Rural Ceramic Manufacture in Precolumbian Honduras: The Application of Petrographic Analysis to the Study of the *Chaînes Opératoires*

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Abstract. This study presents a preliminary attempt to examine stages within the *chaîne opératoire* of Late Classic (650–900 C.E.) ceramic manufacture at the Precolumbian site of Rancho del Rio, Honduras. Materials recovered from patio, house mound, and midden excavations in a rural setting, including finished vessel sherds and potstands, in addition to briquettes made from local clay sources, are examined through thin section petrography. This attempt to outline technological chains and styles allows the classification and understanding of behaviour and ultimately, cognition, through the identification of the series of units of actions that bring a material from its natural state to a fabricated form.

Résumé. Cette étude présente une tentative préliminaire d'examiner les étapes de la chaîne opératoire dans la fabrication de céramique au site précolombien (650–900 ap. J.-C.) Rancho del Rio, en Honduras. Des tessons de poterie et des supports à vases recouverts dans les fouilles archéologiques d'un patio, d'un monticule domestique, et d'un dépotoir dans un contexte rurale, en plus de briquettes faites à partir de sources locales d'argile, ont été examinés par analyse pétrographique. Cette tentative de décrire les chaînes et les modèles technologiques permet la classification et la compréhension de comportements, et finalement, l'approche cognitive, par l'identification de la série des unités d'actions qui apporte un matériel de son état normal à une forme fabriquée.

Research Report

Applying macroscopic techniques to the analysis of pottery as a means to understand socio-political identities and boundaries, world systems, and daily activities is commonplace in Precolumbian Mesoamerican studies. Research and the application of microvisual and elemental techniques to address how and where pottery was manufactured were relatively more limited until approximately 20 years ago. Key reasons for ignoring such questions and approaches included issues of preservation, an inability to efficiently recognize manufacture locations and remains, the focus of excavations on major site epicentres and elite civic-ceremonial structures to the detriment of lower strata houselots where much manufacture was likely to have occurred (Robin 2002), and a lack of conviction on the part of many archaeologists as to the advantages of archaeometric and geological approaches to the study of ceramics. Despite numerous ethnographic and ethnoarchaeological studies of pottery-making in Mexico and Central America, literature of the past century reveals additional cause for the omission of archaeometry and geology from these studies including: an absence

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of questions posed regarding the *chaîne opératoire* of manufacture; and the belief that archaeological typologies based on macroscopic characteristics can supply significant and abundant information regarding finished vessels (Wardle 1992:11).

This paper presents a study in the characterization of the micro-nature of ceramics from the Precolumbian site of Rancho del Rio in northwestern Honduras through the use of thin section petrographic analysis to outline the *chaîne opératoire* of manufacture. This study serves as a preliminary attempt to combine macrovisual and microvisual analyses of both finished ceramics and manufacture residue in the discussion of manufacture behaviour on a local, community level in Precolumbian Honduras.

Identifying Ceramic Manufacture

Why study ceramic manufacture and production?[1] Is it important to understand where, how, and by whom vessels were made? Manufacture, or technology, is "not simply a body of explicitly formulated and objectively described knowledge," but "is one of the social processes by which individuals negotiate and define their identities, in terms of gender, age, belief, class, and so on" (Sinclair 2000:196). Individuals learn the techniques of manufacture as members of their respective societies, making them part of the social processes that archaeologists and anthropologists are so keen to understand. As such, outlining the manufacturing processes of ceramic vessels can lead to an understanding of incorporated social processes and behaviours.

Understanding ceramic manufacture through the behaviour of producers is an attempt to codify phenomenal orders within ceramic variation as opposed to the ideational orders of typical type-variety systems (Ford and Steward 1954). The adoption of techniques that focus on the understanding of manufacturing choices, or *chaînes opératoires,* allows the classification and consideration of behaviour and potentially cognition, through the identification of series of behavioural units or actions that bring a material from its natural state to a fabricated form (Bleed 2001; Cresswell 1976; Lemonnier 1986). Such actions are imbued with cultural and even individual influences while at the same time being restricted by the physiochemical properties of the raw materials (Arnold 1971; Hassan 1988; Schiffer 1976). This approach to material culture allows archaeologists a closer view of dynamic individual agency and shared ideas within given social groups of the prehistoric past, through the identification of patterns and differences in static "things" that are reflective of choices (Lemonnier 1992). The *chaîne opératoire* approach serves to outline the four elements of any technological process—materials, tools, actions, and specific knowledge (Sheets et al. 1975)—and focuses directly on the behaviours of artisans and the use of discontinuities in the manufacture process to isolate analytical taxa in an attempt to place behaviours in a framework of theoretical interrelationships (Sheets et al. 1975:378).

Considering behavioural units, Arnold (1991:87) distinguishes three classes of data that might potentially serve to identify Mesoamerican ceramic manufacture locations and inferred behaviour from the archaeological record including: 1) the tools and facilities of manufacture, including often cited "enigmatic firing features"; 2) the mistakes and residues of manufacture; and 3) the finished products (see Rice

1996 and Stark 1983 for similar classes of data). This third class of data can provide a wealth of important information concerning patterns of distribution, characteristics of consumer populations and most importantly, information on the physical manufacture of the items. The ability to recover such diverse data from this final category is critical as most often it is the third class archaeologists are left to consider.

Any combined analysis of all three of Arnold's classes can therefore potentially provide more in-depth interpretations regarding the reconstruction of specific primary and secondary technological behaviours comprising the *chaînes opératoires* involved in ceramic manufacture. A study of these chains therefore requires multi-step approaches involving both the characterization of finished products and the linking of these items to a manufacturing location, associated tools, and material source on the landscape.

