CORRELATIONS BETWEEN LITHIC RAW MATERIAL QUALITY AND AVAILABILITY AND THE FORMATION OF FLAKED STONE TOOL ASSEMBLAGES: EXAMPLES FROM THE CHORRO VALLEY, SAN LUIS OBISPO COUNTY

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ABSTRACT

Fieldwork conducted along Segment 2 of the Chorro Valley Water Transmission Pipeline presented a unique opportunity to explore the interrelationship between lithic technology and the availability of lithic raw materials. The project area, located in the uplands of the Chorro Valley, is rich in sources of toolstone. Through the analysis of artifactual remains recovered from two project sites, it was found that raw material abundance and quality had significant influences on the development of stone tool assemblages. These influences distinguished the project sites from others in the region where toolstone was less abundant. This paper explores the impact that the lithic resource base may have in technological adaptation between hunter-gatherer groups and their environment.

Introduction

Project Setting

This research was conducted in the upper reaches of the Chorro Valley, on California's south-central coast. This coastal valley stretches northwest from the hills outside of San Luis Obispo to the ocean at Morro Bay. Excavations to the north and south have established human occupation in the area for at least 9000 years (Greenwood 1972, Erlandson 1994). The sites discussed here were all located to the north of the main valley drainage (Chorro Creek) in the foothills of the Santa Lucia Range.

The geology of the area surrounding the Chorro Valley provides abundant sources of flakable raw materials for the production of stone tools. This region is underlain primarily by Franciscan Formation bedrock, a mélange containing a variety of rocks and minerals, including graywacke, schist, basalt, quartz and serpentine, as well as toolstone quality chert that occurs at scores of outcrops across the study area and throughout the upper Chorro drainage. Most Franciscan chert available within the study area is mediocre to poor in flaking quality and hosts a variety of flaws including internal fracture planes and cracks. The vast majority of these Franciscan chert exposures are quite small and exhibit very sparse flake and core concentrations around them. When examined singly, these small sources do not impress one with having been the focus of more than casual exploitation. However, taken as a whole, they certainly provided a substantial resource base from which workable stone was drawn (c.f. Kamp and Whittiker 1986).

Monterey Formation shales containing chert occur in proximity to the coast north and south of Morro Bay as well as in the interior in the Salinas Valley. An additional isolated and less distant ridge-top source of Monterey chert has been found approximately 1 mile north of the study area in the foothills of the Santa Lucia Mountains (CA-SLO-1760). This closer interior source was more heavily exploited than were the coastal sources by the prehistoric populace of the upper Chorro Valley, judging by the color similarities of the recovered Monterey chert artifacts and the chert observed at this source.

This source area contained a dense concentration of Monterey chert flaking debris, cores, and early stage bifacial blanks made on large cortical flakes. The Monterey chert available here is of very high quality and, judging by the size of many of the flakes, was available in very large nodules. Unlike the Monterey chert that can be found along the coast, the material here is very light in color and appears to be visually distinct from other sources. While Monterey chert colors were not separated during the debitage and tool analyses, a subjective impression can be offered that a minimum of 90% of the Monterey chert artifacts recovered from project sites originated at this source. The location of this quarry at a high elevation and the possible presence of mining pits and large rock breaking cleavers suggest that extraction costs for this material may have been considerably higher than for Franciscan chert.

Theoretical Background

The Chorro Valley provides a rich archaeological terrain to study how hunter-gatherer land-use strategies affected the production of stone tools across a landscape that is geologically abundant in lithic raw materials. While group mobility is generally considered to be a prime shaping factor in technological organization (Kelly 1988; Parry and Kelly 1987; Nelson 1991; Torrence 1989), other variables such as toolstone abundance, accessibility, and quality also play important roles (Bamforth 1986, 1990, 1992; Andrefsky 1994; Henry 1989; Wiant and Hassen 1984). All of these variables, and certainly many more not listed, shape the character of lithic assemblages. To assess the character of one variable, such as the anthropologically important issue of group mobility or land-use strategies, issues such as raw material availability and suitability for stone tool production must be first isolated and understood.

