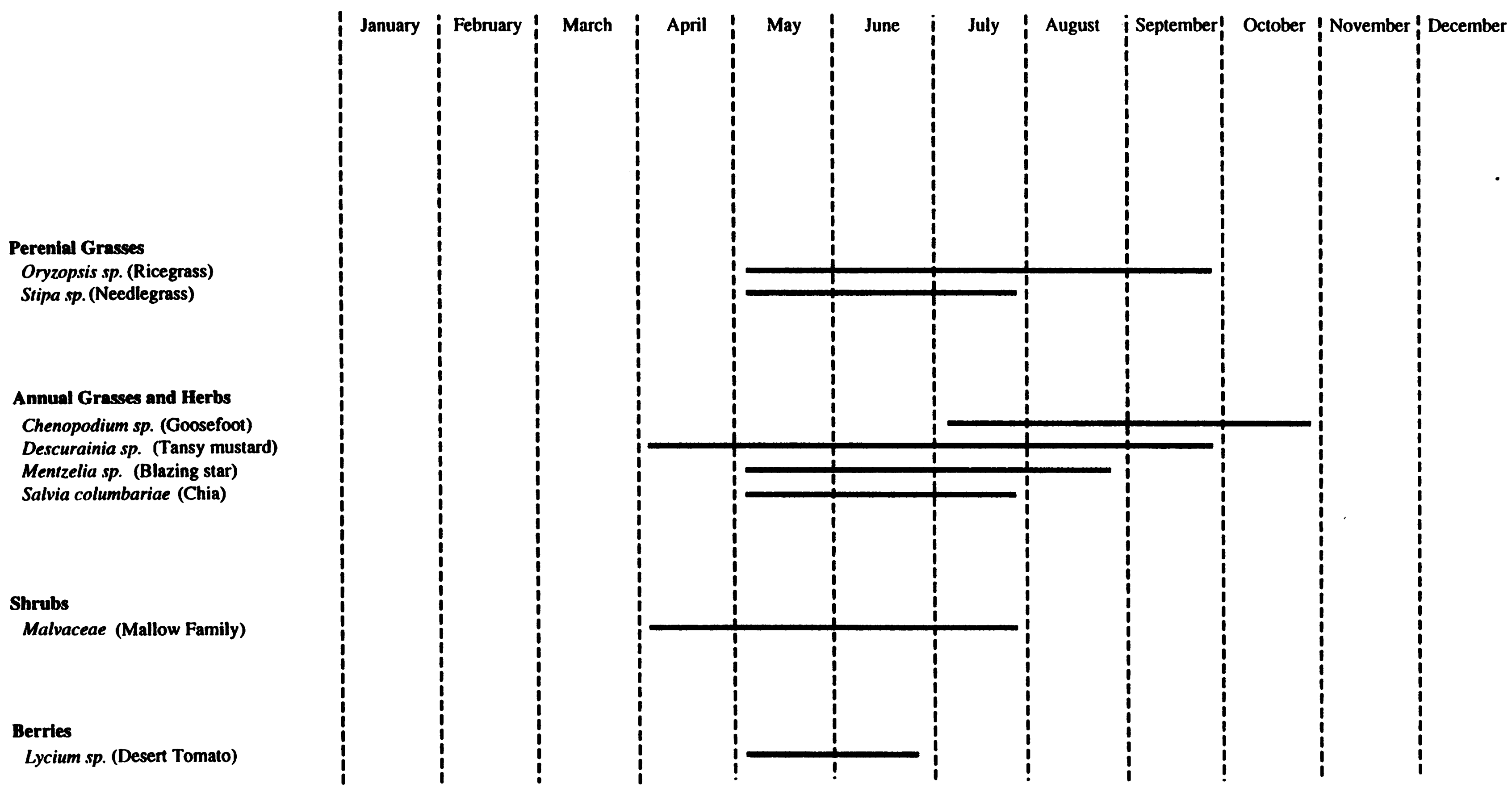


Figure 23. Seasonal Availability of Recovered Seeds.

FAUNAL REMAINS

Faunal remains, like seeds, are rare in all but a few Marana period deposits (Table 81), making it difficult to compare the nature of animal exploitation patterns over time. The pre-Marana collection consists of two jack rabbit bones (neither burned) and eight unidentifiable small mammal fragments (none burned). The Marana assemblage comes from features and includes two jack rabbit bones (both burnt) and 106 unidentifiable small mammal fragments, the majority burnt. Large mammal remains are restricted to a single unidentifiable fragment at INY-4267.

Table 81. Faunal Remains from Components.

	Lepus		Small Mammal		Large Mammal		Intrusive/	
	Burnt	Unburnt	Burnt	Unburnt	Burnt	Unburnt	Indeterminate	Total
Early								
1984B*	-	1	-	-	-	-	-	1
3299A*	-	-	-	-	-	-	3	3
Total	-	1	-	-	-	-	3	4
Little Lake								
3299A*	-	-	-	-	-	-	3	3
4330A	-	-	-	3	-	-	-	3
Total	-	-	-	3	-	-	3	6
Newberry								
1906B	-	1	-	1	-	-	-	2
1907A	-	-	-	1	-	-	-	1
1984A	-	-	-	1	-	-	-	1
1984B*	-	1	-	-	-	-	-	1
4244A	-	-	-	2	-	-	-	2
4329K	-	-	-	-	-	-	2	2
Total	-	2	-	5	-	-	2	9
Marana								
1816C	-	-	-	-	-	-	53	53
1906F*	-	-	36	4	-	-	8[a]	48
1906H	2	-	37	14	-	-	105	158
4267A	-	-	1	2	1	-	10	14
4329A	-	-	-	-	-	-	4	4
4329D	-	-	7	-	-	-	-	7
4329N	-	-	3	1	-	-	1	5
4329W	-	-	-	1	-	-	-	1
Total	2	-	84	22	1	-	181	290

NOTE: Intrusive/indeterminant includes bones that are obviously modern and those that could not be classified as large or small mammal. * - dual period assignment; [a] - one sample missing (8 pieces).

To determine the influence of soil acidity on faunal remains, pH tests were conducted on a series of soil samples from INY-1906H, where bone was abundant, and INY-4329E, where it was not. Two samples from the former yielded readings of 6.2-6.4 (slightly acidic) and 6.8 (very slightly acidic), while three samples from the other location produced 6.8 (very slightly acidic), 6.8-7.0 (very slightly acidic to very slightly alkaline), and 7.0-7.2 (very slightly alkaline). The overall low level of acidity observed, combined with the correlation between slightly higher levels of acidity and the abundant presence of bone, suggests the scarcity of faunal remains is not a function of poor preservation. We conclude, therefore that game animals such as pronghorn and bighorn sheep were rarely hunted and consumed during forays into the Volcanic Field. Rather, it seems that local subsistence resources of all kinds were of secondary importance until the Marana period, at which time exploitation of small seeds and, to a lesser extent, rabbits and smaller game, became the primary reason for visiting the area.

DISCUSSION

The review of subsistence-settlement pattern studies from areas surrounding the Coso Volcanic Field presented in Chapter 2 indicates that adaptive strategies were largely consistent across much of eastern California during the early Holocene. Most Early sites investigated produce assemblages indicative of high degrees of residential mobility, minimal use of seed resources, and a probable emphasis on hunting large and small game animals. With the possible exception of the Stahl site (see also Delacorte 1988), Pinto/Little Lake period adaptations appear to be quite similar with respect to mobility and hunting strategies, but differ from the Early period by showing an increased use of milling equipment, a development thought by many to reflect increased dependence on seed resources in response to declining mid-Holocene environmental conditions.

Within Owens Valley, Gypsum/Newberry settlement systems remained mobile, but appear to have been less expansive and more regularized than in earlier times. Unlike the Mojave Desert, where numerous short-term occupations were used to take advantage of a variety of resource zones, Owens Valley populations established fewer seasonal residential bases (probably spending summers near Long Valley and winters in southern Owens and Rose valleys), from which logistically organized groups would set out to various resource patches to obtain materials necessary to support the residential base. By Haiwee times, the Owens and Rose valley areas were characterized by increased sedentism, territoriality, and sociopolitical complexity — phenomena made possible by the more intensive exploitation of progressively smaller pieces of land, as well as a more diverse use of areas previously used almost exclusively for hunting (e.g., Sierra Nevada, White Mountains). Although the general pattern appears to have continued into the Marana period in Owens Valley, permanent or semi-permanent residential bases rarely developed in surrounding areas. Instead, most groups required the use of numerous short-term residential base camps to exploit the various resource zones within their respective territories.

Findings from the current study, although representing only a small part of the overall land-use systems in operation during the prehistoric past, are largely consistent with the various adaptive strategies outlined above. Early assemblages, lacking milling equipment and other subsistence-related material, seem to represent only quick visits to the Volcanic Field. The Little Lake data, like in most other areas, reflect a pattern not dissimilar to the Early period. Although quarries remain the dominant manifestation, off-quarry biface production loci increase in relative proportion, perhaps indicating some kind of subsistence-settlement shift not clearly delineated by the data currently in hand. The Newberry period, previously viewed as a single entity, appears to have had a great deal of internal variability. Early and Middle Newberry period materials within the Volcanic Field seem to represent a transitional phase between the early emphasis on short-term quarry use and the Late Newberry focus on the production of bifaces. Most Early Newberry period components are associated with lag quarries in the northern half of the study area. All three Middle Newberry components lie to the south in off-quarry contexts where biface manufacture and limited subsistence pursuits took place.

In addition to the increased production of bifaces, many undoubtedly for exchange (see the following chapter), Late Newberry quarrying shifts to the use of primary deposits. Given the subsistence-settlement models developed for the Owens Valley/Rose Valley area, these patterns may reflect logistically organized groups visiting the Volcanic Field from base camps in Rose Valley, similar in organizational structure to those who traveled to the Sierra Nevada from the Lubkin Creek site (INY-30) to obtain pinyon, marmots, and mountain sheep. Several of the biface production sites are highly specialized and are therefore consistent with such a scenario. Others also include a small amount of subsistence-related materials and may reflect opportunistic pursuits by the stone workers, or more diversified social groups originating from desert areas to the east and south.

Evidence for Haiwee period use of the Volcanic Field is meager at best, largely due to a sudden decrease in the number of biface production sites. In contrast to the Late Newberry pattern, it appears that only a few high quality seams of obsidian were exploited, with secondary reduction occurring at nearby residential areas like Coso Junction Ranch (INY-2284) and the Rose Spring site (INY-372). By the Marana period, the Volcanic Field was intensively used for its small seed resources. As originally hypothesized by Bettinger and Baumhoff (1982) and Bettinger (1991), this latter development clearly demonstrates not only a more intensive use of small seeds late in time, but also a late period expansion into areas under-used by earlier subsistence-settlement systems.

CHAPTER 8: COSO OBSIDIAN EXCHANGE PATTERNS

The goals of this chapter are to develop a sense of the relative and perhaps absolute amount of Coso glass that found its way into prehistoric sites in surrounding areas, in order to better appreciate the breadth and depth of the Coso glass production and exchange system; to document Coso glass consumption patterns outside the procurement zone, assessing their influence on production activities at the source; and, assuming that exchange networks are responsible in part for the prehistoric distribution of Coso glass, to identify the prevalent directions of movement so that mechanisms of exchange and interaction can be isolated. To assess the time-space distribution of Coso obsidian necessitated reviewing hydration and sourcing information from numerous archaeological projects laying within a fairly expansive area. Special effort was expended in trying to trace the prevalence of Coso glass outward, roughly in cardinal directions, from the source. Given the varying intensity and types of archaeological investigations throughout southern California, it was in some instances difficult to differentiate areas where data were absent, from areas where Coso glass does not occur in prehistoric contexts. Notwithstanding the difficulties inherent in trying to draw fairly standardized observations from research presented by different scholars with different interests, a fairly reliable picture of the quantity and form of Coso obsidian exists for many outlying areas.

Two large-scale projects provide evidence for the quantity of Coso obsidian prehistorically carried into lands laying to the east (Map 2): excavations at some 60 sites in the Mojave B Range of China Lake Naval Air Weapons Station (Bouey and Mikkelsen 1989), and the Fort Irwin Archaeological Project (excavations at over 100 locations by Wirth and Associates, followed by Far Western Anthropological Research Group, Inc.). Excavations at the Rose Spring site (INY-372, Locus 1 [Lanning 1963; Yohe 1992]) and the Coso Junction Ranch site (INY-2284 [Allen 1986]) provide evidence of the intensity of stone-working activities at two major habitation sites just west of the Volcanic Field, occupied during the Newberry and Haiwee periods. In tracing the distribution of Coso obsidian to the north, data from the Contel Project (Delacorte and McGuire 1993) are useful, supplemented by information from the Lubkin Creek site (INY-30 [Basgall and McGuire 1988]). The former project involved excavations at about 20 sites within a north-south corridor between Little Lake (at the south end) and Big Pine (at the north end). Investigations at the Lubkin Creek site, south of Lone Pine, provide evidence of Coso glass consumption patterns at a residential base some 70 km to the north, occupied during the late Newberry and Marana periods. Looking to the west, data from several projects on the Kern Plateau are combined to paint a picture of the temporal distribution of Coso glass in the southern Sierra uplands, 40 km from the Volcanic Field. Following distributions onto the western slope of the southern Sierra, data from Lake Isabella and the Tule River Indian Reservation are next considered. Too few archaeological data are available from the southern San Joaquin Valley to build a composite hydration curve, but work completed by Wedel (1941), Fredrickson and Grossman (1977), and Hartzell (1992) is important for our assessment, as it indicates that obsidian is perhaps less than one percent of the chipped stone in sites around Buena Vista Lake. Next, we move southwest into the Los Angeles basin and southern California coastal areas (Ventura, Los Angeles, and Orange counties). Hughes and True (1985) have shown that Coso glass is present in extreme southern California (San Diego, San Bernardino, and Riverside counties) in only trace amounts, and so we make no effort to compile item-specific data from this area. Their study, however, points to two equally noteworthy patterns: Coso glass is more numerous in coastal than in inland sites, suggesting a coastal distribution route; and it is extremely rare in late-period sites, most pieces are found instead in earlier deposits. The scarcity of Coso glass in inland San Diego County sites is reaffirmed by Laylander and Christianson (1988) and McDonald (1992). Using McDonald's (1992) research at Indian Hills Rockshelter in Anza Borego as an example, the deposit there extends back to about 4000 B.P., but only one of the 239 pieces of obsidian subject to XRF-analysis was Coso. Coming full circle, our review is completed with a synopsis of Sutton's (1988a, 1988b, and 1991) observations pertaining to the distribution of Coso obsidian in Antelope and Fremont valleys, encompassing areas up to 150 km south of the Volcanic Field.

For each of these localities, a hydration profile was developed from readings from varying numbers of sites (Table 82). We recognize that many factors could readily influence a composite curve such that it poorly correlates with what the actual relative frequency of Coso obsidian was at varying points in the past for any one area; nonetheless, for lack of standardized data amenable to rigorously tracking and quantifying the amount of Coso glass distributed over a huge area through time, we ask that the reader grant us this admittedly and necessarily subjective review.

Table 82. Coso Glass Hydration Values for Various Archaeological Projects.