Valle de Cacaulapa

During the summers of 2003 and 2004, archaeological survey, testing, and excavations were conducted at the Precolumbian site of Rancho del Rio in the lower Valle de Cacaulapa of the Santa Barbara District, northwestern Honduras (Figure 1). The Valle de Cacaulapa is a narrow valley of the Rio Chamelecón and its tributary, the Rio Cacaulapa, and is located approximately 35 km west of the modern city of San Pedro Sula. Originating in the igneous/volcanic and metamorphic highlands to the south, the rivers carry water year-round and the valley itself is situated at the nexus of three geological zones: the Atima limestone formation to the southeast;

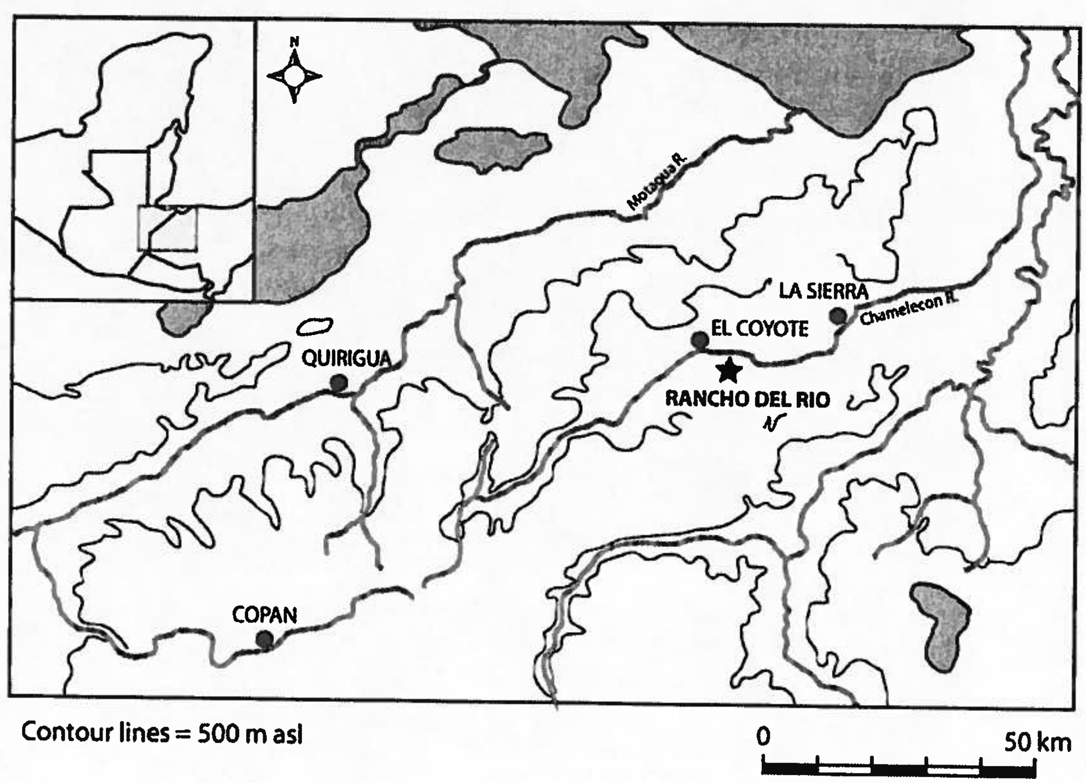

FIGURE 1. Map showing location of Rancho del Rio in northwestern Honduras (redrawn from Small and Shugar 2004:Figure 1).

igneous rock intrusions and flows to the south; and various areas of sand and siltstone to the north and east (Wells 2004:68–69). This unique position provided numerous resources for the Precolumbian populations of the valley: copper ores, basalt, perlite, limestone, chert, volcanic tuff/ash, and clay-based soils. Valley soils are of limestone origin and are highly fertile, while other valley sediments are well suited for ceramic production (Wells 2004:69).

The valley was first extensively surveyed in the late 1990s (Urban et al. 2000; Wells 2003), at which time 38 sites were identified, the largest being El Coyote in the southern portion of the valley. This site covers approximately 6 km^2 and encompasses a minimum of 360 platform structures, 28 of which form the site epicentre. El Coyote was occupied from the Middle Preclassic (ca. 600–400 B.C.E.) until the Early Postclassic (900–1100 C.E.), with its strongest episode of occupation occurring in the Late Classic (650–900 C.E.) and Early Postclassic (900–1100 C.E.) periods (Small and Shugar 2004; Urban 2007). The rural hinterland sites associated with El Coyote range from hamlets composed of 22 mounds to mere artifact scatters; Rancho del Rio is included among these rural hinterland sites.

Rancho del Rio

The small site of Rancho del Rio, situated on private farmland immediately adjacent to the main highway and a school yard, was first visited and surveyed by archaeologists in 1997 as part of the larger valley reconnaissance (Small and Shugar 2004). The site consists of at least seven mounds, ranging in height from under .5 m to 5 m, surrounding a large central courtyard (Figure 2). This configuration suggests a small rural settlement in the hinterlands of El Coyote likely inhabited by a loosely connected group of people. The initial investigative season at the site in 2003 aimed to understand its physical extent and to construct a chronology of its occupation. Test excavations concentrated on the primary courtyard of the site and the area to the south of Mound 1 to reveal the relationship of these open areas with surrounding mounds (Small and Shugar 2004). Occupation was found to be limited to the Late Classic and Early Postclassic periods, with the majority of activity taking place in the former. A very similar occupation span was noted at many other small hamlet locations studied to date in the valley (Urban 2007). Excavations in 2004 opened up a large section of the northeast portion of the courtyard (Suboperation B) and Mound 7, following discoveries made in the previous season (Small and Peuramaki-Brown 2004).

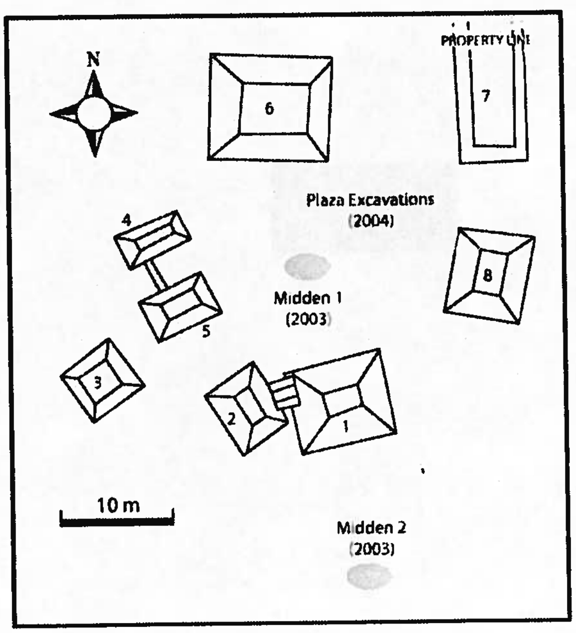

FIGURE 2. Rectilinear map of Rancho del Rio site and location of 2004 excavations and 2003 midden discoveries (redrawn from Small and Shugar 2004:Figure 2).

