Ceramic Distribution, Migration and Cultural Interaction Among Late Prehistoric (ca. 1300–200 B.P.) Hunter-Gatherers in the San Diego Region, Southern California

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Abstract

The composition of 40 pottery sherds from three separate excavation units at the Late Prehistoric (ca. 1300-200 B.P.) hunter-gatherer habitation site of Mine Wash (CA-SDI-813) in eastern San Diego County has been characterised by a combination of thin section petrography and geochemistry and compared to a database of raw materials and additional ceramic artefacts from across the region. This reveals a compositionally diverse pottery assemblage that contains ceramics from several non-local sources in the Colorado Desert to the east and the nearby Peninsular Range mountains to the west. Possible cultural mechanisms for the movement of pottery to Mine Wash are assessed, including seasonal migration between different landscape zones along ethnohistoric trails, trade and exchange, and settlement shift due to subsistence stress. Additionally, intra-site compositional variation in ceramics across the three excavation units is considered as evidence for the cohabitation of the site by several different social groups of hunter-gatherers.

Keywords

Hunter-gatherers, ceramics, compositional analysis, migration, cultural interaction

Introduction and Aims

The San Diego region of southern California was occupied at the time of European contact (by convention, AD 1769, the date of the founding of the Spanish mission San Diego de Alcalá) by several ethnolinguistic groups of hunter-gatherers associated with specific geographic territories (Fig. 1). These people migrated seasonally and are known to have interacted with one another. Contact and co-operation between the bands and tribes of this area may have been essential in order to gain access to specific food and material resources (Luomala, 1978), as well as to facilitate settlement shifts at times of environmental pressure (Shipek, 1982). It is also believed that different social groups may have participated in common ritual activities connected with social maintenance and spiritual beliefs (Sampson, 2004).

Despite a fairly extensive ethnohistoric record, reconstructing patterns of movement and interaction among the pre-contact hunter-gatherer populations of this multi-cultural region has so far been challenging. This is due to a variety of reasons, notably the homogeneous material culture assemblage that they left behind and problems in refining chronology (Laylander, 1997a; Schaefer, 1994a). Late Prehistoric (ca. 1300–200 B.P.) villages and campsites in the area are typically characterised by bedrock grinding features, portable manos, metates, pestles and mortars, projectile points, shell beads and abundant plainware ceramic sherds. Attempts to subdivide the latter into typological categories that are indicative of specific geographic regions, chronological periods or cultural groups (e.g., Laylander, 1997b; May, 1978; Van Camp, 1979; Waters, 1982) have been difficult to apply due to the paucity of visible diagnostic traits, as well as the small size of sherds, which may be related to the practise of breaking pots as a death ritual (Hohenthal, 2001: 168).

Recent compositional analyses of the clay paste from which the ceramics of the San Diego region were manufactured has revealed that important clues about their raw material sources (Quinn et al., 2013), craft technologies (Quinn and Burton, 2009) and origins (Hildebrand et al., 2002) exist at the microscopic and atomic level within these otherwise homogeneous sherds. Geographic patterning in clay type and paste preparation practices holds significant potential for the identification of non-local ceramics at pre-contact sites and the reconstruction of seasonal (Hildebrand et al., 2002) or more permanent (Arnold et al., 2004: 47) movement of social groups between the desert, upland and coastal landscape zones that characterise the region (Fig. 1). In addition, the co-occurrence of multiple ceramic compositions at single sites may provide evidence for inter-marriage across lineages/bands and/or for the gathering of neighbouring tribes or bands in one location for specific activities (Quinn et al., 2013), thus supporting ethnohistoric accounts of co-operation and interaction.

In the present study, we build upon the existing compositional database to further explore its potential for reconstructing migration, settlement strategies and interactions of pre-contact hunter-gatherer groups in the region by analysing in detail the ceramic assemblage of a single large Late Prehistoric site. Mine Wash (CA-SDI-813) (Sampson, 1984, 2004) is located in the Colorado Desert, at the foot of the Peninsular Ranges (Fig. 1). It is ideally positioned to investigate likely seasonal movements between upland and desert lowland areas (Schaefer, 1994b), as well as a possible settlement shift in latest prehistoric times that may have been triggered by the desiccation of ancient Lake Cahuilla to the east (Fig. 1) (Waters, 1983). We apply a combination of thin section petrography and instrumental geochemistry to define compositional patterning within the ceramic assemblage of this site and identify its likely origins. Our interpretations of the movement of pottery and people to and from Mine Wash are given cultural meaning by assessing the available archaeological and ethnohistoric evidence for traditional pottery manufacture, resource exploitation, migration, trade and exchange, and socio-political structure.

Mine Wash and its Ceramics

Mine Wash is located within Mescal Bajada, a gently sloping alluvial plain that is fed by ephemeral drainages flowing out of the adjacent Pinyon Mountains in eastern San Diego County (Fig. 2a). The site is centred on a large granitic outcrop, located just north of a boulder-strewn hillside (Fig. 2b). Mine Wash falls within the traditional ethnohistoric territory of the Yuman-speaking Tipai (Fig. 1), a Kumeyaay group, who may have occupied Mescal Bajada during the winter and spring months for the purpose of food procurement and ceremonial activity (Sampson, 2004). The site contains abundant bedrock mortars and metates, an agave roasting pit, as well as cupule petroglyphs and features identified as fertility symbols or 'yonis' (Thomson, 2012). Archaeologists from California

State Parks excavated six units at Mine Wash in 1984 and 1985 (Sampson, 1984, 2004) (Fig. 2b). This revealed two phases of occupation; the later phase was ceramic-bearing. The excavations yielded 5642 obsidian flakes, 5245 bone fragments, 96 manos, 18 shell beads, eight projectile points and 438 plain-ware pottery sherds. No direct evidence of pottery production has been found at the site. The geologic source for the obsidian specimens was Obsidian Butte, 65 km to the east (Fig. 1). The shell beads are likely to have originated on the Pacific Coast, 85 km to the west.

We selected material from three of the six excavated units at Mine Wash for ceramic compositional analysis. Units B1 and B3 are located close to one another, just south of the main granitic outcrop that dominates the site (Fig. 2b). Unit A5 is situated on the other side of the site near a small group of boulders, 150 m north of Units B1 and B3. A total of 115 sherds were studied from Units B1, B3 and A5 (Table 1). These came from several levels within the ceramic-bearing Late Prehistoric phase. Though no cultural stratigraphy was visible, obsidian hydration values indicate that the increasing age of the deposits correlates with increasing depth. A radiocarbon date of 360 ± 50 years B.P. was obtained from 40–50 cm within Unit B3.

Analytical Methods

All 115 samples were classified as either rim or body sherds and attempts were made to identify the vessel form from which they came. Each sherd was classified within one of two broad ware categories commonly used in San Diego County (Euler, 1959; Lyneis, 1988; Schroeder, 1958) (Table 1). Buff Ware is distinguished by its light colour and low proportion of coarse mineral inclusions seen with the hand lens (x10) and the presence of clay-rich inclusions. Brown Ware sherds have a darker brown colour, a rough fracture and contain abundant mineral inclusions.

A subset of 40 sherds with a largest dimension of 3 cm or more was selected for the purpose of detailed compositional analysis (Tables 1 and 2). These comprised 11 from Unit B1, 20 from Unit B3 and nine from Unit A5, including representatives from most of the ceramic-bearing levels. All 40 sherds were impregnated with epoxy resin and prepared as standard 30 μm thin sections. The samples were grouped visually into petrographic fabrics based on the composition, abundance, shape, size, orientation and distribution of their dominant inclusions, as well as the nature of their clay matrix and voids (Quinn, 2013: 73-102) (Appendix A).

The nature and location of the raw materials used for the production of the ceramics was interpreted by means of geological maps and field guides, as well as thin sections of 78 clay, rock and sand samples collected from 52 locations in the Peninsular Ranges and the Colorado Desert (Fig. 3; Appendix B). The identified fabrics were also compared to those recorded in 298 thin sections of Late Prehistoric pottery from 10 other sites in San Diego County (Quinn and Burton, 2009; Quinn et al., 2013) (Fig. 1), in order to identify matches.

Small (1 g) subsamples of the 40 sherds were prepared for instrumental neutron activation analysis (INAA) characterisation at the University of Missouri Research Reactor (MURR) using in-house protocols (Glascock, 1992) and irradiated with certified reference materials RM-1633b (coal fly ash) and SRM-688 (basalt rock). The concentrations of 33 elements were recorded as parts per million (ppm): Al, As, Ba, Ca, Ce, Co, Cr, Cs, Dy, Eu, Fe, Hf, K, La, Lu, Mn, Na, Ni, Nd, Rb, Sb, Sc, Sm, Sr, Ta, Tb, Th, Ti, U, V, Yb, Zn and Zr (Appendix C). Nickel (Ni) was below the limits of detection in many samples, so was omitted from the dataset. The concentrations of the remaining 31 elements were log-transformed to base-10 logarithms and subjected to principal components analysis (PCA). Compositional patterning was then examined by plotting the first two principal components against one another and investigating the elements that contribute most to the variability in the samples.

Selected clay-rich field samples (n=33) were also analysed by INAA and compared to that of the ceramics in order to identify matches that might be indicative of the sources of raw materials used to manufacture the pottery.

The results of the geochemical grouping of the 40 samples were compared to the macroscopic and petrographic classifications of the sherds. This provided technological meaning to the geochemical groups and was also used to crosscheck the reliability of all three methods of classification.

Macroscopic, Petrographic and Geochemical Classification

Only seven rim sherds were present within the 115 samples studied from Units B1, B3 and A5. These are suggestive of open mouthed, as well as more constricted, vessels or 'ollas', which were commonly used by native groups in southern California to prepare, store and transport water, food stuffs and possessions (Griset, 1996: 181). Such vessels were round-bottomed. No decoration was visible on any of the sherds.

Buff Ware sherds dominate the studied assemblage (89%) (Table 1) with Brown Ware sherds accounting for a much smaller proportion of the total ceramics (11%) and are mainly restricted to Unit A5. No stratigraphic patterning was apparent in the ceramics of the studied units.

The independent petrographic and geochemical classifications of the subset of 40 sherds closely match one another, and correlate well with macroscopic ware group assignment of the samples (Table 2). A plot of principal components 1 and 2, which explained 61% of the total variance in the dataset (Fig. 4a,b) reveals the presence of one geochemical group and several outliers. The main group is characterised by relatively high concentrations of the elements Ce, Cs, K, Nd and Rb, compared to the outliers (Appendix C). It is composed entirely of Buff Ware sherds (Fig. 4a) that can be classified into two petrographic fabric groups (Fig. 4b). The Grog Tempered Fine Sedimentary Fabric is characterised by intentionally-added ceramic temper or 'grog' and possible crushed clay particles in a very fine, light-brown coloured, non-calcareous clay matrix (Fig. 5a), and the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric (Fig. 5b) contains significant amounts of naturally occurring fine biotite mica inclusions, which stand out against the generally dark-brown coloured, fine non-calcareous clay matrix.

Two related sherds also manufactured from fine sedimentary clay are distinguishable petrographically from the other 32 Buff Ware sherds. One of these two contains occasional sand-sized temper inclusions of volcanic rock, possibly andesite (Grog and Sand Tempered Fine Sedimentary Fabric - Fig. 5c), yet plots in the main Buff Ware group in Fig. 5b. The other has a distinctive texture (Grog Tempered Biotite-Rich Sedimentary Fabric – Fig. 5d). The latter sample forms an outlier in the geochemical classification due to its high Co, Mn, Nd, Sc and V (Fig. 4b). The four tempered sedimentary Buff Ware fabrics correspond well to the definition of this broad macroscopic category and confirm the occurrence of several distinct compositional subgroups that various researchers have attempted to define in hand specimen (e.g., Laylander, 1997b; Van Camp, 1979; Waters, 1982).

Three sherds that were identified as Buff Ware are characterised in thin section by abundant naturally-occurring inclusions, which is more in keeping with the definition of Brown Ware. These include two samples classified within the Biotite-Rich Residual Fabric (Quinn et al., 2013) that are characterised by poorly-sorted inclusions of quartz, polycrystalline quartz, plagioclase feldspar and abundant biotite (Fig. 5e), and plot at the edge of the main group of the scatterplot (Fig. 4b). Their fabric is suggestive of a residual clay source rather than the fine sedimentary material used in the Buff Ware sherds with which they are geochemically related. They may indicate the presence at the site of 'Salton Brown Ware', defined macroscopically by Rogers (1945a) and recognised compositionally by Hildebrand et al. (2002).

The four Brown Ware samples in the 40 analysed sherds are geochemically distinguishable from the main group of sherds (Fig. 4a,b) in terms of their relatively low concentrations of the elements Ce, Cs, K, Nd and Rb (Appendix C). All were made with relatively coarse, residual or minimally transported clay containing abundant mineral inclusions of quartz, polycrystalline quartz, plagioclase feldspar, biotite and igneous rock fragments, and can be classified into two separate petrographic fabrics based on the proportion of amphibole inclusions that they contain (Fig. 5f,g). The Residual Granitic Fabric (Quinn and Burton, 2009) (Fig. 5f) is made from residual clay formed on amphibole-poor acid igneous rock such as granite or granodiorite, whereas the Amphibole-Rich Residual Igneous Fabric (Quinn et al., 2013) (Fig. 5g) was manufactured from a more intermediate diorite or perhaps gabbro-derived clay source with a significant amphibole content (>30% of the total inclusions). The latter sample is distinguished geochemically from all other sherds by its extremely low Ce, Cs, K, Nd and Rb, and its high Al and Ti content.

Finally, a single sherd macroscopically classified as Buff Ware was found to be petrographically related to the Amphibole-Rich Residual Igneous Fabric, but has a finer texture, less amphibole and contains grog temper (Fig. 5h). Despite its buff colour, it was made from an inclusion-rich residual or redeposited clay source and is geochemically related to the Brown Ware sherds of the Residual Granitic Fabric.

