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Ceramic Production and Consumption in the Maya Lowlands During the Classic to Postclassic Transition: A Technological Study of Ceramics at Lamanai, Belize

VOLUME II

by

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CHAPTER 8

PETROGRAPHIC ANALYSIS OF THE TERMINAL CLASSIC TO EARLY POSTCLASSIC CERAMIC ASSEMBLAGE: COMPOSITIONAL AND TECHNOLOGICAL VARIABILITY AT THE MICROSCOPIC LEVEL

8.1. INTRODUCTION

Although ceramic studies have been carried out at several sites in northern Belize with occupations spanning the Classic to Postclassic transition, detailed technological analyses of site assemblages using scientific techniques, have not been carried out until the present work at Lamanai. As a result, current explanatory models regarding ceramic change at sites situated in this area of the lowland region have been built upon the limited physical evidence that macroscopic examination of pottery brings to light. At this level of analysis it is difficult to accurately assess the mineralogy of ceramic fabrics, to identify their raw material ingredients and to link raw materials to potential sources. Without this information it is often difficult to discriminate locally produced and imported pottery, to characterize local pottery technology and to examine change over time in the interplay between stylistic and compositional variability. This information is of fundamental importance to achieving reliable reconstructions of patterns in the production and consumption of pottery items across time and space. Building upon the patterns and trends that were identified in the previous chapter with regard to continuity and change in stylistic characteristics of the Lamanai assemblage, this chapter presents the results of the microscopic analysis of compositional variation relating to provenance and paste technology. Compositional groups identified through thin section analysis are described and discussed and their relationships to the functional and stylistic categories considered in previous chapters are investigated. Diachronic patterns in local raw material choice and manipulation are examined and temporal trends in the kinds and origins of foreign ceramics entering the site are identified.

8.2. General Composition of the Sample Set

A total of 646 vessels from the Terminal Classic to Early Postclassic assemblage were selected for petrographic analysis, representing 26% of the minimum of vessels recorded. This total includes all 152 of the whole and reconstructed vessels deriving from specialized deposits associated with architectural structures, 475 fragmentary vessels deriving from the temple middens associated with structures N10-27 and N10-9 and 18 different chalice base fragments recovered from the large smash-and-scatter offering covering the central stair of N10-9 (LA243) (Table 8.1). These chalice fragments were sampled in addition to the five reconstructed vessels recovered from this offering to examine compositional variation among stylistically similar vessels deposited at the same time as part of this comparatively large-scale offertory event.

As reported in Chapter 7, 96.1% (N=146) of the whole and reconstructed vessels are fine ware or serving/table ware and the remaining six are coarse ware vessels, including three large jars, a pedestal-based censer, a comal and a broad-rimmed deep bowl. Among the fragmentary vessels sampled from the midden associated with structure N10-27, 66.3% (N=232) are fine ware vessels and 33.7% (N=118) are coarse ware vessels, the large majority of which are large utilitarian storage jars (91.5%; N=108). Similarly, the majority of vessels sampled from the midden abutting N10-9 are serving vessels (71.4%; N=90), with storage jars representing the majority (63.9%; N=23) of the sampled coarse ware. Table 8.2 gives a breakdown of the vessels sampled for petrographic analysis from the two temple midden assemblages according to their surface treatment and form (see Table 6.7 for the breakdown for the whole and reconstructed vessel).

The disproportionately high representation of fine ware vessels within the sub-set of material sampled for petrographic analysis, considering that coarse ware and fine ware have near equal representation in the two temple middens, reflects the greater variability among the fine ware with regard to vessel surface treatment and morphology. Acknowledging this disparity between the compositions of the petrographic sample set vs. the actual assemblage, the observations reported in this chapter concerning diachronic patterns in the compositional characteristics of coarse ware vessels can be considered to be conservative.

Table 8.1: A breakdown of the petrographic sample set.

CONTEXT	Fine Ware Vessels		Coarse Ware Vessels		Total	
	count	**%**	**count**	**%**	**count**	**%**
Whole Vessels – various contexts	146	96.1	6	3.9	152	100
Fragmentary Vessels Smash-and-Scatter Offering N10-9 (LA243)	18	100	0	0	18	100
N10-9 Midden	90	71.4	36	28.6	126	100
N10-27 Midden	232	66.3	118	33.7	350	100
Grand Total	486	75.2	160	24.8	646	100

Table 8.2: Breakdown of the vessels sampled for petrographic analysis from the two temple midden assemblages according to their surface treatment and form.

SURFACE TREATMENT		FORM	LA 187		N10-27 All Lots	
			Count	**%**	**Count**	**%**
Polychrome Slipped and Painted		vases	0	0.0	4	1.1
		bowls	0	0.0	11	3.1
		tripod bowls	0	0.0	2	0.6
		composite silhouette dishes	0	0.0	2	0.6
	(interior slipped)	dishes	0	0.0	20	5.7
	Total		**0**	**0.0**	**39**	**11.1**
Black on Red Slipped and Painted	**Total**	massive bowls	**0**	**0.0**	**1**	**0.3**
Red-Orange-Black Resist	**Total**	composite silhouette dishes	**0**	**0.0**	**8**	**2.3**
Monochrome Black (all decorative treatments)		vases	0	0.0	4	1.1
		bowls	0	0.0	5	1.4
	Total		**0**	**0.0**	**9**	**2.6**
Monochrome Red Slipped		bowls	0	0.0	6	1.7
		jars	1	0.8	8	2.3
		composite silhouette dishes	0	0.0	13	3.7
		Chalices	0	0.0	2	0.6
	(interior-slipped)	Rounded bowls	0	0.0	10	2.9
		Rounded dishes	0	0.0	3	0.9
	Total		**1**	**0.8**	**42**	**12.0**
Monochrome Orange Slipped		composite vessels	1	0.8	0	0.0
		Sieve	1	0.8	0	0.0
		Vases	0	0.0	2	0.6
		Bowls	14	11.1	21	6.0
		tripod bowls	4	3.2	7	2.0
		Jars	19	15.1	13	3.7
		Drums	1	0.8	5	1.4
		plate/lid	1	0.8	0	0.0
		composite silhouette dishes	0	0.0	7	2.0
		Chalices*	3	2.4	14	4.0
		Pedestal basis	0	0.0	4	1.1
	(interior slipped)	Rounded bowls	0	0.0	1	0.3
		Rounded dishes	1	0.8	9	2.6
	Total		**45**	**35.7**	**83**	**23.7**
Monochrome Red to Orange	(interior slipped)	Rounded bowls	0	0.0	3	0.9
		rounded dishes	0	0.0	0	0.0
	Total		**0**	**0.0**	**3**	**0.9**

Table 8.2: Breakdown of the vessels sampled for petrographic analysis from the two temple midden assemblages according to their surface treatment and form (continued).

SURFACE TREATMENT		FORM	LA 187		N10-27 All Lots	
			Count	%	Count	%
Monochrome Orange Slipped and Incised		bowls	15	11.9	19	5.4
		tripod bowls	11	8.7	1	0.3
		pedestal-based jars	4	3.2	1	0.3
		jars	3	2.4	1	0.3
		drums	0	0.0	2	0.6
		frying pans	3	2.4	2	0.6
		whistles	1	0.8	0	0.0
		chalices	6	4.8	6	1.7
	Total		**43**	**34.1**	**32**	**9.1**
Monochrome Orange Slipped and Groove-Incised		drum	0	0.0	1	0.3
		vases	0	0.0	2	0.6
	Total		**0**	**0.0**	**3**	**0.9**
Monochrome Orange to Red Slipped - Notched and Incised	**Total**	composite silhouette bowls	**1**	**0.8**	**5**	**1.4**
Total Monochrome Orange with Appliqué	**Total**	bowls	**0**	**0.0**	**3**	**0.9**
Total Buff/Cream Slipped - Plain or Incised	**Total**	bowls	**0**	**0.0**	**2**	**0.6**
Total Monochrome Grey (Plumbate or Slate ware)	**Total**	pedestal base	**0**	**0.0**	**1**	**0.3**
Total Monochrome Red Slipped and Notched	**Total**	large bowls	**0**	**0.0**	**2**	**0.6**
Total Fine Ware			**90**	**71.4**	**232**	**66.3**
Slipped Rim/Lip - Smoothed Body	**Total**	jars	**1**	**0.8**	**29**	**8.3**
Red-Brown-Striated	**Total**	jars	**0**	**0.0**	**4**	**1.1**
Unslipped/Smoothed-Perforated	**Total**	Incense burners	**3**	**2.4**	**0**	**0.0**
Unslipped/Smoothed-Buff		jars	16	12.7	8	2.3
		plate/lid	4	3.2	0	0.0
		bowls	0	0.0	2	0.6
		broad rimmed bowl	0	0.0	1	0.3
	Total		**20**	**15.9**	**11**	**3.1**
Unslipped Utilitarian		jars	6	4.8	66	18.9
		plates/lids	6	4.8	7	2.0
Unslipped Utilitarian	**Total**		**12**	**9.5**	**73**	**20.9**
Unslipped and Incised (appliqué impressed fillet)	**Total**	Jar	**0**	**0.0**	**1**	**0.3**
Total Washed/smoothed	**Total**	jars	**0**	**0.0**	**1**	**0.3**
Total Coarse Ware			**36**	**28.8**	**118**	**33.7**
GRAND TOTAL BY CONTEXT			**126**		**350**	

Notes: * Includes samples from dish and base portions

8.3. FABRIC CLASSES, GROUPS AND SUBGROUPS

The petrographic analysis revealed seven main fabric classes, differentiated according to properties and characteristics of their groundmass and primarily by the composition and physical properties of their aplastic inclusions. These distinctions reflect basic differences in the types and/or combination of raw material ingredients that form the basis of these general paste categories. The classes, themselves, therefore, can be considered to reflect fundamentally different paste recipes in terms of the raw material ingredients involved. The main classes of fabrics recognised are:

- Crystalline Calcite-Tempered
- Dolomitic-Calcitic Marl-based
- Grog-Mixed Carbonate
- Quartz Sand
- Sascab
- Sascab-Quartz
- Volcanic Glass

Four of these general fabric classes sub-divide into fabric groups (Crystalline Calcite-Tempered, Dolomitic-Calcitic Marl-based, Sascab, Sascab-Quartz, Volcanic Glass). Distinctions at the group level primarily relate to differences in the mineralogy and composition of the clay component and/or added constituents (temper), as well as the textural properties and features of the fabrics. These distinctions reflect geologically significant differences in the compositional characteristics of the raw materials involved and, in some cases, the treatment or processing of the raw materials. Accordingly, fabric groups can be regarded as reflecting apparent differences in the geological associations of the specific raw materials chosen for use, as well as paste preparation techniques. Three of the fabric classes (Quartz Sand, Grog-Mixed Carbonate, and Sascab) contain only a single fabric group. The Quartz Sand and Grog-Mixed Carbonate classes, both of which are represented by a large number of vessels, are characterized by a high level of internal variability in comparison to the other fabric groups. The continuous and overlapping nature of the internal variation within these fabric classes, with respect to a range of compositional and textural characteristics, did not permit reproducible sub-divisions or 'groupings' below the class level. In contrast, the Sascab class, being represented by just two samples, is comparatively internally consistent. The discrimination of these fabrics at the class level underscores their compositional dissimilarity to other classes of fabrics in terms of the mineralogy of the raw material ingredients chosen for use.

Several of the fabric groups contain one or, in two cases, two subgroups. These subgroups are similar in most respects to the main group of fabrics to which they relate, except for one or two differences in the compositional characteristics or features of the groundmass. In most instances, these differences relate primarily to the added constituents of the fabrics, distinguished by the presence, in one or a few samples, of an additional tempering material such as grog. The subgroups highlight geologically or technologically significant variation within the fabric group, whilst underscoring the equally important characteristics that unite the group and distinguish it from other groups and classes.

The main fabric classes are summarised here, whilst detailed descriptions of their associated fabric groups, organized alphabetically by class, are presented in Appendix X.

8.3.1. Petrographic Characteristics of the Main Fabric Classes and Their Associated Fabric Groups

8.3.1.1. CRYSTALLINE CALCITE-TEMPERED

The Crystalline Calcite-Tempered class represents 27.2% (N=176) of the sample set, comprising 10 fabric groups which can be characterized as calcareous clays tempered with freshly crushed crystalline calcite (Table 8.3 and Figures 8.1 and 8.2). The groups are distinguished primarily by reference to the mineralogy of their fine and coarse fractions, as well as by their textural properties. Calcite C is particularly distinctive, as these fabrics also contain added micrite (or sascab temper) deriving from a parent material that is clearly independent of the accompanying crystalline calcite. These fabrics thus contain two tempering materials. Four of the calcite-tempered fabric groups (Calcite A, B, C and H) are consistent geologically with raw material resources available in the immediate vicinity of the site. In the case of Calcite H, the presence in some fabrics of possible organic temper and calcite mosaics containing chalcedony is suggestive of differences in paste recipes that may reflect the work of different potters and, possibly, differences in the origin of these ceramics. This group, therefore, likely contains both locally produced and non-local vessels. Another distinctive feature of the local calcite-tempered fabric groups is that they each contain a petrographic subgroup distinguished by the presence of grog temper.

Table 8.3: Summary of mineralogy, distinguishing features, paste technology and provenance of the fabric groups comprising the Crystalline Calcite-Tempered class.

Fabric Group	Inclusions (in order of abundance)	Distinguishing Features	Paste Technology	Associated Provenance
A	calcite, qtz, cc-fc calcite mosaics R-VR =- micrite, pqtz, chal, chert	- angular, rhombic to irregular-shaped fragments of calcite - rare to very rare micrite and calcite mosaics	a calcareous clay, containing few siliceous inclusions tempered with colourless, coarsely crystalline calcite	*local* – similarities to clays that form directly below the ground's surface at the site
Petrographic subgroup – grog tempered variant				
B	calcite, fc-cc calcite mosaics, qtz, micrite VR = pqtz, chal, chert	-bimodal (calcite predominate lower mode) - grainy appearance (discrete calcite grains dominate the matrix) - common mosaics of finely to coarsely crystalline calcite Very few to rare micrite lumps	a calcareous clay containing discrete calcite grains, and lesser quantities of other minerals, tempered with and finely to coarsely crystalline calcite	*local* - similarities to clays at the site that are associated with weathering limestone
Petrographic subgroup – grog tempered variant				
C	calcite, micrite, fc-cc calcite mosaics, qtz VR = pqtz, chal, chert.	- grainy appearance (discrete calcite grains dominate the matrix) - common micrite inclusions, calcite mosaics	a calcareous clay containing discrete calcite grains, and lesser quantities of other minerals, tempered with sascab and finely to medium crystalline limestone	*local* - similarities to clays at the site that are associated with weathering limestone
Petrographic subgroup – grog tempered variant **Petrographic subgroup i** – distinguished due to the highly micritic clay matrix				
D	calcite, mc-cc calcite mosaics, micrite, qtz VR = qtz with microlites etc., pqtz , chal, chert, shell, oolites	- shell fragments - quartz containing microlites, vacuoles and fragments of volcanic glass, and calcite mosaics containing these inclusions	a calcareous clay containing shell fragments and rounded siliceous inclusions tempered with a white, sugary textured, medium to coarsely crystalline calcite (containing distinctive quartz)	*non-lcoal?* – similarities to samples local Yalbac clays analysed, but rare shell fragments are distinctive. The temper is non-local

Table 8.3: Summary of mineralogy, distinguishing features, paste technology and provenance of the fabric groups comprising the Crystalline Calcite-Tempered class (continued).

Fabric Group	Inclusions (in order of abundance)	Distinguishing Features	Paste Technology	Associated Provenance
E	calcite, mc&fc calcite mosaics, micrite, qtz VR – qtz and pqtz with microlites etc, finely crystallized pqtz, oolites	- mono- and polycrystalline quartz containing microlites, volcanic glass frags. and vacuoles - co-occurrence of angular and rounded, equant calcite grains	A calcareous clay containing carbonate sand (rounded inclusions of calcite and micrite) and quartz tempered with a white, sugary-textured medium crystalline and finely crystalline calcite	*non-local* - presence of carbonate sand in the clay component suggests a connection to areas adjacent to the north east coast of northern Belize, extending into the Yucatan (stylistic links well-known to Yucatecan wares)
F	calcite, mc calcite mosaics, micrite, qtz R-VR= finely crystallized pqtz with microlites etc.,chert, chalcedony	- well-sorted - contain several different types of siliceous inclusions -finely crystallized polycrystalline quartz containing microlites, volcanic glass frags and chalcedonic quartz co-occurrence of rounded and angular calcite inclusions	A calcareous clay containing carbonate sand (rounded inclusions of calcite and micrite) and siliceous inclusions, tempered with a white, sugary-textured medium crystalline calcite	*non-local* - presence of carbonate sand in the clay component suggests a connection to areas adjacent to the north east coast of northern Belize, extending into the Yucatan
G	calcite, , vcc-cc calcite mosaics, qtz VR pqtz, chal, mudstone (?)	- angular, rhombic to irregular-shaped inclusions of crystalline calcite - few to common ferromanganiferrous nodules (Acfs) - calcite mosaics containing chalcedony	a calcareous clay containing few to common ferromanganiferrous nodules and a small quantity of quartz, tempered with colourless, coarsely crystalline to very coarsely crystalline calcite containing chalcedony	*non-local* – composition, mineralogy and textural properties of clay component suggest a connection to deep clay beds overlying horizons of weathering limestone west of the New River
H	calcite, qtz, mc-cc mosaics, micrite R-VR= pqtz, chal, clino, shell	- bimodal (calcite predominates upper mode) - large, angular to irregular-shaped inclusions of crystalline calcite - greater quantity and comparatively large siliceous inclusions - presence of carbon residues in some samples Variation in the frequency, presence/absence of inclusion types (particularly siliceous)and the roundness of siliceous inclusions	a calcareous clay containing a significant quantity of siliceous rock and mineral inclusions tempered with colourless, medium to coarsely crystalline calcite. Some samples may also have organic temper. In sample 504 calcite mosaics contain chalcedony	*local and non-local*- general similarities to clays that form directly below the ground's surface at the site fabrics. Samples containing a greater quantity of chalcedony and polycrystalline quartz may derive from quartzy-calcareous soils situated between the eastern coast and the New River.
Petrographic subgroup – grog tempered variant				

Table 8.3: Summary of mineralogy, distinguishing features, paste technology and provenance of the fabric groups comprising the Crystalline Calcite-Tempered class (continued).

Fabric Group	Inclusions (in order of abundance)	Distinguishing Features	Paste Technology	Associated Provenance
I	calcite, qtz R-VR=pqtz, micrite, chert, feldspar	- common distinctive ferromanganiferrous nodules - fine feldspar inclusions in the clay component	a calcareous clay containing common, and often large-sized, ferromanganiferrous nodules and a small quantity of quartz, chert, feldspar and perhaps calcite, tempered with crystalline calcite	*non-local* - dissimilarity to fabric groups that are generally consistent with the geology of northern Belize suggest that this group's provenance lay outside of this general region. The mineralogy of the fabric suggests a connection to areas underlain by limestone.
J	calcite, micrite containing calcite and ferrous nodules etc., qtz, mc-cc cacite mosaics, silicified limestone/mudstone, limestone R=pqtz	- frequent lumps of micrite that are rusty-brown in colour and contain grains of cryatalline calcite and ferrous nodules and segregations - presence of fragments of silicified limestone and limestone fragments comprising micrite, crystalline calcite and silicified limestone/mudstone - common ferrous nodules and segregations in the clay component	a calcareous clay containing quartz, tempered with limestone	*non-local* - the presence of silicified limestone/mudstone suggests a connection to the Orange Walk Group formation prevalent in areas north of the New River Lagoon, which characteristically contain a lithified carapace

Key for Tables 8.3 – 8.6
R = rare; VR = very rare; qtz = quartz; pqtz = polycrystalline qartz; cc = coarsely-crystalline;
fc = finely-xrystalline; mc = microcrystalline; chal = chalcedony; clino = clinopyroxene;
dol. = dolomitic; ortho = orthoclase; plagio = plagioclase; vg = volcanic glass; frags = fragments

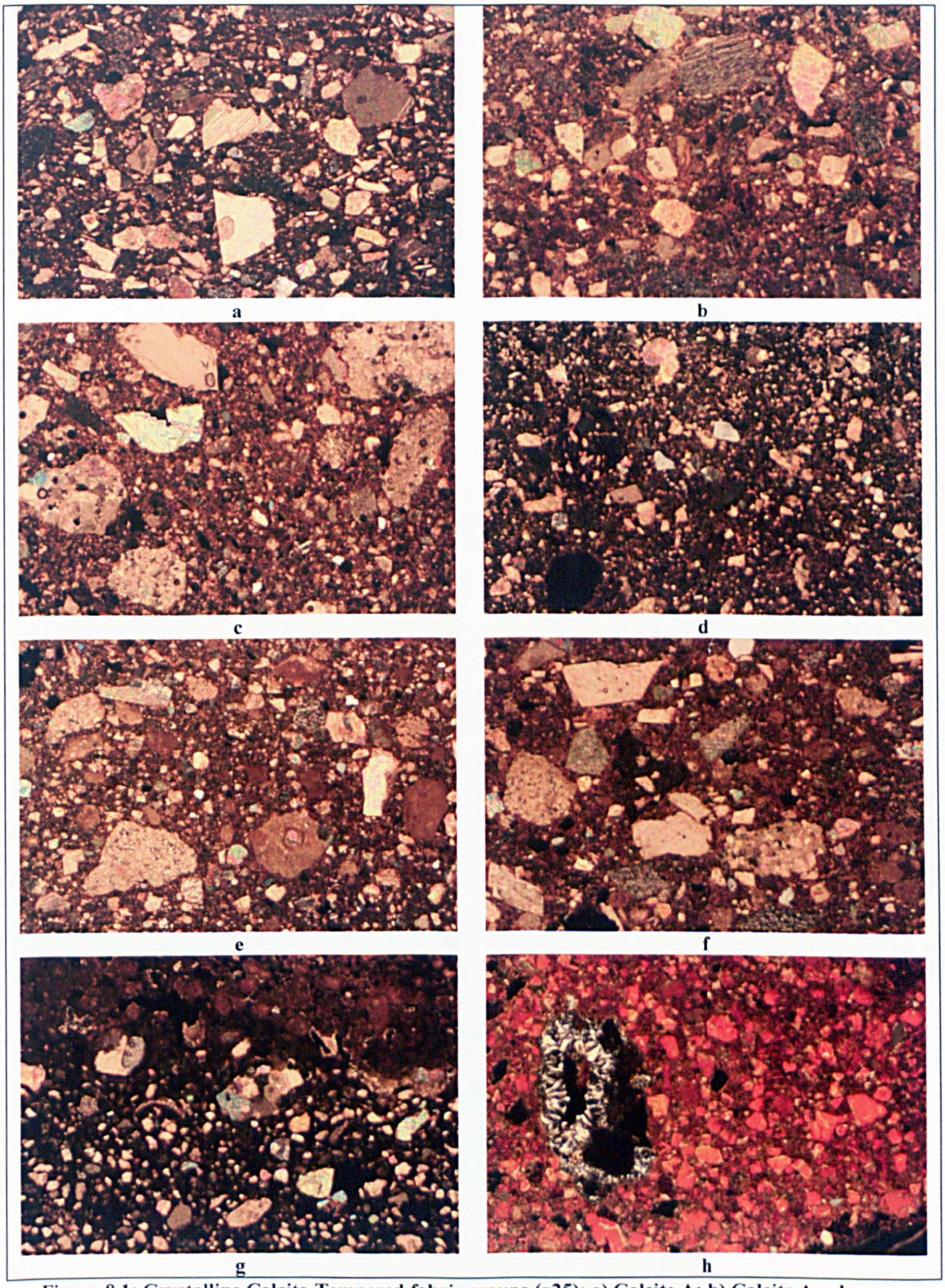


Figure 8.1: Crystalline Calcite-Tempered fabric groups (x25): a) Calcite A; b) Calcite A subgroup – grog-tempered variant; c) Calcite B; d) Calcite B subgroup – grog-tempered variant; e) Calcite C; f) Calcite C subgroup – grog tempered variant; g) Calcite D; h) Calcite E (crystalline calcite inclusions are stained pink). Field of view = 3mm.

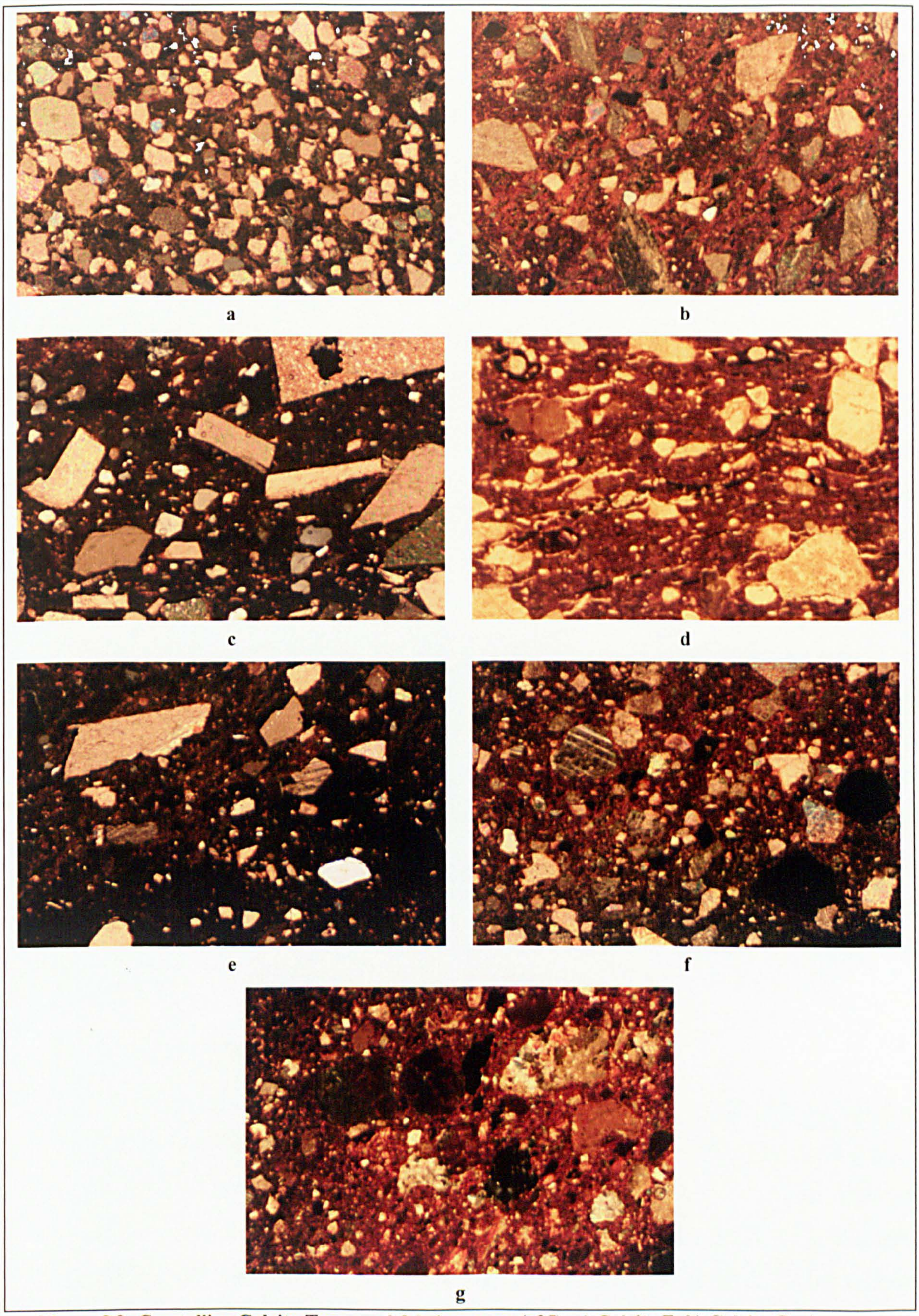


Figure 8.2: Crystalline Calcite-Tempered fabric groups (x25): a) Calcite F; b) Calcite G; c) Calcite H; d) Calcite H containing possible organic temper; e) Calcite H subgroup – grog-tempered variant; f) Calcite I; g) Calcite J. Field of view = 3mm.

Of the six remaining fabric groups within the Crystalline Calcite-Tempered class at least five clearly derive from non-local raw materials (Calcite E, F, G, I and J). A non-local provenance for Calcite D is less certain since the calcite temper has features which suggest a non-local provenance, whilst the clay component is generally consistent with clays available in the immediate vicinity of the site. Since the ceramics in group D overlap stylistically with those that occur in the calcite-tempered groups for which a local provenance is fairly certain, a non-local provenance for Calcite D cannot simply be assumed. The different calcite temper in Calcite D fabrics might also reflect the work of different potters or the use of slightly different raw materials over time.

The geological characteristics of all calcite-tempered groups designated non-local, with the exception of Calcite I, indicate connections to inland areas of northern Belize, where calcareous soils directly overlay Tertiary limestone and, possibly, to soils and rock formations located further to the northeast and extending into the Yucatan area of Mexico. Calcite I and J, which are each represented by only one sample, are compositionally unique within the sample set as a whole. Calcite J is distinguished by the large amount of Fe-oxides, in the form of nodules, staining and segregations, in addition to the presence of silicified limestone. These inclusions suggest a connection to the Orange Walk Group formation prevalent in areas north of the New River Lagoon, which characteristically contains a lithified carapace. The main distinguishing feature of Calcite I is the presence of distinctive amorphous concentration features (ACFs) in the clay component. Since similar ACFs were not observed in any of the other fabrics analysed, the compositional uniqueness of this vessel may indicate a provenance outside the general area to which other crystalline calcite-tempered ceramics are geologically connected.

8.3.1.2. DOLOMITIC-CALCITIC MARL-BASED

Representing 4.8% (N=31) of the sample set, the Dolomitic-Calcitic Marl-based class comprises four fabric groups characterized by a fine-textured, well-sorted groundmass dominated by dolomitic to calcitic grains (Table 8.4, Figure 8.3). The frequent inclusions and the textures of these fabrics links them to sandy-textured marls associated with weathered limestone, dolomitic limestone and dolomite. Their texture suggests a basic untempered clay, perhaps highly processed to achieve the uniform, fine texture. The four groups within this class are distinguished by their mineralogy, and by the form of the calcite, partially dolomitized, and dolomite grains, particularly their crystallinity.

Table 8.4: Summary of mineralogy, distinguishing features, paste technology and provenance of the fabric groups comprising the Dolomitic-Calcitic Marl-based class.

Fabric Group	Inclusions (in order of abundance)	Distinguishing Features	Paste Technology	Associated Provenance
A	dolomite and dolomitic grains and mosaics, qtz, chert, chal, finely crystallized pqtz, calcite, VR=- feldspar dol. limestone	- well sorted, unimodal, fine-textured groundmass - cryptocrystalline, rhombic gains of dolomite dominate the groundmass -siliceous inclusions are comparatively rare	sandy-textured marl deriving from weathered dolomite, likely untempered and perhaps highly processed to achieve the uniform, fine texture	*non-local* – associated with clays that form in association with horizons of weathering dolomite. Likely connected to dolomite present in east and northeast northern Belize (Cayo Group?). Fabrics are similar to the numerically dominant fine ware fabric at Late Classic Altun Ha.
Petrographic subgroup – distinguished due to greater quantity of crystalline calcite present (common)				
B	calcite, qtz, micrite R-VR = cc calcite mosaics feldspar(ortho),pqtz, chal, chert, amphibole, micrite	-well sorted, unimodal - cryptocrystalline, rhombic gains of calcite dominate the groundmass -siliceous inclusions are comparatively rare and small-sized	sandy-textured highly calcareous marl, likely untempered and perhaps highly processed to achieve the uniform, fine texture	*non-local* – associated with coastal deposits containing calcareous sands mainly consisting of cryptocrystalline grains composed dominantly of micrite in northeastern northern Belize, extending into southern Yucatan
Petrographic subgroup – grog tempered variant				
C	calcite, dolomite, dolomitic grains, qtz, micrite, mc mosaics of the above VR =shell, anhydrite	- well sorted, unimodal - equant to irregular-shaped of crystalline calcite and dolomite dominate the groundmass - rounded quartz inclusions - comparatively greater quantity of quartz 152 contains grog	sandy-textured dolomtic marl containing quartz sand, likely untempered and perhaps highly processed to achieve the uniform, fine texture	*non-local* – associated with coastal deposits adjacent to the northeast coast of northern Belize, extending into southern Yucatan and adjacent areas, where sandy marls overly dolomitic limestone (Cayo Group?)
D	calcite, dolomite, dolomitic grains, qtz, micrite, cc & fc mosaics of the above VR = qtz & pqtz containing vacuoles, pqtz, chert, chal feldspar	- well sorted, unimodal - equant to irregular-shaped of crystalline calcite and dolomite dominate the groundmass - both coarsely and finely crystalline aggregates are present - presence of distinctive quartz and polycrystalline quartz containing vacuoles and Fe-oxide residues	sandy-textured dolomtic marl containing a small quantity of siliceous rock and mineral inclusions, likely untempered and perhaps highly processed to achieve the uniform, fine texture	*non-local* – associated with clays that form in association with horizons of weathering dolomitic limestone in coastal and adjacent areas of northern Belize - possibly connected with Cayo Group formation (?).

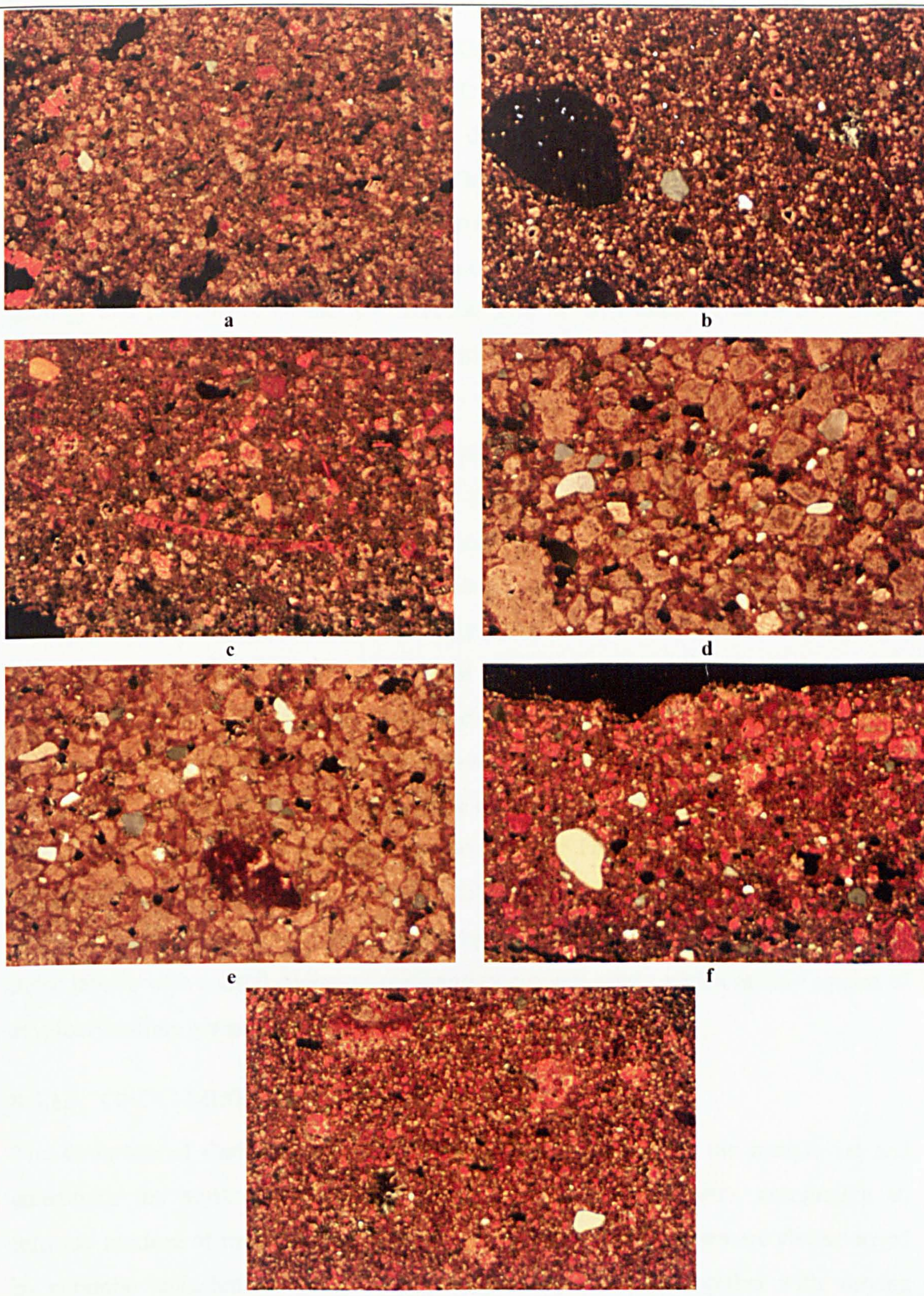


Figure 8.3: Dolomitic/Calcite Marl-based fabric groups (x25): a) Marl A (crystalline calcite inclusions are stained pink); b) redced Marl A fabric (crystalline calcite inclusions are stained pink); c) Marl A subgroup showing more frequent crystalline-calcite inclusions (stained pink) and shell fragments; d) Marl B; e) Marl B subgroup - grog-tempered variant; f) Marl C (crystalline calcite inclusions are stained pink); g) Marl D (crystalline calcite inclusions are stained pink). Field of view = 3mm.

For example, the fabrics in group A are dominated by rhombic cryptocrystalline grains of dolomite, whereas the fabrics in Group B are dominated by rhombic, cryptocrystalline calcite. Groups C and D comprise dolomitic fabrics, containing predominantly equant grains of calcite and dolomite, as well as partially dolomitized grains, and crystalline grains predominate. Group C fabrics are further distinguished by a greater quantity of quartz and other siliceous rock, and Group D, by more frequent polycrystalline quartz and dolomitic mosaics. These differences clearly relate to the geology and provenance of the raw material used in each case. Two of the groups contain fabrics tempered with grog, and in the case of group B these fabrics are distinguished as a petrographic subgroup.

The presence of dolomite and dolomitic inclusions in three of the marl-based fabric groups (A, C and D) clearly differentiates these fabrics geologically from local raw material resources, indicating these ceramics were not produced locally. Group B fabrics also appear to be non-local, based on the physical properties of the distinctive micritic inclusions they contain. The geology of the dolomitic marl-based fabric groups indicates a connection to the northeast coast of northern Belize and southern Yucatan and adjacent areas, including the lower reaches of the New River, where sandy marls overlie dolomite and dolomitic limestone (most likely of the Tertiary Cayo Group). It is noteworthy that Group A fabrics are striking similar to the numerically dominant fabric type associated with fine wares at Late Classic Altun Ha (Howie et al. 2004; Howie-Langs 1999), suggesting that the similar fabrics at Lamanai might derive from this particular area of northern Belize. The compositional properties of group B associate these fabrics with coastal deposits containing calcareous sands, which mainly consist of cryptocrystalline grains composed dominantly of micrite.

8.3.1.3. GROG-MIXED CARBONATE

The Grog-Mixed Carbonate class represents 35.4% (N=229) of the sample set and constitutes the most technologically complex of the fabric classes, comprising an intricate mixture of multiple raw material ingredients. These fabrics are characterised by common inclusions of grog, or crushed pottery, occurring together with varying amounts of micrite, crystalline calcite (mosaics, discrete grains and spar fragments) and quartz, and can generally be described as constituting calcareous clay tempered with grog, varying amounts of sascab, crystalline calcite and perhaps, sand (Table 8.5 and Figures 8.4 and 8.5). There is considerable variation across this class with regard to the compositional characteristics and physical properties of the groundmass.

Table 8.5: Summary of mineralogy, distinguishing features, paste technology and provenance of Grog-Mixed Carbonate, Quartz Sand, Sascab and Sascab-Quartz classes.

Fabric Group	Inclusions (in order of abundance)	Distinguishing Features	Paste Technology	Associated Provenance
Grog-Mixed Carbonate Class	micrte, qtz, calcite, finely crystalline calcite mosaics, pqtz, chal, chert, limestone frags. VR=feldspar, amphibole, shell	- common grog inclusions - co-occurrence of grog lumps of micrite and fragments and mosaics of crystalline calcite - comparatively fine-textured - high internal variation - distinctive firing horizons and commonly optically inactive to slightly active	a calcareous clay tempered with grog and varying amounts of sascab and crystalline calcite. The comparatively fine texture of the groundmass indicates a careful or more rigorous processing of raw materials.	*local* – connections to Yalbac clays, both those that form directly below the ground's surface and those associated with horizons of weathering limestone, as well as Filipe Subsuite clayey soils associated with wash deposits of Pleistocene alluvium situated on the north side of the site
Subgroup A – variant with a highly micritic clay and containing comparatively less and larger grog inclusions. Petrographic similarities to Sascab-Quartz A **Subgroup B** – variant distinguished by the distinctive composition of the grog it contains. The dominant type of grog is composed on fine grains of calcite or dolomite. This grog is petrographically similar to fabrics of Dolomitic-Calcitic Marl-based A, which may suggest a non-local provenance for this vessel.				
Quartz Sand Class	qtz, pqtz, chert, feldspar (alkali and plagio), VR= sandstone, micrite, olivine, clino, shell, amphibole, gypsum, calcite	- predominant siliceous inclusions occurring together with igneous-related accessory minerals - very rare, and predominantly absent carbonate inclusions high internal variation	Sandy low to non-calcareous clay, possibly tempered with sand in some cases.	*local and non-local* – multiple different provenances. Consistent with clayey soils that form in association with deep deposits of Pleistocene alluvium that occur throughout northern Belize. Some fabrics are virtually identical to the clay samples taken from the area of Pleistocene alluvium (Boom Subsuite soils) situated directly east of Lamanai, across the New River Lagoon, suggesting local manufature. Fabrics containing greater amounts of chert and chalcedony likely derive from flinty clays associated with alluvial deposits situated between the coast and the Northern Lagoon drainage system. Fabrics containing comparatively fewer inclusions that are comparatively well-sorted and rounded, shell and micrite mostly likely derive from clays associated with waterways.
Subgroup – crystalline calcite-tempered variant				

Table 8.5: Summary of mineralogy, distinguishing features, paste technology and provenance of Grog-Mixed Carbonate, Quartz Sand, Sascab and Sascab-Quartz classes (continued).