Rancho del Rio Ceramic Manufacturing

During the 2003 testing it was discovered that the ancient inhabitants of Rancho del Rio were possibly engaged in pottery production. Large middens, consisting primarily of ceramic debris, were encountered in the courtyard and south of Mound 1. This debris included opportunistic ceramic tools (broken sherds used as scrapers, shapers, and smoothers in pottery manufacture, similar to those found at the site of K'axob in Northern Belize [Varela et al. 2001:186–187]), vitrified ceramic (occasionally labelled as ceramic "slag"), pieces of clay waste, crushing implements (manos and metates), countless broken sherds of the four paste groups examined in this study, possible temper blocks of a low-grade schist (discussed below), and potstands.

Potstands comprise a distinctive artifact class in this region during the Late Classic. They typically conform to a fairly standard design consisting of a flaring base surmounted by a straight neck terminating in a flat rim, usually fashioned from a modified jar rim (Figure 3). Many are spattered with clay globules toward their bases, possible tell-tale signs of manufacture. This presence of globules, often multiple layers thick, implies the use of these artifacts as supportive rests for vessels while they were still wet and being shaped. The baked nature of the clay globules also suggests that the stands held the shaped vessels during the firing stage, thus serving as a piece of firing furniture (Urban 2007:44).

Similar potstands have been recovered at the nearby site of Las Canoas and elsewhere in the valley (Stockett 2005:388). Despite excavation of two Late Classic pottery kilns at La Sierra in the neighbouring Naco valley, no similar

FIGURE 3. Ceramic potstand with arrow indicating clay globules on exterior surface (photographed by M. Peuramaki-Brown, 2004).

artifacts were unearthed along with these firing features (Urban et al. 1997:44). Such a pattern might suggest ceramics were fashioned at the same time in both areas, but following different procedures within each valley. The potstands therefore serve a potential direct link in the *chaîne opératoire*, from the raw material through the forming stage to the finished object, as they supply two, and sometimes three, possible identifiable local fabrics—the original pot and the adhering clay(s). Work with ceramic sherds and potstands recovered from 2003 testing and the more extensive 2004 excavations at the site strives to create a preliminary base from which investigations into the *chaînes opératoires* of ceramic manufacture and resultant questions concerning production might be launched.

Thin Section Petrography

> The importance of knowledge of the potter's materials is self-evident. The materials set limits within which the potter had to work and the status of the craft has to be judged within these limits. Furthermore, the potter's choice of materials and the ways in which she used them, together with form and style of decoration, are trademarks—our means, often powerful, of locating centres of production [Shepard 1965: xii].

In order to begin the study of ceramic manufacturing processes it is necessary to adopt techniques that provide greater insight into the physical materials (characterization of finished products) than is provided by traditional macroscopic type-variety systems. Thin section petrographic analysis is a geological technique employed to systematically describe, classify, and identify mineral and rock (Barclay 2001:9; Bishop et al. 1982:285; Gribble and Hall 1992:6; Rice 1987:376; Rye 1981:51–52; Shepard 1965:139; Tite 1999:195; Vince 2003). It is derived from the broader field of petrology and is concerned with the origin, occurrence, composition, and history of rocks, including both chemical and physical-optical characterizations (Rice 1987:376). The technique is not complex but requires time to prepare thin sections (or, less frequently, individual grain mounts [Rice 1987:381]), and to perfect identification skills. Even after many years of application this technique remains a qualitative and individual method that varies from practitioner to practitioner. For a brief history of the technique, see references in Bishop (1994) and Thompson (1991).

The application of petrographic analysis to pottery studies is hinged on a view of ceramics as "an anthropogenic low pressure meta-sediment... an artificial mudstone ... usually containing temper ... Typically this material is also geological, e.g., sand grains, shells or rock fragments" (Groom 2004; see also Rice 1987:376). Petrography is applied to ceramic analysis for a number of potential purposes including the description and classification of fabrics, identification of raw materials and paste recipes, prediction of raw material source-locations and manufacture locales, and technological studies (Barclay 2001:10; MacSween 1995:135). Each of these issues cannot always be successfully addressed, however, "in regions with a relatively complex igneous and metamorphic geology, it is often possible, in the case of coarse-textured pottery, to suggest the general area (or areas) from which the temper could have originated on the basis of petrographic description of the pottery fabric itself" (Tite 1999:196; see also Vince 1995:121). For an ideal example of ceramic petrographic analysis, see Shepard's (1936) work on the ceramics from Pecos in the southwestern United States in which she demonstrates that pottery previously believed to have been made locally had actually been traded in from neighbouring regions.

The Petrographic Process

Petrographic analysis initially involves the preparation of thin sections, a process involving the removal of a slice of the sherd perpendicular to the surface using a tile saw (Barclay 2001:9; Vince 2003). If the specimen is found to be brittle or friable, as is often the case with low-fired ceramics, it is impregnated with epoxy resin prior to fine grinding and polishing. The section (roughly 2 cm^2) is then glued to a frosted glass slide with epoxy and once dry, is ground to an ideal thickness of .03 mm (30 μm), and sealed with a thin cover slip using Canadian balsam sap that allows removal of the slip if desired (Barclay 2001:9–10; Shepard 1965:139).[2]

The prepared thin section is then placed under a polarizing microscope for examination. Light is directed to vibrate/travel in a single plane, rather than multiple planes as normal by passing through two polarizers (calcite prism reflectors) (Gribble and Hall 1992:1–4; Rice 1987:377–379). When the light is passed through both prism reflectors (the lower polarizer and the analyzer) the specimen is under a "crossed polarized" condition (Rice 1987:377).

Since mineral crystals are distinguished from each other by different internal and external morphologies (faces, planes, axes, cleavage points), the transmission of the polarized light through the various mineral crystals produces unique images, textures, and colours that can be interpreted by the analyst to produce an identification (Gribble and Hall 1992; Mason and Berry 1968:12; Rice 1987:376). There are several primary properties examined as a means of mineral identification: relief, pleochroism, and colouration (under plane polarized light); birefringence, twinning, and isotropism (under crossed-polarized light); and mineral features including cleavage, fracture, habit (shape), and degradation (Gribble and Hall 1992:6–15; Rice 1987:378–379; Whitbread 1986:79). Simple chemical staining of sections can also be used to differentiate between minerals of similar optic and petrographic appearance (e.g., calcite and dolomite) (Barclay 2001:9).