Matches with Raw Material Samples

Several sedimentary clay samples collected east of Mine Wash in the thick Cenozoic marine and non-marine succession of the Salton Basin (Fig. 3) bear petrographic similarities to one or other of the two common Buff Ware fabrics. However, the fine nature of these field samples and the base clay used to manufacture the Buff Ware sherds does not permit further comparison on petrographic grounds alone. A scatterplot of PCA conducted on the 40 Mine Wash sherds and the 33 clay-rich raw material field samples reveals that sedimentary clay samples 13, 33, 42 and 43, as well as recent alluvial clay sample 8, are geochemically closely related to the sherds attributed to the dominant fabrics (Fig. 4c). Samples 42 and 43 were collected from the Borrego Formation in the Borrego Badlands (Fig. 3), which is petrographically related to the Grog Tempered Fine Sedimentary Fabric, and sample 33, taken from the nearby Inspiration Wash Member at Fonts Point (Fig. 3), was identified as a possible petrographic match for the Grog and Sand-Tempered Biotite-Rich Sedimentary Fabric. This agreement between the independent petrographic and geochemical data may suggest that these two sedimentary units could be the source of clay used to produce the main Buff Ware fabrics, though it is worth bearing in mind that the addition of grog to the Buff Ware fabrics may have altered the geochemical composition of the clay used for their production.

Alluvial and wind-blown quartz and feldspar-rich sand covers most of the Colorado Desert, so locating the exact sources of sand used to temper the buff ware ceramics is likely to be difficult. An exception might be the volcanic material within the Grog and Sand Tempered Fine Sedimentary Fabric, which is likely to have a more restricted distribution. Bedrock of basic andesite composition and surface sand with volcanic clasts collected at and around outcrops of the Alverson Volcanics at Volcanic Hills (samples 70–75) (Fig. 3) bear similarities to the inclusions seen in this ceramic sample. Williams (1989a) found andesite clasts in a clay sample from Fossil Canyon in Imperial County (Fig. 3).

Primary clay deposits that match petrographically the ceramics of the Residual Granitic Fabric (sample 52A, Cuyamaca Mountains) and the Amphibole-Rich Residual Fabric (samples 34, 35, 36, 48a, 49a, 51a, 53a, Laguna and Cuyamaca Mountains) occur in the Peninsular Ranges, to the west of Mine Wash (Fig. 3). These samples occur as outliers in the PCA scatterplot (Fig. 4d), and confirm some of the compositional associations seen in thin section. For example, two of the Residual Granitic Fabric sherds are correlated with clay sample 52A and the single sherd of the Amphibole-Rich Residual Fabric plots towards the bottom of the scatterplot closest to clay sample 34.

The two Biotite-Rich Residual Fabric sherds plot with Quaternary alluvial clay samples 1 and 44 (Fig. 4d), collected from the eastern base of the Peninsular Ranges and the edge of the Salton Sea. This may suggest that the ceramics of this fabric could have been made from relatively coarse, recent alluvial clay rather than a residual source. Alluvial clay sample 58, which was collected from the dried-up creek bed beside Mine Wash and is rich in biotite clasts, is not however geochemically related to the Biotite-Rich Residual Fabric sherds (Fig. 4d).

Ceramic Provenance and Patterns of Movement

The compositional diversity of the Mine Wash assemblage revealed by our macroscopic, petrographic and geochemical analyses indicates that its ceramics were manufactured using several different raw material types and/or recipes. Fieldwork suggests that clay deposits suitable for the manufacture of pottery are scarce in the vicinity of Mine Wash, with the possible exception of sandy material left by intermittent winter run-off in the nearby wash. With this in mind, it is likely that most of the ceramics analysed from the site were produced with non-local raw materials.

In provenance studies of archaeological ceramics, it is usually assumed that clay and temper were obtained close to the site of pottery production (Quinn, 2013: 119; Tite, 1999: 195). This is based on observations of the raw material procurement distances of traditional potters in sedentary communities (e.g., Arnold, 1985: 32–60). However, the collection of raw materials may have been combined with other subsistence or social activities (Michelaki et al., 2014), especially in mobile populations, who are known to travel further to collect clay for pottery manufacture. Early ethnographic accounts of native pottery manufacture in southern California indicate that such a process could have taken place, with potters travelling up to 90 km to visit particular prized clay beds (Heizer and Treganza, 1944: 334; Rogers, 1936: 4). However, it is likely that these reflect patterns of raw material procurement that had already been transformed by European incursions. Long distance transport of raw materials was probably the exception rather than the norm during the Late Prehistoric period (Gallucci, 2001: 17).

Regionally, it is thought that pots were made primarily during the summer months (Rogers, 1936: 4), when the weather was most conducive to the drying and firing process. Mine Wash, on the other hand, was most likely occupied during the winter and early spring due to the excessive summer temperature in the Colorado Desert (Cline, 2008; Sampson, 1984). Furthermore, no direct evidence for on-site ceramic manufacture, such as unused clay, tools or the remains of firing pits, has been reported at Mine Wash. The presence at the site of several abundant compositional groups of ceramics made from exotic material might, therefore, be better explained by the movement of finished ceramics from several distinct sources, rather than occasional pottery production using imported clay.

The tempered sedimentary Buff Ware ceramics that form the main geochemical group are likely to have been produced somewhere in the Colorado Desert area to the east of the site of Mine Wash (Fig. 1). Possible clay sources include the Pliocene Borrego Formation for the ceramics of the Grog Tempered Fine Sedimentary Fabric and the Pleistocene Inspiration Wash Member in the case of the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric. Both of these ancient sedimentary deposits outcrop in the Borrego Badlands c. 20 km northeast of Mine Wash (Fig. 3).

The two other tempered sedimentary ceramic samples are also likely to have been produced using clay from the Colorado Desert. In the case of the single Grog and Sand Tempered Fine Sedimentary Fabric sherd, the presence of sand temper inclusions of volcanic origin may be indicative of a provenance some 25–40 km south of Mine Wash near to outcrops of the Alverson Canyon Formation at Volcanic Hills, Fish Creek Mountains or Carrizo Mountain/Coyote Mountain Wilderness (Fig. 3).

The coarse residual Brown Ware sherds, which represent outliers in the geochemical analysis, appear to have originated from several sources within the Peninsular Ranges to the west of the site. Petrographic matches for the Residual Granitic Fabric and Amphibole-Rich Residual Fabric have been found among clay samples collected from the Cuyamaca and Laguna Mountains and in the ceramic assemblages of sites CA-SDI-4787, 12947/H and 17666 in these mountains (Quinn et al., 2013) (Fig. 1), suggesting that this mountain area could be the source of these ceramics. The provenance of the Biotite-Rich Residual Fabric is less certain. Compositionally related ceramics seem to occur at the same three sites in the Peninsular Ranges (Quinn et al., 2013), however, no biotite-rich residual clay has yet been detected in this area, and the two Biotite-Rich Residual Fabric sherds from Mine Wash appear to be geochemically related to recent alluvial clay from the Colorado Desert (Fig. 4c).

Based on these provenance interpretations it is likely that pottery and people were making their way to the site from multiple directions (Fig. 6). The dominant signal is of tempered sedimentary Buff Ware material travelling westwards from the lowland region near the present day Salton Sea. A promising source area could be the Borrego Badlands to the northeast. Smaller numbers of Brown Ware ceramics made from residual clay were being transported to Mine Wash from the Peninsular Ranges in a roughly eastward direction. Strong connections with the Cuyamaca and Laguna Mountains area seem to suggest a more specific pattern of northeasterly transport of material, possibly along ethnohistorically-documented routes (Cline, 2008: 13, 16–17). Lastly, tempered sedimentary Buff Ware ceramics with volcanic sand inclusions seem to have been brought to the site from somewhere on the desert margin to the south.

Evidence for Migration, Trade and Cultural Interaction

The transport of finished ceramics from multiple directions to Mine Wash might be explained in terms of several possible cultural processes that could have been taking place in this part of southern California in Late Prehistoric times. These include seasonal migration, trade/exchange, the cohabitation of the site by more than one community group and settlement shift. By examining the interpreted movement of ceramics to Mine Wash within the context of published archaeological and ethnohistoric evidence, we can assess the likelihood of these different possible explanations.

Seasonal Migration and Logistical Forays

The idea that pottery was made by a single community group while residing in different geographic regions during seasonal migration (Hildebrand et al., 2002) could explain the compositionally diverse nature of the ceramic assemblage of Mine Wash. It has been proposed that Mine Wash served as a winter base for the Kwaaymii band of Tipai, who lived in semi-permanent villages in the Peninsular Ranges and migrated eastwards to the desert floor in the colder months (Sampson, 2004). It is therefore quite likely that some of the small proportion of Brown Ware ceramics detected in its assemblage represents pottery made near their upland villages from residual mountain clay; these vessels would have been used to carry food or possessions to lower altitudes.

The presence of fish bones at Mine Wash (Sampson, 1984, 2004) indicates that people who lived at the site took advantage of the lacustrine resources of ancient Lake Cahuilla. This oasis-like freshwater environment in the Colorado Desert (Fig. 1) provided important plant and animal resources and was incorporated within the seasonal rounds of hunter-gatherer groups. People might have undertaken expeditions from Mine Wash along trail systems within the Colorado Desert to specific collecting zones such as Lake Cahuilla. Whilst at this location they could have produced Buff Ware ceramics from the sedimentary clay resources of the nearby Borrego Badlands or other deposits. Some of these finished ceramics may then have been brought back to Mine Wash, perhaps in conjunction with the transport of lacustrine resources.

The use of Mine Wash as a winter base for mountain community groups, from which they made forays into the Colorado Desert, is a tempting scenario with which to explain the compositional diversity of the ceramics at the site. However, this relies on the assumption that the same people made pottery in several locations at different times of the year. To have produced both Brown Ware and Buff Ware ceramics, a potter would have needed to adapt her/his technology to the very different raw materials from which these two broad ware types are made. Their contrasting physical behaviour during forming and firing would have required the potter to fundamentally change the way that she/he prepared the clay: either refining the coarse, particle-rich residual material of the Peninsular Ranges or adding temper to the fine, sticky sedimentary clay of the Salton Trough (Campbell, 1999; Hildebrand et al., 2002; Hohenthal, 2001: 166; Quinn and Burton, 2009). Such a practice is contrary to the generally accepted notion of indigenous pottery making 'traditions' in which technological choices are socially-embedded and not easily changed (Rice, 1984; Sillar and Tite, 2000; Whitbread, 2001). The use of natal clay sources by female potters in exogamous groups (Griset, 1996: 286; Wade, 1999) is an often-cited example of this type of conservatism in native pottery manufacture in the San Diego region. Another example is the occasional addition of grog temper to coarse residual clay, which was detected by Quinn and Burton (2009: 278). This would not have been necessary for purely functional reasons and may therefore provide evidence for the strong influence of technological tradition and symbolic behaviour.

A strategy of producing small batches of 'disposable' pots (Gibbs, 2012) at multiple locations at different times of the year, as and when needed, would tend to give rise to a heterogeneous, poorly-standardised ceramic assemblage. This is due to differences in raw materials from place to place, as well as variation in vessel size between episodes of manufacture. Unfortunately, formal or metric variation cannot be assessed in the case of Mine Wash due to the highly fragmented nature of the ceramics. While the assemblage contains significant compositional diversity in terms of the number of petrographic fabrics present, the dominance of the two main Buff Ware groups, which exhibit only moderate variation in mineralogy, texture and geochemistry, is more in keeping with the repeated production of pottery at a single location, using the same raw materials.

A third line of evidence that may rule out the production of both Brown and Buff Ware ceramics by the same community group is their spatial distribution at Mine Wash. Brown Ware sherds were mainly restricted to Unit A5, at the edge of the site, with the other two units dominated by Buff Ware ceramics. No distinct function has been interpreted for this portion of the site based on its other archaeological remains, and differing utilitarian uses of brown and buff pottery have not been proposed for the San Diego region. In the absence of such differentiations, the restriction of Brown Ware to Unit A5 and the dominance of Buff Ware in Units B1 and B3 on the southern side of the main granitic outcrop seems most likely to indicate the habitation of the site by more than one community group. This possibility will be returned to below.

Trade/Exchange

If the transport of clay is unlikely, then a second explanation for the compositional diversity and multiple origins of the Mine Wash assemblage is trade or exchange, of either pottery or goods carried within vessels. It has been proposed and reported ethno-historically that indigenous groups of the San Diego region traded and exchanged certain goods with one another (Luomala, 1978: 601; Sample, 1950). This enabled them to obtain foodstuffs and other materials that were not available in their own territory, including salt, dried seafood, acorns and mesquite beans (Luomala, 1978: 601–602), as well as shell beads (Schaefer 1994b) and obsidian (Dominici, 1984; Hughes and True, 1985). Primary sources of obsidian have a restricted occurrence within the region (Fig. 1), so the widespread distribution of flaked artefacts is best explained by a system of trade or exchange (Laylander and Christensen, 1990).

Accounts of pottery being traded are rare in comparison, although such a process has been proposed in some cases (e.g., Rogers, 1936: 27–28). The hunter-gatherer populations of the Owens Valley, California are suspected to have intentionally over-produced pottery for formalised exchange (Steward, 1933; see Eerkens 2001:155 for an opposing view) and mobile populations of the Gila River, Arizona may have obtained vessels from sedentary neighbours to supplement their own pots (Beck, 2009). Perhaps a similar situation could be proposed for the native groups of southern California, with the mountain Kumeyaay inhabitants of Mine Wash and desert groups such as the Kamia engaging in reciprocal trade that involved ceramics and other goods such as mountain acorns, or agave or mesquite from Mescal Bajada.

