Online Supplemental Materials: Description of Petrographic Fabric Groups

The seven petrographic fabric groups detected within the 128 sherds from CA-SDI-12947/H (Pine Valley Creek or PVC) and CA-SDI-17666 (Stacked Stone Site or SSS) are described in detail below. Reference is made to specific samples from the two sites, as well as previously studied material of Gallucci (2001) from CA-SDI-4787 (Wikalokal or WIK) and that of Quinn and Burton (2009) from sites in the Anza-Borrego Desert State Park (ABD).

Residual Granitic Fabric (Figure 4a and b; Figure 6a and b)

This common coarse- to medium-grained fabric is characterized by the presence of poorly sorted angular mineral and rock inclusions deriving from granitic acid to intermediate igneous rock, within a non-calcareous clay matrix. The principal mineral inclusions include quartz, plagioclase feldspar, orthoclase feldspar, biotite, and amphibole. Smaller amounts of microcline (ABD053), muscovite (PVC012), tourmaline (ABD008), zircon, and igneous mineral intergrowths such as perthite (ABD03), myrmekite (ABD053), and micrographic texture (ABD018) occur in some samples. Agglomerations of minerals are present (ABD069). These represent fragments of the original parent rock.

Based on the intact rock inclusions and the relative proportion of different isolated mineral species, the samples appear to have been produced from clay

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deriving from the weathering of medium-grained igneous rock of acid to intermediate composition dominated by quartz, with plagioclase as the most common feldspar (ABD014), and containing biotite, amphibole, and less commonly muscovite as the accessory minerals. This inferred composition is indicative of micro-granodiorite. Polycrystalline quartz occurs in small amounts in some samples (ABD017, PVC007), suggesting that the source rock may have been slightly recrystallized. The good preservation of feldspar (with the exception of PVC072) and the poorly sorted angular nature of the inclusions in most samples (ABD004) suggest that this fabric was made from a residual clay source. However, some samples have a more sedimentary character (ABD037, 052) and the material may therefore have been transported from its source. The rock fragments and isolated mineral inclusions represent different stages in the breakdown of the parent rock.

The samples in this fabric were made from weathered clay without modification, except perhaps for the removal of very large rock inclusions. Burnt organic matter occurs in some samples (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) that may have been accidentally introduced during clay preparation. Some samples exhibit relic coils (ABD017, 047) or coil joins (ABD044),

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indicating that coiling was the primary 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 800–850°C in an oxidizing atmosphere. Several samples were fired > 800–850°C in a reducing atmosphere (ABD023). Differences in the degree of firing and firing atmosphere may reflect variation within the firing process rather than intentional control, with reduced (ABD051) and incompletely oxidized (ABD058) samples starved of oxygen during firing.

Significant variation occurs within the fabric in terms of its 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, 068: Coarse-grained

ABD002, 016: More rounded inclusions, possibly transported

ABD016, 037, 052: Better sorted, possibly transported

ABD008: Contains tourmaline

ABD014: Higher proportion of plagioclase

ABD018, 021, 69: Higher proportion of biotite

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ABD011, 069, PVC071: Higher proportion of amphibole

ABD044, 048, PVC012: Higher proportion of muscovite

ABD053, 066: Low biotite and amphibole

ABD050: Higher proportion of iron

PVC007, ABD 017: Higher proportion of polycrystalline quartz

ABD014, 028, 053: No amphibole

PVC024: Lower proportion of plagioclase

PVC072: Weathered feldspar and quartz

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 percent) and biotite (< 20 percent). However, end members of these three fabrics can be hard to distinguish. Some Residual Metamorphic Fabric samples are closely related to the Residual Granitic Fabric, but are distinguished by the presence of distinctive metamorphic inclusions.

