Petrographic Analysis of Pottery from CA-RIV-6897, Coachella Valley, California

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PETROGRAPHIC ANALYSIS OF POTTERY FROM CA-RIV-6897, COACHELLA VALLEY, CALIFORNIA

This study examined, through thin section petrography, eight sherds and three clay samples from the Coachella Valley environs. The sherds were excavated by Applied EarthWorks from site CA-RIV-6987. In addition, one modeled clay object was described through binocular microscopy. Thorough petrographic analysis of the thin sections specified the clay, mineralogy, and textural features for each sample. This information was related to the geology of the Coachella Valley and the results of three previous petrographic studies of samples from southern California (Hildebrand 2003; Quinn and Burton 2009; Zhai 1996).

GEOLOGICAL SETTING

The Coachella Valley, located in southern California, is a deep sediment-filled basin running for 45 miles in a northwest-southeast direction. For most of this length, the valley is 15 miles wide. The most obvious feature within the valley is the Salton Sea, the remnants of ancient Lake Cahuilla. The valley is surrounded by the Little San Bernardino Mountains on the north and eastern side, the Santa Rosa Mountains on the southwestern side, and the San Jacinto Mountains to the northwest. The San Andreas Fault runs parallel to the valley along the western edge of the Little San Bernardino Mountains.

The Coachella Valley occupies the northern portion of the faulted basin (tectonic subsident) called the Salton Trough and is considered an alluvial plain in geomorphic terms, consisting mainly of unconsolidated sands and gravels, silt deposits, and erosional debris from the surrounding mountains (Baldwin 1997). The mountains enclosing the Coachella Valley are the result of uplifted and tilted blocks that are part of the Southern California Batholith, which is a massive intrusion of several types of granitic rocks injected successively over more or less 10 million years into the crust as a series of plutons. The batholith mass is rich in high-silica related rock types and roughly 90 percent of the mass is composed of igneous rocks (diorite, quartz-diorite, granodiorite, quartz-monzonite and granite).

The Santa Rosa and San Jacinto mountains share the same core (diorite and granodiorite) surrounded and covered extensively with remnants of an early Paleozoic metamorphic series. While the San Jacinto Mountains are an uplifted block tilted west, the Santa Rosa Mountains are an uplifted block tilted east. Both of them posses a high degree of fracturing with well carved canyons, therefore due to geomorphic considerations, most of the material deposited on the valley floor appears to come from the eastern slopes of the San Jacinto Mountains.

The Little San Bernardino Mountains are essentially an elevated and faulted block, but they are much lower in elevation than the Santa Rosa and San Jacinto Mountains. They are composed of an assemblage of quartz-diorite, gneiss and granitic rocks as well as members of the Chuckwalla metamorphic complex.

PETROGRAPHIC ANALYSIS

Eight samples of pottery from CA-RIV-6897 were submitted for petrographic analysis, along with three samples of clay for comparison (Table 1). A single hand-modeled baked clay object (Sample No. 351-1) was analyzed under a binocular microscope. For each thin section, a list of qualitative attributes was recorded for the clay, pores, and inclusions (Table 2). These parameters follow standard petrographic procedures for ceramic samples (Whitbread 1989), but also included categories found in two previous studies (Hildebrand 2003; Zhai 1996). This enabled the results of the current study to be easily compared to those from the previous analyses.

Table 1. Sample Inventory.

Sample No.	Sample Type	Ceramic Types
4-1	sherd	Parker Buff
19-1f	sherd	Salton Brown
99-5	sherd	Salton Buff?
176-2	sherd	Ocotillo Buff
179-1	sherd	Salton Brown
338-1	sherd	Salton Buff Stucco
341-1	sherd	Salton Buff
347-1	sherd	Topoc Buff?
155-3	clay, from site	NA
171-1	clay, from site	NA
1	clay, southwest of site	NA
351-1	modeled object	NA

Table 2. Codes for descriptions of clay, pores, and inclusions in thin sections.

Category	Code	Definition
Size	1	Very fine (0.0625-0.125)
	2	Fine (0.125-0.25)
	3	Medium (0.25-0.5)
	4	Coarse (0.5 – 1 mm)
	5	Very Coarse (1 – 2 mm)
	1.1	Very fine to fine
	1.2	Very fine to medium
	1.3	Very fine to coarse
	1.4	Very fine to very coarse
	2.1	Fine to medium
	2.2	Fine to coarse
	2.3	Fine to very coarse
	3.1	Medium to coarse
	3.2	Medium to very coarse
	4.1	Coarse to very coarse
Frequency	1	Very rare (1-5 grains)
	2	Rare (c. 10%)
	3	Sparse (c. 10-25%)
	4	Frequent (c. 25-50%)
	5	Abundant (c. 50-75%)
	6	Highly Abundant (c. >75%)

RESULTS

The petrographic examination of the samples identified a large group containing six samples all exhibiting similar features (Tables 3 and 4). Two other samples are unlike this group or each other and form "outliers". The clays are also unique, but appear similar to some of the ceramic samples. The binocular analysis of the modeled clay object identified inclusions that were analogous to those seen in the largest group of sherds.

Sample Nos. 4-1, 19-1f, 99-5, 179-1, 341-1, and 347-1 all have noticeable inclusion of granodiorite (Figure 1), an igneous rock comprised of quartz, feldspars (mostly plagioclase), amphibole (usually hornblende), and biotite. A similar rock, quartz monzonite, with the same types of minerals but equivalent amounts of plagioclase and orthoclase is seen in Sample No. 19-1f, while Sample No. 179-1 also has grains of quartz monzogranite, a granite rich in biotite. Some samples also contain gneiss, a metamorphic rock composed mostly of quartz and feldspar. All samples feature common quartz and feldspar (plagioclase and potassium feldspar, usually orthoclase) inclusions derived from the breakdown of the rock fragments. Mafic minerals such as amphiboles and biotite are also present and likely derived from the granodiorite. Other inclusions consist of iron oxides, opaques, a few grains of epidote, sphene, muscovite, and rarely clinopyroxene or sillimanite. See Appendix A for images of the thin sections.

The frequency of these inclusions in the paste[1] varies from 20 to 50 percent, often with poor sorting, and a size range of very fine to very coarse. The open pore spaces, or vugs, are usually irregular and often elongate. They represent air trapped in the paste during forming and are normally fine to coarse in size. Pore frequency ranges from 10 to 20 percent for most of the samples. The well-mixed clay fraction, between 40 and 60 percent, is often translucent to semi-opaque in appearance. Every sample had an optically active to slightly active paste indicating the firing temperature was normally below 850°C. All of the described features suggest a clay that was probably weathering close to the rock outcrops. This would explain the angular nature of the inclusions, although mafic minerals are naturally angular. However, some samples with a high percentage of inclusions may have had temper added from sources where the minerals had not traveled a great distance and from the same geological outcrops as the clay. Overall, the paste was thoroughly mixed, although trapped air was common, and then formed using enough pressure to elongate the voids. This feature probably suggests the use of a paddle and anvil. Finally, the vessels were low-fired in a mostly oxidizing to incompletely oxidizing atmosphere.