The presence at Mine Wash of obsidian from Obsidian Butte (Fig. 1) and shell beads from the Pacific Coast suggest that the site participated within regional exchange systems, either directly or as a conduit (Sampson, 2004). It is located close to San Felipe Wash, a major drainage running out of the foothills of the Peninsular Ranges and into the Salton Basin (Fig. 2a) that was used by native inhabitants of the area (Cline, 2008: 16–17; Von Werlhof, 1988). The presence of significant numbers of non-local pots at Mine Wash is in keeping with a picture of material goods and foodstuffs passing through the site in multiple directions. Buff Ware ceramics also occur at many sites in the Peninsular Ranges, albeit in low numbers (Quinn et al., 2013) and even as far west as the coast (Hildebrand et al., 2002; Schaefer, 1994a). It is therefore tempting to propose that these vessels were changing hands as part of the exchange of some sort of commodity, or in their own right due to a perceived aesthetic or functional value. Unfortunately, evidence to support this is scarce and the paddle-and-anvil pottery of the San Diego region is usually viewed as a utilitarian good that was produced and used by the same group. A rare exception is Rogers (1936: 27–28) who, in discussing the presence of 'typical Kamia and Yuma buff-colored wares' in Cahuilla territory, notes that "Americans who have talked with the potters of an earlier time inform me that these were procured in trade". There are no obvious physical characteristics that set Buff Ware sherds apart from their Brown Ware counterparts except for difference in fabric and colour, though systematic investigations into the functional performance of these two broad ware types have not been carried out.

Community Interaction at a 'Central Place'

Another form of cultural interaction that could have been responsible for the deposition of Buff and Brown Ware ceramics of several compositions at Mine Wash is the cohabitation of the site by more than one community group, each bringing pottery made in their own primary territory. It has been proposed that as many as four different Kumeyaay bands sometimes camped in certain favoured locations (Hildebrand and Hagstrum, 1995), perhaps to take advantage of specific plant or animal resources. Kumeyaay social organisation, particularly the kinship structure of 'sibs', which crosscut tribes and bands (Shipek, 1982), may have promoted fluidity of community membership (Laylander, 1997a) and the temporary residence of one group with another during ceremonies or other occasions (Schneider, 2005). Neighbouring Tipai groups such as the Kwaaymii, the Teshill and the Kwatatl are thought to have coalesced in single locations on the desert margin to carry out spring ceremonies, before returning to their mountain homes (Cline, 2008: 15, 18; Hildebrand and Hagstrum, 1995).

The partitioned spatial distribution of the different fabrics in the three excavation units at Mine Wash might suggest that pots were brought to the site by different community groups, arriving from different directions and maintaining discrete habitation areas. For example, the Buff Ware pottery at Mine Wash could signify the presence at the site of desert Kumeyaay groups such as the Kamia, whose main territory lies within the Salton Trough (Fig. 1), while the Brown Ware pottery might reflect mountain community groups such as the Kwaaymii, who travelled eastward through canyons to the desert floor in late-winter and spring (Cline, 2008). Assuming contemporaneity of occupation of the different areas at Mine Wash, the pattern of compositional variation seems to imply logistical transporting of resources with perhaps some inter-community exchange, possibly related to ceremonial/ritual activities. The large cupule petroglyph rock and 'yoni' features at Mine Wash may be evidence that the site was a central gathering place for such activities, serving to reinforce inter-community ties (Sampson, 2004).

Settlement Shift

Distinguishing among possible factors that may have contributed to the multiple origins of the Mine Wash ceramic assemblage is difficult. A major hindrance is the lack of stratigraphy at the site and the low number of secure calendric dates. This is a common problem at sites in the San Diego region related to their relatively recent formation and often intense bioturbation. The single radiocarbon date within the ceramic-bearing sequence of Unit B3 seems to suggest that it was deposited at some time during the 16–17th centuries A.D. Lake Cahuilla was almost certainly receding at this point in the Patayan/Yuman III Phase of Late Prehistory (Waters, 1983) and may have become too saline to sustain the plant and animal resources that once drew native groups to its shore (Rogers, 1945b; Schaefer, 1994a). This 'subsistence stress' (Hildebrand and Hagstrum, 1995) is suspected to have triggered a demographic and cultural shift (Schaefer, 1994a) that resulted in increased population densities in parts of the San Diego region. Such a process might provide another explanation for the dominance of Buff Ware at Mine Wash. This pottery could have been brought to the site by the Kamia or other desert groups from the east as they abandoned the shrinking lake and sought out alternative food resources in the Peninsular Ranges to the west. Such a scenario has been proposed by Arnold et al. (2004: 47) to account for the regional differences in ceramic composition detected by Hildebrand et al. (2002) and warrants further investigation.

Conclusion

Our combined petrographic and geochemical analysis of the Late Prehistoric ceramic assemblage of Mine Wash (CA-SDI-813), San Diego County, further highlights the value of scientific approaches for revealing variability in the raw materials (Quinn et al., 2013) and aspects of manufacturing technology (paste preparation, forming and firing, Appendix A; Quinn and Burton, 2009) of these otherwise homogeneous sherds. By defining integrated compositional groups and linking these to the landscape via complementary field sampling and analysis, it has been possible to detect the multiple origins of the pottery deposited at Mine Wash. This information holds significant potential for reconstructing a range of past cultural processes including: migration and resource procurement by pre-contact hunter-gatherer populations across topographic and ecological zones; cultural interaction between neighbouring communities via trade, formalised exchange and co-habitation; intra-community fluidity and fission/fusion; and settlement shifts in response to environmental stress. However, attributing the compositional signals within the Late Prehistoric sherds of the San Diego region to the influence of one or more cultural processes, such as those listed above, is more difficult due in part to certain characteristics of pottery manufacture and use by hunter-gatherers. These include raw material procurement distances and the small-scale expedient manufacture of pottery in several locations. This calls for the interpretation of scientific data within a well-structured archaeological and anthropological framework that includes a secure chronology and comparative data from additional sites. Analysis of large sample sets from excavated and ^{14}C-dated sites, rather than scattered surface finds, is the best way forward.

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Figures and Tables

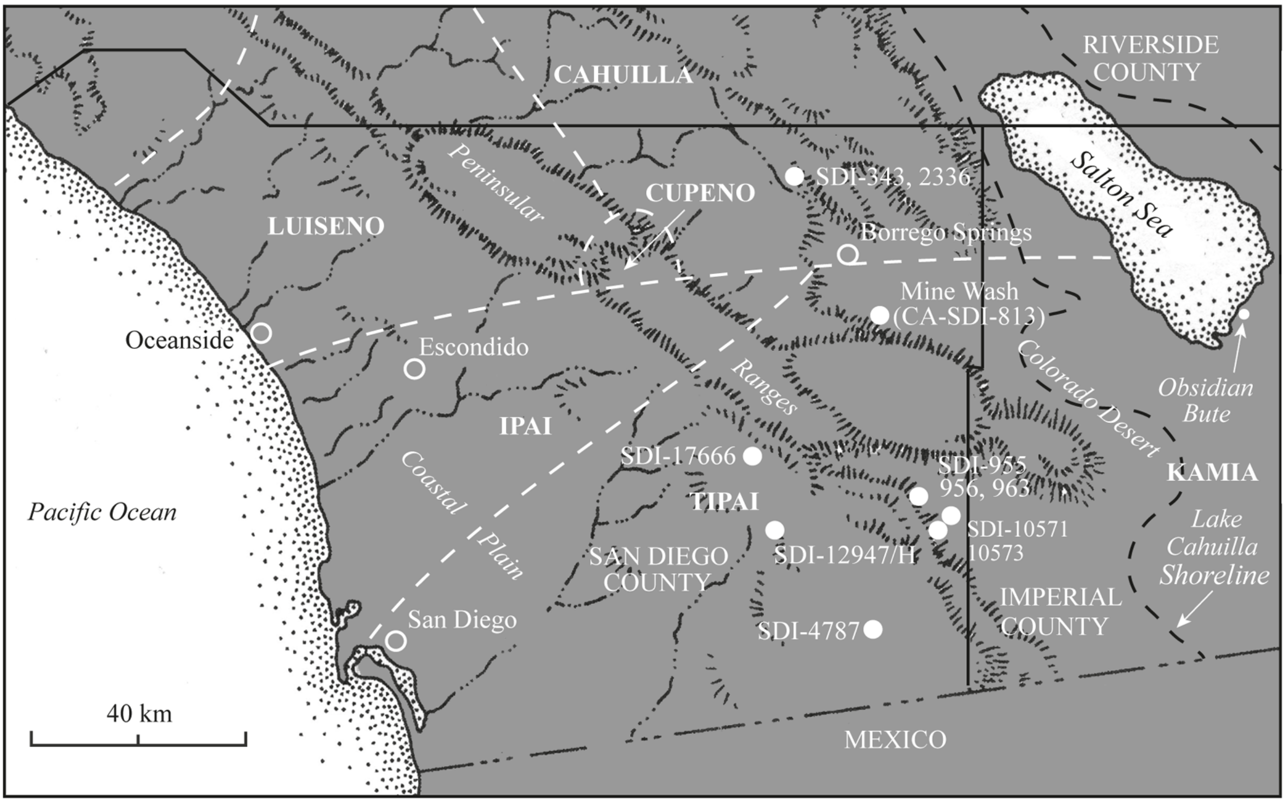

Figure 1. Map showing the location of the Late Prehistoric habitation site of Mine Wash (CA-SDI-813) in San Diego County, southern California, with ethnohistoric territories of ethnolinguistic groups, landscape zones, administrative boundaries and selected modern towns indicated. Sites yielding comparative thin sections are CA-SDI-343, 2336, 955, 956, 963, 10571, 10573, Quinn and Burton (2009); CA-SDI-4787, 12947/H, 17666, Quinn et al. (2013). The former shoreline of ancient Lake Cahuilla is indicated by a dashed line; the Salton Sea filled a portion of the dry lake basin in the early 20th century AD as a result of overflow from the Colorado River.

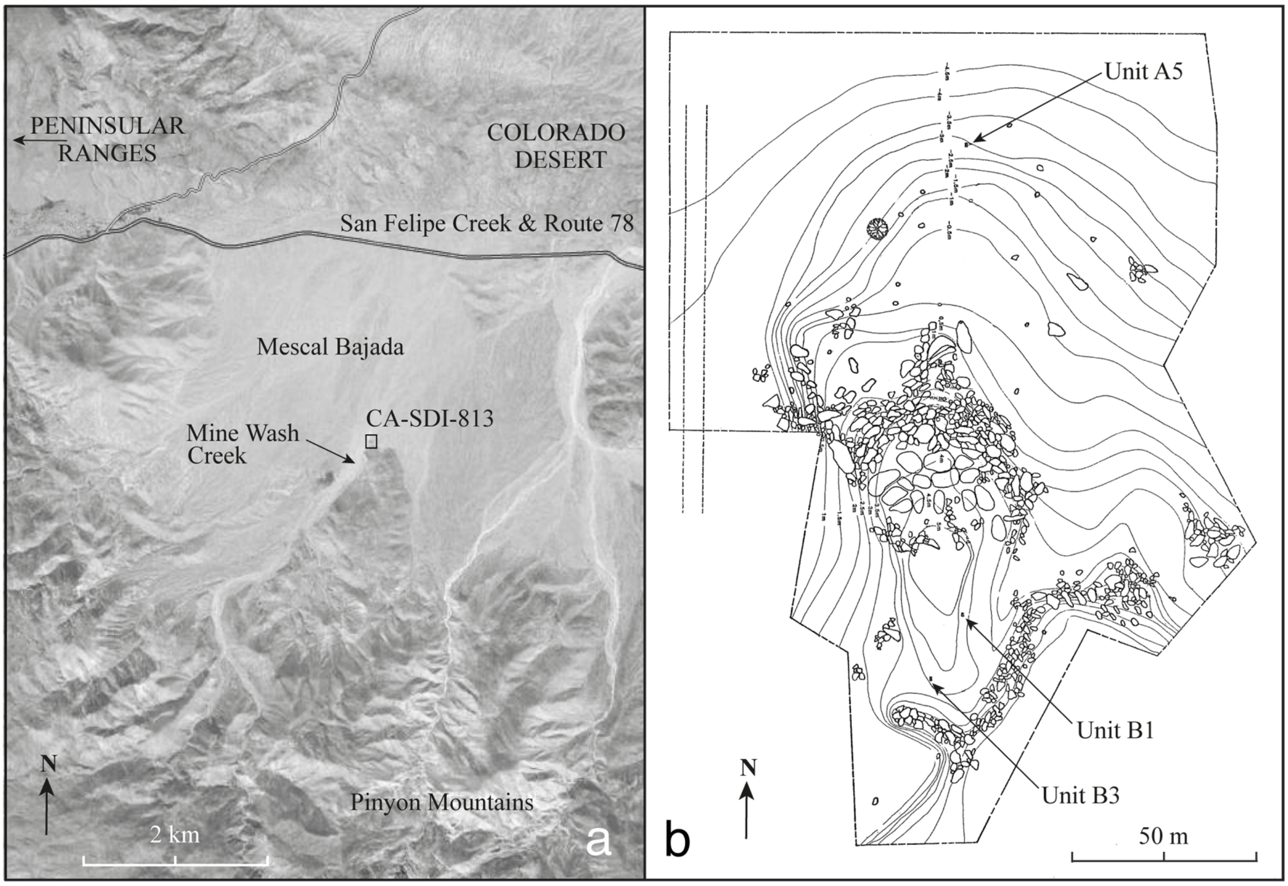

Figure 2. Map (a) and detailed plan (b) of the site of Mine Wash (CA-SDI-813) with the location of Units B1, B3 and A5 from which the analysed ceramics in this study were excavated. Small square in (a) indicates area represented in (b).