Fabric Group	Inclusions (in order of abundance)	Distinguishing Features	Paste Technology	Associated Provenance
Sascab Class	micrite, calcite, mosaics of finely crystalline calcite VR, qtz, shell, limestone (comprising micrite and fc calcite aggregates)	- bimodal (micrite lumps comprising upper mode) - inclusion types other than micrite of crystalline (and fine grains) - highly micritic matrix	highly micritic clay with rare vary fine inclusions of quartz tempered with sascab	*non-local* – predominance of fine inclusions of micrite and crystalline calcite in the clay component suggests a connection to clays that form in association with horizons of weathering limestone. Since the clay contains very little quartz, and the sascab temper contains none, an association with Cretaceous limestone is suggested. Cretaceous limestone outcrops at three principal locations north of the Maya Mountains: below an escarpment situated west of the southern end of the Rio Bravo, below the Booth's River escarpment, and along the western edge of the New River Lagoon
Sascab-Quartz Class				
Sascab-Quartz A	qtz, micrite, calcite, pqtz R-VR=pqtz, chal, feldspar (alkali and plagio), amphibole, clino, shell, oolites	- dominant to common quartz inclusions - frequent to few lumps of micrite - very rare amphibole, clinopyroxene and feldspar	a sandy calcareous clay, tempered with sascab	*local* - similarities to clay associated with wash deposits of Pleistocene alluvium situated at the north side of the site adjacent to Barber Creek(Filipe Subsuite). The sascab temper is compositionally and visually identical to samples taken from the outcrop southwest of the central precinct. This sascab is associated with cretaceous limestone
Subgroup – grog tempered variant characterized by a comparatively fine-textured groundmass				
Sascab-Quartz B	qtz, micrite, fc calcite mosaics, chal, chert, feldspar (ortho) R-VR= pqtz, biotite and sandstone	clay matrix is brick-red in colour presence of biotite and sandstone fragments micrite lumps contain finely crystalline calcite aggregates, quartz and biotite	a sandy calcareous clay containing biotite tempered with sascab comprising micrite, finely crystalline calcite, quartz and biotite inclusions	*Non-local-* The clay component is consistent with Xaibe Subsuite soils that overly Orange Walk Group limestone in the Corazal District, between the Rio Hondo and Corozal Town. The presence of the quartz inclusions, their quantity and roundness suggests an association with alluvial deposits. The presence of quartz inclusions in the micrite lumps suggests a connection to sascab associated with the Tower Hill or Orange Walk Group limestones characteristic of areas to the north of the New River Lagoon.

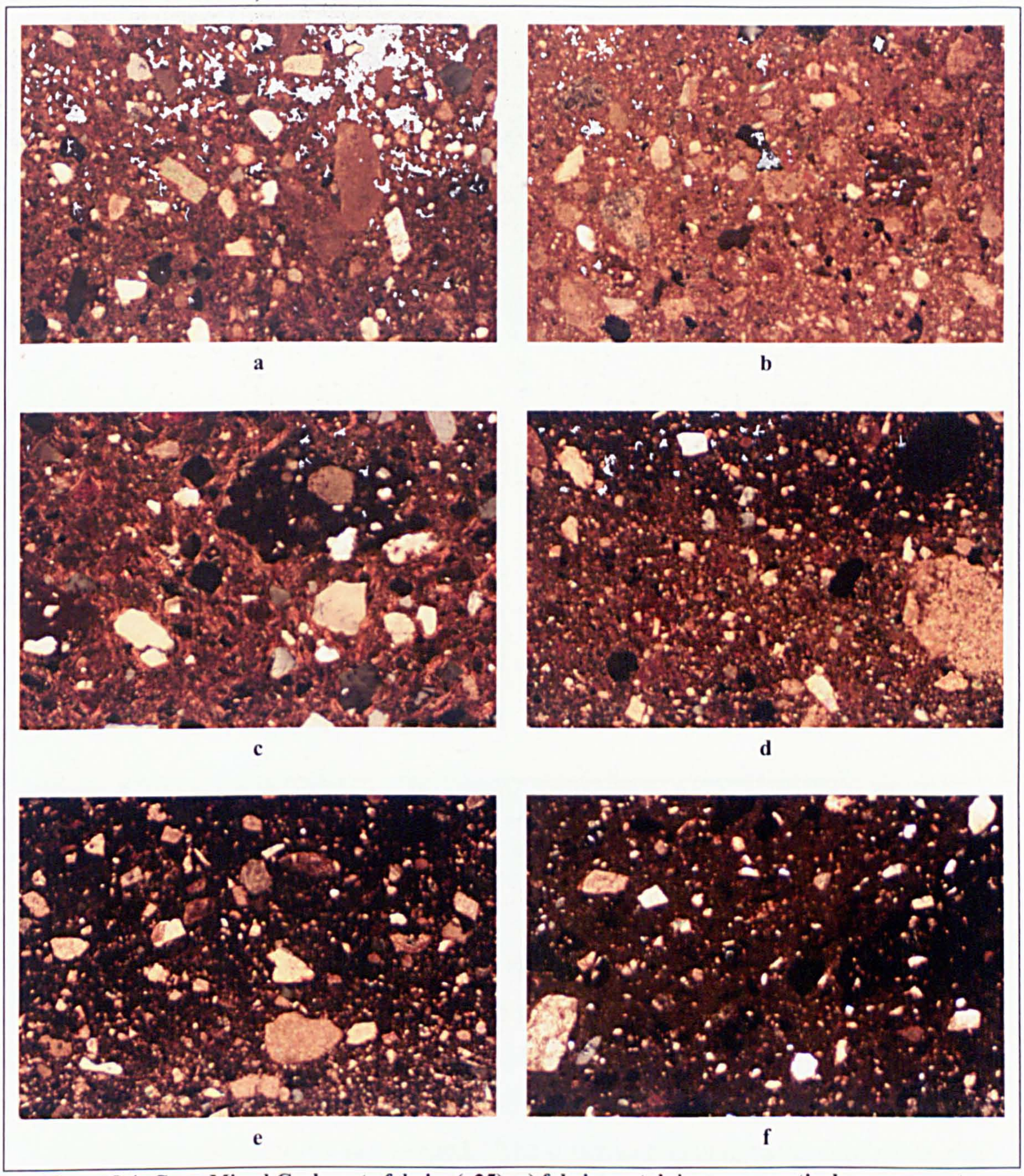
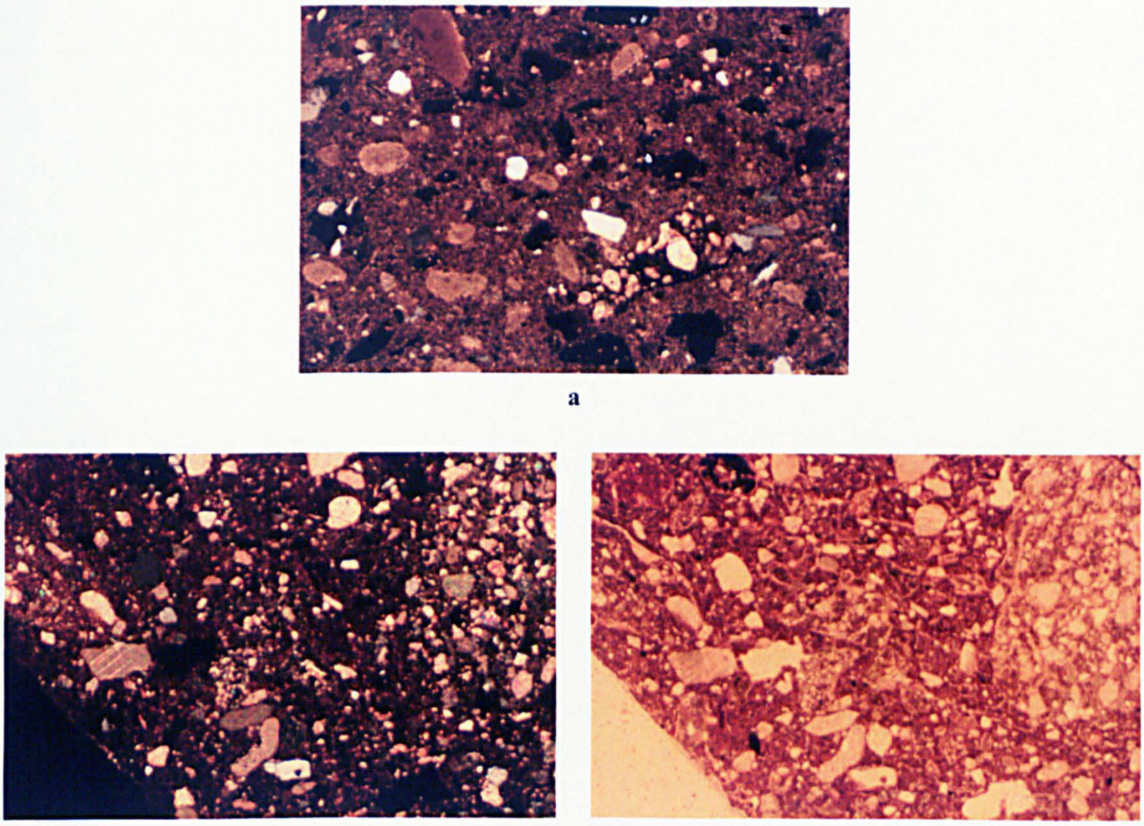


Figure 8.4: Grog-Mixed Carbonate fabrics (x25): a) fabric containing comparatively more quartz; b) fabric containing less quartz and more calcite and micrite; c) fabric containing rare micrite; d) fabric with a matrix dominated by fine calcite grains and containing finely crystalline mosaics; e) fabric containing a dark-coloured core that obscures compositional features and properties of the groundmass; f) comparatively high fired fabric with an optically inactive clay matrix. Field of view = 3mm.



a

b c

Figure 8.5: Grog-Mixed Carbonate fabrics (x25): a) Subgroup A showing comparatively large inclusions of grog and with a highly micritic clay component; b) Subgroup B showing distinctive grog likely deriving from a marl-based fabric c) same fabric as b) in PPL (grog inclusions are more easily distinguished). Field of view = 3mm.

The high level of compositional variation appears to relate to natural differences in the clay component (deriving from differences in the geological contexts within which the clays were formed), as well as to the specific combination and proportions of the raw materials put into the paste. Clays with slightly different, but mineralogically related, compositions appear to be represented. The difference among them may relate most directly to the geological and/or environmental context from which they derive. No significant dissimilarity can be demonstrated, on geological grounds, to raw material resources that occur on the west side of the lagoon (in the immediate vicinity of the site), which suggests that these ceramics were produced locally. Nonetheless, the area of Pleistocene alluvium situated directly east of the site can be discounted as the source of the associated clays due to their obvious geological dissimilarity. The distinctive compositional characteristics of the grog inclusions in subgroup B may reflect a non-local provenance for this particular vessel.

Additional variation across this class with respect to the physical properties of the groundmass relate to differential firing, as indicated by major differences in the optical activity of the clay matrix as well as the presence/absence of dark-coloured cores that vary in both colour and thickness. The continuous nature of the variation within this class with respect to a range of compositional and physical attributes made it impossible to subdivide these fabrics below the class level, into reproducible groups. In addition, the presence of a thick black core in many samples (more than 60%) obscured other characteristics and properties of the groundmass. The main characteristics that unite these fabrics are the presence and relative frequency of the grog inclusions, their general rock and mineral content and the presence of multiple tempers. These fabrics also exhibit comparatively fine textures in comparison to other local fabric groups, rarely containing inclusions larger than coarse sand. Consequently, their complex paste recipe might have been accompanied by a more careful preparation of raw materials.

8.3.1.4. QUARTZ SAND

The Quartz-Sand class comprises 14.6% (N=94) of the sample set. These fabrics are characterized by predominant siliceous inclusions, occurring together with igneous-related accessory minerals (Table 8.5 and Figure 8.6), as well as by a rarity of carbonate inclusions. These fabrics are mineralogically and compositionally consistent with clayey soils that form in association with deep deposits of Pleistocene alluvium throughout northern Belize. Igneous-related accessory minerals such as olivine, clinopyroxene and feldspar emphasize a connection to the Maya Mountains as the original source of the alluvium. Nonetheless, some of the fabrics are virtually identical to the clay samples taken from the area of Pleistocene alluvium (Boom Subsuite soils) situated directly east of Lamanai, across the New River Lagoon. The striking similarity between some of the archaeological specimens and the samples of local clays taken from both inland and creek-side localities within this particular alluvial deposit suggests that at least some of the fabrics within this class derive from local raw materials.

There is considerable variation among the Quartz-Sand fabrics with regard to the textural and physical properties of the groundmass, as well as their rock and mineral content. This variation is suggestive of differences in the provenance of the raw materials. For example, fabrics containing greater amounts of chert and chalcedony probably derive from clays formed in areas of Pleistocene alluvium situated east of

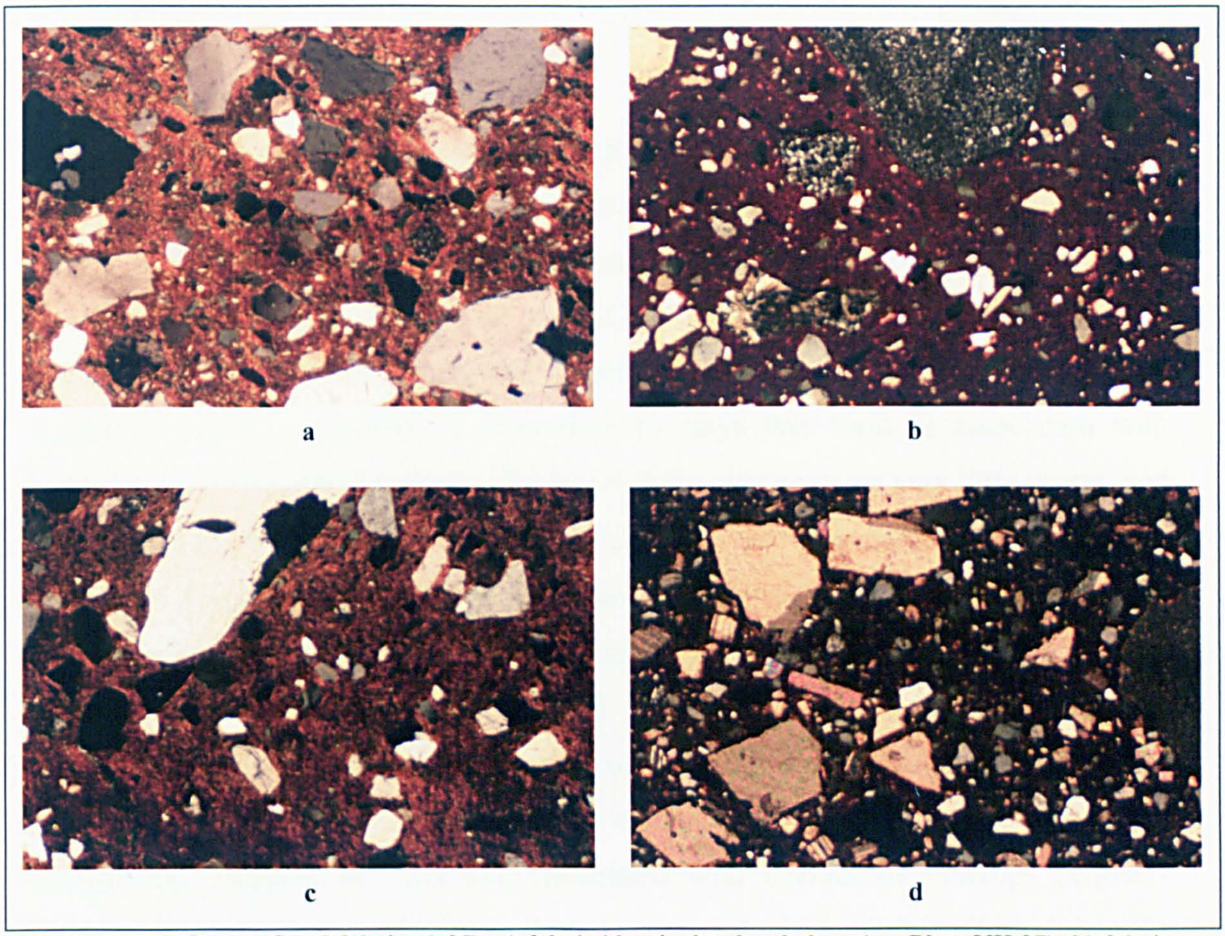


Figure 8.6: Quartz Sand fabrics (x25): a) fabric identical to local clays (see Plate VII.27); b) fabric containing large amounts of chert and chalcedony; c) fabric containing comparatively few, well-sorted inclusions; d) Quart Sand subgroup – crystalline calcite-tempered variant. Field of view = 3mm.

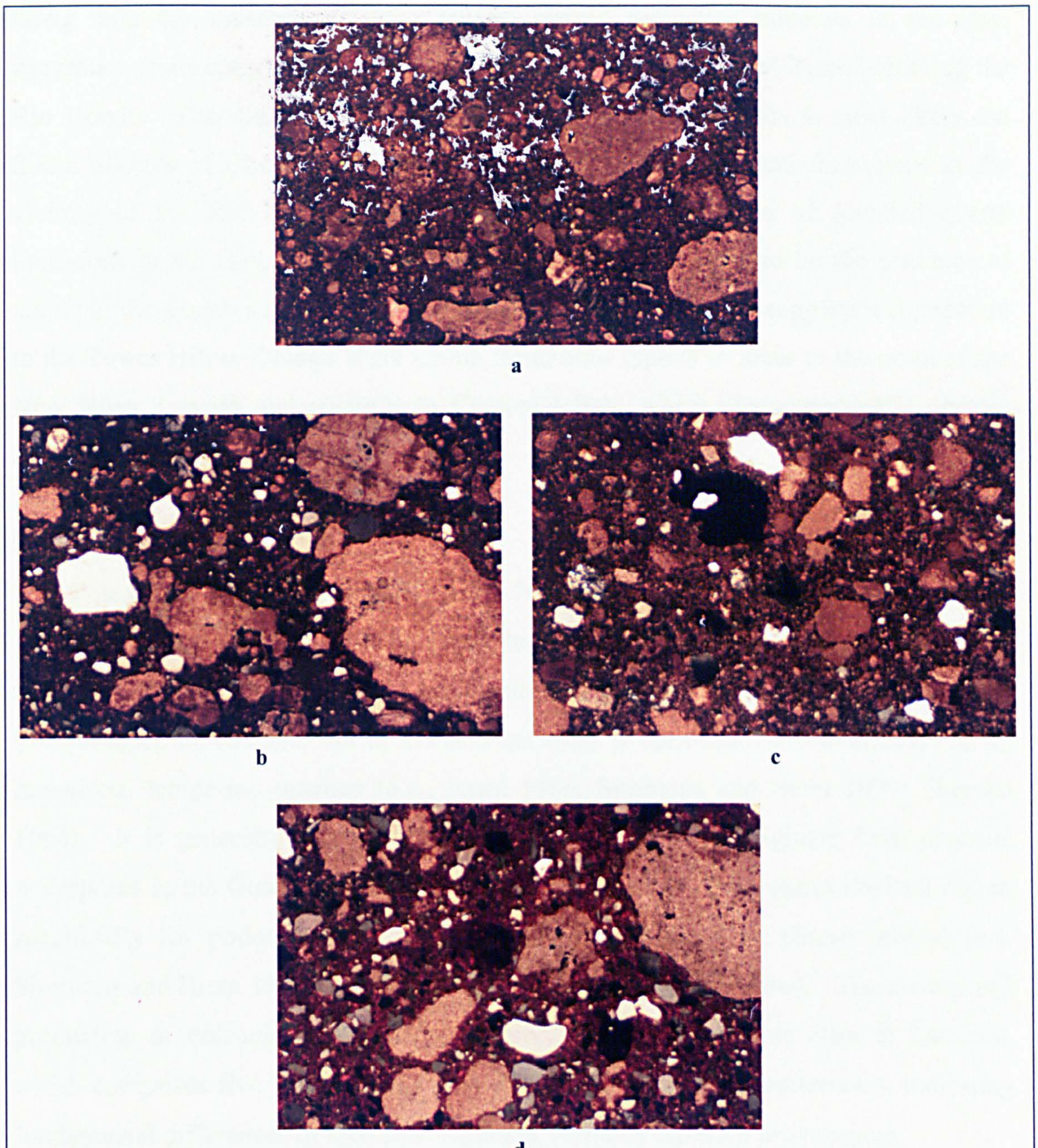
Lamanai, between the coast and the Northern Lagoon drainage system, since these rock types are characteristically more prevalent in the soils of this particular area of northern Belize. In addition, fabrics containing less frequent, better sorted and more rounded inclusions mostly likely derive from clays associated with waterways (creeks, streams and rivers). The presence of shell fragments and lumps of micrite in some samples also suggests a connection to river or creek deposits. A bimodality of grain size in some fabrics suggests the addition of a little sand as temper, while crystalline calcite temper is present in the sample distinguished as a petrographic subgroup. Based on these apparent differences among the fabrics, and their geological and technological significance, it is postulated that the Quartz-Sand class comprises both local and non-local fabrics, with some differences also in the approach to paste manufacture. The characteristic that unites the group is that all of the fabrics derive from the same general type of clay. The continuous nature of the variation among these fabrics does not permit more discrete petrographic distinctions below the class level and hence, more discrete provenance distinctions

8.3.1.5. SASCAB

This class of fabrics, which is represented by only two samples (0.3% of the sample set), can be characterized as a highly micrtic clay tempered with sascab (Table 8.5 and Figure 8.7). The main distinguishing characteristic of these fabrics is the rarity of quartz and any other inclusion type, except for micrite lumps and fine inclusions of crystalline calcite. The clay component is dominated by fine inclusions of micrite and crystalline calcite, suggesting a connection to clays that form in association with horizons of weathering limestone. The fact that the clay contains very little quartz, and the sascab temper contains none, is suggestive of an association with Cretaceous limestone, as opposed to the Teritary formations, since sascab deposits associated with the latter characteristically contain a significant quantity of sand. Cretaceous limestone formations outcrop at only three principal locations north of the Maya Mountains: below an escarpment situated west of the southern end of the Rio Bravo, below the Booth's River escarpment, and along the western edge of the New River Lagoon. Nonetheless, samples of local clay associated with Cretaceous outcrops generally contain more quartz than is present in these archaeological fabrics. Considering the distinctive nature of the Sascab fabrics within the sample set as a whole, it is most likely that these two vessels are of non-local orign.

8.3.1.6. SASCAB-QUARTZ

The Sascab-Quartz class represents 15.2% (N=98) of the sample set and comprises two fabric groups, distinguished based on significant differences in their mineralogy (Table 8.5 and Figure 8.7). Sascab-Quartz fabrics comprise a sandy calcareous clay tempered with sascab that has been comminuted into micrite lumps due to crushing of the parent rock. Sascab A, the larger of the two groups, is geologically consistent with raw material resources available in the local area. The clay component of these fabrics is mineralogically and compositionally consistent with the Filipe Subsuite soils that occur in association with wash deposits containing Pleistocene alluvium situated directly north of the site, adjacent to Barber Creek (King et al. 1992, see also Chapter 5). Samples of local clay deriving from the western bank of Barber Creek bear striking similarities to these fabrics, except that inclusions of micrite are rare in the clay



a b c d

Figure 8.7: Sascab and Sascab-Quartz fabrics (x25): a) Sascab fabric; b) Sascab-Quartz A; c) Sascab-Quartz A subgroup – grog-tempered variant; d) Sascab-Quartz B. Field of view = 3mm.

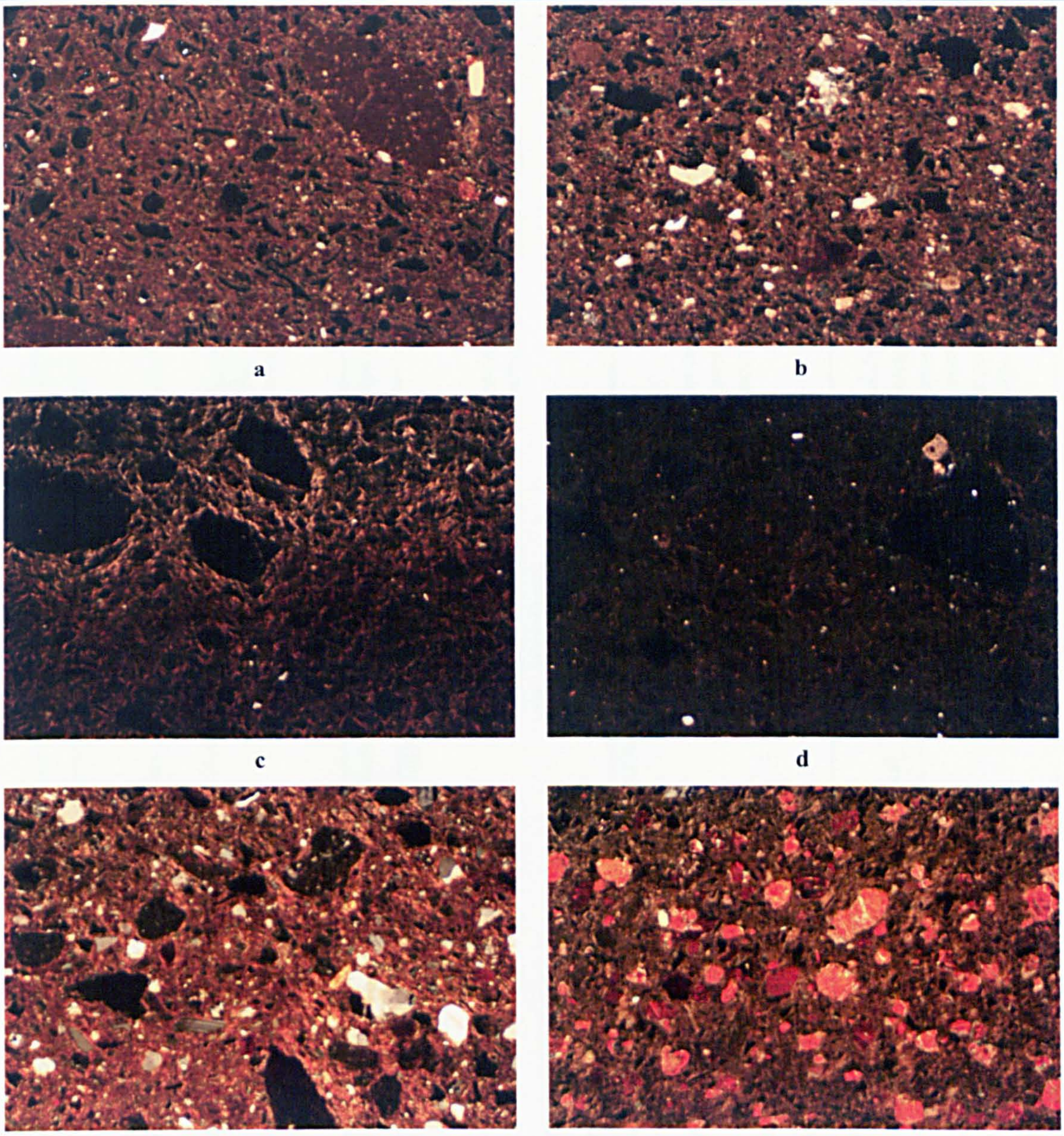
samples. The sascab temper in these fabrics is identical in appearance and composition to samples of local sascab associated with Cretaceous limestone. The temper and the geological samples both contain ghosts of gastropods and foraminifera and quartz inclusions are generally absent. Also noteworthy is that Sascab-Quartz A contains a subgroup of fabrics, distinguished by their finer texture and presence of grog temper.

The distinctive mineralogy of the Sascab-Quartz B fabrics indicates that they derive from non-local raw material resources. The presence of biotite in both clay and temper, along with the presence of other igneous-related accessory minerals in the clay, suggests a connection to micaceous soils typical of areas of central Peten bordering the Rio Hondo. The ultimate source of the igneous-related minerals is most likely the Sierra Madres of Chiapas, Mexico. The connection to geological formations in the vicinity of the Rio Hondo is supported by the predominance of rounded quartz inclusions in the clay, which suggest an alluvial deposit, and also by the presence of quartz in the sascab temper. The presence of quartz in the sascab suggests a connection to the Tower Hill or Orange Walk Group formations typical in areas to the north of the New River Lagoon and adjacent to Chetumal Bay, which characteristically contain quartz.

8.3.1.7. VOLCANIC GLASS

The Volcanic Glass class represents just 2.5% (N=16) of the sample set. The fabrics within this class are distinguished mineralogically by the presence of volcanic glass fragments and tuff, deriving from unconsolidated and lithified forms of volcanic ash. The presence of volcanic ash in lowland ceramics is conventionally interpreted as an intentional tempering practice (e.g., Jones 1986; Simmons and Brem 1979; Shepard 1964). It is generally held that volcanic ash, presumed to originate from deposits widespread in the Guatemala Highlands, was widely traded throughout lowland region specifically for pottery production, especially during the Late Classic period (e.g. Simmons and Brem 1979; see Arnold 1985:59 for an opposing view).. The widespread production of volcanic ash-tempered ceramics is reflected in this class at Lamanai, which comprises five fabric groups with different geological characteristics, indicating fundamental differences in their raw materials, and thus different provenances.

Four of the groups within the Volcanic Glass class are represented by a single sample, whilst Volcanic Glass A comprises several samples, including a petrographic subgroup distinguished by slight mineralogical differences in the clay component (Table 8.6 and Figure 8.8). The distinctive mineralogical and compositional characteristics of the Volcanic Glass groups clearly reflect differences in their provenance. For example, the geological characteristics of the clay component of Volcanic Glass E, suggest a connection to coastal areas of northeastern northern Belize and the Yucatan. In contrast, Volcanic Glass D can be linked to volcanoclastic rocks from the Bladen



a b c d e f

Figure 8.8: Volcanic Glass fabrics (x25): a) Volcanic Glass A; b) Volcanic Glass A subgroup showing more frequent rock and mineral inclusions; c) Volcanic Glass B; d) Volcanic Glass C; e) Volcanic Glass D; f) Volcanic Glass E (crystalline calcite inclusions are stained pink). Field of view = 3mm.

Volcanic Member of the Santa Rosa Group (metasedimentary rocks), situated on the southern margin of the Maya Mountains. The provenance of the other three groups is less certain, due to the absence of diagnostic mineral and rock inclusions, particularly in the case of Volcanic Glass B and C. Nonetheless, these fabrics clearly differ from each other, and their geology is inconsistent with clays local to Lamanai, indicating these

Table 8.6: Summary of mineralogy, distinguishing features, paste technology and provenance of the fabric groups comprising the Volcanic Glass class.

Fabric Group	Inclusions (in order of abundance)	Distinguishing Features	Paste Technology	Associated Provenance
A	vg & tuff frags, qtz, micrite, biotite, feldspar VR = calcite	- sickle and lunate shaped frags of volcanic glass and equant to elongated tuff frags - micritic matrix containing lumps of micrite	micritic calcareous clay tempered with volcanic ash	*non-local* – from outside of northern Belize/Yucatan region but associated with area underlain by limestone, possibly Central Peten?
Petrographic subgroup – distinguished due to presence of polycrystalline quartz ferromanganiferrous nodules, more frequent calcite and rare biotite				
B	vg & tuff frags, qtz, feldspar, R-VR = mica, amphibole, basalt	- sickle and lunate shaped frags of volcanic glass and equant to elongated tuff frags - slightly bimodal appearance due to presence of large tuff fragments - very fine mineral inclusions - presence of muscovite, amphibole and basalt	calcareous clay, likely heavily processed to remove rock and mineral inclusions, tempered with volcanic ash	*non-local* – unknown but from outside of northern Belize/Yucatan region
C	vg & tuff frags, qtz, feldspar, biotite, micrite VR = chal	- sickle and lunate shaped frags of volcanic glass and equant to elongated tuff frags - olive green clay matrix (XP) - bimodal appearance due to presence of large, angular tuff fragments - presence of chalcedony	calcareous clay containing chalcedony and quartz, likely heavily processed to remove larger rock and mineral inclusions, tempered with volcanic ash (crushed tuff?)	*non-local* – unknown but from outside of northern Belize/Yucatan region. Stylistic links to Yucatan area.
D	vg frags, qtz, igneous and volcanoclastic rock frags, feldspar (alkali and plagio), biotite, pqtz R = tuff frags, muscovite	- sickle and lunate shaped frags of volcanic glass - slightly bimodal appearance due to large rock and quartz inclusions - presence of igneous and volcanoclastic rock fragments - orangish- to reddish-brown clay matrix	non calcareous clay containing igneous and volcanoclastic rock fragments, tempered with volcanic ash	*non-local* – connected geologically to the Bladen Volcanic Member of the Santa Rosa Group (metasedimentary rocks), situated on the southern margin of the Maya Mountains due to the presence of igneous and volcanoclastic rock fragments and frequency of quartz inclusions

Table 8.6: Summary of mineralogy, distinguishing features, paste technology and provenance of the fabric groups comprising the Volcanic Glass class (continued).

Fabric Group	Inclusions (in order of abundance)	Distinguishing Features	Paste Technology	Associated Provenance
E	calcite, vg frags, tuff frags R-VR = chal, qtz, biotite	- sickle and lunate shaped frags of volcanic glass and equant to elongated tuff frags - dominant, rounded, equant and irregular shaped inclusions of crystalline calcite - presence of chalcedony and quartz	calcareous clay containing rounded calcite inclusions (carbonate sand), chalcedony and quartz, tempered with volcanic ash	*non-local* – the clay component, containing carbonate sand, chalcedony and quartz, suggests a geological connection to coastal areas of northeastern northern Belize, extending into the Yucatan

ceramics were not manufactured locally. In addition, the vessel representing Volcanic Glass C, conforms stylistically to 'Slate ware', suggesting that it may derive from the Yucatan.

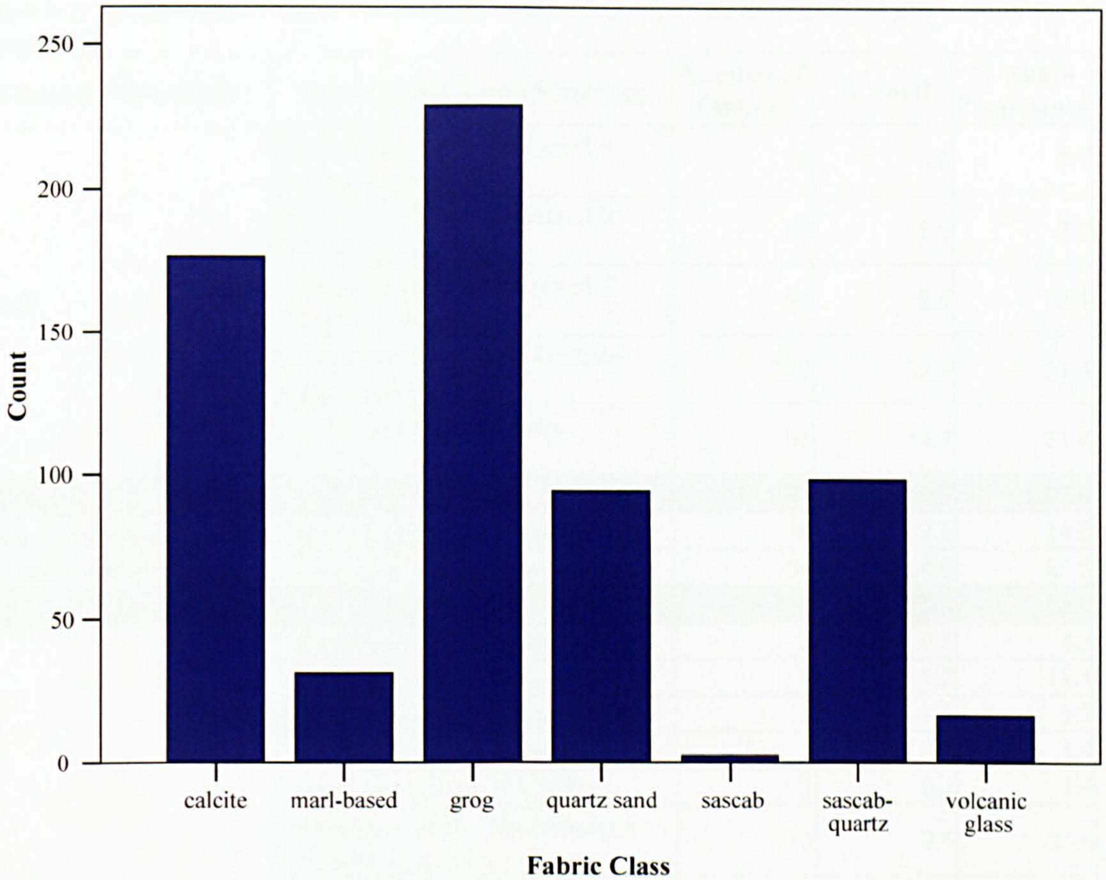
8.3.2. The Relative Frequencies of Different Fabric Types and Their Provenance and Temporal Associations

Class Frequencies

The sample set of vessels analysed petrographically divides into seven main fabric classes, representing 24 distinct fabric groups, which includes the three fabric classes that are represented by a single group. Figure 8.9 presents the relative frequencies of the main fabric classes based on the number of vessels they contain and as percentages of the total number of samples analysed. As can be observed, the numerically dominant fabric type within the sample set is the Grog-Mixed Carbonate class, representing 35% of the samples analysed. Crystalline Calcite-Tempered fabrics are the next most abundant, representing 27.2% of the sample set, followed by the Sascab-Quartz and the Quartz Sand classes, which represent 15.2% and 14.6%, respectively. Dolomitic-Calcitic Marl-based and Volcanic Glass fabrics are rare by comparison, representing just 4.8% and 2.5%, respectively, of the samples analysed. The Sascab fabrics, represented by just two samples, constitute the least common fabric type.

Provenance Associations – Local vs. Non-local

Table 8.7 presents a summary of the fabric groups and their provenance ascription (local vs. non-local), including their relative frequencies within the sample set. The fabric groups ascribed as local comprise 68.7% of the vessels analysed. Two fabric groups contain ceramics that derive from non-local as well as locally available raw materials. These groups include group H of the Crystalline Calcite-Tempered class and the Quartz Sand class. Together, these fabric groups comprise 17% of the sample set. Although, based on the current body of evidence and geological information, the exact number of samples deriving from local raw materials cannot be determined for these groups, the fact that they contain ceramics consistent with local raw materials, indicates that the actual proportion of local vs. non-local ceramics within the sample set, is far greater than the 68.7% minimum determined based on the local fabric groups alone. There are 16 fabric groups suggested to be non-local. These groups include five of the



Ware	Crystalline Calcite-Tempered	Grog-Mixed Carbonate	Dolomitic-Calcitic Marl-Based	Quartz Sand	Sascab	Sascab-Quartz	Volcanic Glass	Total
Fine	17.0	35.4	4.8		0.3	15.2	2.5	75.2
Coarse	10.2			14.6				24.8
Total	**27.2**	**35.4**	**4.8**	**14.6**	**0.3**	**15.2**	**2.5**	**100.0**

Figure 8.9: Fabric class frequencies based on counts and percent of total number of analyzed samples.

Crystalline Calcite-Tempered fabric groups (E, F, G, I and J), Sascab-Quartz B, the Sascab class and all of the fabric groups within the Dolomitic-Calcitic Marl-based and the Volcanic Glass classes. The non-local fabric groups, together, comprise only 11.1% of the sample set. Provenance could not be determined with confidence for group D of the Crystalline Calcite-Tempered Class, as well as the sample distinguished as subgroup B of the Grog-Mixed Carbonate Class. These compositionally ambiguous fabrics comprise just 3.1% of the sample set. If the relative frequencies of local vs. non-local ceramics within the sample set can be assumed to accurately reflect assemblage-wide patterns, then an important conclusion that can be drawn is that the large majority of pottery comprising the Lamanai assemblage was of local manufacture.

Table 8.7: Frequencies of fabric classes and associated groups and their general provenance association.