Range in Microns	China Lake		Fort Irwin		Rose Spring Locus 1 INY-372	Coso Junction Ranch INY-2284	Contel Project		Lubkin Creek INY-30		Kern Plateau		Lake Isabella/ Tule River Indian Reservation	Orange County	Los Angeles County	Ventura County	Coso Volcanic Field
	all	tools	all	tools	all	all	all	tools	all	tools	all	tools	all	all	all	all	all
0-0.4	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	7
0.5-0.9	-	-	-	-	-	-	-	-	-	-	9	1	1	-	-	-	- -
1.0-1.4	4	-	1	1	-	-	4	3	-	-	23	9	5	-	1	-	8
1.5-1.9	5	2	2	1	1	-	3	-	5	1	37	17	5	2	2	-	13
2.0-2.4	6	-	11	5	-	-	4	3	20	14	57	20	5	-	2	1	12
2.5-2.9	8	1	6	3	1	9	3	-	22	17	49	5	10	1	1	2	20
3.0-3.4	7	2	9	5	-	5	1	-	16	13	66	8	7	1	6	2	20
3.5-3.9	5	2	13	10	-	7	5	1	17	12	53	6	12	2	4	2	37
4.0-4.4	10	1	33	30	3	33	26	2	17	8	39	5	14	5	7	7	81
4.5-4.9	15	3	38	33	2	52	28	8	26	20	35	3	15	13	18	7	103
5.0-5.4	21	3	46	40	6	57	16	2	24	17	22	3	12	16	12	14	176
5.5-5.9	37	1	50	45	12	96	23	6	22	14	30	3	11	12	7	8	345
6.0-6.4	18	2	43	35	15	111	10	3	16	10	26	4	18	16	15	8	417
6.5-6.9	7	-	20	18	8	59	8	4	12	5	20	3	14	13	6	3	373
7.0-7.4	2	-	12	8	26	32	17	4	4	1	18	-	10	9	2	1	341
7.5-7.9	3	-	9	7	14	5	6	2	5	4	13	1	9	10	-	2	261
8.0-8.4	2	-	12	9	31	3	5	2	4	1	11	1	4	13	4	3	199
8.5-8.9	2	-	15	11	9	4	6	1	5	4	7	2	1	7	1	1	224
9.0-9.4	3	-	15	12	6	2	3	1	9	8	7	1	3	9	1	1	160
9.5-9.9	-	-	11	9	1	3	1	-	2	2	5	1	5	3	1	-	150
10.0-10.4	1	1	16	9	-	1	-	-	2	2	8	-	4	8	-	-	116
10.5-10.9	2	-	17	15	2	2	3	-	2	-	6	1	2	3	-	-	126
11.0-11.4	6	1	27	25	1	1	1	1	7	6	2	1	4	1	-	-	119
11.5-11.9	-	-	22	19	-	1	3	-	4	3	-	-	-	5	-	-	114
12.0-12.4	1	-	32	26	-	1	-	-	3	3	2	-	-	3	-	-	110
12.5-12.9	1	-	30	25	-	-	-	-	3	2	2	1	1	1	-	-	71
13.0-13.4	1	-	29	22	-	-	-	-	2	1	-	-	-	-	-	-	82
13.5-13.9	1	-	27	23	-	-	-	-	3	1	1	-	-	-	-	-	42
14.0-14.4	3	1	30	28	-	-	2	-	1	1	1	-	-	-	-	-	52
14.5-14.9	1	-	27	23	-	-	-	-	1	1	-	-	-	1	-	-	50
15.0-15.4	-	-	28	23	-	-	1	-	-	-	-	-	-	-	-	-	37
15.5-15.9	1	-	16	14	-	-	-	-	1	-	2	-	-	-	-	-	30
16.0-16.4	-	-	14	12	-	-	-	-	-	-	-	-	-	-	-	-	29
16.5-16.9	3	1	7	5	1	-	2	-	-	-	-	-	1	-	-	-	22

Table 82. Coso Glass Hydration Values for Various Archaeological Projects (continued).

Range in Microns	China Lake all	China Lake tools	Fort Irwin all	Fort Irwin tools	Rose Spring Locus 1 INY-372 all	Coso Junction Ranch INY-2284 all	Contel Project all	Contel Project tools	Lubkin Creek INY-30 all	Lubkin Creek INY-30 tools	Kern Plateau all	Kern Plateau tools	Lake Isabella/ Tule River Indian Reservation all	Orange County all	Los Angeles County all	Ventura County all	Coso Volcanic Field all
17.0-17.4	-	-	13	11	-	-	1	-	-	-	-	-	-	1	-	-	22
17.5-17.9	-	-	12	8	-	-	-	-	1	1	-	-	-	-	-	-	23
18.0-18.4	-	-	2	2	-	-	-	-	-	-	1	-	-	1	-	-	15
18.5-18.9	-	-	2	2	-	1	-	-	-	-	-	-	-	-	-	-	13
19.0-19.4	-	-	4	2	-	-	-	-	-	-	1	-	-	-	-	-	12
19.5-19.9	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	16
20.0-20.4	-	-	4	4	-	-	-	-	-	-	-	-	-	-	-	-	10
20.5-20.9	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	3
21.0-21.4	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	6
21.5-21.9	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	5
22.0-22.4	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	11
22.5-22.9	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
23.0-23.4	-	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-	5
23.5-23.9	-	-	3	2	-	-	-	-	1	1	-	-	-	-	-	-	5
24.0-24.4	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	6
24.5-24.9	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	2
25.0-25.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
25.5-25.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26.0-26.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
26.5-26.9	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	7
Debitage Only	155		595				139		84		460						
Tools	21		129				43		173		96						
Total	176		724		139	485	182		257		556		174	156	90	62	4111

MOJAVE B RANGE

A test evaluation project of 60 sites in the Mojave B Range of China Lake Naval Air Weapons Station (Map 2), located about 75 km southeast of the Coso Volcanic Field, was completed by Bouey and Mikkelsen (1989). Only small quantities of obsidian exist in prehistoric sites in this area, but virtually all of the obsidian was obtained from Coso. All but 31 of 221 (86.0%) pieces of obsidian from 23 sites submitted for geochemical sourcing were identified as Coso (Bouey and Mikkelsen 1989:78-82). By count only about 0.3% of all debitage is obsidian (Bouey and Mikkelsen 1989:195), and most of this is pressure flakes (70.7% of the diagnostic obsidian pieces).

The 176 Coso hydration values (Figure 24a), form a unimodal distribution, with 51.7% of the values falling between 4.5-6.4 μ (Table 82). The distribution is essentially the same when 21 formed tools are excluded. Applying the EHT correction factor derived for Fort Irwin (Table 83), the distribution shows a rapid rise in the amount of obsidian at the end of the Late Newberry period, maximal amounts during the Haiwee/Saratoga Spring period, with quantities trailing off rapidly thereafter. Persistently low amounts of obsidian were brought into the project area prior to ca. 2000 B.P.

Table 83. Coso Obsidian EHT Corrections for Select Locations (adapted from Basgall 1990).

Locality	Mean Annual Temperature in °C	Correction Factor (6%)
Grant Grove	7.25	1.3600
Long Valley	9.30	1.2328
Bishop	12.30	1.0666
Lone Pine	13.50	-
Cajon Pass	14.60	0.9445
Malibu	15.30	0.9946
Haiwee/Coso	15.70	0.8723
Randsburg	17.00	0.8211
Fort Irwin	17.50	0.8072

FORT IRWIN

Fort Irwin is approximately 140 km southeast of the Coso Volcanic Field (Map 2). Information provided in a compendium of chronological data from Fort Irwin (Gilreath et al. 1987), from excavations at 47 sites in Nelson Basin (Basgall 1991), and from seven sites in Tiefort Basin (Hall 1992), show that comparatively little obsidian is present in these prehistoric sites. Pieces occurring are typically pressure flakes or projectile point fragments — the vast majority of Coso obsidian. In Nelson Basin, for example, obsidian is less than 1% (by count) of all debitage (Jones 1991:329); and in Tiefort Basin that proportion is slightly higher at about 2.5%. Debitage analysis identified 49.0% of the technologically diagnostic obsidian pieces from Nelson Basin as pressure flakes and an additional 29.7% as late stage thinning flakes (Jones 1991). Obsidian is better represented among the projectile points, accounting for about 10% (118 of 1156; Gilreath et al. 1987; Jones 1991, 1992). Basgall (1991:49) has indicated that obsidian is relatively more abundant in early Holocene deposits than in later contexts. Approximately 80% of the 1338 pieces of obsidian geochemically analyzed from Fort Irwin have been traced to Coso.

Some 724 Coso hydration values from Fort Irwin are reported, ranging from 1.0-26.9 μ (Table 82 readings compiled from Basgall 1991; Gilreath et al. 1987; and Hall 1992). The composite hydration curve shows a bimodal distribution (Figure 24b). A broad secondary peak spans hydration values from about 12.0-15.4 μ (28.0% of all values, Table 82), and the primary peak spans hydration values from 4.5-6.4 μ (24.4% of all values). The distribution is essentially the same when formed tools are excluded. Using the EHT correction factor for Fort Irwin

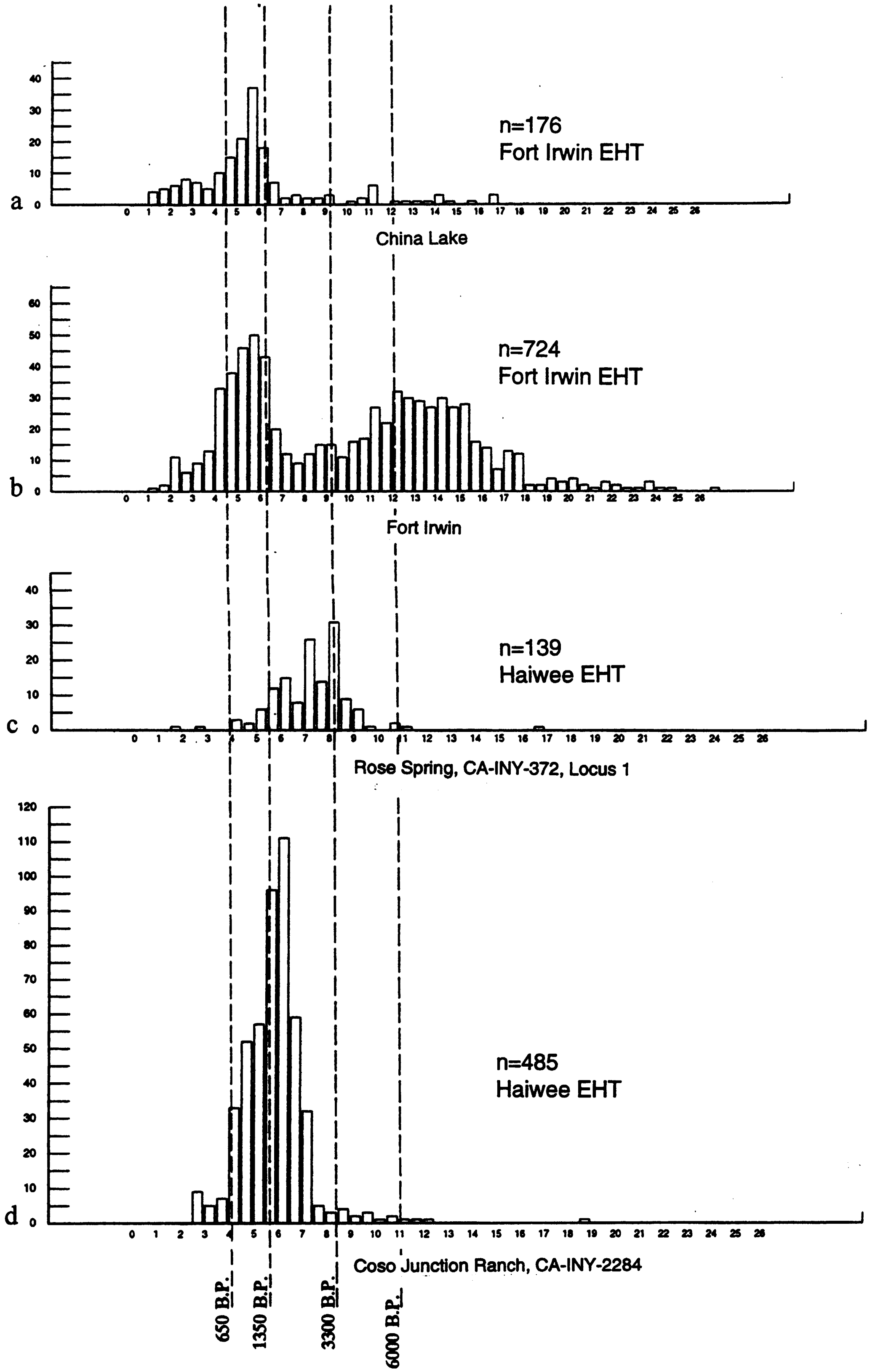


Figure 24. Frequency Distribution of Coso Hydration Values for Various Projects in the Western Mojave Desert.

derived by Basgall (1990), the broad peak pre-dates 6000 B.P., quantities decrease throughout the Little Lake period, then rises dramatically at the end of the Newberry period, to attain apparent maximal frequency during the Haiwee period. Quantities decrease throughout the Marana period. The discrepancy between the shape of the curve and Basgall's statement that obsidian is more prevalent in early Holocene deposits is a result of sampling bias. The greater quantities of obsidian recovered from early contexts typically require that a sample be drawn for hydration and sourcing analysis, while in later periods, the quantity is so low that nearly every piece recovered has received analysis. Were a less biased sample graphed, the pre-6000 B.P. values would simply rise to meet or exceed the Haiwee period peak.

THE ROSE SPRING SITE (INY-372, LOCUS 1)

The Rose Spring site lies only 15 km northwest of the Volcanic Field near the eastern base of the Sierra Nevada at the extreme north end of Rose Valley (Map 2). The site has long been heralded as a significant Rose Spring/Haiwee period village with an extensive midden (Lanning 1963). Yohe (1992) recently completed re-examination of the site, and determined, however, that the zenith of activities occurred ca. 1500 years ago, in late Newberry times. In total, 139 hydration rim values are reported on material for Locus 1: Ericson (1978) reports 39 items geochemically identified as Coso glass, and Yohe (1992:284-286) reports 68 values on debitage geochemically sourced to Coso and 32 on debitage reasonably presumed to be Coso obsidian. The composite profile (Figure 24c) indicates roughly a unimodal distribution, with 51.1% of the rim values falling between 7.0-8.4 μ (Table 82). Using the Haiwee EHT correction factor (Table 83), fully two-thirds (67.6%) of the rim values fall between ca. 3300-1350 B.P. (8.4-5.8 μ), and only 17 (12.2%) between 5.8-4.2 μ, corresponding to 1350-650 B.P. It should be noted that Yohe (1992) clearly discounts hydration profiles from the deposit as temporally meaningful since they failed to confirm his assessment of well-stratified vertical deposits, giving preference instead to radiocarbon dates and projectile point distributions.

Despite Yohe's (1992) reservations regarding the usefulness of obsidian hydration, a great deal of data support the contention that Locus 1 at the Rose Spring site was foremost a late Newberry obsidian reduction workshop and secondarily a Haiwee and Marana period occupation site. First, debitage from units X-1, X-2, and X-3 (Yohe 1992:230) is bimodally distributed with depth, the first peak occurs between 20-40 cm, followed by a sharp drop in density between 40-50 cm, and then an increase to previous or higher values between 50-140 cm (Table 84). Subsurface debitage densities in the upper component (0-40 cm) calculate to 6,300 pieces/m^3 (1/8" units), and 10,550 pieces/m^3 in the lower component (50-150 cm). The vertical distribution of projectile points from the same block of units tracks the same upper and lower components (Table 84). All Elko and Gypsum series points were recovered below 60 cm, and 86.4% of the Desert and Rose Spring series points were recovered from above 70 cm. Finally, hydration values corroborate two major occupations. Half of the 16 values from 0-50 cm measure $\leq$5.8 μ, compared to only three of 48 rims below 50 cm. The overall pattern of hydration readings suggests that most of the debitage in the site was generated during Newberry period occupations. Due to the massive accumulation of this material, it was incorporated into later dating deposits, creating the clean Newberry hydration profile below 50 cm and the mixed suite of readings nearer to the surface. Unfortunately, the projectile points recovered from the deposit have not been submitted for hydration analysis. But based on the evidence at hand, we would predict that when these data are available, most Rose Spring points will display rinds < 5.8 μ, while Elko points, corresponding to the deeper deposits, will have rims > 6.0 μ.

Given the site's importance as an obsidian reduction workshop, the nature of the flintknapping activities that occurred on site are of much interest. Expecting a reduction in the size of bifaces to correlate with the introduction of the bow-and-arrow ca. 1500 years ago, Yohe's analysis indicated, instead, that "there is a reduction in biface size only in the last 600 years" (1992:219). Further, "the bifacial core reduction trajectory apparently remained largely the same throughout the most intensive period of use at the site, with exhausted bifacial cores or large, trimmed flake blanks serving as the source of preforms" (1992:221). Regarding debitage characteristics in the deposit, Yohe (1992:234) comments "Probably the most striking thing about the debitage analysis is the apparent homogeneity maintained in most categories through time". From our interpretation of data from Locus 1 at the Rose Spring site, the overwhelming abundance of Newberry period debitage throughout the deposit would preclude documenting a diachronic change in reduction technologies. Yohe provides the following characterization:

Table 84. Subsurface Distribution of Projectile Points and Debitage from INY-372, Locus 1 (1987-89).

Depth	Desert and Rose Spring Series	Elko and Gypsum Series	Debitage Unit X-1 (per k)	Debitage Unit X-2 (per k)	Debitage Unit X-3 (per k)	Volume Excavated (m^3)
0-10	4	-	0.5	0.4	0.1	.675
10-20	7	-	1.3	1.4	0.3	.675
20-30	3	-	1.6	2.6	2.4	.675
30-40	3	-	1.4	3.5	1.5	.675
40-50	7	-	1.0	1.6	0.7	.675
50-60	7	-	2.2	2.6	1.0	.675
60-70	7	1	1.9	2.9	1.8	.675
70-80	2	-	2.0	2.8	1.7	.675
80-90	1	-	2.4	2.8	2.6	.675
90-100	2	-	2.3	3.0	unit terminated	.450
100-110	1	-	3.1	2.8		.450
110-120	-	-	2.5	2.5		.450
120-130	-	-	2.3	2.2		.450
130-140	-	-	2.6	1.8		.450
140-150	-	1	3.8	1.4		.450
150-160	-	1	1.7	unit terminated		.225
160-170	-	1	1.6			.225
170-180	-	2	1.9			.225
180-190	-	-	0.7			.225
190-200	-	1	1.1			.225
200-210	-	1	0.3			.225
210-220	-	-	unit terminated			-
220-230	-	-				-
TOTAL	44	8	38,200	34,300	12,100	10.125

NOTE: Information derived from Yohe (1992:Table 24 and Figure 45); Excavation unit dimensions were 1.5 x 1.5 m, 1/8" mesh.

