CERAMIC PETROGRAPHY & THE RECONSTRUCTION OF HUNTER-GATHERER CRAFT TECHNOLOGY IN LATE PREHISTORIC SOUTHERN CALIFORNIA

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Introduction

Plain, undecorated ceramic sherds are a common component of archaeological assemblages from villages, temporary camps and resource processing sites across southernmost California (Figure 1). Ceramic technology arrived in this area during the last 1000-1300 years (Laylander, 1992; Campbell, 1999, p. 119; Griset 1996) and perhaps as recently as 1450-1500 AD in western San Diego County, where its appearance is used as a chronological marker for the Late Prehistoric period. Based on archaeological and ethnohistoric evidence, indigenous societies of the San Diego area practiced a mobile hunter-gatherer lifestyle with seasonal movements across environmental zones to exploit a range of plant, animal and geological resources. The manufacture and use of ceramics by these groups thus provides another example, within a growing corpus of recently studied cases (e.g. Sassaman, 1993, 2000; Eerkens *et al*., 2002; Eerkens, 2003; Skibo and Schiffer, 2008; Thompson *et al*., 2008) of pottery technology among hunter-gatherers.

Despite their abundance, southern California ceramics have, to date, contributed only limited information towards reconstruction of the region's prehistory. Important ethnographic studies document 'traditional' southern California pottery making as it existed in the 20th century (e.g. Rogers, 1936; Wilken, 1982), however very little attention has been given to the nature of prehistoric ceramic technology, with the entire occurrence of pottery often thought of as a single paddle-and-anvil 'tradition' (Griset, 1996, p. 9) (Figure 1A). In addition, a number of technological, depositional and post-depositional factors have worked against the definition of clear-cut and useful typological categories. First, Late Prehistoric ceramic assemblages in this area are dominated by plain, undecorated brown and buff coloured sherds (Figure 1B,C) representing a restricted range of simple, round-bottomed vessels, such as jars or 'ollas' and bowls (Figure 1D). The many large, non-standardised, globular forms with restricted necks result in archaeological accumulations with high ratios of body sherds to rim sherds, a high degree of within vessel-type variability and a general absence of decoration, making typological classification of sherd assemblages difficult. Lack of well-preserved site stratigraphy and the apparent long use-life of many vessels tend to further obscure any chronological patterning in forms, manufacturing methods, or decoration. Numerous attempts at classifying southern California ceramics based upon characteristics such as form, rim shape and the nature of their paste in hand specimen (Schroeder, 1958; May, 1978; Van Camp, 1979; Waters, 1982; Laylander, 1997) have only added to the debate regarding the replicability of proposed typologies and their cultural, chronological and technological significance.

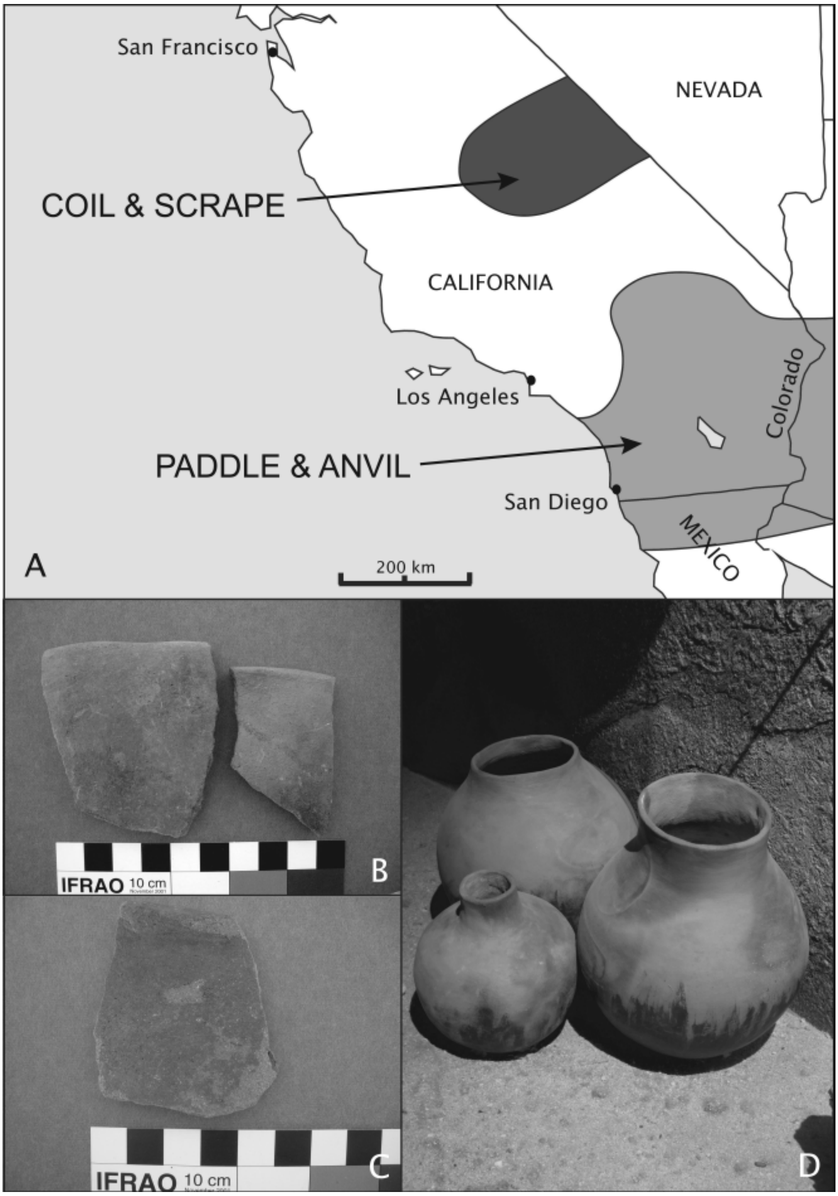

Figure 1. Late Prehistoric plainware ceramics and their distribution in southern California. a) The approximate geographic distribution of the 'paddle and anvil' ceramic tradition (modified from Griset, 1996, figure 2, p. 9), b,c) Plainware sherds from sites analysed in this study, d) Typical plainware ceramic vessels including holemouth jar and 'olla', in museum display at Anza-Borrego Desert State Park Headquaters, Borrego Springs, California.

More recently, a small number of scientific analyses (Pymale-Schneeberger, 1993; Hildebrand *et al.*, 2002; Gallucci, 2004) have highlighted the use of compositional data to detect archaeologically meaningful patterns in the region's ceramics, such as large-scale shifts in population density (Arnold *et al.*, 2004, p. 47) and social group movements during the Late Prehistoric Period (Hildebrand *et al.*, 2002). Documenting the composition of southern California ceramics is a first step towards understanding these artefacts. However, previously described compositional groupings remain broad and generalised and, more crucially, associated raw materials, technology and cultural affiliations remain poorly understood.

Given the high geological heterogeneity and historic ethno-linguistic diversity of the southern California region, it is likely that a more thorough and refined analysis of the ubiquitous Late Prehistoric ceramics might reveal much archaeological meaningful variation about how they were made and the people who made them. Inspired by this, the present study has applied thin section ceramic petrography to reconstruct in detail the craft of pottery manufacture within a restricted area of southern California during the Late Prehistoric period. By interpreting the specific technological choices and steps taken by potters in the past, it has been possible to decipher valuable information about their knowledge and exploitation of the natural environment, their technological skills and their appreciation of the performance characteristics of raw materials. Documenting some of the different recipes or styles of southern California pottery making for the first time has also provided valuable data with which to begin to examine the cultural identities and traditions of the hunter-gatherer groups that made ceramics, used them and eventually left them behind.

Archaeological Sites and Samples

The present study focuses on the inland region of eastern San Diego County. Much of this area is now contained within the boundaries of the Anza-Borrego Desert State Park (Figure 2). This vast, relatively undeveloped landscape is rich in archaeological sites, but remains only superficially investigated. During the Late Prehistoric period, groups ancestral to the present-day Kumeyaay, Luiseño and Cahuilla Indian tribes appear to have established seasonal winter camps in this area (Schaefer, 1994a). Known trails run westwards into the mountains and eastwards into the low-lying desert plain of the Salton Basin (Cline, 1979, p. 17, 18, 21, 1984, p. 13, 16-17), which in Late Prehistoric times was intermittently occupied by the freshwater Lake Cahuilla (Waters, 1983). For this study, ceramics were selected from seven sites situated on the western margin of the Colorado Desert and close to the eastern base of the Peninsular Range mountains. The studied sites lie within the traditional territories of the Shoshonean-speaking Cahuilla Indians in the north (sites CA-SDI-343 and CA-SDI-2336) and Yuman-speaking Tipai linguistic group of Kumeyaay Indians in the south (sites CA-SDI-955, CA-SDI-956, CA-SDI-963, CA-SDI-10571 and CA-SDI-10573) (Figure 2).

Figure 2. Late Prehistoric sites analysed in this study. a) Location of the seven sites in San Diego County with environmental/landscape zones, the Anza-Borrego Desert State Park and traditional ethno-linguistic boundaries, b) Collins Valley and Coyote Canyon with the locations of the northern sites analysed, c) Indian Valley and Bow Willow Canyon with the location of the southern sites analysed.