General Provenance	Fabric Class/Group/Subgroup	Number of Samples	% Total	% within Provenance
Local	Crystalline Calcite Tempered A (includes subgroup)	34	5.3	7.7
	Crystalline Calcite Tempered B (includes subgroup)	32	5.0	7.2
	Crystalline Calcite Tempered C (includes 2 subgroups)	55	8.5	12.4
	Grog-Mixed Carbonate (includes subgroup A)	228	35.3	51.4
	Sascab-Quartz A (includes subgroup)	95	14.7	21.4
Total		**444**	**68.7**	**100.0**
Groups containing local and non-local vessels	Calcite H (includes subgroup)	16	2.5	14.5
	Quartz Sand (includes subgroup)	94	14.6	85.5
Total		**110**	**17.0**	**100.0**
Non-local	Crystalline Calcite Tempered E	3	0.5	4.2
	Crystalline Calcite Tempered F	8	1.2	11.1
	Crystalline Calcite Tempered G	7	1.1	9.7
	Crystalline Calcite Tempered I	1	0.2	1.4
	Crystalline Calcite Tempered J	1	0.2	1.4
	Dolomitic-Calcitic Marl-Based A (includes subgroup)	17	2.6	23.6
	Dolomitic-Calcitic Marl-Based B (includes subgroup)	7	1.1	9.7
	Dolomitic-Calcitic Marl-Based C	2	0.3	2.8
	Dolomitic-Calcitic Marl-Based D	5	0.8	6.9
	Sascab	2	0.3	2.8
	Sascab-Quartz B	3	0.5	4.2
	Volcanic Glass A (includes subgroup)	12	1.9	16.7
	Volcanic Glass B	1	0.2	1.4
	Volcanic Glass C	1	0.2	1.4
	Volcanic Glass D	1	0.2	1.4
	Volcanic Glass E	1	0.2	1.4
Total		**72**	**11.1**	**100.0**
Possibly Non-local	Crystalline Calcite Tempered D	19	2.9	95.0
	Grog-Mixed Carbonate subgroup B	1	0.2	5.0
Total		**20**	**3.1**	**100.0**
Grand Total		**646**	**100.0**	

Temporal Associations and Trends

The frequency distribution of the main fabric classes by stratigraphic context within the two temple middens is presented in Figure 8.10. The basic pattern that emerges is that the Crystalline Calcite-Tempered class, the Volcanic Glass class and the Sascab-Quartz

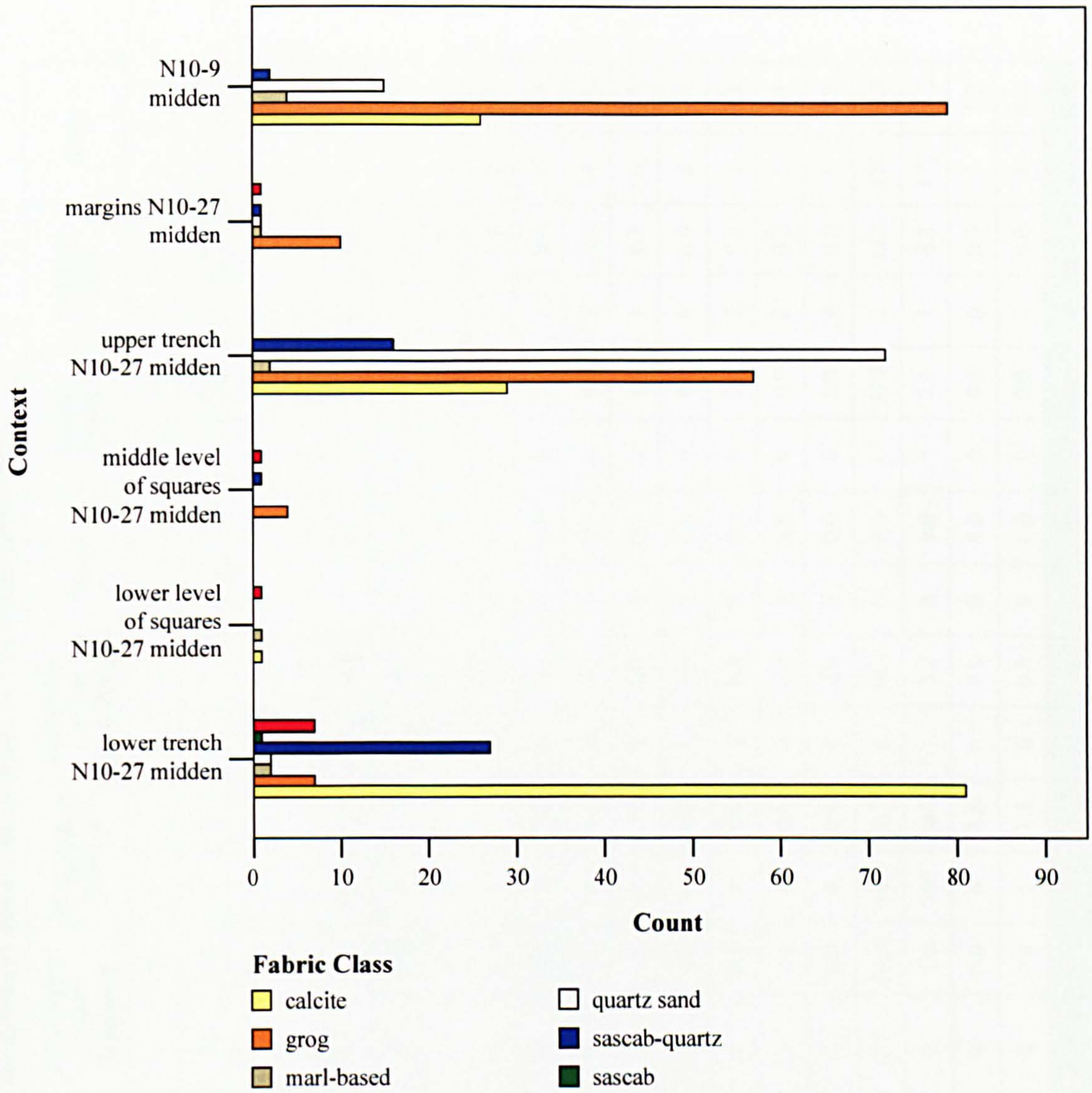


Figure 8.10: Temporal association of fabric classes based on their relative frequencies within different stratigraphic contexts.

class significantly decrease over time, whilst the Grog-Mixed Carbonate class and Quartz Sand class increase. Also significant is that the frequency of the Dolomitic-Calcitic Marl-based class, albeit represented by comparatively few samples, remains quite stable. The changes in the frequencies of different fabric classes reflect the fact that the Crystalline Calcite-Tempered, Volcanic Glass and Sascab-Quartz classes are strongly associated with early vessel styles (Terminal Classic), whereas the Grog-Mixed Carbonate class is more strongly associated with Early Postclassic styles (Table 8.8). In comparison, the Dolomitic-Calcitic Marl-based class contains both early and late styles within the sequence. Also apparent is that there is little change in fabric diversity over

Table 8.8: A breakdown of fine ware stylistic groups within the different fabric classes (Note: % = % within fabric class).

	Stylistic Group	Crystalline Calcite-Tempered		Grog-Mixed Carbonate		Dolomitic-Calcitic Marl-Based		Sascab		Sascab-Quartz		Volcanic Glass		Total	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Early Styles	Polychrome Slipped and Painted	4	3.6	1	0.4	4	12.9	2	100.0	29	**29.6**	8	**50.0**	48	9.9
	Black on Red Slipped and Painted	0	0.0	0	0.0	0	0.0	0	0.0	7	7.1	0	0.0	7	1.4
	Red-Orange-Black Resist	9	8.2	0	0.0	1	3.2	0	0.0	0	0.0	0	0.0	10	2.1
	Monochrome Black	8	7.3	0	0.0	17	**54.8**	0	0.0	0	0.0	0	0.0	25	5.1
	Monochrome Red Slipped	48	**43.6**	4	1.7	2	6.5	0	0.0	15	15.3	1	6.3	70	14.4
	Monochrome Red Slipped and Groove-Incised	2	1.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.4
	Monochrome Red Slipped and Notched	3	2.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.6
	Monochrome Red to Orange Slipped (interior slipped)	0	0.0	0	0.0	0	0.0	0	0.0	2	2.0	0	0.0	2	0.4
	Monochrome Orange Slipped and Groove-Incised	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0	3	18.8	4	0.8
	Buff/Cream Slipped	2	1.8	0	0.0	0	0.0	0	0.0	1	1.0	1	6.3	4	0.8
	Monochrome Brown	2	1.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.4
	Monochrome Red Slipped and Incised	1	0.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
	Monochrome Red Slipped and Model-Carved	1	0.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
	Monochrome Grey (Plumbate)	1	0.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
	Monochrome Orange Slipped	27	**24.5**	107	**46.7**	6	19.4	0	0.0	37	**37.8**	2	**12.5**	179	36.8
	Monochrome Orange Slipped and Incised	2	1.8	107	**46.7**	1	3.2	0	0.0	7	7.1	1	6.3	118	24.3
	Monchrome Orange to Red Slipped - Notched and Incised	0	0.0	6	2.6	0	0.0	0	0.0	0	0.0	0	0.0	6	1.2
Late Styles	Monochrome Orange with Applique	0	0.0	3	1.3	0	0.0	0	0.0	0	0.0	0	0.0	3	0.6
	Total	**110**	**100.0**	**229**	**100.0**	**31**	**100.0**	**2**	**100.0**	**98**	**100.0**	**16**	**100.0**	**486**	**100.0**

time. That is, although certain fabric classes clearly dominate the early and later ends of the sequence and class frequencies change, a similar range of different fabric types (classes) occurs throughout the sequence. This continuity in the diversity of fabrics stands in direct contrast to the loss of stylistic diversity with regard to surface treatment that occurs.

8.4. Functional and Stylistic Associations of the Fabric Classes

When the main fabric categories are considered in light of the functional associations and the surface treatment characteristics of the vessels they contain, several significant patterns emerge. These patterns can be considered to reflect behaviourally meaningful correlations between the main fabric types (classes) and, in some cases, fabric groups, and the functional and stylistic categories discussed in previous chapters.

Figure 8.11 presents a frequency distribution of the main fabric classes for fine ware and coarse ware. Fine ware includes serving/table wares (a range of service and drinking vessels), musical instruments (drums and whistles) and special purpose vessels presumably used in ritual (sieves, frying pan censers, incense burners, 'torches' and 'stands'), whilst coarse ware primarily includes vessels with broadly utilitarian functions relating to food preparation and storage, but in this assemblage also includes incense burning paraphernalia (incense burners and a censer). As can be observed, all of the fabric classes except the Quartz Sand class contain fine ware vessels. In contrast, coarse ware vessels are confined to just two classes: the Crystalline Calcite-Tempered class and the Quartz Sand class, with incense burning vessels occurring in both. This pattern indicates a strong correlation between vessel composition at the class level, and vessel function. It is also evident that the fine ware, or vessels used in service and ritual, exhibits greater compositional diversity than vessels serving broadly utilitarian functions. Another significant pattern is that all of the fabric classes except the Quartz Sand class contain service and drinking vessels, while in all cases except three (a drum and the only 'torch' and 'stand' within the assemblage), musical instruments and special purpose vessels are restricted to the Grog-Mixed Carbonate class.

When considering the relationship between compositional and stylistic variability within these general functional categories, several additional observations can be made.

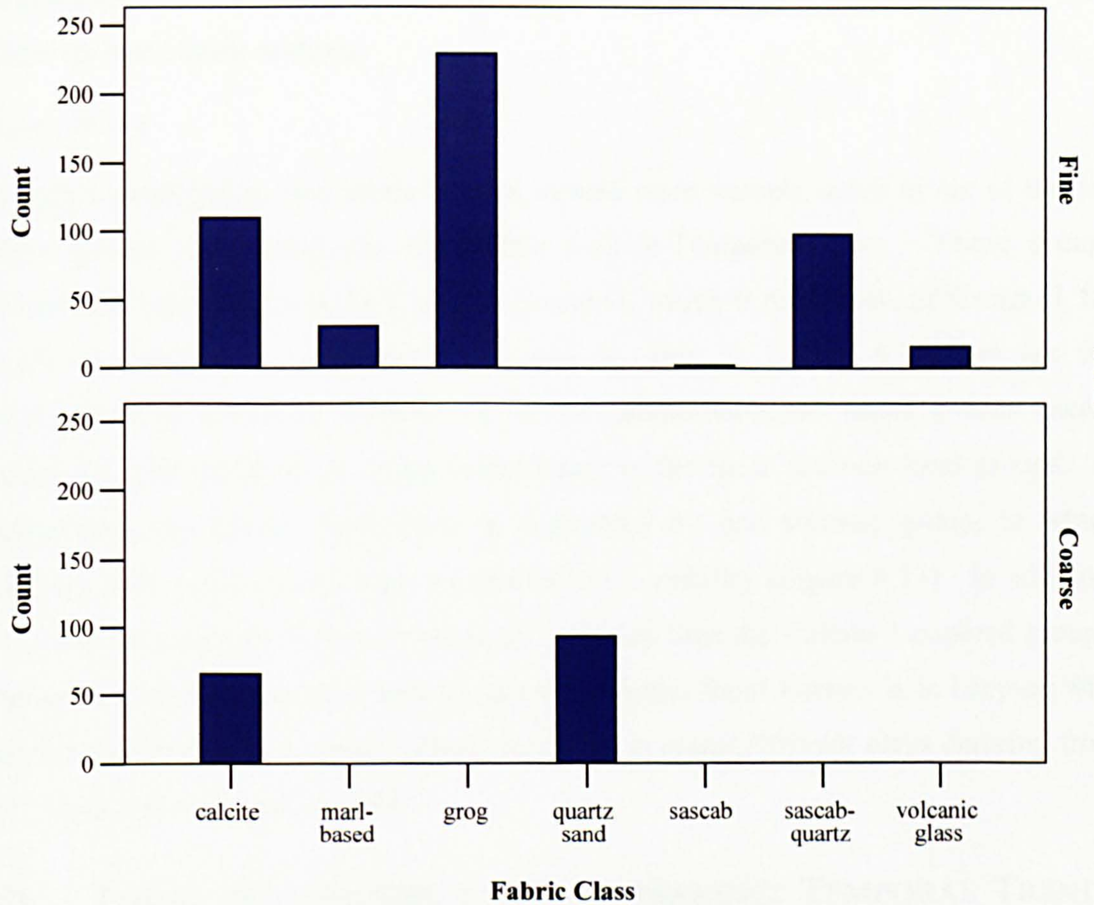


Figure 8.11: The frequency distribution of fine ware and coarse ware according to fabric class.

Fine ware

All of the fabric classes, except the Sascab Class, which comprises two polychrome bowls, contain multiple stylistic groups (Table 8.8). In all cases, however, one or two stylistic groups comprise the majority of vessel within a particular class. For examples, close to 70% of the vessels within the Crystalline Calcite-Tempered Class are monochrome red or orange slipped. In comparison, monochrome orange slipped vessels with or without incised decoration comprise over 90% of the vessels in the Grog-Mixed Carbonate class. More than 50% of the ceramics in the Dolomitic-Calcitic Marl-based class are black slipped, whereas polychrome and orange slipped vessels comprise over 60% of both the Sascab-Quartz and the Volcanic Glass classes. In the case of the Volcanic glass class, however, the orange slipped vessels tend to have groove incising. It is notable that while all of the fabric classes, except the Sascab class, contain orange slipped vessels, they comprise over 95% of the Grog-Mixed Carbonate class. Accordingly, there appears to be some correlation between vessel composition at the class level and the stylistic categories presented in Chapter 7. The nature of the relationship between vessel composition and style among the fine ware is explored further in subsequent sections.

Coarse Ware

Although restricted to two fabric classes, coarse ware vessels occur in six of the ten fabric groups comprising the Crystalline Calcite-Tempered class. These groups include: the local groups A, B, C and H, Group G, which is non-local and Group D, for which provenance is ambiguous. As can be seen in Figure 8.12, jars are the predominant or exclusive form in all of the calcite-tempered fabric groups except Calcite C, with different jar styles predominant in the local and non-local groups. In comparison, the Quartz Sand class is dominated by one stylistic group, in which different form types exhibit high morphological variability (Figure 8.13). In addition, this class also contains a greater range of jar styles than the Calcite-Tempered groups. The greater stylistic variation among jars with Quartz Sand Fabrics is in keeping with the fact that this class contains vessels made using many different clays deriving from both local and non-local sources.

8.5. LOCAL APPROACHES TO PASTE-MAKING: TEMPORAL TRENDS AND STYLISTIC CORRELATIONS

Petrographic analysis of the Lamanai assemblage has revealed two fabric classes and five fabric groups that are geologically compatible with raw material resources that occur in the local area (Crystalline Calcite-Tempered groups A, B, C and H, group A of the Sascab-Quartz class, the Grog-Mixed Carbonate class and the Quartz Sand class). The petrographic differences among the local groups relate to the selection of raw material ingredients – i.e. different choices in paste-making. We might refer to the four different classes of local fabrics as 'traditions', as they occur at the site over extended periods of time. Fabrics strikingly similar to the crystalline calcite-tempered fabric groups and Sascab-Qaurtz A fabrics occur as early as the Late Preclassic period (Powis and Howie n.d.; Powis et al. 2002; Powis 2002). Similarly, recent macroscopic analysis conducted by the author of Middle and Late Postclassic assemblages at the site has indicated that Grog Mixed Carbonate and Quartz Sand fabrics continue into these later time periods.

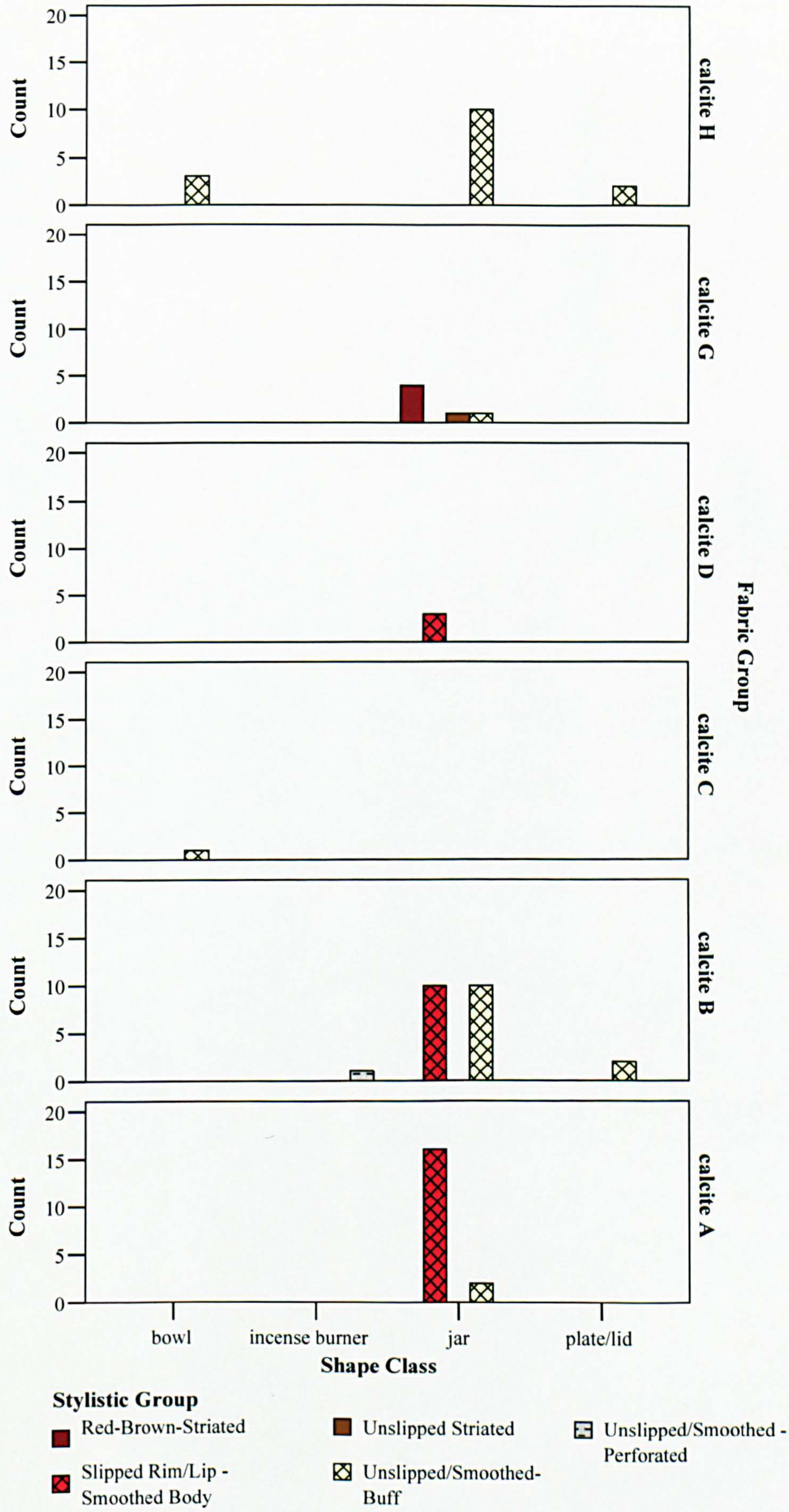


Figure 8.12: Frequency distribution of stylistic groups according to form within Crystalline Calcite-Tempered fabric groups.

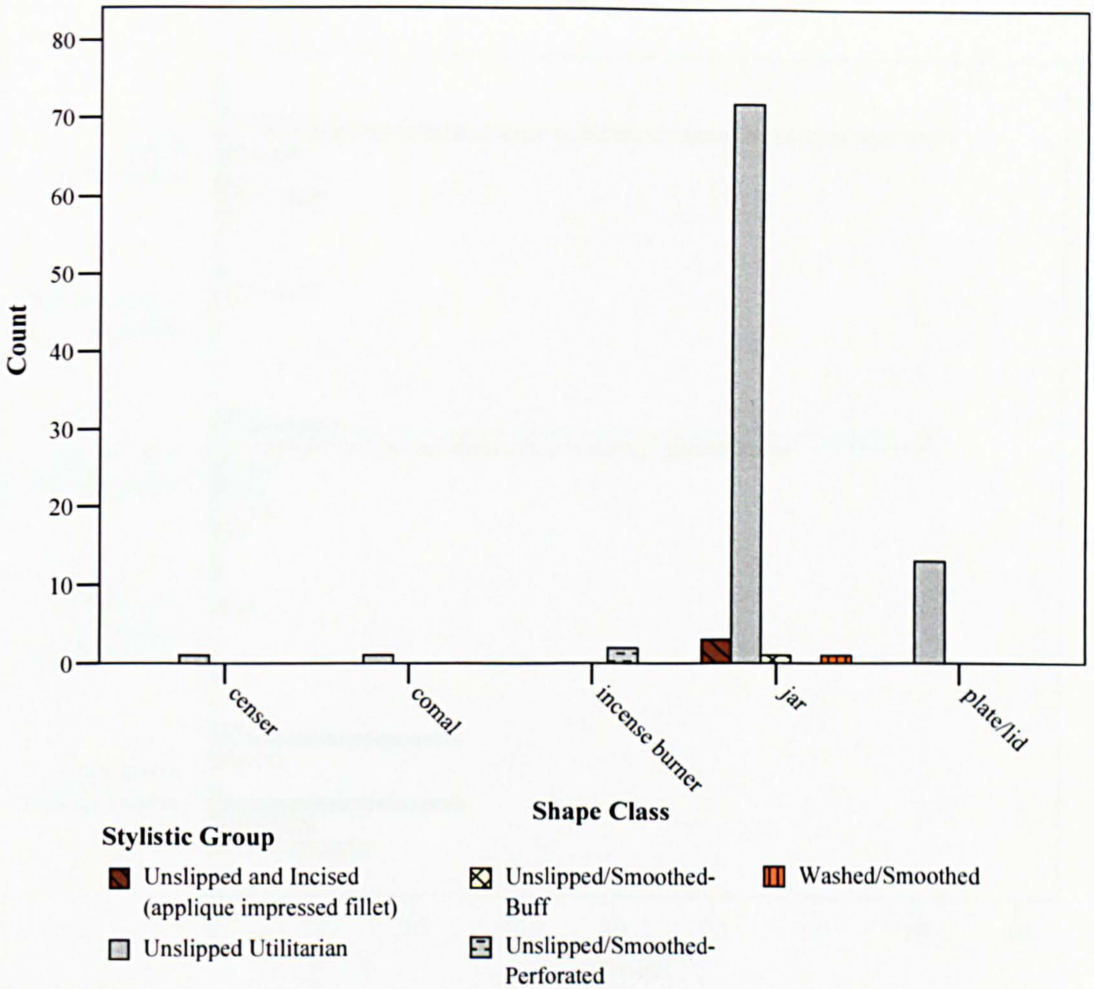


Figure 8.13: Frequency distribution of stylistic groups according to form within the Quartz Sand class.

The temporal association of the local fabric groups is shown in Figure 8.14. As can be seen, the calcite-tempered groups A, B and C and Sascab-Quartz A dominate the earliest stratigraphic context (the lower trench lot from N10-27) and their proportional representation decreases significantly in the most recent stratigraphic context (the upper trench lot and margins of N10-27 and in the midden at N10-9). In contrast, the Grog-Mixed Carbonate and the Quartz Sand classes and group H of the Crystalline Calcite-Tempered class are poorly represented in the earliest stratigraphic contexts and clearly dominate temporally later contexts. Accordingly, the former groups can be characterized as 'early' fabric types within the sequence that decrease in prevalence over time, whilst the latter classes and group can be considered as fabric types that become predominant by the end of the sequence, seemingly at the expense of the earlier fabric types.

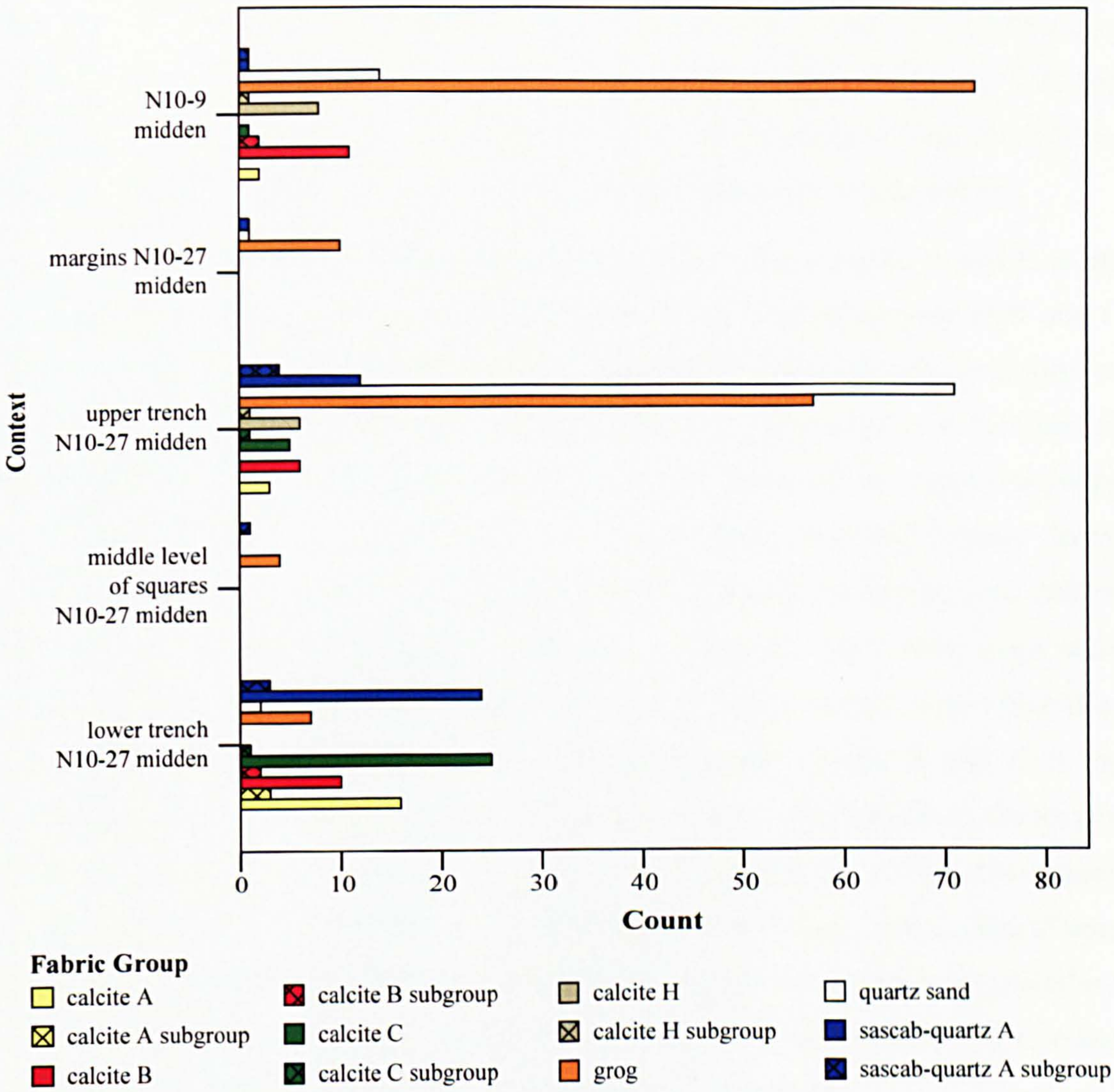


Figure 8.14: Frequency distribution of local fabric groups and classes within different stratigraphic contexts.

8.5.1. The Local Crystalline Calcite-Tempered Tradition

The Crystalline Calcite-Tempered fabric groups derive from a basic paste recipe that involves calcareous clay mixed with freshly crushed crystalline calcite. All of the groups appear to derive from clay resources that occur at the site and in the surrounding inland area characterized by Yalbac soils, and they are all tempered with forms of crystalline calcite that generally occur as veins or nodules in the underlying limestone bedrock and associated horizons of weathering limestone. Groups A and H appear to derive from local clays that form directly below the ground's surface (at the site and in the surrounding area), and the calcite temper used in both derives from the colourless, coarsely-crystalline form of calcite that occurs locally. The essential difference between these two groups is the greater quantity of quartz in the fabrics comprising Group H, as well as their comparatively coarse-textured groundmass. In addition, three of the fabrics within group H contain carbon residues that exhibit a consistent morphology and are associated with channel voids. These residues may represent an organic temper that was incorporated into the paste in addition to calcite temper.

A main characteristic that distinguishes Calcite B and C from Calcite A and H is the predominance of fine grains of crystalline calcite in the clay component of B and C fabrics, which gives them a distinctly 'grainy' appearance. The high aplastic content of the groundmass links them to local clays that form in association with horizons of weathering limestone. These clayey horizons directly underlay the clays associated with Calcite A and H. Consequently, it is quite likely that the primary factor responsible for the compositional differences observed among the groups with respect to the clay component is the specific geological context in which these clays were formed or, alternatively, the relative depth below the ground's surface from which they were procured. A further characteristic that distinguishes groups B and C is the physical properties of the crystalline calcite used for temper. In these cases, the temper derives from the finely crystalline form of the mineral, which has a distinctive sugary texture and is white in colour. The main characteristic that distinguishes Calcite C from Calcite B is that Calcite C fabrics contain sascab temper, in addition to crystalline calcite. In fact, these two fabric groups are so similar in all respects that C could possibly be described as a 'sascab-tempered version' of Calcite B.

Groups A, B and C are internally homogeneous, except for the samples distinguished within their petrographic subgroups due to the presence of grog temper. In comparison, group H exhibits significant internal variation, which in some cases appears to reflect provenance differences related to clay sources. This group also contains a grog-tempered variant. In each of the groups, the grog-tempered variant contains the same vessel styles as the main group (see accompanying figures below).

The close compositional relationship between the local calcite-tempered fabric groups is reflected by an overlap in the vessel styles they contain. The predominant types within groups A and B are well made coarse ware jars of the Slipped Rim/Lip-Smoothed Body and Unslipped/Smoothed Buff stylistic groups and rounded fine ware bowls with a red to orange slip that extends to just below the rim on the exterior surface ('interior-slipped bowls') (Figures 8.15 and 8.16). Composite silhouette dishes, which constitute the predominant vessel type in Calcite C, are also present in these two groups (Figure 8.17).

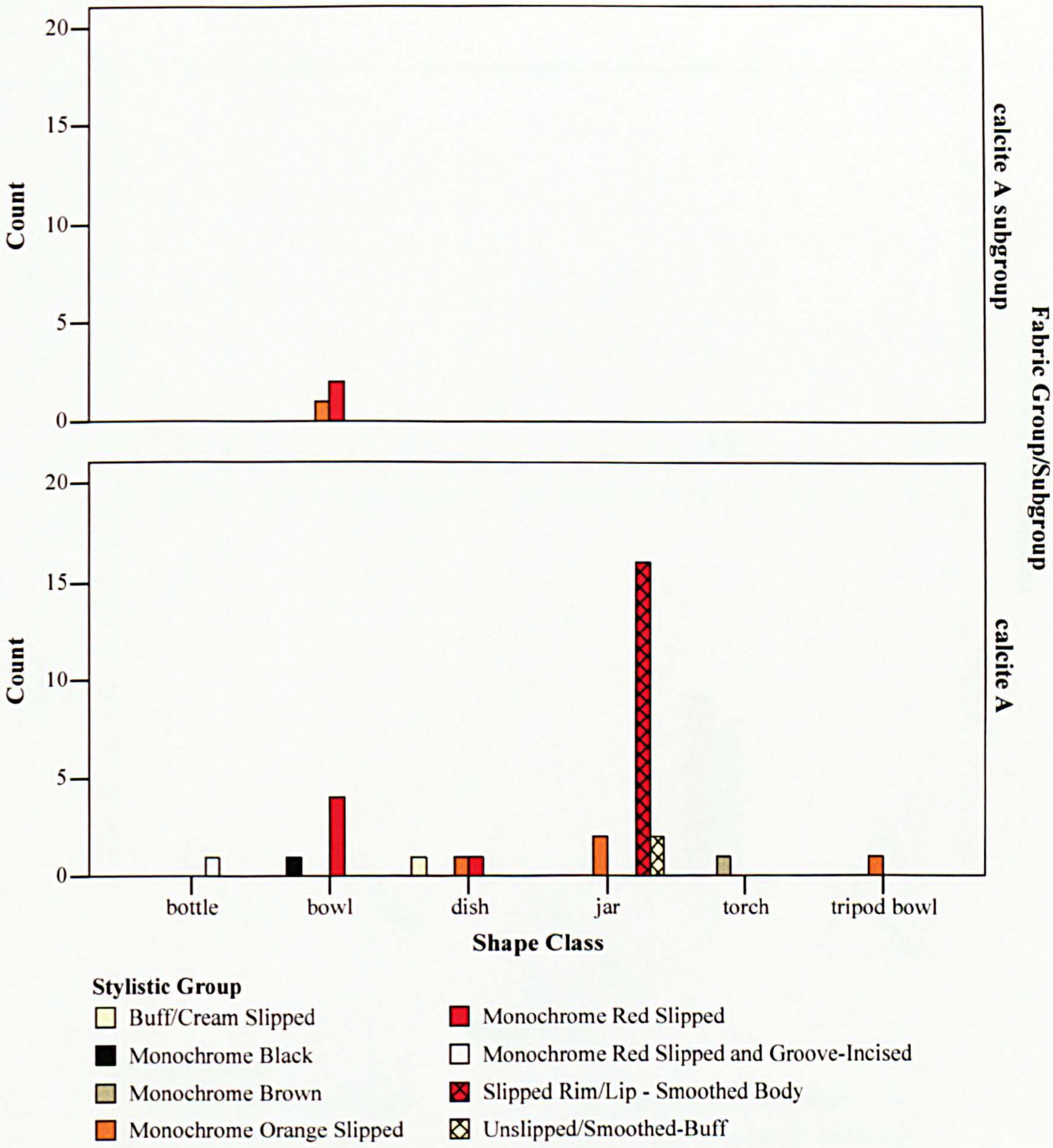


Figure 8.15: Vessel styles within group A of the Crystalline Calcite-Tempered class summarized according to surface treatment and form.

The slipped jars and bowls, which might be considered to reflect a 'service set', in the sense that the red and cream exteriors of these vessels express a particular and distinctive stylistic convention, represent early vessel styles within the sequence, whereas the unslipped jars clearly reflect later jar styles. These unslipped jars are dominant in Calcite H. Given the similarities between groups A, B and H, this overlap in the jar styles seems to document a stylistic shift in a local tradition of calcite-tempered storage jars. The petrographic differences among these groups clearly relate to natural variation in clays due to differences in their geological context, and therefore,

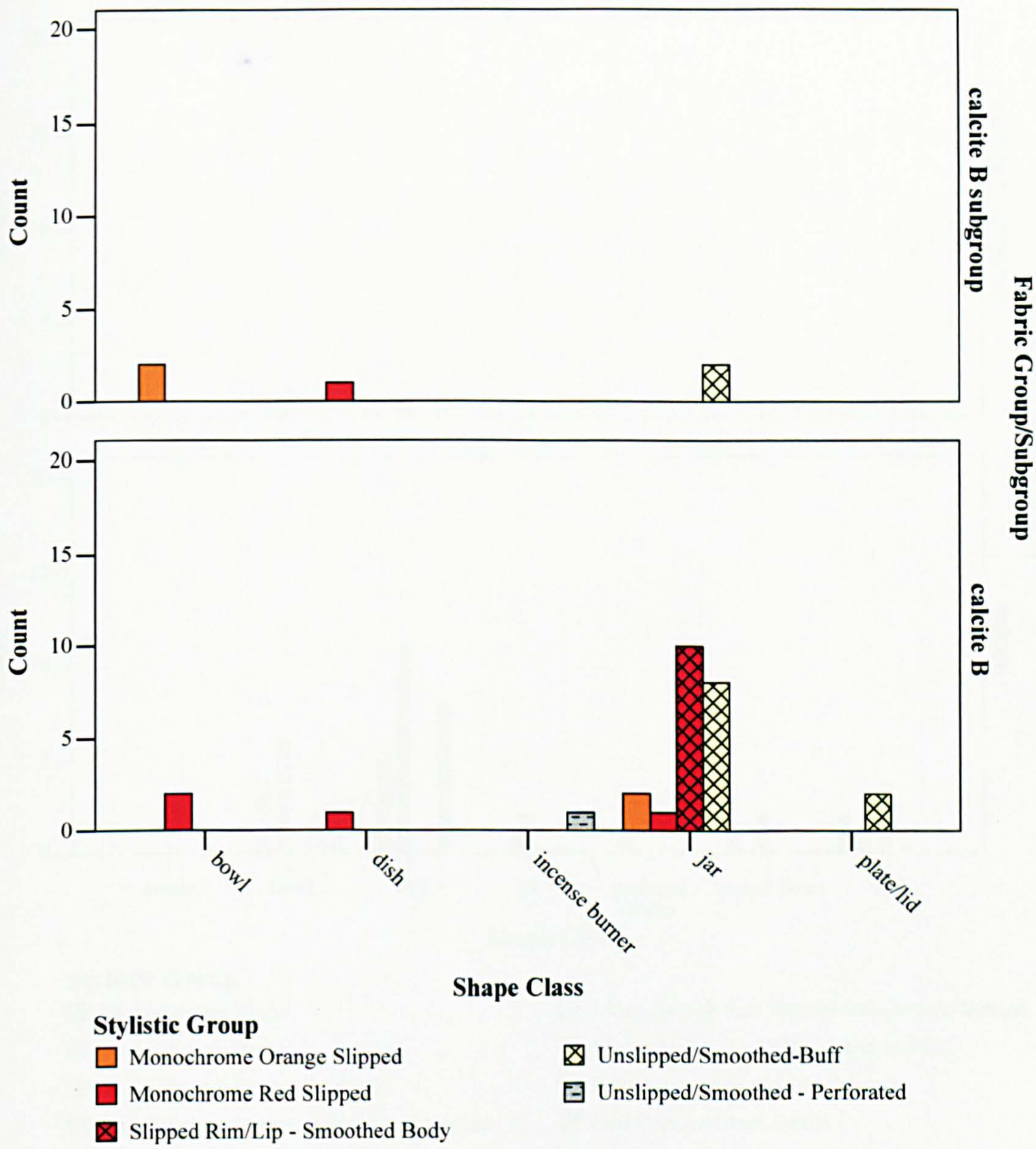


Figure 8.16: Vessel styles within group B of the Crystalline Calcite-Tempered class summarized according to surface treatment and form.

might reflect the exploitation of different clay resources over time, within a circumscribed geological zone.

The close petrographic and stylistic relationship between groups A and B requires further discussion. These groups contain the same range of Terminal Classic vessel styles and yet they are clearly distinguished, petrographically, by their raw materials. The basic question that emerges is whether these groups can be considered to reflect the activities of contemporaneous potters that use slightly different raw materials or

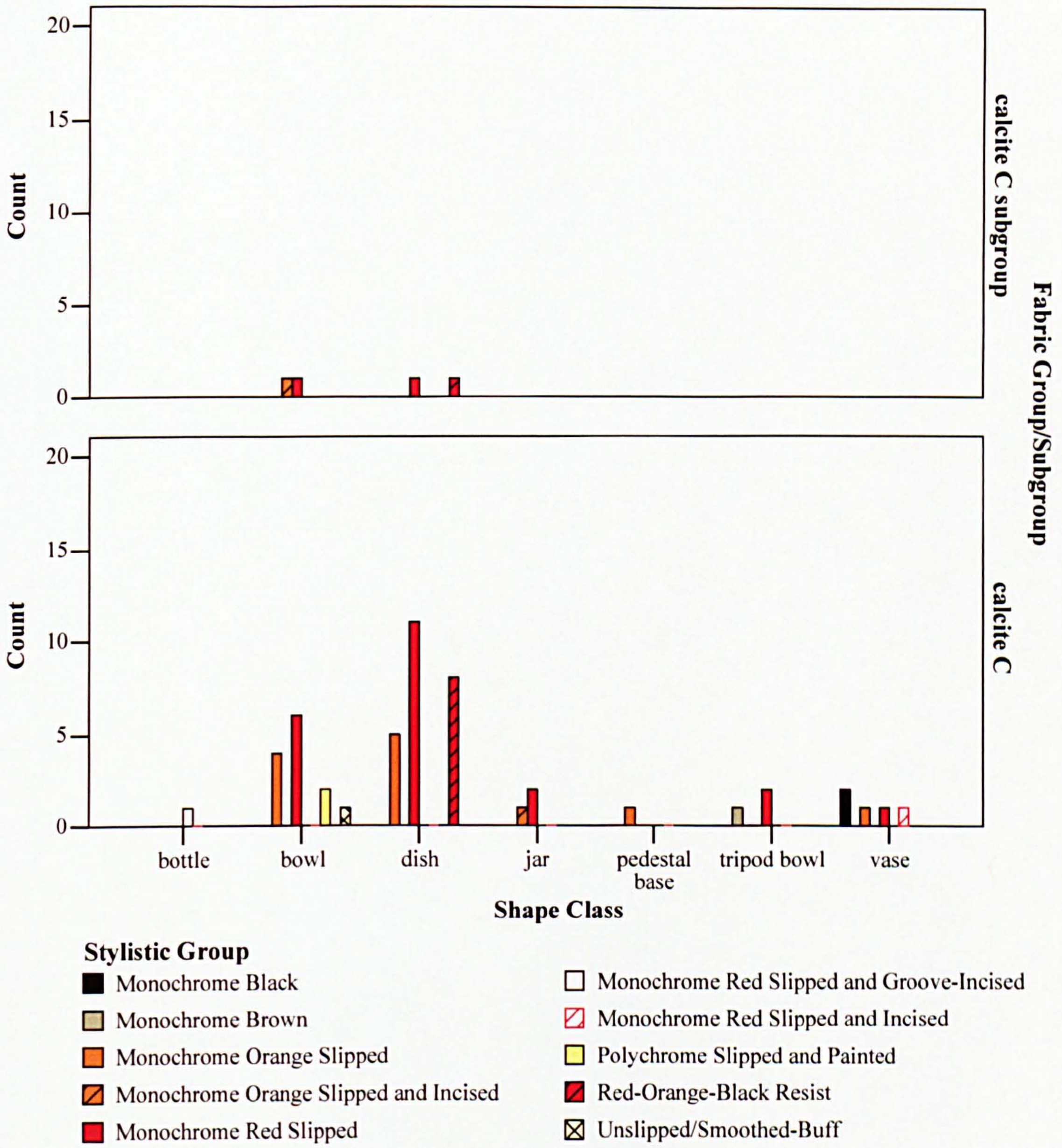


Figure 8.17: Vessel styles within group C of the Crystalline Calcite-Tempered class summarized according to surface treatment and form.

changes over time in raw materials related to source or resource exploitation. It could be argued that either of these explanations is equally plausible and, supportable. And certainly, a more fine-grained chronological control over these fabric groups than the current data permit, would be required to justify any distinction made in this regard. The relationship between these two groups is interesting nevertheless, because of the insight that might be gained into potters' understanding and use of the raw material resources available them in the local area. For example, did observable differences in the physical properties of mineralogically equivalent raw materials have any significance or meaning to local potters? Did they differentiate, or make a qualitative distinction, in any way, between the colourless coarse-textured form of calcite and the white sugary-textured form as a raw material to produce temper? Furthermore, did the natural colour and texture of different clays have any significance to potters if they fired to the same colour and could both be used successfully? The petrographic evidence suggests that these differences *were* recognized by local potters, and potentially informed their choice of raw materials, since there is no indication that the different clays and calcite tempers were used interchangeably or combined in the same paste. Rather, groups A and B represent two distinct combinations of raw materials, or paste recipes, based on different, but geologically related, clays and temper source materials.