When dealing with ceramics, petrographic analysis serves to identify naturally occurring mineral/rock inclusions (aplastics) in the clay body and may also lead to the identification of intentionally added materials known as "tempers" (Barclay 2001:10). This technique serves an ideal middle-ground between macrovisual and compositional (elemental) analysis, thus shedding light on such issues as potting choices, raw material access, and paste recipes. Each aplastic type is identified, using the above mentioned characteristics, and is counted through either a technique known as "point counting" or an area percentage estimation. Research comparing the effectiveness of both, as well as grain size estimates, suggest little variation between results from each method (Friedman 1958).

For the petrofabric descriptions made in this study, I expressed aplastic abundance as a percentage of the total ceramic body (due to time constraints), achieved by visually comparing the aplastic grains present in the thin sections with prepared charts illustrating different percentages. Granulometry or textural analysis was performed by observing grain size, shape, degree of roundedness and sphericity, degree of sorting, and particle density for each aplastic type and determined by comparison with charts developed by sedimentologists (Figure 4). These characteristics can help to further distinguish different petrofabrics represented in a ceramic assemblage and may also provide clues concerning the geographic or geologic location of raw material sources and manufacturing centres as well as vessel function. Each description consisted of macroscopic detail (colour based on the subsurface margins of the sherds, believed to represent the "natural" clay colour [see Rye 1981:119]) and a petrographic description. Descriptions are modelled after those of Sunahara (2003).

Stages of Analysis

The following analysis addresses the question of pottery manufacture at Rancho del Rio during the Late Classic (650–900 C.E.) (for complete analysis results and interpretations, see Peuramaki-Brown [2004]). Petrographic analysis was chosen above other analytical techniques due to the large number of aplastics within the pastes. The analysis was composed of three stages, conforming to Arnold's three classes of data aforementioned.

Stage 1: Preliminary Identification (Arnold's Third Class)

Stage 1 consisted of the selection and petrographic description of 20 unslipped (utilitarian) ceramic sherds from four prominently represented paste groups within midden material at the site. The Cacaulapa, San Joaquin, Pueblo Nuevo, and Pitones paste groups were based on the type-variety-mode system employed by Urban and Schortman for the Valley of Cacaulapa (Henderson and Beaudry-Corbett 1993). The sample consisted of five jar rim sherds from each of the macrovisual paste groups. As differences in paste can occur between different parts of a vessel (e.g. the base versus the rim), only sherds of the same type (rims) were selected for the analysis. This ensured valid comparisons could be drawn when the sherds were observed microscopically.

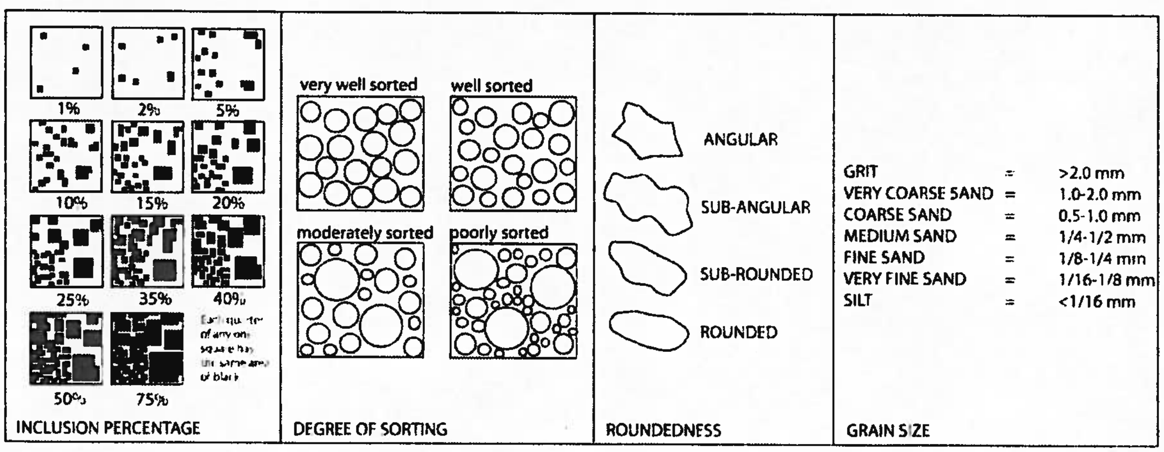

FIGURE 4. Granulometry visualization charts (redrawn from Groom 2004 based on various sedimentology source material; no associated figure or page numbers).

The sherds (including potstands mentioned below) were systematically selected from midden and occupation debris lots in Suboperation B. These lots were directly associated with the late Late Classic courtyard surface, which, in turn are associated with the middens identified in 2003. Each sherd was described macroscopically, illustrated, photographed, and thin sectioned. This sampling strategy was based on suggestions in Orton (2000) and Schneider (1995) for preliminary petrographic studies. Time constraints and available funding further restricted the number of samples analyzed. Petrofabric descriptions were conducted based on qualitative analyses: individual aplastic identification; aplastic abundance (as percentage); and granulometry (inclusion sphericity, size, and degree of sorting). Any changes due to firing were also noted.

Stage 2: Potstand Analysis (Arnold's First and Second Classes)

Stage 2 consisted of the petrographic analysis of clay globules on potstands from Rancho del Rio courtyard debris and middens. Thin sections were created from five identified potstand sherds (P1, P2, P3, P4, and P5) with globules representing two macrovisually different residues (large tan-coloured globules and a thinner less clumping grey residue) in an attempt to match this manufacturing waste to one or more of the identified petrofabrics.

Stage 3: Clay Sourcing (Arnold's Second and Third Classes)

The final stage consisted of attempts to identify the environment and/or sources from which the clays and possible tempers used in pottery manufacture at Rancho del Rio were obtained. Three clay sources were collected, based primarily on proximity to the site and ease of current access, and tested through briquette manufacture and open-pit firing: Source A consisted of an exposed clay bed on the west side of the Rio Cacaulapa, southeast of the site; Source B was an exposed clay bed from the north side of the Rio Chamelecón beneath the highway bridge south of the site; Source C was an open pit in an escarpment approximately 250 m northwest of the site on the opposite side of the main highway. The clay from this pit is currently mined as wash for *bajareque* (wattle and daub) houses. During Precolumbian times it was possibly used in a similar fashion, as well as in ceramic production. A fourth briquette included the crushed schist (possible temper) from courtyard and midden testing and excavations. Thin sections of each briquette were examined macroscopically and petrographically.