> The extremely low incidence of single-facet platforms, and the ubiquity of biface-thinning flakes throughout the deposit appear to support the original contention that bifacial cores were the most commonly used core type at the site. Platform abrasion prior to flake detachment seems to have been an uncommon practice. The small incidence of bulb-removal flakes suggests that the incipient bifacial cores were completely prepared prior to arrival on the sites, a contention that also is supported by the small numbers of alternate flakes and flakes bearing traces of cortex [1992:234].

It appears that less than 10% of the diagnostic flakes overall are attributed to pressure flaking (1992:235). It should be noted, too, that less than one percent of the chipping debris was of material other than obsidian.

COSO JUNCTION RANCH SITE (INY-2284)

Twelve km due west of Sugarloaf Mountain, the Coso Junction Ranch site sits at the eastern base of the Sierra Nevada at a well-developed spring (Map 2). The site was tested by the UCLA Field School in Archaeology in the mid-1980s, and has been described as an extensive Rose Spring/Haiwee village with numerous structural remains, and voluminous amounts of chipping debris (Allen 1986).

Nearly 500 hydration rim values are reported from this deposit: Allen (1986:52-56) presents about 350 rim values on 287 pieces; Whitley (1988) presents 140 values on 129 additional specimens. All specimens are presumed to be Coso obsidian; the specimens reported by Allen are identified as debitage, while it is unknown if those reported by Whitley are from debitage or formed tools. The resultant sample shows a unimodal distribution with two-thirds of the values spanning 5.0-6.9 μ (Figure 24d, Table 82). Using the Haiwee EHT correction factor, the most readings correspond to the recent end of the Late Newberry period, ca. 1350 B.P., and frequencies decline as rapidly through the Haiwee and Marana period as they rose throughout the Early and Middle Newberry periods.

Also interested in monitoring the impact of the transition from dart to bow-and-arrow hunting technology on the consumption/reduction patterns of Coso glass, Allen segmented the vertical deposit into five phases based on hydration rim data. No appreciable differences were found to exist, however, in the debitage characterization from one phase to the next (Table 85). Enormous quantities of debitage occur in all phases, debitage exhibiting cortex is always rare, and in contrast to the Rose Spring site, tool finishing (i.e., pressure flaking) is always by far the overwhelming flintknapping activity. In sum, like the Rose Spring site, the deposit spans the Newberry and Haiwee periods, and when the transition from dart-sized to arrow-sized projectiles purportedly occurs, it fails to affect debitage profiles.

Table 85. Hydration Profile and Debitage Characterization at INY-2284.

Phase	Hydration Range μ	Debitage Density per m³ (kg)	(k)	% Early Reduction	% Middle Reduction	% Late Reduction	% tool finishing	% cortex
a	5.2-5.7	6.4	23	0.6	3.2	17.3	78.8	0.7
b	5.8-6.1	6.1	19	0.9	3.2	22.4	73.4	0.5
c	6.4-6.6	6.4	22	1.0	2.9	19.3	76.7	0.1
d	6.7-6.9	4.0	14	0.6	4.0	17.0	78.3	0.7
e	7.3	1.9	10	0.4	1.5	9.6	88.5	0.7

NOTE: Data derived from Allen 1986:Tables 6, 7, and 10. Allen's debitage categories 1-4, 10 and 11 are combined for Early Percussion Reduction; categories 5, 6, 12, and 13 for Middle Percussion Reduction; categories 7, 8, 14, and 15 for Late Percussion Reduction; and category 9 for Finishing (pressure flaking). Percent on which cortex is present is the result of combining categories 1, 3, 5, 7, 10, 12, and 14. Debitage recovered from 1/8" mesh units.

THE CONTEL PROJECT

Results of an evaluation of 23 sites on a north-south corridor between Little Lake and Big Pine (Map 2) indicate that Coso obsidian is common in prehistoric sites as far north as Lone Pine, but that it decreases rapidly in prevalence 10-15 km further north. In total, 182 hydration values are reported on 178 specimens of Coso glass recovered from 14 of the sites: 51 specimens were from sites located in the Little Lake vicinity, 104 specimens from sites located between Cottonwood Creek and Olancha, and the remainder from the vicinity of Lone Pine and northward. A composite profile of the hydration values shows three peaks of increasing magnitude, the lowest from 7.0-7.4 μ, the second at 5.5-5.9 μ, and the highest spanning 4.0-4.9 μ (Figure 25a, Table 82). Omission of readings on formed tools has little impact on the relative distribution. Using the Haiwee rather than the Lone Pine EHT correction factor (given that the majority of the readings derive from the south end of the corridor), the tertiary peak falls within the Newberry period, the secondary peak crosses the Haiwee/Newberry division, and the highest peak falls within the Haiwee period (Figure 25a). Minimal amounts of readings prior to ca. 3000 B.P. and post-650 B.P. are represented.

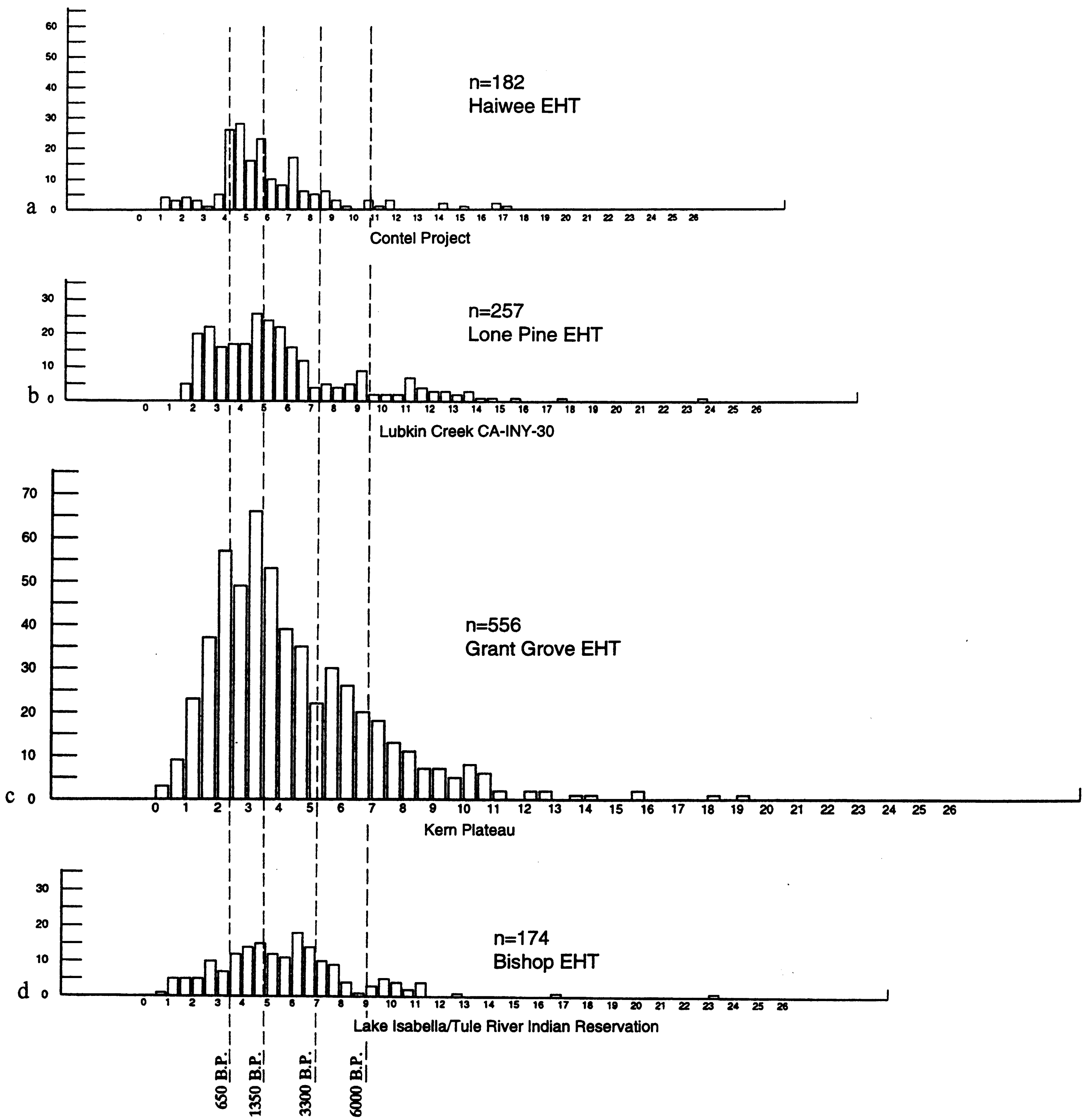


Figure 25. Frequency Distribution of Coso Hydration Values for Various Projects in Southern Owens Valley and the Southern Sierra Nevada.

LUBKIN CREEK SITE (INY-30)

At INY-30, seven km south of Lone Pine, (70 km NNW of the Volcanic Field), roughly 90% (by count) of the debitage recovered from excavation was obsidian, of which approximately 75% was visually identified as Coso, with pressure flakes accounting for 73.6% of the diagnostic pieces (Gilreath 1988:193). The site contains numerous Marana and late Newberry structures, with a minimal Haiwee period deposit represented in the area investigated. Subsurface debitage densities are highly variable across the site, ranging from 92 to 1663 pieces/m^3 (1/8" units) in fill zones overlaying various structural remains.

Just over 250 hydration values on Coso specimens are reported (Basgall and McGuire 1988), and the composite curve (Figure 25b) shows a bimodal distribution, with the earliest significant peak falling at values between 4.5-6.0, followed by a peak in values between 2.0-2.9 μ (Table 82). Accounting for EHT, the quantity of readings increases throughout the Newberry period, peaking at the Newberry/Haiwee period division, decreases in the latter part of the Haiwee and early Marana period, then rises again in late Marana times. Nearly 70% of the hydration values were obtained on formed tools (Table 82), a plot of hydration rim values on only debitage generates a fairly uniform distribution of values between 1.5-7.4 μ.

KERN PLATEAU

The composite picture of Coso obsidian from the Kern Plateau is the result of combining data from several test evaluation reports (sites in the vicinity of Kennedy Meadows reported by Bard et al. 1985 [TUL-896, -897, -898, and -899]; the Bear Mountain, Lamont, and Morris Peak segments of the Pacific Crest Trail reported by Garfinkel et al. 1980 [TUL-481, -482, -488, KER-743, -748] and McGuire and Garfinkel 1980 [TUL-619, -621, -623, -625, -629, and -636]; and at KER-878 [Schiffman 1988]); and data recovery investigations in Rockhouse Basin (reported by Garfinkel, et al. 1984 [TUL-877, -879, -884, -889, and -894]); supplemented by hydration values at other sites in this portion of Tulare County as summarized by TCR/ACRS (1984:139; [TUL-511, -618, -630, -634, -877, -879, -882, -887, -889, -890, 891, -895). In sum, approximately 550 rim values are reported on Kern Plateau specimens known or likely to be Coso obsidian (Table 82). The cumulative profile shows a bimodal distribution with a low secondary peak at 5.5-6.4 μ, and a broad primary peak centered on 3.0-3.4 μ (Figure 25c). Omitting hydration values on the approximately 100 formed tools has an impact on only the recent end of the hydration sample (Table 82). Approximately 60 artifacts (nearly exclusively Desert and Rose Spring series projectile points) have hydration rim values of less than 3.5 μ, and when excluded from the curve, the rate at which levels decline after the peak appears accelerated.

An historic temperature record of significant time depth does not exist for the Kern Plateau. In its absence, the record from Grant Grove is used to derive an EHT correction factor. Grant Grove is 90 km northeast of the Kern Plateau, and sits at an elevation of 2030 m (6600 ft), roughly comparable to that of the Tulare County sites listed above. Factoring the Grant Grove EHT correction (Table 83), the composite hydration distribution (Figure 25c) shows obsidian increased in frequency throughout the Newberry period, to a maximal amount in the Haiwee period, followed by a decline throughout the Marana period. A slight secondary peak occurs ca. 3500 years ago, suggesting obsidian from Coso has for a long time been carried up into the plateau.

Data recovery excavations at five sites reported by Garfinkel et al. (1984) provide robust information regarding the quantity of Coso obsidian and the nature of stone tool reduction practices represented. To engender an appreciation for the quantity of Coso obsidian transported about 45 km from the source, of approximately 32,000 pieces of debitage recovered from 1/8" screened deposit, only 126 (< 1.0%) were of material other than obsidian (Garfinkel et al. 1984:8-148). A maximal subsurface debitage density of 11,820 pieces of debitage/m^3 is reported for TUL-889, Locus 1, though densities at the other four sites are less impressive, ranging from 25-536/m^3. It should be noted, too, that the site area with extraordinary amounts of Coso glass was concluded to date between 4450-650 B.P., and all diagnostic points (n=7) from that deposit were Humboldts. Summary comments indicate that cortical pieces are rare; pressure flaking was the prevalent reduction activity, followed by late stage percussion thinning; and only minor amounts of non-biface thinning flakes were present, leading to the interpretation that only bifacially worked blanks were transported into the sites, where they were further reduced. They conclude:

A detailed analysis of the prehistoric lithic technology shows that the bifacial reduction of imported Coso obsidian was one of the main economic activities carried out at these sites. An examination of the lithic debitage and artifactual data clarified the nature of these sites as important lithic workshops in trans-Sierran obsidian manufacturing and exchange networks [Garfinkel et al. 1984:i].

LAKE ISABELLA AND THE TULE RIVER INDIAN RESERVATION

On the western slope of the southern Sierra Nevada, information regarding the relative abundance of Coso glass and associated hydration rim values are reported for two survey projects: Lake Isabella and the Tule River Indian Reservation, both approximately 75 km WNW and WSW of the Volcanic Field, respectively. Reporting results from the survey around Lake Isabella, which lays at an elevation of approximately 800 m (2600 ft), Dillon (1988) presents hydration values on approximately 50 specimens collected from the surface of seven prehistoric sites. Data are not available indicating the relative abundance of obsidian at the sites, other than his passing comment that "only a small percentage of the total amount available was collected, and of the sample, only a further fraction was measured in the hydration lab" (1988:65). Similarly whether the samples represent formed tools or pieces of debitage is not reported, suggesting they are most likely debitage.

The Tule River Indian Reservation covers elevations ranging from 340-2215 m (1100-7200 ft), but most hydration specimens were collected from sites lying between 460-1385 m (1500-4500 ft) (Gehr 1981, 1988). Of 96 prehistoric sites identified in surveys, 28 had obsidian present, indicating an overall decrease in access to Coso glass, relative to that afforded people who lived around Lake Isabella and on the Kern Plateau. The full hydration sample from sites on the reservation consists of 121 items from the surface of the 28 sites. Geochemical analysis of 49 samples identified 88% as Coso obsidian, allowing the reasonable conclusion that, with rare exception, obsidian in this area derived from Coso.

Recognizing that the magnitude of the hydration values decreased as elevation rose, Gehr (1988:25) developed a mean temperature gradient based on elevation, and correlated 13.59° C with an elevation of 835 m (3040 ft), and 11.16° C with an elevation of 1430 m (4640 ft). Of the various locations for which EHT correction factors have been figured, Bishop comes the closest to having a roughly equivalent annual temperature. At a value of 12.3° C, it falls between the two estimates given above for select elevations in the Tule River Indian Reservation. For the sake of parsimony, the Bishop EHT correction factor is applied to the Lake Isabella and Tule River Indian Reservation hydration samples (Figure 25d). The composite hydration curve resulting from the combined samples shows a broad unimodal distribution, with the highest number of readings plotting between 3.5-7.9 μ, and a decline in prior and subsequent periods. This distribution suggests maximal exploitation/access to Coso glass during the Newberry period, with availability decreased in the previous Little Lake and subsequent late Haiwee and Marana periods.