Sample No. 176-2 is unique in having a mica-rich clay and only gneiss rock fragments, suggesting a metamorphic origin (see Appendix A). The inclusions comprise 50 percent of the paste, are fairly sorted, and range in size from very fine to very coarse. The irregular open pore spaces are fine to coarse in size and are at a frequency of 10 percent. The remainder of the paste, 40 percent, is the well-mixed clay, semi-opaque, and slightly active. Thus, while this vessel was produced in a similar manner to the other samples described above, the clay and inclusions indicate a different origin for the raw materials. The high amount of inclusions may indicate tempering.

[1] Paste is defined as the pre-fired mixture of clay and inclusions.

Table 3. Descriptions of clay and pores.

Sample No.	Color PPL[1]	Color XPL[2]	Matrix Opacity	Optical Activity	Percent of clay	Degree of Mixing	Type of Pores[3]	Percent of pores	Pore Size	Pore Shape
4-1	Light yellowish-brown	Yellowish-brown to orange	Translucent	Active	60	Good	Open spaces	10	2.2	Irregular, elongate
19-1f	Yellowish-brown to brown	Dark grayish- brown to dark brown	Semi-opaque	Active	40	Good	Open spaces	20	2.3	Irregular
99-5	Grayish-brown	Dark grayish-brown	Semi-translucent	Active	60	Good	Open spaces	20	2.1	Irregular, ovoid
176-2	Dark brown	Very dark brown to black	Semi-opaque	Slightly active	40	Good	Open spaces	10	2.2	Irregular, elongate
179-1	Orange-brown to reddish-orange	Dark reddish-orange	Semi-translucent	Active	40	Good	Open spaces	10	2.1	Irregular
338-1	Brown	Brownish-black	Semi-opaque	Inactive	50	Good	Open spaces	30	4	Irregular
341-1	Reddish-brown to greenish-brown	Dark reddish-brown to grayish-brown	Translucent	Active	50	Good	Open spaces	20	2.3	Irregular, elongated
347-1	Brown	Brownish-black	Semi-opaque	Slightly active	40	Good	Open spaces	20	2.2	Irregular
155-3	Reddish-brown to brown	Brown to brownish-black	Semi-opaque	Slightly active	90	Good	Open spaces	5	2.3	Irregular, elongate
171-1	Grayish	Grayish	Translucent	Inactive	40	Good	Open spaces	20	2.3	Irregular, ovoid
1	Reddish-brown	Dark reddish-brown	Semi-translucent	Active	40	Good	Open spaces	20	2.2	Irregular

[1] PPL: plane polarized light

[2] XPL: cross polarized light

[3] Pores can be either open spaces or vugs resulting from air trapped in the paste when the vessel was formed, burnt-out plant remains, or inclusions plucked from the section during its production.

Table 4. Descriptions of inclusions.

Sample No.	Temper Type[1]	Percent of inclusions	Sorting	Size Range[2]	Quartz Freq.	Quartz Shape[3]	Feldspars Freq.	Feldspars Shape	Mafic Minerals Freq.	Mafic Minerals Shape	Rock Frags Freq.	Rock Frags Shape	Inclusions[4]
4-1	None	20	Poor	1.4	4	angular to subang.	3	angular to subang.	3	very angular	2	subang	qtz, plag, orth, am, bio,ep, fox, op, grdio
19-1f	None?	40	Poor	2.3	4	subang to subround	3	subang to subround	2	angular	2	subang to subround	qtz, plag, orth, am, bio, mus, fox, op, sph, qmon, gn
99-5	Grog	20	Very poor	1.4	4	subang	4	angular	3	angular	1	subround	qtz, orth, am, bio, mus, fox, op, grdio, gn, grog
176-2	Sand?	50	Fair	1.4	4	subang to subround	4	subang	2	subang	2	subround	qtz, plag, ortho, am, bio, mus, ep, gar, fox, op, gn
179-1	Sand?	50	Poor	1.4	4	subang to subround	4	angular to subang	2	subang	2	subround	qtz, plag, orth, am, py, bio, mus fox, op, sph, grdio, qmongr, gn
338-1	None	20	Fair	2.3	3	subang	3	angular to subang	2	angular	2	subang	qtz, plag, ortho, am, bio, mus, sil, op, sph, grdio, qmon, gn, sch
341-1	None?	30	Fair	1.3	4	subang	4	subang	2	angular	2	subang to subround	qtz, orth, am, bio, mus, fox, op, sph, grdio, gn
347-1	None?	40	Poor	1.4	4	subang	4	subang	2	angular	2	subang to subround	qtz, plag, orth, am, py, bio, sil, ep, fox, op, sph, grdio, qmon or qmongr
155-3	None	5	Good	1.2	2	subang	1	angular to subang.	1	subang	0	NA	qtz, plag, am, bio, mus
171-1	None	40	Very poor	1.4	4	subang to subround	4	subang	2	subang	2	subang to subround	qtz, orth, am, py, bio, mus, ep, fox, op, sph, grdio, qmon, gn
1	None?	40	Fair	1.4	4	subang to subround	2	subang	2	angular to subang.	2	subround	qtz, plag, orth, am, py, bio, mus, sil, ky, gar, fox, op, gn, sch

[1] Temper is defined as intentional non-plastic materials added to the clay, features such as bimodal grain sizes, roundness of grains and geological differences between inclusions and clay are criteria for indicating temper.

[2] See Table 2 for size range categories, usually defined for sand-sized particles as from 0.0625 to 2 mm.

[3] subang=subangular; subround=subrounded.

[4] qtz=quartz, plag=plagioclase, orth=orthoclase, am=amphibole (mostly hornblende), py=clinopyroxene, bio=biotite (often grading to chlorite), mus=muscovite, sil=sillimanite, ky=kyanite, ep=epidote, gar=garnet, fox=iron oxides, op=opaques, sph=sphene; grdio=granodiorite, qmon=quartz monzonite, qmongr=quartz monzogranite, gn=gneiss, shc=schist.