The presence of sascab temper in Calcite C fabrics clearly distinguishes this group from groups A, B and H, indicating a slightly different approach to paste-making within the general calcite-tempered tradition. The compositional distinctiveness of this fabric group is mirrored in the types of vessels it contains (Figure 8.17). Storage jars and other coarse ware forms are entirely absent from this group and composite silhouette dishes and bowls with different surface treatments predominate. The dishes have either monochrome slipped surfaces, ranging in colour from deep red to orange or feature a bichrome decorative effect produced through a resist technique. The bowls have either red or orange slips or polychrome painted decoration. Considering the internal petrographic consistency of this fabric group, the occurrence of conformal vessels with different surface treatments is quite significant. Chronological variation might be a contributing factor, but the contemporaneous use of different decorative treatments can not be discounted, as conformal vessels with different decorative treatments occur together in primary contexts such as burials at Lamanai.

Despite the apparent differences in the predominant vessel types between Calcite C and the other calcite-tempered groups, a close stylistic relationship to groups A and B is indicated by the stylistic overlap between these three groups. For example, Calcite A and B also contain composite silhouette dishes, albeit very few, and all three groups contain rounded 'interior slipped' bowls – the stylistic counterpart of the storage jars with the red slipped rims. These bowls are visually indistinguishable in terms of their morphological and surface treatment attributes, suggesting interaction, if not a close relationship, among the potters who produced them.

8.5.2. The Local Sandy-Sascab-Tempered Tradition - Sascab Quartz A

Sascab-Quartz A fabrics are clearly based on a completely different set of local raw materials than the calcite-tempered groups and, therefore, can be considered to reflect a different, yet contemporaneous, paste-making tradition. The paste recipe involved can be described as sandy calcareous clay mixed with a freshly crushed, solidified form of sascab. As with the calcite-tempered fabric groups, this group contains a petrographic subgroup, which is distinguished by the presence of grog temper and a comparatively fine-textured groundmass.

The petrographic distinctiveness of the fabric group is reflected in the vessel styles it contains (Figure 8.18). The large majority of vessels within the main group are morphologically identical rounded dishes with different surface treatments, including polychrome painted decoration on an orange or buff slipped background, black painted decoration on a red slipped background and monochrome red to orange and buff slipped. On all of these dishes the slip extends to just below the rim area on the exterior surface ('interior slipped'). Dishes with polychrome decoration are numerically dominant, followed by monochrome slipped dishes. These dishes can be considered to represent a functional equivalent of the calcite-tempered composite silhouette dishes and, therefore, they might be interpreted as reflecting a different and contemporaneous local tradition of dish-making. As was suggested for Calcite C, the occurrence of conformal vessels with different surface treatments can be attributed either to chronological variation or the contemporaneous use of different decorative treatments by potters working within the Sascab-Quartz A paste-making tradition. Also significant is that four composite silhouette dishes and a chalice (pedestal-based dish) are present in the main group of Sascab-Quartz A fabrics. Two of the composite silhouette dishes have polychrome decoration that is identical, stylistically, to that which occurs on the rounded dishes, and interestingly, these two vessels are the only examples of polychrome decorated composite silhouette dishes that occur within the assemblage. These dishes could be interpreted as an instance of potters imitating the products of other local producers, but they might also be considered as evidence of direct social interaction among local potters working within different manufacturing traditions. The presence of 'interior slipped' bowls that are stylistically identical to the more usual calcite-tempered vessels is another example of stylistic overlap that is suggestive of these sorts of behaviour.

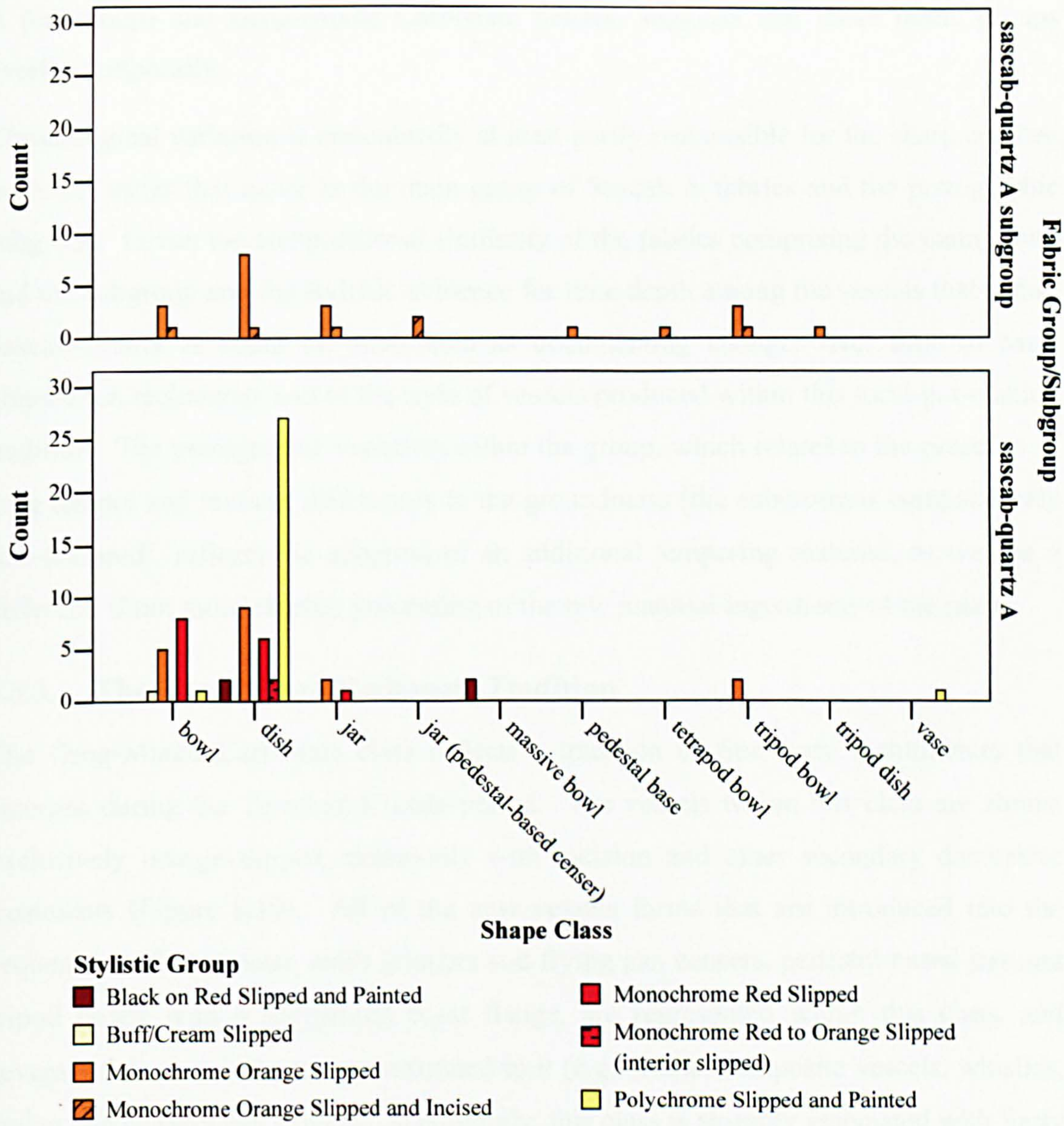


Figure 8.18: Vessel styles within Sascab-Quartz A summarized according to surface treatment and form.

The occurrence of the chalice within the main group of Sascab-Quartz A fabrics is significant as it is the only instance, within the corpus of ceramics analysed petrographically, of a chalice that does not contain grog temper. Within the grog-tempered subgroup of Sascab-Quartz A, all of the dishes are chalices, and the remaining vessels within the subgroup conform to Early Postclassic stylistic conventions, in both surface treatment and morphology. The presence of Early Postclassic vessel styles within both the subgroup and the main group of Sascab-Quartz A indicates an important connection, on both stylistic and compositional grounds, to the Grog-Mixed Carbonate class, which nearly exclusively comprises Early Postclassic vessel styles. The co-occurrence of Early Postclassic style vessels, particularly chalices, with Sascab-Quartz A (subgroup) and Grog-Mixed Carbonate fabrics, suggests that these fabric groups overlap temporally.

Chronological variation is undoubtedly at least partly responsible for the sharp contrast in vessel styles that occur in the main group of Sascab A fabrics and the petrographic subgroup. Given the compositional similarity of the fabrics comprising the main group and the subgroup and the stylistic evidence for time depth among the vessels that occur, Sascab-Quartz A could be interpreted as documenting changes over time in paste preparation techniques and in the style of vessels produced within this local pot-making tradition. The petrographic variation within the group, which relates to the presence of grog temper and textural differences in the groundmass (the subgroup is comparatively fine-textured), reflects the adoption of an additional tempering material, as well as a different, if not more careful, processing of the raw material ingredients of the paste.

8.5.3. The Grog-Mixed Carbonate Tradition

The Grog-Mixed Carbonate class reflects a tradition of fine ware manufacture that emerges during the Terminal Classic period. The vessels within this class are almost exclusively orange-slipped, commonly with incision and other secondary decorative treatments (Figure 8.19). All of the new vessels forms that are introduced into the sequence, such as drums, chilli grinders and frying pan censers, pedestal-based jars and tripod bowls with a segmented basal flange, are represented within this class, and several of these new forms are restricted to it (e.g. drums, composite vessels, whistles, frying pan censers and sieves). Accordingly, this class is strongly associated with Early Postclassic vessel styles. The presence of three monochrome composite silhouette dishes and a polychrome composite silhouette bowl provides evidence of a stylistic overlap with the local fabric groups in which 'early' or Terminal Classic vessel styles predominate.

Petrographically this class of fabrics is characterized by significant internal heterogeneity, which has been interpreted as related to natural differences in the clay component, reflecting the use of compositionally different local clays, as well as variation in the specific combination of raw materials and their relative proportions. Although not unprecedented in the other local fabric groups, the use of multiple tempering materials, including freshly crushed pot sherds, sascab and both the white

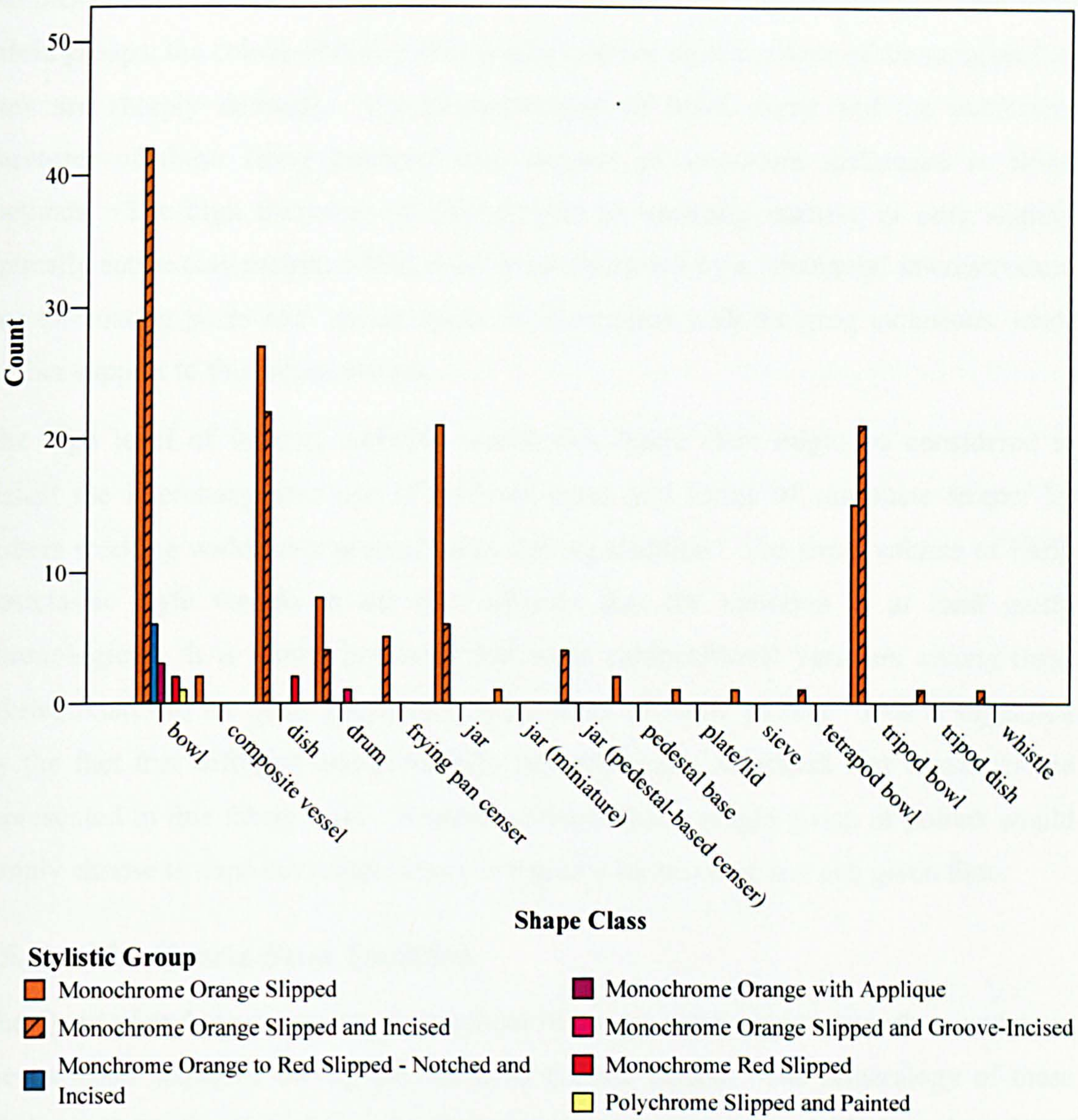


Figure 8.19: Vessel styles within the Grog-Mixed Carbonate class summarized according to surface treatment and form.

and colourless forms of crystalline calcite, is particularly distinctive of this approach to paste-making. These fabrics are also comparatively fine-textured, suggesting a more careful or rigorous processing of raw materials. Connections to Yalbac clays, both those that form directly below the ground's surface and those associated with horizons of weathering limestone, as well as Filipe Subsuite clayey soils, can be demonstrated petrographically. The connection to Filipe soils is particularly apparent with regard to the samples comprising subgroup A, which constitute an internally consistent subgroup characterized by a highly micritic groundmass containing a significant quantity of rounded siliceous inclusions or 'quartzy' sand. These fabrics also contain comparatively few large grog inclusions.

Another distinctive characteristic of this fabric class is the large percentage (>70%) of samples containing black cores. Unlike the firing horizons characteristic of other local fabric groups, the colour of core rarely grades into the lighter colour of the margins (i.e. they are sharply defined). The preponderance of black cores and the distinctive character of these firing horizons may suggest an important difference in firing methods. The high frequency of fabrics with an optically inactive or only slightly optically active clay matrix, which is often accompanied by a 'channely' microstructure due to bloating pores and 'shrink voids' in association with the grog inclusions, lends further support to this interpretation.

The high level of internal variation within this fabric class might be considered to reflect the interchangeable use of different clays and forms of carbonate temper by potters working within this general paste-making tradition. The sheer volume of Early Postclassic style vessels at the site suggests that the variation is at least partly chronological. It is likely, however, that some compositional variation among these fabrics relates to the paste preparation methods of different potters. This is suggested by the fact that different and potentially geographically separated clay resources are represented in this fabric class. It seems unlikely that a single group of potters would simply choose to exploit multiple clays and source locations at any one given time.

8.5.4. The Quartz-Sand Tradition

The Quartz-Sand class represents a tradition of coarse ware manufacture that appears in the Lamanai sequence during the Terminal Classic period. The mineralogy of these fabrics indicate that they derive from clays formed in association with deep deposits of Pleistocene alluvium, and a connection to the deposit bordering the east side of the New River Lagoon is demonstrated through the striking similarity between many of the archaeological samples and the clay samples taken from this area. The Quartz Sand class contains the only local fabrics that derive from raw material resources situated on the opposite side of the lagoon. Hence, the appearance of this fabric type at the site can be considered to reflect the introduction of a significantly different approach to coarse ware production, based on previously unexploited raw material resources.

8.5.5. The Significance of Grog-Tempered Variants

A final issue concerns the potential significance of the petrographic subgroups within the Crystalline Calcite-Tempered and Sascab Quartz A fabric groups, which were distinguished primarily due to the presence of grog temper. The comparative rarity of fabrics containing grog in the early part of the sequence and the predominance of the Grog-Mixed Carbonate class by its end is indicative of a strong temporal trend toward the prevalence of grog-tempering as a practice. In addition, the presence of grog temper as a compositional attribute is strongly associated with vessel forms and surface treatments that become the standard by the Early Postclassic period. This close relationship is clearly reflected in the surface treatment and morphology of the vessels comprising the subgroup of Sascab A in comparison to the main group. Nonetheless, grog temper is also present in a small number of vessels reflective of early styles within the sequence. Within the calcite-tempered fabric groups, these grog-tempered vessels are virtually identical in terms of surface treatment and morphology to their non-grog-tempered counterparts. Similarly, the composite silhouette dishes and bowl that occur within the Grog-Mixed Carbonate are also visually indistinguishable from the more usual, calcite-tempered versions of these vessels. The occurrence of these grog-tempered variants of early vessel styles provides evidence that the use of grog as a tempering material did not necessarily coincide with an alteration in the stylistic characteristics of the vessels being produced. The implication is that this change in local paste-making practices, as indicated by the increasing prevalence of grog-tempering throughout the sequence, occurred independently of the incorporation of new vessel forms and surface treatments into the local ceramic repertoire.

8.6. TEMPORAL TRENDS IN THE INFLUX OF NON-LOCAL CERAMICS TO THE SITE

Thin section analysis has produced several, compositionally distinct fabric groups that are geologically incompatible with raw material resources available in the local area. These include: five groups within the Crystalline Calcite-Tempered class, Sascab-Quartz B, the Sascab class, the five groups comprising the Volcanic Glass class, and the four groups comprising the Dolomitic-Calcitic Marl-Based class. Since each of these groups is petrographically distinctive in its own right, it is suggested that they derive from different points of origin. Some of the groups represent different and geographically separated manufacturing areas, as indicated by their geology (e.g. Volcanic Glass D and E), whist other appear to reflect different manufacturing conventions or the use of different raw material resources that occur within the same broad geological zone (e.g. the groups with geological links to coastal areas of northern Belize and southern Yucatan). The Quartz Sand class and group H of the Crystalline Calcite-Tempered class also contain vessels deriving from non-local raw materials.

In many cases, the compositional distinctiveness of the non-local fabric groups, as well as the petrographic differences among them, are mirrored in the stylistic characteristics of the vessels they contain (Table 8.9). For example, Sascab-Quartz B exclusively comprises red-slipped rounded dishes with black painted decoration, and the two vessels comprising the Sascab class are similarly decorated polychrome composite silhouette bowls. Similarly, the model-carved vessel representing group I of the Crystalline Calcite-Tempered class is stylistically unique within the assemblage as a whole. Also evident is that Monochrome orange vessels with groove-incising are confined to Volcanic Glass A, Red-Brown Striated storage jars are restricted to group G of the Crystalline Calcite-Tempered class and Monochrome Black vessels only occur in Dolomitic-Calcitic Marl-based A and Calcite E.

The provenance associations of the different non-local fabric groups are presented in Table 8.10. As can be observed, non-local ceramics within the Lamanai assemblage derive from several different areas within the lowland region and from different localities within northern Belize and the Yucatan. In addition, at least one vessel, represented by Volcanic Glass D, has geological connections to the Maya Mountains area. Due to the absence of diagnostic rock and mineral fragments in Volcanic Glass A, it is not possible to assign a provenance based on the geology of the associated raw materials. In addition, this group contains a range of different vessel styles, and so stylistic criteria provide no further insight. Nonetheless, the clay component of these fabrics is calcareous, suggesting a connection to an area underlain by limestone as the source of the clay, and igneous-related inclusions, which would suggest a connection to the Maya Mountains or Sierra Madres, are absent. In addition, these fabrics are clearly dissimilar to the fabric groups that are geologically compatible with clay resources located in northern Belize and southern Yucatan. It is well recognized that volcanic ash tempering is characteristic of Late and Terminal Classic fine wares at sites in Central Peten and much of this area is underlain by limestone. Accordingly, by process of elimination, it is possible, but not demonstrable geologically (based on the present body of evidence and information), that the vessels comprising Volcanic glass A originate from Central Peten.

When the functional and temporal associations of the non-local fabric groups are considered, three significant patterns emerge with regard to local consumption of foreign ceramics. These patterns can be considered to reflect changes over time in the

Table 8.9: Vessel style within the non-local fabric groups and classes.

Fabric Group/Class		bowl	dish	drum	jar	pedestal base	stand	tripod bowl	tripod dish	vase	Total
Crystalline Calcite-Tempered											
Group E	Buff/Cream Slipped	1									1
	Monochrome Grey (Plumbate)					1					1
	Monochrome Red Slipped and Notched	1									1
	Total	2				1					3
Group F	Monochrome Black	3								2	5
	Monochrome Orange Slipped				1						1
	Monochrome Red Slipped	1									1
	Polychrome Slipped and Painted									1	1
	Total	4			1					3	8
Group G	Monochrome Orange Slipped				1						1
	Red-Brown-Striated				4						4
	Unslipped Striated				1						1
	Unslipped/Smoothed-Buff				1						1
	Total				7						7
Group I	Monochrome Red Slipped and Model-Carved	1									1
Group J	Monochrome Red Slipped				1						1
Dolomitic-Calcitic Marl-based											
Group A	Monochrome Black	11								6	17
Group B	Monochrome Orange Slipped	1			2				1		4
	Monochrome Orange Slipped and Incised						1				1
	Monochrome Red Slipped				2						2
	Total	1			4		1		1		7
Group C	Monochrome Orange Slipped			1				1			2
Group D	Polychrome Slipped and Painted	4									4
	Red-Orange-Black Resist		1								1
	Total	4	1								5

Table 8.9: Vessel style within the non-local fabric groups and classes (continued).

Fabric Group/Class		bowl	dish	drum	jar	pedestal base	stand	tripod bowl	tripod dish	vase	Total
Sascab-Quartz B	Black on Red Slipped and Painted		3								3
Sascab	Polychrome Slipped and Painted	2									2
Volcanic Glass											
Group A	Monochrome Orange Slipped	1								1	2
	Monochrome Orange Slipped and Groove-Incised									3	3
	Monochrome Orange Slipped and Incised	1									1
	Polychrome Slipped and Painted	2						2		2	6
	Total	4						2		6	12
Group B	Monochrome Red Slipped							1			1
Group C	Buff/Cream Slipped	1									1
Group D	Polychrome Slipped and Painted	1									1
Group E	Polychrome Slipped and Painted									1	1

Table 8.10: Non-local fabric groups and their provenance associations.

Fabric Group/Class	**Provenance Association based on Geological Characteristics**
Crystalline Calcite-Tempered	
Group E	Areas adjacent to north east coast of northern Belize and in Yucatan, with stylistic links to Yucatan
Group F	Areas adjacent to north east coast of northern Belize and in Yucatan
Group G	Inland areas of northern Belize, likely surrounding or west of the New River
Group I	Unknown, but likely outside of northern Belize
Group J	Inland areas of northern Belize north of the New River Lagoon
Dolomitic-Calcitic Marl-based	
Group A	Coastal areas of northeastern eastern northern Belize - similarity to numerically dominant fabrics at Late Classic Altun Ha
Group B	Coastal areas of northeastern northern Belize, extending into southern Yucatan
Group C	Coastal areas of northeastern northern Belize, extending into southern Yucatan
Group D	Coastal areas of northeastern northern Belize, extending into southern Yucatan
Sascab-Quartz B	Corozal District likely in proximity to the Rio Hondo
Sascab	Inland areas of northern Belize
Volcanic Glass	
Group A	Outside of northern Belize/Yucatan, possibly Central Peten
Group B	Unknown but clearly non-local
Group C	Stylistic links to Yucatan
Group D	Maya Mountains with specific connections to Bladen Volcanic Member of the southern fringe
Group E	
Quartz Sand	Inland areas of northern Belize, specific links to areas east of the Northern Lagoon drainage system
Crystalline Calcite-Tempered H	Inland areas of northern Belize, specific links to areas east of the Northern Lagoon drainage system

kinds of foreign ceramic products entering the site and from which areas of the lowland region they originated. Firstly, the large majority of non-local vessels are drinking vessels and jars used for storing (and serving) liquids and other food stuffs (Figure 8.20). When considering the provenance associations of the different non-local fabric groups, it is also evident that fine ware vessels derive from a range of geographically widespread localities, whereas coarse ware jars derive mainly from northern Belize. Secondly, the frequency of foreign fine ware, including drinking vessels, decreases over time, whilst the frequency of coarse ware jars appears to increase (Figure 8.21). Even though these figures include the two groups containing both local and non-local coarse ware jars, an increase in non-local storage jars is clearly indicated. Thirdly, ceramics deriving from inland areas of northern Belize, coastal areas of north eastern northern

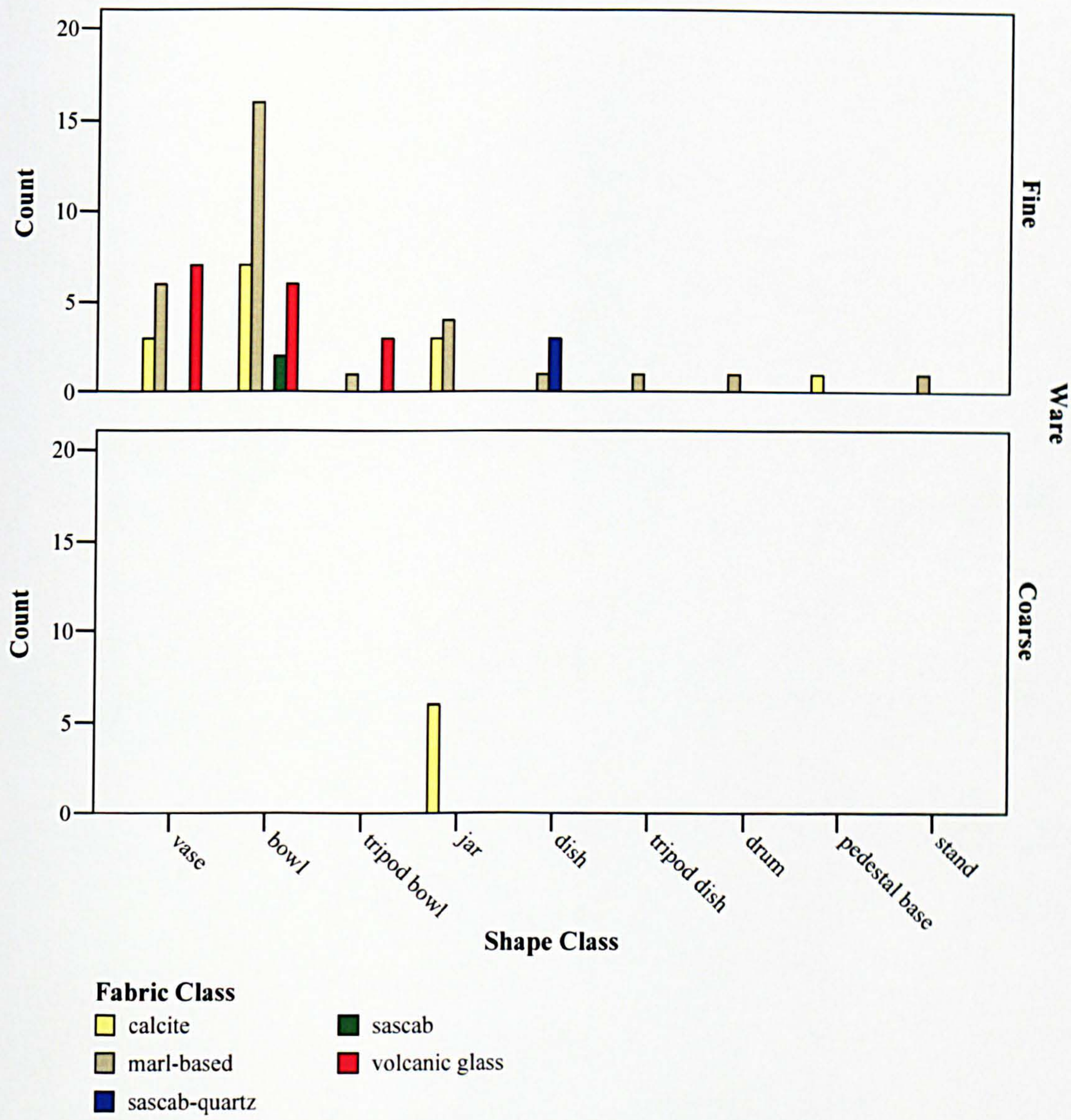


Figure 8.20: The frequency of vessel forms within the non-local fabric groups.

Belize, extending into southern Yucatan, and with stylistic connections to the Yucatan area continue throughout the sequence (Figure 8.22). In contrast, vessels deriving from the Maya Mountains area and which potentially derive from Central Peten only occur in the earliest stratigraphic contexts. Although the sample sizes are admittedly small for some stratigraphic contexts, these general patterns within the sequence can be considered to be accurate, given the sampling strategy that was employed in the selection of vessels for thin section analysis. A major implication of these findings is that a reorientation of economic and social contacts towards the northern lowlands is not demonstrated, as has been suggested for sites in northern Belize (e.g. Masson and Mock 2004). Rather, the evidence indicates that these contacts were ongoing by the

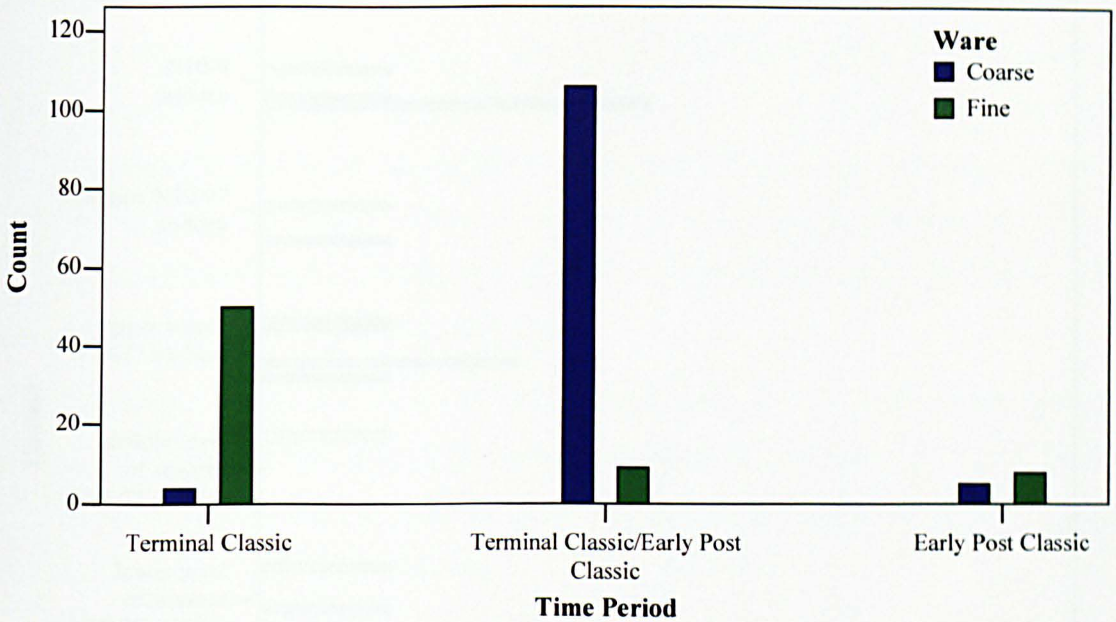


Figure 8.21: Temporal trends in the frequency of non-local fine ware and coarse ware vessels according to stylistic and contextual criteria (counts reflect totals for non-local groups and groups containing both local and non-local ceramics).

beginning of the sequence and simply continued into Early Postclassic period. This and other aspects of community level patterns in the consumption of foreign ceramics will be explored and elaborated upon in greater detail in Chapter 11.

8.7. SUMMARY

The petrographic study of the Lamanai assemblage has revealed several significant patterns relating to local pot-making activities as well as the consumption of local and foreign pottery items. These patterns are summarized as follows:

1) Thin section analysis produced seven different fabric classes, representing general paste recipes characterized by the types of raw material ingredients involved, and 24 fabric groups that reflect geological differences related to raw material sources.

2) The large majority of the ceramics within the archaeological contexts analyzed were manufactured locally.

3) Certain fabric classes clearly dominate the early and later ends of the sequence and class frequencies change over time. Nonetheless, a similar range of different fabric types, defined on the class level, occurs throughout the sequence, indicating continuity in the diversity of fabrics that occur over time.

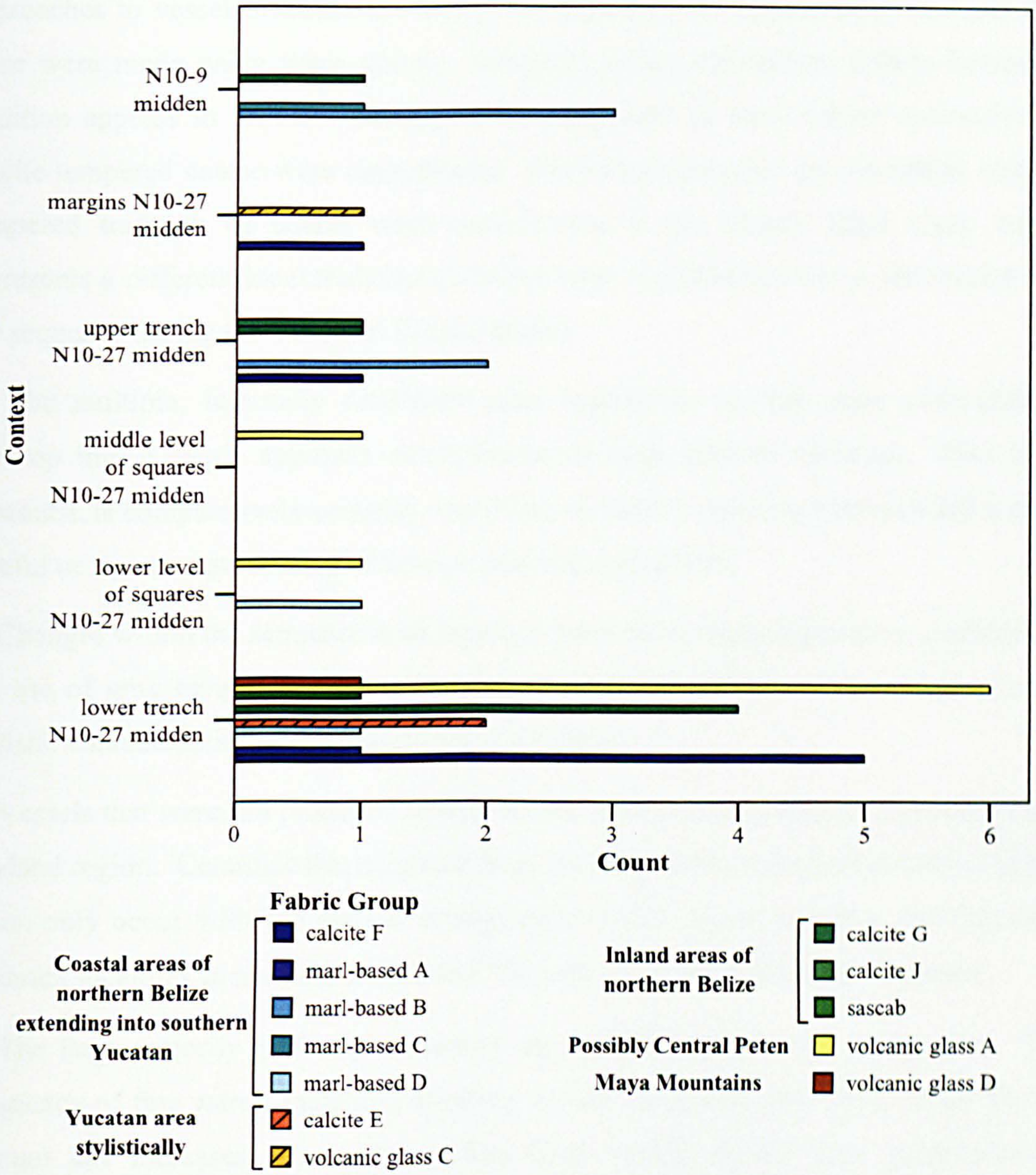


Figure 8.22: Stratigraphic associations of non-local groups summarized by provenance.

4) There is a strong correlation between vessel composition at the class level and vessel function, indicating that vessels used in service and ritual tend to have different compositions than those serving broadly utilitarian functions. In addition, fine ware exhibits greater compositional diversity than coarse ware.

5) Four different local traditions of paste-making are represented. Within these traditions, Group C of the Crystalline Calcite-Tempered class and Sascab Quartz A reflect different contemporaneous approaches to fine ware manufacture that give way to the significantly different approach represented by the Grog-Mixed Carbonate Class.

Groups A and B of the Crystalline Calcite Tempered tradition also reflect early approaches to vessel manufacture within the sequence, but both coarse ware and fine ware were made using these pastes. Group H of the Crystalline Calcite-Tempered tradition appears to reflect a developmental outgrowth of these earlier approaches to calcite-tempered coarse ware manufacture. Occurring alongside the crystalline calcite-tempered tradition of coarse ware manufacture is the Quartz Sand class, which represents a different local tradition of coarse ware manufacture that is introduced into the sequence during the Terminal Classic period.

6) The multiple, internally consistent local approaches to fine ware paste-making develop into a single approach characterized by high internal variation. This latter approach, is comparatively complex, involving multiple tempering materials and a more careful or rigorous processing of the raw material ingredients.

7) Changes within the sequence with regard to local paste-making practices, particularly the use of grog temper, appear to have occurred independently of the changes in the stylistic characteristics of the vessels being produced.

8) Vessels that were not produced locally derive from several different areas within the lowland region. Ceramics that originate from the Maya Mountains and possibly Central Peten only occur with the earliest stratigraphic levels, whilst ceramics deriving from different localities in northern Belize and Yucatan occur throughout the sequence.

9) The large majority of foreign ceramics are drinking vessels and storage jars. The frequency of fine wares, including drinking vessels, decreases over time, whilst that of storage jars increases. In addition, fine ware vessels derive from geographically widespread localities within the lowland region, whilst storage jars derive mainly from northern Belize.

These patterns have several implications for current understanding of the nature of ceramic change and during the Classic to Postclassic transition, as well as the kinds of factors influencing distributional patterns and stylistic trends on both the local and regional levels. Their potential archaeological and behavioural significance, when considered in light of the broader setting of community activities within which the manufacture, use and deposition of ceramic items took place, will be explored in Chapter 11, which examines the human and material dimensions of continuity and change in the local ceramic record.

CHAPTER 9

CHEMICAL VARIABILITY WITHIN THE LAMANAI ASSEMBLAGE

9.1. INTRODUCTION

Chemical analysis by neutron activation offers an independent means of investigating and characterizing compositional variability, generating complementary information to that generated through thin section petrography. Comparison of ceramic groups distinguished on the basis of chemical, petrographic and visual criteria provides important insight into the relationship between mineralogical, geochemical and stylistic aspects of ceramic variation. This information is fundamental to interpretation of ceramic groupings with regard to characterizing and discriminating their technological and provenance characteristics (Day et al. 1999).

Neutron activation analyses undertaken by Arnold and colleagues of ethnographic pottery and constituent raw materials from contemporary communities in Guatemala (Arnold et al. 1991) and the Yucatan Peninsula of Mexico (Arnold et al. 1999) have shown that the pottery produced by different communities exploiting similar raw material resources within a delimited 'resource area' can be distinguished chemically. Their Mexican case study is particularly significant as it demonstrates that different production centres located within close geographic proximity may produce distinct chemical profiles, even when they use they same clay. In this case, the chemical distinctiveness of the products of each community derives from the fact that they use tempering materials containing clay minerals, which they procure from their own local resource area (Arnold et al. 1999:81-82). Chemical analysis thus revealed the corporate behaviour of communities of potters.

In light of these findings, Arnold et al. suggest that it should be possible to recognize source-related chemical subgroups in the analysis of archaeological pottery, even when the pottery derives from multiple sources within a broadly geologically homogeneous environment. They recommend that such a study might begin by inspecting the fine-structuring of chemical groups produced through cluster or principal components analysis, searching for subgroups within the main groups identified.

The potential to differentiate pottery with similar mineralogical compositions through chemical analysis is of particular relevance to the present study since the potential problems posed by a geologically homogeneous source area reside on two different scales. Firstly, ceramics identified as 'locally manufactured' through thin section analysis, derive from different combinations of local clays and temper materials but the associated deposits are proximate and, in some cases, potentially adjoining. Secondly, the large majority of the pottery identified as 'non-local' is mineralogically similar to the local ceramics, deriving from the same broad source area underlain by limestone. An issue that is central to the present study, therefore, is whether it is possible to discriminate mineralogically similar pottery deriving from a single site on these two scales of source-related differentiation. More specifically, is it possible to chemically distinguish the products of local potters working within different paste-making traditions, as well as the products of different non-local production centres, given their similar mineralogy and the fact that similar approaches to paste-making or 'paste recipes' are sometimes employed? As Day et al. (1999) have shown, it is sometimes impossible to attribute chemical variability to either technology or provenance, especially when great similarity exists between raw materials found in different locations and approaches to paste preparation are akin (also see Hein et al. 2004a).