GREATER LOS ANGELES VICINITY

In general, obsidian is scarce in prehistoric sites within the greater Los Angeles vicinity. What little occurs has been shown to derive nearly exclusively from Coso (Meighan 1978:27), requiring that it be transported some 235 km from its origin. The composite profiles of Coso hydration values from archaeological sites in Los Angeles, Ventura, and Orange counties were developed by reviewing data reported by the UCLA Obsidian Hydration Laboratory (Meighan and Russell 1981; Meighan and Scalise 1988; Meighan and Vanderhoeven 1978). Though one or two specimens from a variety of sites have been noted, preference was given to sites from which 10 or more hydration values are reported; in addition, sites with mission-period occupations were similarly excluded from the sample. References for the data compiled and presented in Figures 26a-c and Table 82 are presented in Table 86. The data set for Orange County is based on readings from four sites, totaling 156 readings on 147 specimens; that for Los Angeles County derives from five sites, totaling 90 readings; while two sites with a total of 62 readings constitute the Ventura County sample (Table 86). The EHT correction factor developed for Malibu (Table 83) is applied to convert these values into age estimates. Taking into consideration EHT, the distribution of hydration readings in Orange County indicates coastal groups appear to have had regular access to Coso glass as long ago as

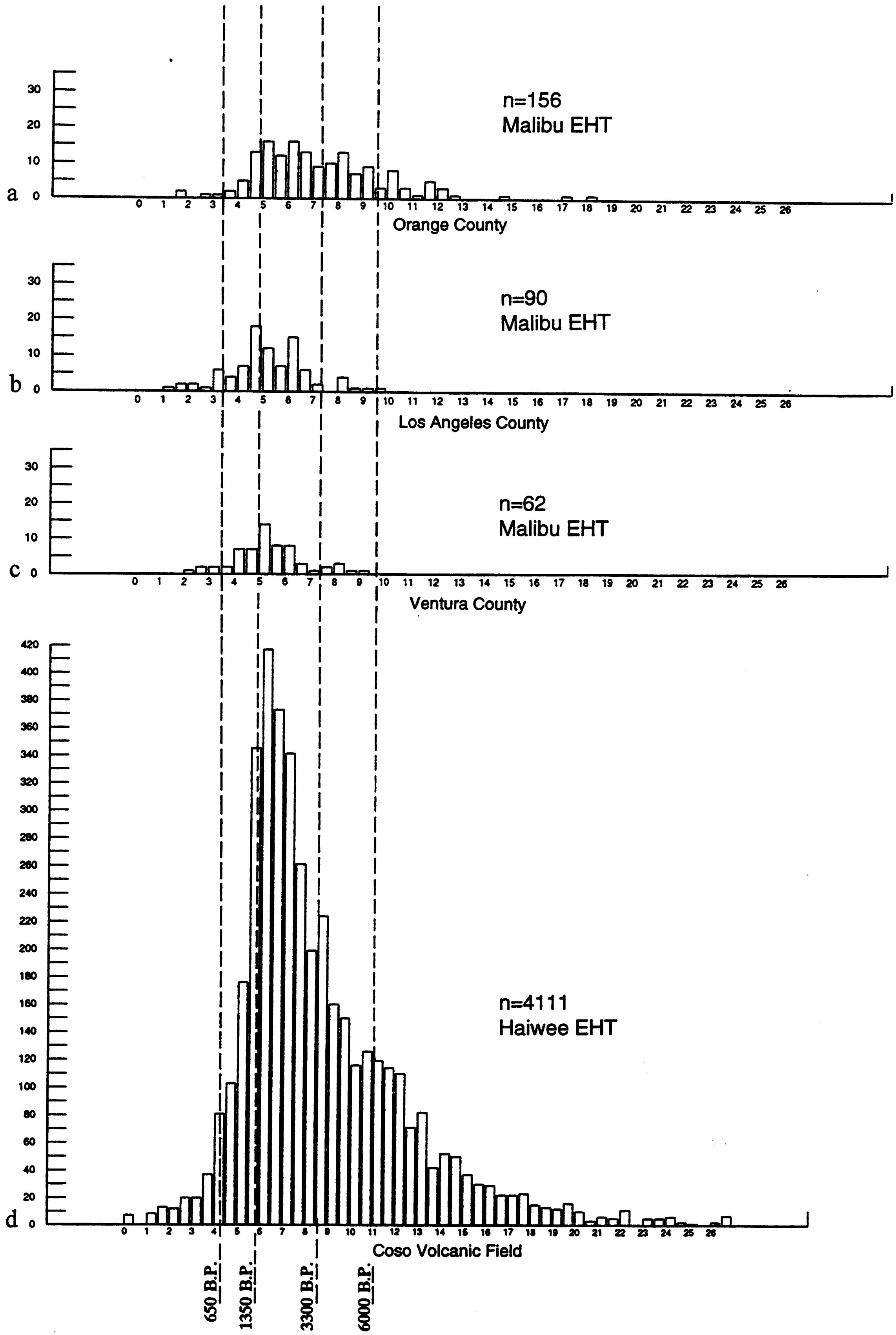


Figure 26. Frequency Distribution of Coso Hydration Values for Various Projects in Coastal Southern California and the Coso Volcanic Field.

Table 86. Hydration Data Compiled from the Greater Los Angeles Vicinity.

Site	Number of rims	Number of specimens	Reference
Orange County			
ORA-64	16	14	Koerper et al. 1986
ORA-119A	23	22	Koerper et al. 1986
ORA-119B	15	15	Cottrell 1988b
ORA-244	34	33	Cottrell 1988a
ORA-378	10	8	Koerper et al. 1986
ORA-378	58	55	Ericson et al. 1989
Los Angeles County			
LAN-59	22	20	Meighan 1988
LAN-61	37	34	Meighan 1988
LAN-264	11	11	Meighan 1978
LAN-702	10	10	Cottrell 1981
LAN-774	10	10	Singer 1981
Ventura County			
VEN-294	17	17	Rosen 1988
VEN-594	45	45	Cottrell 1988c

ca. 4500 years ago, which stayed relatively stable throughout the Newberry period, and was disrupted in the mid-Haiwee period (Figure 26a). Distributions for Los Angeles and Ventura county sites indicate stable access to Coso glass began considerably later, during the middle Newberry period, but also was disrupted in the mid-Haiwee period (Figures 25b and c).

ANTELOPE AND FREMONT VALLEYS

Though a substantial amount of archaeological investigations have taken place in Antelope and Fremont valleys, few published reports document the findings. Consequently, the assessment of the relative abundance and temporal distribution of Coso glass in prehistoric sites here is considerably more impressionistic than that offered for other areas. As Sutton (1988a:61) points out, in contrast to the southern Sierra Nevada/Tehachapi area, obsidian is uncommon in the desert area immediately to the south. Nonetheless, "all of the obsidian so far sourced from western Mojave Desert sites has come from the Coso Volcanic Field" (Sutton 1988b:43). Small quantities of Coso obsidian were brought into the area as early as the Pinto/Little Lake period, as evidenced by a cluster of 35 rim values in excess of 9.0 μ from Edwards Air Force Base (Greenwood and McIntyre 1981:Appendix 10) and by the few Pinto series Coso points (one with a hydration band of 10.5 μ) that have been found. In reviewing the archaeological record for the western Mojave Desert, Sutton notes that obsidian is more common in Fremont than Antelope valley, most obsidian occurs as finished tools, and a higher proportion of Elko and Rose Spring series items than Desert Series points found in the area were made of Coso glass (1988b). More recently, York (1992), working with data from Edwards Air Force Base, noted that Coso obsidian debitage tends to be late Newberry (mostly) or earlier in age, but that Coso projectile points recovered are most commonly late period forms. Citing burial practices, site structure, and the abundance of California marine-shell ornaments in burial contexts, Sutton concludes "the western Mojave Desert was integrated into the mainstream of events of southern California prehistory," and tentatively suggests that KER-303, and perhaps other similar large midden sites in the area, might have served as trade centers between 3000-300 B.P., where marine shell and Coso obsidian, among other commodities, were exchanged. Both Sutton and York perceive a major reduction in the quantity of Coso glass brought into this area in late times (cf. Byrd et al. 1994).

DISCUSSION

Review of the distribution of Coso obsidian throughout southern California supports three major trends. First, Coso obsidian was the primary glass used by prehistoric peoples who occupied lands as far east as Fort Irwin, as far north as Lone Pine, throughout the southern Sierra south of Mt. Whitney (see Roper-Wickstrom 1992), west to Porterville, southwest to the Pacific coast reaching as far as the border, and as far south as Lancaster/Palmdale. Second, outside of the procurement zone, impressive quantities of Coso glass occur in only two areas, at major occupation sites within 15 km of Sugarloaf Mountain near the eastern base of the Sierra (e.g., INY-372 and -2284), and some 40 km west on the Kern Plateau. The quantity of Coso obsidian in sites in the southern third of Owens Valley, as far north as Lone Pine, indicate people living here also had ready access to the material. Only minimal quantities are recovered to the east and south. Third, nearly all areas considered show a growing increase in the quantity of obsidian during the Newberry period, with the quantity peaking near the Late Newberry/Haiwee period boundary, and declining, usually rapidly, in the latter part of the Haiwee period and continuing to fall during the ensuing Marana period.

The composite hydration profile for the Volcanic Field (Figure 26d), without consideration of sampling bias, suggests exploitation/production was at its zenith during the Late Newberry period, with 35.9% of the rim values falling between 5.5-7.4 μ (Table 82), and that the intensity of exploitation was comparatively low during the Haiwee period — a pattern at odds with overall trends outside of the Volcanic Field showing peak consumption typically in the Haiwee period. Reasons for this incongruity lay in the differing exploitation patterns and overall land-use practices operative during the Late Newberry and Haiwee periods, as well as the sampling bias inherent in the Volcanic Field's composite hydration profile. Figure 26d is based on samples from numerous sites (n=381) spread over an extensive area (15,000 acres), with many sites, regardless of how sparse or dense their flaking debris, having near equal representation. In large part, then, the profile reflects the relative number of sites by time in the Volcanic Field. An overview of the archaeological resources within the Volcanic Field (Gilreath and Hildebrandt 1991) reaffirms this contention, showing Late Newberry off-quarry sites to be the most numerous type of resource in the Sugarloaf District (Table 87).

Table 87. Single Period Loci Densities Standardized to 100-year Spans in the Coso Volcanic Field (from Gilreath and Hildebrandt 1991:Table 19).

	TEMPORAL PERIOD							
	Marana	Haiwee	Late Newberry	Middle Newberry	Early Newberry	Little Lake	Early	
Quarry loci	0.67	1.60	2.87	4.0	1.86	1.65	0.63	0.18
Secondary Reduction loci[a]	0.66	4.16	8.78	4.2	2.57	0.95	0.84	0.45
TOTAL	1.33	5.76	11.65	8.2	4.43	2.60	1.47	0.63
100 year spans	4.50	6.25	10.25	5.00	7.00	20.00	30.00	70.00

NOTE: [a] - excludes "Milling Station/Features and Milling Camps.

In the preceding chapters we showed that prior to the Middle Newberry period, widely dispersed, typically small pockets of lag deposits were used, with exploitation shifting to major obsidian outcrops in Late Newberry times — a pattern continuing into the Haiwee period. That obsidian quarrying in the Late Newberry and Haiwee periods was confined to few massive obsidian exposures instead of less plentiful but more widespread deposits is a secondary source of distortion in the composite hydration profile. Late Newberry and, to a far greater degree, Haiwee quarries contribute little to the profile because relatively few exist. Results of our investigations parallel those of Gilreath and Hildebrandt (1991) in finding that Late Newberry groups exploited more primary deposits than did Haiwee period groups. It is suggested that obsidian exploitation in the Haiwee period was nearly exclusively restricted to the massive exposure on Sugarloaf Mountain, with other deposits, by comparison, largely ignored. A further distinction between Late Newberry and Haiwee quarrying practices involves the use (or lack thereof) of secondary reduction stations. Secondary reduction locations are numerous and widespread throughout the Volcanic Field, and the vast majority date to the Late Newberry period. In addition, the Late Newberry period saw the inception of several highly specialized stone tool production sites focused on the manufacture of biface blanks or preforms — a task differentiation not observed in prior times. Secondary reduction locations within the Volcanic Field are far less common in the Haiwee period. Secondary reduction must have occurred either at the quarry or at sites outside the Volcanic Field, like the Coso Junction Ranch and perhaps the Rose Spring sites.

Assuming that the level of tool stone reduction in Middle Newberry and earlier times directly correlates to resident population's toolstone needs, then the significant increase in the production level in the Late Newberry period is excessive, even when a healthy population growth during this interval is conceded. Evidence of increased production levels during the Late Newberry period is found in the increased number of secondary reduction locations and intensity of manufacture at primary quarries. Subsurface debitage densities of 1000-3000 flakes/m^3 are recorded at Late Newberry and Haiwee period primary quarries, while densities of 200-400 flakes/m^3 are recorded at earlier lag quarries (Chapter 6, Table 61); i.e., one cubic meter of deposit at a primary quarry generates on average as much chipping debris as seven cubic meters of lag quarry deposit. The magnitude of differing production levels becomes more extreme when one appreciates the fact that primary quarries maintain such high densities over areas substantially larger than lag quarries.

Up through the Early Newberry period, fairly scant lag deposits were exploited, production intensity was low, reduction activities and the flaked stone artifact repertoire were fairly diverse within any one location, and sites were widely spread across the landscape. All factors combine to suggest exploitation by mobile, small groups, who quarried as the opportunity afforded itself, to provide themselves with satisfactory quantities and kinds of obsidian for their own needs, within the constraints of their normal subsistence pursuits. The exploitation pattern undergoes changes throughout the Middle Newberry period, and by the Late Newberry period only primary quarries are in use, the intensity of production increases magnificently, and secondary reduction locations are abundant with the focus of reduction activities varying from one location to the next. The stoneworking activities at Coso during this period represent a healthy mixture of reduction for personal consumption as well as surplus production for exchange. It is during this period that people living throughout southern California have increasing access to Coso obsidian, with the quantity of Coso glass rising sharply in many distant locations.

While access to Coso obsidian appears to have been unrestricted into the Late Newberry period, several traits suggest some measure of control by the start of the Haiwee period. The radical decrease in the Late Newberry period in the number of obsidian deposits quarried provides the first indication of control. Obsidian is available at Coso over an area covering about 17 km north-south by 7 km east-west, and it is difficult to imagine that groups coming from diverse regional locations all would have ignored the lag deposits, choosing instead only the same few primary exposures. By the Haiwee period quarrying was restricted to even fewer and only the very best exposures. The location of nearby large Haiwee-period villages would have facilitated restricted access. People occupying the Coso Junction Ranch site (on the western front of the Volcanic Field) directly overlooking the Coso obsidian motherlode, and the Rose Spring site (at the narrows separating Owens and Rose valleys) would have been able to effectively monitor its access. Extraordinary amounts of secondary reduction took place at both these sites, suggesting they were key nodes in the exchange system that was well developed by the end of the Late Newberry period. It is easy to imagine that impressive quantities of Coso obsidian were moved north from the Rose Spring site, into the hands of neighboring, and probably closely related Owens Valley populations. In a similar fashion, large quantities of Coso obsidian moved from habitation/secondary reduction workshops like the Coso Junction Ranch site, up southern Sierra canyons, into the Kern River drainage, and from there into the hands of south coast groups.

CHAPTER 9: SUMMARY AND CONCLUSIONS

Obsidian toolstone is abundantly present in the Coso Volcanic Field. Nodules are available at numerous lag deposit quarries, while larger concentrations of higher quality material are also found at a limited number of primary seams. Subsistence resources are much less abundant, primarily restricted to a variety of seeds and small game. Lacking a broader range of foods, the Volcanic Field never supported more than a small portion of any subsistence-settlement system. These characteristics, although limiting on some levels, have produced an archaeological record sensitive to the changing role of obsidian within both local and inter-regional economic systems, as well as useful in determining how marginal environments relate to higher-order issues of subsistence-settlement pattern change. After providing a brief summary of the major project findings, we conclude the report with discussions of comparative data obtained from the Casa Diablo and Bodie Hills procurement zones, and address problems associated with exchange and its relationship to sociopolitical complexity in California, the Great Basin, and other regions as well.

LOCAL CHRONOLOGICAL SEQUENCE

Because so much of the Coso archaeological record consists of stone working areas lacking materials traditionally used for dating (e.g., organics for radiometric dating, diagnostic artifacts for cross-dating), chronological ordering of the project assemblages relied largely on the use of obsidian hydration data. Conversion of hydration readings to calendric years was accomplished using a rate developed by Basgall (1990) based on a series of hydration-radiocarbon pairings obtained from a nearby site (INY-30), augmented with an EHT correction factor developed from pairings gathered from numerous other sites located in contrasting environmental settings. When applied to projectile points recovered from the Volcanic Field, the rate conversions successfully placed most diagnostic forms in their expected temporal interval. Beginning at around 3400 B.P. and moving forward, the sequence included Thin Elko forms (<6.5 mm thick [mean=7.4 μ, s.d.=1.0]), Humboldt Basal-notched (mean=6.3 μ, s.d.=1.0), Rose Spring (mean=5.2 μ, s.d.=0.8), Saratoga Spring (mean=4.8 μ, s.d.=0.8), and Desert series (mean=3.0, s.d.=1.2). Contrasting with this clean unilinear progression, point types pre-dating 3400 B.P. included Thick Elko (mean=12.3 μ, s.d.=3.3), Little Lake/Pinto (mean=14.2 μ, s.d.=4.3), and Great Basin Stemmed (mean=12.9 μ, s.d.=2.7). All exhibited large, overlapping standard deviations, perhaps reflecting: (1) contemporaneous use over long periods of time (Flenniken and Wilke 1989); (2) problems in hydration rim development magnified by several thousand years of exposure to variable environmental circumstances (Rhode 1992); and/or (3) tool rejuvenation practices (Flenniken and Raymond 1986). Review of projectile point hydration data from surrounding areas produced the same relative sequence, varying only with respect to local differences in temperature (i.e., cooler areas produced relatively smaller rim values).

