SPATIAL AND TEMPORAL PATTERNING OF BEDROCK MORTAR SITES IN THE SOUTHERN SIERRA NEVADA: A REGIONAL EXPLORATION

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[OUTSTANDING STUDENT PAPER AWARD, PRESENTED AT THE ANNUAL MEETINGS, 2002]

Dating the initial appearance of bedrock mortar sites in the southern Sierra Nevada has proven difficult for a number of reasons. Overlapping occupations appear to be present at many sites, and clear stratigraphy is a rarity. Consequently, associations between datable materials and bedrock milling features are seldom straightforward when viewed from the perspective of individual sites. A course-grained regional approach to dating these sites is offered as a potential solution to this problem. Comparisons of large numbers of temperature-corrected obsidian hydration dates associated with bedrock mortar sites from a variety of elevations provide evidence for a late-prehistoric intensification of use at sites above 5,000 feet in elevation.

INTRODUCTION

Bedrock mortar features are frequently encountered at prehistoric archaeological sites along the western slope of the southern Sierra Nevada. Although the use of bedrock mortar technology is commonly assumed to have become widespread in central California sometime after 2000 years before present (B.P.), it has been difficult to firmly date the appearance and spread of this technology in the southern Sierra Nevada for a number of reasons. First, bedrock mortars are surface features, whereas datable materials (e.g., carbon, obsidian) are often recovered from buried contexts, meaning clear associations can be difficult to make. Second, many sites, especially sites in prime locations, appear to have been occupied long before bedrock mortars were used, resulting in mixed deposits. Third, despite the ubiquity of obsidian at many of these sites, hydration data are not readily comparable across the region due to the wide range of elevations and temperature regimes represented.

Previous researchers have dated the appearance of bedrock mortars in the region between ca. 1650 and 650 B.P. (Jackson and Dietz 1984; McGuire and Garfinkel 1980; Moratto 1984). It is not known, however, whether the initial appearance of this technology occurred simultaneously across the region. Considering the different elevations and vegetation zones where bedrock mortar sites are found, it stands to reason that some diversity in their use and the timing of their appearance could be expected (cf. Hull and Moratto 1999). Thus, it may be important to know not only when bedrock mortars first appeared, but also in what environments they were used and how widespread they were through time. If such variability can be discerned in the archaeological record, it may contribute to our understanding of the relationships between technological change and the development of regional subsistence-settlement systems.

BACKGROUND

The lack of accurate chronological control has been a persistent problem to researchers in the southern Sierra Nevada. Since the early 1980s, many archaeologists in the region have turned to obsidian hydration to provide chronological control where other traditional sources of temporal information (e.g., radiocarbon dating, artifact cross-dating) are not available. Generally, however, obsidian hydration data have been employed at single-site or single-project scales.

Over the last several decades, the number of sites sampled has grown, and the general outlines of the prehistory of this region are becoming clearer. Many questions, however, remain unanswered, and the lack of chronological control has hindered the ability of archaeologists to examine large-scale regional changes. Consequently, the development of more explanatory models of prehistoric culture change has lagged behind other regions in California.

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Proceedings of the Society for California Archaeology, Volume 16, 2003, pp 175-182

Rather than attempting to solve the myriad problems with chronology in the southern Sierra Nevada, this paper will present an example of how obsidian hydration can be used on a regional scale to explore long-term changes in the archaeological record. I will attempt to show that, despite problems with obsidian hydration dating, it is a method that holds promise for integrating the results of archaeological work performed in the southern Sierra Nevada over the last several decades.

METHODS

In order to explore spatial and temporal patterns of bedrock mortar sites, a database of hydration data was constructed. This database included a variety of information for each site, including location (UTM coordinates), elevation, artifact types, obsidian source assignments, and hydration rim measurements. Data were acquired from CRM reports pertaining to the Sierra Nevada region from Madera, Fresno, and Tulare counties. The database included additional data obtained by students participating in Anthropology 226 under the direction of Dr. Mark Basgall at California State University, Sacramento. In all, the database included a total of 2,699 hydration readings from 40 bedrock mortar sites ranging from 550 to 7,760 ft. in elevation.