With these fundamental issues in mind, the chemical compositional analysis aimed to address the following questions:

- How do the compositional groups identified through chemical analysis correspond with those produced by thin-section analysis?
- Does chemical analysis discriminate the local and non-local fabric groups identified in the previous chapter?
- Does chemical analysis also discriminate the different local paste-making traditions suggested in the previous chapter?
- How does the chemistry of local clays compare to that of the pottery identified as 'locally produced' based on petrographic criteria? Is it possible to link the local fabric groups identified in the previous chapter to extant clay resources?

We will return to these questions at the end of the chapter after the results of the statistical analysis of the chemical data have been discussed. The analytical strategy recommended by Arnold et al. (1999) has been employed to discriminate groups and subgroups potentially reflecting chemical differences related to source. It should be noted, however, that calcium was included in both the cluster and principal component analysis. Although the authors recommend that calcium and strontium should be discounted due their diluting/enrichment effect, its removal during analyses of the Lamanai data set did not alter group membership or the chemical relationships between the groups. Due to the high overall variability of the present data set, the groups derived from cluster analysis were evaluated on the basis of their internal variability. As a measure of this internal variability, the standard deviation of the mean value was used.

9.2. BASIC STRUCTURE OF THE DATA SET

As can be seen in the dendrogram presented in Figure 9.1, cluster analysis of the ceramic samples produced a main cluster containing the large majority of the samples analysed and two smaller clusters (Groups 1 and 2). The main cluster is separable into at least five groups (Groups 3-7), and with the exception of Group 7, each of these groups is separable into two to several chemical 'sub-clusters' or subgroups.

The average element values and standard deviations (actual and in %) for the seven chemical groups are given in Table 9.1. It can be observed that for each group the standard deviations of the concentrations of all of the elements are quite high, generally well above 15%. In fact, Group 5 is the only group for which multiple elements have standard deviations below 15% (e.g. Sm, Lu, Eu, Fe, Th and Sc). Accordingly, overall variability within the data set is high and the emergent chemical groups are characterized by high internal variability.

The removal of chemical outliers, containing exceedingly high or low concentrations (not necessarily in one direction) for three or more elements, from the ends of the group clusters did not significantly reduce the internal variation within individual groups, except in the case of Group 1. The removal of four outliers from the end of this group reduced the standard deviations of the majority of elements to below 15%, and to below 10% for Cr, Hf, Fe, and Eu (Table 9.1). These outliers can be considered as chemically related to the remaining samples comprising Group 1, but their chemical profiles are significantly different in important respects. For example, samples 55 and 158 contain comparatively high concentrations of La, Ce, Th, Sc and Fe, whereas sample 215 contains comparatively low concentrations of La and Ce, but high concentrations of Sc and Fe (see Appendix VI). Sample 610 is separated from the main group due to its low

Table 9.1: A summary of the average compositions and standard deviations (actual and percent) for the main chemical groups identified. Concentrations are given in ppm apart from Ca, Na and Fe. High element values are marked in yellow and low values are marked in blue.

	Group 1			Group 1 without Outliers			Group 2			Group 3			Group 4			Group 5			Group 6			Group 7		
	Ave. Value	S.D.	% S.D.	Ave. Value	S.D.	% S.D.	Ave. Value	S.D.	% S.D.	Ave. Value	S.D.	% S.D.	Ave. Value	S.D.	% S.D.	Ave. Value	S.D.	% S.D.	Ave. Value	S.D.	% S.D.	Ave. Value	S.D.	% S.D.
Sm	5.84	1.05	17.91	5.7	0.99	17.39	7.2	1.85	25.73	6.57	1.32	20.08	5.03	1.53	30.41	2.73	0.4	14.72	3.31	0.77	23.18	5.45	1.48	27.21
Lu	0.41	0.07	16.79	0.39	0.05	13.96	0.47	0.08	17.83	0.43	0.07	15.44	0.33	0.07	20.64	0.25	0.03	13.57	0.25	0.06	22.25	0.33	0.06	19.13
U	3.25	1.34	41.28	2.91	0.95	32.5	3.25	0.93	28.62	3.02	1.56	51.73	2.86	1.65	57.71	1.8	0.28	15.4	1.15	0.37	32.13	1.56	0.57	36.48
Yb	3.28	0.55	16.71	3.13	0.45	14.51	3.8	0.77	20.25	3.52	0.61	17.38	2.6	0.63	24.15	2.01	0.28	14.08	2.07	0.51	24.72	2.83	0.55	19.47
As	8.52	2.46	28.89	8.05	1.48	18.4	2.81	1.27	45.33	4.48	2.71	60.46	3.53	2.57	72.75	2.29	1.17	51.16	2.79	2.12	76.19	4.06	2.52	61.97
Sb	1.5	0.35	23.34	1.38	0.2	14.67	1.07	0.12	11.23	1.16	0.25	21.47	1.03	0.24	23.42	0.96	0.07	7.2	0.96	0.26	27.6	1.06	0.32	30.7
Ca	6.05	2.63	43.48	7.12	1.7	23.86	1.23	0.37	30.3	13.05	3.77	28.9	18.23	5.99	32.83	9.88	3	30.39	22.12	4.53	20.46	19.56	3.45	17.63
Na	1.06	0.25	23.38	1.13	0.15	13.03	0.14	0.07	48.73	0.14	0.04	30.6	0.13	0.06	50.96	0.13	0.04	27.32	0.11	0.04	36.98	0.13	0.04	27.99
La	30.1	5.82	19.33	29.03	4.3	14.81	36.37	9.64	26.51	33.71	6.86	20.35	26.09	9.09	34.84	16.25	2.98	18.31	16.09	3.55	22.06	28.85	8.33	28.87
Ce	65.72	12.62	19.21	63.07	9.05	14.35	81.99	22.54	27.49	80.92	31.11	38.44	55.88	18.13	32.45	34.62	5.48	15.84	38.14	9.59	25.15	72.03	18.35	25.48
Th	12.54	3.91	31.17	11.44	3.01	26.28	12.7	1.83	14.39	13.15	2.33	17.75	10.05	2.31	22.98	10.65	0.99	9.32	8.38	1.98	23.69	10.89	3.11	28.52
Cr	37.37	20.47	54.78	29.96	2.64	8.8	55.73	9.81	17.61	59.99	12.99	21.65	58.78	17.09	29.08	42.84	6.8	15.88	47.77	14.26	29.85	55.05	12.58	22.85
Hf	5.65	0.75	13.25	5.27	0.35	6.67	8	1.51	18.87	6.74	1.51	22.45	5.06	2.37	46.86	7.98	1.19	14.92	4.84	0.94	19.44	6.68	1.92	28.68
Cs	8.78	2.95	33.57	8.83	3.2	36.25	7.24	3.33	46	5.7	2.24	39.34	4.95	2.56	51.73	3.79	1.44	38.06	1.38	0.61	43.97	1.41	0.39	27.32
Tb	0.73	0.14	18.95	0.7	0.14	19.37	0.9	0.2	22.66	0.83	0.17	20.62	0.62	0.18	29.43	0.38	0.06	14.55	0.45	0.12	26.57	0.69	0.17	24.87
Sc	9.13	2.91	31.91	7.87	0.92	11.74	11.29	2.71	23.96	11.75	2.04	17.38	10.7	2.26	21.12	8.62	0.7	8.08	7.76	1.33	17.09	9.06	1.68	18.55
Rb	138.95	32.28	23.23	142.68	35.86	25.13	68.2	31.89	46.76	57.47	17.7	30.81	55.1	24.05	43.64	36.16	8.96	24.78	25.78	10.44	40.52	32.69	13.91	42.55
Fe	2.17	0.53	24.32	1.93	0.17	8.61	2.37	0.41	17.2	2.65	0.48	18.2	2.09	0.43	20.46	1.98	0.21	10.77	1.66	0.31	18.67	2	0.42	21.15
Ta	1.07	0.29	26.8	0.98	0.22	22.56	1.56	0.28	17.71	1.38	0.3	22.12	0.92	0.19	21.09	1.15	0.18	15.31	0.72	0.11	15.13	0.94	0.15	16.11
Co	5.91	1.23	20.73	5.5	0.63	11.53	5.83	1.43	24.43	6.07	1.7	28.05	4.19	0.75	17.84	4.32	0.9	20.94	2.78	0.72	25.92	3.72	1.23	33
Eu	0.89	0.18	20.21	0.82	0.06	7.45	1.31	0.38	29.48	1.2	0.27	22.19	0.9	0.29	32.45	0.48	0.07	14.07	0.63	0.15	24.68	1.02	0.3	28.91

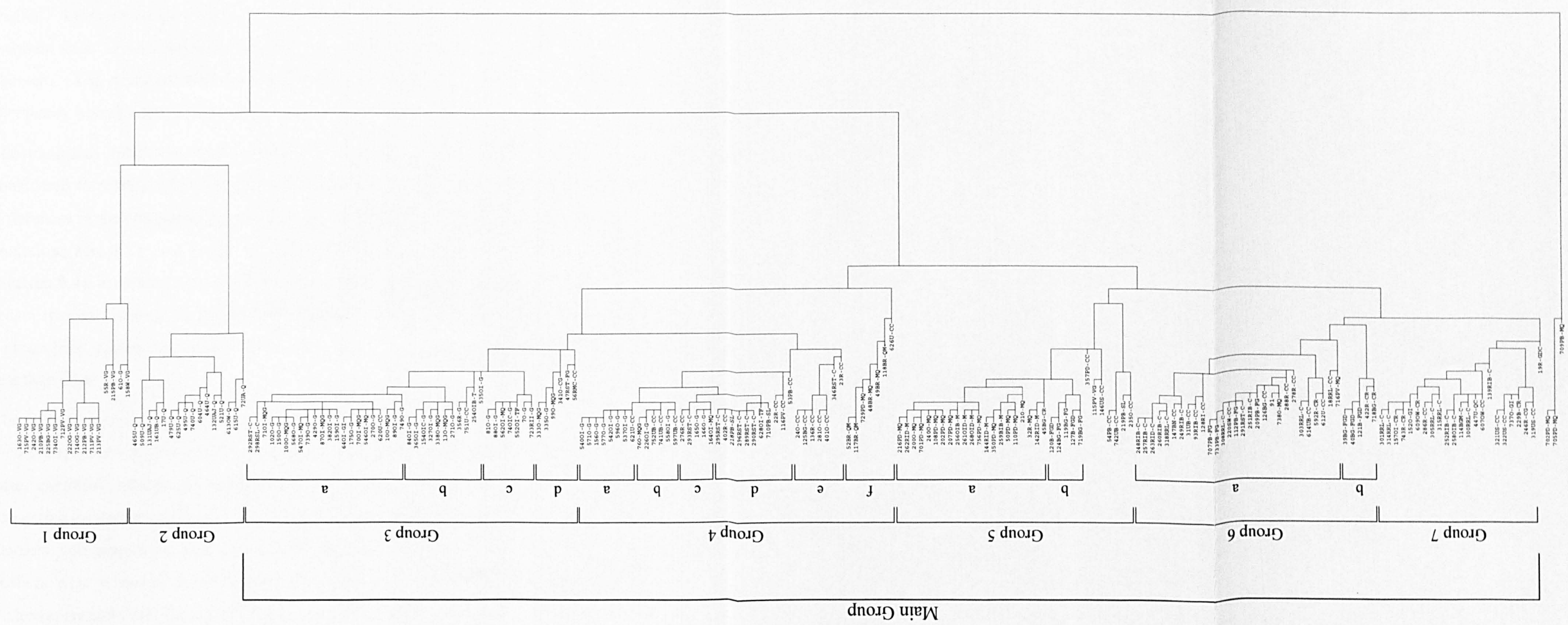


Figure 9.1: Dendrogram of the Lamanai data set showing the three principal clusters, and the chemical groups and subgroups.

Na content. The different concentrations for the rare earth elements, in particular, (i.e. La, Ce and Th) most likely reflect natural chemical differences in the clay component of these pastes (see Glascock et al. 2004 and Bishop et al. 1982 for a discussion).

With the exception of Groups 1 and 5, the within-group variation in element concentrations greatly exceeds the acceptable range of below 10-15 %, which is the conventional 'benchmark' that is considered to denote a coherent chemical group or profile. In most cases, however, inspection of the fine-structuring of each group resolves them into subgroups that exhibit an acceptable range of variation for most elements. The exceptions are Groups 2 and 7, which are not separable into relatively chemically homogenous subgroups.

The identified subgroups within Groups 3, 4, 5 and 6 of the main cluster can be considered to represent chemically discrete groupings within these larger groups, since differences in the concentrations of particular elements are apparent even when standard deviations across the subgroups are taken into account. As will be discussed below (Section 9.4), in certain cases these chemical distinctions can be related to differences in 'paste recipes' among locally *and* non-locally produced ceramics, when stylistic and petrographic information is considered. In other cases, however, such connections are less than clear.

The stylistic and petrographic characteristics of the vessels comprising each group and their component subgroups, when present, are summarized in Tables 9.2 to 9.8. In each case, chemical outliers are marked with an asterisk. Since their removal from the respective groups or subgroups does not significantly decrease within-group variation in element concentrations, they have been included in the group summaries. These outliers were removed for the principal components analysis, however, to achieve a better separation of the groups and subgroups in the component plots.

9.3. CHEMICAL CHARACTERISTICS OF THE IDENTIFIED GROUPS AND THEIR PETROGRAPHIC AND STYLISTIC CORRELATES

9.3.1. Group 1

Group 1 is the smallest of the groups identified, containing 12 samples, not including the four outliers. The samples within this group contain comparatively high concentrations of Na, Cs, and Rb and comparatively low Ca (Table 9.1). This group exclusively comprises non-local polychrome and plain and groove-incised orange slipped bowls and vases with Volcanic Glass A fabrics (Table 9.2). Perhaps not surprisingly, three of the four outliers within Group 1 also derive from non-local ash-tempered vessels, corresponding to the Volcanic Glass groups B, C and D. As was discussed in the previous chapter, these fabric groups are represented by only one sample each and are clearly differentiated from Group A fabrics on mineralogical grounds. Hence, the compositional differences observed among the volcanic ash-tempered fabrics on the microscopic level are also reflected in their chemistry. The high concentrations of the alkali metals Na, Rb and Cs in Group 1 derive from the fact that these pastes contain an appreciable quantity of alkali feldspar, which is naturally present in the ash or tuff used for temper.

9.3.2. Group 2

Group 2, comprising 16 samples, is also a comparatively small chemical group within the data set. It is separated due to comparatively high concentrations of the rare earth elements Sm, Lu, Yb, La and Ce, as well as Hf, and by low Ca concentrations (Table 9.1). This group almost exclusively contains utilitarian vessels made with sandy clays deriving from areas of Pleistocene alluvium (Quartz Sand fabrics) (Table 9.3). The exception is the incense burner with the same fabric type. This group's distinct chemical profile, especially with regard to the rare earth element concentrations, indicates significant chemical differences in the clay component of this utilitarian pottery. The high levels of Hf most likely reflect the presence of zircon in the clay, occurring as aplastic inclusions, which are too small in size to permit identification through thin section analysis (c.f. Buxeda et al. 2003a). The presence of zircon might be expected given the siliceous mineralogy of the aplastic component of these fabrics (V. Kilikoglou, personal communication 2004). Whilst the low Ca content of the samples comprising Group 1 also relates, in part, to the geological parentage of these particular clays, which are associated with deep deposits of siliceous sand deriving ultimately from the Maya Mountains, it also reflects the fact that these pastes do not contain carbonates. Interestingly, discrete chemical subgroups are not apparent within Group 2, even though thin section analysis suggested that different Pleistocene-alluvium-related clay resources are represented within the Quartz Sand class. Nonetheless, the results of the chemical analysis would seem to be in keeping with the fact that mineralogical variation within the Quartz Sand class is continuous rather than discrete.

Table 9.2: Stylistic and petrographic characteristics of the vessels comprising Group 1. Chemical outliers are marked with an asterisk.

Stylistic Categories Represented	Compositional Categories Represented	No.
Polychrome Slipped and Painted (*vases, flaring bowls, deep bowl, tripod deep bowls*)	Volcanic Glass Group A	6
Monochrome Orange Slipped and Groove-Incised (*vases, rounded bowl*)		4
Monochrome Orange Slipped (*vase, flaring bowl*)		2
*Buff/Cream Slipped (plain) - slate ware (*rounded bowl*)	Volcanic Glass Group C	1
*Monochrome Red Slipped (*flaring tripod bowl*)	Volcanic Glass Group B	1
*Polychrome Slipped and Painted (*flaring bowl*)	Volcanic Glass Group D	1
*Monochrome Orange Slipped (*rounded bow*l)	Grog-Mixed Carbonate Class	1
	Total	**12 + 4OL**

Table 9.3: Stylistic and petrographic characteristics of the vessels comprising Group 2. Chemical outliers are marked with an asterisk.

Stylistic Categories Represented	Compositional Categories Represented	No.
Unslipped Utilitarian (*$^{=1}$*jars, plate/lids, comal,* * *pedestal-based censer*)		11
Unslipped and Incised (appliqué impressed fillet) (*strap handle jars*)	Quartz Sand Class	3
Unslipped/Smoothed – Perforated (*incense burner*)		1
*Washed/Smoothed (*jar*)		1
	Total	**16**

9.3.3. The Main Cluster

9.3.3.1. GROUP 3

Group 3 is the largest of the five chemical groups that form the main cluster within the dendrogram. This group contains 46 samples and is separable into four sub-groups (3A, 3B, 3C and 3D) of varying size. Subgroup 3A is the largest, containing 22 samples, and 3D, with just 6 members, is the smallest. On the whole, Group 3 is characterized by high mean values for Cs, Th, Cr, Sc and Fe, although the concentrations of these elements vary considerably (see the standard deviations listed in Table 9.1). The chemical differences apparent among the subgroups comprising Group 3 relate to the relative concentrations of particular rare earth elements. For example, the samples comprising subgroup A contain lower concentrations of La and Eu than those comprising subgroup D, even when taking into account the standard deviations of these elements for both subgroups. Similarly, subgroup C is clearly differentiated from subgroups A and B by comparatively high Th levels.

With few exceptions, Group 3, as well as its component subgroups, predominantly consists of grog-tempered Monochrome Orange Slipped and Monochrome Orange Slipped and Incised vessels (Table 9.4). Vessel forms are typically Early Postclassic in style, with a similar range of forms occurring within each subgroup. In addition, the large majority of samples within each subgroup correspond to the Grog-Mixed Carbonate class, although the grog tempered variants of the Sascab Quartz A fabric group and groups B and C of the Crystalline Calcite-Tempered class are also represented. In the case of Group 3, therefore, there is also a strong correspondence with particular stylistic and petrographic categories on the group level. Further distinctions among the vessels that occur within the subgroups, however, are not apparent.

9.3.3.2. GROUP 4

Group 4 is the second largest of the groups comprising the main cluster, containing 43 samples. On the whole, this group is characterized by a comparatively high average value for Ca and a comparatively low average value for Hf, but with marked variability in both cases (Table 9.1). Group 4 is separable into six discrete chemical subgroups, which are represented by less than 11 samples in each case. The differences among the subgroups are reflected in their Eu content in particular. In addition, subgroup F is clearly distinguished by higher concentrations of Sm, Lu, Yb, La and Hf. The higher concentrations of some of the rare earth elements in this subgroup most likely relates to natural differences in the clay component of these particular samples. As with Group 2, higher Hf levels may reflect the presence of zircon, which is in keeping with the siliceous mineralogy of the aplastic inclusions within these fabrics (see below). The chemical distinctiveness of subgroup F is reflected in the vessels it contains, with five of seven samples deriving from Black on Red vessels with sandy sascab-tempered fabrics (Sascab-Quartz class) (Table 9.5). Significantly, both this stylistic category and the Sascab-Quartz B fabric group are confined to this particular chemical subgroup, being entirely absent in any of the

Table 9.4: Stylistic and petrographic characteristics of the vessels comprising Group 3. Chemical outliers are marked with an asterisk.

	Stylistic Categories Represented	Compositional Categories Represented	No.
Subgroup A	Monochrome Orange Slipped and Incised (*jar rounded, composite silhouette and out-curving bowls, tripod bowls with segmented basal flange, tetrapod bowl, pedestal-based jars (censer)*)	Grog-Mixed Carbonate Class (main group & subgroup A) (N=7) Sascab-Quartz A subgroup (grog-tempered variant) (N=3) Crystalline Calcite-Tempered C subgroup (grog tempered variant) (N=1)	11
Subgroup A	Monochrome Orange Slipped (*various jar forms, drum, chalice, composite silhouette and out-curving bowls*)	Grog-Mixed Carbonate Class (N=7) Sascab-Quartz A subgroup (grog-tempered variant) (N=1)	8
Subgroup A	Unslipped/Smoothed-Buff (*jar*)	Crystalline Calcite-Tempered Group H	1
Subgroup A	*Red-Orange-Black Resist (*composite silhouette dish*)	Crystalline Calcite-Tempered Group C	1
Subgroup A	*Slipped Rim/Lip - Smoothed Body (*jar*)	Crystalline Calcite-Tempered Group D	1
		Total	**22**
Subgroup B	Monochrome Orange Slipped and Incised (*chalices, drum, rounded bowl, tripod dish*)	Grog-Mixed Carbonate Class (main group)	5
Subgroup B	Monochrome Orange Slipped (*=1 *chalices, out-curving tripod bowl*)	*Grog-Mixed Carbonate Class (main group) (N=1) Sascab-Quartz A subgroup (grog-tempered variant) (N=2)	3
Subgroup B	*Monochrome Orange Slipped (interior slipped) (*rounded bowl*)	Crystalline Calcite-Tempered Group B subgroup (grog tempered variant)	1
Subgroup B	*Monochrome Red Slipped (*composite silhouette bowl*)	Grog-Mixed Carbonate Class (main group)	1
Subgroup B	Unslipped/Smoothed-Buff (*jar*)	Crystalline Calcite-Tempered Group G	1
		Total	**11**
Subgroup C	Monochrome Orange Slipped and Incised (*chalice, tripod bowl with segmented basal flange, pedestal-based jar (censer)*)	Grog-Mixed Carbonate Class (N=2) Sascab-Quartz A subgroup (grog-tempered variant) (N=1)	3
Subgroup C	Monochrome Orange Slipped (*rounded bowl with strap handles, out-curving dish*)	Grog-Mixed Carbonate Class (main group)	2
Subgroup C	*Monchrome Orange to Red Slipped - Notched and Incised (*composite silhouette bowl*)	Grog-Mixed Carbonate Class (main group)	2
		Total	**7**
Subgroup D	Monochrome Orange Slipped (*chalices, out-curving tripod dish*)	Grog-Mixed Carbonate Class (main group) (N=2) Sascab-Quartz A subgroup (grog-tempered variant) (N=2)	4
Subgroup D	*Red-Orange-Black Resist (*out-curving dish*)	Dolomitic-Calcitic Marl-based Group D	1
Subgroup D	*Monochrome Red Slipped and Model-Carved (*flaring bowl*)	Crystalline Calcite-Tempered Group I	1
		Total	**6**

Table 9.5: Stylistic and petrographic characteristics of the vessels comprising Group 4. Chemical outliers are marked with an asterisk.

	Stylistic Categories Represented	Compositional Categories Represented	No.
Subgroup A	Monochrome Orange Slipped (*chalice, composite vessel and rounded bowl, plate/lid*)	Grog-Mixed Carbonate Class (main group) (N=3) Sascab-Quartz A subgroup (grog-tempered variant) (N=1)	4
	Monochrome Orange Slipped and Incised (*tripod bowls with segmented basal flange, chile grinder*)	Grog-Mixed Carbonate Class (main group)	3
	Unslipped/Smoothed-Buff (*jar*)	Crystalline Calcite-Tempered Group H	1
		Total	**8**
Subgroup B	Unslipped/Smoothed-Buff (*jars, plate/lid*)	Crystalline Calcite-Tempered Group A (N=1) Crystalline Calcite-Tempered Group B (N=2)	3
	Monochrome Orange Slipped and Incised (*chalice, out-curving bowl*)	Grog-Mixed Carbonate Class (main group)	2
	Monochrome Orange Slipped (*chalice*)	Sascab-Quartz A subgroup (grog-tempered variant)	1
		Total	**5**
Subgroup C	Monochrome Orange Slipped and Incised (*chalice, frying pan censer*)	Grog-Mixed Carbonate Class (main group) (N=1) Sascab-Quartz A subgroup (grog-tempered variant) (N=1)	2
	Monochrome Orange Slipped (*drum*)	Grog-Mixed Carbonate Class (main group)	1
	Monochrome Red Slipped (*composite silhouette dish*)	Crystalline Calcite-Tempered Group C	1
	Red-Orange-Black Resist (*composite silhouette dish*)		1
		Total	**5**
Subgroup D	Red-Orange-Black Resist (*composite silhouette dish*)	Crystalline Calcite-Tempered Group C	4
	Polychrome Slipped and Painted (*=1*composite silhouette bowls*)	Sascab-Quartz A (main group) (N=2) *Crystalline Calcite-Tempered Group C(N=1)	3
	Monochrome Red Slipped (*=1*composite silhouette dish*)	Crystalline Calcite-Tempered Group C	2
	Monochrome Orange Slipped and Incised (*jar*)		1
	*Monochrome Red Slipped, Stuccoed and Painted (*vase*)		1
		Total	**11**
Subgroup E	Monochrome Orange Slipped (*composite silhouette dishes and a bowl*)	Crystalline Calcite-Tempered Group C (N=2) Crystalline Calcite-Tempered Group D (N=1)	3
	Monochrome Red Slipped (*=1*composite silhouette dishes*)	Crystalline Calcite-Tempered Group C	2
	Monochrome Black (groove-incised and punctated) (*vase*)		1
	*Red-Orange-Black Resist (*composite silhouette dish*)		1
		Total	**7**
Subgroup F	Black on Red Slipped and Painted (*rounded dishes, massive bowl*)	Sascab-Quartz A (main group) (N=2) Sascab-Quartz B (N=3)	5
	Polychrome Slipped and Painted (*composite silhouette dish*)	Sascab-Quartz A (main group)	1
	*Unslipped/Smoothed-Buff (*jar*)	Crystalline Calcite-Tempered Group B	1
		Total	**7**

other main chemical groups. In comparison, subgroups D and E, with only two exceptions, consist of vessels with crystalline calcite-tempered fabrics and these are mainly monochrome and 'resist' composite silhouette dishes and polychrome composite silhouette bowls (subgroup D only). Subgroup C also contains composite silhouette dishes with calcite-tempered fabrics, but plain and incised orange-slipped vessels with grog tempered fabrics also occur. These later vessels, representing typical Early Postclassic forms and paste compositions, are stylistically and petrographically similar to those that occur in Group 3. The same orange-slipped, grog-tempered vessels also occur in subgroups A and B of Group 4. In both cases, however, they are accompanied by unslipped utilitarian vessels with calcite-tempered fabrics, primarily large jars that conform to later jar styles within the ceramic sequence. It is significant that, with the exception of subgroup F, Group 4 exclusively comprises locally manufactured vessels, but both early and late vessel styles and paste compositions within the ceramic sequence are represented.

The chemical separation of subgroup F and its placement virtually in the middle of the main cluster of samples requires further comment, given the provenance associations of some of the Black on Red vessels it contains. As will be recalled, the Sascab-Quartz B fabric group, which exclusively comprises Black on Red rounded dishes, was ascribed a non-local provenance on mineralogical grounds. In comparison, the vessels comprising the other subgroups within Group 4, as well as the chemical group that directly follows 4F in the dendrogram (i.e. 5A), correspond to fabric groups that were ascribed a local provenance. The occurrence of these non-local fabrics both within a subgroup that also contains local fabrics and between chemical groupings that consist of local fabrics (albeit corresponding to different fabric classes) is interesting. The positioning of the Sascab-Quartz B fabric group within the dendrogram might be partly explained by the fact that it occurs amidst samples corresponding to the Sascab-Quartz A fabric group: that is fabrics belonging to the same general fabric class. These two fabric groups share in common a particular paste recipe involving a sandy calcareous clay tempered with sascab. Hence, the close chemical relationship between Sascab A and Sascab B fabrics may reflect a fundamental similarity in the approach to paste making – i.e. the use of the same general kind of clay and temper – whereas the clear chemical separation of Sascab-Quartz B fabrics from the main group of Sascab-Quartz A fabrics (5A) indicates inherent differences related to the specific source of the raw materials used (perhaps specifically with regard to the clay component, as indicated by the different concentrations of the rare earth elements Sm, Lu, Yb, and La for 4F and 5A).

9.3.3.3. GROUP 5

Group 5 contains 25 samples and is separable into two subgroups (5A and 5B), with the large majority of samples occurring in subgroup A (Table 9.6). On the whole, Group 5 is characterized by comparatively low average concentrations of many of the rare earth elements, including Sm, Lu, Yb, La, Ce, and Eu, and comparatively high Hf, levels (Table 9.1). The two subgroups are separated due to differences in their Na, Co and Cr content, with 5A containing higher levels of Na and Co and lower levels of Cr. The chemical differences between the subgroups are mirrored in the kinds of vessels they contain. Subgroup A consists primarily of monochrome and polychrome rounded dishes and monochrome rounded bowls with sandy sascab-tempered fabrics. From a petrographic standpoint, subgroup A corresponds to the main group of Sascab-Quartz A fabrics, which was ascribed a local provenance (Table 9.6). In contrast, subgroup B consists of monochrome black deep bowls and vases with dolomitic marl-based fabrics corresponding to the non-local Dolomitic-Calcitic Marl-based A fabric group. In both cases, however, the chemical subgroups correspond to early vessel styles and paste compositions within the sequence.

As with subgroup F of Group 4, it is interesting that 5B, corresponding to a fabric group ascribed a non-local provenance based on mineralogical characteristics, occurs within the same chemical group as locally produced vessels, albeit forming a distinct chemical subgroup. It is also noteworthy that 5A comprises the large majority of vessels analysed from the main group of Sascab-Quartz A fabrics (i.e. the main group of vessels not containing grog temper), but the grog-tempered variant of this fabric group is entirely absent, occurring primarily in Group 3.

9.3.3.4. GROUP 6

Group 6 contains 33 samples and comprises 2 distinct chemical subgroups (6A and 6B). Subgroup 6A is the largest of the two, containing 28 samples. As with Group 5, Group 6 is characterized generally by comparatively low average concentrations for many of the rare earth elements, including Sm, Lu, Yb, La, Ce, and Eu (Table 9.1). In Group 6, however, the average values of Hf, Cs and Co are also comparatively low and average Ca content is very high, but variability is high in all

Table 9.6: Stylistic and petrographic characteristics of the vessels comprising Group 5. Chemical outliers are marked with an asterisk.

	Stylistic Categories Represented	Compositional Categories Represented	No.
Subgroup A	Polychrome Slipped and Painted (interior slipped) (*rounded dishes*)		8
	Monochrome Red Slipped (interior slipped) (*rounded dishes and a bowl*)		4
	Monochrome Orange Slipped (interior slipped) (*rounded dishes and a bowl*)		3
	Monochrome Orange Slipped (*rounded bowl*)	Sascab-Quartz A (main group)	1
	Polychrome Slipped and Painted (*composite silhouette dish*)		1
	Buff/Cream Slipped (plain) (*rounded bowl*)		1
	Monochrome Orange Slipped (*composite silhouette dish*)		1
	Monochrome Black (*rounded bowl*)	Dolomitic-Calcitic Marl-based Group A (subgroup)	1
		Total	**20**
Subgroup B	Monochrome Black - plain and decorated (*deep bowls, vases*)	Dolomitic-Calcitic Marl-based Group A	5
		Total	**5**

cases. Subgroup 6A separates chemically from 6B due to higher concentrations of the rare earth elements Sm, Yb, La, and Eu, indicating an important compositional difference in the clay component of thesamples comprising the two subgroups. It is also significant that the samples comprising Subgroup 6B have a lower Ca content, which is in keeping with the fact that this subgroup nearly exclusively consists of vessels with dolomitic marl-based fabrics, corresponding to Dolomitic-Calcitic Marl-based group A (Table 9.7). These vessels are stylistically and petrographically indistinguishable from the Monochrome Black vessels that comprise subgroup B of Group 5. Hence, the separation of these vessels into subgroups of two different chemical groups is rather interesting, especially considering the high level of stylistic and petrographic homogeneity they exhibit.

In comparison, the samples comprising subgroup A predominantly derive from calcite-tempered vessels, with various local and non-local fabric groups of the Crystalline

Table 9.7: Stylistic and petrographic characteristics of the vessels comprising Group 6. Chemical outliers are marked with an asterisk.

	Stylistic Categories Represented	Compositional Categories Represented	No.
Subgroup A	Monochrome Red Slipped (interior slipped) (*rounded bowls*)	Crystalline Calcite-Tempered Group A (N=3) Crystalline Calcite-Tempered Group B (N=1) Crystalline Calcite-Tempered Group C (N=2) Crystalline Calcite-Tempered Group D (N=1)	7
	Polychrome Slipped and Painted (**vase, composite silhouette bowls*)	*Sascab-Quartz A (main group) (N=1) Dolomitic-Calcitic Marl-based Group D (N=4)	5
	Monochrome Red Slipped (*-2*jars, composite silhouette dishes*)	*Crystalline Calcite-Tempered Group C (N=2) Crystalline Calcite-Tempered Group D (N=1) *Dolomitic-Calcitic Marl-based Group B (N=1)	4
	*-1Slipped Rim/Lip - Smoothed Body (*jars*)	Crystalline Calcite-Tempered Group A (N=1) *-1Crystalline Calcite-Tempered Group B (N=2)	3
	*Unslipped/Smoothed-Buff (*jars*)	Crystalline Calcite-Tempered Group H	2
	Monochrome Brown (*torch*)	Crystalline Calcite-Tempered Group A	1
	Buff/Cream Slipped (plain) (*rounded dish*)		1
	Monochrome Red Slipped and Incised (*vase*)	Crystalline Calcite-Tempered Group C	1
	Monochrome Black (raised band with a central groove) (*vase*)		1
	Red-Orange-Black Resist (*composite silhouette dish*)		1
	Monochrome Grey (Plumbate ware) (*pedestal base*)	Crystalline Calcite-Tempered Group E	1
	Monochrome Orange Slipped (*jar with strap handles*)	Sascab-Quartz A - main group	1
		Total	**28**
Subgroup B	Monochrome Black - decorated (*flaring and deep bowls, vases*)	Dolomitic-Calcitic Marl-based Group A	4
	Monochrome Red Slipped (*jar*)	Dolomitic-Calcitic Marl-based Group B	1
		Total	**5**

Calcite-tempered class represented. This internal variation in the fabric groups that occur in subgroup A is mirrored in the diversity of vessel styles it contains, with stylistically different fine ware *and* coarse ware vessels present. It is interesting that 6A corresponds to a range of local and non-local fabrics groups and that the non-local fabric groups represent two distinct approaches to paste-making, as reflected by the Crystalline Calcite-Tempered and the Dolomitic-Calcitic Marl-based fabric classes. Nonetheless, subgroup A can be considered as strongly associated with local calcite-tempered vessels, with the majority of samples deriving from groups A, B and C of the Crystalline Calcite Tempered Class.

9.3.4. Group 7

Cluster 7 includes 22 samples and chemical subgroups are not apparent. Positioned at the end of the main cluster, this chemical group exhibits the highest level of internal variation, with standard deviations well above 20% for most elements (Table 9.1). The high level of chemical variability within this group is mirrored in the fact that it contains samples that correspond to a wide range of stylistic categories, as well as multiple local and non-local fabric groups (Table 9.8). Nonetheless, discounting the numerous chemical outliers within Group 7, the majority of samples derive from locally produced, crystalline calcite-tempered vessels.

9.4. Relationships Between the Chemical Groups and Subgroups

Further inspection of the structure of the Lamanai data set with principal components analysis provides additional insight into the relationships between the different chemical groups and subgroups identified, as well as the elements most responsible for the differences among them. The first four components derived by PCA account for account nearly 85% of the total variation within the data set. As shown in Table 9.9, component 1 is loaded mainly by the rare earth elements Lu, Yb, Sm, La, Ce and Eu, whilst component 2 is characterized by high loadings for the alkali metals Na, Rb and Cs. Together, these two components account for approximately 64% of the total variation. Component 3 is loaded mainly by the transition metals Sc, Cr and Fe, and component 4, by Hf and Ca. Figure 9.2 presents of plot of components 1 and 2 with Varimax rotation. As can be seen, there is a clear separation of Group 1, which consists of volcanic ash-tempered ceramics, from the remaining chemical groups, which comprise fabric groups from northern Belize and the Yucatan. The position of Group 1 at the top centre of the plot indicates that its discrimination is dependent upon component 2, which is mainly loaded by the alkali metals. As already has been discussed, these elements reflect the presence of alkali feldspar, which occurs in volcanic ash and tuff. This plot also reveals that although all of the chemical groups, except group 1, overlap to form a large, dispersed cluster situated at the centre of the plot, the different chemical groups separate to occupy particular areas of the cluster.

Table 9.8: Stylistic and Petrographic characteristics of the vessels comprising Group 7. Chemical outliers are marked with an asterisk.

Stylistic Categories Represented	Compositional Categories Represented	No.
Monochrome Orange Slipped (*$^{-1}$*jars*, **drum, tripod bowl*)	*Crystalline Calcite-Tempered Group A (N=1) Grog-Mixed Carbonate Class (subgroup B)(N=1) Dolomitic-Calcitic Marl-based Group B subgroup (N=1) *Dolomitic-Calcitic Marl-based Group C (N=2)	5
Slipped Rim/Lip - Smoothed Body (*jars*)	Crystalline Calcite-Tempered Group A	5
Monochrome Red Slipped (*rounded bowls, composite silhouette dishes*)	Crystalline Calcite-Tempered Group A (N=1) Crystalline Calcite-Tempered Group A subgroup (grog tempered variant) (N=1) Crystalline Calcite-Tempered Group C (N=1)	3
*Red-Brown-Striated (*jars*)	Crystalline Calcite-Tempered Group G	3
*Monochrome Orange Slipped (interior slipped) (*rounded bowl*)	Crystalline Calcite-Tempered Group A subgroup (grog tempered variant)	1
Monochrome Red Slipped (interior slipped) (*rounded bowl*)	Crystalline Calcite-Tempered Group B	1
Monochrome Black (*flaring bowl*)	Dolomitic-Calcitic Marl-based Group A	1
Monochrome Orange Slipped and Incised (*stand*)	Dolomitic-Calcitic Marl-based Group B	1
*Unslipped/Smoothed-Buff (*jar*)	Quartz Sand Class subgroup (calcite-tempered variant)	1
	Total	**21**

The tendency of these groups to form a single dispersed cluster may reflect the inherent overlap in the mineralogical characteristics of the different fabric groups deriving from northern Belize and the Yucatan. Nonetheless, the internal structure of the cluster reflects chemical differences at the group level, and its existence suggests that a clear separation of the main chemical groups could be achieved through detailed statistical analyses with measures of variance such a Malhalanobis distance and best relative fit (c.f. Glascock et al. 2004 and Arnold et al. 1999).

As illustrated in Figure 9.3, when components 1 and 4 are plotted, Group 2 and Group 5 are discriminated from the other main chemical groups. These groups form disparate but separate clusters just to the right and left of centre, at the top of the plot, indicating that the discrimination is mainly dependent upon component 4, which is loaded primarily by Hf and Ca, but also relates in part, to component 1, which reflects rare earth element concentrations. As will be recalled, both of these groups are characterised by comparatively high concentrations of Hf, which most likely reflects the

Table 9.9: Rotated component matrix showing loadings of the components plotted in Figures 9.2 and 9.3.

	Component			
	1	2	3	4
Eu	**.961**	.065	.210	.034
Sm	**.952**	.204	.183	.072
La	**.925**	.199	.135	.191
Ce	**.914**	.138	.146	.182
Yb	**.891**	.197	.161	.266
Lu	**.846**	.294	.238	.252
Rb	.203	**.908**	.098	-.097
Cs	.213	**.809**	.294	.108
Na	.108	**.743**	-.366	.169
Co	.413	.584	.233	.319
Sc	.319	.243	**.859**	.020
Cr	.132	-.258	**.851**	.016
Fe	.254	.286	**.671**	.280
Hf	.128	-.117	.116	**.931**
Ca	-.255	-.252	.012	**-.776**
Th	.298	.266	.530	.572

presence of zircon, and they correspond to fabric groups characterized by abundant inclusions of siliceous rocks and minerals, deriving from sandy clays. Accordingly, the discrimination of these Groups 2 and 5 from the others, reflects a distinction between ceramics containing a significant siliceous aplastic component and those with a predominantly calcitic mineralogy.

The clear separation of these groups from each other reflects the fact that Group 2 is characterized by comparatively high rare earth element concentrations, whereas Group 5 is characterized by low concentrations. The discrimination of these groups, therefore, reflects fundamental chemical differences in the clay components of the respective fabric groups with which Group 2 (Quartz Sand) and Groups 5 (Sascab-Quartz A and Dolomitic-Calcitic Marl-based A) are associated. It is also significant that the Group 4 samples occurring within the loose cluster formed by Group 2 are those from 4F with Sascab-Quartz B fabrics, which also derive from sandy clays.