Development of a local sequence for the Volcanic Field was based on hydration data obtained from several hundred single period loci recorded during extensive surveys of the area (Gilreath and Hildebrandt 1991). Organized into two populations (quarry versus off-quarry), hydration frequency distributions revealed several shifts in the intensity and character of obsidian production. These shifts resulted in the formulation of eight periods, most corresponding to Bettinger and Taylor's (1974) regional chronological scheme. Beginning at the recent end of the sequence, the Marana (650-200 B.P.) and Haiwee (1275-650 B.P.) periods correspond rather closely to the original construct. The Newberry period was subdivided into Late (2300-1275 B.P.), Middle (2800-2300 B.P.), and Early (3500-2800 B.P.), while the Little Lake period was assigned to the 5500-3500 B.P. temporal interval. Although Gilreath and Hildebrandt (1991) defined two additional earlier periods, the standard deviations on hydration clusters reached such magnitudes that attempts at high resolution dating seemed inappropriate. Because of these difficulties, pre-5500 B.P. accumulations were simply considered Early.

PREHISTORIC LAND-USE CHANGE WITHIN THE COSO VOLCANIC FIELD

Early (pre-5500 B.P.) and Little Lake (5500-3500 B.P.) period use of the Volcanic Field was largely limited to short-term use of lag quarry deposits. Lacking firm evidence of subsistence oriented activities, most areas reflect the on-site production of cores, early stage bifaces, and a lesser number of unifacial items. The large number and variable size/quality of these areas indicates a rather generalized, opportunistic approach to the acquisition of obsidian. This is also reflected by relatively low densities of debitage (dominated by shatter and core production debris) and the presence of variable tool morphologies, the latter showing little preference for one form over another. When combined with archaeological data obtained from the surrounding area, the current findings indicate that Early and Little Lake period lithic procurement activities were largely embedded within subsistence-settlement systems characterized by high degrees of residential mobility, minimal use of seed resources, a probable emphasis on hunting both large and small game, and little concern with the inter-regional exchange of obsidian.

In addition to the exploitation of lag quarries, Early Newberry and Middle Newberry period components (3500-2300 B.P.) showed a significant increase in the use of off-quarry, biface production areas. Increased concern with biface manufacture was also found among the lag quarries, where bifaces were more abundant than cores, and biface reduction debris was also significantly present. The off-quarry areas, as would be expected, were dominated by Stage 2 and 3 bifaces, and variable densities of bifacial thinning debris. Some of these sites, as well as one of the quarry locations, also produced a variety of other artifacts including projectile points, milling equipment, and numerous flake tools. Although some of the materials certainly indicate use of local subsistence resources, most occupations remained short-term, and primarily concerned with the acquisition of obsidian.

The trend away from lag quarry use reached a peak during the Late Newberry period (2300-1275 B.P.). Of these 23 components, only two were quarries, both primary outcrops on Joshua Ridge. This shift corresponds with Elston and Zeier's (1984) proposals regarding the declining importance of lag quarries, as well as their discovery of two major Late Newberry (our dating) mining areas on the Sugarloaf/West Sugarloaf primary quarry complex. The primary deposits investigated showed that stone working activities focused on the highest quality seams, and produced assemblages with relatively high frequencies of bifacial cores, and early stage (often triangular shaped) bifaces that were substantially larger than equivalent items found at lag quarries. Off-quarry sites consisted almost entirely of biface production areas. Most were dominated by Stage 2 and 3 bifaces (significantly smaller than their quarry counterparts), and high densities of biface reduction debris. Some differentiation of the reduction activities occurs among these secondary reduction areas: biface blank manufacture was the focus at some, while preform manufacture was the focus at others. Some of these sites also produced subsistence-related materials (mostly millingstones). Lacking accumulations of midden, plant macrofossils, and faunal remains, most of the aforementioned tools represented casual use of plant foods to support individuals focused on the production of bifaces.

The Late Newberry changes in production organization were no doubt related to an expanded network of obsidian exchange. Increased demands for volcanic glass were no longer met by the expedient use of lag quarry deposits. Instead, the less accessible primary seams were mined for materials that were subsequently refined into blanks and preforms at nearby biface production areas. Corresponding changes in land-use, although present, do not evidence the emergence of sedentary populations or local control of the quarries. Data collected from Owens and Rose valleys (Basgall and McGuire 1988; Delacorte and McGuire 1993) reveal a Late Newberry subsistence-settlement system maintaining a relatively high degree of residential mobility. In contrast to previous systems, however, annual movements were less extensive and followed a more regularized schedule. Some groups traveled along a north-south axis at least 200 km in length (Basgall 1989), occupying a series of seasonal residential bases. Many of these sites were reused on a regular basis, judging by the presence of structures, features, and caches, and supported to some degree by logistically organized forays to distant resource areas (e.g., pinyon, mountain sheep, and marmots in lowland sites; see Basgall and McGuire 1988).

Increased predictability of settlement locations during the annual subsistence-settlement cycle is hypothesized to have allowed regularized exchange relationships to develop. This is supported by increases in the frequency of Newberry period hydration readings at Rose Spring (Yohe 1992), Coso Junction Ranch (Allen 1986), several sites along Rose and Owens valleys (Basgall and McGuire 1988; Delacorte and McGuire 1993) and, importantly, more distant localities such as the Kern Plateau (Garfinkel et al. 1984; McGuire and Garfinkel 1980), west slope of the southern Sierra (Dillon 1988; Gehr 1981, 1988), and various locations within Ventura and Los Angeles counties. It is also important to note that desert areas to the southeast did not produce similar increases (Basgall 1991; Bouey and Mikkelsen 1989; Gilreath et al. 1987; Hall 1992), rather the increases are largely confined to the Haiwee interval, while the composite profile from several sites in Orange County showed only a marginal Newberry period rise. Although far from conclusive, these trends suggest that most Late Newberry production surpluses were ultimately consumed by the relatively large population centers of coastal southern California.

Use of the Volcanic Field dropped significantly during the Haiwee period (1275-650 B.P.). Lithic production areas investigated were essentially limited to a single biface production station and one primary quarry. Seed processing areas, which dominate in the Marana period, were also quite rare, represented by a few scattered examples. This drop in obsidian production could be attributed to collapse of the Late Newberry exchange system, perhaps related to changes in technological orientation, i.e., a reduced demand for toolstone caused by the introduction of the bow and arrow (see Skinner 1989; Wilke and Flenniken 1988; cf. Singer and Ericson 1977). When moving to the hydration profiles developed for the outlying areas, however, a different picture emerges. The Newberry period rise in hydration values was maintained through the early half of the Haiwee period in nearly all settings, while new peaks were established only in the desert areas to the southeast. This apparent contradiction (i.e., little production activity within the Volcanic Field during the Haiwee period but ample consumption elsewhere) can be resolved by more closely examining Haiwee period production. Only two Haiwee period quarries have been investigated thus far, one during the current project on Joshua Ridge and the other by Elston and Zeier (1984) on West Sugarloaf Mountain. Both locations were intensively used, focusing on specific concentrations of high quality material, and the quarrying was structured in a way that eliminated the need for secondary reduction locations within the procurement zone. That large numbers of people from diverse localities would have traveled to the Volcanic Field, used such a limited number of quarry locations, and *not* left indications of their stays in surrounding non-quarry contexts seem unlikely. Instead, these changes probably reflect production by a limited number of local people who regularly exploited favored seams of obsidian, and transported the products to residential bases outside the Volcanic Field for further reduction (e.g, Coso Junction Ranch). Reduced access to the Coso quarries by non-local people is also supported to some degree by a region-wide reduction in mobility. Bettinger (1989) and Delacorte and McGuire (1993), for example, argue that seasonal movements within the Owens Valley/Rose Valley area became increasingly confined during the Haiwee period, perhaps facilitating local control of an expanding system of inter-regional exchange.

By the Marana period (post 650 B.P.), evidence for local flaked stone production is scant, as is consumption in outlying areas. Just when mobility had been reduced to a point where some level of control over the quarries could have been achieved, the obsidian production and exchange system collapsed, and the Volcanic Field became the focus of intensive seed processing activities. With the exception of a few locations where relatively long-term occupations took place, most Marana period areas were temporary seed camps consisting of milling equipment, hearths, and little else. Judging by the high number and wide distribution of these sites, and the relatively large size of the millingstones contained within them, it appears they were established adjacent to productive resource patches and reused on a regular basis.

RESOURCE INTENSIFICATION IN THE COSO VOLCANIC FIELD

Increased use of small seed resources within the Coso Volcanic Field is consistent with a major late period shift in subsistence orientation that Bettinger and Baumhoff (1982) think helped fuel the spread of Numic speaking populations throughout much of the Great Basin. According to the Bettinger and Baumhoff (1982) model, pre-Numic peoples used a "traveling strategy" where a substantial amount of time was spent pursuing game and covering large tracts of land in search of highly-ranked plant resources. Numic groups followed a "processing strategy" where travel time was reduced due to an increased use of lower-ranked plant resources (mostly small seeds) widely available in most environmental settings. Although encumbering less processing time per unit of output, the pre-Numic strategy supported relatively low population densities and required high degrees of mobility. The Numic strategy, in contrast, increased population density and lowered mobility through intensifying the use of a broader range of resources within progressively smaller foraging areas. Simply stated, the increasing number of Numic peoples, combined with their ability to occupy environmental zones previously under-used by pre-Numics, established the competitive advantages that ultimately led to the spread of Numic speakers throughout the Great Basin.

Late period expansion into previously under-used environments has also been addressed by Bettinger (1991) as part of his ongoing research project in the White Mountains. Prior to 1400 B.P., most upland areas were used almost exclusively for hunting. Later components are quite different, containing house structures associated with artifactual debris related to hunting, vegetal processing, and a variety of other domestic activities — no doubt reflecting relatively long periods of occupation. This land-use shift was thought to have been a response to regional population increases that lowered the rates of return for lowland foods, thereby increasing the relative value of resources found in the uplands (Bettinger 1991).

The Coso Volcanic Field also provides an excellent example of late period resource intensification within a previously under-used area. Largely restricted to seeds and small game, the local subsistence base was of limited value relative to surrounding areas from which a wide variety of both upland (acorns, pine nuts, deer) and lowland (fish, shellfish, brine fly larvae, waterfowl, greens and shoots, roots and tubers) resources could be had. Not surprising, little evidence exists in the project area for the use of local foods prior to the Late Newberry period. During the Late Newberry-Haiwee interval of expanding obsidian production, some subsistence pursuits did occur, but most were in support of the extensive stone working activities that took place.

With the advent of the Marana period, temporary seed processing areas proliferate across the Volcanic Field. Largely restricted to milling equipment and hearths, the sporadic distribution of these sites suggests that most were located adjacent to seed producing areas rather than in places conducive to longer-term occupation. Moreover, most contained relatively large millingstones selected for long term durability rather than ease of transport, clearly indicating the desire to reuse particular seed patches in the future. Due to the ephemeral nature of these areas, floral and faunal remains were rarely associated. Where such associations existed, animal bone was limited to rabbit-sized taxa and smaller, while the plant remains included ricegrass, goosefoot, tansy mustard, blazing star, chia, and desert tomato. As noted by Delacorte (1990), the interval of time between when seeds become ripe for harvest, and fall to the ground unused or are lost to competing animals, is extremely short. It follows, therefore, that a full use of this resource base required keen knowledge of the distribution and condition of local seed-bearing plants, a knowledge attainable only by people occupying relatively limited tracts of land.

COMPARISON WITH OTHER OBSIDIAN PRODUCTION SYSTEMS

To gain better insight into the factors possibly involved with the collapse of the Late Newberry-Haiwee period production system at Coso, we look at general trends in the use of obsidian from sources in northern California and southern Oregon, as well as those observed in the Casa Diablo and Bodie Hills procurement areas. Similar to Coso, Casa Diablo and Bodie have multiple obsidian flows (e.g., Hughes 1994a), and reveal production peaks during the Newberry and early Haiwee periods, followed by major declines thereafter (Bouey and Basgall 1984; Goldberg et al. 1990; Hall 1983; Hall and Basgall 1994; Jackson and Ericson 1994; Singer and Ericson 1977).

The decline of obsidian production ca. 1300 B.P. also seems to have been widespread throughout northern California and Oregon. Fredrickson and White (1988:81) report a significant drop at about 1500 B.P. in obsidian production at the Borax Lake source in the North Coast Ranges of California. This is also the case for Medicine Lake obsidian sources in northeastern California (Hildebrandt et al. 1994:8-58). The trend continues even further north, occurring at Newberry Crater near Bend, Oregon (Skinner 1995a:5-39). Moreover, individual major obsidian flows formed since 1300 years ago — the Glass Mountain Flow in the Medicine Lake Highlands (Hughes 1982) and the Big Obsidian Flow at Newberry Crater (MacLeod et al. 1982) — show little evidence of use. Less than 2.0% of the 5,600 pieces (XRF) identified as Medicine Lake Highlands glass match the geochemical profile for the Glass Mountain Flow (Gilreath 1997:7), while only 27 (1.0%) of over 2,700 pieces identified as Newberry Crater glass match the profile for the Big Obsidian Flow (Skinner 1995b:4-31).

Obsidian hydration data on Casa Diablo materials collected from the west side of the Sierra Nevada roughly parallel the production profiles, and are thought to represent a trans-Sierran exchange system initiated by the development of large sedentary consumer populations living across the divide (Goldberg et al. 1990; King 1976; Moratto 1972; Moratto et al. 1978). Various scenarios have been forwarded to explain the late period decline of this system. Hall (1983) argues that recurrent volcanic eruptions in the eastern Sierra may have restricted access to the Casa Diablo quarries, thereby inhibiting the flow of obsidian across the mountains. Jackson and Dietz (1984), Moratto and Davis (1988), and Goldberg et al. (1990), alternatively, suggest the rapid onset of drought during the Haiwee period disrupted the socio-political organization of west-side populations, in turn undermining existing trade relations by which Casa Diablo glass was dispersed.

Neither of the environmental explanations proffered for Casa Diablo adequately accounts for the events that appear to have been occurring on an inter-regional scale. Looking first at Hall's hypothesis, if volcanism alone forced the decline in Casa Diablo exploitation, it is reasonable that exploitation increased or expanded in alternative quarrying zones to satisfy demand. Coso is the closest substantial obsidian quarrying zone south of Casa Diablo (Map 6, [Fish Springs is by comparison small]); it was not affected by late Holocene volcanism in the Inyo-Mono chain; it displayed no exploitation increase to off-set the decline in the availability of Casa Diablo obsidian. Although it is difficult to know the geographic extent of the Haiwee-period drought events (see Stine 1994), it is unlikely that obsidian quarries located considerably to the north (e.g., in southeast Oregon and northwest California) would have been affected in the same way as those in the more arid regions of southeastern California.

Goldberg et al. (1990:179) also consider the importance of technological change, stating that "It is tempting to posit that reduction in production at the Casa Diablo quarries was related chiefly to technological changes, which, beginning during the Haiwee Period with diminished size of flaked stone tools, required smaller pieces of obsidian for tool production." Much of this material, it is further argued, could have been obtained through scavenging off local sites where obsidian was deposited during earlier periods of occupation (Skinner 1989; Wilke and Flenniken 1988). Ericson (1982) has also attributed production shifts to technological change, but argued that introduction of the bow and arrow increased demand for glass, resulting in export of unmodified cores that were subsequently reduced elsewhere, leaving little or no evidence at the quarries (see also Jackson 1988). We have shown that this latter proposal is not borne out by the consumer hydration profiles obtained from much of southern California.

Similar to our interpretations of the Coso situation, Bouey and Basgall (1984) argue that Newberry period adaptations along the eastern Sierra were characterized by high residential mobility and little or no territoriality — qualities they view as incongruent with the development or persistence of a large-scale production system. They thought it more likely that groups living on the western slope traveled to Casa Diablo, directly procuring obsidian themselves, and later trading it to populations occupying California's Central Valley. The ultimate demise of the system occurred when east side populations became increasingly territorial (see Bettinger and Baumhoff 1982) and direct access to the source was constrained.