Results and Discussion

As is common practice, petrofabrics[3] are named for their most abundant inclusion (Sunahara 2003:187). As the five petrofabrics from Rancho del Rio have volcanic ash as their most abundant inclusion, I will use this rule for only three fabrics and will name the remaining two for their next most abundant inclusion that distinguishes these groups from the others. From the four type-variety paste groups represented in the Rancho del Rio ceramic sample, five petrofabric groups were identified using the aforementioned observation categories: Volcanic Ash 1 (VA1); Volcanic Ash 2 (VA2); Volcanic Ash 3 (VA3); Muscovite 1 (M1); and Muscovite 2 (M2) (Figure 5 and Table 1).

The clay bodies appear very similar in aplastic content, including volcanic ash and many fine particles of muscovite and polycrystalline quartz, and are likely

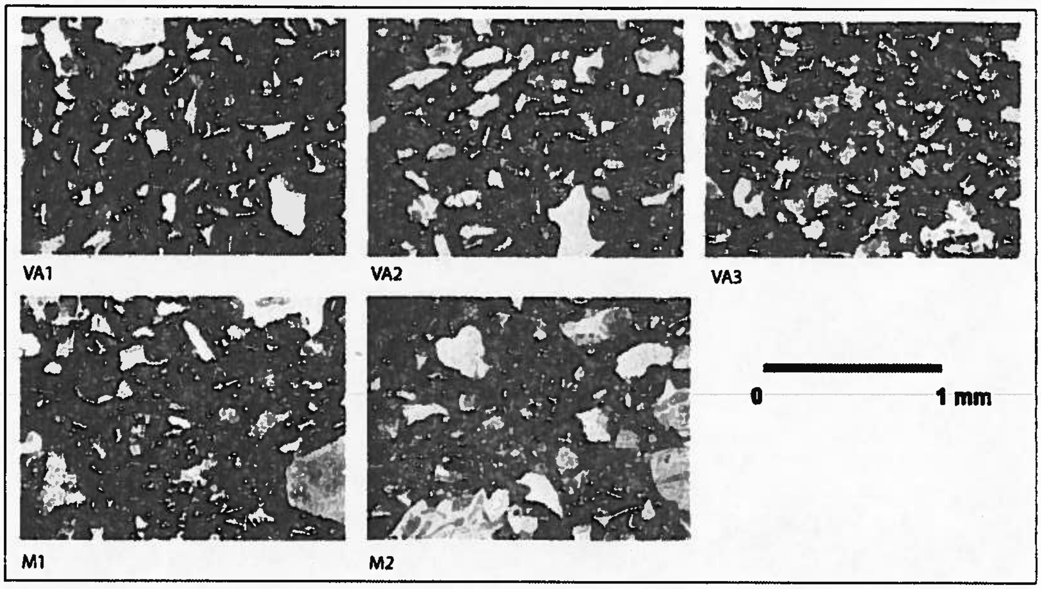

FIGURE 5. Rancho del Rio petrofabrics, plane polarized light 10x magnification (photographed by M. Peuramaki-Brown, 2004).

derived from similar environments. They are secondary in nature and likely of metamorphic and igneous origin, indicated by metamorphic and igneous rock fragments within the clay body (natural inclusions), volcanic ash, and polycrystalline quartz (MacKenzie and Adams 1994:48,153–155; MacKenzie and Guilford 1980:71). This would seem typical of river sediments in the area, particularly from the Chamelecón River, which has its headwaters in the igneous/volcanic and metamorphic highlands to the south. Unfortunately, good geological maps are not currently available for the valley (the creation of such a map would be a useful future project). Trace amounts of ash in current local clay deposits (discussed below) may be a result of the temporal nature of ash deposits as layers within clay sediments.

Petrofabrics

Although the aplastic content appears to represent a continuum, differences in ratios of aplastics, grain size, as well as shape, provide a rationale for the proposed division of the petrographic groups. All contain a high percentage of volcanic ash, though only VA1 appears to have ash temper. The "crisp" edges of the ash within the clay body, unlike the "blended" ash borders seen in VA2, VA3, M1, and M2, together with the great abundance of ash, lends credence to this premise (for similar observations, see Jones [1991:172]). Volcanic ash is a desirable inclusion because its low level of thermal expansion and irregular particle shapes allow for stronger bonds with clay (Arnold 1991:23–24). During the Late Classic throughout most of lowland Mesoamerica, volcanic ash is a highly favoured tempering material (Ford and Rose 1995). Therefore it is possible this temper addition is related to larger world-systems trends. Overall, VA1 is extremely homogenous when compared with the other petrofabrics in the sample. The relatively fine grain size of all inclusions and the abundance of volcanic ash suggest that this paste was carefully prepared, possibly by sieving the clay prior to manufacture and/or the addition of ash temper.

TABLE 1. Comparison of granulometric observations for each of the five petrofabrics.

Petrofabric	Aplastics	%	Shape	Sorting	Grain size
Volcanic Ash 1	volcanic ash	39	angular	well	fine to medium sand
	plagioclase	1	subrounded to subangular	poorly	very fine to medium sand
	gypsum	<1	subangular to angular	moderately	very fine to medium sand
	schist	<1	subrounded to subangular	poorly	very fine to coarse sand
	polycrystalline quartz	5	subangular to angular	poorly	very fine to coarse sand
	opaques	<1	rounded	well	fine to medium sand
	basalt	<1	subangular	moderately	medium to coarse sand
	chert	<1	subangular	moderately	medium to coarse sand
	muscovite	5	subangular	poorly	silt to medium sand
	grog	0			
	chlorite	0			
	pseudobone	1	angular	well	medium to coarse sand
	granite/gneiss	<1	subangular to angular	well	medium to coarse
Volcanic Ash 2	volcanic ash	32	angular	moderately	fine to coarse sand
	plagioclase	3	subangular	poor	very fine to coarse sand
	gypsum	1	subangular to angular	moderately	very fine to medium sand
	schist	3	subangular	poor	very fine to very coarse sand
	polycrystalline quartz	10	subangular to angular	poor	very fine to medium sand
	opaques	5	rounded	moderately	very fine to medium sand
	basalt	<1	subangular	well	medium to very coarse sand
	chert	<1	subrounded to subangular	well	medium to coarse sand
	muscovite	5	subangular	moderately-well	medium sand
	grog	1	angular	well	medium to coarse sand
	chlorite	0			
	pseudobone	3	angular	well	coarse sand
	granite/gneiss	<1	subangular to angular	well	medium to coarse
Volcanic Ash 3	volcanic ash	32	angular	moderately	fine to medium sand
	plagioclase	3	subangular	moderately	very fine to fine sand
	gypsum	1	subangular to angular	moderately	very fine to fine sand
	schist	3	subangular	poor	very fine to coarse sand
	polycrystalline quartz	8	subangular to angular	poor	very fine to fine sand
	opaques	2	rounded	moderately	very fine to medium sand

TABLE 1 continued.