From a regional perspective, the technological interpretation of Chorro Valley lithic assemblages should include contextual reference to the geologic landscape from which raw materials were collected. Bamforth (1992:132) provides insight gathered from studying a series of low grade chert sources in California's Mojave desert. Key variables used to characterize these quarries in terms of how they were exploited prehistorically included source distribution, raw material quality at sources, and accessibility. Access in Bamforth's (1992) terms regarding quarry exploitation refers to such criteria as the physical ease of procuring raw material from a source; for example, whether toolstone is easily picked up from talus deposits (which seems to be the case at Chorro Valley Franciscan chert outcrops) or whether it must be quarried and pried from bedrock deposits in the substrate (which apparently occurred at the Monterey chert quarry site, CA-SLO-1760).

Recent research conducted by Andrefsky (1994) indicates that the quality of toolstone, as well as its abundance, may have a strong influence on the way raw materials are reduced into tools. If high quality raw materials are abundantly distributed across a landscape, as was seen in his Pinon Canyon study area (1994:25-27), no preference was shown for the production of formal or informal tools, regardless of whether sites were occupied for long or short periods, that is, whether or not groups were residentially mobile. For areas abundant in poor quality material, such as in his Rochelle study area (1994:28-29), local materials were utilized expediently while better stone was imported for the production of formal tools. Andrefsky states that even highly residentially mobile groups will opt for an informal tool kit if only low grade raw materials are available (1994:29). This example has been supported by work conducted in the Moyie River Valley in Northern Idaho (Lebow and Atwell 1995: 6-41-6-42) where foraging groups used an expedient lithic technology in apparent response to abundant, low-quality raw materials.

Bamforth (1990:98) states that when raw material sources for tool manufacture are abundantly distributed across a landscape, tool production becomes shaped by "the

time available for tool production and the amount of stone that can be transported from place to place," rather than directly tied to land-use strategies. Decreased distances from sites to sources allow greater quantities of raw materials to be moved and stockpiled at both short-term as well as long-term occupation sites. If outcrops of exploitable toolstone occur on-site, as is the case with the project sites discussed below, the required energy/time investment in procurement is very low; thus, increased energy in the production of formalized implements intended for long use-lives is unnecessary. The manufacture of low-input tools, in this case, is a response to decreased raw material procurement costs and reduced risk of being far from replacement stone. For these reasons, the manufacturing technology at sites within the Chorro Valley is expected to be oriented more expediently as a consequence of raw material availability than would otherwise be the case. Data from project sites support this general assertion in that the locally abundant Franciscan chert was consumed in a largely expedient fashion.

To summarize, these studies suggest that (1) as availability is held constant, raw material of lower quality has a restricting effect on tool formality, and (2) the influence of readily abundant toolstone may effectively eclipse forces such as residential mobility from shaping technological organization. Simply stated, low grade chert is difficult to successfully shape into well-formed tools; therefore the risk of breakage makes high-input, formalized tool production a wasteful and non-optimizing strategy to pursue. Secondly, and more pertinent to the issues confronting this project, data from a number of researchers such as Andrefsky (1994), Lebow and Atwell (1995), Kelly (1988) and Wiant and Hassen (1984), show that abundantly distributed sources of raw material effectively neutralize the technologically different adaptations between high and low residentially mobile groups. In other words, the stresses which conspire to make mobile groups opt for transportable, maintainable and versatile tool forms greatly decline when toolstone is plentiful. Basically, the diminished spatial separation of lithic sources from habitation sites and food resources makes tool curation less of a necessity.

Two expectations for the Chorro Valley sites can be thus presented based on previous research and theory generated from studies discussed above.

1. The abundance of raw material should relax the need for high-input, formalized tools.

2. Low grade chert will be associated with the production of simple flake tools which require very little shaping.

The discussion which follows is necessarily exploratory in nature due to time and budget constraints and the limited scope of work required for projects such as this one. The sites discussed generally have small tool and core samples compared to others in the region (e.g. Bouey and Basgall 1991; Greenwood 1972; Jones, et al 1994; Jones and Waugh 1995). Thus, inferences drawn from these collections are necessarily tentative.