Due to the wide range of elevations, and hence temperature regimes, hydration rates were constructed which take into account effective hydration temperature (EHT) (Lee 1969). Three hydration rates were used for this paper, one for each of the three most common obsidian sources in the region: Casa Diablo, Fish Springs, and the Coso Volcanic Field.

To construct the hydration rates, weather-station data from Fresno, Tulare, Inyo, and Mono counties were used to calculate EHT at a variety of elevations and environmental settings. Using these data, regression equations were constructed that allow an estimated EHT to be calculated for any given location and elevation. One equation was used for sites in Inyo and Mono counties, and a separate equation was used for sites on the western slope of the Sierra Nevada. The equations follow:

East of Crest $EHT(C)=Elev.-12643.206/-516.717$

West of Crest $EHT(C)=Elev.-11862.196/-561.797$

Once EHT values were calculated for sites throughout the region, hydration readings from time-sensitive projectile point types were grouped according to EHT and averaged for each two-degree (C) interval. The resulting hydration and period midpoint values were graphed according to the method described in Hull (2001), where the natural log of hydration squared, divided by time in thousands of years ($\ln X^2/t$), is plotted against EHT ($1/T$) in degrees Kelvin. In all, a total of 679 projectile points from both the western Great Basin and the Sierra Nevada was used to construct hydration rate equations for each of the three obsidian sources: 445 from Casa Diablo, 143 from Coso, and 91 from Fish Springs. The resulting hydration rates are shown in Figure 1. When these rates are applied to time-sensitive projectile points from across the region, most cluster within accepted ranges (see Figure 2).

After hydration rates had been constructed, they were applied to hydration rim readings from bedrock mortar sites in the southern Sierra Nevada. Two percentage histograms were then made which grouped years B.P. values into 500-year intervals. The first grouped together bedrock mortar sites below 5,000 feet in elevation, and the second grouped together bedrock mortar sites above 5,000 feet (refer to Figure 3). The 5,000-foot elevation was used as a dividing line between the two groups of sites because it represents the average winter snowline (Jackson 1984). Areas above snowline can be thought of as more marginal as a result of being seasonally restrictive.

A second set of percentage histograms was then made, grouping years B.P. values from *each site* into 500-year intervals. The percentages of values occurring in each 500-year interval for each site were then entered into a new table that allowed relative percentages of years B.P. values for each period to be compared across all 40 sites. Using this new table, a series of maps was produced showing the relative percentages of years B.P. values superimposed on a relief map of the region (refer to Figure 4).

Figure 1: Hydration rate equations for the three most common obsidian sources in the study region.

Casa Diablo:

$$x^2/\left[7.4719*10^{10}e^{-6507.3(1/T)}\right]= t$$

Fish Springs:

$$x^2/\left[3.4198*10^{10}e^{-6314.25(1/T)}\right]= t$$

Coso Volcanic Field:

$$x^2/\left[2.409*10^{15}e^{-9398.6(1/T)}\right]= t$$

Note: x=hydration in microns, e=base of natural logarithms (2.718), T=temperature in degrees Kelvin, t= time in thousands of years