Petrofabric	Aplastics	%	Shape	Sorting	Grain size
	basalt	<1	subangular	well	medium to very coarse sand
	chert	3	subrounded to subangular	well	medium to coarse sand
	muscovite	3	subangular	well	fine sand
	grog	<1	angular	well	medium sand
	chlorite	0			
	pseudobone	3	angular	well	medium to coarse sand
	granite/gneiss	<1	subangular to angular	well	medium to coarse
Muscovite 1	volcanic ash	25	angular	poorly	fine to very coarse sand
	plagioclase	1	angular	poorly	fine to coarse sand
	gypsum	<1	subangular to angular	moderately	fine to coarse sand
	schist	15	subrounded to angular	poorly	medium to very coarse sand
	polycrystalline quartz	15	subangular to angular	poorly	very fine to coarse sand
	opaques	7	rounded to subangular	moderately	very fine to medium sand
	basalt	<1	subrounded	well	coarse to very coarse sand
	chert	1	subrounded	poorly	fine to coarse sand
	muscovite	15	subangular to angular	moderately	fine to medium sand
	grog	2	subangular to angular	moderately	fine sand to grit
	chlorite	<1	angular	very well	coarse sand
	pseudobone	5	angular	well	coarse sand
	granite/gneiss	<1	subangular to angular	well	medium to coarse
Muscovite 2	volcanic ash	15	angular	moderately	very fine to medium sand
	plagioclase	2	angular	poor	fine to coarse sand
	gypsum	1	subangular to angular	moderately	fine to coarse sand
	schist	10	subrounded to angular	poor	fine to coarse sand
	polycrystalline quartz	10	subangular to angular	poor	very fine to coarse sand
	opaques	7	subrounded	moderately	very fine to medium sand
	basalt	<1	subrounded	well	coarse
	chert	1	subrounded	well	coarse to very coarse sand
	muscovite	10	subangular to angular	moderately	fine sand
	grog	<1	angular	moderately	medium sand
	chlorite	<1	angular	very well	fine to medium sand
	pseudobone	5	angular	well	coarse sand
	granite/gneiss	<1	subangular to angular	well	medium to coarse

VA2 and VA3 are similar to VA1 in their high content of volcanic ash and their relatively porous body; however, the ash in these petrofabrics is more similar to that of M1 and M2. The borders of the ash are blended making it appear to be a natural part of the clay. They also possess a slightly higher percentage of inclusions (other than ash) when compared with VA1, though less than the Muscovite petrofabrics. They are slightly coarser than VA1 and the lighter colour (7.5 YR 6/3 to 7/2, light brown to pinkish gray) of VA2 as compared with VA1 and VA3 (7.5 YR 6/4 to 5 YR 5/4 light brown to reddish brown) may be due to its higher content of muscovite and polycrystalline quartz. When fired, higher silica contents produce a cream-pink to light brown colour (de la Fuente 2004:6).

While the most abundant inclusion in M1 and M2 is volcanic ash, they differ significantly from their Volcanic Ash petrofabric counterparts in their very high content of muscovite mica, polycrystalline quartz, and micaceous schist. The presence, although small, of chlorite (likely part of the schist) also distinguishes these petrofabrics from the three Volcanic Ash pastes. The abundance of these three inclusions, as well as their more angular and coarse nature (characteristic of materials that have been ground up) when compared with the previous three petrofabrics suggest their possible addition as temper (Rye 1981:37).

During excavations in the courtyard, lumps of easily flaked low-grade metamorphic micaceous schist were recovered in association with other ceramic debris. Schist blocks were not used in the architecture of the valley, nor have known source outcrops been identified to date. The nearby Naco Valley does have schist sources and Precolumbian inhabitants used varieties of the stone in architectural construction. As is explained below, experimentation with the schist found at the site produced results similar to those observed in the Muscovite petrofabrics. The possibility of trade in schist between the two valleys is a subject that deserves future investigation. Finally, the differences in ratios of muscovite, polycrystalline quartz, and micaceous schist between M1 and M2 may account for the colour differentiation between the two petrofabrics, as it does between VA2 and VA3.

While grog (crushed, recycled sherds) could add strength to a vessel, due to the angular nature of the crushed particles, and would have been a readily available material at any ceramic manufacture location (Jones 1986:20), only a small amount was present in four of the five petrofabrics. These pieces were distinguished from other argillaceous inclusions by their angular shape, inclusions (similar to those of the identified petrofabrics, though the clay body appears different), and narrow interface between inclusion and clay body (a corona shaped void) (Jones 1986:20; Whitbread 1986). Although it is possible that only a small amount of grog was purposely added to these ceramic fabrics, perhaps for ritual purposes including the transference of *mana* (spiritual force) as suggested by L. Cecil for some lowland Maya censer pastes (personal communication), it is also possible that the addition of any grog was unintentional. For example, crushed bits of ceramic on work surfaces could have been accidentally kneaded into the clay bodies during preparation.