Ceramics of the Residual Granitic Fabric are a good match for the dominant quartz and plagioclase-rich residual ceramic fabric in the dataset of Quinn and Burton (2009). This was suspected to have an origin in the eastern Peninsular Ranges where granitic rocks such as granodiorite, quartz diorite, and tonalite weather to form coarse residual clay. Rock and clay of this type occur in the comparative geological samples collected from Cuyamaca Rancho State Park and

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the Laguna Mountains. It is therefore possible that ceramics of the Residual Granitic Fabric from Pine Valley Creek and the Stacked Stone Site were produced locally at these sites. Compositionally very similar ceramics account for 16 percent of the 100 thin sections analyzed by Gallucci (2001) from the nearby site of Wikalokal. However, coarse quartz and feldspar-rich ceramics derived from residual igneous clay also appear to have been encountered at many other sites in San Diego County and Riverside County, including CA-SDI-10780 (Williams 1989), CA-SDI-308, CA-SDI-682, CA-SDI-860, CA-SDI-2537, CA-SDI-5133, CA-SDI-6014 and CA-RIV-1139 (Griset 1996) and CA-SDI-10156 (Wade 1999). If the Residual Granitic Fabric is considered to be equivalent to geochemical group SDI-2 of Hildebrand et al. (2002), then the occurrence of this group at sites in the mountains (CA-SDI-4787 and CA-SDI-14283) and coastal plain (CA-SDI-4609 and CA-SDI-12557) in the dataset of these authors confirms the broad distribution of the fabric. As with the Amphibole-Rich Residual Igneous Fabric, this may indicate the manufacture of ceramics at several locations from compositionally similar raw materials and/or the distribution of this pottery over a wide area.

Amphibole-Rich Residual Igneous Fabric (Figure 4c and d; Figure 6c)

This large heterogeneous coarse- to fine-grained fabric is characterized 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

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weathering of a medium-grained intermediate igneous rock. The principal mineral inclusions 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 (SSS047), zoosite (SSS051), orthopyroxene (SSS014, PVC019), and muscovite (PVC033) occur in some samples. Based upon these mineral inclusions, as well as the composition of rock fragments that occur in the coarser samples (PVC028, 065), the raw materials used to produce these ceramics appear to have come from medium-coarse-grained igneous rock rich in plagioclase and amphibole with a varying proportion of quartz. This composition is indicative of diorite. The angularity of the inclusions and their poor degree of sorting suggests that the clay source was residual in origin, or minimally transported. The presence of abundant iron in many samples (SSS005, 013, PVC036, 051) and soil-like textural features (SSS001, 045) that give the fabric an impure appearance seem to confirm that the clay source was formed in situ. However, finer-grained, better-sorted samples of a similar mineralogical composition, which appear to have been transported, are also included in this fabric. This and other variation is outlined below.

The samples in this fabric were made from weathered clay without significant modification. Relic coils occur in several samples (SSS022, 027, PVC047, 055) and internal voids that might be associated with coiling occur in some others (SS001, 010, 021). The ceramics were fired at a range of temperatures

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< 750°C (SSS046, PVC033) and > 800–850°C (PVC030, 047) in an oxidizing (SSS012, PVC036) or reducing atmosphere (SSS003, PVC032). The atmospheric conditions appear to have varied within individual sherds, and several samples were incompletely oxidized (SSS042, 049).

Significant compositional and textural variation has been 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. Notable variation includes:

SSS002, PVC003, 0144: 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: Contain orthopyroxene

SSS023, PVC001: Extremely rich in amphibole

SSS044, PVC033: Contain muscovite

SSS030, PVC065: Coarser-grained with rock fragments

This fabric can be distinguished from the other coarse residual fabrics in this study on the basis of its high proportion (ca. 30–60 percent) of amphibole

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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 percent) and are thus are related to the Biotite-Rich Residual Fabric. The gradation between the coarse residual fabrics in this study is perhaps related to the mineralogical variation within the igneous rocks of the Peninsular Ranges. The four grog-tempered amphibole-rich samples (Grog Tempered Amphibole-Rich Residual Igneous Fabric) detected in this study were made from a similar clay source, but with the addition of crushed pottery fragments.

Clay samples containing plagioclase feldspar, quartz, iron, and abundant amphibole that are a good match for the type of material used to manufacture the ceramics of the dominant Amphibole-Rich Residual Igneous Fabric occur among the comparative geological material from Cuyamaca Rancho State Park and the Laguna Mountains area. These include field samples from Pine Valley and Descanso, as well as material collected adjacent to the Stacked Stone Site itself. The analysis of associated bedrock samples from these locations suggests that this relatively coarse “residual” clay derives from the in situ weathering of amphibole-rich, intermediate, plutonic igneous rock such as a diorite. Rock of this type is widespread in the eastern Peninsular Ranges of San Diego County.