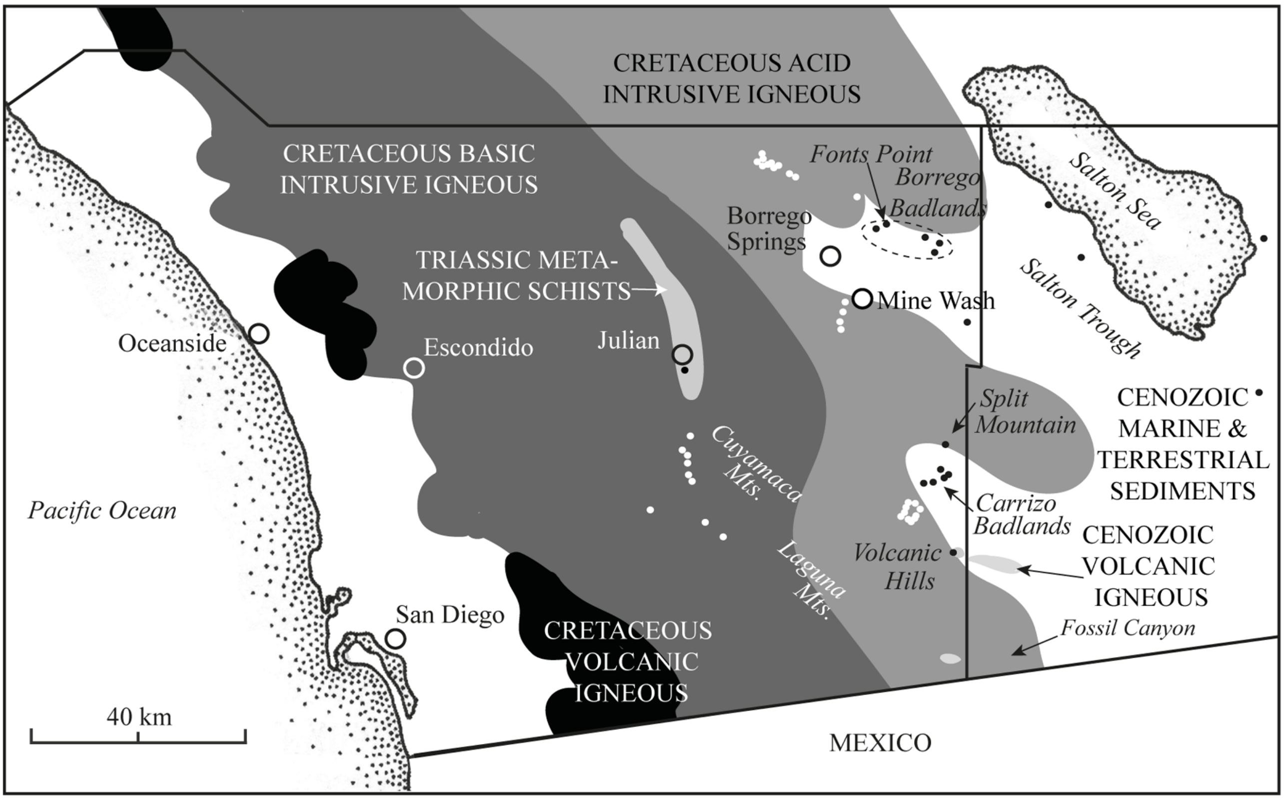

Figure 3. Generalised geological map of eastern San Diego and Imperial Counties showing sampling locations (n = 52; small dots) of geological field samples (n = 78) that have been compared to the Late Prehistoric ceramics of Mine Wash (CA-SDI-813) in this study. A full list of the field samples is presented in Appendix B.

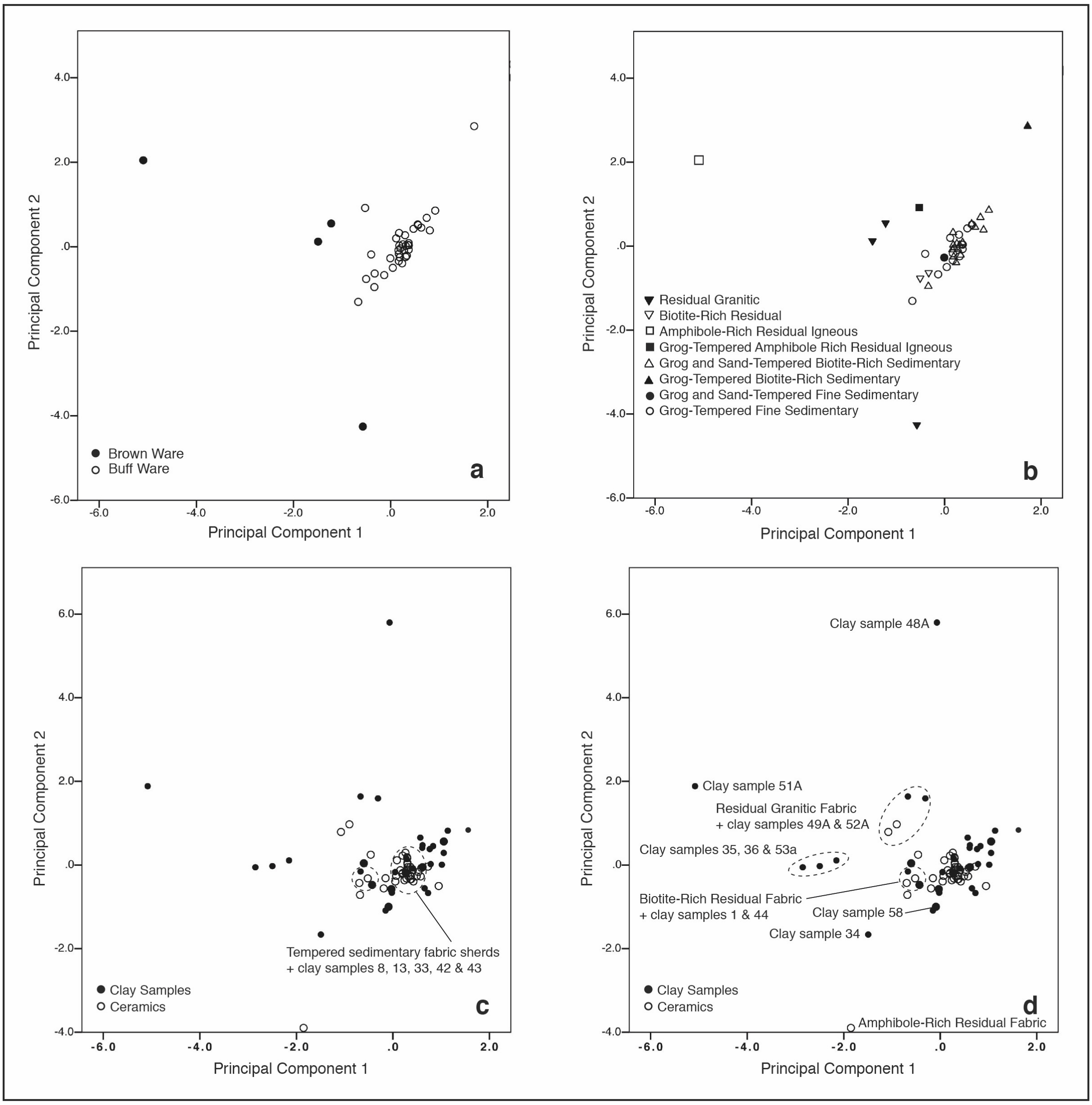

Figure 4. Principal components analysis (PCA) of geochemical data collected via INAA on the 40 Late Prehistoric sherds from the site of Mine Wash (CA-SDI-813) analysed in this study. (a) Scatterplot of the scores for principal components 1 and 2 with the macroscopic classification of the sherds indicated. (b) Scatterplot with the petrographic assignment of the sherds indicated. (c and d) Scatterplots of PCA conducted on the Mine Wash sherds and 33 clay-rich raw material samples collected in southern California, with specific archaeological and geological samples indicated (see text).

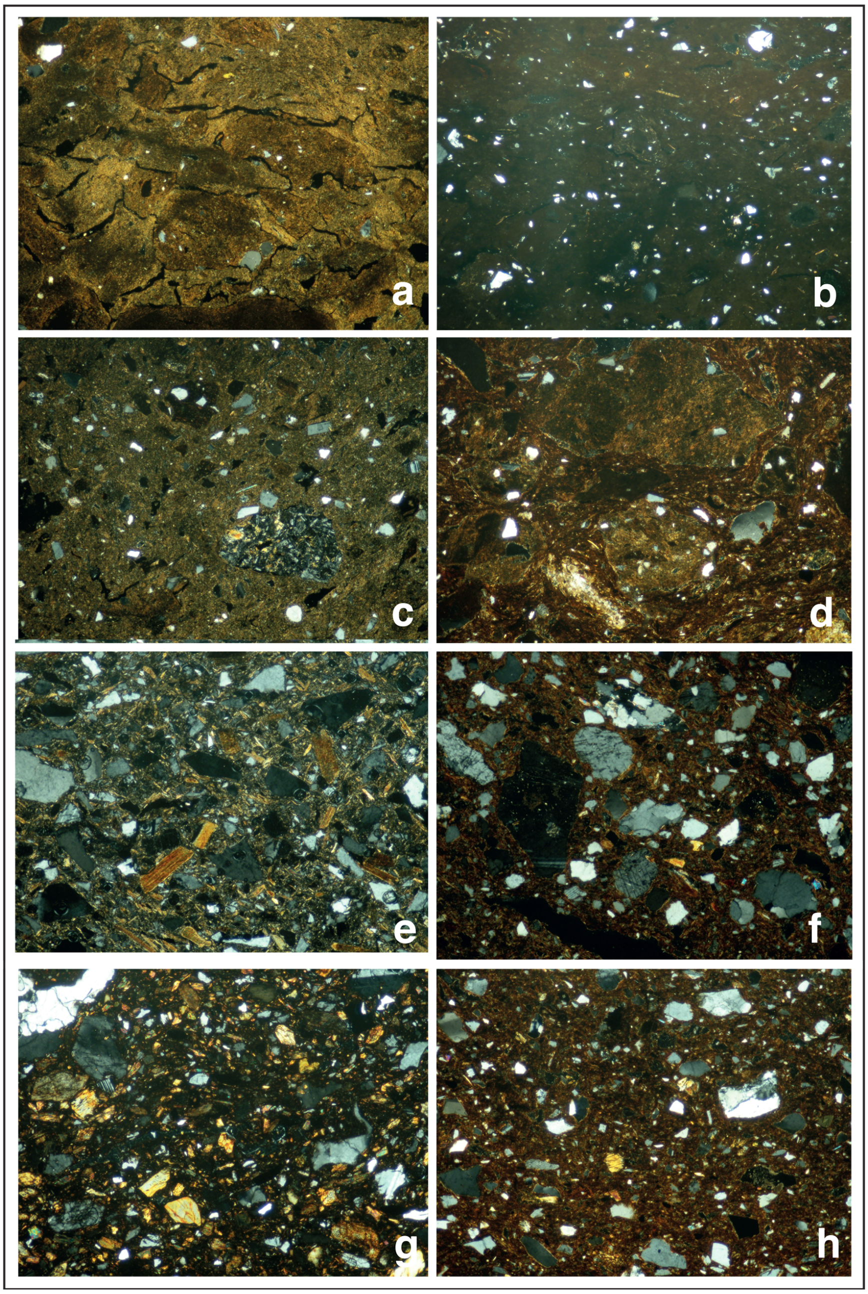

Figure 5. Photomicrographs of petrographic fabrics detected within the 40 Late Prehistoric ceramic thin sections from the site of Mine Wash (CA-SDI-813) analysed in this study: (a) Grog Tempered Fine Sedimentary Fabric, (b) Grog and Sand Tempered Biotite-Rich Sedimentary Fabric, (c) Grog and Sand Tempered Fine Sedimentary Fabric (d), Grog Tempered Biotite-Rich Sedimentary Fabric, (e) Biotite-Rich Residual Fabric, (f) Residual Granitic Fabric, (g) Amphibole-Rich Residual Igneous Fabric, (h) Grog Tempered Amphibole-Rich Residual Igneous Fabric. All images taken in crossed polars. Image width = 3.8 mm.