With the exception of CA-SDI-343, which was part of the large Cahuilla village site of ‘Los Coyotes’, all sites appear to have been temporary winter camps associated with food collecting and processing activities. Bedrock milling features occur at most sites (Figure 3) and both CA-SDI-956 and CA-SDI-10573 may also contain the remains of house platforms. Abundant ceramic sherds were recovered from shallow cultural layers and surface scatters at the sites during archaeological surveys in the 1950s-70s (Wallace and Taylor, 1958; Wallace, 1962). Other artefacts include manos, metates, hammerstones, choppers, pestles, projectile points, debitage and shell beads. With the exception of CA-SDI-963, all sites are situated close to creeks where water would have been available, at least in the winter months. No direct evidence of ceramic production such as firing pits, tools, or unused ceramic raw materials have been found at any of the archaeological sites.

Sample	Site	Form	Lip Form	Recurved Rim	Decoration
1	CA-SDI-2336	Indeterminate	N/A	N/A	None
2	CA-SDI-2336	Indeterminate, flat	Rounded	No	None
3	CA-SDI-2336	Jar	Flattened, thickened to exterior	Slightly recurved	None
4	CA-SDI-2336	Jar	Flattened, thickened to exterior	No	None
5	CA-SDI-2336	Jar	Slightly flattened	No	None
6	CA-SDI-2336	Jar? (neckless or holemouth?)	Rounded	No	None
7	CA-SDI-2336	Jar	Flattened	No	None
8	CA-SDI-2336	Indeterminate	Rounded	No	None
9	CA-SDI-343	Bowl	Rounded	No	None
10	CA-SDI-343	Jar	Slightly flattened everted lip, thickened to exterior	Yes	None
11	CA-SDI-343	Bowl	Rounded	No	Burnished exterior, smoothed interior
12	CA-SDI-343	Jar (neckless or holemouth)	Rounded	No	None
13	CA-SDI-343	Indeterminate	Flattened, slightly thickened to exterior	No	None
14	CA-SDI-343	Jar	Flattened, everted	Slightly recurved	None
15	CA-SDI-343	Bowl	Slightly flattened, thickened to exterior	No	biconical drilled hole
16	CA-SDI-343	Jar (chimney neck)	Flattened	No	None
17	CA-SDI-343	Bowl	Slightly flattened, thickened to exterior	No	None
18	CA-SDI-343	Indeterminate	Slightly flattened, slightly thickened to interior	Indeterminate	None
19	CA-SDI-343	Bowl	Slightly flattened, thickened to exterior	No	Basket impression on interior surface? Possible red pigment on rim
20	CA-SDI-343	Jar (chimney neck)	Slightly flattened, slightly thickened to exterior	No	None
21	CA-SDI-343	Jar	Slightly flattened everted lip, thickened to exterior	Slightly recurved	None
22	CA-SDI-343	Jar (chimney neck)	Flattened, slightly to exterior	No	None
23	CA-SDI-343	Jar	Slightly flattened everted lip, thickened to exterior	Yes	None
24	CA-SDI-343	Scoop?	Rounded	No	None
25	CA-SDI-343	Bowl	Slightly flattened	No	None
26	CA-SDI-343	Bowl (hemispherical)	Slightly flattened	No	incised rim
27	CA-SDI-343	Jar	Slightly flattened everted lip, thickened to exterior	Slightly recurved	None
28	CA-SDI-343	Jar	Slightly flattened, slightly thickened to exterior	Slightly recurved	None
29	CA-SDI-343	Disk or lid	Rounded	No	None
30	CA-SDI-343	Indeterminate	Flattened, slightly thickened to ?	No	None
31	CA-SDI-343	Jar	Flattened, everted	Yes	Beige slip?
32	CA-SDI-343	Bowl (straight-sided)	Rounded	No	None
33	CA-SDI-343	Jar	Flattened, thickened to exterior	Slightly recurved	None
34	CA-SDI-343	Jar	Flattened, everted. Slightly thickened to exterior.	Slightly recurved	none
35	CA-SDI-343	Jar (neckless or holemouth)	Rounded	No	Red paint? vertical band from lip. Light burnishing.

Table 1. Details of the 70 Late Prehistoric sherds analysed in this study (continued in Table 2 below).

Table 2. Details of the 70 Late Prehistoric sherds analysed in this study (continued from Table 1 above).

Sample	Site	Form	Lip Form	Recurved Rim	Decoration
36	CA-SDI-955	Jar (neckless or holemouth)	Rounded	No	None
37	CA-SDI-955	Jar (neckless or holemouth)	Rounded	no	molded basket or basket impressed anvil
38	CA-SDI-955	Bowl (hemispherical)	Flattened, slightly everted	No	Lightly burnished
39	CA-SDI-956	Bowl	Flattened	No	None
40	CA-SDI-956	Bowl (hemispherical)	Flattened	No	None
41	CA-SDI-956	Jar	Slightly flattened	No	None
42	CA-SDI-956	Bowl (hemispherical)	Flattened (thickened to interior and exterior)	No	None
43	CA-SDI-956	Bowl	Flattened, thickened to interior and exterior	No	incised rim
44	CA-SDI-956	Bowl	Flattened	No	incised rim
45	CA-SDI-956	Jar	Slightly flattened	Yes	None
46	CA-SDI-963	Bowl (straight-sided)	Flattened	No	None
47	CA-SDI-963	Bowl (hemispherical)	Everted lip, tapered to a point	No	None
48	CA-SDI-963	Jar (neckless or holemouth)	Flattened, slight upward inflection	No	None
49	CA-SDI-963	Bowl (straight-sided)	Rounded	No	None
50	CA-SDI-10571	Jar (chimney neck)	Flattened	No	None
51	CA-SDI-10571	Plate or lid	Rounded	No	None
52	CA-SDI-10571	Jar (chimney neck)	Slightly flattened	No	None
53	CA-SDI-10571	Jar (neckless or holemouth)	Rounded	No	None
54	CA-SDI-10571	Jar (necked)	Flattened	Yes	None
55	CA-SDI-10571	Bowl	Slightly flattened	No	None
56	CA-SDI-10573	Bowl	Flattened	No	anvil impression on interior?
57	CA-SDI-10573	Jar	Flattened, thickened to exterior	No	None
58	CA-SDI-10573	Bowl	Flattened, slightly thickened to interior	No	None
59	CA-SDI-10573	Bowl (hemispherical)	Flattened	No	None
60	CA-SDI-10573	Jar	Flattened	Yes	None
61	CA-SDI-10573	Bowl (straight-sided)	Flattened	No	None
62	CA-SDI-10573	Bowl	Rounded	No	basket impressed anvil on interior below rim
63	CA-SDI-10573	Bowl	Flattened	No	None
64	CA-SDI-10573	Jar (neckless or holemouth)	Rounded	No	Possible whitish slip
65	CA-SDI-10573	Bowl	Rounded	No	None
66	CA-SDI-10573	Bowl	Rounded	No	None
67	CA-SDI-10573	Bowl	Flattened, thickened to exterior	No	None
68	CA-SDI-10573	Bowl	Flattened, thickened to interior	No	None
69	CA-SDI-10573	Jar (neckless or holemouth)	Rounded, thickened to exterior	No	None
70	CA-SDI-10573	Bowl	Flattened	No	biconical drill hole

A total of 70 rim sherds were selected from the ceramic assemblages of the seven sites (Tables 1 and 2). The samples tested comprised between 5-12% of each site assemblage, with 35 sherds selected from the northern and the southern ends of the study area. Most of the sherds had been originally collected from the site surface and are therefore of uncertain relative chronological assignment. In total, the studied sample consists mainly of bowls and jars, plus a lid, a plate and a scoop (Tables 1 and 2). Fragments of both hemispherical and straight-sided bowls as well as restricted chimney-neck jars and open neckless or 'holemouth' jars were present. Only 17 of the 70 sherds represented rim circumferences of 10% or more of the total aperture. Therefore the ability to identify reliable vessel size categories was limited and requires an expanded sampling program. Most of the vessels from which the sherds originated appear to have been undecorated, however, a few had incised rims and biconical drilled holes. Possible evidence for burnishing and painting was also found on a few sherds.

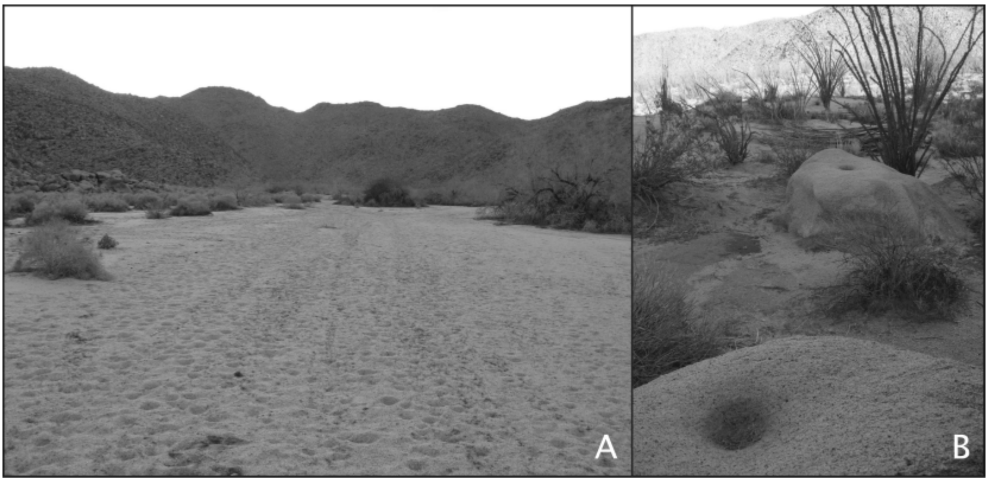

Figure 3. Late Prehistoric archaeological sites in the western Colorado Desert. a) Bow Willow Canyon with rocky granitic canyon walls and sandy alluvial soil, b) Prehistoric bedrock mortars at site CA-SDI-955 in Indian Valley.