Given the striking similarities between Casa Diablo, Bodie, and Coso production curves, as well as those from northern California and Oregon, it seems probable that similar sets of causative factors influenced their development and demise. A combination of two factors provides the best explanatory power: increased territoriality and technological change. Similar to the scenario forwarded by Bouey and Basgall (1984), the acquisition and distribution of obsidian reached peak proportions when various groups had access to the quarries. Whether they originated from across the Sierra Nevada, or were east-side people conducting exchanges with westerners and southerners during a regularized seasonal round, the crucial point is there was a demand for obsidian and little or no constraints inhibiting its acquisition. Later in time, decreased mobility accompanied by increased population density and territoriality (Bettinger and Baumhoff 1982), may have constrained free movement across the landscape and ultimately complicated the flow of obsidian (i.e., the number of exchanges per unit distance traveled increased). These developments, coupled with decreasing demands due to changes in flaked stone technology (Goldberg et al. 1990; Wilke and Flenniken 1988), compounded by increasing exploitation of plant resources, significantly decreased the importance of toolstone throughout much of southern California.

EXCHANGE, CRAFT SPECIALIZATION, AND SOCIOPOLITICAL ORGANIZATION

Overviews of California prehistory routinely tell a tale of population growth and increasing social complexity, resulting in the "extraordinary variability of California cultures" (Jennings 1975:176). This is evidenced by Heizer's (1978:ix) tribal territories map for California. This is also indicated by the high degree of competition in late times for select resources with limited natural distributions. Aikens (1978:143), for example, states, "evidence of growing social complexity might be seen in the increase throughout central and southern California over the past several thousand years of both violent deaths and trade goods." From such accounts, we have come to assume that trade was more important in the late period that in earlier times, and since California ethnographic studies often list obsidian among the items traded, it is often accepted as fact that late period obsidian trade was widely practiced on a significant scale. Archaeologists working elsewhere in the world often have the same expectations.

Recent research in the American Southwest indicates that the production and exchange of obsidian reached peak proportions during the Classic period, after 850 B.P. (Mitchell and Shackley 1995; Shackley 1995). This period of cultural complexity is evidenced by several large Hohokam settlements in southern Arizona that were supported through the intensive use of irrigation agriculture and the widespread exchange of a variety of items. Common trade goods recovered from archaeological contexts include pottery vessels, marine shell, obsidian, and turquoise. This perceived correlation between late period cultural complexity and the increased importance of obsidian exchange has also influenced prehistoric studies in Alta California and the Baja peninsula, where several researchers have argued for parallel patterns of development among hunter-gatherer populations in these areas (e.g., Bettinger and King 1971; Ericson 1984; Fredrickson 1974; Heizer 1974; Shackley et al. 1996).

Hughes (1994b:364) refers to this view as "the incremental model of culture change" where the "prevailing view was that the earliest peoples rarely, if ever, engaged in much trade, but that the frequency increased steadily through prehistoric time, culminating in the flow of commodities documented in ethnographies." This perspective is clearly illustrated by Ericson's (1984) attempt to explain the origin of formalized exchange systems among hunter-gatherers:

> Sedentism, which changes people-land relationships, requires increased scheduling and dependability of resources. Sedentism, population growth, and growing dependency of the population on regional resources as well as the establishment of territoriality within the region favor the growth of a regional exchange system [1984:7].

He also argued that large-scale exchange systems often used the labor of occupational specialists which usually required the centralized redistribution of surplus resources to support them. Torrence (1986) and Arnold (1987), focusing on the archaeological implications of such phenomena, have proposed the following indicators of occupation specialization: (1) very high volumes of production materials; (2) identifiable workshops separated from other subsistence/residential areas; (3) distinct patterns in regional distribution, reflecting organized and controlled production and exportation; (4) high degrees of technological standardization and low rates of production failures; (5) control over critical resources; and (6) specialist's tools in certain burials. Direct access to quarry areas by non-specialized producers, in contrast, would be evidenced by a wider range of reduction technologies and end-products (Ericson 1984).

While the latter prediction broadly corresponds to assemblages and adaptive patterns assigned to the Early, Little Lake, and Early/Middle Newberry periods at Coso, the Torrence-Arnold criteria — though closely approximating the Late Newberry archaeological record — would no doubt misinterpret the degree of organizational complexity involved. Late Newberry production specialization is clearly indicated by spatially discrete workshop areas, large volumes of obsidian debitage, high degrees of technological standardization and success, and distinct regional distributions of material (flowing largely to the west and southwest). Rather than representing occupational specialization, we conclude that these characteristics are a likely outcome of logistically organized groups sent to the Volcanic Field for the specific purpose of producing bifacial blanks and preforms. Such forays probably originated from a seasonal residential base located outside the Volcanic Field, and would have been organizationally equivalent to hunting parties sent to upland areas in pursuit of deer.

Haiwee period production organization presents a different set of interpretive difficulties. Lacking biface production areas within the procurement zone, most toolstone (in reduced forms) was probably moved directly from the primary quarries to outlying residential bases where further modification took place (e.g., Coso Junction Ranch). Although substantial amounts of obsidian were reduced for exchange, perhaps by individuals controlling access to the quarries, the archaeological record provides few hints as to the degree of production specialization involved.

Moving to the late prehistoric-ethnographic periods, Bettinger and King (1971) have also considered the importance of obsidian exchange in their analysis of sedentary settlement structure among the Owens Valley Paiute. Rather than attributing the late period emergence of permanent villages and non-egalitarian social organization to the rich resource base of Owens Valley (see Steward 1938), they proposed that intergroup exchange was a necessary component of the system because:

> ... in the face of increasing social circumscription, trade provides a means whereby local populations can be maintained at levels higher than would be possible on the basis of local resources alone [Bettinger and King 1971:142].

Obsidian was viewed as an integral component of this system because it could be used to obtain shell beads from the west, which could in turn be traded for foodstuffs during periods of subsistence stress. Most bead-for-food exchanges occurred during inter-village fiestas where groups from a variety of locations would converge, and redistribute resources from areas with surpluses to those experiencing deficits. Bettinger and King (1971) further predicted that the development of the fiesta-shell bead economic system coincided with a dramatic increase in trans-Sierran obsidian trade.

Although some aspects of the socio-economic relationships outlined above no doubt existed (e.g., the redistributive fiesta system is clearly documented in the ethnographic record), the role of obsidian — at least as seen from the archaeological records of Casa Diablo and Coso — appears to have been over stated. Obsidian exploitation at Coso was at its lowest level ever in the late period. The fact that most ethnographic accounts rarely mention obsidian, and when they do, rank it below more favored trade items such as salt, basketry, hides and pelts, shell beads, acorns, and fish (see Bettinger 1982a, 1982b; Davis 1961; Ericson 1977), provides further evidence of the reduced importance of volcanic glass as a late period commodity of exchange.

REFERENCES CITED

Adams, C. J.
1986 *CA-MNO-833, An Obsidian Stoneworking Camp in Long Valley, Mono County, California.* Submitted to the California Department of Transportation, Office of Environmental Analysis, Sacramento.

Aikens, C. M.
1978 The Far West. In *Ancient Native Americans*, edited by J. D. Jennings, pp. 131-182. W. H. Freeman and Company, San Francisco.

Allen, M. W.
1986 *The Effects of Bow and Arrow Technology on Lithic Production and Exchange Systems: A Test Case Using Debitage Analysis.* Unpublished Master's thesis, Department of Anthropology, University of California, Los Angeles.

Arnold, J. E.
1987 *Craft Specialization in the Prehistoric Channel Islands, California.* University of California Publications in Anthropology 18. University of California Press, Berkeley.

Bacon, C. R., R. MacDonald, R. L. Smith, and P. A. Baedecker
1981 Pleistocene High-Silica Rhyolites of the Coso Volcanic Field, California. *Journal of Geophysical Research* 86:10233-10241.

Bacon, C. R., D. M. Giovanetti, W. A. Duffield, G. B. Dalrymple, and R. E. Drake
1982 Age of the Coso Formation, Inyo County, California. *U. S. Geological Survey Bulletin* 1527.

Bard, J. C., C. I. Busby, and R. J. Dezzani
1985 *Kennedy Meadows Cultural Resources Data Recovery Project.* Submitted to the USDA Forest Service, Sequoia National Forest, Porterville, California.

Basgall, M. E.
1983 *Archaeology of the Forest Service Forty site (CA-Mno-529), Mono County, California.* Submitted to the USDA Forest Service, Inyo National Forest, Bishop, California.

1984 *The Archaeology of CA-MNO-1529: A Secondary Reduction Site in Mammoth Lakes, Mono County, California.* Submitted to the USDA Forest Service, Inyo National Forest, Bishop, California.

1987 Paleoindian Occupation in Central-eastern California: The Komodo site. *Current Research in the Pleistocene* 4:50-54.

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

1990 Hydration Dating of Coso Obsidian: Problems and Prospects. Paper presented at the 24th meeting of the Society for California Archaeology, Foster City.

1991 *The Archaeology of Nelson Basin and Adjacent Areas, Fort Irwin, San Bernardino County, California.* Submitted to the U. S. Army Corps of Engineers, Los Angeles District Office, California.

Basgall, M. E., and M. C. Hall
1992 *Archaeology of the Awl Site (CA-SBR-4562), Fort Irwin, San Bernardino County, California: An Early Holocene Residential Base in the North-Central Mojave Desert*. Submitted to U. S. Army Corps of Engineers, Los Angeles District Office, California.

Basgall, M. E., and K. R. McGuire
1988 *The Archaeology of CA-INY-30: Prehistoric Culture Change in the Southern Owens Valley, California*. Submitted to the California Department of Transportation, Office of Environmental Analysis, Sacramento.

Basgall, M. E., and D. L. True
1985 *Archaeological Investigations in Crowder Canyon, 1973-1984: Excavations at Sites SBR-421B, SBR-421C, SBR-421D, and SBR-713*. Submitted to the California Department of Transportation, Office of Environmental Analysis, Sacramento.

Basgall, M. E., M. C. Hall, and W. R. Hildebrandt
1988 *The Late Holocene Archaeology of Drinkwater Basin, Fort Irwin, San Bernardino County, California*. Submitted to U. S. Army Corps of Engineers, Los Angeles District Office, California.

Bedwell, S. F.
1973 *Fort Rock Basin: Prehistory and Environment*. University of Oregon Books, Eugene.

Bennyhoff, J. A., and R. E. Hughes
1987 *Shell Bead and Ornament Exchange Networks between California and the Western Great Basin*. Anthropological Papers of the American Museum of Natural History 64(2). New York.

Bettinger, R. L.
1975 *The Surface Archaeology of Owens Valley, Eastern California; Prehistoric Man-Land Relationships in the Great Basin*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Riverside.

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

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

1982b *Archaeology of the East Range of Light: Aboriginal Human Ecology of the Inyo Mono-Region of Central-Eastern California*. Monographs in California and Great Basin Anthropology, No. 1. University of California, Davis.

1989 *The Archaeology of Pinyon House, Two Eagles, and Crater Middens: Three Residential Sites in Owens Valley, Eastern California*. Anthropological Papers of the American Museum of Natural History 67.

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

Bettinger, R. L., and M. A. Baumhoff
1982 The Numic Spread: Great Basin Cultures in Competition. *American Antiquity* 47:485-503.

Bettinger, R. L., and T. F. King
1971 Interaction and Political Organization: A Theoretical Framework for Archaeology in Owens Valley, California. *University of California Archaeological Survey Annual Report* 13:187-195.

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

Bettinger, R. L., M. G. Delacorte, and K. R. McGuire
1984 *Archaeological Excavations at the Partridge Ranch Site (CA-INY-2146), Inyo County, California.* Submitted to the California Department of Transportation, Office of Environmental Analysis, Sacramento.

Bettinger, R. L., J. F. O'Connell, and D. H. Thomas
1991 Projectile Points as Time Markers in the Great Basin. *American Anthropologist* 93(1):166-172.

Billings, W. D.
1951 Vegetational Zonation in the Great Basin of Western North America. *Union Internationale des Sciences Biologiques,* Serie B9:101-122.

Bostwick, T. W., and J. H. Burton
1993 A Study in Sourcing Basalt Ground Stone Implements. *Kiva* 3:357-372.

Botkin, S. G., T. A. Clewlow, M. C. Brown, and C. W. Clewlow
1987 *Final Report on Archaeological Investigations Along the CLJV 28.5 Mile Transmission Corridor, China Lake Naval Weapons Center, Inyo and Kern Counties, California.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Bouey, P. D.
1991 Recognizing the Limits of Archaeological Applications of Non-Destructive Energy-Dispersive X-Ray Fluorescence Analysis of Obsidians. *Materials Research Society Symposium Proceedings* 185:309-320.

Bouey, P. D., and M. E. Basgall
1984 Trans-Sierran Exchange in Prehistoric California: The Concept of Economic Articulation. In *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 135-172. Contributions of the University of California Archaeological Research Facility No. 45. Berkeley.

Bouey, P. D., and P. J. Mikkelsen
1989 *Survey and Test Evaluation for the China Lake-Fort Irwin Joint Land Use Area, San Bernardino County.* Submitted to the U. S. Army Corp of Engineers, Los Angeles District Office, California.

Bouscaren, S., and P. J. Wilke
1987 Excavation at Mammoth: Archaeological Data Recovery at Four Sites near Mammoth Creek, Mono County, California. *University of California Archaeological Research Unit Project Report No. UCRARU773*, Riverside.

Byrd, B. F., D. Pallette, and C. Serr
1994 Prehistoric Settlement along the Eastern Margin of Rogers Dry Lake, Western Mojave Desert, California. *Brian F. Mooney Associates Anthropological Technical Series* 2.

Callahan, E.
1979 The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts. *Archaeology of Eastern North America* 7(1):1-180.

Cleland, J. H.
1988 Problems in the Hydration Dating of Coso Obsidian at the Source. Paper presented at the 22nd Annual Meeting of the Society for California Archaeology, Redding.

1989 Induced Hydration Rates for Coso Obsidian: An Update. Paper presented at the 23rd Annual Meeting of the Society for California Archaeology, Santa Rosa.

1990 *Sugarloaf Archaeological District Cultural Resources Management Plan*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Cleland, J. H., R. M. Apple, and E. Nilsson

1990 *Sugarloaf Mountain in Prehistory: Archaeological Testing and Data Recovery for the Exploratory Drilling Program II and the Unit No. 1 Project*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Clewlow, C. W., R. F. Heizer, and R. Berger

1970 An Assessment of Radiocarbon Dates for the Rose Spring Site (CA-INY-372), Inyo County, California. *Anthropology of the Great Basin Contributions of the University of California Archaeological Research Facility No*. 7, pp. 19-27.

Clewlow, C. W., H. F. Wells, and D. S. Whitley

1980 *Cultural Resources Technical Report on the Coso Geothermal Study Area. Rockwell International Technical Report (EMSC8312.20) for the 1980 BLM Coso Leasing EIS*. Submitted to Environmental Branch, Naval Air Weapons Station, China Lake, California.

Collins, M. B.

1975 Lithic Technology as a Means of Processual Inference. In *Lithic Technology: Making and Using Stone Tools*, edited by E. Swanson, pp. 15-34. Mouton Publishers, The Hague, Paris.

Cottrell, M. G.

1981 In *Obsidian Dates III: A Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory*, edited by C. W. Meighan and G. S. Russell, pg. 22. University of California, Los Angeles.

1988a Obsidian Hydration: An Analysis of Readings Obtained from CA-ORA-183, A Coastal Shell Midden, Huntington Beach, California. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory,* edited by C. W. Meighan and J. L. Scalise, pp. 30-34. University of California, Los Angeles.

1988b Tomato Springs Site (CA-ORA-244): Obsidian Hydration Readings and Radiocarbon Dates. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory,* edited by C. W. Meighan and J. L. Scalise, pp. 35-39. University of California, Los Angeles.

1988c Analysis of Radiocarbon Dates and Obsidian Hydration Readings Obtained for Two Sites in the Southern California Coastal Region. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory,* edited by C. W. Meighan and J. L. Scalise, pp. 40-41. University of California, Los Angeles.

Crabtree, D. E.

1973 Experiments in Replicating Hohokam Points. *Tebiwa* 16:10-45.

Davis, J. T.

1961 Trade Routes and Economic Exchange Among the Indians of California. *University of California Archaeological Survey Reports* 54:1-71. Berkeley.

DeDecker, M.

1984 Flora of the Northern Mojave Desert, California. *California Native Plant Society Special Publication* 7.

Delacorte, M. G.
1988 *Beyond the Horizon: Adaptive Variation in Central Eastern California*. Manuscript prepared for University of California, Los Angeles, Institute of Archaeology Monographs.

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

Delacorte, M. G., and K. R. McGuire
1993 *Archaeological Test Evaluation at 23 Sites Located Along a Proposed Fiber-Optic Telephone Cable Route in Owens Valley, California*. Submitted to Contel of California Inc., and the Department of Interior, Bureau of Land Management, California Desert District, Ridgecrest, California.

Dillon, B. D.
1988 Southern Sierra Nevada Obsidian Hydration: Kern County's Isabella Basin. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory,* edited by C. W. Meighan and J. L. Scalise, pp. 64-69. University of California, Los Angeles.