Site Summaries

Two sites were used for this study. CA-SLO-906 and CA-SLO-1647 yielded lithic artifact collections large and diverse enough to warrant in-depth descriptions. Both these sites contained Franciscan outcrops that had been casually exploited as raw material sources as well as being within sight of numerous other recorded quarry locations. Current interpretation sees these locations as specialized logistical sites where a limited variety of activities took place during short term, possibly seasonal, occupations.

For the purposes of this paper, tools have been reclassified to reflect only the most basic technological characteristics of production. Tools have been segregated into high-input (bifaces) and low-input (flake tools) categories. With exceptions, all

patterned, formalized tools were bifacially produced. Implements classified as flake tools were generally unmodified or marginally retouched along a single edge, suggesting they were expediently made to serve situational tasks. Only flakes displaying abrasion wear visible at 50x magnification were classified as tools. Subsequently, flake tools utilized to a degree that would not result in visible wear were not included in this study. Cores were classed separately.

CA-SLO-1647

CA-SLO-1647 lies on a hilltop and covers an area of over 25,000 m2. In addition to various lithic scatters and a small quarry location, this site contained a handful of bedrock mortars and unusually high frequencies of marine shell within a spatially discrete locus. Directly upslope (ca. 1 mile northeast) in the Santa Lucia foothills is the large source of Monterey chert described previously (CA-SLO-1760). In contrast to expectations, considering the availability of local Franciscan chert, most of the lithic assemblage at CA-SLO-1647 is composed of Monterey chert. The higher density of Monterey artifacts at CA-SLO-1647 suggests that off-site activities within which raw material procurement may have been embedded were oriented more often to the interior highlands. Alternatively, this pattern could be a response to a greater need for high input tools, such as bifaces, which created an increased demand for higher quality Monterey chert.

The relatively high density of Monterey chert at CA-SLO-1647 suggests this site functioned, at least partly, as a workshop for the production of Monterey chert tools. The Franciscan chert debitage profile is much different from the Monterey with high rates of cortical flakes and percussion shatter; flakes retaining detachment scars or attributes diagnostic of biface production are rare. The profile for Franciscan chert suggests raw material testing and freehand core reduction were the primary forms of reduction.

Overall, tool production for Monterey and Franciscan chert at CA-SLO-1647 follow different trajectories. Debitage data show biface production was rare for Franciscan chert, but relatively common for Monterey. Monterey chert was apparently brought to the site as partially reduced or tested cobbles and possibly as very early-stage bifacial blanks. As reduction progressed on-site, flake blanks were made into primary-thinned bifaces that were largely removed from the site to be further reduced elsewhere. Tool data support these conclusions; bifaces comprise a larger proportion of Monterey chert artifacts. In contrast, Franciscan chert is best represented by cores. Stages for bifacial tools recovered from the excavations for both chert types are skewed toward the earlier stages of reduction; 63.6% are Stages 2 or 3 (highlighting a paucity of finished bifaces). As a measure of the expediency to which each chert type was consumed at CA-SLO-1647, Monterey chert bifaces outnumber flake tools 4.25:1. Franciscan chert has only 1.25 bifaces for every low-input flake tool, suggesting that Franciscan chert was much less likely to be made into more formalized high-input tool forms.

CA-SLO-906

CA-SLO-906 is located in the lower Pennington Creek Valley adjacent to CA-SLO-1647 covering an area of 370,000 m2. In addition to several discrete lithic scatters and quarry outcrops the site contained several widely scattered bedrock mortars and two, possibly related, rock features. Poor to mediocre Franciscan chert can be found at numerous outcrops throughout this secondary valley, some of which fall within the site boundaries of CA-SLO-906.