Analytical Methods

Standard (30 μm) petrographic thin sections (Reedy, 2008, p. 1-3) were cut vertically through the vessel rim (Whitbread, 1996) of each of the selected sherds. These were analysed under the polarising light microscope using a modification of the holistic, descriptive approach pioneered by Whitbread (1989, 1995). This approach focuses on the nature of the clay matrix and voids as well as the more conspicuous aplastic inclusions. Using this method, it was possible to detect important microstructural and textural evidence in thin section for the techniques used to manufacture the ceramics. Such information is not readily detected by more quantitative petrographic methods such as point counting or the modal analysis of inclusions (Middleton *et al.*, 1985) that have been applied in the compositional analysis of southern California ceramics so far

(Pymale-Schneeberger, 1993; Griset, 1996; Gallucci, 2001, 2004; Hildebrand *et al*., 2002).

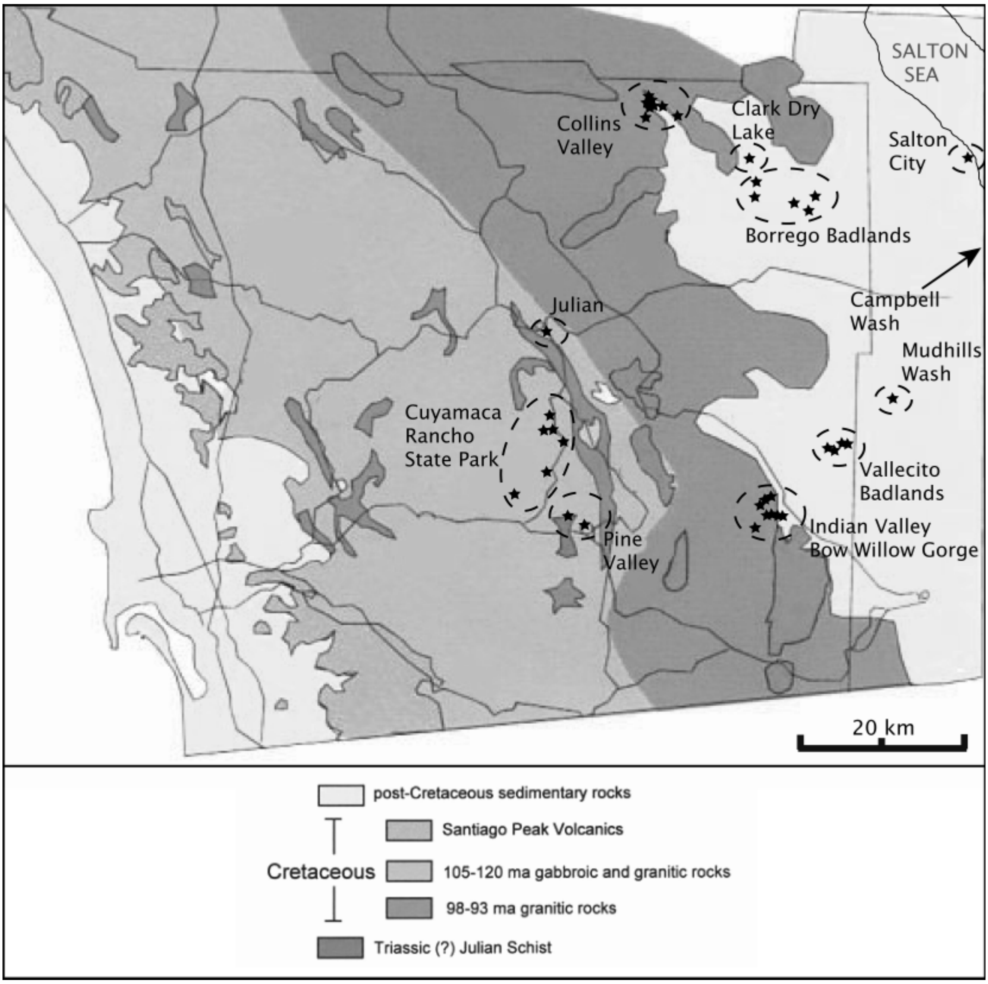

Figure 4. Generalised geology of southern California with the location of the geological field samples analysed in this study.

The ceramic thin sections were sorted into petrographic fabric groups, based on the overall composition of their inclusions, matrix and voids under the microscope, each representing a specific combination of raw materials and manufacturing techniques. Individual petrographic fabric groups were then characterised in detail by interpreting the type(s) of raw materials and the various steps involved in their manufacture, as well as their relationship to other classes. Compositional, microstructural and textural criteria were used to detect the presence of specific practices such as raw material processing, the intentional addition of different types of particulate matter or ‘temper’ and vessel forming techniques, as well as the atmosphere and degree of firing (Woods, 1984; Whitbread, 1986; Whitbread, 1995, p. 393-394; Whitbread, 1996; Rice, 1987, p. 409-411; Cuomo di Caprio and Vaughan, 1993; Roux and Courty, 1998; Reedy, 2008,

p. 146-148, 173-189).

In order to identify the possible sources of raw materials used to manufacture the Late Prehistoric ceramics, a program of geological field sampling and complementary analysis was undertaken. Geologically, the study area lies at the junction between the Mesozoic granitic and gabbroic igneous plutons of the Peninsular Range Mountains and the deep Cenozoic marine and non-marine sedimentary succession of the Salton Basin (Figure 4). All seven sites are situated within steep-sided northwest or southwest trending valleys cut into the eastern Peninsular Range Batholith. These valleys are characterised by light-coloured granitic rocks that weather into large boulders and form coarse sandy soil (Figure 3A).

Using geological maps (Strand, 1962; Rogers, 1965; Jennings, 1967) and field guides (Remeika and Lindsay, 1993; Clifford *et al*., 1997; Jefferson and Lindsay, 2006), detailed prospecting was carried out in the environs of the seven sites, as well as within the eroded sediments of the Salton Basin and the igneous terrain of the eastern Peninsular Range mountains (Figure 4; Table 3). Simple field tests on grain size and workability were used to identify and sample suitable clayey raw materials (Howard, 1982) that could have been used to produce ceramics. Samples of loose sandy sediment that may have represented suitable tempering material were also collected, as well as hard rock samples representative of the geology of each archaeological site.

Sample	Area	Type	Description	Sample	Area	Type	Description
1	Bow Willow	Sand	Recent alluvium	30	Collins Valley	Clay	Recent alluvium
2	Bow Willow	Rock	Granitic bedrock	31	Collins Valley	Sand	Recent alluvium
3	Bow Willow	Sand	Recent alluvium	32	Collins Valley	Rock	Granitic bedrock
4	Bow Willow	Rock	Metamorphic bedrock	33	Borrego Badlands	Clay	Pleistocene lacustrine Inspiration Wash Member
5	Bow Willow	Sand	Quaternary non-marine terrace	34	Borrego Badlands	Clay	Weathered intermediate igneous soil
6	Bow Willow	Sand	Weathered granitic soil	35	Cuyamaca Rancho State Park	Clay	Weathered intermediate igneous soil
7	Bow Willow	Rock	Granitic bedrock	36	Cuyamaca Rancho State Park	Clay	Weathered intermediate igneous soil
8	Vallecito Badlands	Clay	Recent alluvium	37	Cuyamaca Rancho State Park	Sand	Weathered intermediate igneous soil
9	Vallecito Badlands	Clay	Pliocene alluvium of Hueso Member	38	Clark Dry Lake	Clay	Recent lacustrine deposit
10	Vallecito Badlands	Sand	Pliocene alluvium of Hueso Member	39	Borrego Badlands	Clay	Pleistocene lacustrine Inspiration Wash Member
11	Vallecito Badlands	Clay	Pliocene alluvium of Hueso Member	40a	Borrego Badlands	Clay	Pliocene lacustrine Borrego Formation
12	Vallecito Badlands	Clay	Pliocene alluvium of Hueso Member	40b	Borrego Badlands	Clay	Pliocene lacustrine Borrego Formation
13	Vallecito Badlands	Clay	Pliocene laustrine Tapiado Member	41	Borrego Badlands	Clay	Pliocene lacustrine Borrego Formation
14	Vallecito Badlands	Rock	Pliocene laustrine Tapiado Member	42	Borrego Badlands	Clay	Pliocene lacustrine Borrego Formation
15	Vallecito Badlands	Clay	Pliocene alluvium of Diabo Formation	43	Borrego Badlands	Clay	Pliocene lacustrine Borrego Formation
16	Mudhills Wash	Clay	Pliocene marine Mudhills Member	44	Salton Sea	Clay	Recent lacustrine deposit
17	Mudhills Wash	Rock	Pliocene marine Mudhills Member	45	Campbell Wash	Clay	Quaternary lacustrine deposit
18	Indian Valley	Rock	Granitic bedrock	46	Campbell Wash	Clay	Quaternary lacustrine deposit
19	Indian Valley	Sand	Weathered granitic soil	47	Julian	Rock	Metamorphic bedrock
20	Indian Valley	Rock	Granitic bedrock	48a	Cuyamaca Rancho State Park	Clay	Weathered intermediate igneous soil
21	Indian Valley	Sand	Recent or Quaternary alluvium	48b	Cuyamaca Rancho State Park	Rock	Basic igneous bedrock
22	Indian Valley	Rock	Granitic bedrock	49a	Cuyamaca Rancho State Park	Clay	Weathered intermediate igneous soil
23	Collins Valley	Clay	Recent alluvium	49b	Cuyamaca Rancho State Park	Rock	Intermediate igneous bedrock
24	Collins Valley	Sand	Recent or Quaternary alluvium	50	Cuyamaca Rancho State Park	Rock	Granitic bedrock
25	Collins Valley	Rock	Metamorphic bedrock	51a	Cuyamaca Rancho State Park	Clay	Weathered intermediate igneous soil
26	Collins Valley	Clay	Recent alluvium	51b	Cuyamaca Rancho State Park	Rock	Intermediate igneous bedrock
27	Collins Valley	Sand	Sand dune	52a	Cuyamaca Rancho State Park	Clay	Weathered granitic soil
28a	Collins Valley	Rock	Metamorphic bedrock	52b	Cuyamaca Rancho State Park	Rock	Granitic bedrock
28b	Collins Valley	Rock	Metamorphic bedrock	53a	Pine Valley	Clay	Weathered intermediate igneous soil
28c	Collins Valley	Rock	Metamorphic bedrock	53b	Pine Valley	Rock	Intermediate igneous bedrock
29a	Collins Valley	Rock	Metamorphic bedrock	54	Pine Valley	Rock	Granitic bedrock
29b	Collins Valley	Rock	Metamorphic bedrock				

Table 3. Geological field samples collected and analysed in this study.