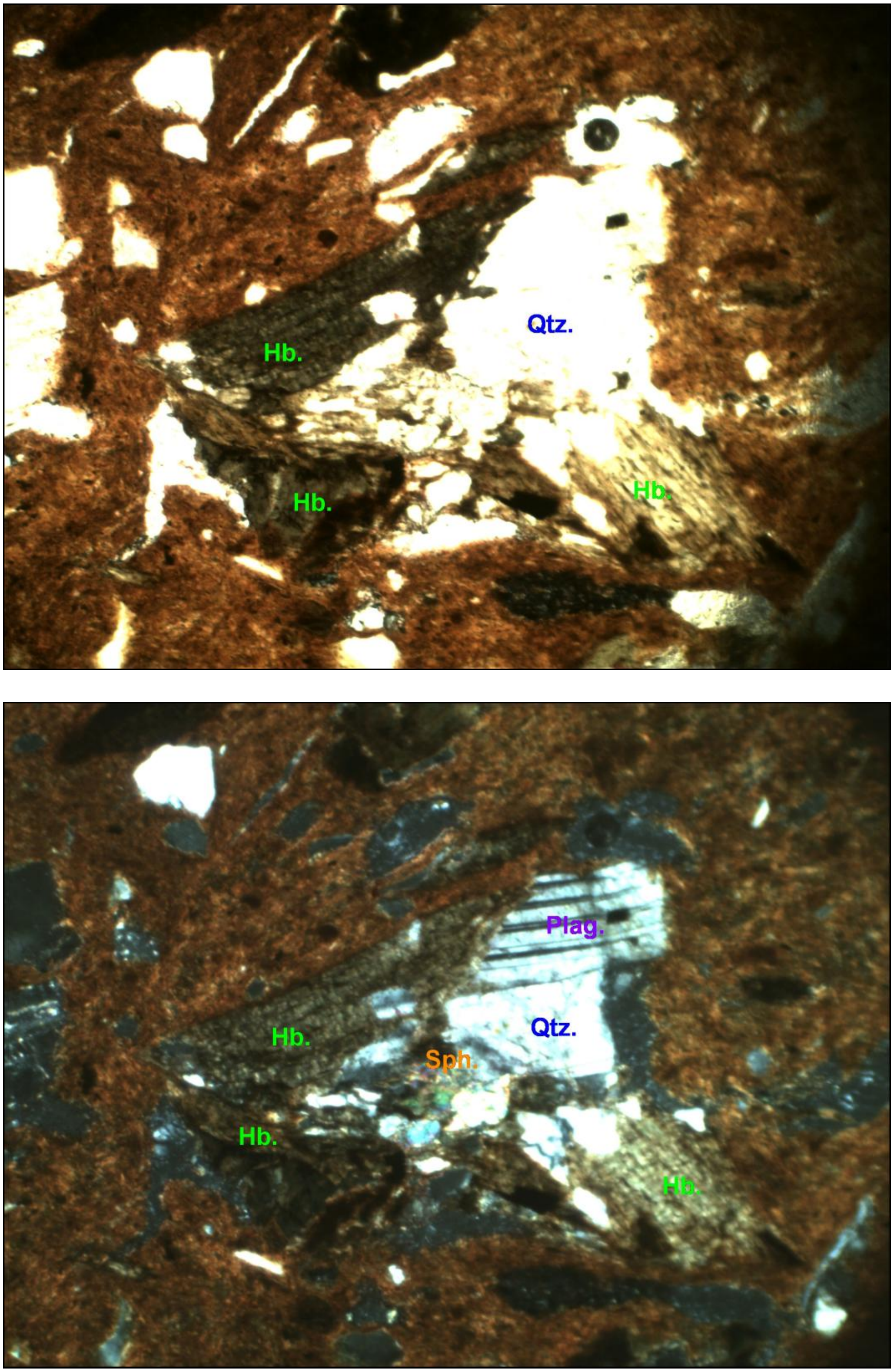


Figure 1. Polarized images: (a) plane polarized image of granodiorite fragment in Sample No. 179-1, taken at 100x magnification; (b) cross polarized image of granodiorite fragment in Sample No. 179-1, taken at 100x magnification. Qtz=quartz, Plag=plagioclase, Hb=hornblende (an amphibole), and Sph=sphene

The last sherd, Sample No. 338-1, is also unique, in this case more for its technology and combination of inclusions (see Appendix A). The rock fragments comprise granodiorite, quartz monzonite, gneiss, and schist (a metamorphic rock with quartz, feldspars, and micas). The fairly sorted inclusions make up only 20 percent of the paste, and are found in fine to very coarse sizes. The irregular pores are coarse in size and at a frequency of 30 percent. The clay is 50 percent of the paste, with good mixing, and a semi-opaque appearance. The optically inactive paste and large, plentiful voids suggest this sample may have been over fired to temperatures around or above 900°C. The presence of so many different igneous and metamorphic rock types is also unusual.

The three clay samples are each quite different (see Appendix A). Sample No. 155-3 has very few inclusions, 5 percent of the paste, mostly quartz, plagioclase, and amphibole, but micas are common and related to the development of the clay. The inclusion size ranges from very fine to medium and the sorting is good. Pores are also at a frequency of 5 percent, fine to very coarse in size, and irregular and elongate. Not surprisingly, the clay makes up 90 percent of the paste and is well mixed. The paste is semi-opaque and slightly active. This clay is similar to that found in the large group of samples, however, with more biotite and fewer inclusions.

The next clay sample, No. 171-1, has plentiful inclusions including granodiorite, quartz monzonite, and gneiss. They encompass 40 percent of the paste, are very poorly sorted, and range from very fine to very coarse in size. Irregular and elongate pores are also common at a frequency of 20 percent and range in size from fine to very coarse. The clay, 40 percent of the paste, is very carbonate rich and resembles more a "plaster." Further, it is translucent although optically inactive. The inclusions are similar to those found in the large group of samples.

Finally, clay sample 1, contains mostly quartz and biotite/chlorite grains with plagioclase, orthoclase, gneiss, schist (sillimanite and kyanite rich), amphibole, iron oxides, opaques, muscovite, pyroxene, sillimanite, kyanite, and garnet inclusions. While 40 percent of the paste, they are fairly sorted and very fine to very coarse in size. The irregular pores are 20 percent of the paste and in sizes fine to coarse. The clay, at a frequency of 40 percent, is semi-translucent and active, along with being well mixed. The inclusions suggest a more metamorphic origin for the clay, and it resembles that found in Sample No. 176-2.

The hand-modeled sample is composed of a combination of silt and clay that were deposited in a low energy environment (i.e. pond). This setting also contained a variety of grains, ranging from fine sand to granule in size. They comprise:

- Volcanic grains: usually subrounded to occasionally subangular in reddish to purple colors; the most common are rhyolite, rhyodacite, and a few metamorphosed grains; grain size often ranges from medium to coarse sand.
- Plutonic grains: often present as subangular grains, with granitic-interlocking texture; yellowish, white, and less frequently a pink-peach color; some of the grains have dark specks (either hornblende or biotite flakes); grain size ranges from medium to very coarse sand.

- Metamorphic grains: mostly subrounded, prolated, and less frequent subangular grains; mostly gneiss and grayish/silvery schist, and the latter is massive to foliated in appearance; grain size often ranges from medium to granule.
- Quartz and Feldspars: as free-floating angular to subangular monomineralic grains, which are derived from either metamorphic sources (i.e. gneiss and schist) and/or granitic sources (granodiorite, monzonite, granite, etc); grain size ranges from fine to coarse sand.
- Micas: biotite, chlorite, and muscovite occur on the surface of the sample (due to their platy nature); grain size ranges from very fine to medium in size.
- Mafic minerals: typically subhedral amphiboles, most likely derived from granodiorite and dioritic sources; deep olive green to black in color with a subvitreous luster; grain size varies from fine to medium sand.
- Iron Oxides: as small dark reddish (hematite-goethite), and/or black-steel (magnetite) crystals; grain size is mostly fine sand with scattered crystals ranging to medium sand.

The grain types are similar to those found in the large group of ceramic samples.

DISCUSSION

The site of CA-RIV-6897 is located southwest of the town of Indio in the basin of the Coachella Valley, in the dunes overlooking the edge of ancient Lake Cahuilla. Sediments near to the site would consist of erosional debris deriving predominantly from the San Jacinto Mountains to the west with a lesser amount of sediments from the Santa Rosa Mountains to the southwest. A large alluvial plain of clay and sand separates the site from the San Andreas Fault to the east. Between this fault and the Little San Bernardino Mountains, located to the north and east of the site, the alluvial sediments are intermixed with Pliocene non-marine sedimentary sediments.