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Ceramics manufactured from coarse residual igneous material with substantial amounts of amphibole were recorded by Hildebrand et al. (2002) at the site of Wikalokal (SDI-4787), not far from Pine Valley Creek and the Stacked Stone Site. These sherds constituted a separate geochemical group (SDI-1) in their dataset, which was restricted to SDI-4787. Re-examination of the thin sections of Gallucci (2001), also from Wikalokal, confirms the presence of the Amphibole-Rich Residual Igneous Fabric at this site. Ceramics of this composition account for 49 percent of the 100 sherds sampled by Gallucci (2001).

The dominance of amphibole-rich ceramics at Pine Valley Creek, Wikalokal, and the Stacked Stone Site, as well as the presence nearby of compositionally similar clay sources, strongly suggests that these ceramics could have been produced in the Laguna and Cuyamaca Mountains area. This may be further corroborated by sherds analyzed by Griset (1996) from the site of Cuyamaca Rancho (CA-SDI-860). However, coarse amphibole-rich ceramics have also been encountered by Williams (1989a) at site CA-SDI-10780; Williams (1989b) at CA-SDI-10882; Pymale-Schneeberger (1993) at sites CA-RIV-722, CA-RIV-1864, CA-RIV-2229; Griset (1996) at sites CA-SDI-308, CA-SDI-682, CA-SDI-2537, CA-SDI-5130, SDI-5133 and CA-RIV-2769, Wade (1999) at site CA-SDI-10156 and Guerrero (2004) at sites CA-SDI-5699 and CA-SDI-10158 (Figure 2b). While it is not possible to determine whether this material is an exact

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match for the Amphibole-Rich Residual Igneous Fabric, compositionally related ceramics clearly have a wide distribution in San Diego County.

Biotite-Rich Residual Fabric (Figure 4e and f; Figure 6d and e)

This medium-grained fabric is characterized by poorly sorted sub-angular mineral and rock inclusions of weathered igneous or metamorphic origin, including abundant biotite mica (40–60 percent), within a non-calcareous clay matrix. Individual mineral inclusions of quartz, plagioclase feldspar, untwinned alkali feldspar, and biotite, as well as agglomerations of these minerals, are suggestive of a poorly modified clay produced from the breakdown of a medium-grained acid or intermediate igneous rock rich in biotite. However, small quantities of metamorphic inclusions including possible amphibolite (ABD022), 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.

The residual clay source appears to have been used in a more or less unmodified state. Relic coils occur in several samples (ABD022, PVC029). Most samples were fired at < 800–850°C and perhaps < 750°C. Some were fired in an oxidizing atmosphere (SSS053, PV050, PV053). However, many were incompletely oxidized and have a thick, dark reduced core (ABD022, PVC064, PVC066) indicative of a short firing duration.

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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 percent). Amphibole occurs in some samples (SSS011, PVC029), but is very rare (1–2 percent) compared to the Amphibole-Rich Residual Igneous Fabric.

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 sizable polymineralic 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 at Julian to the north of Pine Valley Creek and the Stacked Stone Site, where they weather to form clay (Hildebrand et al. 2002).

Ceramics that closely match the Biotite-Rich Residual Fabric occur at Wikalokal, where they account for 35 percent of the 100 samples thin-sectioned by

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Gallucci (2001). A single sample of this composition was also recorded by Quinn and Burton (2009) at site CA-SDI-343 in Collins Valley on the eastern margin of the Colorado Desert. Other less definite matches include coarse ceramics analyzed by Griset (1996) at site CA-SDI-682, Wade (1999) at site CA-SDI-10156, and Guerrero (2004) at site CA-SDI-812 (Figure 2b). 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 and the Stacked Stone Site, as well as its high abundance at Wikalokal, might suggest that it is a local phenomenon of the Laguna and Cuyamaca Mountains.