Proportions of tool types follow the pattern described for CA-SLO-1647. Monterey chert was most often recovered in the form of bifaces, whereas Franciscan chert was best represented as cores. Unlike at CA-SLO-1647, where the majority of bifaces made of both cherts were recovered still in early stages, the bifaces at CA-SLO-906 show differing distributions across

bifacial stages. Proportions of bifacial stages for Monterey chert bifaces show a bimodal distribution (with modes at Stages 2 and 5) suggesting both manufacturing rejects and finished tools that were no longer usable were being discarded at the site. The second mode probably represents the "dumping" of finished Monterey bifaces which were discarded during retooling activities. This pattern is not present for Franciscan bifaces where bifacial stage representation declines with increasingly later stages. The ratios of bifaces to flake tools for each chert type parallel those at CA-SLO-1647; Monterey chert bifaces outnumber flake tools 3:1, whereas bifaces of Franciscan chert are only 1.38 times more frequent than low-input flake tools.

Discussion

In order to view the results of our research in a broader geographic sense, comparable and potentially related sites were sought for comparison. The number of archaeological investigations in San Luis Obispo County compares poorly to neighboring areas. With few exceptions (e.g. Greenwood 1972), comprehensive subsurface investigations of a range of prehistoric site types has been restricted to the last 5-6 years. Fortunately, the bulk of this new research has been conducted nearby along the northern coast and coastal valleys from Morro Bay to Piedras Blancas. The majority of these sites display assemblages accentuating marine resource exploitation. In regards to lithic reduction and tool manufacture, these sites all share a common emphasis on biface production and rejuvenation.

Overall, bifacial tool and flaking debris appears to be very common at the vast majority of sites tested across the region (Bouey and Basgall 1991; Jones et al. 1994; Jones and Waugh 1995). The Chorro Valley sites are a notable exception. Expedient tools played a greater role here, especially for tools made of Franciscan chert. These differences are best explained by variation in raw material availability between the Chorro Valley uplands and other areas across the county where toolstone was often gathered from dispersed river gravel deposits.

In addition, variation in production technology seems greater between chert types than between the archaeological sites sampled here. This contrasts with other sites in the region which generally show chert types to have been consumed along similar lines. Franciscan chert tool collections and flaking debris at CA-SLO-906 and CA-SLO-1647 point toward expedient core reduction for the production of single flake tools with relatively few formalized bifacial tools manufactured. Monterey chert, in contrast, seems generally oriented toward formalized biface production, but expedient core reduction is also present.

The disparity along raw material lines could be the result of differences in raw material availability based on the increased distance to the Monterey chert source. However, this is unlikely to be the only factor since the nearest Monterey chert source is available within a one hour hike. An alternative explanation is that this is a response to differences in inherent flaking quality between these two types of chert. Since patterned bifacial flaking requires a greater degree of fracture control than core reduction, and its success is thus more dependant upon toolstone quality, the best raw materials area is expected to be selected for biface manufacture. These data suggest Monterey chert may have been chosen over lower-grade Franciscan chert for the manufacture of bifacial tools.

Summary

To summarize, toolstone outcrops in the Chorro uplands are so frequent that they approach being "site furniture" (sensu Binford 1979) to be exploited situationally as needs warranted. We believe that it is the relaxation of stresses resultant from the decreased spatial separation of task loci and toolstone sources that allowed tool users in the area to opt for less formalized tool forms

compared to sites elsewhere on the central coast. In equal measure, the effect of raw material quality may also have had a restricting influence on tool production by limiting the degree of shaping that could be placed into a tool. Since the theorized effects of both increased raw material availability and decreased quality are similar (that tools should show less input during production), it is difficult to discern which has had more influence on the Chorro assemblages. The differing proportions of formal tools between the project sites and other site collections in the county suggest that raw material availability was a primary influence; the same differences between the two chert types examined here indicate that raw material quality was also of great influence. Discerning the separate impact that each of these materials had on technological organization is deserving of future work but beyond the scope of this rather limited report.

Returning to the expectations listed earlier, our research has met with varying results. Our first expectation found that in the Chorro Valley where raw material is abundant, if not of high quality, formalized tool assemblages are less developed in comparison to neighboring areas. This appears to be valid since the Chorro sites have lower proportions of bifacial implements and flaking debris than do other sites in the regions (Bouey and Basgall 1991; Jones et al. 1994; Jones and Waugh 1995). Our second expectation, that low-grade stone will be associated with expedient low-input tools, also appears sound, based on the technological differences in the way low quality Franciscan and high quality Monterey cherts were consumed at the project sites.