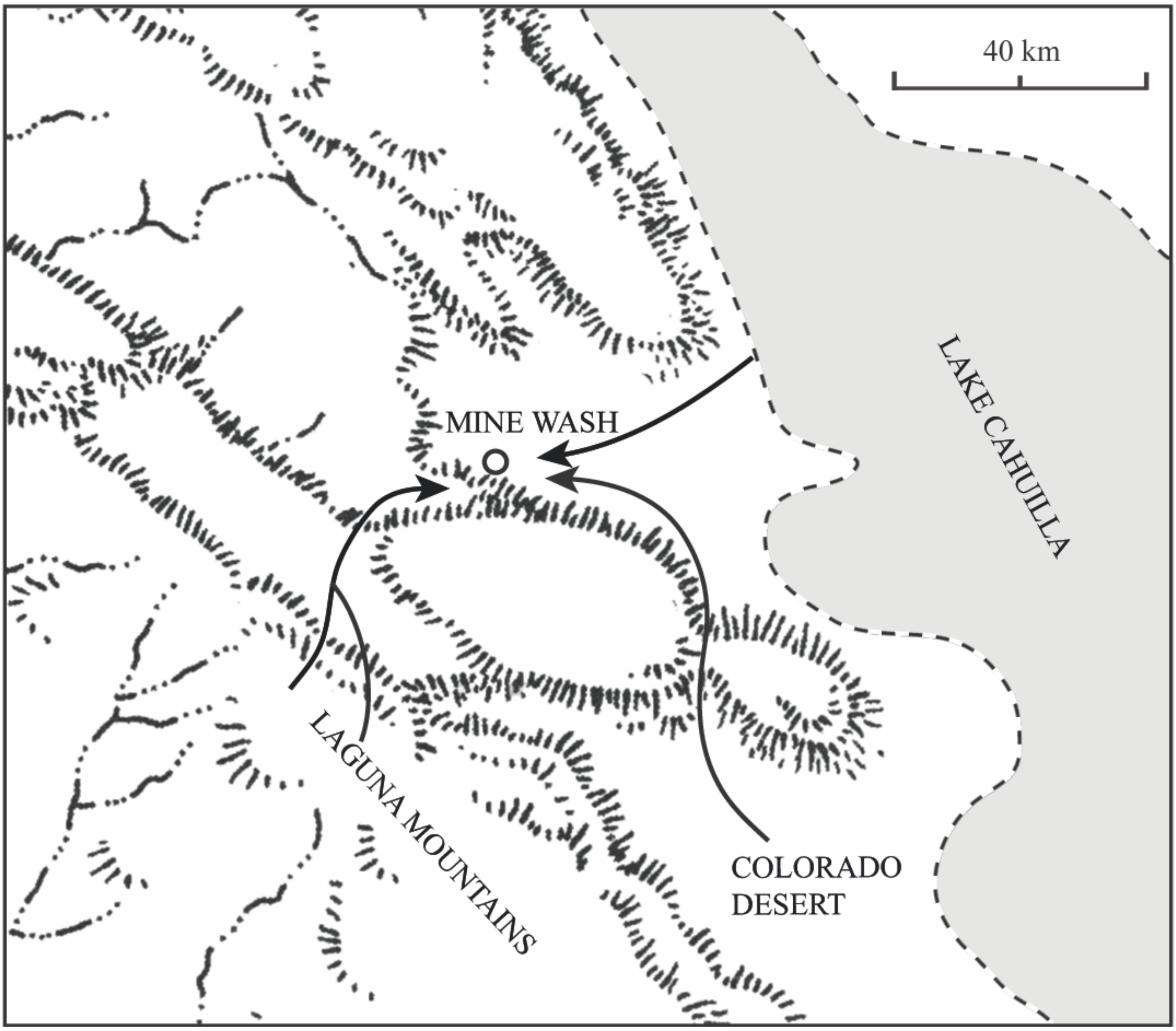

Figure 6. Interpreted movement of archaeological ceramics from multiple directions to Mine Wash in Late Prehistoric times.

Unit	Level	Sherd count	Macroscopic classification		Analysed sherds
			Buff Ware	Brown Ware	
B1	0–10 cm	6	6	–	2
	10–20 cm	7	7	–	3
	20–30 cm	3	2	–	1
	30–40 cm	9	9	–	2
	40–50 cm	2	2	–	–
	50–60 cm	1	1	–	1
	60–70 cm	1	1	–	–
	70–80 cm	2	2	–	1
	80–90 cm	–	–	–	–
	90–100 cm	1	1	–	1
	100–110 cm	–	–	–	–
	110–120 cm	2	2	–	–
	120–130 cm (*)	–	–	–	–
	130–140 cm	–	–	–	–
	140–150 cm	–	–	–	–
	150–160 cm	–	–	–	–
B3	0–10 cm	15	14	1	4
	10–20 cm	7	6	1	3
	20–30 cm	14	14	1	1
	30–40 cm	4	4	–	4
	40–50 cm (*)	9	9	–	3
	50–60 cm	8	7	1	2
	60–70 cm	3	3	–	1
	70–80 cm	2	2	–	1
	80–90 cm	1	1	–	–
	90–100 cm	1	1	–	1
A5	0–10 cm	–	–	–	–
	10–20 cm	8	3	5	3
	20–30 cm	3	2	1	2
	30–40 cm	3	2	1	3
	40–50 cm	2	–	2	1
	50–60 cm	1	–	1	–
		115	102	13	40

* = Radiocarbon date.

Table 1. Distribution of 115 Late Prehistoric ceramic sherds within Units B1, B3 and A5 at Mine Wash (CA-SDI-813) with macroscopic ware classification and 40 samples selected for detailed compositional analysis.

Sample	Unit	Level	Ware group	Fabric
MWC001	B1	0–10 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC002	B1	0–10 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC007	B1	10–20 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC011	B1	10–20 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC013	B1	10–20 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC014	B1	20–30 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC017	B1	30–40 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC020	B1	30–40 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC028	B1	50–60 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC030	B1	70–80 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC032	B1	90–100 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC035	B3	surface-10 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC036	B3	surface-10 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC037	B3	surface-10 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC039	B3	surface-10 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC052	B3	10–20 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC053	B3	10–20 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC057	B3	10–20 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC069	B3	20–30 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC071	B3	30–40 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC072	B3	30–40 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC073	B3	30–40 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC074	B3	30–40 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC077	B3	40–50 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC079	B3	40–50 cm	Buff Ware	Grog and Sand-Tempered Fine Sedimentary
MWC083	B3	40–50 cm	Buff Ware	Grog-Tempered Biotite-Rich Sedimentary
MWC087	B3	50–60 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC088	B3	50–60 cm	Buff Ware	Grog and Sand-Tempered Biotite-Rich Sedimentary
MWC093	B3	60–70 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC095	B3	70–80 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC098	B3	90–100 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC099	A5	10–20 cm	Buff Ware	Grog-Tempered Amphibole-Rich Residual Igneous
MWC102	A5	10–20 cm	Brown Ware	Amphibole-Rich Residual Igneous
MWC105	A5	10–20 cm	Brown Ware	Residual Granitic
MWC107	A5	20–30 cm	Buff Ware	Biotite-Rich Residual
MWC108	A5	20–30 cm	Buff Ware	Biotite-Rich Residual
MWC110	A5	30–40 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC111	A5	30–40 cm	Buff Ware	Grog-Tempered Fine Sedimentary
MWC112	A5	30–40 cm	Brown Ware	Residual Granitic
MWC113	A5	40–50 cm	Brown Ware	Residual Granitic

Table 2. Details of 40 Late Prehistoric ceramic sherds from Mine Wash selected for detailed petrographic and geochemical analysis with macroscopic ware group assignment and petrographic fabric classification indicated.

On-line Supplementary Material

Appendix A. Descriptions of petrographic fabrics detected within 40 Late Prehistoric ceramic sherds from Mine Wash (CA-SDI-813) in this study. Also included are all samples assigned to each fabric from additional sites within the datasets of Quinn and Burton (2009) and Quinn et al. (2013), and a reassessment of the thin sections of Hildebrand et al. (2002) and Gallucci (2001, 2004) from site CA-SDI-4787 (Quinn et al., 2013). Description format follows Quinn (2013, Appendix A.3, pp. 242-244), an adaptation of Whitbread (1995, Appendix 3).

Grog Tempered Fine Sedimentary Fabric (Fig. 5A)

Samples:

CA-SDI-813 - MWC002, 011, 020, 030, 032. 039, 053, 073, 077, 093, 095, 098, 110, 111
CA-SDI-343 - ABD30
CA-SDI-955 - ABD036
CA-SDI-956 - ABD042
CA-SDI-4787 - Hildebrand et al. (2002) SIC073, 076.

General description:

This distinctive fabric is characterised by the presence of abundant grog temper in a very fine non-calcareous clay matrix.

Raw materials and paste preparation:

The extremely fine well-sorted base clay is likely to have originated from a marine or lacustrine sedimentary deposit. A range of poorly-sorted, angular to sub-rounded argillaceous inclusions occur in all samples. These include distinctive angular fine-grained grog inclusions of several different colours and compositions (e.g. ABD042, MWC077) and less obvious, more rounded clay rich inclusions that blend into the clay matrix (e.g. ABD036, MWC039, 111). The latter may be semi-plastic clay inclusions deriving from the base clay used to manufacture the samples, or could represent grog deriving from very fine ceramics. Sand-sized sub-rounded quartz and less commonly feldspar and mica inclusions occur in small amounts in most samples (e.g. ABD042, MWC011, 032). These may have found their way into the matrix by the break up of grog containing similar inclusions or could represent the intentional addition of small amounts of sand temper. Some rock fragments composed of quartz, feldspar and mica occur in sample MWC032. These might represent temper, though one piece is clearly associated with a piece of grog. The fine base clay may have been crushed and rehydrated resulting in the aforementioned clay inclusions. It has a mottled, iron-stained appearance in some samples (e.g. MWC020, 039, 095) that is likely to be an original feature of the clay used to manufacture these samples rather than a post-depositional alteration. Sample MWC020 has a particularly heterogeneous clay matrix. Grog temper of several types was added to the samples. The grog can vary in colour and composition between and within samples (e.g. MWC002), though some samples contain grog of a single type (e.g. MWC030). Characteristic elongate voids are present in many samples (e.g. ABD036, MWC039); these may have formed during the drying of the fine paste. Several grog inclusions contain second generation grog (e.g. ABD042).

Relic vessel surfaces are also present in some cases (e.g. MWC077, 095), confirming the presence of grog.

Forming and firing technology:

No evidence of forming methods is present in the thin sections. Most samples of this fabric have a moderately to highly optically active clay matrix suggesting a firing temperature of <850°C. Sample ABD036 may have been fired at a higher temperature in a more reducing atmosphere. Sample ABD036 contains some post-depositional secondary calcite along the margins of voids.

Variation:

Variation exists in this fabric group in terms of the abundance of sand inclusions. A few samples containing significant sand-sized quartz, feldspar and rock fragments, particularly sample MWC032, 093 and 111 are likely to have been tempered. In this respect, they could be classified as a separate fabric. However, small amounts of similar inclusions occur in many other Grog Tempered Fine Sedimentary Fabric samples. The samples in this fabric also exhibit variation in terms of the colour and composition of the grog temper. Non-grog argillaceous inclusions that are interpreted as lumps of poorly hydrated clay or clay temper do not occur in all samples. These can be difficult to distinguish from the grog. Samples MWC110 and 111 stand out by virtue of their finer grog, sand and argillaceous inclusions. These samples are related to SIC073.

Relationship to other fabrics:

The Grog Tempered Fine Sedimentary Fabric is related to the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric, but differs in that it has a much finer base clay and does not contain fine biotite inclusions. While the Grog Tempered Fine Sedimentary Fabric can contain sand-sized quartz and feldspar inclusions, these are not as abundant as in the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric. The Grog Tempered Fine Sedimentary Fabric is distinguished from the Sand and Grog Tempered Fine Sedimentary Fabric in that the latter contains more sand inclusions, some of which are composed of volcanic rock.

Distribution:

The Grog Tempered Fine Sedimentary Fabric has been found at sites CA-SDI-343, CA-SDI-813, CA-SDI-955 and CA-SDI-956 on the western margin of the Colorado Desert. It accounts for 32.5% of the ceramics analysed from CA-SDI-813, but occurs as single samples at sites CA-SDI-343, CA-SDI-955 and CA-SDI-956. Its absence at CA-SDI-963, CA-SDI-10573, CA-SDI-10571 and CA-SDI-2336 might be due to the small numbers of samples analysed from these sites.

Two samples belonging to the Grog Tempered Fine Sedimentary Fabric occur in the 25 thin sections analysed by Hildebrand et al. (2002) from site CA-SDI-4787 in the Laguna Mountains. Its absence from the additional 125 samples analysed from CA-SDI-4787 by Gallucci (2001, 2004), suggests that it is rare at this mountain site. No examples of the fabric were encountered among the datasets from the nearby sites of CA-SDI-17666 or CA-SDI-12947/H.

Source:

Geological samples 16 (talus from weathering of Cenozoic Mudhills Member outcrop south of Split Mountain), 41 (mudstone from Borrego Formation in Palo Verde Wash) and 46 (Quaternary Cahuilla Lake clay in Campbell Wash), 61 (Quaternary Cahuilla Lake clay, Salvation Mountain) and 62 (Quaternary Cahuilla Lake clay, Calipatria) bear similarities to the Grog Tempered Fine Sedimentary Fabric on account of being very fine, almost devoid of mineral clasts and in the case of samples 16 and 46, having argillaceous features. The argillaceous features are likely to be a result of the preparation of the clay briquette. Samples 61 and 62 are slightly calcareous, which may rule these out as a source of the ceramics. The fine nature of these samples and the clay matrix of the ceramics do not permit comparison on mineralogical grounds, and the resemblance of the geological samples to the ceramics may therefore be superficial. Nevertheless, it is likely that the Grog Tempered Fine Sedimentary Fabric was produced from a non-calcareous sedimentary clay, perhaps of lacustrine origin that is part of the Cenozoic-Quaternary sedimentary succession of the Salton Basin. With this in mind ceramics of the Grog Tempered Fine Sedimentary Fabric are not likely to have been made locally to the sites at which they have currently been found. They have therefore been transported westwards, in the case of the samples at site CA-SDI-4787, over a significant distance. The high abundance of this fabric at site CA-SDI-813 is noteworthy. Appropriate raw materials do not occur around this site, so the sherds of this fabric are likely to be non-local.

Grog and Sand Tempered Biotite-Rich Sedimentary Fabric (Fig. 5B)

<u>Samples:</u>

CA-SDI-813 - MWC001, 007, 013, 014, 017, 028, 035, 036, 037, 052, 057, 069, 071, 072, 074, 087, 088
CA-SDI-343 - Quinn and Burton (2009) ABD012, 031
CA-SDI-956 - Quinn and Burton (2009) ABD039, 045, 054
CA-SDI-10573 - Quinn and Burton (2009) ABD064
CA-SDI-12947/H - Quinn et al. (2013) PVC059

<u>General description</u>:

This fabric is characterised by grog and sand temper in a generally dark coloured non-calcareous clay with abundant fine biotite inclusions.