The collected clay samples were allowed to dry and were then crushed, re-hydrated and formed into test tiles or briquettes. These were fired in a laboratory kiln at 700°C under oxidising conditions and thin sectioned. Loose sandy sediment samples were set in resin before thin sectioning. All field samples were studied under the petrographic microscope and compared with the ceramic fabric classes in order to identify compositional matches that might be informative of the raw materials, technology and provenance of the archaeological samples.

Petrographic Fabric Classification

In thin section, the 70 Late Prehistoric ceramic samples exhibited a high degree of petrographic variability. Clear compositional similarities and differences between the samples in terms of mineralogy, petrography, texture and microstructure enabled a total of 18 different fabric groups to be identified, characterised by specific raw materials and manufacturing techniques (Table 4; Figures 5-7). These range from a large dominant group consisting of 30 out of the 70 analysed samples (Residual Granitic Fabric Group), to several groups composed of single unique sherds (e.g. Igneous Tempered Fabric Group, Fine Grog Tempered Fabric Group and Grog Tempered Calcareous Fabric Group).

Fabric Group	Samples	Sites
Residual Granitic Fabric Group	1, 2, 3, 4, 6, 8, 11, 14, 15, 17, 18, 21, 23, 25, 28, 37, 40, 43, 44, 48, 50, 51, 52, 53, 57, 58, 62, 66, 69, 70	CA-SDI-343, CA-SDI-2336 , CA-SDI-10571, CA-SDI-10573, CA-SDI-955, CA-SDI-956, CA-SDI-963
Well-Packed Alluvial Fabric Group	38, 41, 47, 55, 56, 59, 61, 67	CA-SDI-10571, CA-SDI-10573, CA-SDI-955, CA-SDI-956, CA-SDI-963
Grog Tempered Residual Granitic Fabric Group I	10, 20, 24, 27, 33, 34	CA-SDI-343
Residual Metamorphic Fabric Group	9, 19, 26, 29, 35	CA-SDI-343
Grog Tempered Fine Alluvial Fabric Group I	46, 49, 68	CA-SDI-963, CA-SDI-10573
Grog Tempered Fabric Group	30, 36, 42	CA-SDI-343, CA-SDI-955, CA-SDI-956
Sand and Grog Tempered Fabric Group	39, 54	CA-SDI-956, CA-SDI-10571
Sand and Grog Tempered Calcareous Fabric Group	63, 65	CA-SDI-10573
Gneiss Tempered Fabric Group	5, 7	CA-SDI-2336
Igneous Tempered Fabric Group	16	CA-SDI-343
Grog Tempered Residual Granitic Fabric Group II	60	CA-SDI-10573
Grog Tempered Residual Metamorphic Fabric Group	32	CA-SDI-343
Biotite-rich Residual Granitic Fabric Group	33	CA-SDI-343
Fine Biotite-Rich Grog Tempered II Fabric Group	31	CA-SDI-343
Grog Tempered Fine Alluvial Fabric Group II	12	CA-SDI-343
Igneous, Grog and Plant Tempered Fabric Group	64	CA-SDI-10573
Fine Grog Tempered Fabric Group	45	CA-SDI-956
Grog Tempered Calcareous Fabric Group	13	CA-SDI-343

Table 4. Petrographic fabric classification of the 70 Late Prehistoric sherds.

Significant petrographic variability was found to exist within the ceramic assemblages of each of the seven individual Late Prehistoric desert sites studied. A total of 11 different fabric groups, composed of geologically distinct raw materials and manufacturing techniques, were detected in the 27 sherds analysed from site CA-SDI-343. Even the three sherds analysed from the small ceramic assemblage of site CA-SDI-955 were compositionally distinct from one another in thin section. Some petrographic fabric groups (e.g. Sand and Grog Tempered Calcareous Fabric Group, Gneiss Tempered Fabric Group) were restricted to one or a few sites in the samples analysed, whereas others (e.g. Residual Granitic Fabric Group, Grog Tempered Fabric Group) had a more widespread distribution, occurring at sites in the north and south of the study area. Very little correspondence was detected in this study between the general form types of the sherds and their petrographic classifications. Common fabric classes included sherds from both bowls and jars with different lip forms and variously sized apertures. A larger sample size is needed to more rigorously test for associations between the fabric groups and vessel forms and sizes and their related functions.

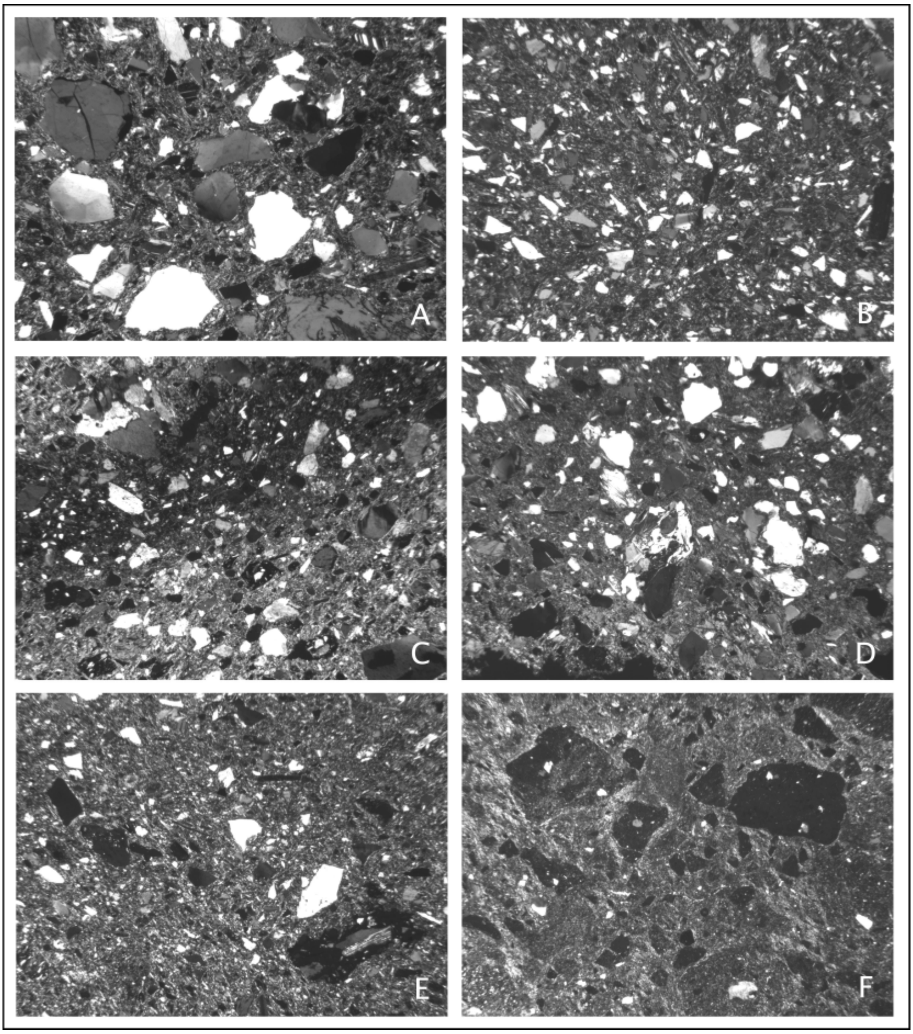

Figure 5. Photomicrographs of petrographic fabric groups detected in the Late Prehistoric sherds. a) Residual Granitic Fabric Group, sample 4, b) Well-Packed Alluvial Fabric Group, sample 41, c) Grog Tempered Residual Granitic Fabric Group I, sample 10, d) Residual Metamorphic Fabric Group, sample 19, e) Grog Tempered Fine Alluvial Fabric Group I, sample 46, f) Grog Tempered Fabric Group, sample 42. All images taken in crossed polars. Image width = 3.8 mm.