Muscovite-Rich Residual Fabric (Figure 5a and b)

This medium-grained fabric is characterized by the presence of poorly sorted quartz, polycrystalline quartz, feldspar, and abundant muscovite mica inclusions within a non-calcareous clay matrix. The dominant inclusions are sub-angular quartz, polycrystalline quartz, elongate muscovite mica, and iron. Plagioclase feldspar and amphibole inclusions are rare, as are rock fragments composed of quartz and muscovite. The poorly sorted sub-angular nature of the inclusions and the abundance of iron suggest that they were naturally occurring in a non-calcareous clay source, perhaps of residual or minimally transported origin. The parent material from which the clay was derived may have been a muscovite-rich

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granitic igneous rock. However, the abundance of polycrystalline quartz and muscovite mica might be indicative of a mica schist. Possible relic coils are suggestive of methods used to form the two samples. Both samples were fired at or above 800–850°C and incompletely oxidized. The Muscovite-Rich Residual Fabric is distinct from the other fabrics on account of its high proportion of muscovite mica (15–25 percent).

Ceramics of the Muscovite-Rich Residual Fabric from Pine Valley Creek and the Stacked Stone Site do not match any of the comparable geological or archaeological materials analyzed in this study. As with the Biotite-Rich Residual Fabric, it is not clear whether the clay used to manufacture this fabric derived from an igneous or a metamorphic source. Muscovite mica is present in both igneous and metamorphic rock field samples collected from the Peninsular Ranges and the western Colorado Desert, but does not occur in the high proportion that characterizes the Muscovite-Rich Residual Fabric. The presence of this fabric at Pine Valley Creek and the Stacked Stone Site and its absence in the comparative materials analyzed might suggest it was manufactured locally. However, it accounts for only a small proportion (1–2 percent) of the ceramics analyzed at both sites.

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Residual Metamorphic Fabric (Figure 5c and d; Figure 6f)

This medium- to coarse-grained fabric is characterized by the presence of poorly sorted sub-angular to sub-rounded mineral and rock inclusions of metamorphic and perhaps igneous origin in a non-calcareous clay matrix. The poorly sorted sub-angular to sub-rounded inclusions in this fabric are dominated by quartz, polycrystalline quartz, and distinctive schistose metamorphic inclusions with biotite and needle-like sillimanite. Less common inclusions include biotite (ABD001), amphibole (ABD026), plagioclase, and muscovite (ABD019). Opaque ferruginous inclusions are common in most samples. The coarse, poorly sorted, generally angular nature of the inclusions and the abundance of iron suggest that the samples of this fabric were produced from a non-calcareous residual or minimally transported clay source. The parent material from which this clay derived appears to have been low-grade metamorphic rock and perhaps granitic igneous rock.

Several samples in this fabric contain possible relic coils left over from vessel forming. The ceramics were fired between 750–850°C in an oxidizing (ABD019, ABD029) or reducing atmosphere (ABD026). Sample ABD001 was fired at < 750°C in an oxidizing atmosphere and ABD009 was fired at > 850°C in a reducing atmosphere.

Samples ABD009, 019, 026, 029 are closely related to one another. Sample SSS015 contains a higher proportion of polycrystalline quartz than the other

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samples. Sample ABD001 contains more biotite than the others and less sillimanite metamorphic inclusions. Sample ABD001 is closely related to the Residual Granitic Fabric, particularly sample ABD050, but differs due to the presence of rare sillimanite metamorphic inclusions.

Ceramics of this composition have been reported by Quinn and Burton (2009) from site CA-SDI-343 in Collins Valley on the western margin of the Colorado Desert. Substantial clay deposits are absent in this arid valley. However, sillimanite-bearing metamorphic rocks that are a good match for the distinctive inclusions in the Residual Metamorphic Fabric occur nearby. While metamorphic rocks occur in several places in San Diego County, including the Laguna Mountains, sillimanite was not encountered in the other geological field samples analyzed in this study.