<u>Raw materials and paste preparation</u>:

The samples in this fabric appear have been made from the use of a non-calcareous sedimentary clay source that contains a significant proportion of elongate biotite mica. These inclusions stand out against the dark clay matrix of the majority of the samples. The biotite-rich sedimentary clay also contained some fine quartz inclusions, though these can be difficult to distinguish from sand temper in some samples. This base clay was mixed with crushed pottery and varying amounts of sand temper. Grog from more than one type of pottery has been added to some samples (e.g. MWC001, 037, ABD064), this includes grog from the same biotite-rich sedimentary fabric (e.g. MWC071, 088) that can be difficult to see in XP, as well as grog from what appears to be a residual fabric (MWC001). Red coloured grog containing quartz, plagioclase, biotite and amphibole occurs in ABD012 and ABD039. The sand temper has a generally rounded shape and is composed of quartz, polycrystalline quartz, plagioclase feldspar, alkali feldspar, amphibole (ABD012, 039 and 045) and in the case of MWC028 and 035, occasional quartz, feldspar and biotite rock fragments that may have derived from an acid-intermediate igneous rock. Some of the larger inclusions of biotite may have also been part of the sand temper that is suspected to have been added to the samples. There is significant variation in terms of the amount of sand added to the samples (see below). Some samples contain calcareous inclusions, such as shell (MWC052, 087) and micritic limestone (MWC013, 014, 017, 036, ABD054). These may have been part of the sedimentary clay source, or could have been accidentally incorporated. In the case of sample MWC014, the calcareous inclusions may have been intentionally added. Samples MWC017 and ABD064 both contain distinctive voids that may have been left from the destruction of plant matter. Though most samples of this fabric have a characteristic dark brown base clay, several samples (MWC013, 017, 035) with a lighter coloured clay matrix are also included. These also contain fine biotite mica, grog and sand temper, but appear to have been subjected to different conditions during firing.

Forming and firing technology:

Little evidence exists in thin section for the techniques used to form the samples of this fabric. Possible relic coils exist in the thin sections of samples ABD012, PVC059, MWC087 and 088. Sample MWC028 has distinctive sub-parallel alignment of biotite mica relative to the vessel walls that is likely to have been caused by forming.

The majority of the sherds included in this fabric have a dark brown clay matrix that is suggestive of firing in a neutral to reducing atmosphere. However, a few samples have a lighter coloured matrix or firing horizons from the presence of greater oxygen during firing. These latter samples have an optically active clay matrix that is suggestive of firing to temperatures <850°C. The reduced samples are optically inactive or have a glassy appearance (e.g. MWC071, 074), which may indicate that they were fired to a higher temperature. Several of these samples contain evidence for the degradation of primary calcite inclusions (e.g. MWC014, 036, 072), whereas optically active sample MWC013 has a well-preserved calcite inclusion. Amphibole, where present, is either green (ABD039, 054) or brown (MWC014, PVC059) suggesting a firing temperature of below or above 750°C respectively.

Secondary calcite is present in several samples including ABD039, MWC001, 035, 036, and 037. In addition, small amounts occur on the edges of several other samples from site CA-SDI-813.

Variation:

This fabric currently contains significant variation in terms of the abundance of the sand temper, with samples MWC028, 037, 072, 087 and PVC059 containing more sand and samples MWC036, 071 and 074 containing less sand. The size of the sand varies with samples MWC072 and 087 characterised by fine, well-sorted sand and samples MWC028 and 037 containing coarser, less well-sorted sand. Some variation exists in terms of the abundance of grog, for example MWC028 contains less grog than most other samples. The abundance of fine biotite varies with samples MWC028 and ABD031, for example, containing more and sample MWC076 containing less. Some samples contain calcareous inclusions (e.g. MWC014, 017, 036, 052 and 087, ABD054) whereas others do not. Samples PVC059 and particularly ABD012, 039 and 045 contain amphibole inclusions in the sand temper, as does MWC028, though in lesser abundance. Sample ABD039 contains several metamorphic inclusions, one of which contains sillimanite. Several samples have a lighter clay matrix that is likely to be due to more oxidising firing conditions (e.g. MWC013, 017, 035).

Relationship to other fabrics:

The Grog and Sand Tempered Biotite-Rich Sedimentary Fabric bears some similarities to the Grog Tempered Fine Sedimentary Fabric, especially in the case of the lighter coloured oxidised examples. However, the Grog Tempered Fine Sedimentary Fabric has a finer clay matrix which does not contain significant fine biotite. Sample ABD012 bears similarities to samples 8R and IR-21 of Gallucci (2004) from CA-SDI-4787.

Distribution:

This fabric occurs abundantly at site CA-SDI-813 on the western edge of the Colorado Desert in central Anza-Borrego Desert, where it accounts for 42.5% of the ceramics analysed. Petrographically similar, related ceramics also occur in small numbers among the material analysed from sites CA-SDI-343, CA-SDI-956 and CA-SDI-10573, also on the western edge of the Colorado Desert by the foot of the Peninsular Ranges. Single samples have been found at mountain site CA-SDI-12947/H to the west.

Source:

Biotite-rich sedimentary materials have been sampled by the authors at various locations in the Anza-Borrego Desert State Park. These include the Pleistocene lakebed clay of Inspiration Wash Member, near Fonts Point (geological sample 33) and the alluvial Hueso Member of the Pliocene Palm Spring Formation in the Carrizo Badlands (geological samples 9, 10, 11, 12). Both sources contain fine clay with abundant biotite and fine quartz. The briquettes of geological samples 11 and 33 contain textural features arising from clay preparation that emphasize their resemblance to the ceramics of the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric. Based on these matches it is likely that the ceramics were produced from an alluvial or lacustrine sedimentary clay source located somewhere in the Colorado Desert.

The quartz and feldspar temper added to many of the ceramics may have come from recent sandy alluvial surface deposits that cover large areas of the Colorado Desert. The presence of igneous rock fragments in some samples indicates that this material may have come from the weathering and erosion of the igneous rocks that form the Peninsular Ranges. Such material would have been readily available in many places within the Colorado Desert. The roundness of the clasts may support an alluvial origin. The presence of amphibole in samples ABD012, 039 and 045 and metamorphic inclusions in sample ABD039 may indicate that the sand used to temper these samples may have come from a different area than that in the samples from site CA-SDI-813. It is worth noting that fine sand grains occur in the biotite-rich, sedimentary raw material samples 11 and 33.

The interpreted sedimentary clay source for the ceramics of the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric do not occur near any of the sites at which this fabric has been detected. For this reason, the ceramics are unlikely to have been made locally to the sites at which they occur in the current dataset. It is suspected that they were manufactured somewhere to the east in the Colorado Desert and brought to the sites. In the case of the sites located on the western margin of the Colorado Desert, this distance may not have been very great. However, the sherds of this fabric that occur at site CA-SDI-12947/H were transported a significant distance up from the desert floor into the mountains.

Given the variability in this fabric, it is possible that it was produced from similar raw materials in different locations. This may be true of samples PVC059, ABD012, 031, 039, 045, 054 and 064, which are not identical to one another or to the other sherds classified within this fabric group. However, the large number of samples of this fabric that occur at CA-SDI-813 show some strong matches with one another and form a continuum. With this in mind, they are likely to have come from a single location.

Grog and Sand Tempered Fine Sedimentary Fabric (Fig. 5C)

Samples:

CA-SDI-813 - MWC079

General description:

This fabric is characterised by grog and sand temper in a fine non-calcareous clay matrix. Inclusions of volcanic rock are present in the sand-sized temper inclusions.

Raw materials and paste preparation:

This fabric appears to have been made from the addition of sand and grog temper to a fine non-calcareous base clay. The majority of the grog inclusions have a dark brown to black colour and sparse fine quartz inclusions. In addition to the grog, the sample contains several inconspicuous textural features that may be poorly-hydrated lumps of base clay. The mineral and rock inclusions are poorly sorted and dominated by sub-angular to rounded fine sand-sized quartz and feldspar. Other fine inclusions include biotite, muscovite, chert and calcite. Some larger, more angular quartz and polycrystalline quartz inclusions occur as well as rare rock fragments. One rock fragment composed of polycrystalline quartz and muscovite contains fine needles of sillimanite. Two conspicuous volcanic rock fragments occur, one composed of plagioclase, biotite. opaque iron and possible amphibole, which may be classified as andesite. The other is composed of plagioclase and clinopyroxene and could therefore have come from basalt. It is suspected that much of the sand-sized rock and mineral inclusions in this fabric may have been added as temper. However, finer inclusions of quartz seem to have been present in the base clay.

Forming and firing technology:

No evidence for the methods used to form this sample are visible in thin section. The sample was fired <850°C in an oxidising atmosphere. The sample is completely oxidised on one edge. Iron-rich material has been deposited in some voids and secondary calcite encrustation is present on the surface of the sherd.

Relationship to other fabrics:

The Grog and Sand Tempered Fine Sedimentary Fabric bears similarities to both the Grog Tempered Fine Sedimentary Fabric and the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric. It has a fine non-calcareous clay matrix and grog as in the former, but contains more sand-sized inclusions of probable temper. The presence of significant grog and sand temper is reminiscent of the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric, however the Grog and Sand Tempered Fine Sedimentary Fabric may contain less fine biotite. A notable distinguishing feature of the single sample of the Sand and Grog Tempered Fine Sedimentary Fabric is the presence of sand-sized volcanic rock inclusions, which do not occur in these related fabrics.

Distribution:

This fabric has only been detected at site CA-SDI-813 in the current dataset.

Source:

The base clay used to manufacture this fabric is likely to have derived from lacustrine or alluvial sedimentary deposits within the Cenozoic succession of the Salton Basin in the Colorado Desert. Given the similarity of this fabric to the Grog Tempered Fine Sedimentary Fabric and the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric, the potential raw material matches for these two fabrics may suggest possible sources for the base clay used. As with these related sedimentary fabrics, the fine nature of the clay matrix makes petrographic comparison difficult.

The sand temper that is suspected to have been added to the single sample of this fabric could have come from the ubiquitous loose sandy surface deposits of alluvium and wind blown material that covers much of the Colorado Desert. This is characterised by quartz, feldspar and other minerals derived from the erosion of the Peninsular Range batholith and is likely to be broadly similar over large areas. However, the occurrence of metamorphic and in particular volcanic igneous material within the sand temper might be suggestive of a more specific origin.

Volcanic rocks are not widespread in the Peninsular Ranges and Colorado Desert. They occur in several restricted areas. These include Miocene Anderson Canyon Volcanics of the Volcanic Hills, Carrizo Mountain and the Fish Creek Mountains. These are situated in the southern part of the study area on the eastern edge of the Peninsular Ranges close to the Colorado Desert. Bedrock of basic andesite composition and surface sand with volcanic clasts has been collected at and around outcrops of the Alverson Volcanics at Volcanic Hills (samples 70–75). These bear some similarities in thin section to the rare volcanic inclusions seen in the archaeological ceramic sample. Andesitic volcanic rocks also occur in the nearby Jacumba Mountains, close to the USA/Mexico border. These belong to the Jacumba Volcanics and are characterised by andesite and basalt.

Other small volcanic outcrops west of the Salton Sea include the Quaternary rhyolite, pumice and obsidian of Obsidian Butte and the Pliocene rhyolite of Rainbow Rocks on the eastern side of the Santa Rosa Mountains. East of the Salton Sea, Tertiary volcanics occur in various places in the Chocolate Mountains. These are composed of andesites, pyroclastic rocks and some basalt.

Sillimanite has been detected in two residual metamorphic fabrics occurring at CA-SDI-343 in Collins Valley and CA-SDI-17666 and CA-SDI-12947/H in the Laguna Mountains. Based on the presence of sillimanite-bearing metamorphic rocks and sediments in Collins Valley, these ceramics were suspected to have come from this area. Given the co-occurrence of sillimanite with volcanic clasts, it is likely that other sillimanite bearing rocks occur in the study area. The location of these cannot be determined without fieldwork. However, metamorphic rocks occur across large areas of the Jacumba Mountains.

The absence of volcanic rocks at Mine Wash and volcanic clasts within the sediment samples collected from close to the site, suggests that sample MWC079 has a non-local origin. Based on the distribution of volcanic material, it may have come from further south in the Colorado Desert, or perhaps from the other side of Lake Cahuilla, close to the Chocolate Mountains. This needs to be confirmed by geological fieldwork and sampling of these rocks and sandy desert alluvium nearby.

Grog Tempered Biotite-Rich Sedimentary Fabric (Fig. 5D)

Samples:

CA-SDI-813 - MWC083

General description:

This fabric is characterised by grog temper in a generally dark coloured non-calcareous clay with abundant fine biotite inclusions.

Raw materials and paste preparation:

The single sherd in this fabric appears have been made from the use of a non-calcareous sedimentary clay source containing a significant proportion of elongate biotite mica. This also contained fine quartz inclusions and rare muscovite mica and feldspar. This base clay was mixed with crushed pottery with a fabric that resembles the Grog Tempered Fine Sedimentary Fabric. Some of this contains second-generation grog. Some sand-sized quartz, feldspar and calcite inclusions occur in the sample. It is not clear whether these were added as temper or were naturally occurring in the base clay. The sample has a distinctive texture that sets it apart from the other tempered sedimentary fabrics. This may be attributed to the composition of the clay matrix and the presence of fine biotite mica.

Forming and firing technology:

Little evidence exists in thin section for the techniques used to form this sample. The sherd was fired in an oxidising atmosphere and it has an optically active clay matrix that is suggestive of firing to a temperature of <850°C.

Relationship to other fabrics:

The single sherd of the Grog Tempered Biotite-Rich Sedimentary Fabric is related to the Grog and Sand Tempered Biotite-Rich Sedimentary Fabric in that it contains abundant fine biotite inclusions and grog temper. The distinctive texture of the sample sets it apart from this larger fabric group. It is also related to the Grog Tempered Fine Sedimentary Fabric in that it contains grog temper that may have originated from pottery of this composition.