This brief discussion has sought to outline the potential importance that influencing variables such as the abundance and quality of lithic raw materials might play in the shaping of stone tool technological organization. While these factors appear to be more acutely realized in the Chorro uplands, other parts of the county, and along the Central Coast at large, may also benefit from research questions thus framed.

REFERENCES CITED

Andrefsky, William Jr.
1994 Raw Material Availability and the Organization of Technology. American Antiquity 59:21-34.

Bamforth, Douglas B.
1986 Technological Efficiency and Tool Curation. American Antiquity 51(1): 38-50.
1990 Settlement, Raw Material, and Lithic Procurement in the Central Mojave Desert. Journal of Anthropological Archaeology 9(1):70-104.
1992 Quarries in Context: A Regional Perspective on Lithic Procurement. In Stone Tool Procurement, Production, and Distribution in California Prehistory, edited by Jeanne E. Arnold, pp. 131-150. Perspectives in California Archaeology, Volume 2, University of California, Los Angeles.

Binford, Lewis B.
1979 Organization and Formation Processes: Looking at Curated Technologies. Journal of Anthropological Research, vol.35, no.3.

Bouey, Paul D. and Mark E. Basgall
1991 Archaeological Patterns Along the South Central Coast, Point Piedras Blancas, San Luis Obispo County, California. Report prepared for the California Department of Transportation 05-SLO-1 P.M. 61.2/63.2 Contract No. SA05B86100 by Far Western Anthropological Research Group, Inc., Davis Ca.

Erlandson, Jon
1994 Early Hunter-Gatherers of the California Coast. Plenum Press, New York.

Greenwood, Roberta
1972 9000 Years of Prehistory at Diablo Canyon, San Luis Obispo County, California. San Luis Obispo County Archaeological

Society Occasional Paper No. 7.

Henry, Donald O.
1989 Correlations Between Reduction Strategies and Settlement Patterns. In Archaeological Papers of the American Anthropological Association no.1.

Jones, Terry L., Kathleen Davis, Glenn Farris, Steven D. Grantham, Teresa W. Fung, Betty Rivers
1994 Towards a Prehistory of Morro Bay: Phase II Archaeological Investigations for the Highway 41 Widening Project, San Luis Obispo County, California. Report prepared for the Department of Transportation, District 05- San Luis Obispo, San Luis Obispo, California.

Jones, Terry and Georgie Waugh
1995 Central California Coastal Prehistory: A View from Little Pico Creek. Perspectives in California Archaeology, Volume 3, Series Editor Jeanne E. Arnold, University of California, Los Angeles.

Kamp, Kathryn A. and John C. Whittiker
1986 Unproductive Lithic Resources at Lake Mead. American Antiquity 51(2): 383-388.

Kelly, R. L.
1988 The Three Sides of a Biface. American Antiquity 53:717-734.

Lebow, Clayton G. and Ricky G. Atwell
1995 Lithic Production Technology: Pacific Northwest. In Archaeological Investigations PGT-PG&E Pipeline Expansion Project Idaho, Washington, Oregon, and California, Volume IV: Synthesis of Findings., Michael Moratto, general editor. INFOTECH Research, Inc., Fresno, CA. Submitted to Bechtel Corporation, San Francisco, Contract No. 20822-SC-41.