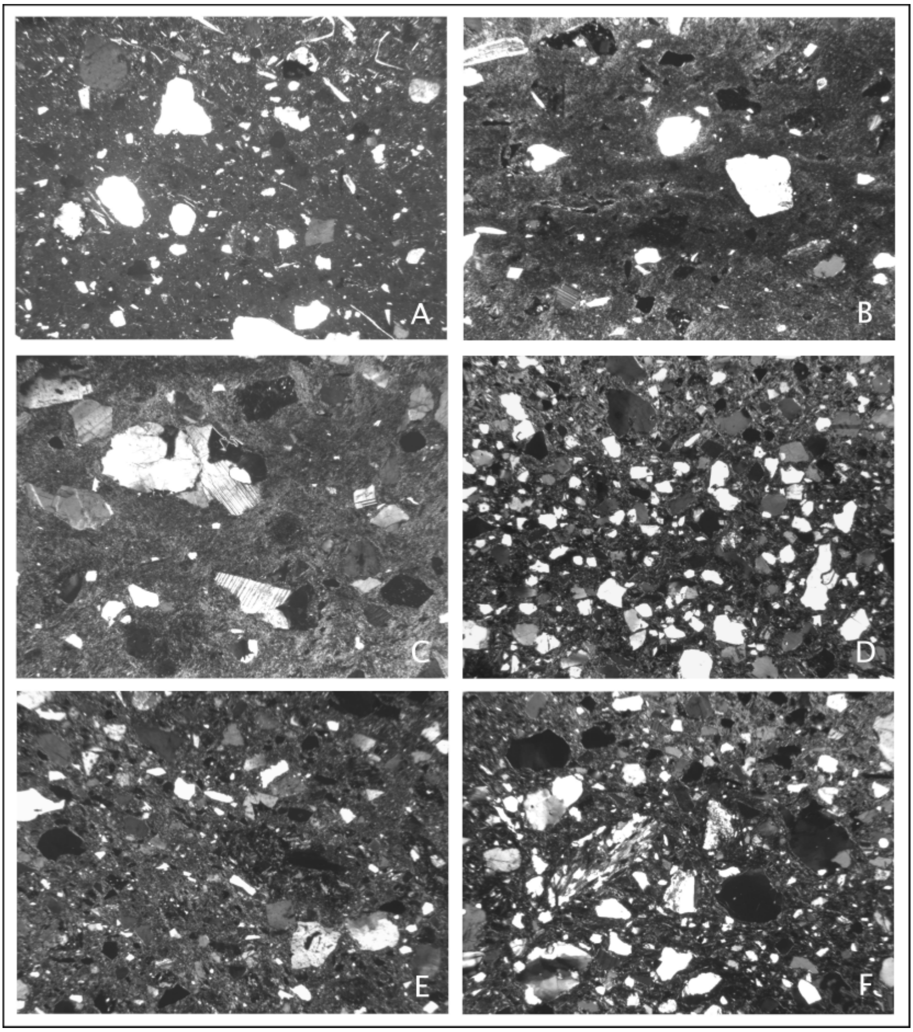

Figure 6. Photomicrographs of petrographic fabric groups detected in the Late Prehistoric sherds. a) Sand and Grog Tempered Fabric Group, sample 54, b) Sand and Grog Tempered Calcareous Fabric Group, sample 63, c) Gneiss Tempered Fabric Group, sample 7, d) Igneous Tempered Fabric Group, sample 16, e) Grog Tempered Residual Granitic Fabric Group II, sample 60, f) Grog Tempered Residual Metamorphic Fabric Group, sample 32. All images taken in crossed polars. Image width = 3.8 mm.

Ceramic Raw Materials

Based upon the mineralogy, petrography and texture of the 18 petrographic fabric groups and their comparison with the geological samples collected in the field, it has been possible to characterise the types of raw materials used for the production of the ceramics found at the seven Late Prehistoric desert sites. A surprising variety of different clay, particulate matter and hard rock appear to have been utilised by the indigenous potters of this region, although certain materials were used more commonly than others. By examining the availability of these raw material types using geological literature and the database of field samples, it has been possible in several cases to identify likely sources of the ceramic raw materials.

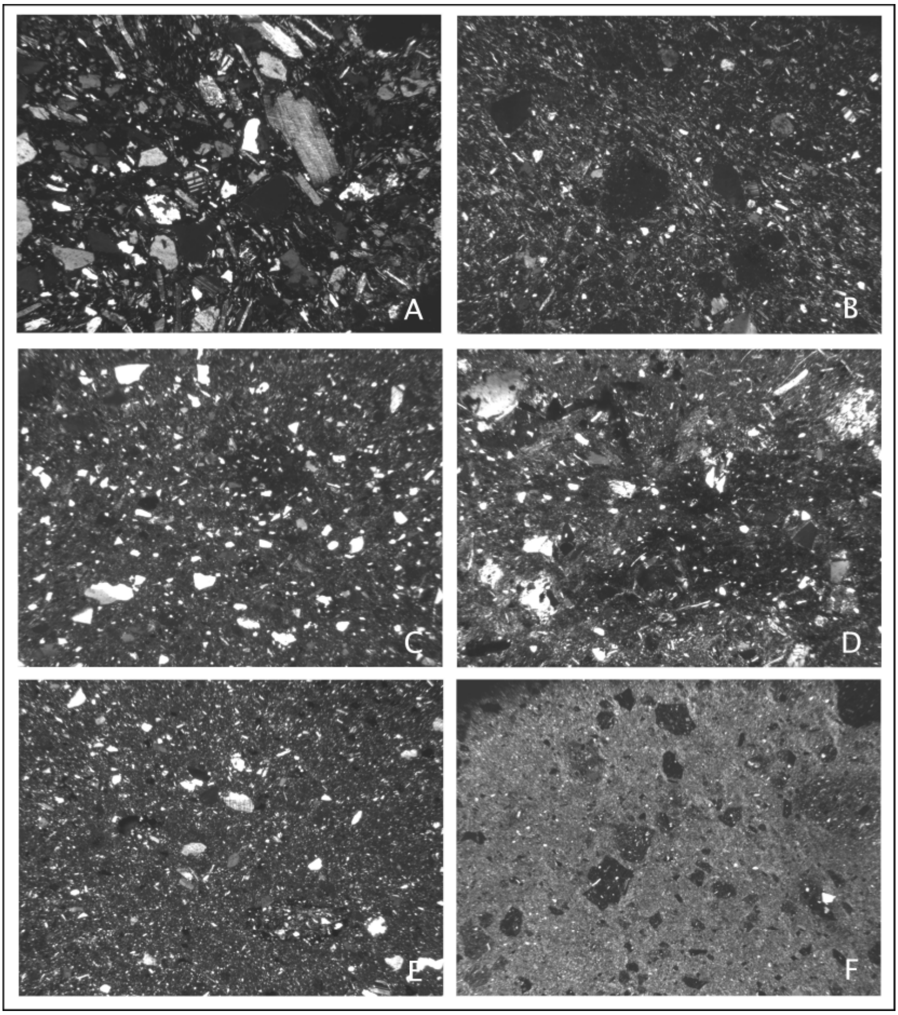

Figure 7. Photomicrographs of petrographic fabric groups detected in the Late Prehistoric sherds. a) Biotite-rich Residual Granitic Fabric Group, sample 22, b) Fine Biotite-Rich Grog Tempered II Fabric Group, sample 31, c) Grog Tempered Fine Alluvial Fabric Group II, sample 12, d) Igneous, Grog and Plant Tempered Fabric Group, sample 64, e) Fine Grog Tempered Fabric Group, sample 45, f) Grog Tempered Calcareous Fabric Group, sample 13. All images taken in crossed polars. Image width = 3.8 mm.

Coarse-grained, poorly sorted, residual clay, rich in quartz, plagioclase feldspar and biotite, deriving from the *in situ* weathering of granitic igneous rocks, appears to have been used for several fabric classes, such as the Residual Granitic Fabric Group (Figure 5A) and the Biotite-rich Residual Granitic Fabric Group (Figure 7A). The first of these accounts for 30 of the 70 sherds analysed and occurs at all seven sites. Field prospecting indicates that granitic igneous rocks such as granodiorite, quartz-diorite and tonalite occur in the three valleys in which the archaeological sites are situated (Geological samples 2, 7, 18, 20, 22 and 32). However, these weather slowly in the arid desert climate and break down into loose, coarse-grained, sandy soil, which is very poor in clay minerals. The same granitic rock types also occur in the eastern Peninsular Range mountains to the west of the study sites. Here in a wetter environment, the bedrock weathers chemically to form clay-rich soil (e.g. geological sample 52A) which is more likely to be the source of the ceramics of the of the Residual Granitic Fabric Group and the Biotite-rich Residual Granitic Fabric Group.

Variation in the mineralogy and texture of the large Residual Granitic Fabric Group exists in terms of the proportion of the mineral hornblende, which occurs in small amounts in ceramics from the northern sites, but is more or less absent in samples from the south. This pattern, which is also seen in the analysis of geological samples from the two ends of the study area, suggests that potters utilised several different granitic clay sources along the eastern edge of the Peninsular Range mountains. Several sherds from site CA-SDI-343 in the north belonging to the Residual Metamorphic Fabric Group (Figure 5D) and the Grog Tempered Residual Metamorphic Fabric Group (Figure 6F) are related to the main Residual Granitic Fabric Group, but also contain conspicuous sillimanite-bearing metamorphic rock fragments. The analysis of clay, hard rock and sand (Geological samples 27, 28a, 28b and 30) from Collins Valley has revealed a close match for this metamorphic material and may indicate that it is indicative of this area.