Potstands

When the potstand thin sections were examined (Figure 6), the thinner less

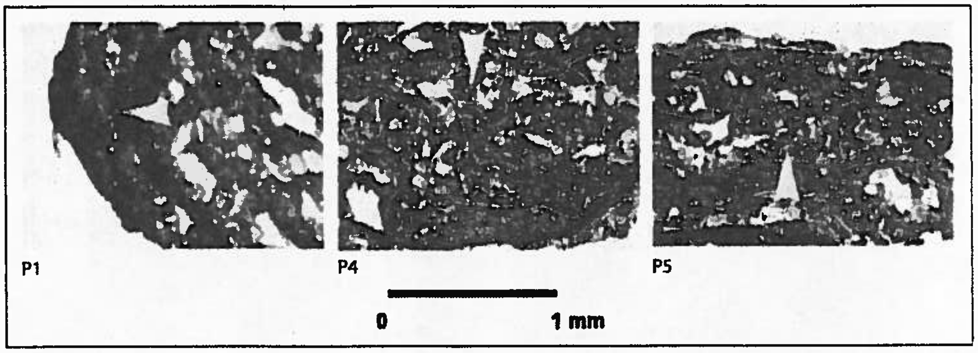

FIGURE 6. Rancho del Rio potstands with arrows indicating globule layers on exteriors, plane polarized light 10x magnification (photographed by M. Peuramaki-Brown, 2004).

clumped gray sediment found coating P1, P2, and P3 did not resemble any of the petrofabrics represented in the Rancho del Rio ceramic thin sections. Under the microscope, the residue appeared to be of silt size grains instead of clay. It is possible this silty residue was the result of past flooding in areas of the courtyard due to a rise in water levels in the nearby Chamelecón River. The high quantity of calcite in the silt might be related to the calcite observed in the clay sources analyzed from the valley and linked to the flow of the river through the Atima formation. P4 and P5 were much more typical in appearance for potstands with globules observed at other sites in the valley. The similarity of the exterior globules with two of the petrofabrics (VA2 and VA3 respectively) represented in the Rancho del Rio ceramic material suggest that manufacture was indeed occurring at the site; however, it is important to remember these are only preliminary studies and other potstands similar to those in this study should be analyzed before any firm conclusions are attained.

Clay Sources

Although none of the clay sources (Figure 7) analyzed were an exact match to the ceramic petrofabrics, primarily due to the presence of temper in the ceramics and lack of large volcanic ash percentages in the sources, some similarities were observed. Muscovite, polycrystalline quartz, micaceous schist, plagioclase feldspar, basalt, and gypsum are all rocks and minerals found in both the Rancho del Rio petrofabrics and the three clay sources. The lack of ash within the sources, except for a small amount in Source B, could be due to the spatial and temporal distribution of volcanic ash deposits (correct clay bed not sampled) and addition of volcanic ash as temper to ceramics. If sources from different geological times/periods are tested from the valley, it is possible volcanic ash deposits will be located within the sediments. The high content of calcite in all sources (absent in ceramics), likely due to river flow through the Atima formation, may also be a temporal characteristic. Overall, the particular minerals and rocks found within the clay sources (metamorphic and igneous/volcanic), as well as their angularity, suggest a possible match in environmental sourcing. However, there can be no definite conclusion drawn as analyses of more source and sherd samples are required.

When some of the easily flaked muscovite schist (a low-grade metamorphic)

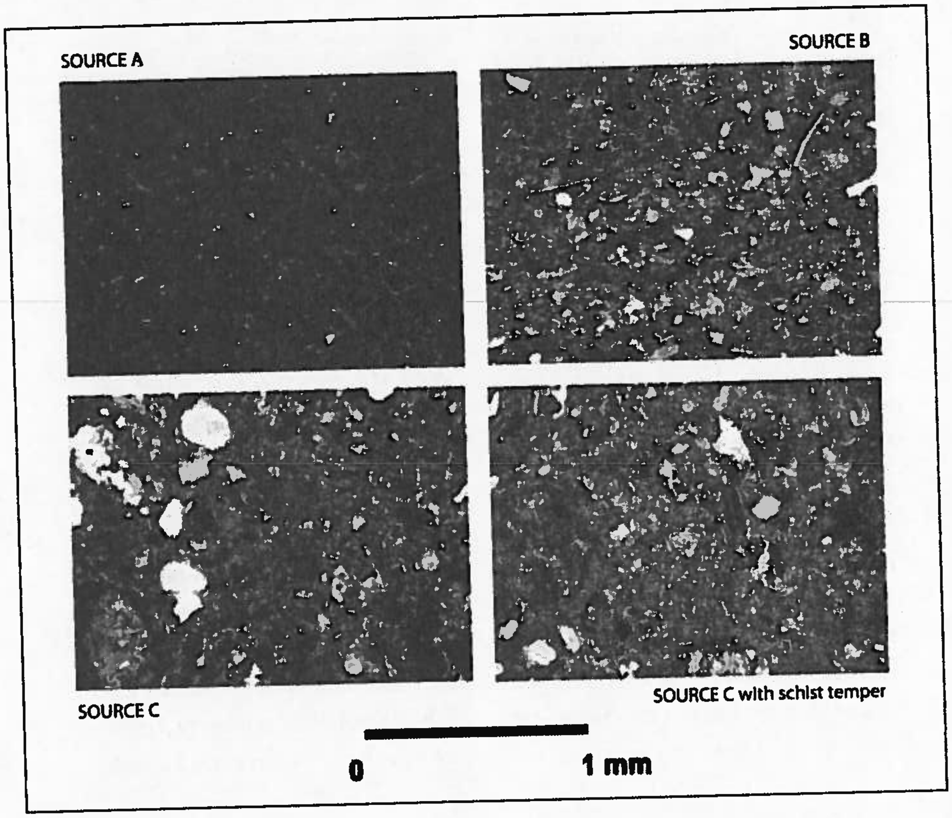

FIGURE 7. Clay sources tested, plane polarized light 10x magnification (photographed by M. Peuramaki-Brown, 2004).

that was recovered from courtyard excavations was crushed and added to a test briquette with Clay Source C, some interesting observations were made. The overall percentage of muscovite (common in schistose rock), polycrystalline quartz, and micaceous schist increased. Also present after the addition of the temper was chlorite, which is found primarily within the identified schist fragments.

Numerous observations indicate the addition of this material as temper by Late Classic potters. First, the presence of this rock associated with pottery sherds, possible ceramic manufacturing tools, and manufacture residue within the late facet of the Late Classic courtyard suggest associated use patterns. The absence of known outcropping in the valley and the lack of use of this type of rock in Late Classic valley architecture suggest an anomalous use pattern for such stone sources. Finally, the increased presence of muscovite, polycrystalline quartz, micaceous (muscovite) schist, and chlorite within two of the petrofabrics from the Rancho del Rio sample and the angular nature of these inclusions suggest the addition of schist temper.