The shoreline of Lake Cahuilla was very close to the mountains, suggesting available raw materials for pottery manufacture would not have traveled far, and would be related to the outcrops along this shoreline. These are predominantly Mesozoic quartz diorite, some grading to gneiss, which intrude into older metamorphic rocks found in both the San Jacinto and Little San Bernardino mountains (Dibblee 2008). In addition to in situ weathering, mountain runoff and washes would probably have carried these rock fragments and their constituent minerals, including prevalent biotite, towards the basin. Quartz monzonite is less frequently found in these Mesozoic outcrops. Precambrian igneous and metamorphic rocks can be found outcropping along the basin to the northwest of CA-RIV-6897 as a part of the San Jacinto Mountains.

Based on the geology close to the site, all of the analyzed samples were potentially produced locally. The large group of samples contains characteristic inclusions of the nearby Mesozoic outcrops and the Chuckwalla Formation. Further, the shape of the granodiorite, often subrounded, suggests it had traveled some distance from the original source, while the quartz and feldspar grains were more angular showing their more recent breakdown and development. Thus, the transport distance from the parent material was not large, suggesting raw materials from nearby outcrops, although some distance was achieved as indicated by the prevalence of monomineralic grains (i.e. quartz and feldspars) derived from the rock fragments, with the latter being rarer in the samples. Similarly, the "clay" sample No. 171-1 contained inclusions analogous to those in the Mesozoic outcrops. In fact, this sample appears to represent the dune environment of the site, which may have been altered and/or utilized by the human inhabitants. When the ware of the samples within the large group is considered, it appears several types were made of similar materials including Parker Buff, Salton Buff, and Topoc Buff. Thus, these wares may have been locally produced and their difference is not based on raw materials.

Sample No. 176-2 could also have been made with local materials, but was typed as Ocotillo Buff suggesting possibly the intentional use of specific resources for this ware. On the west side of the Coachella valley, above the Mesozoic granite, diorites, and gneiss, is an older outcrop, the Oberdoo Formation, rich in metamorphic rocks such as mica schist, phyllite, and gneiss. The break down of these rocks into a clay would have produced one rich in the micas muscovite and biotite along with a few residual grains of schist and gneiss, as seen in the sherd. This is probably also the source of clay sample 1, although the garnet and sillimanite suggest an amphiolite metamorphic facies probably found in the Precambrian outcrops of the Santa Rosa Mountains where the sample was collected.

The clay in Sample No. 155-3 was probably derived from a Mesozoic source, but was transported further from the outcrops and naturally levigated to produce an almost pure clay. It may have been naturally available near the lakeside.

Sherd Sample No. 338-1 with fragments of granodiorite, quartz monzonite, gneiss and schist is likely to have come from an area on the border between the Mesozoic igneous and metamorphic outcrops. This sample was typed as Salton Buff Stucco and may also have been produced from a specific recipe that differed from the other wares.

Therefore, all of the available evidence suggests that the analyzed sherds and clay samples were potentially manufactured in proximity of CA-RIV-6897. Clay Sample No. 1 derives from the Santa Rosa Mountains, approximately 20 miles southwest and about 1500 feet above the site, while samples Nos. 155-3 and 171-1 were collected from the cultural contexts of the site. These confirm the availability of local materials and their composition; however, the Mesozoic outcrops found throughout the mountain ranges on both sides of the Coachella Valley offer other potential locations for materials acquisition and pottery production (Rogers 1966). Therefore, additional on-site prospecting of clay and sediment resources is needed to establish the exact composition of materials near the site and how these may differ from those available throughout the valley.

PREVIOUS STUDIES

Zhai (1996), as a part of Griset's Ph.D. dissertation on Southern California Brown Ware, analyzed petrographically 113 sherds representing Malcolm Roger's ceramic typology as of 1945 and sherds from sites in the coastal ranges (Zhai 1996). Since rock fragments are the most diagnostic, they will be discussed in some detail. Almost half of the samples (51 of 113, 45 percent) did not contain rock fragments, of those that did, their frequency was low, usually less than 5 percent to trace. Only a few samples had higher amounts, such as No. 27 with 40 percent and No. 69 with 15 percent. These samples derive from Rincon 360 (a ceramic cache on the southern flanks of Palomar Mountain in northern San Diego County) and Rogers' Colorado Beige (from site C86-S, the Outer Picacho Trail, between the Imperial Sand Dunes and Picacho and the Chocolate Mountains, west of Yuma). However, the rock fragments in these samples were those typical for the corpus as a whole, suggesting the raw materials utilized were closer to the parent rock and contained more intact fragments or the clay was tempered with sand.

Most samples with rock fragments had granite, usually with quartz, plagioclase, and K-feldspar, or some variety of plutonic rock such as tonalite (quartz plus plagioclase), granite (quartz plus K-feldspar), quartz diorite (plagioclase, quartz, and amphibole), granite aplite (microgranite), or granite andesite porphyry (fine-grained with andesine groundmass and quartz and feldspar phenocrysts). These rocks probably derived from the same Mesozoic plutonic complex as those found in the samples of the current study.

A few samples, Nos. 74, 77, 78, 86, 89, 91, and 93, had rock fragments unlike the above. Sedimentary rock types such as chert, quartzites, sandstone, and siltstone were in a few samples, while two samples contained volcanic tuff. These inclusions may have come from the Pliocene outcrops found along the edge of the Little San Bernardino Mountains (Dibblee 2008, Rogers 1966). One sample contained inclusions of andesite, biotite schist, and chert probably indicative of an environment where igneous, metamorphic, and sedimentary rocks are located in proximity.

Quartz was commonly present between 10 and 40 percent, but upwards of 65 percent, while plagioclase and K-feldspars (perthite, orthoclase, and microcline when specified) were in amounts of 5 to 20 percent with the highest being 45 percent. The larger quantities of quartz and feldspars, in addition to the rounded shape of some of the inclusions, suggest sand temper. However, some samples have angular quartz and feldspars suggesting materials acquired closer to the parent rock.

Mafic minerals were found in amounts of 5 percent or less and comprised mostly amphibole and biotite, with less common instances of muscovite, pyroxenes, and epidote. Calcite was noted in two samples, while tourmaline was seen in one. The mafic minerals are likely to be from either the break down of rock fragments and/or the clay.

Clay inclusions described as angular with inclusions are probably grog. These were found in 24 samples, which were also sherds with little to no intentionally added non-plastics, and unusual rock fragments.

Given the wide expanse from which these samples were derived, there was great variability in the percentage of clay and inclusions. Rarely did samples contain roughly half clay and half inclusions; rather they were either clay-rich or inclusion-rich. This reflects a difference between Southern California Brown Ware and Lower Colorado Buff Ware samples. Therefore, for the former ware untempered clay with some natural inclusions (occasionally with added grog) was common, while for the latter, large quantities of temper and occasional grog were added. Pores were consistently between less than 5 percent to no more than 15 percent of the paste. Finally, the clay itself was stated as deriving from the weathering of various rocks including the Mesozoic diorite, quartz-diorite, granodiorite, granite, and tonalite. Other clays appeared to be from the breakdown of biotite or biotite and muscovite, probably from a more metamorphic region.