Drews, M., and R. G. Elston
1983 *An Archaeological Investigation of Drilling Locations and Power Plant Site in the Coso Known Geothermal Resource Area, China Lake Naval Weapons Center*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Duffield, W. A., and C. R. Bacon
1981 Geologic Map of the Coso Volcanic Field and Adjacent Areas, Inyo County, Ca. *U.S. Geological Survey Miscellaneous Investigations* (series map 1-1200, scale - 1:50,000).

Duffield, W. A., C. R. Bacon, and G. B. Dalrymple
1980 Late Cenozoic Volcanism, Geochronology, and Structure of the Coso Range, Inyo County, California. In Geothermal Investigations in the Coso Range, California. *Journal of Geophysical Research* 85(5):2381-2404.

Elston, R. G., and C. D. Zeier
1984 The Sugarloaf Obsidian Quarry. *Naval Weapons Center Administrative Publication* 313, China Lake, California.

Elston, R. G., S. Seck, and S. James
1981 *An Intensive Archaeological Investigation of Two Proposed Drilling Locations in the Coso Known Geothermal Resource Area, China Lake Naval Weapons Center*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Ericson, J. E.
1977 *Prehistoric Exchange Systems in California: The Results of Obsidian Dating and Tracing*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Los Angeles.

1978 Date lists, INY-372. In *Obsidian Dates II, a Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory,* edited by C. W. Meighan and P. I. Vanderhoeven, pp. (3)18-19. Monograph VI, Institute of Archaeology. University of California, Los Angeles

1982 Production for Obsidian Exchange in California. In *Contexts for Obsidian Exchange*, edited by J. E. Ericson and T. K. Earle, pp. 129-148. Academic Press, New York.

1984 Toward the Analysis of Lithic Production Systems. In *Prehistoric Quarries and Lithic Production,* edited by J. E. Ericson and B. A. Purdy, pp. 1-9. Cambridge University Press, Cambridge.

1989 Toward Flow-Specific Obsidian Hydration Rates: Coso Volcanic Field, Inyo County, California. In *Current Directions in California Obsidian Studies*, edited by R. E. Hughes, pp. 13-22. Contributions of the University of California Archaeological Research Facility No. 48.

Ericson, J. E., H. C. Koerper, C. E. Drover, and P. E. Langenwalter II
1989 Advances in Obsidian Hydration Dating and Obsidian Exchange in Prehistoric Orange County. *Pacific Coast Archaeological Society Quarterly*, 25(2):45-60.

Flenniken, J. J., and A. W. Raymond
1986 Morphological Projectile Point Typology: Replication, Experimentation, and Technological Analysis. *American Antiquity* 51(3):603-614

Flenniken, J. J., and P. J. Wilke
1989 Typology, Technology, and Chronology of Great Basin Dart Points. *American Anthropologist* 91(1):149-158.

Fowler, C. S.
1986 Subsistence. In *Great Basin* edited by W. L. d'Azevedo, pp. 64-97. Handbook of North American Indians, Vol. 11, W. C. Sturtevant, general editor. Smithsonian Institution, Washington D. C.

Fratt, L., and J. L. Adams
1993 New Trends in Ground Stone Research: Its Not the Same Old Grind. *Kiva* 58(3):313-317.

Fredrickson, D. A.
1974 Cultural Diversity in Early Central California: A View from the North Coast Ranges. *Journal of California Anthropology* 1(1):41-53.

Fredrickson, D. A., and J. Grossman
1977 A San Dieguito Component at Buena Vista Lake, California. *Journal of California Anthropology* 4(2):173-190.

Fredrickson, D. A., and G. G. White
1988 The Clear Lake Basin and Early Complexes in California's North Coast Ranges. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface*, edited by J. A. Willig, C. M. Aikens, and J. L. Fagan. Nevada State Museum Anthropological Papers 21:75-86.

Friedman, I., and W. Long
1976 Hydration Rate of Obsidian. *Science* 191:347-352.

Friedman, I., and J. Obradovich
1981 Obsidian Hydration Dating of Volcanic Events. *Quaternary Research* 16:37-41

Friedman, I. and R. L. Smith
1960 A New Dating Method Using Obsidian: Part 1, The Development of the Method. *American Antiquity 48: 544-547.*

Frison, G. C., and B. A. Bradley
1980 *Folsom Tools and Technology at the Hanson Site, Wyoming*. University of New Mexico Press, Albuquerque.

Garfinkel, A. P., and K. R. McGuire

1980 Subsistence-Settlement Systems of the Southern Sierra Nevada. In *Archaeological Investigations in the Southern Sierra Nevada: The Lamont Meadow and Morris Peak Segment of the Pacific Crest Trail,* by A. P. Garfinkel, R. A. Schiffman, and K. R. McGuire. Submitted to the USDA Forest Service, Sequoia National Forest, Porterville, California.

1981 Chronometrics. In *Archaeological Investigations in the Kennedy Meadows/Rockhouse Basin Segment of the Pacific Crest Trail,* by K. R. McGuire. Submitted to the USDA Forest Service, Sequoia National Forest, Porterville, California.

Garfinkel, A. P., C. A. Schiffman, and K. R. McGuire

1980 *Archaeological Investigations in the Southern Sierra Nevada: The Lamont Meadow and Morris Peak Segments of the Pacific Crest Trail.* Bureau of Land Management, Cultural Resources Publications, Archaeology. Bakersfield

Garfinkel, A. P., L. S. Kobori, J. C. Bard, and R. J. Dezzani

1984 *Rockhouse Basin Data Recovery Project.* Submitted to the USDA Forest Service, Sequoia National Forest, Porterville, California.

Gehr, E. A.

1981 Obsidian Hydration Data from Various Tulare County Sites: Tule River Indian Reservation. In *Obsidian Dates III: A Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory,* edited by C. W. Meighan and G. S. Russell, page 35. University of California, Los Angeles.

1988 Mean Temperature Scaling of Source Specific Hydration Rates. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory,* edited by C. W. Meighan and J. L. Scalise, pp. 19-26. University of California, Los Angeles.

Gilreath, A. J.

1987 *Survey and Evaluation of Cultural Resources on a Portion of Federal Lease CA-11402 Lands (Parcel 20) within the Coso K.G.R.A., Inyo County, California.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

1988 *Survey and Evaluation of Cultural Resources on a Portion of the Navy Contract Lands (Navy 2) within the Coso K.G.R.A., Inyo County, California.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

1997 *Cultural Resources Sample Survey and Sensitivity Assessment for the Fourmile Hill Geothermal Project, Modoc and Klamath National Forests.* Submitted to the U.S.D.A. Forest Service, Modoc National Forest, Alturas, California.

Gilreath, A. J., and W. R. Hildebrandt

1988 *Survey and Evaluation of Cultural Resources on a Portion of the Navy/C.L.J.V. Contract (Navy 1) Lands Within the Coso K.G.R.A., Inyo County, California.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

1991 *National Register of Historic Places Registration Form: Sugarloaf Archaeological District.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

1995 Prehistoric Use of the Coso Volcanic Field, Volumes I-III. Submitted to the Environmental Branch, China Lake, NAWS, and Eastern Information Center, Department of Anthropology, University of California, Riverside.

Gilreath, A. J., and K. R. McGuire
1987 *Preliminary Report of Investigations Conducted at Seven Archaeological Sites in Conjunction With the Placement of Eight California Energy Company, Inc. Drill Pads in the Coso K.G.R.A. B.L.M. Lease CA-11402, Inyo County, California*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Gilreath, A. J., M. E. Basgall, and M. C. Hall
1987 *Compendium of Chronologically Indicative Data From Fort Irwin Archaeological Sites, San Bernardino County, California*. Submitted to the U. S. Army Corps of Engineers, Los Angeles District Office, California.

Gilreath, A. J., B. P. Wickstrom, and W. R. Hildebrandt
1991 *Survey and Evaluation of Cultural Resources on Federal Lease CA-11402 (Residual B.L.M.) Within the Coso K.G.R.A., Inyo County, California*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Glennan, W. S.
1971 *A Glimpse at the Prehistory of Antelope Valley - Archaeological Investigations at the Sweetser Site (KER-302)*. Kern-Antelope Historical Society. Lancaster.

Goldberg, S. K., E. J. Skinner, and J. F. Burton
1990 *Archaeological Excavations at sites CA-MNO-574, -577, -578, and -833: Stoneworking in Mono County, California*. Submitted to the California Department of Transportation, Office of Environmental Analysis, Sacramento.

Goldberg, S .K., S. S. Salzman, E. J. Skinner, J. Burton, M. E. Scully, J. J. Holson, and M. J. Moratto
1986 *Cultural Resources of the Crane Valley Hydroelectric Project Area, Volume III: Archaeological Testing, Resource Evaluation, Impact Assessment, and Management Planning*. Submitted to Pacific Gas and Electric Company, San Francisco.

Grant, C., J. W. Baird, and J. K. Pringle
1968 *Rock Drawings of the Coso Range, Inyo County, California*. Maturango Museum Publication No. 4, Ridgecrest, California.

Greenwood, R. S., and M. J. McIntyre
1981 *Cultural Resources Management Plan for Edwards Air Force Base*. Submitted to Edwards Air Force Base, California.

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

1984 Obsidian, Paleoeconomy, and Volcanism in the Eastern Sierra Nevada. Paper presented at the 18th Great Basin Anthropological Conference, Boise, Idaho

1992 *Final Report on the Archaeology of Tiefort Basin, Fort Irwin, San Bernardino County, California*. Submitted to the U. S. Army Corps of Engineers, Los Angeles District Office, California.

Hall, M. C., and M. E. Basgall
1994 *Casa Diablo Obsidian in California and Great Basin Prehistory*. Paper presented at the 24th Great Basin Anthropological Conference, Elko, Nevada.

Harrington, M. R.
1951 A Colossal Quarry. *Masterkey* 25(1):15-18.

1957 A Pinto Site at Little Lake, California. *Southwest Museum Papers* No. 17. Los Angeles.

Hartzell, L. L.
1992 *Hunter-gatherer Adaptive Strategies in Lacustrine Environments in the Buena Vista Lake Basin, Kern County, California*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Davis.

Heizer, R. F.
1974 Studying the Windmiller Culture. In *Archaeological Researches in Retrospect*, edited by G. A. Willey, pp. 179-204. Winthrop Publishers, Cambridge, Massachusetts.

1978 *California*. Handbook of North American Indians, Volume 8, W. C. Sturtevant, general editor. Smithsonian Institution, Washington D.C.

Heizer, R. F., and M. A. Baumhoff
1962 *Prehistoric Rock Art of Nevada and Eastern California*. University of California Press, Berkeley and Los Angeles.

Heizer, R. F., and T. R. Hester
1978 Great Basin. In *Chronologies in New World Archaeology*, edited by R. E. Taylor and C. W. Meighan, pp. 147-199. Academic Press, New York.

Hester, T. R.
1973 Chronological Ordering of Great Basin Prehistory. *Contributions of the University of California Archaeological Research Facility* 17. Berkeley.

Hildebrandt, W. R., and A. J. Gilreath
1988 *Survey and Evaluation of Cultural Resources on a Portion of the Navy/C.L.J.V. Contract (Residual Navy 2) Lands within the Coso K.G.R.A., Inyo County, California*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Hildebrandt, W. R., P. J. Mikkelsen, and D. A. Jones
1994 Toolstone Procurement and Lithic Production Technology, California. In *Archaeological Investigations PGT-PG&E Pipeline Expansion Project Idaho, Washington, Oregon, and California*; edited by M. J. Moratto, Volume IV:8.1-8.63. Report submitted to Bechtel Corporation, San Francisco.

Hughes, R. E.
1982 Age and Exploitation of Obsidian from the Medicine Lake Highland, California. *Journal of Archaeological Science* 9(2):173-185.

1988 The Coso Volcanic Field Re-examined: Implications for Obsidian Sourcing and Hydration Dating Research. *Geoarchaeology* 3(4):253-265.

1994a Intrasource Chemical Variability of Artifact-Quality Obsidians from the Casa Diablo Area, California. *Journal of Archaeological Science* 21(2):263-271.

1994b Mosaic Patterns in Prehistoric California - Great Basin Exchange. In *Prehistoric Exchange Systems in North America*, edited by T. Baugh and J. E. Ericson, pp. 363-383. Plenum Press, New York.

Hughes, R. E., and D. L. True
1985 Perspectives on the Distribution of Obsidians in San Diego County, California. *North American Archaeologist* 6(4):325-339.

Hunt, A. P.
1960 Archaeology of the Death Valley Salt Pan, California. *University of Utah Anthropological Papers* 47.

Hunt, C. B.
1975 *Death Valley: Geology, Ecology, Archaeology*. University of California Press, Berkeley.

Iroquois Research Institute
1979 *A Land Use History of Coso Hot Springs, Inyo County, California. Administrative Publication 200*, Naval Weapons Center, China Lake.

Irwin, C. N. (editor)
1980 The Shoshoni Indians of Inyo County, California: The Kerr Manuscript. Edited, annotated and with introductory preface by C. N. Irwin. *Ballena Press Publications in Archaeology, Ethnology, and History* No. 15, edited by P. J. Wilke and A. B. Elsasser.

Jack, R. N.
1976 Prehistoric Obsidian in California I: Geochemical Aspects. In *Advances in Obsidian Glass Studies: Archaeological and Geochemical Perspectives,* edited by R. E. Taylor, pp. 183-217. Noyle Press, Park Ridge, New Jersey.

Jackson, R. J.
1985 *An Archaeological Survey of the Wet, Antelope, Railroad, and Ford Timber Sale Compartments in the Inyo National Forest*. Submitted to the USDA Forest Service, Inyo National Forest, Bishop, California.

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

Jackson, T. L., and S. A. Dietz
1984 *Archaeological Data Recovery Excavations at CA-FRE-798 and CA-FRE-805, Siphon Substation 33kV Distribution Line and Balsam Meadow Hydroelectric Project*. Submitted to Southern California Edison Company, Rosemead, California.

Jackson, T. L., and J. E. Ericson
1994 Prehistoric Exchange Systems in California. In *Prehistoric Exchange Systems in North America*, edited by T. Baugh and J. E. Ericson, pp. 385-415. Plenum Press, New York.

Jenkins, M.
1975 Glass Trade Beads in Alaska. *Bead Journal* 2(1):23-26.

Jennings, J. D.
1975 *Prehistory of North America*. Second Edition. McGraw-Hill Book Company, New York.

Jones, D. A.
1991 Flaked Stone Artifacts from Nelson Basin. In *The Archaeology of Nelson Lake Basin and Adjacent Areas*, by M. E. Basgall. Submitted to the U. S. Army Corps of Engineers, Los Angeles District Office, California.

1992 Flaked Stone. In *Final Report on the Archaeology of Tiefort Basin, Fort Irwin, San Bernardino County, California*, by M. C. Hall. Submitted to the U. S. Army Corps of Engineers, Los Angeles District Office, California.

Kelly, M. S., J. H. Cleland, and A. L. York
1989 *Cultural Resources Investigation for the Shallow Underground Tunnel/Chamber Explosion Test (S.U.T.C.E.T.) Facility*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

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

King, T. F.
1976 *Political Differentiation Among Hunter-Gatherers: An Archaeological Test*. Unpublished Ph.D. Dissertation, Department of Anthropology, University of California, Riverside.

Knaus, E., and J. J. Mazer
1991 *Homogeneity of Water Content in Obsidian from the Coso Field, Inyo County, California.* Submitted to the U.S. Department of Energy, Washington, D.C.

Koerper, H. C., J. E. Ericson, C. E. Drover, and P. E. Langenwalter II
1986 Obsidian Exchange in Prehistoric Orange County. *Pacific Coast Archaeological Society Quarterly* 22(1):33-69.

Kuchler, A. W.
1977 Map of the Natural Vegetation of California. In *Terrestrial Vegetation of California,* edited by M. G. Barbour and J. Major. Wiley and Sons, New York.

Lamphere, M. A., G. B. Dalrymple, and R. L. Smith
1975 K-Ar Ages of Pleistocene Rhyolitic Volcanism in the Coso Mountains, California. *Geology,* 3:339-341.

Lanning, E. P.
1963 The Archaeology of the Rose Spring Site (INY-372). *University of California Publications in American Archaeology and Ethnology* 49(3):237-336. Berkeley.

Laylander, D., and L. E. Christenson
1988 Corral Canyon and Late Prehistoric Exchange in Inland San Diego County, California. *Proceedings of the Society for California Archaeology* 1:134-158.

Lee, R.
1969 Chemical Temperature Integration. *Journal of Applied Meteorology* 8:423-430.

Leitner, B. M., and P. Leitner
1988 *Biological Resources of Certain Lands Within the Coso K.G.R.A., Including Portions of Navy/C.L.J.V. Contract Lands and B.L.M. Lease CA-11402*. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Mazer, J. J., J. K. Bates, C. M. Stevenson, and C. R. Bradley
1992 Obsidians and Tektites: Natural Analogues for Water Diffusion in Nuclear Waste Glasses. *Materials Research Society Symposium Proceedings* 257:513-520.