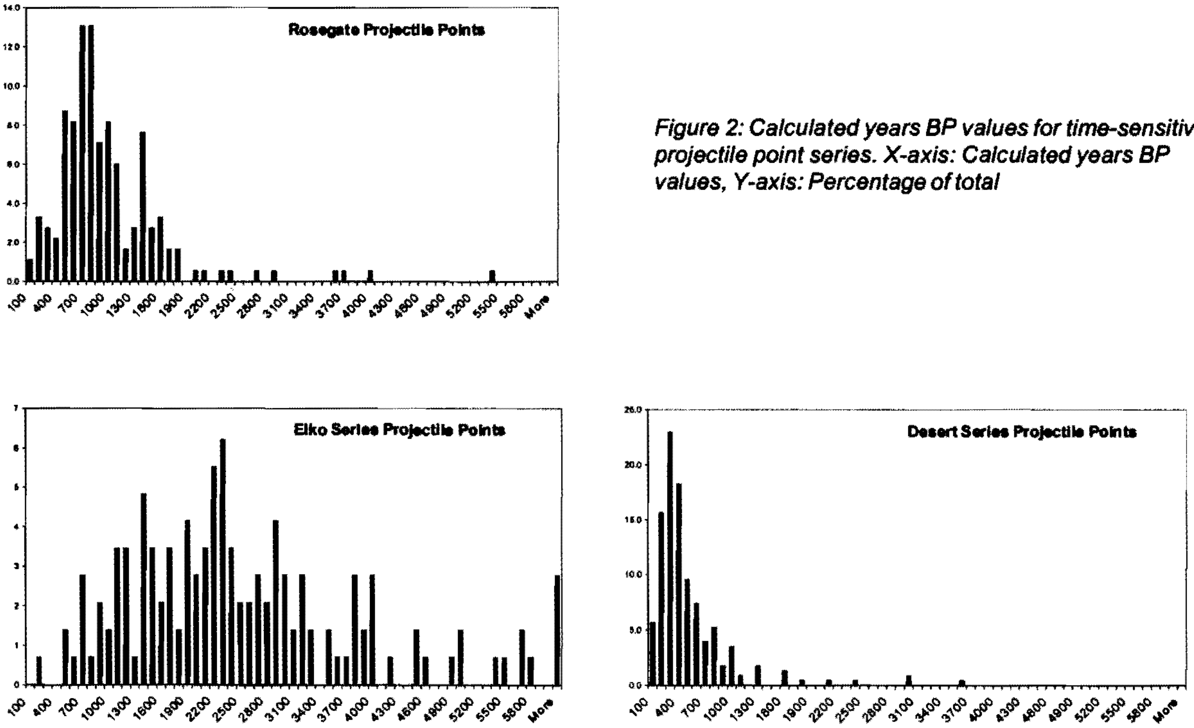

Figure 2: Calculated years BP values for time-sensitive projectile point series. X-axis: Calculated years BP values, Y-axis: Percentage of total

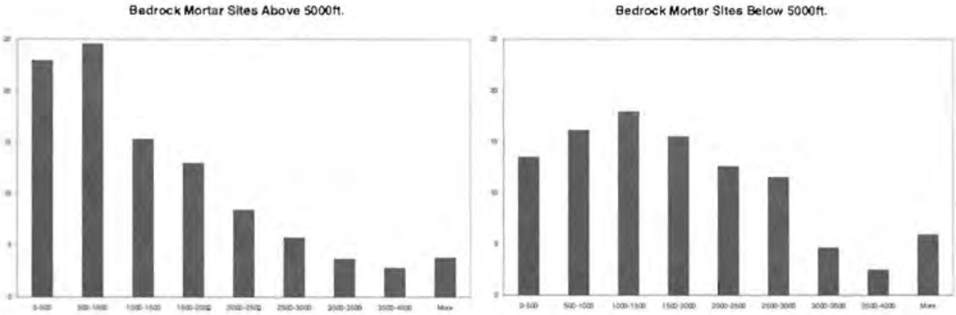

Figure 3: Comparison of calculated years BP values; Bedrock mortar sites above and below 5000 feet in elevation.