Several fabric groups, restricted to the southern sites, including the Well-Packed Alluvial Fabric Group (Figure 5B) and the Grog Tempered Fine Alluvial Fabric Group I (Figure 5E), are related mineralogically to the dominant Residual Granitic Fabric Group, but contain finer, more rounded and better sorted inclusions. This suggests that they were manufactured from immature alluvial clay deposits derived from the erosion of granitic rocks. Recent, locally derived, alluvial material rich in quartz, plagioclase feldspar and biotite exists near all archaeological sites studied (Geological samples 3, 19 and 21), but is generally very sandy. However, deposits of older Quaternary river terrace deposits that occur to the east of the southern sites contain clay-rich horizons (e.g. geological sample 5) that could represent the source of the Alluvial Fabric Group and the Grog Tempered Fine Alluvial Fabric Group I.

Very fine, sedimentary clay of either lacustrine or marine origin appear to have been used as a base-clay for a range of ceramics, such as those belonging to the Grog Tempered Fabric Group (Figure 5F), the Sand and Grog Tempered Calcareous Fabric Group (Figure 6B) and the Grog Tempered Calcareous Fabric Group (Figure 7F). These occur in low numbers at sites in the north and south within the ceramics analysed. Variation in the colour, texture and mineralogy of the clay matrices of these fabric groups, particularly their calcite content, suggests that they came from a range of different sources. Suitable clay beds outcrop within badlands that dissect the deep marine and non-marine sedimentary succession of the Salton Basin to the east of the studied sites. Field sampling in this area has revealed several possible matches such as the Early Pliocene marine Mudhills Member (Geological sample 16), which could be the source of the Grog Tempered Fabric Group and the Pleistocene non-marine Inspiration Wash Member (Geological sample 33) that may have been used to produce the ceramics of the Fine Biotite-Rich Grog Tempered II Fabric Group. However, confidently matching these fine sedimentary fabric groups to their sources of raw materials in thin section is difficult given their relative lack of inclusions.

In addition to the large number of different clay sources represented by the 18 petrographic fabric groups, an equally surprising range of natural particulate materials appear to have been used in the production of the ceramics analysed. Loose unconsolidated deposits of rounded, silt and sand-sized grains of quartz, feldspar, biotite and less commonly hornblende and muscovite were utilised for the ceramics belonging to the Sand and Grog Tempered Fabric Group (Figure 6A) and the Sand and Grog Tempered Calcareous Fabric Group (Figure 6B). Sandy alluvial material derived from the erosion of granitic rock is abundant in the vicinity of all sites (e.g. geological samples 3, 19 and 21) and sand dunes occur in some areas of the eastern desert (e.g. geological samples 27). Such deposits would have represented suitable sources of sandy raw materials for ceramic manufacture.

Other ceramics, such as those of the Igneous Tempered Fabric Group (Figure 6D) and the Gneiss Tempered Fabric Group (Figure 6C), appear to contain angular, crushed weathered rock. Hard igneous bedrock is abundant in the boulder-strewn valleys of the seven studied sites (Geological samples 2, 7, 18, 20, 22 and 32) and pinpointing the source of the material used in the Igneous Tempered Fabric Group is therefore difficult. However, a good match for crushed gneiss found in the Gneiss Tempered Fabric Group was found among the boulders of site CA-SDI-2336 (Geological samples 29A and 29B), close to where the sherds were found.

The geological interpretation of the 70 thin sections and their relationship to the database of field samples indicates that the potters who produced these ceramics made use of a wide range of different types of raw materials. This may suggest an intimate knowledge of the natural geodiversity of the region and perhaps an ability to adapt technologically to the availability of different types of raw materials during seasonal movements or long-term settlement shifts (Lyneis, 1988). Knowledge of the raw material sources used by southern California potters during the Late Prehistoric period is presently very poor (Schaefer, 1994b) and limited to a few historical accounts of favorable locations (Heizer and Treganza, 1972, p. 319, 333-334; Cline, 1984, p. 38; Hohenthal, 2001, p. 167). The compositional matches between the ceramics and geological field samples in this study are therefore significant in terms of determining where prehistoric people may have collected clay and other materials to produce pottery. The occurrence of certain common fabrics among the ceramics analysed, such as the Residual Granitic Fabric Group, seems to indicate that potters preferred certain raw material sources and used them repeatedly. This is supported by ethnographic accounts, which attest to the use of particular highly desirable quarry locations that were returned to on a regular basis (e.g. Wade, 1999, p. 3). However, whether potters in the past maintained personal clay resources for private use (Heizer and Treganza, 1972, p. 334; Hurd, *et al.*, 1990) or considered raw materials to be public domain (Rogers, 1936, p. 4) cannot be determined based on current evidence.

Geological fieldwork in the dry rocky valleys in which the archaeological sites are situated did not reveal many local sources of clay-rich deposits that could have been used for ceramic manufacture. Instead, much of the raw materials used for the production of the ceramics appear to have come from elsewhere, either in the Peninsular Range mountains to the west, or in the Salton Basin to the east. Although ceramic resource procurement distances may have been significantly greater for mobile hunter-gatherers such as the Late Prehistoric period tribes of southern California (Rogers, 1936, p. 4; Heizer and Treganza, 1972, p. 334; Williams, 1989, p. 4) compared to those recorded for potters in more sedentary societies (Arnold, 1985, p. 32-60), it is likely that bulky raw materials would not have been transported over significant distances. Instead, ceramic production probably took place close to sources of clay, temper, water and fuel. With this in mind, much of the compositionally diverse ceramic assemblages recorded at the seven archaeological sites tested must be non-local in origin, having been made elsewhere and transported to the sites as finished pots. The absence of direct evidence for ceramic production at any of the studied sites supports this interpretation. Further, by examining the geographic patterning of the 18 petrographic fabric groups and the occurrence of comparable raw material sources, initial findings suggest that pottery vessels were transported over significant distances (>50 km) in numerous directions, within and beyond the desert. The patterns of movement revealed by the limited sample set in this study correlate well with historic accounts of ancient trail systems (Cline, 1979, p. 17, 18, 21, 1984, p. 13, 16-17)

Ceramic Technology

Based on the composition, microstructure and texture of the 70 Late Prehistoric sherds in thin section, it has been possible to identify many of the technological steps involved in their manufacture, including raw material processing, paste preparation, vessel forming techniques and the conditions of firing. These provide important evidence for the choices and behaviours of potters in the past, as well as their knowledge of raw material properties and their skill in the craft of pottery production.

The clayey raw materials of ceramics belonging to the Residual Granitic Fabric Group and the Biotite-rich Residual Granitic Fabric Group may have been ‘cleaned’ prior to use in order to remove very coarse mineral and rock inclusions. Whilst there is little direct evidence for this process in thin section, the coarse poorly-sorted nature of the residual weathered igneous raw materials that could have been used for these ceramics suggests that a degree of processing or cleaning must have been carried out before the clay was suitable for ceramic manufacture. This kind of activity has been reported in ethnographic studies of traditional southern California potters by Rogers (1936, p. 6), Wilken (1982) and Hohenthal (2001, p. 170).

The occurrence in the Grog Tempered Fabric Group and the Fine Biotite-Rich Grog Tempered II Fabric Group of fine argillaceous inclusions, with sharp to merging boundaries, that have an identical composition to the surrounding clay matrix (Figure 8A), may suggest that they were produced from dry, pulverised clay, which was wetted to form a paste. These inconspicuous inclusions appear to represent fine clay particles that were not sufficiently hydrated and therefore remained aplastic during the pottery manufacturing process. Clay used by traditional potters is often collected in dry state and a first step in the production of ceramics is to grind this into a fine powder. Observations of traditional pottery production in southern California attest to the crushing of chunks or 'clods' of clay in a mortar (Cline, 1984, p. 34) or on a flat rock (Rogers, 1936, p. 5) and subsequent grinding with a metate and mano (Rogers, 1936, p. 6; Bean and Lawton, 1965, p. 6; Wilken, 1982; Cline, 1984, p. 34; Hohenthal, 2001, p. 170). The evidence seen in thin section in this study suggests that such a practise was also carried out during the Late Prehistoric period.

The clay paste used to produce the ceramics of 13 out of the 18 fabric classes detected in this study appears to contain intentionally added particulate matter or temper (Figures 5-7). Temper was distinguished in thin section from naturally occurring aplastic inclusions using a combination of different criteria, including grain-size distribution, roundness, angularity and mineralogical composition (Rice, 1987, p. 409-411; Whitbread, 1995, p. 393). Both the number of fabric groups that contain temper and the range of different tempering agents that was added to the ceramics are surprising. In addition to sand and hard rock temper, noted above, other types of added particulate matter include crushed ceramic sherds or 'grog' (Figure 8B) and plant matter (Figure 8D). Grog temper is particularly common in the ceramics analysed, having been added to some ten different fabric classes including the Grog Tempered Fabric Group, the Grog Tempered Fine Alluvial Fabric Group I and the Grog Tempered Calcareous Fabric Group. In a few thin sections, grog inclusions were found to contain grog themselves (Figure 8C), suggesting that ceramics were repeatedly recycled and used as temper.