McClean, D. D.
1944 The Prong-horned Antelope in California. *California Fish and Game* 30:221-241.

McDonald, A. M.
1992 *Indian Hill Rockshelter and Aboriginal Cultural Adaptation in Anza-Borrego Desert State Park, Southeastern California*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Riverside.

McGuire, K. R.
1981 *Archaeological Investigations in the Kennedy Meadows/Rockhouse Basin Segment of the Pacific Crest Trail*. Submitted to the USDA Forest Service, Sequoia National Forest, Porterville, California.

McGuire, K. R., and A. P. Garfinkel
1980 *Archaeological Investigations in the Southern Sierra Nevada: The Bear Mountain Segment of the Pacific Crest Trail*. Bureau of Land Management, Cultural Resources Publications, Archaeology. Bakersfield.

McGuire, K. R., A. P. Garfinkel, and M. E. Basgall
1982 *Archaeological Investigations in the El Paso Mountains of the Western Mojave Desert: The Bickel and Last Chance Sites, CA-KER-250, -261*. Submitted to the Department of the Interior, Bureau of Land Management, California Desert District, Ridgecrest, California.

MacLeod, N. S., D. R. Sherrod, and L. A. Chitwood
1982 Geologic Map of Newberry Volcano, Deschutes, Klamath, and Lake Counties, Oregon. *U. S. Geological Survey Open File Reports* 82-847.

Meighan, C. W.
1978 Obsidian Dating of the Malibu Site. In *Obsidian Dates II: A Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory,* edited by C. W. Meighan and P. I. Vanderhoeven, pp. 158-161. University of California Institute of Archaeology Monograph 6. Los Angeles.

1981 The Little Lake Site, Pinto Points, and Obsidian Hydration Dating in the Great Basin. *Journal of California and Great Basin Anthropology* 3:200-214.

1988 Obsidian Dates from the Loyola Site, LAN-61. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory,* edited by C. W. Meighan and J. L. Scalise, pp. 27. University of California, Los Angeles.

Meighan, C. W., and G. S. Russell (editors)
1981 *Obsidian Dates III: A Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory*. University of California, Los Angeles.

Meighan, C. W., and J. L. Scalise (editors)
1988 *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory*. University of California, Los Angeles.

Meighan, C. W., and P. I. Vanderhoeven (editors)
1978 *Obsidian Dates II: A Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory*. University of California, Los Angeles.

Michels, J. W.
1965 *Lithic Serial Chronology through Obsidian Hydration Dating*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Los Angeles.

1983 The Hydration Rate for Coso (Sugarloaf) Obsidian at Archaeological Sites in the China Lake Area of California. *MOHLAB Technical Report* 23, State College, Pennsylvania.

Mille, P.
1975 An Historical Explanation of Alaskan Trade Beads. *Bead Journal* 2(2):20-24.

Mitchell, D. R., and M. S. Shackley
1995 Classic Period Hohokam Obsidian Studies in Southern Arizona. *Journal of Field Archaeology* 22(3):291-304.

Mone, S. L.
1986 *CA-MNO-574, A Secondary Reduction Site in Long Valley,* Mono County, California. Submitted to the California Department of Transportation, Office of Environmental Analysis, Sacramento.

Moratto, M. J.
1972 *A Study of Prehistory in the Southern Sierra Nevada Foothills, California*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Oregon, Eugene.

Moratto, M. J., T. F. King, and W. B. Woolfenden
1978 Archaeology and California's Climate. *The Journal of California Anthropology* 5(2):147-161.

Moratto, M. J., and O. K. Davis
1988 Paleoenvironment. In *Culture Change in the Central Sierra Nevada 8000 B.C. - A.D. 1950,* edited by M. J. Moratto, L. H. Shoup, and J. D. Tordoff, pp. 39-88. Submitted to the National Park Service, Washington D.C.

Muto, G. R.
1971 *A Technological Analysis of the Early Stages in the Manufacture of Lithic Artifacts*. Unpublished Master's thesis, Department of Anthropology, Idaho State University, Pocatello.

Newcomer, M. H.
1971 Some Quantitative Experiments in Hand-axe Manufacture. *World Archaeology* 3:85-94.

Rhode, D.
1992 The World According to a Hydrating Obsidian Flake: Steps Towards Chronological Control of an Archaeological Landscape. Paper presented at the 23rd Great Basin Anthropological Conference, Boise.

Roper-Wickstrom, K. C.
1992 *A Study of High Altitude Obsidian Distribution in the Southern Sierra Nevada, California.* Unpublished Master's thesis, California State University, Sonoma, CA.

Rosen, M. D.
1988 Samples Submitted from Ven-294. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory*, edited by C. W. Meighan and J. L. Scalise, p. 331. University of California, Los Angeles.

Ross, L. A.
1993 Glass Beads from Native American Protohistoric Sites in Inyo County, California. In *Archaeological Test Evaluation at 23 Sites Located Along a Proposed Fiber-Optic Telephone Cable Route in Owens Valley, California*, by M. G. Delacorte and K. R. McGuire, Appendix V. Submitted to Contel of California Inc., and the Department of Interior, Bureau of Land Management, California Desert District, Ridgecrest, California.

Schiffman, R. A.
1988 An Experiment in the Use of Obsidian Hydration: Effect of Laboratory Variability on the Research and Interpretation of Sites. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory,* edited by C. W. Meighan and J. L. Scalise, pp. 13-18. University of California, Los Angeles.

Schneider, J. S., and G. D. Everson
1989 The Desert Tortoise (*Xerobates agassizii*) in the Prehistory of the Southwestern Great Basin and Adjacent Areas. *Journal of California and Great Basin Anthropology* 11:175-202.

Shackley, M. S.
1995 Sources of Archaeological Obsidian in the Greater American Southwest: An Update and Quantitative Analysis. *American Antiquity* 60(3):531-551.

Shackley, M. S., J. R. Hyland, and M. de la Luz Gutiérrez
1996 Mass Production and Procurement at Valle Del Azufre: A Unique Archaeological Obsidian Source in Baja California Sur. *American Antiquity* 61(4):718-731.

Sharrock, F. W.
1966 Prehistoric Occupation Patterns in Southwestern Wyoming and Cultural Relationships with the Great Basin and Plains Culture Area. *University of Utah Anthropological Papers* 77.

Singer, C.
1981 Date List, Horse Flats Sites, LAN-474A, -474B, Los Angeles County. In *Obsidian Dates III: A Compendium of the Obsidian Hydration Determinations Made at the U.C.L.A. Obsidian Hydration Laboratory*, edited by C. W. Meighan and G. S. Russell, p. 21. University of California, Los Angeles.

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

Skinner, C. E.
1995a Obsidian Hydration Studies. In *Archaeological Investigations PGT-PG&E Pipeline Expansion Project Idaho, Washington, Oregon, and California*; edited by M. J. Moratto, Volume V:5.1-5.51. Submitted to Bechtel Corporation, San Francisco.

1995b Obsidian Characterization Studies. In *Archaeological Investigations PGT-PG&E Pipeline Expansion Project Idaho, Washington, Oregon, and California*; edited by M. J. Moratto, Volume V:4.1-4.54. Submitted to Bechtel Corporation, San Francisco.

Skinner, E. J.
1989 Lithic Analysis. In *Cultural Resources of the Crane Valley Hydroelectric Project Area, Madera County, California. Volume V, Bass Lake Erosion Control Project, Limited Archaeological Site Data Recovery at CA-MAD-223, -224, and -392*, by S. K. Goldberg and E. J. Skinner. Submitted to Pacific Gas and Electric Co., San Francisco.

Skinner, E. J., and P. W. Ainsworth
1990 Unifacial Bifaces: More Than One Way to Thin a Biface. Paper presented at the 43rd Northwest Anthropological Conference, Eugene, Oregon.

Stevenson, C. M.
1987 *Hydration Rate Development for Selected Obsidians from the Coso Volcanic Field, Inyo County, California*. Submitted to Dames and Moore, San Diego Office, prepared by Archaeological and Historical Consultants, Centre Hall, Pennsylvania.

1990 Vapor Hydration Rates for the Coso Obsidian Source, Inyo County, California. In *Archaeological Testing and Data Recovery for the Exploratory Drilling Program II and the Unit No. 1 Project*, by J. H. Cleland, R. M. Apple, and E. Nilsson, Appendix E. Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Stevenson, C. M., and B. E. Scheetz
1989 Induced Hydration Rate Development of Obsidian from the Coso Volcanic Field: A Compendium of Experimental Procedures. In *Current Directions in California Obsidian Studies*, edited by R. E. Hughes, pp. 23-30. Contributions of the University of California Archaeological Research Facility No. 48.

Stevenson, C. M., J. J. Mazer, and J. K. Bates
1990 Obsidian Hydration Dating as a Function of Temperature, Compositions, and Relative Humidity. Paper presented at the 24th Annual Meeting of the Society for California Archaeology, Foster City.

Stevenson, C. M., E. Knaus, J. J. Mazer, and J. K. Bates
1993 Homogeneity of Water Content in Obsidian from the Coso Volcanic Field: Implications for Obsidian Hydration Dating. *Geoarchaeology* 8(5):371-384.

Steward, J. H.
1933 Ethnography of the Owens Valley Paiute. *University of California Publications in American Archaeology and Ethnology* 33(3):233-350.

1938 *Basin-Plateau Aboriginal Sociopolitical Groups*. Bulletin 120, Smithsonian Institution, Bureau of American Ethnology.

1954 Types of Types. *American Anthropologist*. 56(1):54-57.

Stine, S.
1994 Extreme and Persistent Drought in California and Patagonia During Mediaeval Time. *Nature* 369:546-549.

Sutton, M. Q.
1988a An Introduction to the Archaeology of the Western Mojave Desert, California. *Archives of California Prehistory* No. 14.

1988b Obsidian Analysis in the Mojave Desert, California: Results, Cautions, and Comments. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory*, edited by C. W. Meighan and J. L. Scalise, pp. 51-63. University of California, Los Angeles.

1988c Insects as Food: Aboriginal Entomophagy in the Great Basin. *Ballena Press Anthropological Papers* No. 33.

1991 *Archaeological Investigations at Cantil, Fremont Valley, Western Desert, California*. Museum of Anthropology, Occasional Papers in Anthropology No. 1. California State University, Bakersfield.

Theodoratus Cultural Research, Inc. and Archaeological Consulting and Research Services, Inc. (TCR and ACRS)
1984 *Cultural Resources Overview of the Southern Sierra Nevada*. Submitted to the USDA Forest Service, Inyo National Forest, Bishop, California.

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

1986 Points on Points: A Reply to Flenniken and Raymond. *American Antiquity* 51(3):619-627.

Thornthwaite, C. W.
1948 An Approach Toward a Rational Classification of Climate. *Geographical Review* 38:55-94.

Torrence, R.
1986 *Production and Exchange of Stone Tools.* Cambridge University Press, Cambridge.

Tremaine, K. J.
1989 *Obsidian as a Time Keeper: An Investigation in Absolute and Relative Dating.* Unpublished Master's thesis, Department of Anthropology, Sonoma State University, California.

Tremaine, K. J., and D. A. Fredrickson
1988 Induced Obsidian Hydration Experiments: An Investigation in Relative Dating. *Material Research Society Symposium Procedures* 123:271-278.

Troxell, H. C., and W. Hofmann
1954 Hydrology of the Mojave Desert. In *Geology of Southern California*, edited by R. H. Jahns, pp. 13-17. California Division of Mines Bulletin 170.

W and S Consultants
1985 *Archaeological Survey of Eight Proposed Geothermal Well Pads within Federal Lease CA-11402, Coso K.G.R.A., Inyo County, California.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

1986a *Archaeological Survey of the Proposed C.L.J.V. 28.5 Mile Transmission Line Corridor in the Coso K.G.R.A., Inyo County, California.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

1986b *Archaeological Investigations of Well Pads C and D Within Federal Lease CA-11402, Coso K.G.R.A., Inyo County, California.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Wallace, W. J.
1958 Archaeological Investigations in Death Valley National Monument. *University of California Archaeological Survey Reports* 42:7-22.

1977 A Half-century of Death Valley Archaeology. *The Journal of California Anthropology* 4:249-258.

Warren, C. N.
1967 The San Dieguito Complex: A Review and Hypothesis. *American Antiquity* 32:168-185.

1984 The Desert Region. In *California Archaeology*, by M. J. Moratto, pp. 339-430. Academic Press, Orlando, Florida.

1986 Early Holocene Cultural Adaptation in the Mojave Desert, California. Paper presented at the World Archaeological Congress, Southampton, England.

Warren, C. N., and R. H. Crabtree
1986 Prehistory of the Southwestern Area. In *Great Basin*, edited by W. L. d'Azevedo, pp. 183-193. Handbook of the North American Indians, Vol. 11, W. C. Sturtevant, general editor. Smithsonian Institution, Washington, D. C.

Warren, C. N., M. M. Lyneis, and J. H. Cleland
1984 *Draft Historic Preservation Plan, Fort Irwin, California.* Submitted to the Interagency Archaeological Services, National Park Service, San Francisco.

Wedel, W. R.
1941 Archaeological Investigations at Buena Vista Lake, Kern County, California. Washington, D.C.: *Bureau of American Ethnology Bulletin* 130.

Whitley, D. S.

1988 Obsidian Hydration Dates from the Coso Range. In *Obsidian Dates IV: A Compendium of the Obsidian Hydration Determinations Made at the Obsidian Hydration Laboratory,* edited by C. W. Meighan and J. L. Scalise, pp. 75-76. University of California, Los Angeles.

Whitley, D. S., G. Gumerman IV, J. M. Simon, and E. H. Rose

1987 The Late Prehistoric Period in the Coso Range and Environs. Paper presented at the 21st Society for California Archaeology Meetings, Fresno.

Wilke, P. J., and J. J. Flenniken

1988 Experimental Reduction of a Bifacial Core. Paper presented at the 21st Great Basin Anthropological Conference, Boise.

1991 Missing the Point: Rebuttal to Bettinger, O'Connell, and Thomas. *American Anthropologist* 93(1):172-173.

Yohe, R.

1992 *A Reevaluation of Western Great Basin Cultural Chronology and Evidence for the Timing of the Introduction of the Bow and Arrow to Eastern California Based on New Excavations at the Rose Spring Site (CA-INY-372).* Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Riverside.

York, A.

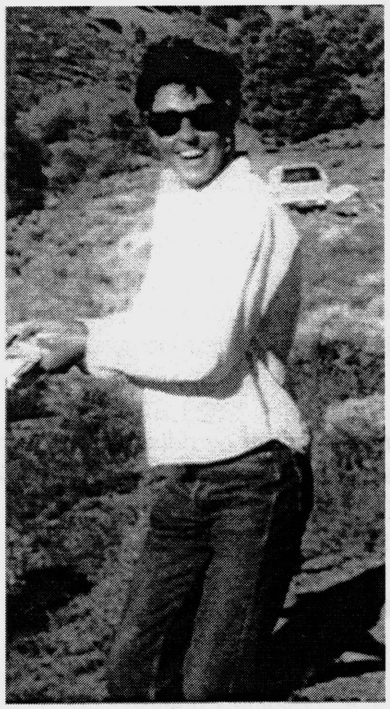
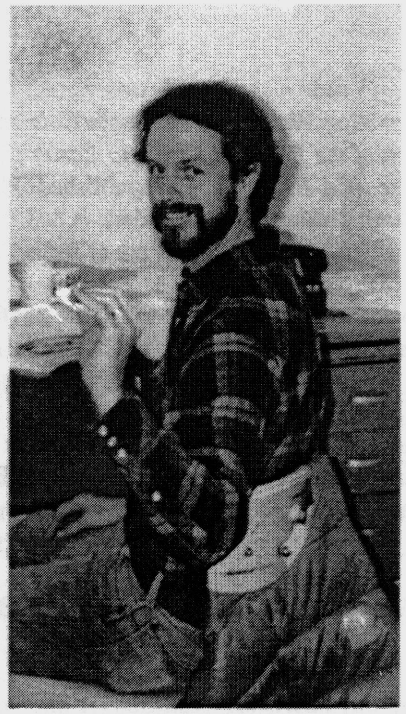
1992 Archaeological Investigations at CA-KER-2816 and -2817 Edwards Air Force Base, California. Paper presented at the Society for California Archaeology Annual Meetings.

Zeier, C. D., and R. G. Elston

1984 *An Analysis of Obsidian Hydration Processes at the Sugarloaf Obsidian Quarry, Inyo County, California.* Submitted to the Environmental Branch, Naval Air Weapons Station, China Lake, California.

Zigmond, M. L.

1981 *Kawaiisu Ethnobotany.* University of Utah Press, Salt Lake City.

Amy J. Gilreath and William R. Hildebrandt are Principals at Far Western Anthropological Research Group, Inc. in Davis, California.