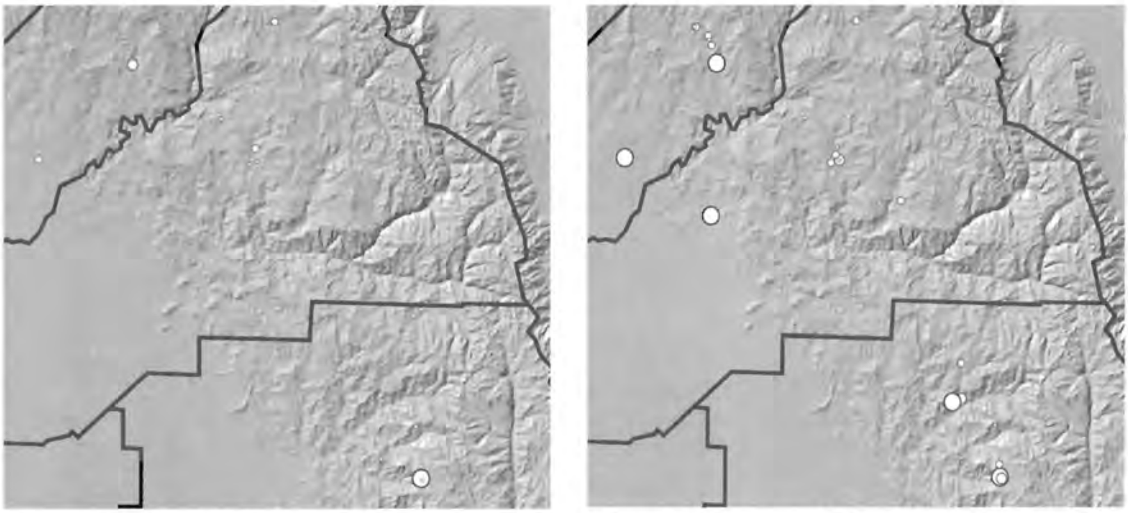

Figure 4a: 3500-4000 BP

Figure 4b: 2500-3000 BP

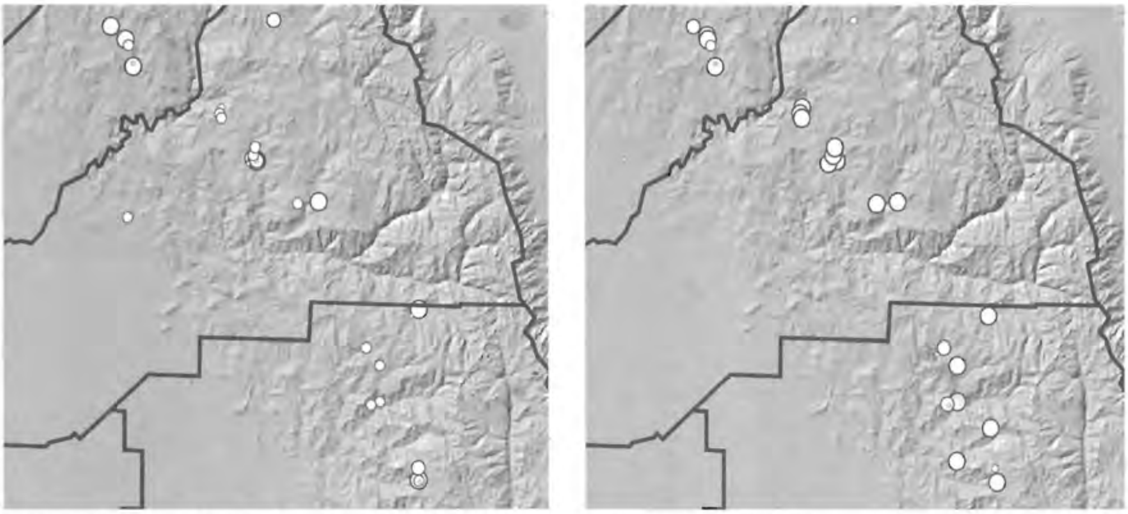

Figure 4c: 1000-1500 BP

Figure 4d: 0-500 BP

Figure 4: Relative percentages of obsidian hydration derived dates at bedrock mortar sites in the Southern Sierra Nevada. Map symbols (from smallest to largest): 1=<5%, 2=5.1-10%, 3=10.1-15%, 4=15.1-20%, 5=>20%

RESULTS

The results suggest that bedrock mortar sites at higher elevations represent a later development in the regional prehistoric sequence. Sites above 5,000 feet are associated with a greater percentage of dates after 1000 B.P. (see Figure 3). Conversely, sites below that elevation show increases in the percentage of dates after 2500 B.P., with a peak between 1000 and 1500 B.P. Spatially, the region as a whole seems to follow the same general pattern. There are no great differences between occupation ranges at bedrock mortar sites from north to south (refer to Figure 4).

It is interesting to note that age ranges at the two lowest elevation sites peak around 2500 years B.P. and then wane thereafter. This is in direct contrast to the pattern at higher elevation sites, where an increase in occupation intensity is evident after ca. 1000 B.P.

Overall, data from lower-elevation bedrock mortar sites suggest that these sites began to be used earlier and continued to be used throughout the late Holocene. Higher-elevation sites, however, show a later initial surge in site use followed by a stronger proportional increase thereafter.

DISCUSSION

Although it is tempting to assume that these results "date" the appearance and spread of bedrock milling technology in this region, caution should be used in their interpretation. Most importantly, it should be recognized that the data used in the above exercise came from a variety of sources with a diversity of research questions, methodologies, and sample sizes. Some sites underwent extensive excavations, while others were only subjected to a small amount of surface collection. The most thoroughly documented sites were represented by hundreds of obsidian hydration rim readings, while others contributed fewer than ten.