The relationships among the groups and subgroups comprising the main cluster within the dendrogram were examined by performing a separate principal components analysis

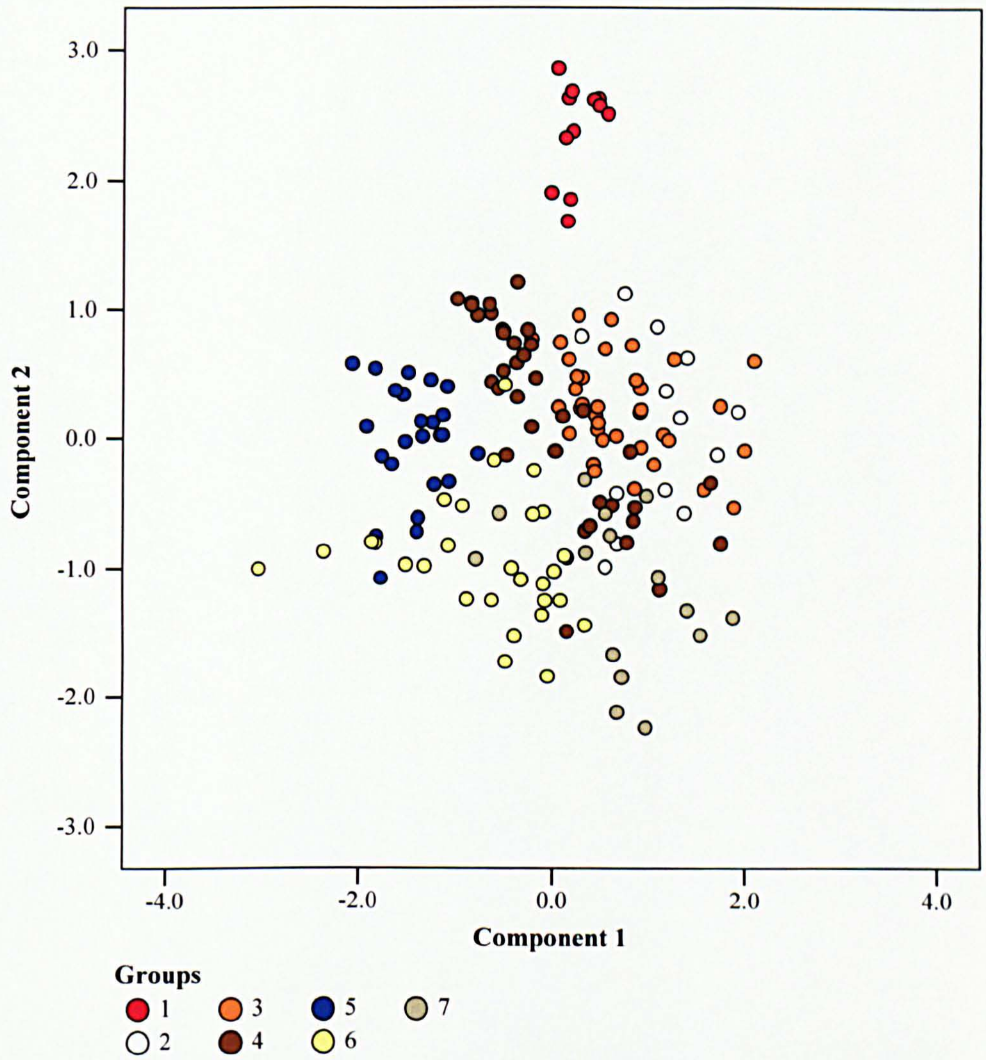


Figure 9.2: A Plot of components 1 and 2 of the Lamanai data set with Varimax rotation based on Sm, Lu, Yb, Ca, Na, La, Ce, Th, Cr, Hf, Cs, Sc, Rb, Fe, Co and Eu. Chemical groups identified through cluster analysis are differentiated with coloured symbols.

of the main cluster alone. A plot of components 1 and 2 is presented in Figure 9.4. Once again, component 1 is mainly loaded by rare earth elements (Lu, Yb, Sm, La, Ce and Eu), whereas component 2 is mainly loaded by Ca and Hf (Table 9.10), with the first four components accounting for approximately 84% of the total variation within the data set. Although a close chemical relationship among the different chemical subgroups is clearly demonstrated, the three local paste-making traditions (i.e. crystalline calcite-tempered, Sascab-Quartz A and Grog-Mixed Carbonate) are clearly discriminated from each other, occupying different areas of the scatter. For example, Group 7 and the subgroups consisting of calcite tempered vessels (marked with squares) cluster together at the top of the scatter, with the different chemical groupings

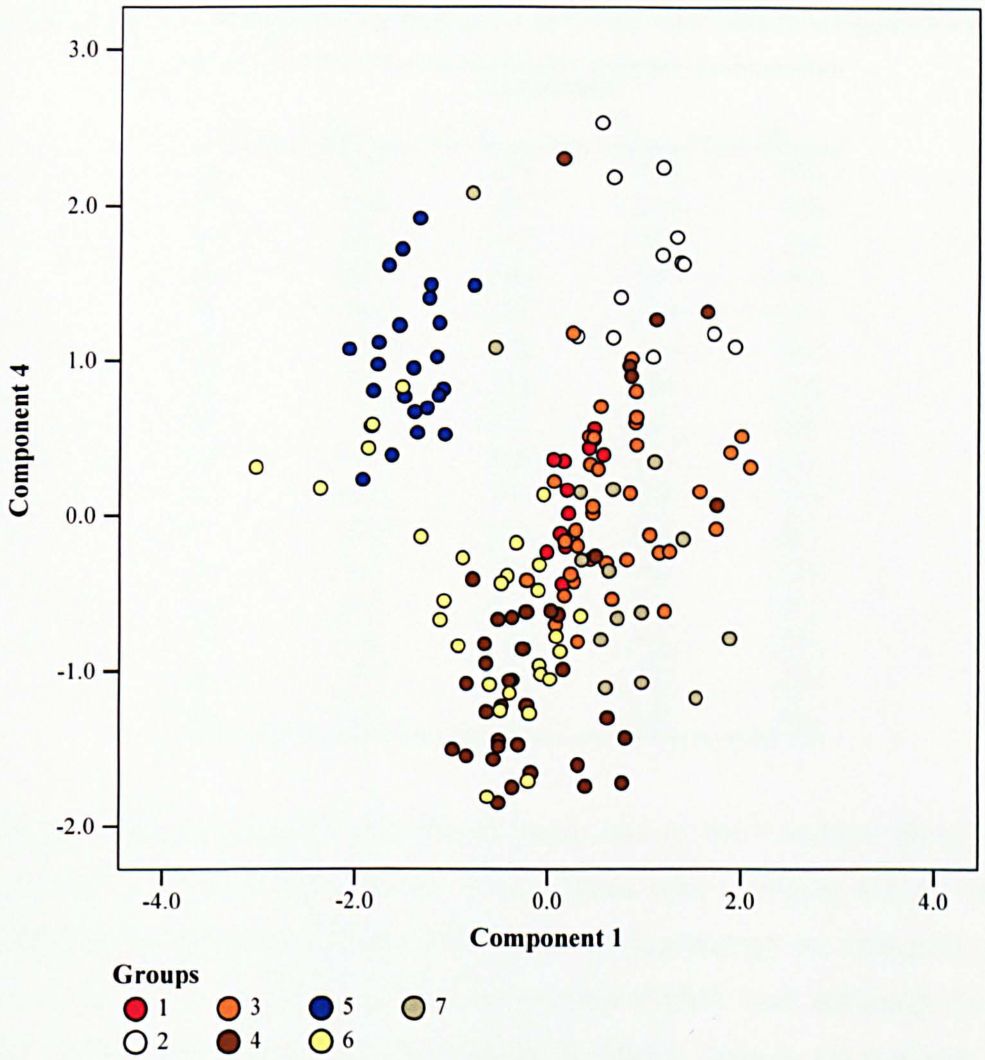


Figure 9.3: A Plot of components 1 and 4 of the Lamanai data set with Varimax rotation based on Sm, Lu, Yb, Ca, Na, La, Ce, Th, Cr, Hf, Cs, Sc, Rb, Fe, Co and Eu. Chemical groups identified through cluster analysis are differentiated with coloured symbols.

occupying different areas of this cluster. The separation of the calcite tempered fabrics is mainly dependent upon component 2, undoubtedly reflecting the high crystalline calcite content of these pastes, primarily due to tempering. In comparison, the Grog-Mixed Carbonate Class (brown and orange circles) dominates the right side of the scatter, with the associated chemical subgroups of Groups 3 and 4 forming separate subclusters. Finally, Sascab-Quartz A fabrics cluster at the left hand side of the scatter. These results indicate that the different local paste-making traditions are characterized by distinct chemical profiles.

Table 9.10: Component matrix showing loadings of the components plotted in Figures 9.4 and 9.5.

	Component			
	1	2	3	4
Lu	**.925**	.214	-.079	.023
Yb	**.888**	.297	-.204	.040
Sm	**.882**	.447	-.078	.033
La	**.881**	.344	-.197	-.093
Ce	**.844**	.374	-.214	-.075
Eu	**.841**	.504	-.110	.024
Sc	.792	-.226	.405	.228
Th	.713	-.455	-.127	.280
Co	.703	-.208	.122	-.528
Fe	.682	-.341	.105	-.173
Cs	.590	-.286	**.533**	-.264
Ca	-.403	**.723**	.401	.139
Na	.425	-.447	-.033	.033
Rb	.538	-.138	**.716**	-.073
Hf	.355	**-.578**	**-.681**	.016
Cr	.493	-.177	.203	**.766**

Principal components analysis also discriminates two of the non-local fabric groups from the main scatter of local fabrics. As can been seen in Figure 9.4, the samples corresponding to Dolomitic-Calcitic Marl-based A (represented by triangles), cluster together at the left edge of the scatter, but overlap slightly with subgroup 5A. The position of the Dolomitic-Calcitic Marl-based A fabrics towards the left side of the scatter reflects a discrimination heavily dependent on component 1, and thus, elements related to clay minerals. Chemical differences related to source can, therefore, be inferred. The apparent chemical overlap between this fabric group and locally produced Sascab-Quartz A fabrics (blue circles) would appear to reflect a fundamental similarity in clay chemistry. However, since the sascab temper in the Sascab-Quartz A fabrics is known to contain clay minerals (see Chapter 5), and this tempering material derives from similar deposits as the base clay of the Dolomitic-Calcitic Marl-based A (both derive from deposits formed through the deep weathering of the underlying bedrock), it is possible that similar clay minerals occur in these different raw materials. As an example, this kind of chemical overlap occurs among geographically separated deposits of Neogene clay in Crete (Hein et al. 2004a).

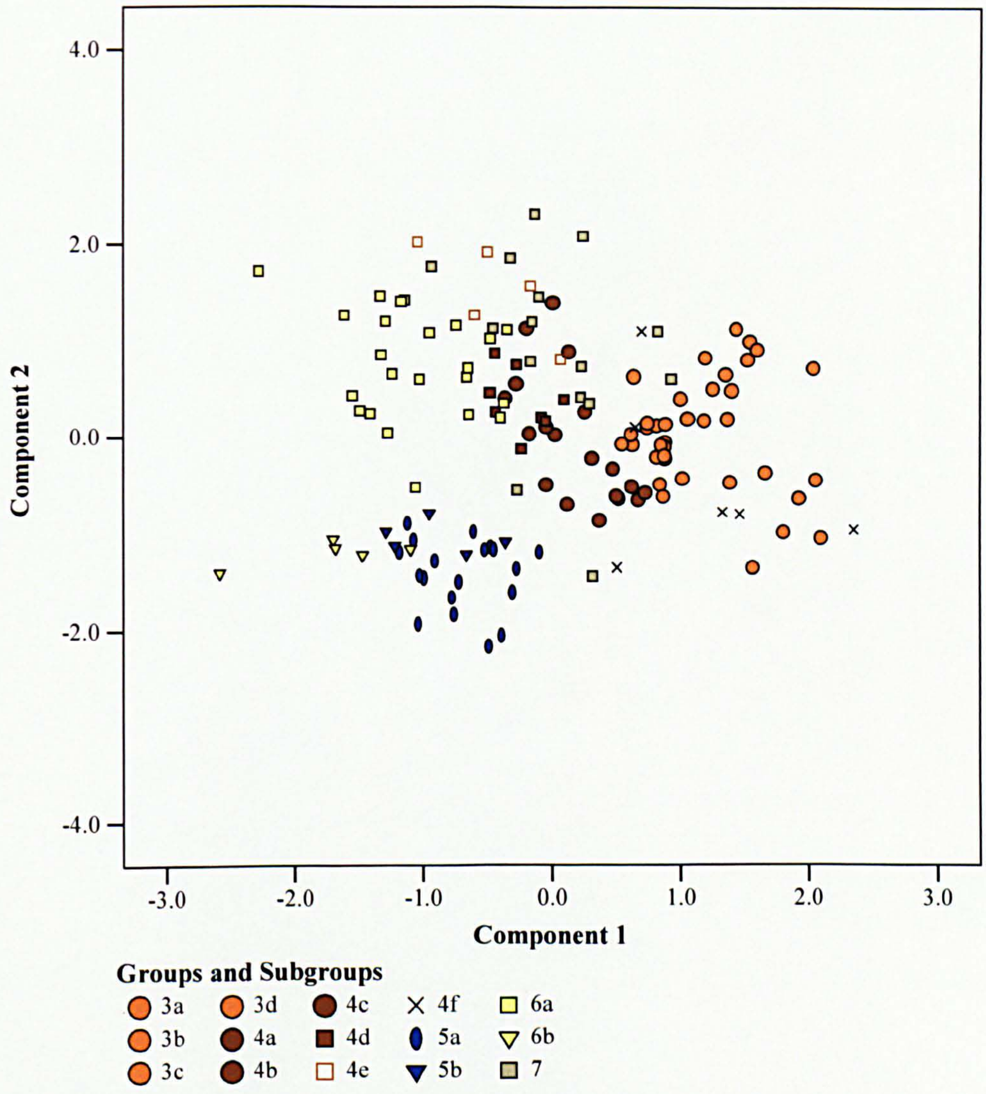


Figure 9.4: A Plot of components 1 and 2 of the main cluster within the Lamanai data set (Groups 3-7) based on Sm, Lu, Yb, Ca, Na, La, Ce, Th, Cr, Hf, Cs, Sc, Rb, Fe, Co and Eu. Chemical groups and their associated subgroups are differentiated with coloured symbols: Sub groups marked with circles are strongly associated with the Grog-Mixed Carbonate class, subgroups marked with squares are primarily associated with calcite-tempered fabrics, subgroups corresponding to Dolomitic-Calcitic Marl-based A are marked with triangles.

As shown in Figure 9.5, which presents a plot of components 1 and 3, Sascab-Quartz B fabrics, which are also non-local, are discriminated from: 1) the other non-local fabric group, Dolomitic-Calcitic Marl-based A, 2) their local technological counterpart Sascab-Quartz A and 3) the other two local paste-making traditions. Scattered in the lower right corner of the plot, the separation of these samples from the main cluster is dependent on both component 1, which relates to rare earth concentrations, and component 2, which reflects the alkali metals Rb, and Cs, and Hf. Chemical differences related to source can therefore be inferred.

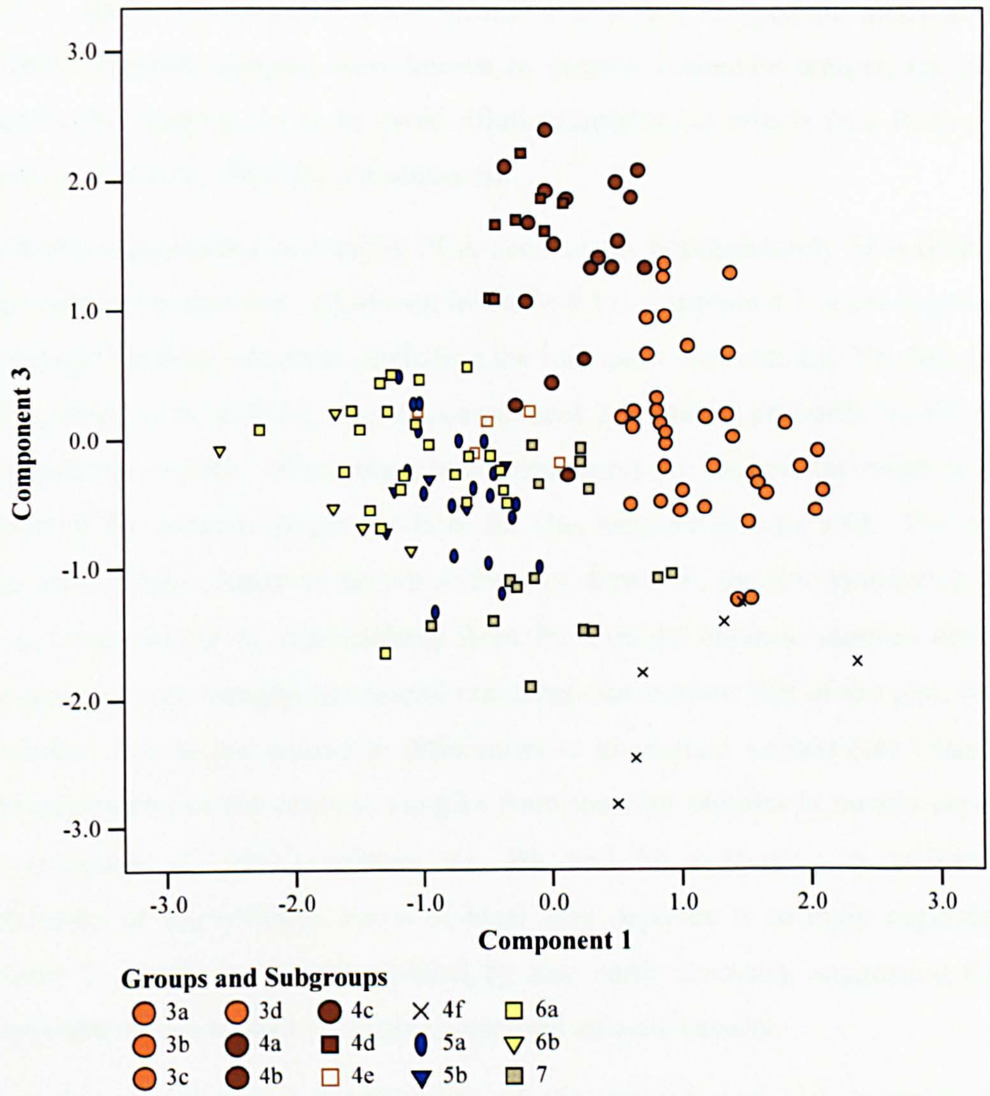


Figure 9.5: A Plot of components 1 and 3 of the main cluster within the Lamanai data set (Groups 3-7) based on Sm, Lu, Yb, Ca, Na, La, Ce, Th, Cr, Hf, Cs, Sc, Rb, Fe, Co and Eu. Chemical groups and their associated subgroups are differentiated with coloured symbols: Sub groups marked with circles are strongly associated with the Grog-Mixed Carbonate class, subgroups marked with squares are primarily associated with calcite-tempered fabrics, subgroups corresponding to Dolomitic-Calcitic Marl-based A are marked with triangles.

9.5. LOCAL FABRIC GROUPS AND MODERN CLAY RESOURCES

As was discussed in the previous chapter, comparison of the petrographic characteristics of fired samples of the modern clays prospected from different geological and environmental contexts in and around Lamanai to those of the ceramic fabric groups suggested that certain fabric groups were connected to particular, and sometimes different, kinds of local clay deposits. To examine the chemical relationship between different modern clays available in the local area and the chemical groups corresponding to the different local paste-manufacturing traditions, a data set comprising the modern clay samples and archaeological samples comprising chemical groups 2, 3, 4A-E, 5A, 6A and 7 was subjected to principal components analysis. Since many of the ceramic samples were known to contain carbonate temper, Ca was not included in the analysis, so as to avoid dilution/enrichment effects (see Bishop et al. 1982 and Arnold et al. 1999 for a discussion).

The first two components derived by PCA account for approximately 82% of the total variation within the data set. As shown in Table 9.11, component 1 is characterized by high loadings for many elements, including the rare earth elements Lu, Yb, Sm, La, Eu, Ce, Th, as well as Sc and Co, whereas component 2 is loaded primarily by Fe and the alkali metals Na and Rb. When these two components are plotted, the result is a clear separation of the ceramic specimens from the clay samples (Figure 9.6). The ceramic samples form a tight cluster at the top of the plot, however, the fine-structuring of this cluster is quite similar to that resulting from PCA of the ceramic samples alone. In comparison, the clay samples are spread out across the bottom half of the plot, forming loose clusters that to correspond to differences in geological context (see Chapter 5). This discrimination of the ceramic samples from the clay samples is mainly dependent upon component 2, which reflects Na, Rb and Fe content. In addition, the differentiation of the different kinds of local clay deposits is strongly dependent on component 1, which is primarily loaded by rare earth elements, suggesting that the discrimination relates to clay minerals as opposed aplastic content.

The fact that the chemical compositions of the ceramic and clay samples do not coincide is not surprising or troublesome, since experimental studies have demonstrated that it is rarely possible match raw clays chemically with finished ceramic products (e.g. Kilikoglou et al 1988). A similar chemical study conducted at K'axob (located just north of Lamanai), of Preclassic ceramics and an extensive sample of modern clays and rocks prospected from the surrounding area also found a lack of correspondence between pottery and raw material compositions, even when the chemical contribution of particular carbonate tempers, such as sascab, were taken into account (Bartlett et al. 2000).

It is well recognized, and has been demonstrated experimentally, that paste preparation techniques such as the purification of clays through levigation or sieving and the addition of temper can cause a chemical distinction between raw clays and 'prepared' ceramics bodies (e.g. Kilikoglou et al. 1988; Neff et al. 1988, 1989). In the case of

Table 9.11: Rotated component matrix showing loadings of the components plotted in Figures 9.6.

	Component	
	1	2
Lu	**.975**	-.105
Yb	**.966**	-.157
Sm	**.938**	-.144
La	**.929**	-.141
Eu	**.921**	-.151
Ce	**.910**	-.162
Th	**.908**	.186
Sc	**.842**	.359
Co	**.817**	-.223
Cr	.785	.253
Hf	.751	-.030
Na	-.183	**.921**
Fe	-.139	**.920**
Rb	.382	**.829**
Cs	.511	.629

temper, if the source material contains clay minerals, as with sascab, the effect on trace element concentrations can be quite significant (Arnold et al. 1999). Another intervening factor is chemical alteration during burial (Franklin and Vitali 1985). With regard to the present study, however, there is some evidence to suggest that paste-preparation techniques, in particular, play an important role in the distinction between the modern clays and the ceramic specimens. For example, in their natural state, raw clays from the Lamanai area, particularly those from the west side of the lagoon, contain large rock fragments. The absence in the ceramic fabrics of inclusions larger that the size of very coarse sand, suggests that clay component was processed, by some means prior to use, to remove at least some of the coarse fraction. In addition, local fabrics most often represent complex mixtures of raw material ingredients. For example, they are heavily tempered and often contain multiple tempers, including grog and sascab, which can greatly effect elemental concentrations. It does not seem unreasonable, therefore, to suggest that the combined effect of these practices alone would result in a chemical distinction between local clay resources and locally produced ceramic products.

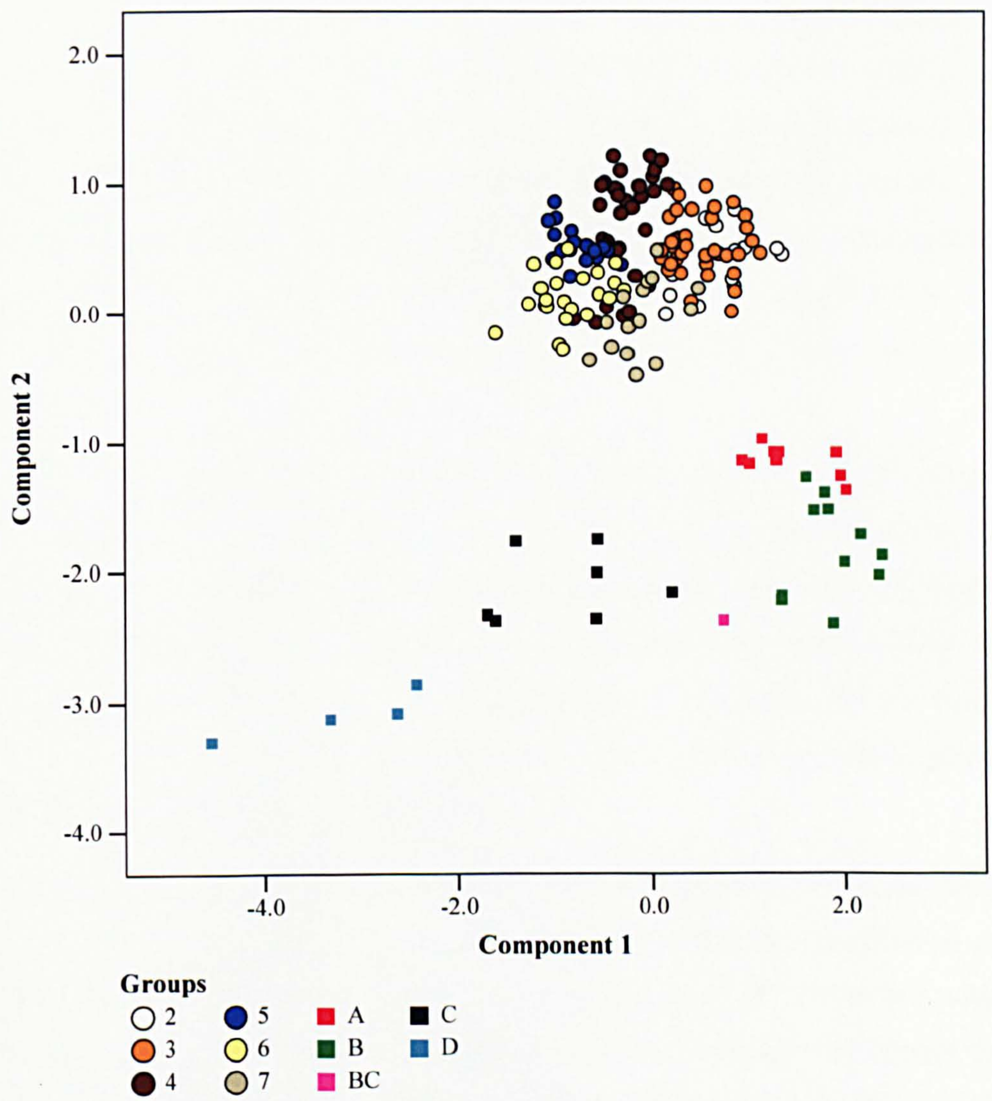


Figure 9.6: A Plot of components 1 and 2 of the chemical groups corresponding to local fabric groups (Groups 2, 3, 4[A,B,D,E], 5A, 6A, and 7) and modern clay samples prospected from the Lamanai area based on Sm, Lu, Yb, Na, La, Ce, Th, Cr, Hf, Cs, Sc, Rb, Fe, Co and Eu. Chemical groups are differentiated with coloured symbols. Ceramic groups are marked with circles and clay groups are marked with squares. For the clays: red square = samples deriving from the east of the New River Lagoon, green squares = samples deriving from the west side of the New River Lagoon, from clay horizons directly below the ground's surface, the pink square = the sample taken from the Barber Creek deposit in the area of modern wash deposits of Pleistocene alluvium, black squares = samples deriving from the west side of the New River Lagoon, from clay deposits that form in association with horizons of weathering limestone, and , turquoise squares = samples deriving from river and creek deposits.

9.6. SUMMARY

With regard to the questions posed at the beginning of this chapter the following observations can be made:

1) The results show that the relationship between geochemical, mineralogical and stylistic variation within the Lamanai assemblage is very complex. In some cases, there

is a direct correspondence between chemical groups and fabric groups, particularly on the class level. Such is the case for Groups 1 and 2, since the associated fabric classes (Volcanic Glass and Quartz Sand, respectively) are confined to these chemical groups. In contrast, the Grog-Mixed Carbonate, the Crystalline Calcite-Tempered and the Dolomitic-Calcitic Marl-based classes occur in different chemical groups, but showing a strong association with only one or two of these groups. Moreover, with regard to the Crystalline Calcite Class, there is a complete lack of correspondence between the different fabric groups within this class and the chemical groups and subgroups identified.

2) In some cases, statistical analysis only discriminates non-local fabrics from local fabrics. For example, Sascab-Quartz B, Dolomitic-Calcitic Marl-based A and the Volcanic Glass fabric groups are differentiated chemically, both from the local fabric groups and from each other. Nonetheless, several non-local fabric groups are not discriminated, especially in cases where mineralogy is calcareous and the number of samples is small (e.g. the non-local Crystalline Calcite-Tempered fabric groups and Dolomitic-Calcitic Marl-based B, C and D).

3) The different local paste-making traditions are discriminated chemically with PCA. In the case of the Grog-Mixed Carbonate fabrics and the local crystalline calcite-tempered fabrics, however, they separate into multiple chemical groups and subgroups and the significance of this fine-structuring is not apparent based on the current body of stylistic, petrographic and chronological evidence. With regard to the Grog-Mixed Carbonate this fine-structuring might be considered to resolve the internal heterogeneity of this fabric group, and perhaps lends support to the suggestion that compositional variation within the Early Postclassic component of the assemblage is partly due to the activities of contemporaneous potters/groups of potters (i.e. the use of slightly different paste recipes).

4) A chemical correspondence between local pottery and the clay resources analysed is not demonstrated.

As a final comment, it is noteworthy that the results of the current study demonstrate that the ability to interpret chemical data sets is greatly enhanced by a comprehensive understanding of the technological and provenance characteristics, relationships and inter-relationships of the pottery under study. In the present study, it would have been difficult, if not impossible, to discriminate among source-related chemical distinctions relating to the activities of local potters vs. non-local producers, for mineralogically similar pottery, in the absence of detailed petrographic and geological information.

CHAPTER 10

VARIABILITY IN DECORATIVE AND SURFACE TREATMENTS AND FIRING OF TERMINAL CLASSIC AND EARLY POSTCLASSIC FINE WARE

10.1. INTRODUCTION

Surface finishing and decorative techniques and firing procedures, are two fundamental aspects of Maya pottery production that have seldom been the focus of systematic scientific investigation. With the exception of Neff's (2003) detailed examination of Plumbate ware with laser ablation-inductively coupled plasma-mass spectrometry, scientific enquiry into these aspects of Maya ceramic technology have not advanced substantially beyond Shepard's (e.g. 1939) pioneering investigations using a binocular microscope, re-firing experiments and microchemical analyses (e.g. Rice 1980, 1987b; Reents-Budet 1994). Scanning electron microscopy (SEM) offers a means of examining, in detail, specific points of technological similarity and difference, elucidating information regarding the technical procedures involved in the manufacture of different kinds of pottery.

The present study focuses on the fine ware component of the Lamanai assemblage, using SEM to investigate variation in the nature of the finished surfaces, slips and paints, as well as the microstructural characteristics of the ceramic body, within and among the numerically dominant stylistic categories identified in Chapter 7. A central interest was examining the relationship between the decorative and firing technology of fine ware vessels and their paste technology and provenance, in order to identify additional technological similarities and differences between and among locally produced and imported pottery, as well as changes over time in local technical practices. A total of 31 vessels were included in the study, representing six different stylistic groups. The decorative and morphological characteristics of these vessels, as well as their fabric group and provenance associations are given in Table 10.1. The results of the analyses are organized chronologically for monochrome, bichrome and

Table 10.1: Stylistic characteristics and petrographic group and provenance associations of vessels included in the SEM study. Samples are organized chronologically for monochrome, bichrome and polychrome vessels.

Sample No.	Vessel/Lot No.	Decorative Treatment	Form	General Provenance	Fabric Group
Terminal Classic Vessels					
Monochrome Black					
125	LA508/7	groove-incised and punctated	vase, cylindrical	local	Calcite C
126	LA508/6	raised band with a central groove	vase, barrel-shaped	local	Calcite C
124	LA658/1	groove-incised and stamped	vase, cylindrical	non-local	Marl-Based A
39	LA814/1	groove-incised with false gardooning	vase, cylindrical	non-local	Marl-Based A
40	LA706/1	groove-incised	deep bowl	non-local	Marl-Based A
Monochrome Red And Orange Slipped					
281	LA717	Orange	composite silhouette dish	local	Calcite C
23	LA872/4	Red	composite silhouette dish with a ring base	local	Calcite C
136	LA630/7	Red	composite silhouette dish with a ring base	local	Calcite C
401	LA701	Orange	composite silhouette dish	non-local?	Calcite D
254	LA717	Orange (interior slipped)	bowl, rounded	local	Calcite B (subgroup)
257	LA717	Red (interior slipped)	bowl, rounded	local	Calcite A
252	LA717	Red (interior slipped)	bowl, rounded	local	Calcite B
261	LA717	Orange (interior slipped)	dish, rounded	local	Sascab-Quartz A
144	LA693/1	Red (interior slipped)	dish, rounded	local	Sascab-Quartz A
Red-Orange-Black Resist					
289	LA717		composite silhouette dish	local	Calcite C
291	LA717		composite silhouette dish	local	Calcite C
295	LA717		composite silhouette dish	local	Calcite C
296	LA717		composite silhouette dish	local	Calcite C (subgroup)
Black On Red Slipped And Painted					
48	LA244/2		massive bowl	local	Sascab-Quartz A
118	LA240/1		dish, rounded	non-local	Sascab-Quartz B

Table 10.1: Stylistic characteristics and petrographic group and provenance associations of vessels included in the SEM study. Samples are organized chronologically for monochrome, bichrome and polychrome vessels (continued).

Sample No.	Vessel/Lot No.	Decorative Treatment	Form	General Provenance	Fabric Group
Polychrome Slipped And Painted					
54	LA664		composite silhouette bowl with a ring base	local	Calcite C
707	LA1444		composite silhouette bowl	non-local	Marl-Based D
202	LA717		dish, rounded	local	Sascab-Quartz A
207	LA717		dish, rounded	local	Sascab-Quartz A
Early Postclassic Vessels					
335	LA243	Orange Slipped	chalice	local	Grog
333	LA243	Orange Slipped	chalice	local	Sascab-Quartz A (subgroup)
76	LA243/4	Orange Slipped	chalice	local	Sascab-Quartz A (subgroup)
327	LA243	Orange Slipped and Incised	chalice	local	Grog
81	LA243/1	Orange Slipped	dish, out-curving	local	Grog
99	LA176/1	Orange Slipped (modelled feet)	tripod dish, out-curving	local	Sascab-Quartz A (subgroup)
152	LA71/1	Orange Slipped	drum, single ovoid chamber	non-local	Marl-Based C

polychrome vessels and the data discussed is summarized in Table 10.2. Table 10.3 presents the standard that was used to assess body microstructures and estimated firing temperatures following Maniatis and Tite (1981:68).

10.2. Terminal Classic Monochrome Vessels

10.2.1. Monochrome Black Vases and Deep Bowls

Of the five vessels analysed from the Monochrome Black stylistic group, two were ascribed a local provenance based on their geological characteristics, and three were determined to be imports, likely deriving from coastal areas of northeastern and eastern northern Belize. Both of these fabric types are characterized by dark grey surfaces and dark coloured firing horizons (black cores with a brown subsurface zone). In both cases the clay used is calcareous (>10% CaO), but EDAX analysis shows that the imported

Table 10.2: Summary of macroscopic and microstructural characteristics of vessels analyzed by SEM.

Sample No.	Colour of Fabric	Surface Colour	Slip Colour	Paint Colour	Vitrification Stage	Estimated Firing Temp.	Firing Atmosphere
125	black core bordered by very thin brown horizons and very thin black margins	dark grey	black	—	NV+	approaching 750-850	R-N/O-R
126	black bordered by thin light brown horizons and a very thin black exterior margin	dark grey	black with orange mottles	—	NV+	approaching 750-850	R-N/O-R
124	black core with and very thin brown layers and very thin black margins	dark grey to brown	black	—	NV	>750	R-N/O-R
39	black core with dark brown margins	dark grey to brown	black with orange mottles	—	NV	>750	R-N/O-R
40	black core with and very thin brown layers and very thin black margins	dark grey to brown	black with orange mottles	—	NV	>750	R-N/O-R
281	brownish-buff core with light orange margins	light orange	reddish-orange	—	NV+	approaching 800-850	?-O
23	black core with orangish-buff margins	buff	red	—	NV+	approaching 800-850	?-O
136	dark grey core with pinkish-orange margins	light orange	red	—	NV+	approaching 800-850	?-O
401	grey core bordered by thin brownish-buff horizons and light orange margins	buff	reddish-orange	—	NV+	approaching 800-850	?-O
254	black core with brownish-buff margins	buff	reddish-orange	—	NV+	approaching 800-850	?-O
257	buff throughout	buff	red	—	NV+	approaching 800-850	?-O
252	black core with a thin dark brown exterior margin and a brownish-buff interior margin	grey to buff	red	—	NV+	approaching 800-850	?-O
261	grey core with brownish-buff margins	buff	reddish-orange	—	IV	800-850	?-O
144	grey core with brownish-buff margins	buff	red	—	IV	800-850	?-O
289	dark grey core with orangish-brown margins	light orange	burgundy and black	—	NV+	approaching 800-850	?-O
291	greyish-buff core with pinkish-orange margins	light orange	reddish-orange and black	—	NV+	approaching 800-850	?-O
295	black core with thin buff margins	buff	reddish-orange and black	—	NV+	approaching 800-850	?-O
296	black core with orangish-brown margins	light orange	reddish-orange and black	—	NV+	approaching 800-850	?-O
48	grey core with very thin light orange margins	light orange	red	black	NV	<800	?-O
118	reddish-brown throughout	reddish-brown	red	black	IV	800-850	O

Table 10.2: Summary of macroscopic and microstructural characteristics of vessels analyzed by SEM (continued).

Sample No.	Colour of Fabric	Surface Colour	Slip Colour	Paint Colour	Vitrification Stage	Estimated Firing Temp.	Firing Atmosphere
54	dark greyish-brown core with thin orange margins	orange	orange	red and black	NV+	approaching 800-850	O
707	dark grey core with thin brownish-buff margins	buff	N/A	orange and black	IV	800-850	O
202	grey core with light brown margins	brownish-buff	orange	red and black	IV+	around 850	O
207	light grey with a thin light orange interior margin	buff	orange	red and black	IV+	around 850	O
335	orangish-buff throughout	orangish-buff	orange	—	NV+	approaching 750-800	R-O
333	very thin grey core with grayish-buff margins	buff	orange	—	NV+	approaching 750-800	R-O
76	black core bordered by very thin light grey horizons and very thin light orange margins	buff	orange	—	VI+	around 850	R-O
327	dark grey core with a thin brownish-buff exterior margin and greyish-buff interior margin	light orange to light grey (interior)	orange	—	VI+	around 850	R-O
81	buff orange throughout	orangish-buff	orange	—	NV+	approaching 800-850	O
99	grey core bordered by light grey horizons and with a light orange exterior margin	light grey(interior) to buff	orange	—	NV+	approaching 750-800	R-O
152	light orange throughout	orangish-buff	reddish-orange	—	NV+	approaching 800-850	O

Table 10.3: Vitrification stages and firing temperature ranges following the standard presented in Maniatis and Tite (1981: 68).

		Firing Temperature Ranges (°C)	
	Vitrification Stage	**Oxidizing Atmosphere**	**Reducing Atmosphere**
NV	No Vitrification	>800	>750
IV	Initial Vitrification	800-850	750-800
V	Extensive Vitrification	850-1050	850-1050

fabrics contain magnesium, which is absent in the local fabric, as well as comparatively lower levels of iron. The presence of magnesium in the imported fabrics is in keeping with the fact that they derive from dolomitic marl.

Firing

The presence in these fabrics of a brown subsurface zone or horizon, intervening between a black core and dark grey surfaces, suggests a succession of firing conditions (Rye 1981:118). This cycle appears to have involved a period of reduction, followed by a period of mildly oxidizing conditions and ending with a final period of reduction. An intervening period of mildly oxidizing conditions is also suggested by the occurrence of orange splotches on the finished surfaces of two the vessels, representing areas that remained oxidized due to an uneven distribution of air. This apparent lack of control over the firing atmosphere would be expected in conjunction with open firing.

Although the local and imported vessels appear to have been fired under a similar sequence of conditions, the microstructural characteristics of their fabrics suggest differences in firing temperature. The microstructure of the imported fabric suggests a firing temperature of <750°C (NV stage) (see Table 10.3), since there are no signs of sintering or vitrification (Figure 10.1). In comparison, the local fabric appears to have been fired at a slightly higher temperature. These microstructures are characterized by fairly extensive sintering but isolated glassy areas, which are indicative of Initial Vitrification (IV) are absent (Figure 10.2). An estimated firing temperature approaching the range of 750-800°C for IV microstructures is, therefore, suggested.

The distinctive microstructure observed in the local fabrics appears to be characteristic of local calcite-tempered fabrics in general, as identical microstructures were also observed in temporally equivalent (Terminal Classic) monochrome red and orange and bichrome resist vessels corresponding to the three local crystalline calcite-tempered

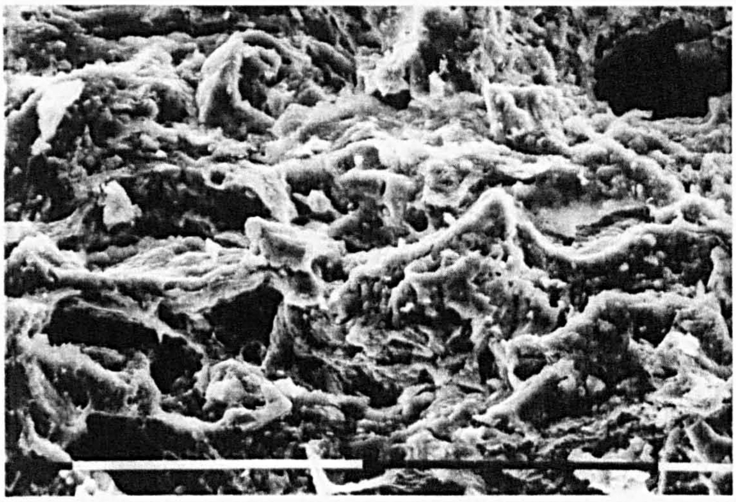


Figure 10.1: Imported Monochrome Black vessel (sample 40) displaying an NV microstructure (x500). Bar scale = 10μm.

Figure 10.2: Local Monochrome Black vessel (sample 125) displaying an NV microstructure with extensive sintering (NV+), which is typical of all monochrome and bichrome vessels with calcite-tempered fabrics (x500). Bar scale = 10μm.

fabric groups (Groups A, B, and C) associated with fine ware production. As will be discussed below, however, a different a firing regime at least involving a period of oxidation at the end of the cycle would have been required to produce the final colour of the later vessels.