When the ware of some of the samples was investigated (Nos. 96-99, and Nos. 102-109) further interesting patterns appear. For sites located near Lake Cahuilla, the wares included one with plentiful sand temper, Salton Brown, and a few that were more clay-rich, Salton Buff, Salton Buff Stucco, and Carrizo Buff II. The latter are types investigated in the current study and were also fairly clay-rich. Samples from sites more in the Santa Rosa Mountains typically had wares that included more inclusions, i.e. Piñon Brown, Santenac Brown, and Hakum Brown. These wares may have been made from clays naturally rich in inclusions due to their location near the parent rock. Interestingly, Piñon Brown was made from a metamorphic clay and may indicate the employment of specific resources for this ware, particularly as the two samples came from different sites. This is just a preliminary investigation into the relationship between site location, ware, and raw materials.

Overall, the study of these 113 samples appears to confirm both the prevalent use of clays and sand deriving from the common Mesozoic outcrops along the Coachella Valley, as well as the technological practice of adding materials such as grog.

Hildebrand (2003:246-247, Appendix K) focused on buffwares from the Lower Colorado region. The analysis of 62 thin sections revealed a range of raw materials and variability in their amounts. Addition of clay inclusions, including grog, was noted although its frequency was quite inconsistent. Of the analyzed wares, Salton Buff, Topoc Buff, and Parker Buff contained the most mineral inclusions and rarely featured clay inclusions. Typical grains comprised quartz, plagioclase, orthoclase, biotite, muscovite, and epidote. Without any further information on rock fragments, noted in a sample of Topoc Buff and a sample of Salton Buff, or the percentages of the mineral inclusions, comparison to the current study is difficult. However, in a general way the eight sherds from CA-RIV-6987 appear to resemble the mineral-rich tempered buffwares.

Quinn and Burton’s (2009) study of samples derived from seven sites in San Diego County, southwest of the Coachella Valley, and dating to the Late Prehistoric period, found similar types of ceramic fabrics to the current study. The sites are located within the eastern Peninsular Range Batholith composed predominantly of granite. The 70 analyzed ceramic samples were categorized into 18 fabric groups, although half of the fabric groups contain only one sample. The groups cross-cut vessel forms such as jars versus bowls (Table 5). The largest group consisted of samples made of residual granitic clay and inclusions.

The fabric groups Residual Granitic and Biotite-rich Residual Granitic were believed to come from the eastern Peninsular Range mountains to the west of the study sites. The wetter climate in this area allows for clays to form from the granitic rocks, such as quartz-diorite, tonalite, and granodiorite. Interestingly, samples from sites located further north had higher amounts of hornblende than those from samples to the south. The overall characteristics of these two fabric groups resemble the group of six samples from the current study, which also contain hornblende. Furthermore, Quinn and Burton noted that some of the samples in these two groups contained grog; one sample in the current study also had grog inclusions.

The Residual Metamorphic and Grog Tempered Residual Metamorphic contained similar inclusions to the Residual Granitic, in addition to fragments of metamorphic rocks. Petrographic analysis of a clay sample from Collins Valley, just to the west of the Salton Sea, revealed this material was analogous to the sherds and may suggest a location for the raw materials for these fabric groups. The CA-RIV-6987 sherd Sample Nos. 176-2, 338-1, and clay Sample No. 1 from Santa Rosa Mountains are similar in terms of metamorphic rock fragments to the samples in these two fabric groups, although the two Coachella Valley sherds did not contain grog. However, similar metamorphic outcrops occur throughout the Peninsular Range.

The remaining fabric groups in the Quinn and Burton study are found predominantly in the southern sites. By their description, none are comparable to the samples from CA-RIV-6987. This is particularly interesting in the case of the fabric groups produced from a sedimentary marine or lacustrine clay, which were believed to derive from sources near the Salton Sea. For whatever reason, these fabric groups were not represented in the material analyzed in the current study.

The addition of sand, grog, and plant remains to form a paste appears to have been employed for finer quality clays with fewer natural inclusions; however, grog was also added to clays with naturally plentiful inclusions and may suggest a cultural practice (Quinn and Burton 2009: 287-288).

Table 5. List of fabric groups, numbers of samples, and a brief description from Quinn and Burton (2009).

Fabric	No. Samples	Description
Residual Granitic	29	Coarse-grained, poorly sorted, rich in quartz, plagioclase and biotite
Biotite-rich Residual Granitic	1	Coarse-grained, poorly sorted, rich in quartz and plagioclase with abundant biotite
Grog-Tempered Residual Granitic I	6	Residual Granitic with the addition of grog
Grog Tempered Residual Granitic II	1	Not described
Residual Metamorphic	5	Residual Granitic but with metamorphic rock fragments
Grog Tempered Residual Metamorphic	1	Residual Granitic but with metamorphic rock fragments and grog
Gneiss Tempered	2	Angular, crushed and weathered gneiss rock fragments
Igneous Tempered	1	Angular, crushed and weathered igneous rock fragments
Igneous, Grog and Plant Tempered	1	Not described
Well-Packed Alluvial	8	Residual Granitic, but with finer, more rounded and better sorted inclusions.
Grog Tempered Fine Alluvial I	3	Residual Granitic, but with finer, more rounded and better sorted inclusions and grog
Grog Tempered Fine Alluvial II	1	Not described
Grog Tempered	3	Sedimentary clay of either lacustrine or marine origin with grog
Fine Grog Tempered	1	Not described
Grog Tempered Calcareous	1	Sedimentary clay of either lacustrine or marine origin with grog

Sand and Grog Tempered	2	Sandy alluvial material from the erosion of granitic rocks; rounded, silt and sand-sized grains of quartz, feldspar, biotite, and less commonly hornblende and muscovite
Sand and Grog Tempered Calcareous	2	Sedimentary clay of either lacustrine or marine origin with sand (similar to Sand and Grog Tempered) and grog
Fine Biotite-Rich Grog Tempered	1	Pleistocene non-marine clay with grog

The conclusions of the Quinn and Burton study are that seasonal migration patterns account for the broad variability in the raw materials utilized for pottery production; however, the preference for residual granitic clays suggests potters had raw material sources that they favored. While these clays are broadly distributed in the Peninsular Range, they are not found close to the sites, suggesting pottery manufacture occurred off-site. This hypothesis is supported by the lack of evidence for pottery making at the sites.

In comparison, the few fabric groups identified in the current study, although from a small sample, and their potential locally available raw materials may suggest that the inhabitants of CA-RIV-6987 were more permanently settled and did not travel great distances to procure other raw materials for pottery production.

CONCLUSION

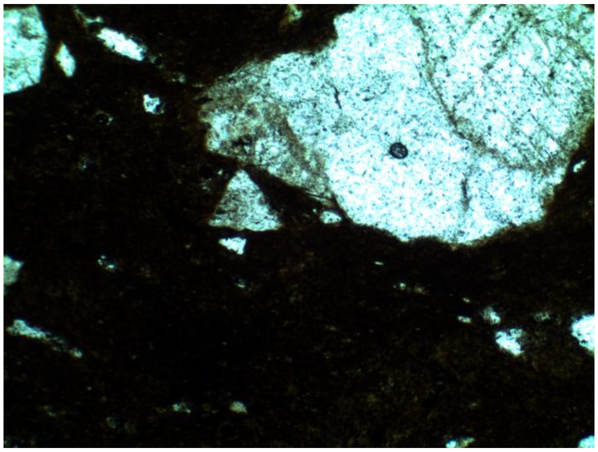
The current study has aimed to provide a thorough description of eight ceramic and three clay samples from the Coachella Valley area. The primary goal was to identify mineral inclusions and rock fragments indicative of the source of the pottery; both suggest that most of the samples could have been produced locally. However, the broad spread of the geological outcrops represented in the samples negates any firm conclusions as to the precise provenance of the samples. Furthermore, any relationship between materials and ceramic ware and type is tentative due to the small number of samples examined.