By comparing a large number of sites at once, it is hoped that many such inconsistencies in the data will even out. There is always the chance, however, that the patterning evident in these data is a reflection of how they were collected, and not of prehistoric activity. Additionally, errors could be introduced by improperly calibrated hydration rates, inaccurate temperature assignments, or the fact that many sites were likely occupied long before bedrock mortars were used. Nevertheless, some intriguing patterns are evident in the data. This is particularly true when current understandings of prehistoric culture change in the area are taken into account.

First, the two lowest-elevation sites (CA-MAD-1531 and CA-FRE-1671, 550 and 600 ft., respectively) show the greatest evidence for occupation between 3000 and 1500 B.P., whereas sites above 5,000 feet in elevation appear to have been largely inhabited after 1000 B.P. (Figures 3 and 5). The first evidence for relatively high populations exploiting Sierran-foothill environments occurs sometime after ca. 3000 B.P. (Moratto 1972; Moratto et al. 1988). After ca. 1500 B.P., however, an abrupt change occurred which appears to have involved settlement shifts, changes in trade relations, and the introduction of new technologies such as the bow and arrow and, in some areas, bedrock mortars. In foothill areas (below ca. 1,000 ft.), many earlier sites were apparently abandoned or inhabited only sporadically. Interestingly, however, middle-elevation (3,000-5,000 ft.) sites in the Sierra Nevada, many with bedrock mortars, show more intensive occupation between 1250 and 650 B.P. (Cleland 1988; Goldberg and Skinner 1990; Hull and Moratto 1999).

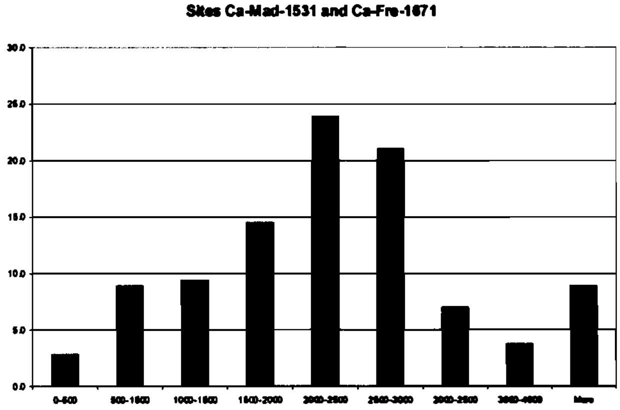

Figure 5: Calculated years BP values for sites Ca-Mad-1531 and Ca-Fre-1671.

Second, higher-elevation sites appear to show more clearly an association between bedrock mortars and late-prehistoric dates. Population growth may be an important factor to consider here. If it is assumed that late-prehistoric human population of the region was larger than previous populations, then many sites may have been initially occupied during this time (cf. Jackson 1984). This is likely to be especially true in more marginal areas such as those above snowline. This could help explain why many lower-elevation bedrock mortar sites have more mixed assemblages when compared with higher-elevation sites.

Third, the fact that many higher-elevation bedrock mortar sites appear to have been intensively used after 500 B.P. brings to mind the Western Mono, the ethnographic group most closely tied to the use of middle- and upper-elevation areas of the southern Sierra Nevada. Based on linguistic evidence, the Western Mono are thought to have settled the western slope of the Sierras about 500 years B.P. (Whistler 1984). It is possible that this late-prehistoric surge in hydration readings corresponds to the initial settlement of the Western Mono, a point which has been made before (Jackson and Dietz 1984; Roper Wickstrom 1992).

The advent of bedrock milling technology in the southern Sierra Nevada was probably a complex phenomenon tied to large-scale diachronic and altitudinal shifts in subsistence-settlement systems. Therefore, determining when bedrock mortars first appeared in the region is not only a problem of chronology, but also one of technology and cultural change. This paper has presented only a preliminary sketch of patterns evident in the archaeological record of bedrock mortar sites in this region. Perhaps future studies involving greater numbers of sites and additional variables will help explain this and other patterns in the archaeological record of the southern Sierra Nevada.

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