Distribution:

The Grog Tempered Biotite-Rich Sedimentary Fabric has only been reported from CA-SDI-813 in the present dataset.

Source:

Biotite-rich sedimentary materials have been sampled by the authors at various locations in the Anza-Borrego Desert State Park. These include the Pleistocene lakebed clay of Inspiration Wash Member, near Fonts Point (geological sample 33) and the alluvial Hueso Member of the Pliocene Palm Spring Formation in the Carrizo Badlands (geological samples 9, 10, 11, 12). Both sources contain fine clay with abundant biotite and fine quartz. Based on these matches it is likely that the ceramics were produced from an alluvial or lacustrine sedimentary clay source located somewhere in the Colorado Desert.

Biotite-Rich Residual Fabric (Fig. 5E)

Samples:

CA-SDI-813 - MWC107, 108
CA-SDI-343 - Quinn and Burton (2009) ABD022
CA-SDI-17666 - Quinn et al. (2013) SSS011, 029, 053
CA-SDI-12947/H - Quinn et al. (2013) PVC029, 050, 053, 063, 064, 066
CA-SDI-4787 - Hildebrand et al. (2002) SIC038, 064, 070, Gallucci (2001) 057, 069, 078, 089, 106, 129, 147, 157, 159, 173, 200, 218, 239, 245, 257, 310, 333, 364, 366, 379, 387, 404, 419, 435, 490, 504, 512, 540, 627, 703, 727, 762, 789, 837, 872, 956.

General description:

This medium-grained fabric is characterised by poorly sorted sub-angular mineral and rock inclusions of weathered igneous or metamorphic origin, including abundant biotite mica (40–60 %), within a non-calcareous clay matrix.

Raw materials and paste preparation:

Individual mineral inclusions of quartz, plagioclase feldspar, untwinned alkali feldspar and biotite, as well as agglomerations of these minerals are suggestive of clay produced by the breakdown of a medium grained acid or intermediate igneous rock rich in biotite. However, small quantities of metamorphic inclusions, including possible amphibolite (ABD022) and possible mica-schist (PVC029) and polycrystalline quartz (SSS011, PVC050, 063) occur in some samples. This may suggest that the parent clay derived from the weathering of biotite-rich metamorphic rock such as biotite mica schist. Samples MWC107 and 108 have a more silty alluvial appearance with a greater proportion of inclusions. Amphibole occurs in some samples as very rare small inclusions (e.g. SSS011) or larger, often weathered inclusions (e.g. PVC029). The residual clay source appears to have been used in a more or less unmodified state.

Forming and firing technology:

Relic coils occur in several samples of the Biotite-Rich Residual Fabric (e.g. ABD022, PVC029). Most samples were fired <850°C and perhaps <750°C. Some ceramics were fired in an oxidising atmosphere (e.g. SSS053, PVC050, 053), however many were incompletely oxidised and have a thick, dark reduced core (e.g. ABD022, PVC064, 066) indicative of a short firing duration.

Relationship to other fabrics:

Ceramics of this fabric bear similarities to some more biotite-rich samples of the Residual Granitic Fabric (ABD018, 021, 069), but contain much more biotite (>40%). Amphibole occurs in some samples (SSS011, PVC029), but is very rare (1-2%) compared to the Amphibole-Rich Residual Igneous Fabric. Samples MWC107 and 108 have a more silty alluvial appearance with a greater proportion of inclusions that is reminiscent of the coarser samples of the Well-Packed Alluvial Fabric (Quinn and Burton, 2009). However, the latter contain less biotite and have a finer texture.

Distribution:

The Biotite-Rich Residual Fabric occurs at sites CA-SDI-17666, CA-SDI-12947/H and particularly CA-SDI-4787 in the Laguna and Cuyamaca Mountains, where it constitutes up to 35% of the analysed ceramics. Small numbers of sherds of this fabric have been encountered in the assemblages from sites CA-SDI-343 and CA-SDI-813 on the western edge of the Colorado Desert.

Source:

The raw materials used to produce the ceramics of the Biotite-Rich Residual Fabric may have derived from the in-situ weathering of either a biotite mica-rich igneous or metamorphic rock. It is difficult to distinguish between these two possible source rocks because of the absence of sizeable polyminerallic rock fragments in the thin sections of this fabric group. No matches for this fabric were found among the database of geological field samples analyzed in this study, although biotite is abundant in many sedimentary clay sources in the Colorado Desert. It is possible that granitic igneous rock containing quartz, plagioclase feldspar, and abundant biotite occurs in the Peninsular Ranges, but this has not yet been sampled by the authors. The abundant elongate biotite combined with the low proportion of plagioclase and the presence of polycrystalline quartz might suggest that the clay used for this petrographic fabric derived from a biotite-mica schist. Schist and other types of metamorphic rock occur near the town of Julian to the north of CA-SDI-12947/H and the CA-SDI-17666, where they weather to form clay (Hildebrand et al., 2002).

While it is difficult at this point to speculate about the distribution of the Biotite-Rich Residual Fabric, it is likely to have been made from a clay source in the Peninsular Ranges. The occurrence of this fabric at Pine Valley Creek (CA-SDI-12947/H) and the Stacked Stone Site (CA-SDI-17666), as well as its high abundance at CA-SDI-4787, might suggest that it is a local phenomenon of the Laguna and Cuyamaca Mountains. The rare samples of this fabric encountered at sites CA-SDI-343 and CA-SDI-813 on the western margin of the Colorado Desert are therefore likely to have been transported eastwards down from the mountains to the desert.

Residual Granitic Fabric (Fig. 5F)

Samples:

CA-SDI-813 - MWC105, 112, 113
CA-SDI-343 - Quinn and Burton (2009) ABD011, 014, 016, 017, 018, 021, 023, 025, 028
CA-SDI-2336 - Quinn and Burton (2009) ABD002, 003,006, 008
CA-SDI-10571 - Quinn and Burton (2009) ABD050, 051, 052, 053, 058
CA-SDI-10573 - Quinn and Burton (2009) ABD062, 066, 069
CA-SDI-955 - Quinn and Burton (2009) ABD037
CA-SDI-956 - Quinn and Burton (2009) ABD040, 043, 044
CA-SDI-963 - Quinn and Burton (2009) ABD048
CA-SDI-17666 - Quinn et al. (2013) SSS004, 006, 031, 032, 036, 037, 039, 040, 041, 044, 043
CA-SDI-1247/H - Quinn et al. (2013) PVC005, 007, 010, 012, 017, 020, 021, 022, 024, 025, 027, 031, 044, 046, 048, 058, 062, 068, 070, 071, 072, 075
CA-SDI-4787 - Hildebrand et al. (2002) SIC066, 072, 074, Gallucci (2004) 51-1, 63R-7, Gallucci (2001) 031, 282, 311, 442, 464, 528, 566, 641, 666, 678, 842, 858, 969, 980.

General description:

This common coarse-medium grained fabric is characterised by the presence of poorly-sorted angular mineral and rock inclusions deriving from a granitic acid to intermediate igneous rock, in a non-calcareous clay matrix.

Raw materials and paste preparation:

The principal mineral inclusions include quartz, plagioclase feldspar, orthoclase feldspar, biotite and amphibole. Smaller amounts of microcline (e.g. ABD053), muscovite (e.g. PVC012), tourmaline (e.g. ABD008), zircon and igneous mineral intergrowths such as perthite (e.g. ABD03), myrmekite (e.g. ABD053) and micrographic texture (e.g. ABD018) occur in some samples. Agglomerations of minerals are present (e.g. ABD069). These represent fragments of the original parent rock. Based on these intact rock inclusions and the relative proportion of different isolated mineral species, the samples appear to have been produced from clay deriving from the weathering of a medium-grained igneous rock of acid to intermediate composition, dominated by quartz, with plagioclase as the most common feldspar (e.g. ABD014) and containing biotite, amphibole and less commonly muscovite as the accessory minerals. This inferred composition is indicative of microgranodiorite. Polycrystalline quartz occurs in generally small amounts in some samples (e.g. ABD017, PVC007, MWC112), suggesting that the source rock may have been slightly recrystallised. The good preservation of feldspar (with the exception of PVC072) and the poorly sorted, angular nature of the inclusions in most samples suggest that this fabric was made from a residual clay source. However, some samples have a more sedimentary character (e.g. ABD037, 052) and can contain rare inclusions not derived from a granitic source (e.g. micritic limestone in ABD025 and MWC105). This may suggest that the material may have been transported/redistributed somewhat from its source; though the samples of this fabric are distinct from the more obviously sedimentary materials used for the Well-Packed Alluvial Fabric and Grog Tempered Alluvial Fabric (Quinn and Burton, 2009), which are better sorted, more inclusion-rich and do not contain rock fragments. The rock fragments and isolated mineral inclusions in the Residual Granitic Fabric represent different stages in the breakdown of the parent rock. The samples in this fabric may have been made from weathered clay in its unprocessed state, save perhaps for the removal of very large rock inclusions. Burnt organic matter occurs in some samples (e.g. ABD043, 066). However, this is not well distributed in individual samples and may therefore represent the natural occurrence of organic matter such as plant roots, rather than deliberate temper. Some samples contain rare inclusions of sedimentary origin (e.g. calcite in ABD025 and MWC105) that may have been accidentally introduced during clay preparation.

Forming and firing technology:

Some samples exhibit relic coils (e.g. ABD017) or coil joins (e.g. ABD044) indicating that coiling was the main forming method used to produce the ceramics. Variation exists in the temperature and atmosphere of firing, but on the whole the ceramics were fired at or below 850°C in an oxidising atmosphere. Several samples were fired >850°C in a reducing atmosphere (e.g. ABD023). Differences in the degree of firing and firing atmosphere may reflect variation within the firing process rather than intentional control, with reduced (e.g. ABD051) fired and incompletely oxidised (e.g. ABD058) samples starved of oxygen during firing.

Variation:

Significant variation occurs within the fabric in terms of texture and the abundance of the main mineral constituents, including amphibole, biotite, plagioclase, muscovite and polycrystalline quartz. Despite this, all samples are unified by their granitic igneous origin and the use of relatively coarse, poorly-sorted clay. Further meaningful subdivision is currently difficult. Some of the variation in the fabric is indicated below:

ABD006, 058 – Medium grained
ABD053, MWC105 – Coarse grained
ABD002, 016 – More rounded inclusions, transported
ABD016, 037, 052 – Better sorted, transported
ABD008 – Contains tourmaline
ABD014 – Higher proportion of plagioclase,
ABD018, 021, 69 - Higher proportion of biotite
ABD011, 069, PVC071 - Higher proportion of amphibole
ABD044, 048, PVC012, MWC113 - Higher proportion of muscovite
ABD053, 066, MWC105 – Lower proportion of biotite and amphibole
ABD050 - Higher proportion of iron
PVC007, ABD 017, MWC112 - Higher proportion of polycrystalline quartz
ABD014, 028, 053 – No amphibole
PVC024 – Lower proportion of plagioclase
PVC072 – Weathered feldspar and quartz
MWC105 - Contains rare micritic inclusions

Relationship to other fabrics:

This common fabric is related to the Amphibole-Rich Residual Igneous Fabric and the Biotite-Rich Residual Fabric, but is distinguished by the lower proportion of amphibole (<10 %) and biotite (<20 %). However, end members of these three fabrics can be difficult to distinguish. The relationship between the Residual Granitic Fabric and the Well-Packed Alluvial Fabric and Grog Tempered Alluvial Fabric is commented on above. Some Residual Metamorphic Fabric (Quinn and Burton, 2009) samples are closely related to Residual Granitic Fabric, but are distinguished by the presence of distinctive metamorphic inclusions.

Distribution:

Ceramics belonging to the Residual Granitic Fabric occur among the assemblages of all 11 analysed sites. Compositional matches for the Residual Granitic Fabric were found in the ceramics analysed by Hildebrand et al. (2002) (SIC 066, 072, 074, 075), Gallucci (2004) (51-1, 63R-7) and Gallucci (2001) (031, 282, 311, 442, 464, 528, 566, 641, 678, 858, 980) from CA-SDI-4787. The Residual Granitic Fabric is abundant at all sites from which a sizeable number of samples have been analysed, except for site CA-SDI-813. It accounts for 28% of the ceramics analysed from CA-SDI-12947/H (n = 76) and 40% at CA-SDI-10573 (n = 15). At all sites analysed from the western margin of the Anza-Borrego Desert State Park, with the exception of CA-SDI-813, it represents the most abundant fabric composition. The Residual Granitic Fabric is much less common in the samples analysed from CA-SDI-813 (n = 40), accounting for 7.5% of the assemblage. At sites CA-SDI-4787, 17666 and CA-SDI-12847/H in the Peninsular Ranges, the Residual Granitic Fabric is less common than on the western desert margin. At these sites it is numerically subordinate to the Amphibole-Rich Residual Igneous Fabric. If the Residual Granitic Fabric can be considered to be equivalent to geochemical group SDI-2 of Hildebrand et al. (2002), then the occurrence of SDI-2 at sites on the coastal plain (CA-SDI-4609 and CA-SDI-12557) in the dataset of these authors suggests that it has an even wider distribution within the San Diego area.