The second goal was to investigate the similarity of these samples to previously analyzed ceramics in several studies. It was shown that similar raw materials were utilized to produce a majority of the samples in this study and that conducted by Zhai (1996). Along with the results from Quinn and Burton (2009), this indicates pottery manufactured from clays produced from the weathering of granitic outcrops was common throughout southern California. This suggests a conservative tradition of pottery making in this region where particular clays were often preferred. However, the mobile nature of the past peoples of this region may also have played a role in the similarity of the utilized pottery raw materials over such a wide area. A further consideration is that the employment of analogous pottery production methods indicates a perceived cultural affiliation among the groups in the area.

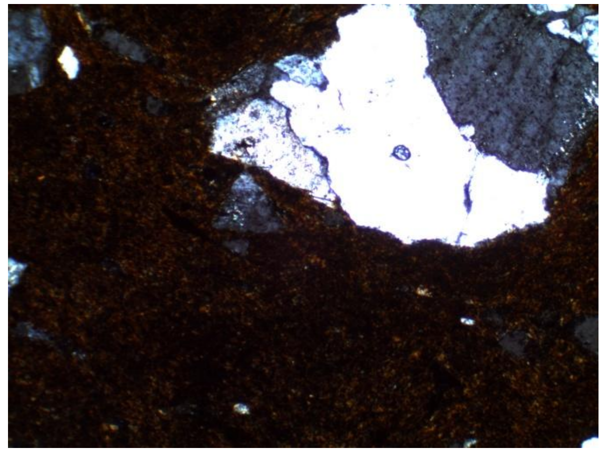
APPENDIX A

THIN SECTION IMAGES

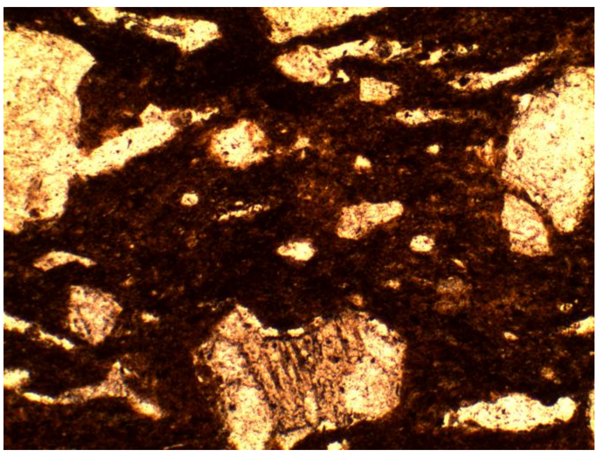
Figure A.1. Plane (PPL) and cross polarized (XPL) images of analyzed thin sections, taken at 40x magnification.