Surface Finishing Techniques

Further technological differences between the local and imported Monochrome Black vessels relate to the techniques employed to achieve their black surfaces. At the surface of the imported vessels, a discrete layer approximately 2-5μm in thickness can be discerned (Figure 10.3). This layer is unvitrified and the clay particles are compacted and aligned, suggesting that is was produced through intense burnishing (c.f. Kilikoglou 1994:70-72). EDAX analysis of this layer and the underlying ceramic body indicated no appreciable differences in the levels of the different oxides present. Hence, there is no conclusive evidence (based on the small number of samples analysed) that this surface treatment involved the application of a slip. Rather, the highly glossy black surface was achieved through intense burnishing and firing in a reducing atmosphere at low temperatures.

In contrast, a thin layer of slip about 5-8μm in thickness is present on both of the local vessels (Figure 10.4). The slip is unvitrified with extensive sintering and appears to have been made using a fine-grained suspension of a clay similar to that used to make the ceramic body. This is suggested by the similarity of compositional readings obtained for the slip layers and bodies, apart from elevated levels of potassium and iron in the slip, which would result from levigation (Aloupi and Maniatis 1990:461). Also present in the slip layers are irregular-shaped voids and spherical inclusions, which were identified as iron oxide conglomerates (also see Noll 1975). The presence of the voids is due to the uneven distribution of iron oxide inclusions. Burnishing marks are readily observable on the exterior of the local vessels, suggesting some compaction of the surface, likely to improve the lustre of the slip. The local vessels, although still glossy in appearance, are characterized by a comparatively dull surface finish. The porosity of the slip is undoubtedly a contributing factor to this aspect of the visual appearance of the local vessels (c.f. Aloupi and Maniatis 1990:468).

To improve understanding of the microstructures that were observed for this stylistic group, a sample taken from one of the imported vessels (sample 40) was refired in an oxidizing atmosphere at 850°C for one hour. Analysis in the SEM showed a substantial change in the microstructure of both the compacted surface layer and the body. Both were vitrified and a microstructure equivalent to the extensive stage of vitrification (V) had developed in the body (Figure 10.5). In addition, the slip had turned orange. These results confirm that the original firing temperatures were below 850°C and that reduction firing was a key element in producing the visual properties of the surface treatment.

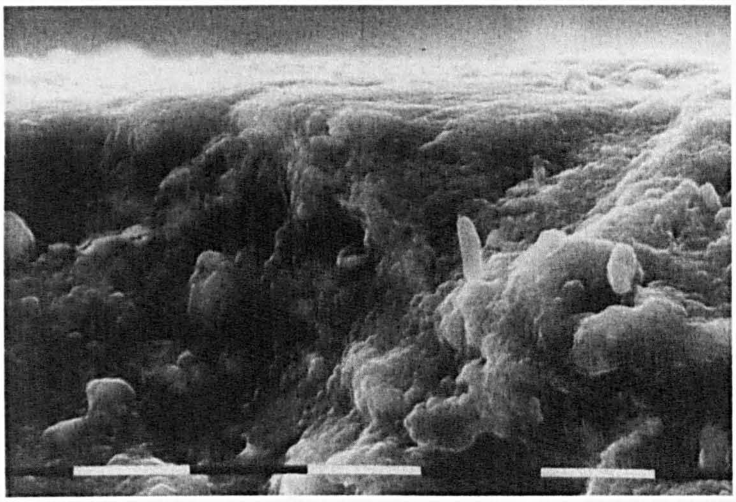


Figure 10.3: Imported Monochrome Black vessel (sample 39) with an unvitrified, compacted surface layer (x2000). Bar scale = 10μm.

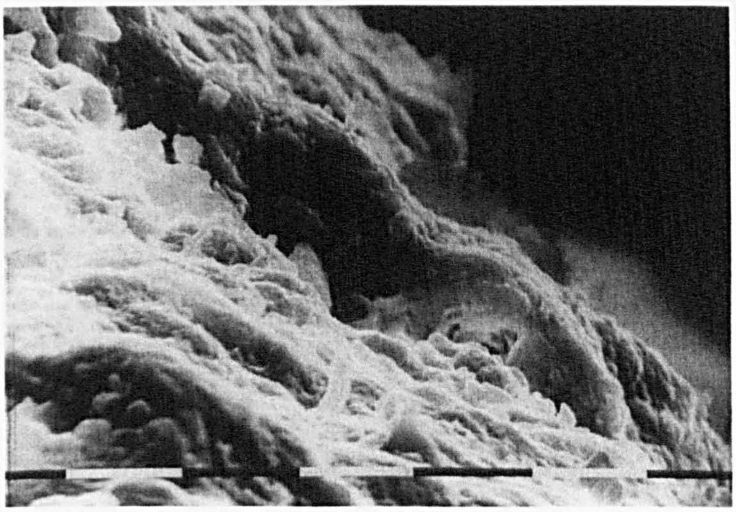
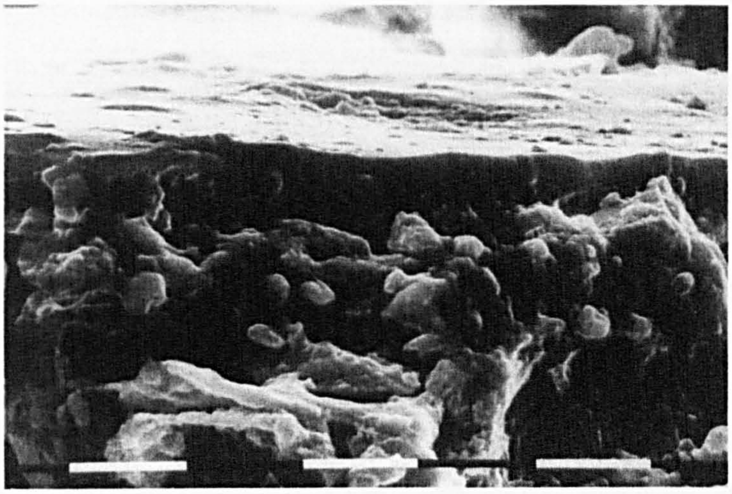


Figure 10.4: Local Monochrome Black vessel (sample 125) displaying an unvitrified layer of slip with extensive sintering and containing irregular-shaped voids and spherical iron conglomerates (x2000). Bar scale = 10μm.

a)



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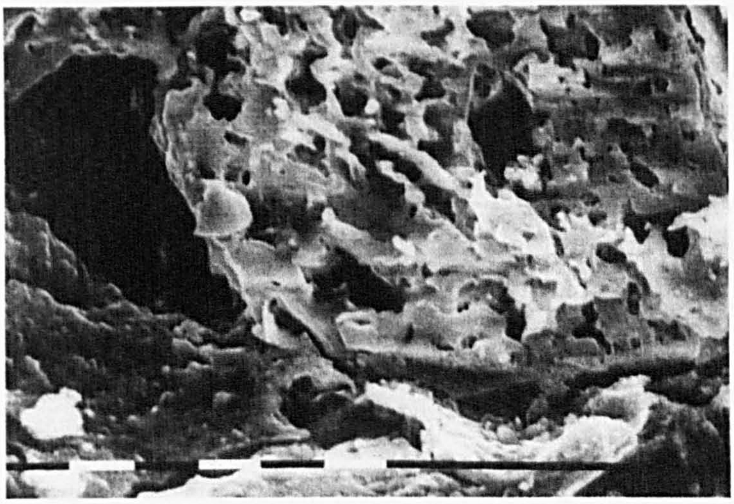


Figure 10.5: a) vitrified surface layer on sample 40 after refiring at 850˚C under oxidizing conditions for 1 hour (x2000); b) body of sample 40 after refiring showing and extensively vitrified microstructure (V) (x1000). Bar scale = 10µm.

10.2.2. Monochrome Red and Orange Dishes and Bowls

The SEM analysis of Terminal Classic red and orange slipped dishes and bowls focussed on three form categories: composite silhouette dishes, rounded dishes and rounded bowls. A total of four composite silhouette dishes were selected for analysis: two with a red slip and two with an orange slip. All of these dishes have calcite-tempered fabrics, and with the exception of sample 401, which is possibly non-local, all were ascribed a local provenance, deriving from group C of this fabric class. Of the three rounded bowls that were analysed, two have a red-coloured slip and one has an orange slip. On all of these bowls, the slip is confined to the interior surface and the rim area of the exterior surface, distinguishing them stylistically from bowls on which the slip completely covers both surfaces. As with the composite silhouette dishes, these bowls have calcite-tempered fabrics but they derive from different local fabric groups within this fabric class (i.e. groups A and B). With regard to the rounded dishes that were analysed, both derive from the Sascab-Quartz A fabric group and, therefore, are associated with a different local tradition of paste-making. One of these dishes has a red slip and the other, an orange slip, and in both cases, the slip is confined to the interior surface and rim area of the exterior.

The SEM analysis showed there to be significant differences between the calcite-tempered vessels and the rounded dishes with Sascab-A fabrics, in terms of both their firing and slip technology. Among the calcite-tempered vessels deriving from different fabric groups, body microstructures were found to be strikingly similar, suggesting similar firing temperatures. With regard to the nature of the slip layer, however, differences were observed among the three form categories with regard to the thickness of the slip layer and its iron content.

Firing

With the exception of one of the rounded bowls (sample 257), the fabrics of all of the vessels described above display firing horizons, with light brown or grey to black cores bordered by lighter-coloured margins (light orange to buff). In all cases, however, the clay used to make the ceramic body is calcareous (>10% CaO). The microstructure of the calcite-tempered fabrics is strikingly similar to that observed in local monochrome black vessels, characterized by extensive sintering, but lacking areas of vitrification. However, the light colour of the body surface, together with the red to orange colour of the slip, indicates that oxidizing conditions prevailed, during the final stages of the firing regime. The darker-coloured cores that are present in all but one of the calcite-tempered vessels are due to incomplete oxidation. Since isolated glassy areas were not observed in these fabrics, an estimated firing temperature approaching the range of 800-850°C for bodies displaying Initial Vitrification (IV) is suggested. Refiring experiments also indicate an original firing temperature below 850°C since samples refired in an oxidizing atmosphere at 850°C (for 1 hour) showed an extensively vitrified body microstructure (stage V) and slip layer. Also noteworthy is that the microstructure of the composite silhouette dish that is possibly of non-local origin is virtually identical to the local calcite-tempered vessels.

The examination of the microstructures of the rounded dishes with Sascab-Quartz A fabrics showed that these vessels were fired at a higher temperature than the calcite-tempered vessels. The microstructure of the rounded dishes corresponds to Initial

Virification (IV) since glassy areas occur throughout the analysed samples (Figure 10.6). An estimated firing temperature within the range of 800-850°C is therefore indicated.

Surface Finishing Techniques

A discrete layer of slip is present on all of the monochrome and red and orange vessels and the there were no differences observed in its microstructure. In all cases, the slip is fine-grained and unvitrified but with extensive sintering. iron-rich conglomerates are present in all samples. The similarity of the compositional readings obtained for the slip layers and bodies of individual vessels, apart from elevated levels of potassium and iron in the slip, suggests that the slips were produced through refinement of clays similar to those used to make the ceramic bodies. Both the slips and bodies of the calcite-tempered vessels (the composite silhouette dishes and the bowls), however, contain higher levels of iron than the rounded dishes, pointing to a chemical difference in the clay used in each case. In addition, there appears to be no apparent difference in the relative amount of iron present in the red and orange slips in either case. This suggests that different slip colours were produced through manipulation of the firing atmosphere. The addition of a small quantity or iron to the slip would have helped to promote intense red colours. Shepard (1939:264-267) reports, however, that localized deposits of iron rich clay at San Jose (located southwest of Lamanai) fire to the same colour as the red slips on vessels dating to the Classic period. Further analyses involving experimental work on local clay resources would help to clarify slip preparation procedures.

A main difference in the slips that occur on the different form categories that were focussed upon is the thickness of the slip layer (Figure 10.7). The slip layer on the calcite-tempered bowls and dishes is comparatively thick, but it is thickest on the bowls. On the bowls it is 15-25μm in thickness, whereas on the composite silhouette dishes it is 10-15μm. The slips on the rounded dishes are appreciably thinner in comparison, measuring 5-10μm. The thickness to which the slip was applied appears to have had a direct affect on the visual and tactile properties of the surface finish. The vessels with a comparatively thick slip layer have a glossier surface finish and a waxy feel.

a)

b)

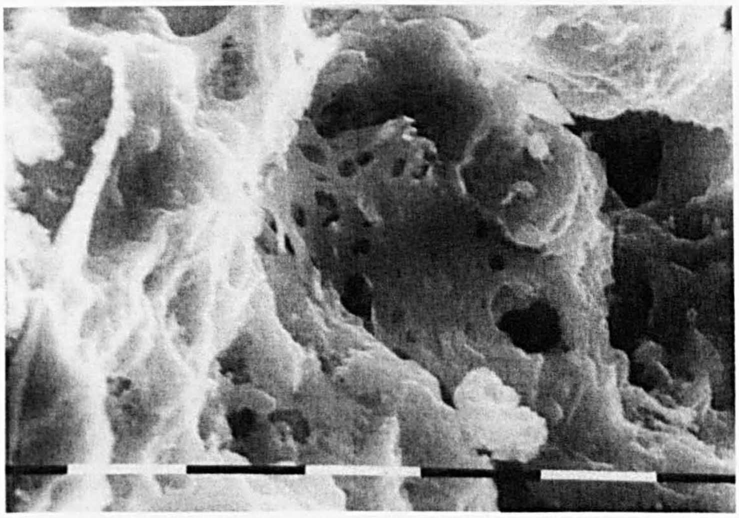
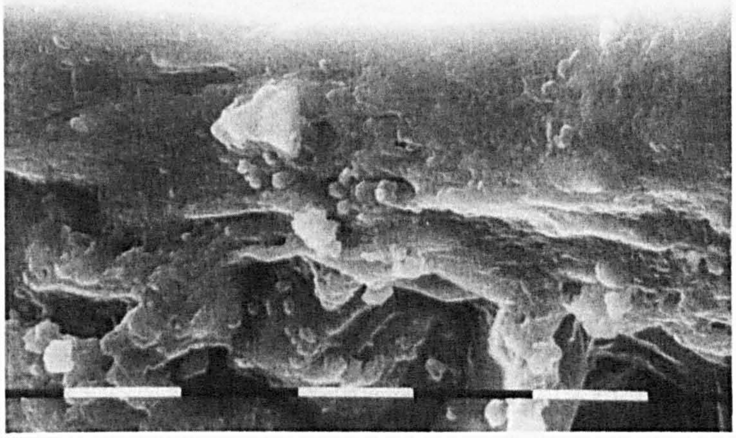


Figure 10.6: a) body of a locally produced monochrome rounded dish with a Sascab-Quartz A fabric (sample 261) displaying an IV microstructure (x500); b) vitrified area (x2000).

a)



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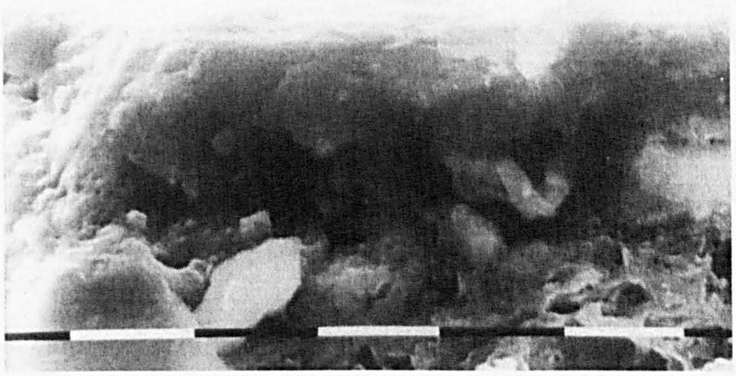

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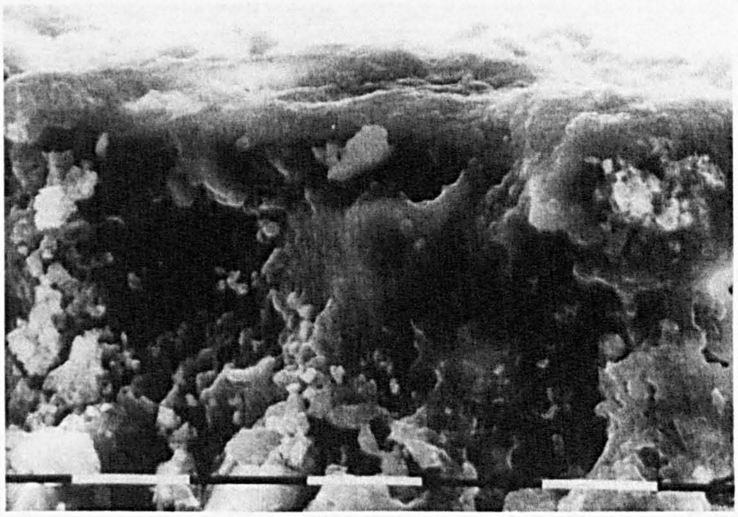


Figure 10.7: a) Red-slipped calcite-tempered rounded bowl (sample 252) displaying a very thick (15-25μm) layer of slip (x2000); b) red-slipped calcite-tempered composite silhouette dish displaying a thick slip layer (10-15μm) (x2000); orange slipped rounded dish with a Sascab-Quartz A fabric displaying a comparatively thin (5-10μm) layer of slip (x2000). Bar scale = 10μm.

10.3. TERMINAL CLASSIC BICHROME AND POLYCHROME VESSELS

10.3.1. Red-Orange-Black Resist Composite Silhouette Dishes

A total of four bichrome composite silhouette dishes were selected for detailed analysis with SEM. On three of these vessels the slipped surface has black decorative elements on a red to orangish-red background and on the remaining vessel, the background colour is burgundy. These dishes are morphologically identical to their monochrome counterparts and they are indistinguishable petrographically from the monochrome composite silhouette dishes that occur in the same fabric group (Group C of the Crystalline Calcite-Tempered class).

Firing

The fabrics of the bichrome composite silhouette dishes display similar firing horizons to those that occur in their monochrome counterparts, with a light grey to black core bordered by lighter coloured subsurface and surface zones. The SEM showed that the microstructure of the bichrome dishes is also similar to that of the monochrome dishes, indicating they were fired within the same temperature range and under similar conditions.

Surface Finishing Techniques

No apparent differences were observed in the microstructural characteristics of the slip layer on the bichrome composite silhouette dishes and those on other locally produced vessels of the Terminal Classic period. In addition, slip thickness was found to be comparable to the monochrome composite silhouette dishes. The absence of microstructural inconsistencies between the red and black coloured areas of the slip on the bichrome vessels provides some evidence that the contrasting colours were in fact produced through a resist technique. This method of colour decoration involves the application of a protective material to select areas of the slipped surface prior to firing to produce localized areas of reduction. The protective material is subsequently removed from the blackened areas, leaving a smooth finished surface (see Shepard 1956:206-213 for a discussion). The light colour of the surface and subsurface zones of the firing horizons indicate that the black decoration was produced whilst firing in an oxidizing atmosphere and the absence of a colorant such as manganese that remains black when oxidized confirms that the black decoration is not simply paint. This interpretation is supported by the results of a refiring experiment, which showed that that the black decoration turns the same red as the background colour when fired under oxidizing conditions (850°C for 1 hour). Interestingly, EDAX analysis of the red and black coloured areas on individual vessels showed that iron levels were consistently lower in the black areas (Figure 10.8). This was the only significant chemical variation observed among the vessels analysed. Based on the current evidence, however, it is unclear what specifically might have caused this chemical difference. The composition of the protective material used to produce negative decorations might have been a contributing factor.

10.3.2. Red Slipped Vessels with Black Painted Decoration

Two vessels from this stylistic group were analysed by SEM: a rounded dish and a massive bowl. Although the fabrics of both of these vessels correspond to the Sascab-Quartz class, the massive bowl corresponds to the local fabric group (Sascab-Quartz A), whilst the dish, connected geologically to areas bordering the Rio Hondo in the Corozal District, is non-local. Both of the fabrics were made using calcareous clay, but spectral analysis indicates that calcium levels are significantly lower in the imported fabric. A further chemical difference between the two fabrics is that the local fabric contains relatively higher levels of iron.

Firing

The imported fabric is completely oxidized, displaying a uniform reddish-brown colour throughout the cross-section. The red colour of both the slip and the body, as well as and the absence of firing horizons, suggests that this vessel was fired under oxidizing conditions. In comparison, the local fabric has a thick grey core that is bordered by thin light orange margins. The light coloured margins, together with the red slip, indicate that the firing cycle ended with a period of oxidation. Whether this was preceded by an initial period of reduction is unclear, as the darker-coloured core might have been caused by incomplete oxidization or fast firing (see Buxeda et al. 2003b).

SEM analysis of the bodies of the imported and local vessels indicates that they were fired at different temperatures. The microstructure of the local fabric is unvitrified, corresponding to the NV stage of vitrification. A firing temperature below 800°C is therefore indicated. A slightly higher firing temperature of 800-850°C can be estimated for the imported fabric since its microstructure, containing glassy areas, corresponds to Initial Vitrification (IV).

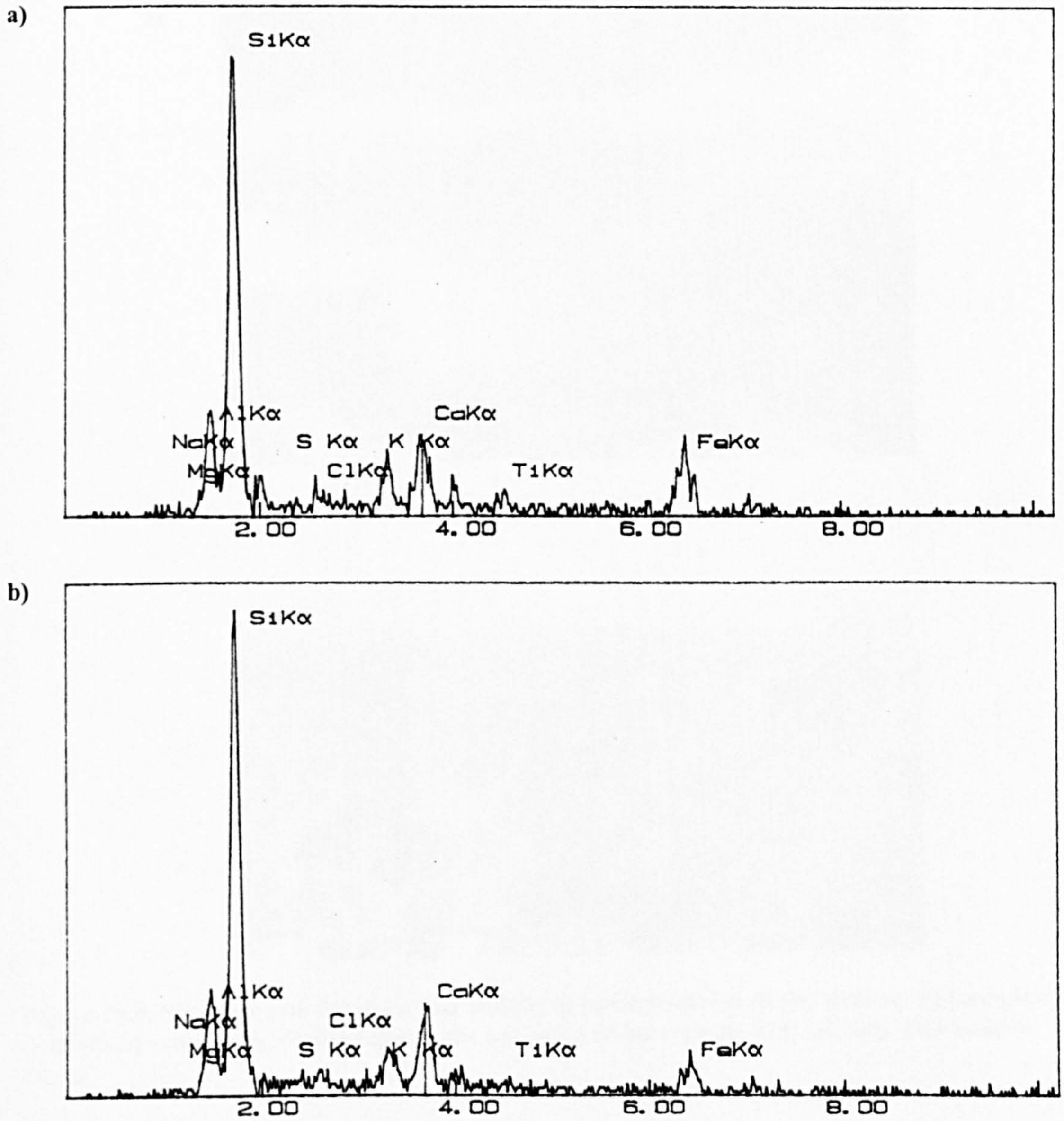
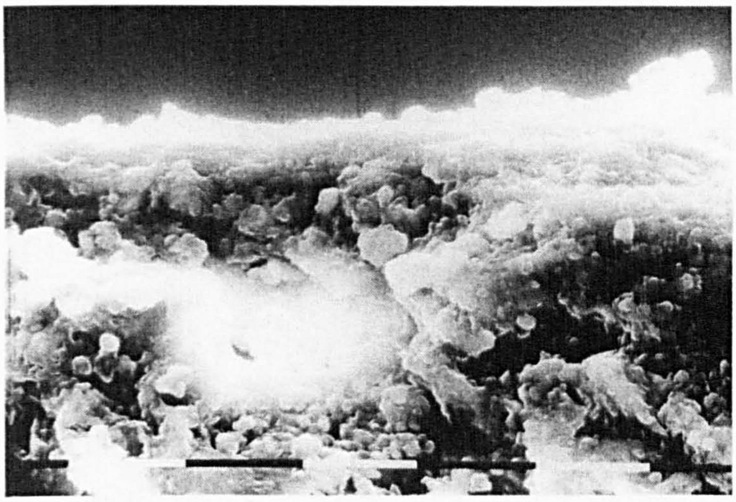


Figure 10.8: Spectra of the red (a) (FSD=181) and black (b) (FSD=202) areas of the slip on a composite silhouette dish with a resist decorative treatment (sample 296) showing elevated levels of iron oxide in the red areas.

Surface Finishing Techniques

Significant differences were observed in the nature of the slip layer and black paint on the local and imported vessels. In both cases, a thin layer of slip approximately 5-10μm in thickness can be distinguished. On the local vessel, the slip is unvitrified (Figure 10.9a) and its micromorphology is inconsistent, exhibiting areas in which the clay particles are compacted and sintering is more extensive. This non-uniform microstructure is caused by an uneven burnishing of the vessel's surface. The general

a)



b)

Figure 10.9: Slip layers on Black on Red vessels; a) unvitrified slip on the local vessel (sample 48) (x2000); b) extensively vitrified slip on the imported vessel (sample 118) (x2000). Bar scale = 10μm.

composition of the slip on the local vessel is similar to that of the body, except that iron and potassium levels are higher in the slip. Elevated iron levels in conjunction with potassium suggest that the slip was produced through levigation of clay similar to that used to make the body. In comparison, the slip layer on the imported vessel is uniform with extensive sintering (Figure 10.9b). Burnishing marks occur on this vessel, but differential compaction of clay particles was not observed with the SEM, suggesting a more careful treatment of the surface. EDAX analysis indicates that the composition of the slip is clearly different from the body, due to the presence of sulphur in the slip. The spectra obtained for the slip are also characterized by a low peak:background ratio, which may suggest the presence of an organic or carbon-based component. The black painted areas of the imported vessel produce similar readings, but with even higher levels of 'noise' (Figure 10.10b).

a)

b)

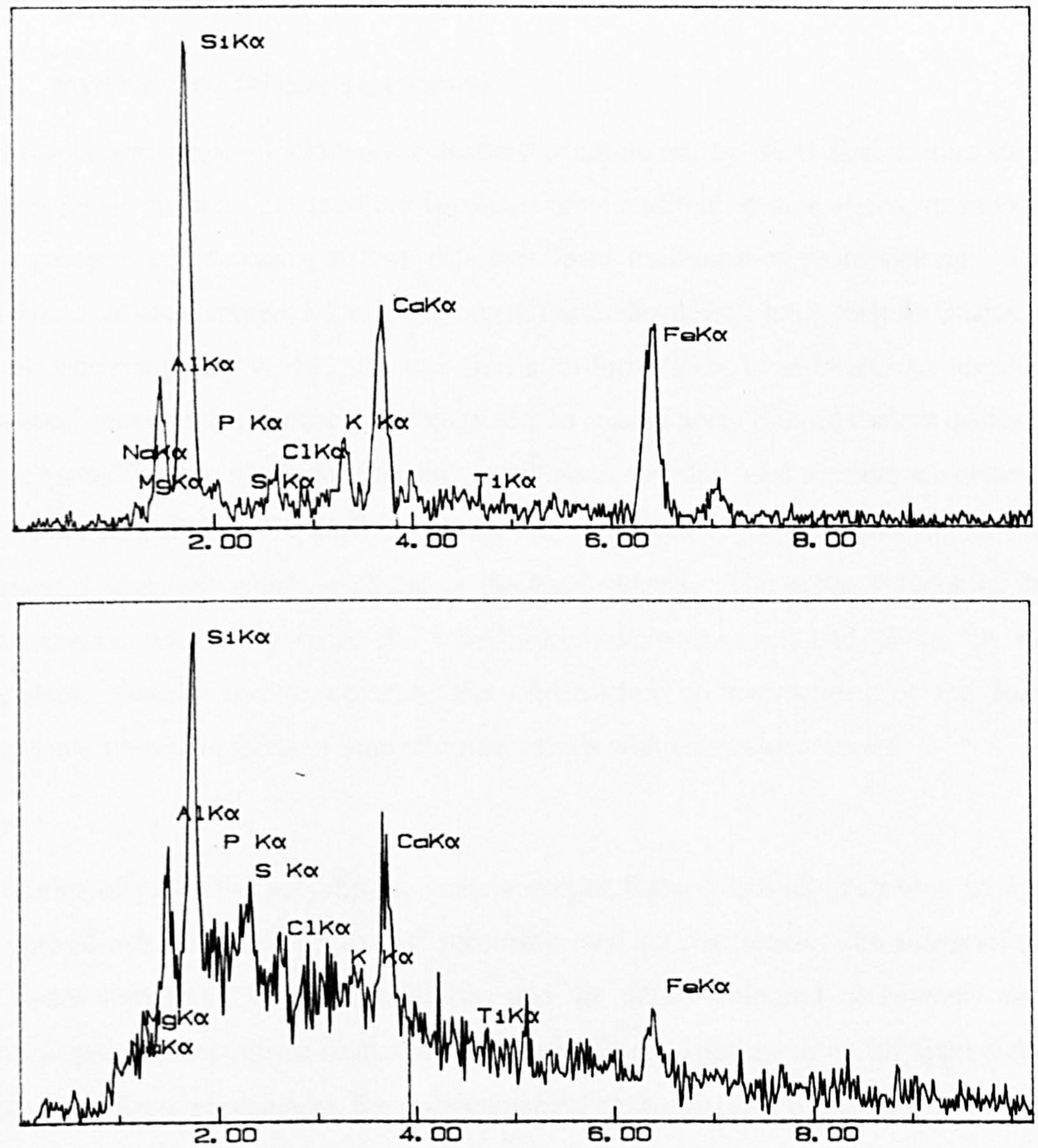


Figure 10.10: Spectra of the black painted areas on the local (a) (FSD=235) and imported (b) (FSD=127) vessels showing significant compositional differences.

On both vessels, a distinct layer of black paint sitting atop the slip layer cannot be distinguished. The presence of aluminium and silicon in the black painted areas of both vessels suggests a clay-based paint. With regard to the local vessel, the spectra obtained for the painted area were not substantially different from those obtained for the slip layer, suggesting that accurate readings were not obtained for the paint. Nonetheless, the painted areas on the local and imported vessels are clearly compositionally different (Figure 10.10). The black painted areas of the imported vessel are characterized by a low count rate and consequent high levels of 'noise'. This 'noise', together with the absence of manganese, suggests that the black paint is carbon-based, being made from a charred organic material.

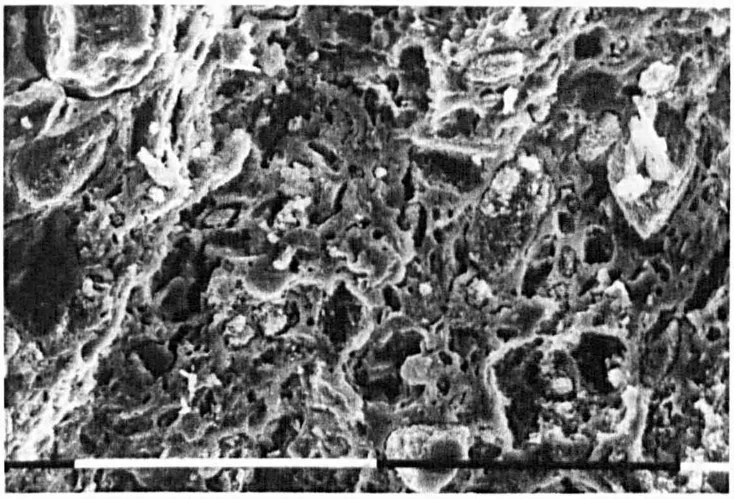
10.3.3. Polychrome Dishes and Bowls

The polychrome vessels included for detailed examination by SEM derive from three different fabric groups. Three of the vessels, a bowl and both dishes, derive from local fabric groups, corresponding to two different local traditions of paste-making. The bowl has a calcite-tempered fabric (Group C) and the dishes have Sascab-Quartz A fabrics. The remaining vessel, although similar in form to the local bowl, was ascribed a non-local provenance, connected geologically to coastal areas of northeastern northern Belize, extending into southern Yucatan. In all cases, the clay used to make the ceramic body is calcareous (>10% CaO), and the imported vessel is distinguished by the presence of titanium, which is absent in the local vessels. The primary focus of the SEM analysis was to compare the vitrification microstructures and paints on the polychrome vessels and to compare the vitrification microstructures of the local polychrome vessels to those of monochrome vessels with equivalent fabrics.

Firing

The fabrics of all of the polychrome vessels exhibit firing horizons, with light to dark grey cores bordered by orange to buff subsurface and surface zones. The colour of the later zones indicates oxidizing conditions and the darker-coloured cores were most likely caused by incomplete oxidation. Although there appears to be no appreciable difference in firing atmosphere, the microstructural characteristics of the fabrics suggest variation in firing temperature. The microstructure of the local calcite-tempered bowl is similar to that observed in the oxidized monochrome and bichrome vessels that were examined from the same fabric group. Thus, a firing temperature approaching 800-850°C can be estimated. In comparison, the microstructure of the local dishes appears to fall between Initial Vitrification (IV) and Extensive Vitrification (V), indicating an estimated firing temperature of 800-900°C (Figure 10.11). Since these fabrics have sascab temper, however, the temperature could not have been much higher than 850°C so as to avoid the decomposition of calcium carbonate. Significantly, the polychrome dishes appear to have been fired at a higher temperature than conformal monochrome dishes with the same fabric. The microstructure of the imported vessel is different from the local vessels, equivalent to Initial Vitrification (IV), which corresponds to an estimated firing temperature of 800-850°C.

a)



b)

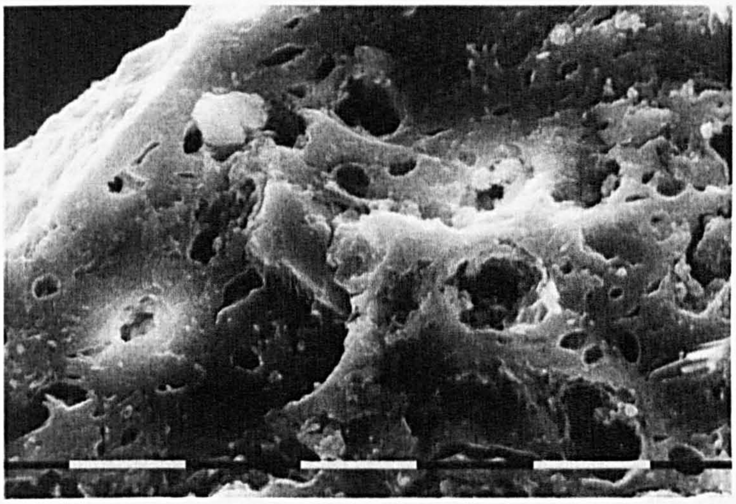


Figure 10.11: a) body microstructure of a polychrome rounded dish with a Sascab-Quartz A fabric (sample 202) displaying a vitrified microstructure (IV+) that falls between the Initial Vitrification and Extensive Vitrification (x500); b) red painted decoration on an orange-slipped polychrome rounded dish with the same fabric (sample 207). Note that the surface layer is vitrified and discrete paint and slip layers can not be distinguished (x2000). Bar scale = 10μm.

Decorative Techniques

A discrete layer approximately 5-10μm can be distinguished at the surface of all of the polychrome vessels. This layer displays extensive sintering in all cases, but vitrified areas were only observed in the local dishes (Figure 10.11b). EDAX analysis showed that orange slips that occur on three of the vessels contain higher concentrations of Fe- and potassium than the respective bodies, suggesting the use of a refined suspension of the body clay for the slip.

Painted decoration occurs on all of the vessels analysed, although it was not possible to get accurate readings for the black paint on the local calcite-tempered vessel and the imported vessel. For all the vessels, no differences were observed in the microstructure of the painted and undecorated areas of the surface layer (Figure 10.11b). In most cases, however, the presence of paint could be detected through EDAX analysis. Comparison of the upper and lower regions of the surface layer showed differences in the concentrations of iron and manganese, indicating the presence of the paint.

In all cases, the paints used appear to be clay-based since aluminium and silicon were consistently found to occur in the painted areas that were distinguished chemically with EDAX analysis. The red paints, which range from deep red to orangish-red, are characterized by high levels of iron in comparison to the slip, indicating that these paints were made using an iron-based pigment. In comparison, the black paints, which could only be distinguished on the local dishes, were found to contain both iron and manganese, suggesting the use of a manganese-rich compound as the colourant. Since the dishes were fired in an oxidizing atmosphere, the presence of the manganese is the key factor in producing the black painted decoration (Noll 1975:608-610).

10.4. Early Postclassic Monochrome Orange Vessels

A total of seven vessels representing vessel styles typical of the Early Postclassic period were selected for detailed analysis by SEM. A range of vessel forms were included as well as vessels with incised and modelled decorative elements and undecorated surfaces. All but one of the vessels (152) derive from local fabric groups (Grog-Mixed Carbonate class and Sascab-Quartz A). The imported vessel is connected geologically to coastal areas of northeastern northern Belize, extending into southern Yucatan. In all cases, the clay used for the body is calcareous (>10%CaO), but the presence of magnesium in the imported fabric clearly distinguishes it from the local fabrics. The presence of magnesium the imported fabric reflects the fact that this vessel was made using a dolomitic marl. Among the local vessels, there is some variation in iron, titanium and potassium levels.

Firing

The fabrics within this group exhibit a range of different firing horizons. Three of the fabrics (samples 335, 81 and 152) are completely oxidized, displaying a uniform orangish-buff colour throughout the cross-section. The colours of the slip and the body, as well as the absence of firing horizons, suggests that these vessels were fired under oxidizing conditions. In the case of sample 335, however, the microstructural characteristics of the fabric are most similar to those displaying firing horizons, suggesting that this vessel was fired under different conditions than the other two vessels with oxidized fabrics (see below).

Firing horizons are present is four of the fabrics, which exhibit grey to black cores, bordered by lighter-coloured subsurface and/or surface zones. A distinctive characteristic of the fabrics displaying a thin light orange oxidized zone adjacent to the surface is that the interior margin of this zone is sharply defined. Rye (1981:118) suggests that the presence of a sharply defined oxidized zone is indicative of rapid oxidation or cooling in air and is characteristic of open firing. The microstructural characteristics of these fabrics indicate that the firing regime involved a period of reduction. Reduction firing is indicated by the presence and abundance of fine bloating pores in extensively sintered and vitrified areas, which gives these fabrics a 'spongy appearance' (Maniatis and Tite 1981:65-66) (Figure 10.12) Such microstructures are also considered to be typical of a fast-firing technique (Buxeda et al. 2003b). This microstructure is distinctive of these particular fabrics and was not observed in any of the other vessels analysed in this study. In this instance, therefore, the presence of the grey to black cores is due to reduction firing. The lighter-coloured subsurface zone, together with the orange colour of the slip, indicates that reduction firing was followed by a period of oxidation. In the case of sample 335, which lacks a dark-coloured core, it would appear that this period was of sufficient duration to remove any carbon present. In addition, the presence of a thin, sharply defined, oxidized surface zone in some fabrics, together with the 'spongy' appearance of the microstructure, suggest that the whole processes happened quite quickly, indicating 'fast-firing' under open-firing conditions (Buxeda et al 2003b).