Source:

Geological samples 2, 7, 18, 20, 22, 32 and 55 indicate that granitic bedrock of granodiorite and quartz diorite composition occurs on the western desert margin at Collins Valley, Indian Valley, Bow Willow Canyon and Mine Wash. In these arid valleys, the granitic bedrock weathers to a sandy soil that contains similar mineral and rock clasts to the Residual Granitic Fabric, but is not sufficiently clay-rich (e.g. geological samples 3, 19). Clay rich residual clay (geological sample 52A) derived from the weathering of granitic bedrock (geological sample 52B) under more moist conditions has been sampled in the Laguna Mountains. Based upon the nature of the weathering products of these two environmental zones, it is likely that the ceramics of the Residual Granitic Fabric were manufactured from residual or minimally transported clay derived from the weathering of granitic bedrock in the eastern edge of the Peninsular Ranges. Given the wide distribution of ceramics of this fabric, the extent of the granitic rocks of the Peninsular Range batholith and the variation that exists within the fabric, it is likely that related ceramics were produced in various locations within this region. At present it is not possible to provenance ceramics of the Residual Granitic Fabric to specific locales within this broad area. However, one possible local difference that may be significant is the low proportion of amphibole in the Residual Granitic Fabric ceramics deriving from the Bow Willow and Indian Valley sites. This appears to be reflected in the composition of bedrock and weathered sand samples from this area. Due to the lack of clay rich residual granitic clay in the vicinity of desert sites CA-SDI-2336, CA-SDI-343, CA-SDI-813, CA-SDI-955, CA-SDI-956, CA-SDI-963, CA-SDI-10571 and CA-SDI-10573, it is unlikely that the Residual Granitic Fabric ceramics from these sites were made locally. They may have therefore been made at one or more sites at higher elevation to the west and transported eastwards down toward the desert. Weathered granitic clay is likely to have been available where this bedrock occurs in the Laguna Mountains, suggesting that ceramics of the Residual Granitic Fabric found at sites CA-SDI-17666, CA-SDI-12947/H, CA-SDI-4787 could be local in origin. It is also possible that Residual Granitic Fabric samples at these mountain sites could have been made elsewhere and transported (Quinn et al. 2013). This possibility cannot presently be investigated due to the wide distribution of granitic rock and the lack of obvious differences between ceramics of this fabric from different sites.

Amphibole-Rich Residual Igneous Fabric (Fig. 5G)

Samples:

CA-SDI-813 - MWC102
CA-SDI-17666 - Quinn et al. (2013) SSS001, 002, 003, 005, 008, 009, 010, 012, 013, 014, 016, 017, 018, 019, 020, 021, 022, 023, 024, 025, 027, 028, 030, 033, 034, 035, 038, 042, 043, 045, 046, 047, 048, 049, 050, 051, 052,
CA-SDI-12947/H - Quinn et al. (2013) PVC001, 002, 003, 004, 006, 008, 009, 011, 013, 014, 015, 016, 018, 019, 023, 028, 026, 030, 032, 033, 034, 035, 036, 037, 038, 039, 041, 042, 043, 045, 047, 051, 052, 054, 055, 060, 061, 065, 067, 069, 073, 074
CA-SDI-4787 - Hildebrand et al. (2002) SIC 31, 33, 34, 35, 36, 39, 63, 65, 67, 68, 69, 75. Gallucci (2001) 018, 038, 047, 090, 120, 130, 153, 175, 188, 213, 228, 275, 293, 330, 347, 423, 451, 474, 484, 520, 547, 559, 593, 609, 625, 634, 654, 681, 695, 710, 724, 745, 750, 767, 785, 811, 825, 861, 885, 886, 901, 908, 919, 927, 949, 1003, Gallucci (2004) SRI 2, 10-1, 10-3, 10-6, 38, 50R-9, 56R-6, 63R-5, 63R-14, IR-3, IR-11, IR-19.

General description:

This large heterogeneous coarse-fine grained fabric is characterised by the presence of generally poorly-sorted, sub-angular to sub-rounded inclusions of quartz, plagioclase and amphibole, that appear to have been derived from the weathering of a medium-grained intermediate igneous rock.

Raw materials and paste preparation:

The principal mineral inclusions in the Amphibole-Rich Residual Igneous Fabric include quartz, plagioclase feldspar and amphibole, plus less common biotite and rock fragments composed of crystals of quartz, plagioclase, amphibole and iron. Smaller amounts of perthite (sample SSS047), zoisite (sample SSS051), orthopyroxene (e.g. samples SSS001, 014) and muscovite (sample PVC033). Based upon the these mineral inclusions, as well as the composition of rock fragments that occur in the coarser samples (e.g. sample PVC028, 065) the raw materials used to produce these ceramics appears to have come from a medium-coarse grained igneous rock rich in plagioclase and amphibole with a varying proportion of quartz and with some pyroxene. This composition is indicative of a diorite or perhaps a quartz diorite. The angularity of the inclusions and their poor degree of sorting suggests that this clay source was residual in origin, or not significantly transported. The presence of abundant iron in many samples (e.g. samples SSS005, 013, PVC036, 051) and soil-like textural features (e.g. samples SSS001, 045) that give the fabric an impure appearance seem to confirm that the clay was formed in-situ. However, finer-grained, better-sorted samples of a similar mineralogical composition, that appear to have been transported, are also included in this fabric (e.g. SSS010, PVC011). This and other variation is outlined below.

Forming and firing technology:

Relic coils occur in several samples (e.g. samples SSS022, 027, PVC047, 055) and internal voids that might be associated with coiling occur in some others (e.g. samples SSS001, 010, 021). The ceramics were fired at a range of temperatures <750°C (e.g. samples SSS046, PVC033) and >850°C (e.g. samples PVC030, 047) in an oxidising (e.g. samples SSS012, PVC036) or reducing atmosphere (e.g. samples SSS003, PVC032). Firing atmosphere appears to have varied within individual sherds and several samples were incompletely oxidised (e.g. SSS042, 049).

Variation:

Significant compositional and textural variation is currently included in the Amphibole-Rich Residual Igneous Fabric and it is likely that it can be subdivided into several smaller groups. However, this has not yet been attempted due to the gradational nature of the variation that the ceramics contain. Nevertheless, the samples classified in this fabric are in most cases clearly distinguishable from other related fabrics (see below) on the basis of their high proportion (>30%) of the mineral amphibole. Notable variation includes:

SSS002, PVC003 - Higher proportion of quartz
SSS003, 013, 021, PVC036, 051 - High proportion of iron
SSS010, 025, 052, PVC011, 073 - Finer-grained
SSS012, 046, PVC026, 038 – Higher proportion of biotite
SSS014, 017, 033, PVC019 - Contains possible clinopyroxene
SSS023, PVC001, MWC102 – Extremely rich in amphibole
PVC033 – Contains muscovite
SSS030, PVC065 – Coarser-grained with rock fragments

Relationship to other fabric classes:

This fabric can be distinguished from the other coarse residual fabrics in this study on the basis of its high proportion (c. 30-60 %) of amphibole inclusions. However, the more quartz-rich end members of this fabric blend into the more amphibole-rich examples of the Residual Granitic Fabric. The same can be said for a few Amphibole-Rich Residual Igneous Fabric samples that contain a higher proportion of biotite (up to 20 %) and are thus related to the Biotite-Rich Residual Fabric. The gradation between the Amphibole-Rich Residual Igneous Fabric and other residual igneous fabrics is likely to be related to the mineralogical variation within the igneous rocks of the Peninsular Ranges. The Grog-Tempered Amphibole-Rich Residual Igneous Fabric is a grog-tempered version of this fabric.

Distribution:

The Amphibole-Rich Residual Igneous Fabric accounts for a large proportion of the ceramics analysed from sites CA-SDI-17666 (71%) and CA-SDI-12947/H (54%) in the Laguna Mountains. This fabric is also the dominant composition at site CA-SDI-4787 in the Peninsular Ranges, as determined by the re-examination of thin sections analysed by Hildebrand et al. (2002) (40%), Gallucci (2001) (49%) and Gallucci (2004) (48%). The Amphibole-Rich Residual Igneous Fabric is not present in the ceramic assemblages of seven of the eight sites analysed from the western margin of the Colorado Desert/Anza Borrego Desert State Park. It occurs in only small numbers (2.5%) in the ceramics analysed from CA-SDI-813 (n=40).

Source:

Residual clay sources containing quartz, feldspar, iron and abundant amphibole that are a good match for the type of clay used to manufacture the ceramics of the Amphibole-Rich Residual Igneous Fabric occur among the geological samples analysed from various locations in the Laguna Mountains (geological samples 35, 36, 48a, 49a, 51a, 53a). Accompanying bedrock samples collected from these locations confirm the source to be an amphibole-rich plutonic igneous rock containing abundant plagioclase and some quartz (i.e., diorite), though most samples were collected from locations mapped as gabbro. Similar rocks are mapped in the vicinity of site CA-SDI-4787. The dominance of the Amphibole-Rich Residual Igneous Fabric at sites CA-SDI-17666, CA-SDI-12947/H and CA-SDI-4787 in the southeastern Peninsular Ranges, its less frequent occurrence at sites analysed in other areas and the ample occurrence of residual igneous, amphibole-rich clay, may suggest that ceramics of this fabric were produced in this area. Hildebrand et al. (2002) distinguished geochemically a group (SDI-1) of ceramics that were restricted to CA-SDI-4787 among their dataset of 100 sherds from six sites within San Diego and Imperial County. Point count data collected by these authors as well as subsequent observations of the thin sections of samples from chemical group SDI-1 confirm that they are equivalent to the Amphibole-Rich Residual Igneous Fabric. Variation in the composition and texture of the samples in this fabric and corresponding variation in the geological samples collected suggests that ceramics of the Amphibole-Rich Residual Igneous Fabric were probably produced from several similar clay sources and perhaps in different locations. Sub-division of the variation in the fabric and the collection and analysis of further raw material samples might shed light on the specific production locales within this region.

Grog Tempered Amphibole-Rich Residual Igneous Fabric (Fig. 5H)

Samples:

CA-SDI-813 - MWC099
CA-SDI-12947/H - Quinn et al. (2013) PVC030, 041, 056, 057

This medium-coarse grained fabric is characterised by the presence of generally poorly-sorted, sub-angular to sub-rounded mineral and rock inclusions derived from the weathering of an amphibole-rich intermediate igneous rock, plus grog temper, in a non-calcareous clay matrix.

Raw materials and paste preparation:

The presence of inclusions of quartz, plagioclase feldspar and amphibole, plus granular rock fragments of these three minerals, suggests that the raw materials used to produce the ceramics of the Grog Tempered Amphibole-Rich Residual Igneous Fabric derived from an intermediate igneous rock such as a diorite. The generally poorly-sorted, sub-angular to sub-rounded nature of the inclusions and the presence of iron are indicative of an in-situ residual clay source. However, sample MWC099 is finer-grained, better-sorted and may therefore have been made from clay of a similar composition that was transported. This sample also contains some micritic limestone inclusions that could have been introduced into the clay by sedimentary processes. Grog temper has been added to the paste of the ceramics. The grog originates from ceramics with a non-calcareous fabric containing quartz, feldspar and biotite.

Forming and firing technology:

Relic coils exist in PVC057, and PVC041 contains a possible coil join picked out by a void. Most samples appear to have been fired to a temperature of between 750 and 850°C. in a moderately oxidising atmosphere.

Variation:

Sample MWC099 differs from the other samples in this fabric in that it is finer-grained, contains less amphibole and contains some micritic limestone inclusions. It may have been made from a more transported clay source. Despite these differences, this sample is currently retained in the Grog Tempered Amphibole-Rich Residual Igneous Fabric.

Relationship to other fabrics:

The Grog Tempered Amphibole-Rich Residual Igneous Fabric is identical to the Amphibole-Rich Residual Igneous Fabric, but differs due to the presence of grog temper. The grog appears to have come from ceramics with a composition similar to the Residual Granitic Fabric. Grog-tempered ceramics made from a residual granitic clay source characterise the Grog Tempered Residual Granitic Fabric. However, these ceramics have a lower percentage of amphibole (<10 %) than those of the Grog Tempered Amphibole-Rich Residual Igneous Fabric in which this mineral can constitute c. 40% of the inclusions.

Distribution:

Three sherds of the Grog Tempered Amphibole-Rich Residual Igneous Fabric occur in the material analysed from site CA-SDI-12947/H in the Laguna Mountains. However, it is absent in the datasets from the nearby sites of CA-SDI-17666 and CA-SDI-4787. One sample of this fabric occurs in the assemblage from site CA-SDI-813 on the western margin of the Colorado Desert.

Source:

Geologically-speaking this fabric is likely to have an origin similar to the Amphibole-Rich Residual Igneous Fabric to which it is related. This is interpreted as being produced in the Peninsular Ranges and perhaps more specifically in the Laguna and Cuyamaca Mountains area. The occurrence of several sherds of the Grog Tempered Amphibole-Rich Residual Igneous Fabric at site CA-SDI-12947/H and its absence at CA-SDI-17666 and CA-SDI-4787, which contain abundant non-grog tempered samples of the Amphibole-Rich Residual Igneous Fabric, might suggest that ceramics of this composition were manufactured at or near this site. Suitable raw materials for the production of the Grog Tempered Amphibole-Rich Residual Igneous Fabric do not occur at site CA-SDI-813 and the single sample of this fabric is therefore likely to be an import from the nearby Peninsular Ranges and perhaps site CA-SDI-12947/H.

Appendix B. Database of geological field samples of clay, sand and rock collected in San Diego and Imperial Counties for comparison with Late Prehistoric ceramic sherds from Mine Wash.

- see Excel file attached.

Appendix C. Concentration of 35 elements within 40 Late Prehistoric ceramic sherds from Mine Wash as recorded by INAA in this study. Context, macroscopic ware group assignment and petrographic fabric classification given for comparison.

- see Excel file attached.

Appendix B. Database of 78 geological field samples of clay, sand and rock collected in San Diego and Imperial Counties for comparison with Late Prehistoric ceramic sherds from Mine Wash.

Appendix C. Concentration (ppm) of 33 elements within 40 Late Prehistoric ceramic sherds from Mine Wash as recorded by INAA in this study. Context, macroscopic ware group assignment and petrographic fabric classification are provided for comparison.