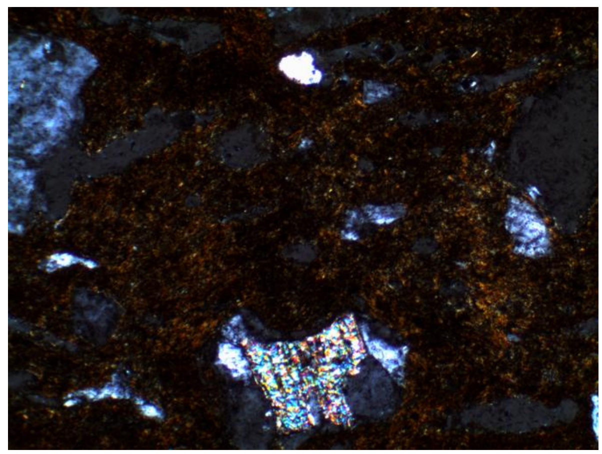
Sample 4-1, PPL



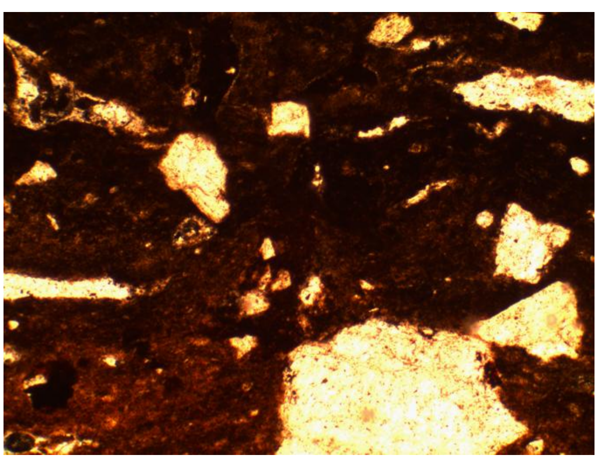
Sample 4-1, XPL



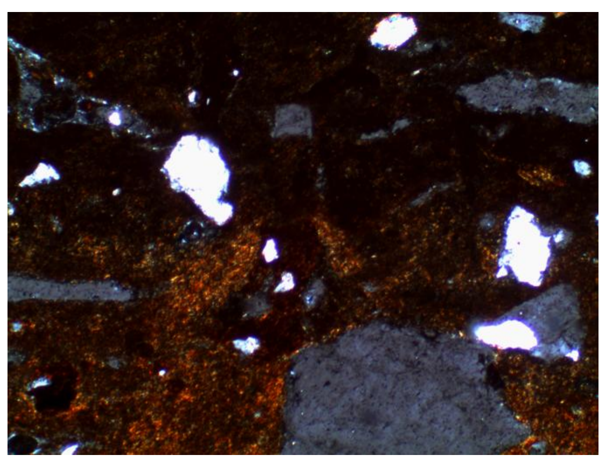
Sample 19-1f, PPL



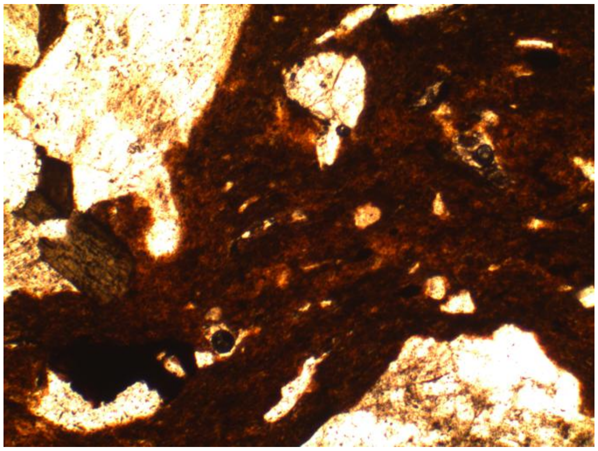
Sample 19-1f, XPL



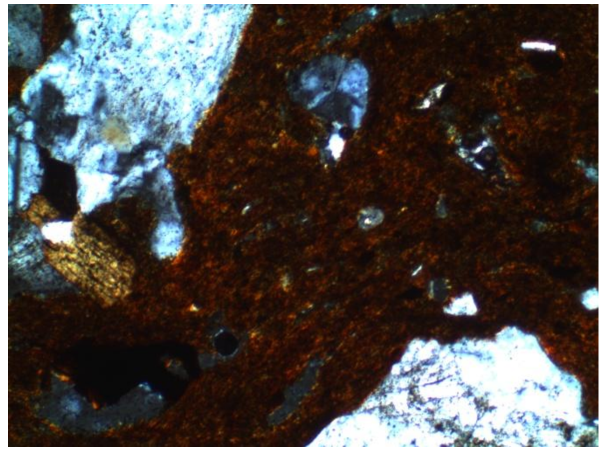
Sample 99-5, PPL



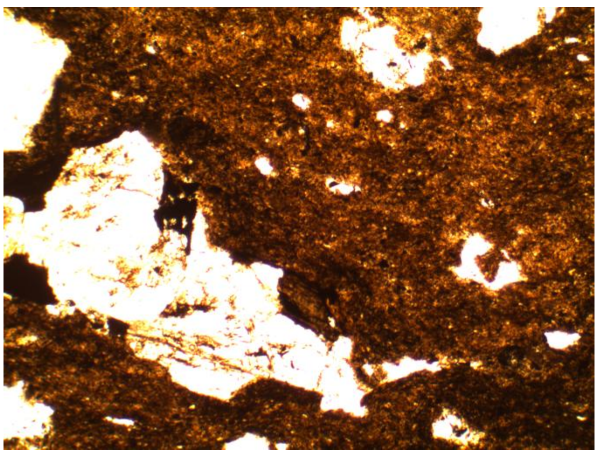
Sample 99-5, XPL



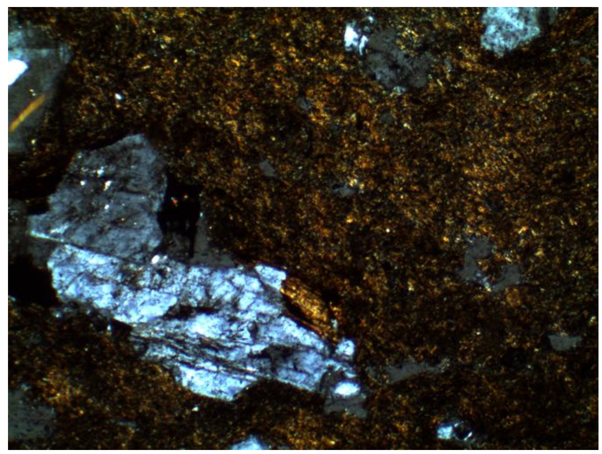
Sample 179-1, PPL



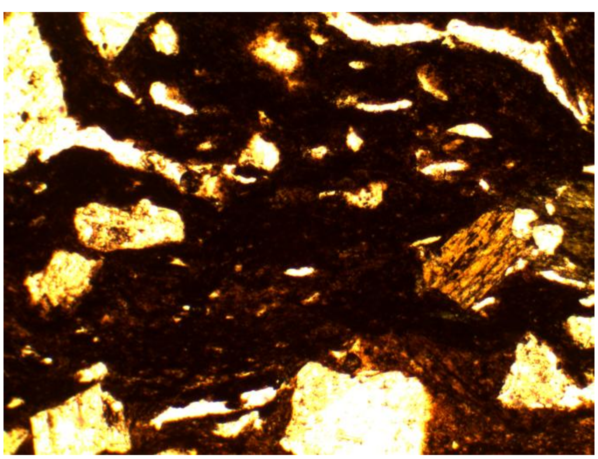
Sample 179-1, XPL



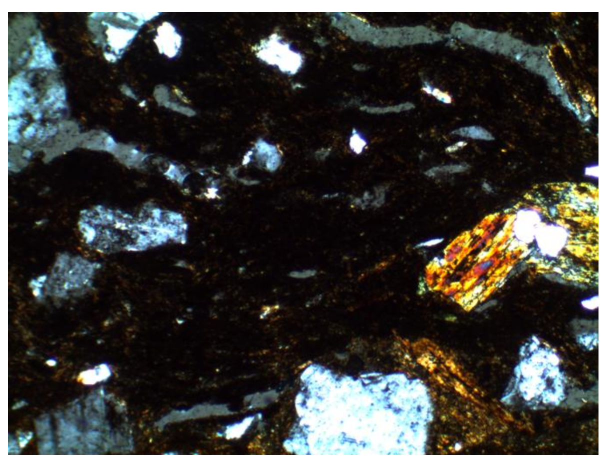
Sample 341-1, PPL



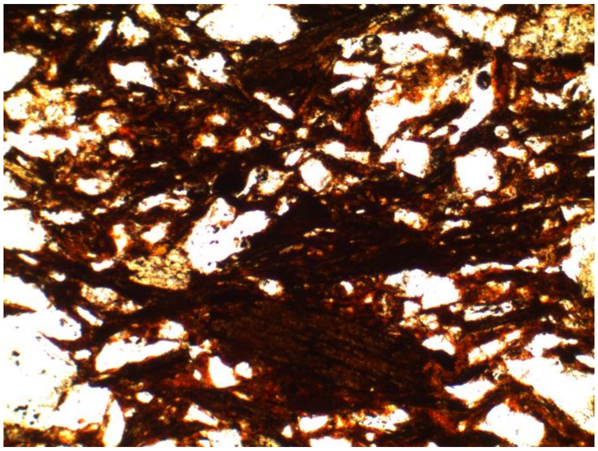
Sample 341-1, XPL



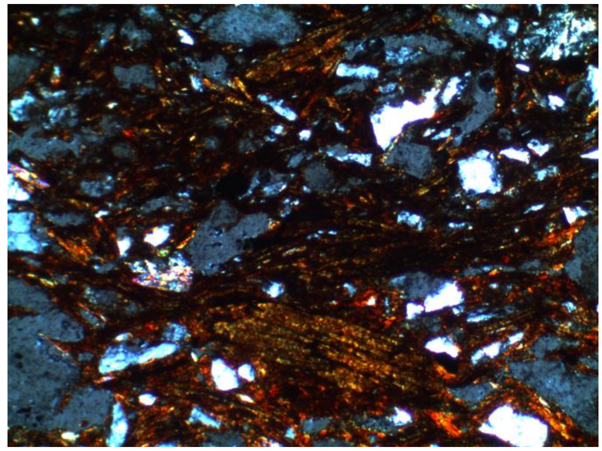