Sand Tempered Sedimentary Fabric (Figure 5e)

This fine-medium-grained fabric is characterized by the presence of rounded sand-sized quartz and feldspar sand temper, within a very fine non-calcareous sedimentary clay matrix with textural features. The equant and elongate, sub-rounded to rounded, fine-medium sand-sized inclusions are composed of quartz, polycrystalline quartz, plagioclase, amphibole, untwinned alkali feldspar, and a possible fragment of rhyolite (PVC059). On account of their rounded nature and the almost total absence of silt-sized inclusions in the grain-size distribution, it is

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probable that the larger inclusions represent sand temper. This is likely to have been a loose alluvial sand perhaps containing material derived from the erosion of plutonic igneous rock. The base clay to which this was added is almost devoid of mineral inclusions, especially in sample PVC059. It is non-calcareous, very dense, and characterized by textural features. The textural features have neutral optical density, merging boundaries, and the same composition as the surrounding clay suggesting that they may be due to the incomplete rehydration of a crushed clay source. Thin elongate voids are associated with these textural phenomena. Sample PVC059 also contains iron-rich textural concentrations. The base clay is likely to have come from a sedimentary deposit of marine or lacustrine origin without appreciable clastic input. Sample PVC059 might contain relic coils. Both samples were fired at > 800–850°C in a weakly oxidizing atmosphere. Sample PVC076 contains much less sand temper than sample PVC059. The Sand Tempered Sedimentary Fabric is related technologically to the Sand and Grog Tempered Fabric of Quinn and Burton (2009) and contains rounded sand temper of similar composition. However, this was added to a different base clay.

Fine sedimentary clay of the sort used to manufacture these samples is not common in the Peninsular Ranges, but occurs among the lacustrine and marine sedimentary strata of the Salton Basin. Numerous sedimentary clay samples exist in the comparative geological database analyzed in this study, but no exact matches were found. The very fine nature of the clay means that few mineral inclusions

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exist for accurate petrographic comparison. Ceramics made from tempered sedimentary clay are common at sites in the Colorado Desert and also occur in small numbers in the mountains and coastal area of San Diego County (Hildebrand et al. 2002). Several different tempered sedimentary fabrics were identified in the 70 ceramic thin sections analyzed by Quinn and Burton (2009) from the western desert margin, though none of these are exact petrographic matches for the Sand Tempered Sedimentary Fabric.

Grog-Tempered Amphibole-Rich Igneous Fabric (Figure 5f)

This coarse- to medium-grained fabric is characterized by the presence of generally poorly sorted sub-angular to sub-rounded mineral and rock inclusions derived from the weathering of amphibole-rich intermediate igneous rock, plus grog temper, within a non-calcareous clay matrix. The presence of inclusions of quartz, plagioclase feldspar, and amphibole, plus granular rock fragments of these three minerals, suggests that the raw materials 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.

Crushed pottery fragments were added as temper to the coarse base clay. The crushed ceramics originate from pottery with a non-calcareous fabric containing quartz, feldspar, and biotite, which could be a match for the Residual

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Granitic Fabric. Relic coils exist in PVC057 and PVC041 contains a possible coil join picked out by a void. All samples were fired at or above 800–850°C. PVC057 was oxidized, whereas PVC041 was oxidized on one side and reduced on the other.

The Grog Tempered Amphibole-Rich Igneous Fabric is identical to the Amphibole-Rich Igneous Fabric, but contains grog temper. The grog appears to have come from ceramics with a composition similar to the Residual Granitic Fabric.

Clay samples containing plagioclase feldspar, quartz, iron, and abundant amphibole that are a good match for the type of material used to manufacture the ceramics of the Grog Tempered Amphibole-Rich Residual Igneous Fabric occur among the comparative geological material from Cuyamaca Rancho State Park and the Laguna Mountains area. Coarse amphibole-rich ceramics have been encountered by Williams (1989a) at site CA-SDI-10780; Williams (1989b) at CA-SDI-10882; Pymale-Schneeberger (1993) at sites CA-RIV-722, CA-RIV-1864, CA-RIV-2229; Griset (1996) at sites CA-SDI-308, CA-SDI-682, CA-SDI-2537, CA-SDI-5130, SDI-5133 and CA-RIV-2769; Wade (1999) at site CA-SDI-10156; and Guerrero (2004) at sites CA-SDI-5699 and CA-SDI-10158. However, none of these studies reported the presence of grog temper in ceramics of this composition.

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