The act of tempering clay with particulate matter such as quartz (Rogers, 1936, p. 25), crushed rock (Kroeber, 1925, p. 722; Rogers, 1936, p. 25; Heizer and Treganza, 1972, p. 334), grog (Curtis, 1908, p. 27; Gifford, 1931, p. 42; Drucker, 1937, p. 22), ash (Wilken, 1982) and manure (Ferenga and Heredia, 1995, p. 4) has been recorded in ethnographic accounts of traditional southern California potters. Such actions may have been motivated by performance characteristics such as the workability of the clay paste or the strength of the vessel during firing (Heizer and Treganza, 1972, p. 334; Wilken, 1982; Campbell, 1999, p. 123). Indeed, within the ceramics analysed in this study, temper appears to be added mainly to those pots made from fine sedimentary clays with few naturally occurring inclusions, suggesting that the practise could be a response to the qualities of the available raw materials. However, several naturally coarse ceramic samples belonging to the Grog Tempered Fine Alluvial Fabric Group I, the Grog Tempered Residual Granitic Fabric Group II and the Grog Tempered Residual Metamorphic Fabric Group also contain grog inclusions (Figure 8E,F). The occurrence in the samples analysed of identical non-tempered versions of these two fabric groups (Residual Granitic Fabric Group and Residual Metamorphic Fabric Group) suggest that their residual base clays, which contained abundant naturally occurring non-plastic inclusions, did not need to be tempered for functional reasons. Equally, the motivation behind the addition of two or more different types of temper to ceramics of the Sand and Grog Tempered Fabric Group, the Calcareous Sand and Grog

Tempered Fabric Group and the Igneous, Grog and Plant Tempered Fabric Group are also not clear.

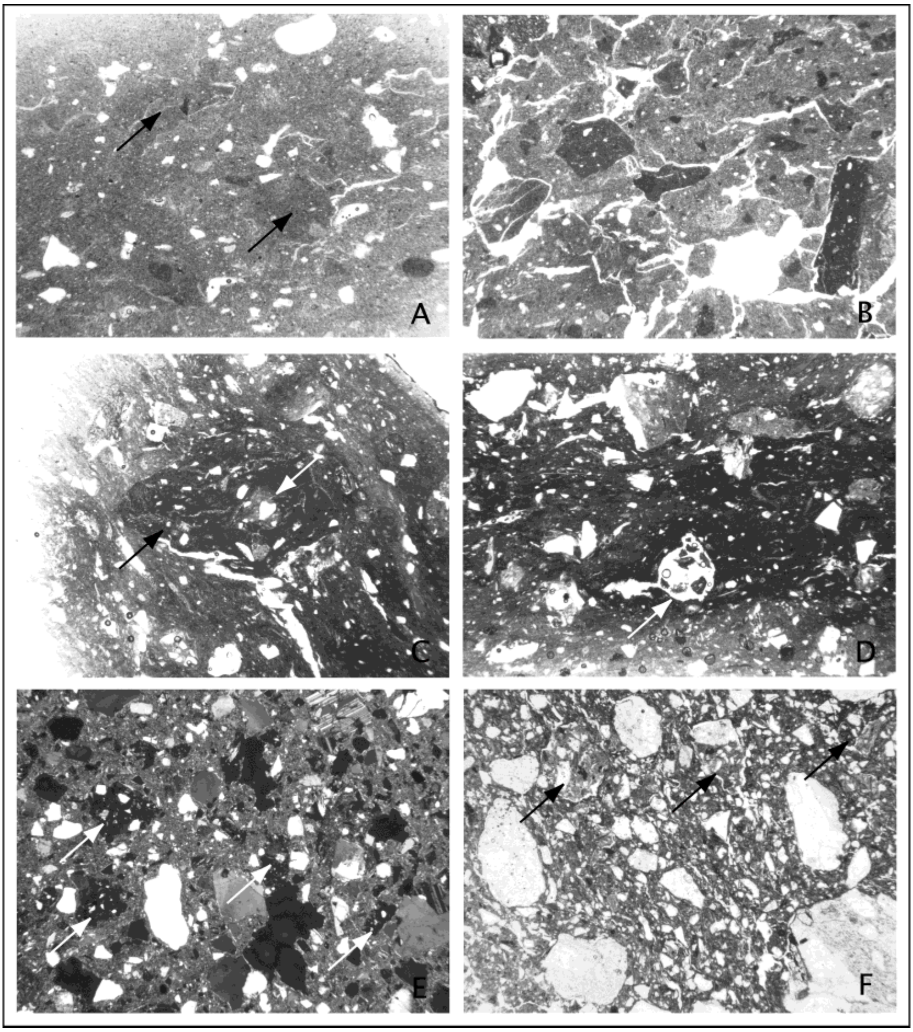

Figure 8. Photomicrographs of evidence for paste preparation techniques of the 70 Late Prehistoric sherds analysed in this study. a) Inconspicuous argillaceous inclusions in sample 65, that may be evidence of grinding dry clay, b) Grog inclusions in sample 36 indicating the addition of crushed ceramic temper, c) Grog inclusion (black arrow) with second generation grog (white arrow) in sample 64, indicating repeated recycling of ceramics, d) Void with charred organic matter in sample 64, possibly indicating addition of plant temper, e,f) Addition of grog to coarse clay rich in inclusions, samples 32 and 34. All images taken in plane polarised light, except e. Image width = 3.8 mm, except c = 2.4 mm.

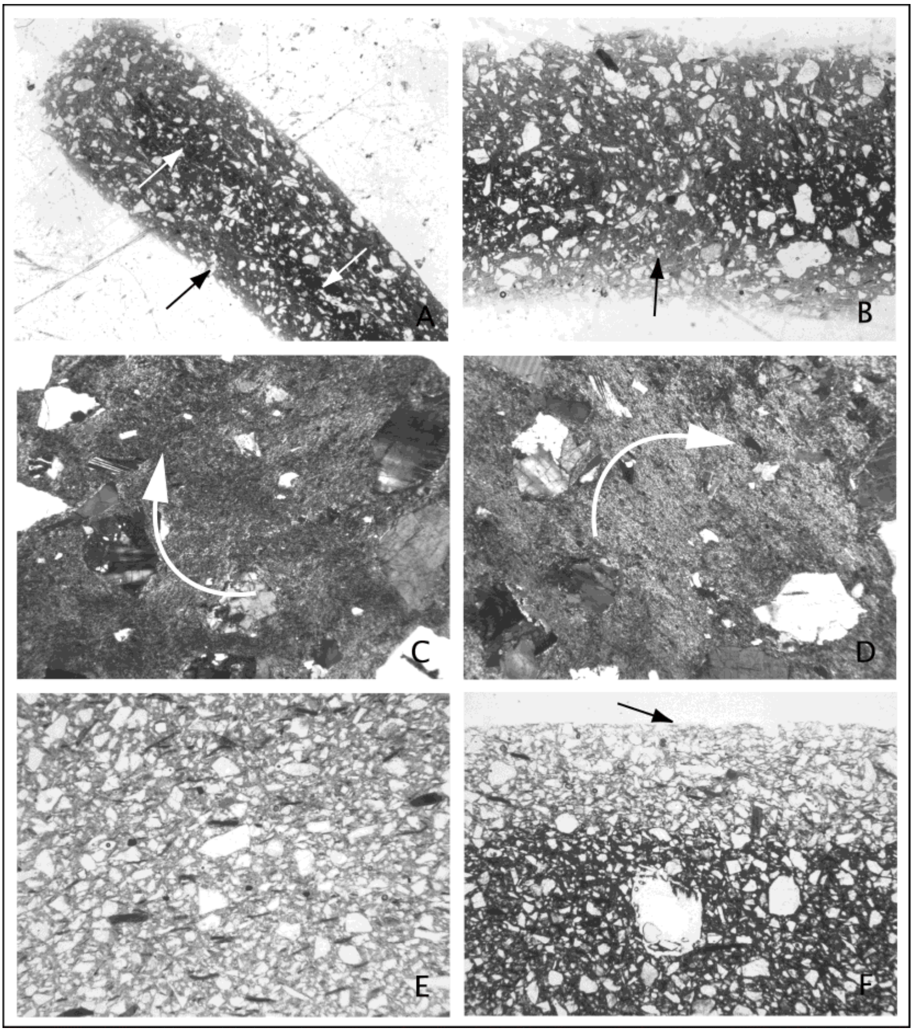

Figure 9. Photomicrographs of evidence for the forming and firing techniques of the 70 Late Prehistoric sherds analysed in this study. a) Relic coils (white arrows) and coil join (black arrow) in sample 58, suggesting construction of vessel by coiling, b) Join between adjacent coils indicated by degree of oxidation of core of vessel in sample 44, c,d) High optical activity of clay matrix during 45° rotation of sample 7 in crossed polars, indicating relatively low degree of firing, e) Light coloured clay matrix in sample 41 due to firing in oxidising atmosphere, f) Oxidised margin and reduced core in sample 55 due to low firing duration and/or high organic content of clay (arrow indicates vessel surface). Images a, c, d taken in crossed polars and b, e, f in plane polarised light. Image width = 3.8 mm, except c, d = 2.4 mm, a = 10.8 mm, b = 5.8 mm.

Microstructural evidence for the techniques used to form the Late Prehistoric desert ceramic vessels can be seen in many of the vertical thin sections analysed. The dominant forming method appears to have been the bonding of successive strands of clay or 'coiling'. Relic coils are highlighted in thin section by the concentric orientation of elongate inclusions and voids (Figure 9A), or by the presence of joins between successive coils (Figure 9B). Evidence for the practice of coiling was found in half of 18 fabric groups and was more evident in coarser grained ceramics, due to their larger, more abundant inclusions. However, relic coils and coil joins were also noted in some other, fine sedimentary ceramics such as the single sample belonging to the Grog Tempered Calcareous Fabric Group.