Sample 347-1, PPL



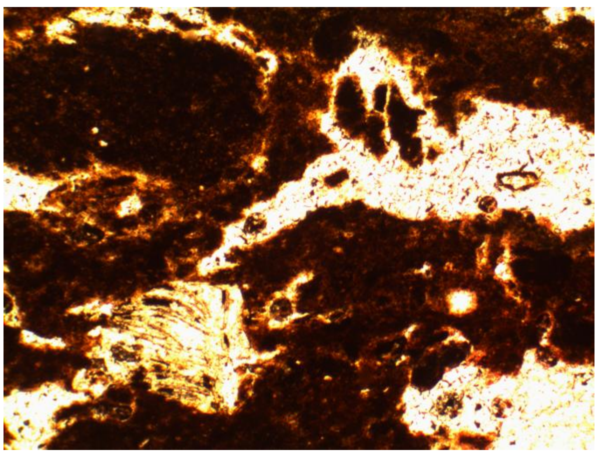
Sample 347-1, XPL



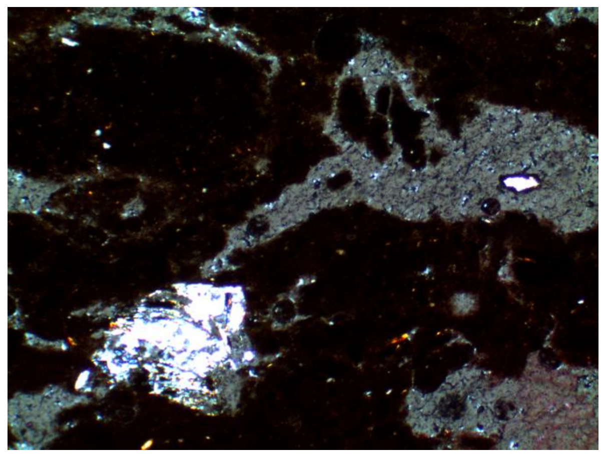
Sample 176-2, PPL



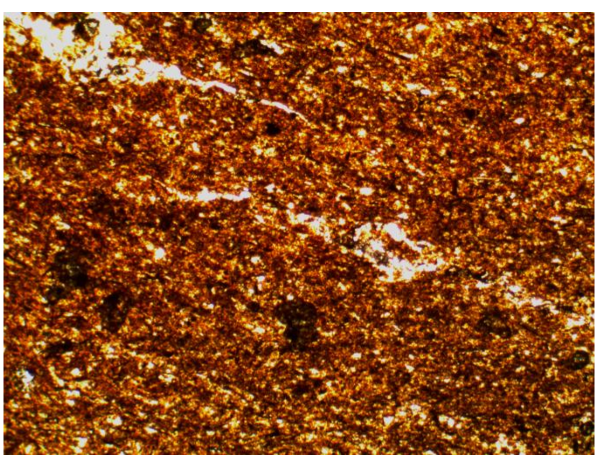
Sample 176-2, XPL



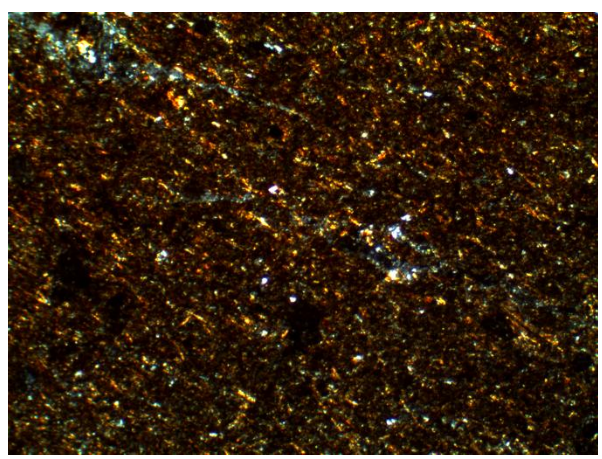
Sample 338-1, PPL



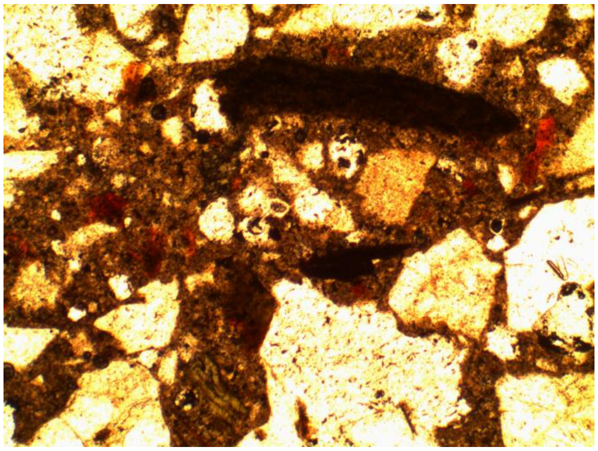
Sample 338-1, XPL



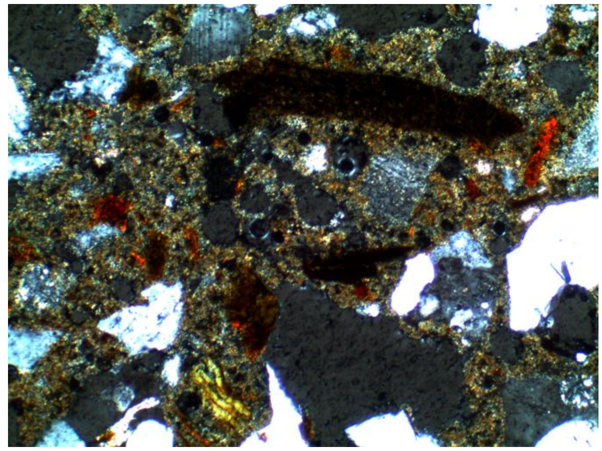
Clay Sample 155-3, PPL



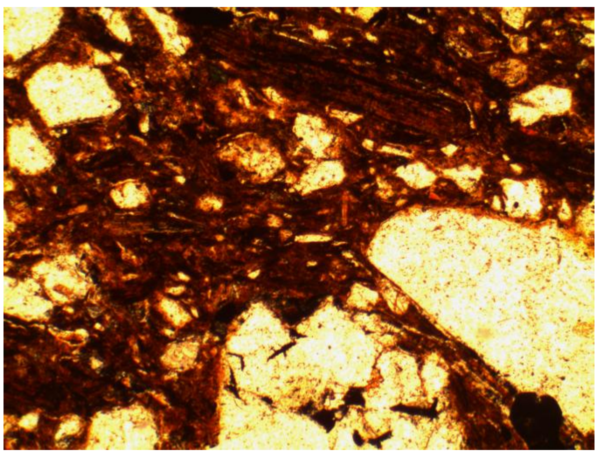
Clay Sample 155-3, XPL



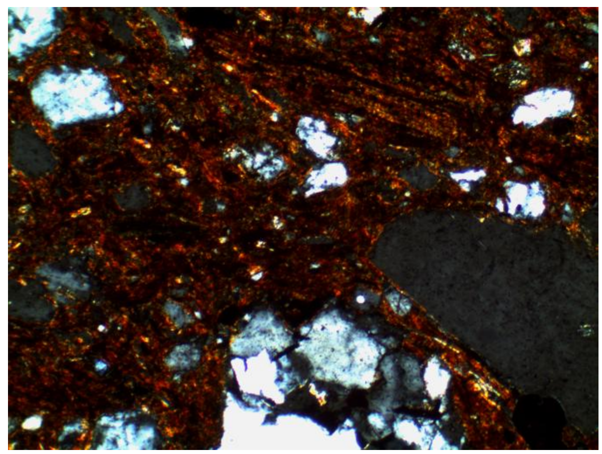
Clay Sample 171-1, PPL



Clay Sample 171-1, XPL



Clay Sample 1, PPL



Clay Sample 1, XPL

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