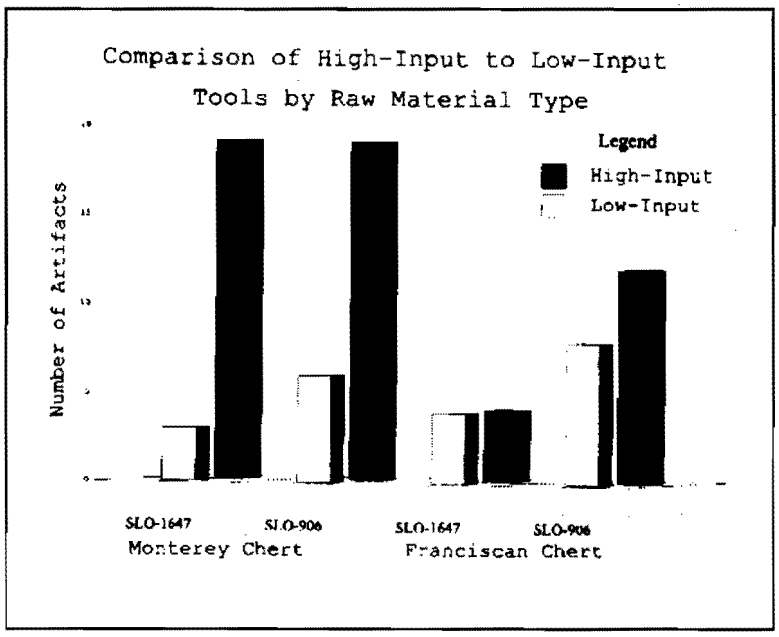
Nelson, M. C.
1991 The Study of Technological Organization. In Archaeological Method and Theory 3:57-100, edited by M.B. Schiffer, University of Arizona Press.

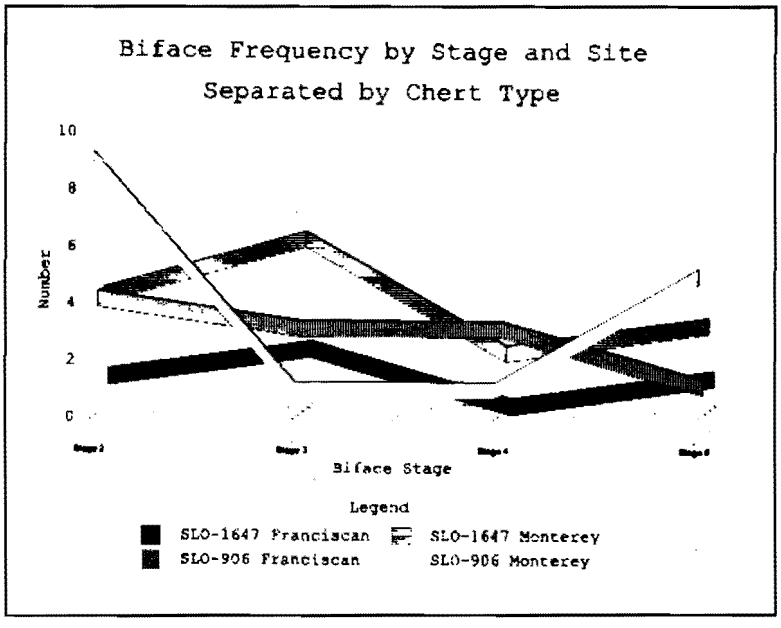
Parry, W. J. and R. L. Kelly
1987 Expedient Core Technology and Sedentism. In The Organization of Core Technology, edited by J. K. Johnson and C. A. Morrow, pp. 285-304. Westview Press, Boulder.

Torrence, R.
1989 Time, Energy, and Stone Tools. Cambridge University Press, New York.

Wiant, Michael D. and Harold Hassen
1984 The Role of Lithic Resource Availability and Accessibility in the Organization of Technology. In Lithic Resource Procurement: Proceedings from the Second Conference on Prehistoric Chert Exploitation, edited by Susan C. Vehik, pp. 101-114. Center for Archaeological Investigations, Occasional Paper No. 4, Southern Illinois University.

Figure 1: Location Map


Comparison of High-Input to Low-Input
Tools by Raw Material Type
Legend
High-Input
Low-Input
Number of Artifacts
SLO-1647
SLO-906
Monterey Chert
SLO-1647
SLO-906
Franciscan Chert


Biface Frequency by Stage and Site
Separated by Chert Type
10
8
6
4
2
0
Number
Biface Stage
Legend
SLO-1647 Franciscan
SLO-906 Franciscan
SLO-1647 Monterey
SLO-906 Monterey