Why schist was added, given that it has no known advantage in pottery manufacture, is uncertain. However, the additional "sparkle" that the muscovite in the schist provides may have been a desired characteristic, exemplified by other high micaceous content paste groups from the valley such as Joya, Monte Redondo, and Minitas (Pat Urban and Edward Schortman, personal communication 2004) and the specular hematite finishes on Coner ceramics at the nearby Maya city of Copan (Goodall et al. 2009). If we consider modern uses, muscovite (the predominant mineral in the RDR recovered schist) is frequently used in windows for high temperature ovens and as a heat and electrical insulator because it is fireproof and withstands extreme temperatures; ideal properties for many vessel types (Deer et al. 1997:1–35). Finally, the addition of the schist to Clay Source C also created a post-firing colour change (10 YR 7/6 yellow when wet, 7.5 YR 6/4 light brown post-firing) not observed in the briquette made only of Clay Source C (10 YR 7/6 yellow when wet, 7.5 YR 7/4 pink post-firing). The addition of the schist caused a colour change from a yellow to a light brown, similar to that observed in M1, M2, and VA2, all of which have more schist, muscovite, and polycrystalline quartz than the other petrofabrics.

Conclusions

Results from this study allow the initial "roughing out" of behavioural units and associated knowledge of the *chaînes opératoires* of ceramic manufacture at Rancho del Rio. The location and contents of middens associated with a number of house mounds and the central courtyard of the site suggest manufacture at a community level, versus individual households, perhaps similar to Stark's ethnographic/ ethnoarchaeological observations of "workshop production" (Stark 1983:160). Such a community level organization of ceramic manufacture might also suggest this activity was integral to the identity of the overall community, both economically and socially, within the larger valley system (Urban 2007:67).

Local river-derived clays beds were the likely source of materials for manufacture, suggesting a degree of knowledge of local environments and sediments. Based on similarities of content characteristics between petrofabrics and local sources, as well as ethnographic studies relating the close proximity of clay sources to vessel manufacture locations (Arnold 1971, 1985; Stark 1983:164), it is reasonable to assume clays were collected near the site with access to clay beds even being controlled by community residents. Clay Source C is currently mined as wash for *bajareque* (wattle and daub) houses and a cursory petrographic analysis of daub from archaeological contexts at the site conducted at the same time as the ceramics of this study shows similar characteristics to this particular source.

Formation of pots was achieved using potstands for at least two of the petrofabrics, and assisted by the use of opportunistic ceramic tools. The use of these specialized ceramic manufacture tools may also support a more specialized view of production for the community as opposed to the occasional firing of pots for individual use. The presence of all materials required for paste preparation and vessel shaping within the courtyard area also suggest unilocal manufacture.

Paste recipes appear very similar and were possibly prepared on hard multipurpose surfaces based on the occasional grog inclusions. Although similar, some recipes vary in terms of the degree of sifting and temper additions, based on observations of degrees of sorting of aplastics and non-local materials found in excavations and petrographic observations. These differences may be linked to individual potter's styles, desired vessel performance, or appearance. Regardless, it does suggest cognition of intended manufacture outcomes.

The presence of particular petrofabrics analyzed in this study at other sites in the valley may suggest exchange from this manufacture locale; however, ceramic manufacture is demonstrated for many other sites in the valley. Complementary petrographic data from other sites is required to further this discussion of individual community differences and roles. If fabrics are found to be manufactured at other rural hamlets, this may suggest that pottery manufacture was important to individual community identity at this time, as opposed to more overarching political entities that may control manufacture and link their identities to more specialized forms and iconography (or shared iconography on widespread forms), as has been suggested for the neighbouring Naco Valley (Schortman et al. 2001; Wells 2003). This would suggest two completely different but neighbouring strategies for political organization and manipulation in this region (Urban 2007:67). A comparison of pastes and manufacturing techniques from different sites might highlight a variety of manufacture and production scenarios, including the sharing or guarding of recipes between communities. Future work should also attempt to address any possible correlations between petrofabric pastes, macrovisual type-variety groups, and vessel form.

Research at the site of Rancho del Rio in the Valle de Cacaulapa, northwestern Honduras has the potential to uncover critical information concerning the *chaîne opératoire* of ceramic manufacture and production in this corner of the Mesoamerican world. Beginning such a study with the analysis of the final stage of manufacture is the most logical starting point. Although traditional type-variety systems of ceramic organization do provide useful information for the study of ceramics in general, more in-depth petrological information is required for the study of ceramic manufacture. Information derived from petrography can complement other forms of ceramic typologies and compositional analyses and might serve to answer questions previously unaddressed by other typological classifications.

This study covered three stages of petrographic analysis on ceramics and clays from the site and area of Rancho del Rio: 1) the creation of petrofabric groups based on 20 ceramic sherds; 2) the comparison of clay globules on manufacture potstands with the identified petrofabrics; and 3) the comparison of the petrofabrics with three clay sources from the valley. This three-stage approach allowed a preliminary glimpse at the various steps of the *chaîne opératoire* of manufacture of particular ceramic types at Rancho del Rio through the identification and analysis of Arnold's three classes of data. The results encourage future investigation into ceramic manufacture and production in this area of Mesoamerica where "typical" ceramic manufacture signatures are recovered (debris, tools, etc.) in addition to "atypical" remains (shaping and firing furniture). Further questions may address the trade of raw materials, such as the schist temper identified in this study, used in pottery manufacture in the valley, and the degree of production represented in the archaeological record, using petrography to examine the standardization of vessel form with petrofabric as well as the standardization of tool and potstand forms. Additional studies would also be encouraged in the comparison of Rancho del Rio petrofabrics and clay sources petrographically with those of other sites in the valley and in neighbouring valleys. The results would further contribute to our understanding of inter- and intra-valley relationships regarding ceramic production in this area, and possibly within Mesoamerica in general.

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Notes

1. Rice (1996:167) distinguishes between manufacture, "the actual act of fabricating ceramics", and production, "the social and economic organizational arrangements within which pottery manufacture is carried out."
2. Initial wet tile sawing, epoxy impregnation, and slide mounting was conducted by the author in the laboratories of the Institute of Archaeology, UCL. Final sample grinding to the .03 mm desired thickness and polishing was conducted by trained geological technicians.
3. The term petrofabric is used to describe ceramic samples that share similar characteristics when viewed under a petrographic microscope (Mason and Tite 1994:20; Sunahara 2003:187).

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