Coiling is suspected to have been the preferred method of vessel forming throughout the ‘paddle and anvil’ potting tradition of southern California (Griset, 1996, p. 9) and has been reported, albeit with minor variations in the implements used, in several ethnographic accounts of traditional pottery manufacture in this area (e.g. Rogers, 1936, p. 9; James, 1960, p. 63; Bean and Lawton, 1965, p. 6; Bean, 1978, p. 579; Kroeber and Hooper, 1978, p. 28; Wilken, 1982; Cline, 1984, p. 34; Hohenthal, 2001, p. 170). Coils, ‘ropes’ (Kroeber and Hooper, 1978, p. 28) or ‘strings’ (Cline, 1984, p. 34) were bonded together with the fingers and the vessel wall was thinned and beaten into shape using a wooden paddle and a clay anvil or river pebble. Evidence for the forming and shaping of ceramics with a paddle and anvil and the use of a basket mould was observed on the surfaces of a few of the sherds in hand specimen. In thin section, parallel alignment of inclusions and voids close to the exterior surface of some sherds may also be indicative of beating with an implement such as a paddle, or the drawing of the vessel walls with the fingers.

Based upon the hardness of the Late Prehistoric sherds in hand specimen and the nature of their clay matrices in thin section, most appear to have been moderately fired, at a temperature high enough to produce *terra cotta*, but almost certainly below 1000°C. Accurately determining the firing temperatures of ancient ceramics can be difficult (Rice, 1987, p. 426-435), however, a rough estimate of the degree of firing can be inferred from the optical state of the clay matrix in thin section (Peacock, 1971; Whitbread, 1995, p. 394; Rice, 1987, p. 431). Clay minerals, though too small to be seen under the polarising microscope, exhibit extinction in thin section, when rotated in crossed polars. This property is progressively lost in fired ceramics as the lattice structure of the clay minerals breaks down and they begin to vitrify, until at high temperatures the clay matrix becomes optically inactive. The clay matrices of the majority of the ceramics analysed in this study were either moderately or highly-optically active in thin section (Figure 9C,D). This suggests that they were not vitrified and were therefore fired at relatively moderate temperatures.

The colour and hue of the ceramics in hand specimen and in thin section suggests that they were fired under a range of different redox conditions, from highly oxidising (abundant oxygen) (Figure 9E) to strongly reducing (oxygen-starved) atmospheres. Samples characterised by a dark core and a lighter margin (Figure 9F), were likely to have been incompletely oxidised during firing, due to the presence of abundant organic matter in the clay paste and/or a short firing duration. The variation in firing atmosphere interpreted for the ceramics, as well as their moderate degree of firing is indicative of a relatively unsophisticated, poorly controlled, non-kiln firing technology (Rye 1981, p. 98; Rice, 1987, p. 109). Ethnographic studies of traditional ceramic production in southern California document the use of a simple firing pit (Rogers, 1936, p. 14; Cline, 1984, p. 38; Hohenthal, 2001, p. 171), in which vessels are placed and covered with fuel. Direct evidence for prehistoric firing technology is almost entirely absent in the region. Pottery may have been fired away from habitation or other activity areas (Rogers, 1936, p. 5; Griset, 1996, p. 288), making firing loci less likely to be found by archaeologists. In this respect, investigation of the prehistoric ceramics in this study provides vital evidence for the ways in which pottery was fired in the past.

Ceramic Technology, Tradition and Cultural Identity

Each of the different petrographic fabric groups that have been detected and characterised in this study represent specific combinations of raw materials and manufacturing technologies that were used to produce Late Prehistoric ceramic vessels. The particular sequence of steps involved in each case, from the selection and processing of clay and temper, through paste preparation, vessel forming, finishing and firing, defines what is referred to as the object's *chaîne opératoire* (Leroi-Gourhan, 1964) or 'technological style' (Lechtmann, 1977). This ontogenic sequence of how a synthetic artefact such as a ceramic vessel came to be is also a record of the potter who produced it, in terms of the conscious decisions that she or he made and the procedures carried out (Whitbread, 2001). These thoughts, choices and actions are likely to have been determined by a range of direct and indirect environmental, material, social, cultural and economic factors that structured the world in which the potter lived (Sillar and Tite, 2000). With this in mind, deciphering the technological styles of Late Prehistoric ceramic sherds can reveal a wealth of valuable archaeological information about the hunter-gatherer societies of southern California.

The petrographic and microstructural evidence for ceramic technology presented in this study and its comparison with ethnographic accounts of the craft provides evidence that the potter's choices and behaviours were guided by the specific material properties of the different types of resources utilised and acquired knowledge about how to manipulate these resources to produce a desirable product. For example, the addition of particulate matter to the fine sedimentary clay used in several fabric groups appears to have been an effort to compensate for the lack of naturally occurring inclusions in these raw materials, which otherwise may have resulted in clay that was too sticky to shape, or a vessel that was likely to crack during firing. Similarly, potters would have known through experience that insufficient reduction of clay raw materials would result in a failed product and therefore processed the clay by grinding and cleaning it of large impurities.

Given that potters, in investing time and effort into the ceramic production process, would have aimed to successfully create a functional object, it is likely that many of their technological decisions would have been based on practical and material constraints. However, within the ceramics analysed in this study, important evidence also exists to suggest that potters made choices and behaved in ways that were influenced by other than strictly functional factors that may have been of equal importance to them. Examples of such choices include the intentional addition of grog to ceramics made from coarse residual clay and the use of several different types of temper in a single clay paste. Ethnographic studies of traditional pottery manufacture in many parts of the world have highlighted the complex, socially-embedded nature of ceramic technology (Stark, 2003) and the reasons behind these behaviours may therefore be related to the potter's social milieu, including local and family traditions and beliefs, as well as a desire for individual expression.

Distinguishing among possible social and cultural influences on prehistoric technology may not be easy. In the case of the occurrence of grog in some coarse residual ceramics in this study, it is possible that the potter(s) that made these vessels added temper because their parents, ancestors or other artisans in their tribe or family group did the same. The potters may have been influenced by their own personal spiritual beliefs or may have been engaged in an established ritual process. Animistic beliefs and practises among southern Californian tribes have been documented (Patencio, 1934, p. 4; Rogers, 1936, p. 2, 5; Wilken, 1982; Bean *et. al.*, 1991, p. 9; Hohenthal, 2001, p. 168). The addition of grog temper to clay may thus have been a symbolic action, representing renewal and remembrance of the deceased. Another possibility, suggested by the occurrence at a single site of both tempered and non-tempered varieties of the same residual clay paste, may be that the addition of grog was a matter of individual choice and expression. Recent ethnographic studies at the traditional potting village of Santa Catarina in Baja California have recorded significant variations in potters' methods that mark the distinctive style or hallmark of individual craftspeople (Wilken 1982). Potters in the past may likewise have carried out specific practises as a way of distinguishing their own products from those of others and expressing their own identity. Ethnohistoric records compiled by Rogers (1936, p. 22, 27) also indicate individual and group variation in the use of grog temper, though this practice appears to have been significantly less common in the early 20th century than in Late Prehistoric times based on the evidence presented in this study.

Moving beyond technical considerations to explore the social and cultural aspects of hunter-gatherer ceramic production is an exciting prospect. The results of this study combined with ethnohistoric and ethnographic reports suggest that petrographic analysis has the potential to help define different cultural or family-based ceramic traditions amoung the various ethno-linguistic groups that inhabited southern California. Despite the apparently homogeneous material culture complex that characterises most Late Prehistoric sites, important variability is likely to exist in the ways in which pots were made by different individuals, families, bands and tribes (Rogers, 1936, p. 2). In this study, a comparison of the ceramics from northern and southern sites within the Anza-Borrego Desert State Park revealed a high degree of variation within a small sample of sherds suggesting that a variety of techniques and raw material sources were used to produce the pottery vessels and that they were likely to have been transported across significant distances. Future comparative analyses of ceramics from a broader region will be needed to better understand the cultural patterning that exists in Late Prehistoric hunter-gatherer ceramic manufacture.

Summary

The compositional analysis of Late Prehistoric hunter-gatherer ceramics from the desert region of eastern San Diego County presented in this study has revealed a previously unexpected level of meaningful variability within these plain, undecorated artefacts. Detailed thin section ceramic petrography resulted in the definition of numerous distinct fabric classes or recipes, characterised by specific combinations of raw materials and technology. The compositional diversity of the ceramics and their correlation with geological field samples suggests that potters had an intimate knowledge of the geodiversity of the region and utilised a wide range of different naturally-occurring raw materials. Much of the pottery found at the seven sites analysed is likely to have been non-local in origin, having been made elsewhere in southern California and transported over significant distances in various directions, perhaps through seasonal movements or trade among hunter-gatherer social groups.

Detailed investigation of the steps involved in the manufacture of the various recipes has provided an important window into the nature of hunter-gatherer ceramic technology. Many of the aspects highlighted in this study could not have been detected by hand specimen studies or earlier geochemical analyses of southern California ceramics. A comparison of this data with ethnographic and historical accounts of the traditional craft as it existed in the 20th century in isolated locales suggests much continuity in practice, but also differences that may represent the impacts of European and Mexican settlers and modern tourism on indigenous cultural traditions (Griset, 1990; Wade, 2004).

By beginning to identify the choices and behaviours of potters in the past, we hope to establish a framework within which to evaluate the different environmental, social and cultural influences that underlie their particular ceramic traditions or styles. Evidence for technological choices based on the performance characteristics of materials was detected in many of the ceramics analysed. This indicates that potters possessed significant acquired skills and knowledge about different raw materials and their properties. In other cases, technological practices appear to have been guided by less readily apparent criteria that may have their origins in social or cultural practices and beliefs, or might be evidence of individual expression. Unraveling this deeper meaning within the plainware ceramics is a challenging undertaking, but holds significant potential for better understanding the role of ceramics and ceramic technology in the hunter-gatherer societies of southern California and elsewhere.

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