Differences in firing temperature were also observed among the Early Postclassic vessels. The microstructures observed in samples 81 and 152, both of which are oxidized fabrics, exhibit extensive sintering but isolated glassy areas were not observed. Since this microstructure falls between No Vitrification (NV) and Initial Vitrification (IV), a firing temperature approaching the range of 800-850°C for IV microstructures can be estimated. Among the fabrics subjected to a reduction-oxidation firing cycle, the microstructure of three of the samples (99, 333 and 335) is extensively sintered and contains abundant fine bloating pores. As with the two oxidized vessels, this microstructure falls between No Vitrification (NV) and Initial Vitrification (IV). However, since these vessels were partly fired in a reducing atmosphere, a slightly

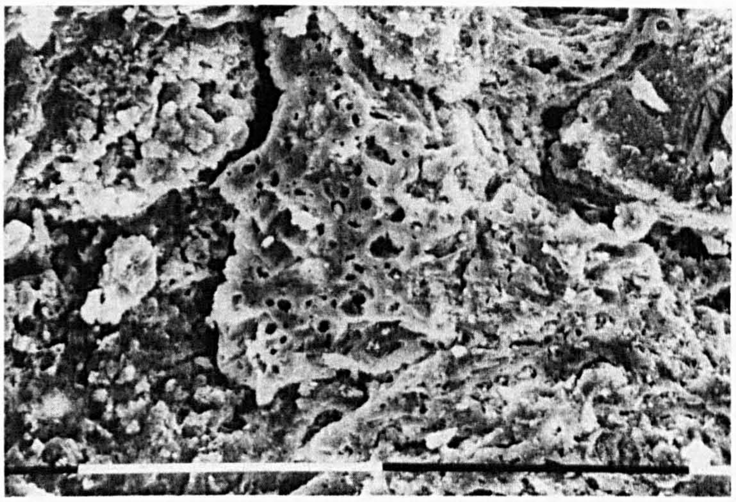


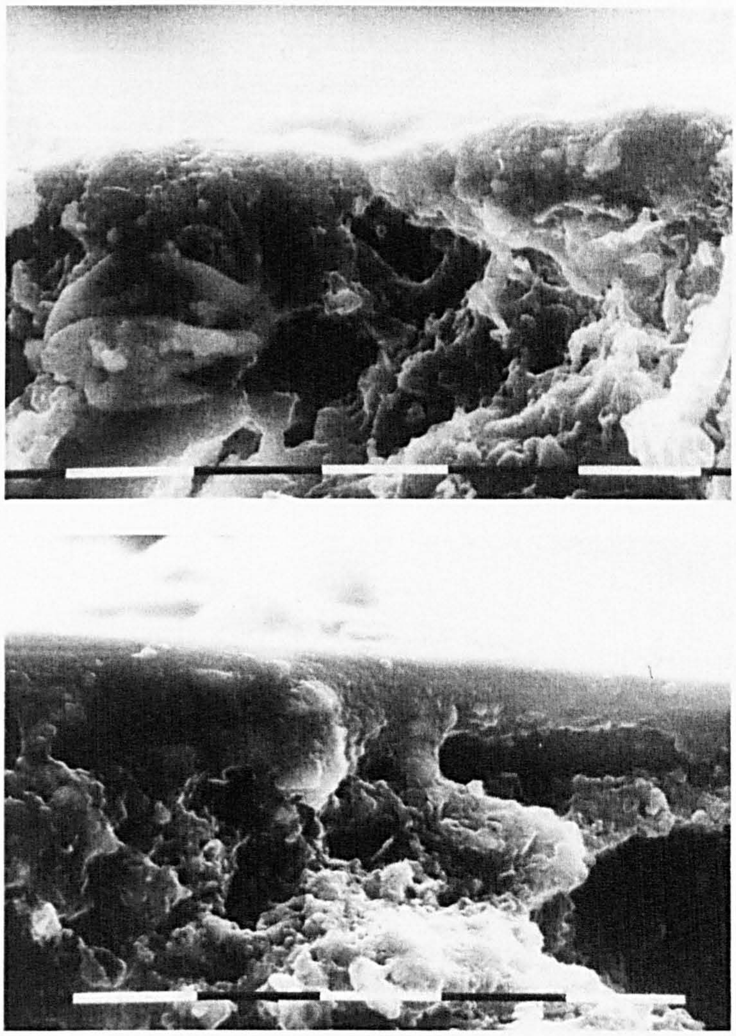
Figure 10.12: Body microstructure of a Early Postclassic chalice (sample 327) subjected to reduction-oxidation firing regime with a maximum firing temperature of 800-900°C, showing abundant fine bloating pores in a vitrified microstructure (x500). Bar scale = 10μm.

lower temperature approaching the range of 750-800°C (IV and a reducing atmosphere) can be estimated. In comparison, the microstructure of samples 76 and 327, which is also characterized by the presence of fine bloating pores, appears to fall between Initial Vitrification (IV) and Extensive Vitrification (V), indicating an estimated firing temperature of 800-900°C. Since these fabrics contain inclusions of micrite and crystalline calcite, however, the temperature could not have been much higher than 850°C so as to avoid the decomposition of calcium carbonate.

Surface Finishing Techniques

A thin, fine-grained layer of slip, approximately 5-10μm, can be distinguished at the surface of all of the vessels analysed (Figure 10.13). This layer is unvitrified, but sintering is more extensive in some cases (e.g. 76, 327 and 99), which appears, in most instances, to relate directly to slight differences in firing temperature. Iron-rich conglomerates are present in all cases. The slip layer on vessel 99, which is a tripod bowl, however, is extensively sintered and compacted, and was likely produced through intense burnishing of the vessel's surface (Figure 10.13b). Although burnishing marks are present on the other Early Postclassic vessels, comparably compacted slip layers were not observed. EDAX analysis of the slips and bodies of individual vessels suggests that the slips were produced through levigation of a clay similar to the body

a)



b)

Figure 10.13: Slip layer on Early Postclassic vessels; a) unvitrifed layer with extensive sintering (sample 333) (x2000); b) vessel 99, displaying a compacted and extensively sintered layer due to intense burnishing (x2000). Bar scale = 10µm.

clay, producing higher iron and potassium levels in the slip. Comparison of the spectra obtained for the slip layers indicated differences in iron levels. Iron levels are comparatively low in samples 335 and 76 (both are chalices). Interestingly, the spectra obtained for these two vessels are strikingly similar to those obtained for the Terminal Classic monochrome rounded dishes that derive from the same local fabric group. In comparison, iron levels in slips of the other Postclassic vessels, are similar to those indicated for monochrome and bichrome Terminal Classic vessels with calcite-tempered fabrics.

10.5. SUMMARY

SEM analysis has revealed several interesting points of technological similarity and difference within and among the different pottery styles analysed with regard to decorative and surface finishing techniques and firing.

1) All of the vessels analysed share two main technological similarities, which can be considered to represent regional commonalities in Maya ceramic technology. Firstly, with the possible exception of the imported Black on Red vessel, slips appear to have been made through the refinement of clay that is compositionally similar to that used for the ceramic body, indicating that similar, or possibly, the same clay was used for both purposes. Secondly, although differences in firing temperature and regime are evident, the maximum temperature to which vessels were fired rarely exceeded 850°C. It is likely that firing temperatures were purposely kept low due to the nature of the clay bodies, which in all cases contain inclusions of either calcite or dolomite. Since calcium carbonate starts to decompose at around 850°C, it would have been necessary to carefully monitor and control firing temperature to avoid failures.

2) The differences observed in surface finishing and decorative techniques correlate with differences in vessel composition. For example, the locally produced vessels that are associated with different paste-making traditions are also discriminated by differences in slip thickness, and in the case of calcite-tempered fine ware, by the compositional characteristics of the slip. Similarly, the imported Monochrome Black and Black on Red vessels are distinguished from local stylistic equivalents by significant differences in surface treatment and decorative techniques. SEM analysis, therefore, has provided further evidence of technological variation among vessels already distinguished by differences in paste technology and provenance.

3) The results of the study indicate that during the Terminal Classic Period there is greater variability in surface finishing and decorative techniques and firing procedures than in the Early Postclassic period. Nonetheless, SEM analysis has documented further aspects of technological variation among Early Postclassic ceramics, indicating fundamental differences in the manufacture of vessels that share a common and distinctive set of stylistic characteristics. For example, the macroscopic and microstructural evidence distinguishes three different types of fired bodies, reflecting differences in firing procedures. It is also significant that the results of the present study suggest that only Early Postclassic vessels were produced using a reduction-oxidation firing sequence that resulted in a substantially different body microstructure. This body

microstructure suggests fast-firing under open-firing conditions. The emergence of this new microstructure is suggestive of a significant shift in local firing practices, representing a new method of producing vitrified bodies at relatively low firing temperatures.

Although the sample size is admittedly small, when the results of the SEM analysis are taken together with the findings of the petrographic and chemical analyses, it would seem that the scientific examination of the Lamanai fine ware pottery has documented an important diachronic change in the relationship between stylistic and technological variability within the assemblage. During the Terminal Classic period, fine ware vessels made using the same set of raw material ingredients also display a high level of consistency in terms of the methods used to slip, decorate and fire these vessels. Generally speaking, stylistic diversity correlates with technological diversity. By Early Postclassic times, however, fine ware pottery exhibits a high level of stylistic consistency, but is characterized by compositional and technological heterogeneity. The nature of this aspect of ceramic change is explored further in the following chapter through a consideration of the wider social setting within which ceramic production and consumption took place.

CHAPTER 11

CERAMIC PRODUCTION AND CONSUMPTION AT LAMANAI DURING THE CLASSIC TO POSTCLASSIC TRANSITION: EMERGENT PATTERNS AND CONTRIBUTING FACTORS

11.1. INTRODUCTION

The preceding chapters have focussed on documenting the nature and temporal dimensions of variability in the stylistic, technological and provenance characteristics of the pottery comprising the Terminal Classic to Early Postclassic assemblage. The data generated through this detailed physical analysis of the pottery provides a basis for the reconstruction of community-level patterns of ceramic production and consumption. Through the identification of instances of continuity and change in manufacturing procedures and ceramic depositional patterns, this chapter investigates shifts in local demand and manufacturing priorities, the nature of ritual and ceremonial practice, and the range of pottery used within different contexts of religious and ceremonial activity. There are two main focal points of the discussion. The first concerns the compatibility of the patterns that have emerged at Lamanai with the conventional characterizations of ceramic economic activities that form the basis of current explanatory models of ceramic change during the Classic to Postclassic transition. The second relates to the contributing role of factors external and internal to the community in shaping local patterns in ceramic production and consumption during this period.

11.2. CONTINUITY AND CHANGE IN LOCAL POTTERY PRODUCTION

As with other community-based activities at Lamanai during the Terminal Classic to Early Postclassic period, local pottery production shows evidence of both continuity and change. Local potters continued to be the primary producers of ceramic items destined for final deposition as part of ritual and ceremonial events that took place within the community, demonstrating a sustained self-sufficiency in terms of fulfilling the community's ceramic requirements in this regard. Nonetheless, changes in the kinds of vessels used in theses activities, as well as their visual appearance and technological characteristics, indicates that ceramic needs and tastes had changed by Early Postclassic times, reflecting an important shift in demand as well as manufacturing priorities. The technological data presented in the preceding chapters provide abundant evidence of the kinds of changes that occurred in local manufacturing procedures, and yet it is also evident that the different choices that potters were making by Early Postclassic times were informed by a local tradition of technical and environmental knowledge that had also guided earlier potters. For example, although paste preparation methods for fine ware production had changed significantly by the Early Postclassic period, potters continued to exploit the same local raw material resources as their predecessors. Similarly, there is good evidence that certain surface-finishing techniques and firing methods continued to be used in the manufacture of local fine ware, although alongside new techniques and a significantly different approach to decorative embellishment. It is also evident that changes in the morphology of the predominant fine ware forms produced locally (i.e. bowls and dishes) document a continuous development from earlier conventions. Accordingly, the ceramic evidence indicates a complex developmental process characterized by the blending and merging of new ideas and approaches with established conventions (Table 11.1). Central to this dynamic was the ongoing dictates of the community's ceramic needs, potters' practical responses to changes in demand and an expanding stock of technical knowledge and 'know-how'.

11.2.1. Temporal Trends in Fine Ware Production

The early part of Terminal Classic to Early Postclassic ceramic sequence is characterized by the existence of several different local approaches to pot-making, distinguished by a particular set of choices with regard to raw material selection, vessel forms, surface-finishing and decorative technology and firing methods (Table 11.2). These approaches are quite consistent, especially with regard to paste and slip technology and firing methods. The stylistic data indicate notable variation and overlap in vessel forms, slip colour and other decorative characteristics within and among these 'technological groups'. Within the assemblage analysed, however, each of these different approaches is characterized by a predominance of stylistically distinctive form categories. Two of these approaches are strongly associated with the production of different fine ware dishes that have a variety of decorative treatments. The remaining two approaches are associated strongly with the production of coarse ware jars with red-

Table 11.1: Local production patterns during the Terminal Classic to Early Postclassic period, according to stages of the production process.

Selection of Manipulation of Raw Materials

Fine ware

- Multiple local approaches to paste manufacture that exhibit a high level of internal consistency give way to a single general approach that is characterized by a high level of internal heterogeneity (as shown by petrographic and chemical analysis).
- A shift in practice away from the use of a single tempering material, primarily different forms of calcium carbonate, and towards the simultaneous use of multiple tempering materials including carbonates, grog and sand.
- A shift towards a more careful or rigorous processing of raw materials resulting in comparatively fine-textured pastes.
- Continuity in the local clay resources chosen for fine ware production.

Coarse Ware

- The emergence of Quartz Sand fabrics, which represent an approach to paste manufacture not prevalent at Lamanai in preceding time periods.
- A continuation of the local tradition of crystalline-calcite-tempered coarse wares, although with some changes in raw material ingredients and perhaps their processing.

Forms and Morphology

- The emergence of new vessel forms, which in many cases represent new functional categories of pottery – e.g. a range of incense-burning paraphernalia, drums and comals.
- Particular forms of service and drinking vessels – e.g. the vase – cease to be produced.
- Vessel morphology increases in complexity, in terms of body geometry and incorporating hand-modelled and possibly mould-made decorative embellishments (e.g. effigy appliqués and foot supports and flanges) and appendages. Dependent composite forms increase in prevalence, often consisting of base, body and connective components and with enlarged or exaggerated rims.
- Bowls and dishes remain the dominant fine ware forms produced and the development of vessel morphologies within these shape classes appears to be continuous in nature, indicating an indigenous development out of earlier conventions.
- Crystalline calcite-tempered coarse ware jars continue to exhibit a comparatively standardized morphology, but with changes over time in surface treatment and specific morphological attributes. In comparison, jars manufactured within the Quartz-Sand tradition exhibit a high level of morphological heterogeneity.
- A loss of diversity in surface treatment and decorative technology.
- A shift in decorative technology away from painting and the manipulation of slip colour through firing methods and a resist technique to produce to different colours and colouring effects, and towards oxidized colours and surface penetrating decorative techniques (incision and gouging). By the Early Postclassic period, vessels exhibiting more than one colour are quite rare, and coloured decoration is achieved applying a coat of stucco to selected areas, such as foot supports, subsequent to firing and painting it, or through the addition of Maya Blue after firing.
- A change of technique for rendering incised decoration. In the early part for the sequence decorative embellishing through stamping, incision, punctation etc, is done prior to slipping. This technique ceases and such decoration is always added to the surface after slipping by Early Postclassic times.

Table 11.1: Local production patterns during the Terminal Classic to Early Postclassic period, according to stages of the production process (continued).

Surface Finishing a Decorative Techniques
• Decorative designs become more intricate and complex. The composition of the designs rendered on individual vessels is most often unique and yet derives from a limited repertoire of fairly standardized motifs. Decorative designs characteristic of the different surface treatment groups dating to the early part of the sequence are comparatively consistent in terms of their composition.
• Decorative embellishment becomes confined almost exclusively to the exterior surface by the end of the sequence. In addition, the scale of the decoration is generally larger and there is a tendency to cover all the available space.
• Continuity in slip manufacturing and application techniques. Techniques used in the Early Postclassic period derive from earlier precedents.
• A simplification of surface treatments accorded to coarse ware jars. By the end of the sequence these vessels are rarely accorded slips or other decorative embellishments.
Firing Methods
• Variability in firing methods is generally greater in the early part of the sequence. In addition, early in the sequence differences in firing technology coincide with differences in other aspects of vessel technology as well as stylistic characteristics. By Early Postclassic times, firing methods still vary but the general style and decorative technology of the vessels being produced are similar.
• The emergence of a firing regime, involving a period of reduction followed by a final oxidation stage, which produces vitrified ceramic bodies with oxidized surfaces at low temperatures.
• A continuation of some firing methods into the Early Postclassic period.

slipped rims and 'interior-slipped' bowls, which seems to represent an original service set comprising vessels for drinking or eating and a storage container. Nonetheless, whether the predominance of these particular vessel forms within the different technological groups can be considered to reflect consumption tendencies within the contexts analysed, or actual production specialization, cannot be judged based on the current body of evidence due to the limited range of depositional contexts considered.

By Early Postclassic times, the multiple, internally-consistent, early approaches to fine ware production, give way to a single, more general approach to vessel manufacture which is characterized by a high level of internal variability (Table 11.2). Unlike earlier approaches to pottery manufacture, this later approach cannot be characterized as expressing a particular set of choices indicative of consistency in technical practices. Rather, variation in paste technology, surface-finishing and decorative treatment and firing methods indicates different technical choices and, thus, the existence of different, but technically overlapping, manufacturing processes. As a result, Early Postclassic

Table 11.2: Varied local approaches to pottery manufacture during the Terminal Classic to Early Postclassic period.

		Paste Making Tradtion	Paste Technology	Predominant Vessel Forms	Surface Treatment	Firing Methods (atmosphere/temp.)
Terminal Classic	Fine Ware	Crystalline Calcite-Tempered (Group C)	Yalbac clays (weathered limestone horizon) tempered with finely-crystalline calcite and sascab	composite silhouette dishes	thick slip layer, monochrome red, orange and bichrome resist	oxidizing conditions/approaching 800-850°C
	Fine Ware	Sascab-Quartz (Group A)	Filipe clay tempered with sascab	rounded dishes	thin slip layer ('interior-slipped'), monochrome red, orange, buff, bichrome black on red and polychrome	oxidizing conditions /800-850°C
	Fine Ware and Coarse Ware	Crystalline Calcite-Tempered (Group A)	Yalbac clays (subsurface) tempered with coarsely-crystalline calcite	rounded bowls and large storage jars	bowls - very thick slip layer ('interior-slipped') jars - red slip on lip or rim to neck area, well smoothed	bowls - oxidizing conditions /approaching 800-850°C
	Fine Ware and Coarse Ware	Crystalline Calcite-Tempered (Group B)	Yalbac clays (weathered limestone horizon) (subsurface) tempered with finely-crystalline calcite	rounded bowls and large storage jars	bowls - very thick slip layer ('interior-slipped') jars - red slip on lip or rim to neck area, well smoothed	bowls - oxidizing conditions /approaching 800-850°C
	Coarse Ware	Quartz Sand	Boom clays, possible sand temper in some cases	large storage jars	unslipped, crudely smoothed	—
	Coarse Ware	Crystalline Calcite-Tempered (Group H)	Yalbac clays (subsurface) tempered with coarsely-crystalline calcite	large storage jars	unslipped, well smoothed	—
Early Postclassic	Fine Ware	Grog-Mixed Carbonate	Yalbac clays (various) tempered with grog, and varying amounts of sascab, calcite and, in some cases, sand	a variety of forms	thin slip layer, orange slip, commonly with incision	various

pottery exhibits a superficial stylistic and technological uniformity, sharing common stylistic and decorative elements and petrographic characteristics, but in terms of technique, is quite variable, due to differences in the specific set of technical procedures employed in its production.

Paste technology is characterized by the use of multiple tempers, including grog, and a more rigorous or careful processing of raw material ingredients to produce fine-textured fabrics. In comparison, earlier paste technologies are characterized by comparatively coarse-textured fabrics, and the use of tempering materials other than sascab and calcite is rare. It is also apparent that design elements and decorative technology of Early Postclassic pottery exhibit a higher level of complexity than is seen in earlier approaches to fine ware manufacture. Early Postclassic vessels display a comparatively complex body geometry and dependent composite forms, consisting of high pedestal bases, bodies characterized by a complex curvature including enlarged or exaggerated rims, and connective elements are common. Basic forms are made more elaborate through the addition of hand-modelled and, possibly, moulded decorative embellishments such as segmented flanges and anthropomorphic and zoomorphic appliqués, handles and foot supports. Additional decorative embellishments most often include the rendering of intricate designs through incision and gouging. In contrast to the earlier technique of incising prior to slipping (which, incidentally, appears to have been rarely employed by local potters in general), the decorative designs on Early Postclassic vessels are always rendered subsequent to slipping, most likely to ensure their visibility. In addition, they tend to cover the majority of the available space on the exterior surface. This focus on extensive decoration of the exterior surface, specifically with regard to open forms, also represents a departure from earlier conventions. The composition of the incised designs on individual Early Postclassic vessels is most often unique, and yet appears to derive from a repertoire of standardized motifs that are repeatedly encountered on different vessels. The net effect of this high level of variation in decorative embellishment is that Early Postclassic vessels often have an individual character that is not prevalent among earlier vessel styles.

Another important aspect of this later approach to local fine ware manufacture is that it is accompanied by an expansion of the local ceramic repertoire to include new kinds of pottery vessels. Of particular significance is the inception of ceramic musical instruments, particularly different drum forms, and a range of distinctive vessel forms, which presumably had specialized functions, but appear to be associated primarily with burning incense and other substances based on the occurrence of carbon deposits (e.g. incense burners, frying pan censers and sieves). These new vessel forms represent functional categories of pottery that were not produced earlier.

11.2.2. Temporal Trends in Coarse Ware Production

Local coarse ware production follows a significantly different developmental trajectory than that of fine ware. The earliest stratigraphic contexts examined in this study are dominated by crystalline calcite-tempered coarse ware vessels, primarily jars. Their prevalence in these contexts suggests a continuation of a well-established local tradition of coarse ware manufacture. These vessels are well made and exhibit a high level of stylistic homogeneity, including a fairly standardized morphology, but were made using two distinct paste recipes, suggesting the existence of two slightly different approaches to calcite-tempered coarse ware manufacture. The results of the petrographic study indicated that this local coarse ware tradition continued into the Early Postclassic period, but with changes in jar morphology and surface treatment, as well as the raw material ingredients of the paste. For example, early jars are slipped to just below the rim or neck area whereas later jars are unslipped. By Early Postclassic times, calcite-tempered coarse ware exhibits greater stylistic and compositional variability, which presents a direct contrast to the high level of stylistic consistency that characterizes the early jars. Nonetheless, the different jar styles that are typical of the Early Postclassic period are still well made and display a fair degree of morphological standardization, with at least three distinct jar styles represented (see Appendix II, Unslipped/Smoothed Buff stylistic group). Occurring alongside these later jar styles in later stratigraphic contexts are new vessel forms, such as plates/lids and incense burners, with identical fabrics. The appearance of these new forms indicates an expansion in the range of vessel forms produced within this local tradition. The absence of slip on the later jars suggests a simplification of surface treatment.

Some time during the Terminal Classic period, a significantly different approach to coarse ware production emerges. This approach appears to lack a prior local precedent, but continues into the Late Postclassic period (see Chapter 8), suggesting that its appearance in the Terminal Classic period represents the inception of a new local tradition of coarse ware manufacture. This new approach continues alongside the calcite-tempered coarse ware tradition into at least the Early Postclassic period.

The new approach to coarse ware manufacture is based on a different set of raw materials, including sandy clays and, possibly, sand that derive from the east side of the New River Lagoon. The vessels produced are comparatively poorly made and are characterized by a high level of morphological heterogeneity, which gives individual vessels a unique character. In addition, a greater range of functional classes of pottery appears to have been produced within this tradition, although large storage jars are most frequent in the assemblage analysed here. Many of the vessels forms with utilitarian functions are also produced within the calcite-tempered coarse ware tradition. It is noteworthy that the jars produced within the new tradition bear stylistic and petrographic similarities to Late Classic jars at Altun Ha, but with mineralogical differences relating to the use of local clays (see Howie-Langs 1999). Similarly, the results of the petrographic analysis suggested that the local jar fabrics reflect an approach to coarse ware manufacture based on a particular choice of raw material ingredients (clays formed in areas of Pleistocene alluvium and sand) that also occurred elsewhere in Northern Belize. A significant aspect of the emergence of this tradition at Lamanai is that it involves the use of raw material resources that had not been habitually exploited previously by local potters.

11.2.3. Local Production Patterns in Comparison to Conventional Perspectives

Conventional perspectives on ceramic economic patterns during the Classic to Postclassic transition emphasize two main dichotomies: 1) that between the level of technological sophistication and standardization exhibited by polychrome pottery and trade wares in comparison to common service and utilitarian wares; and 2) that between the Classic period pattern of variability in pottery styles and technology and the Postclassic pattern of standardization. Taken to imply fundamental differences in organizational aspects of production, these characterizations form the basis of current explanatory models of ceramic change during the Terminal Classic to Early Postclassic period. Of particular relevance to the present study, therefore, is whether or not these characterizations and, thus, associated inferences relating to Maya economic infrastructures, can be considered to accurately reflect the situation at Lamanai. The evidence that has been revealed through detailed scientific examination and comparison of the technological characteristics of locally produced fine ware and coarse ware, suggests that they cannot. For example, the results of the analysis indicate a high level of technological similarity between polychrome rounded dishes, the predominant form of polychrome pottery manufactured locally, and bichrome, and monochrome rounded dishes, especially in terms of paste and slip technology, with no apparent difference in the level of technical consistency exhibited among the polychrome vessels. Just as these vessels are conformal, they are most often virtually indistinguishable petrographically. In addition, the SEM results suggest similar firing regimes, except that the polychrome dishes appear to have been fired at slightly higher temperatures, as indicated by their different body microstructures. The implication is that these vessels, regardless of the colour of their slips or the presence/absence of painted decoration, share important technological similarities reflective of commonalities in manufacturing procedures. In addition, there is no evidence to suggest that the locally-manufactured polychrome vessels are more 'standardized' technologically than their bichrome and monochrome counterparts.

Comparison of the two distinct local approaches to coarse ware production has also revealed a more complex pattern than the conventional characterizations imply. For example, the different styles of storage jars produced within the calcite-tempered tradition tend to exhibit a high level of morphological consistency and a uniform paste technology, reflecting a degree of technical standardization that stands in direct contrast to contemporaneous sandy-pasted jars. These jars exhibit greater variation with regard to their morphology and the petrographic characteristics of their fabrics, indicating an inconsistency in specific technical practices. These different patterns may relate, in part, to differences in organizational aspects of production, suggesting that it cannot merely be assumed that pottery corresponding to the same functional class was produced through similar means and methods. The implication is that there is some evidence that there may have been greater variation in organizational aspects of production on the community level than has been traditionally recognized and, consequently, that the proposed two-tiered system revolving around elite-sponsored workshops and part-time rural producers may be an over-simplistic characterization.

A related issue concerns the absence of slip on calcite-tempered coarse ware jars by Early Postclassic times, which might be considered to reflect a trend towards simplification of the surface treatment of utilitarian vessels. Such changes are often viewed as cost-saving measures related to a shift towards the mass production of ceramics in workshops (e.g. Masson and Rosenswig n.d.). A concomitant trajectory towards increased homogeneity in other aspects of vessel technology is assumed, considered as a natural by-product of potters working closely together in a workshop environment. Interestingly, at Lamanai, this change in the surface finishing techniques used in the production of coarse ware jars does not appear to have been accompanied by an increased homogeneity or standardization of other aspects of vessel technology. The different styles of calcite-tempered jars typical of the Early Postclassic period exhibit a similar level of morphological standardization as the earlier calcite-tempered jars with slipped rims. In addition, they are made to the same high standard, in terms of the time invested in achieving a uniform, high quality surface finish. Nonetheless, the results of the petrographic analysis indicate that the later jar styles exhibit greater compositional variability, in terms of the textural properties and aplastic inclusion content of their pastes. At least some of this variation appears to be chronological, but later jars still exhibit a more variable paste technology. Accordingly, there is no evidence that the change in the surface treatment of calcite-tempered coarse ware jars is somehow linked to a broader change in production methods. Rather, it would seem to relate, at least in part, to demand, reflecting changing ceramic tastes and preferences.

The loss of diversity in surface treatment among fine ware pottery by the Early Postclassic period has also been conventionally interpreted as reflecting a standardization and simplification of vessel styles, which is most often taken to imply technological standardization. Standardized production methods are generally assumed, which is perceived as symptomatic of the inception of mass-production. Analysis of Early Postclassic pottery from Lamanai, however, has revealed, that stylistic and technological similarities are perhaps more superficial than has been recognized previously, as this pottery is characterized by a high level of internal technological and stylistic heterogeneity. In addition, a simplification of elements of design associated with vessel morphology and decorative embellishment is not demonstrated. It could be argued that the stylistic and technological variation within the Lamanai assemblage is just as prevalent in the later part of the ceramic sequence as it is earlier on. In fact the high level of internal variability that characterizes Early Postclassic pottery stands in direct contrast to the high level of consistency exhibited by earlier approaches to fine ware manufacture. Accordingly, whilst it is apparent that stylistic and raw material characteristics of locally produced fine ware become more uniform by the Early Postclassic period, a shift towards technical standardization, that could be taken as indicative of mass-production, is not demonstrated.

11.3. CONTINUITY AND CHANGE IN CONSUMPTION PATTERNS

11.3.1. The Consumption of Pottery in Community-Based Ceremonial and Ritual Activities

The stylistic characteristics, functional associations and provenances of pottery provide important evidence of similarities and differences between the patterns of consumption reflected in ceramic deposits that arise out of different kinds of human activity. This information is fundamental to our understanding of the kinds of activities that took place in different physical and social settings, as well as to the identification and delineation of cultural practices and conventions.

A prominent characteristic of the different types of ceremonial and ritual deposits analysed in this study is the striking overlap in the kinds of pottery they contain. For example, the ceramic components of the midden deposits associated with structures N10-27 and N10-9 are similar in terms of the proportions of fine ware and coarse ware vessels, as well as the range of functional classes of pottery. From this we might surmise a general similarity in the patterns of human activity behind these deposits and, perhaps, the kinds of activities that took place at these different ceremonial structures. Since the midden deposits encompass a sequence of human activity that spans the Terminal Classic to Early Postclassic period, they are also indicative of the longevity of such behaviour. It is also evident that the fine ware pottery used and deposited as part of activities and events that took place at the ceremonial structures was also used in mortuary and offertory ceremonies. The fact that these latter types of ceremonies did not involve different or special kinds of pottery, suggests a basic congruency in the objects used in these different contexts and, perhaps, in certain aspects of ritual practice. Burials and offerings, however, rarely contain coarse ware pottery, particularly large storage jars, whereas these vessels are abundant in the midden assemblages. The presence and abundance of storage jars and other utilitarian pottery in the temple middens, points to an important difference in the nature of the activities that lead to the accumulation of these deposits, perhaps relating to the scale or functional aspects of associated activities and events. This general pattern of similarities and differences in the kinds of ceramics used in different religious and ceremonial contexts continues into the Early Postclassic period, despite the dramatic changes in vessel styles, indicating continuity in certain aspects of local customs or perceptions relating to the kinds of pottery deemed appropriate or required for different ceremonial and ritual events.

The provenance of the pottery comprising the burial, offertory and temple midden assemblages provides insight into the social and economic networks that underlie its use in associated ceremonies and events. The petrographic data indicate that throughout the Terminal Classic and Early Postclassic periods the large majority of the pottery used and deposited as part of these activities continued to be supplied by local producers. In addition, there is no evidence that consumption of non-local or 'imported'[15] pottery substantially increased by Early Postclassic times, as predicted by conventional explanatory models of the development of the lowland ceramic economy during the Classic to Postclassic transition. The petrographic data also indicate that, by the Early Postclassic period, non-local pottery came from a more restricted geographical region of the lowland area than previously. In the early part of the Terminal Classic period, non-local pottery derives from multiple points of origin within several different areas of the lowland region, including northern Belize and adjacent areas of the Yucatan Peninsula of Mexico. By Early Postclassic times, however, non-local ceramics appear to have originated exclusively from localities within this particular geographic area. Also significant is that, throughout the time period, drinking vessels and jars remained the primary types of non-local pottery brought to the site and subsequently used in different ceremonial and ritual activities and events. These ceramics include a number of different styles of service ware and utilitarian jars, which, in most cases, are visually distinct from the locally-manufactured functional equivalents. However, the relative frequencies of non-local fine ware and coarse ware pottery in different stratigraphic contexts within the temple middens provide some evidence that the amount of non-local fine ware, and particularly drinking vessels, used in local ceremonial and ritual events decreased significantly by Early Postclassic times. In contrast, the amount of non-local storage jars brought to the site and deposited as part of these activities appears to have increased over time.

Consideration of the specific archaeological contexts within which non-local pottery occurs yields additional insight into the consumption patterns associated with different kinds of ceramic deposits. Table 11.3 gives a breakdown of the occurrence of local and

[15] I am hesitant to use the term 'imported' as it implies a specific kind of economic behaviour that I am unconvinced can be assumed as primarily responsible for the occurrence of non-local pottery within these depositional contexts. In Mays archaeology, this term is often taken to imply that the movement of pottery from different manufacturing loci to Lamanai is rooted in market-based exchange and there is no evidence to suggest that other distributive mechanisms, such as gift-giving, tribute, or simply pottery being brought to the site with its owners, are not involved, given the archaeological contexts of the material.

non-local ceramics in the different types of ritual/ceremonial deposits according to the type of architectural structures from which individual deposits were recovered. As can be observed, whilst the large majority of pottery deposited as part of different kinds of ceremonial and ritual activity was of local manufacture, non-local pottery also occurs in each of the different kinds of ceramic deposits. The temple middens contain the largest amount of non-local pottery, and it is also evident that the proportion of non-local ceramics is greater in the temple middens than in any of the other deposit types. With regard to burials and offerings, it can be observed that non-local ceramics tend to occur in burials associated with residential structures, whereas offerings containing non-local ceramics tend to be associated with public architecture, including elite residential and administrative complexes. This apparent difference in the kinds of structures with which burials and offerings containing non-local ceramics are associated may relate to a variety of social and ideological factors. But considering the nature of depositional contexts concerned, the association of these 'exotic' items with particular kinds of architecture might be considered to reflect material expressions of wealth, prestige and identity within the context of different kinds of religious and ceremonial events.

11.3.2. Changes in Modes of Consumption

Starting in the Terminal Classic period, the appearance of extensive midden deposits containing large amounts of pottery, perhaps purposefully broken prior to discard, in public areas of the central precinct, not only provides evidence of different depositional practices, but also changes in consumption patterns. It has been argued in previous chapters (Chapters 2, 6 and 7) that the contents of these middens, as well as their pattern of accumulation in relation to the history of maintenance of the ceremonial structures with which they are directly associated, suggests that these garbage dumps are the product of ongoing ritual and ceremonial activities, perhaps partly of a communal nature, that took place in these settings. The fact that at least some of the pottery used in these activities appears to have been purposefully broken during or at the conclusion of these events (as indicated by fragmentation patterns) is indicative of a particular mode of consumption that might not have been as prevalent in preceding time periods. The same observation can be made with regard to the appearance of smash-and-scatter offerings, and the shift towards the interment of purposely broken pottery in burials, albeit with greater certainty, since these practices represent clear departures from earlier patterns. When considering that the midden pottery constitutes ceramics permanently

Table 11.3: Frequencies of locally produced and imported vessels summarised by context.

	Archaeological Context	Provenance				
		Local	Local/ Non-local	Non-local	Non-local?	Total
Burials	ceremonial structure	13	0	0	0	13
	residential structure	26	0	9	1	36
	residential/admin. structure	20	0	0	0	20
	temple	2	0	0	0	2
	post-abandonment interment	2	0	0	0	2
	miscellaneous burial	1	0	0	0	1
	Total	**64**	**0**	**9**	**1**	**74**
Offerings	cache – ceremonial structure	1	0	0	0	1
	cache – residential structure	0	0	1	0	1
	cache – residential/admin. structure	11	0	0	0	11
	cache – temple	25	1	2	0	28
	general – ceremonial structure	0	0	1	0	1
	general – residential structure	4	0	1	0	5
	general – residential/admin. structure.	11	1	4	0	16
	general – temple	5	0	3	0	8
	Total	**57**	**2**	**12**	**0**	**71**
Temple Middens	N10-27	213	83	42	17	355
	N10-9	96	23	5	1	125
	Total	**309**	**106**	**47**	**18**	**480**
Refuse Deposits	residential structure	3	0	0	1	4
	residential/admin. structure	10	2	4	0	16
	miscellaneous refuse deposit	1	0	0	0	1
	Total	**14**	**2**	**4**	**1**	**21**
Grand Total		**444**	**110**	**72**	**20**	**646**

removed from use as part of possibly large scale ceremonial and ritual events, it seems likely that this different mode of consumption may have had a significant effect on demand as well as manufacturing priorities. The deliberate breakage of pottery as part of such activities could have accelerated demand for such pottery since new vessels would have been needed for subsequent events and occasions, leading to an increase in production (Arnold 1985:163). In addition, assuming that the timing of such events would have been known to members of the community, including potters, the demand for ceramics might have increased at certain times of the year, thereby stimulating increased production, or the production of particular kinds of pottery in anticipation of particular ceremonial occasions or festivities. Arnold (1985:160) describes a similar situation in conjunction with festivities associated with All Saints Day for contemporary communities in Yucatan, Mexico and Guatemala.

11.3.3. The Local Ceramic Repertoire and Shifts in Demand

Additional changes in consumption patterns are indicated by the appearance of new functional classes of pottery vessels in burial, offertory and midden deposits, as well as by the loss of stylistic diversity in the fine ware pottery occurring in these deposits by Early Postclassic times. The appearance of ceramic drums, whistles, and a range of new vessel forms that appear to have functioned, at least in part, as receptacles and implements for burning incense and other substances, is reflective of a new demand for particular kinds of ceramic items. This new demand relates directly to the use of musical instruments and incense-burning paraphernalia in ritual and ceremonial activities and hence, is suggestive of innovations or changes in ritual and ceremonial practices, which may have initially stimulated the production of these items. The disappearance of vases from burial, offering and temple midden assemblages provides further evidence of changes in demand and production associated with the use of particular drinking vessels in certain rites and ceremonial events. The loss of stylistic diversity in the repertoire of fine ware vessels used in ritual and ceremonial activities is indicative of a trend towards the consumption of pottery conforming to a particular and distinctive set of stylistic traits. Within the context of ceremonial and ritual activities ceramics act as vehicles for the expression of cultural values and ideological beliefs and ideas (Arnold 1985:158-159). Accordingly, changes over time in their stylistic characteristics, decorative embellishment and the nature of design elements and decorative treatments reflect changes in the manner in which this information is communicated and perhaps, the kinds of ideas being expressed. Viewed from this perspective, the preference for particular vessel shapes, as well as for pottery of a particular colour and with particular kinds of decorative embellishment, suggests a change in the ideological information conveyed by the pottery used in local religious and ceremonial events. It might also be considered to reflect an increased concern for consistency and order, at least in terms of the nature of the pottery used in these behavioural contexts.

11.4. FACTORS CONTRIBUTING TO CERAMIC CHANGE DURING THE TERMINAL CLASSIC TO EARLY POSTCLASSIC PERIOD

Maya scholars have identified four regional-level developments that contributed to the dramatic changes in the material and archaeological manifestations of Maya culture that occurred during the Terminal Classic to Early Postclassic period:

1. Military pressures caused by the predatory expansion of northern lowland City states, particularly Chichen Itza.
2. The disruption of networks of exchange, communication and political affiliation as a result of the decline and failure of elite culture and socio-political institutions in the Maya heartland and the emergence of a new system of trade and commerce as part of the expanding influence of northern lowland hegemonies such as Chichen Itza.
3. Population migrations stimulated by ongoing conflicts and instability in areas of the southern and northern lowlands.
4. Ideological shifts relating to the expansion of a regional religious cult, driven by elites, that emphasized militaristic proselytism.

The evidence from sites in northern Belize suggests that individual communities were affected differentially by these developments, such that the contributing role these factors played in shaping local-level trajectories, either individually or in combination, appear to have varied from site to site. As a result, individual community histories document different local experiences of internal and external pressures, degrees of prosperity, actions and reactions.

The extent to which these regional-level developments affected community life at Lamanai is particularly ambiguous. The archaeological evidence indicates that the community was a hive of activity during a time when nearby city centres such as Altun Ha and Colha were experiencing decline, abandonment and in the case of the latter, militaristic invasion. Construction activities dedicated to the improvement and expansion of the ceremonial precinct suggest a time of continued prosperity and socio-political stability. This general pattern of stability and continuity, however, stands in direct contrast to the often striking changes that occur with regard to other aspects of day-to-day life such as building procedures, offertory and burial practices, the use of public areas associated with large ceremonial structures and material culture, including the stylistic and technological characteristics of locally manufactured pottery. It is also clear that the link between these significant changes and certain regional-level developments is less than direct. For example, the structural remains and artifact inventories of the time offer no indication that Lamanai ever underwent a militaristic invasion, whether as part of the expansion of centres of power based in Northern Yucatan, a religious cult driven by the political ambitions of elites, or otherwise. In fact, there is no compelling evidence of a defensive community posturing starting in the Terminal Classic period, as a response to a perceived external threat, apart from the possibility that the new residential structures built in the vicinity of public areas of the central precinct represent local families that had moved to this area of the settlement for safety reasons. In addition, the large scale construction projects undertaken in the ceremonial precinct starting as early as the Late Classic period, together with the continued local production of material goods, such as pottery, and subsistence products (particularly maize), attest to the ongoing stability of the community's economic and socio-political infrastructure. Accordingly, it would appear that any disruptions in traditional networks of exchange and political affiliation did not have a particularly significant impact on local economic patterns. The question that emerges, therefore, is that if it can be demonstrated that certain external pressures appear to have played a limited role in the community's developmental trajectory (at least in some respects) then what factors did contribute to the changes in local conventions, in both material and behavioural sense, during this period? A closer examination of local patterns of ceramic production and consumption, in light of certain regional-level developments, provides some interesting insight into the kinds of factors involved, from a ceramic point of view.

11.4.1. Evidence of a Reorientation of Politico-Economic Relationships

Local ceramic economic patterns at sites in northern Belize are considered to have been altered significantly during the Terminal Classic to Early Postclassic period due to two developments on the regional level: 1) the loss of trading partners as a direct result of the economic decline of southern lowland polities situated in the heartland area and 2) the expansion of maritime networks of exchange driven by Chichen Itza (Masson and Mock 2004). The absence of ceramics deriving from areas of the southern lowlands to the south and west of Lamanai in later stratigraphic contexts within the Terminal Classic to Early Postclassic sequence offers some evidence that contact and interaction with sites situated in this geographic area broke down during the Terminal Classic period. Based on the paucity of ceramics deriving from this area in general, however, it would appear that the flow of southern lowland pottery into the local community (at least into the central precinct) was quite limited to begin with. Consequently, a disruption or cessation of economic relations with sites situated in and bordering the heartland area would have had little impact on the local ceramic economy. In comparison, the presence of ceramics deriving from areas to the north of Lamanai in both early and late stratigraphic contexts within the ceramic sequence indicates that economic contacts or interaction with sites situated in this particular area of the lowland region continued into the Early Postclassic period. Nonetheless, as with pottery that originated from areas to the south and west of Lamanai, the evidence suggests that the volume of ceramics coming into the community from sites in the north was quite small, with no evidence of a substantial increase by Early Postclassic times. When considering Lamanai's potential involvement in trade networks stimulated by the expansion of northern lowland hegemonies such as Chichen Itza, the ceramic evidence has two major implications. Firstly, whatever contacts and interaction the community had with areas to the north were firmly in place by the early part of the Terminal Classic period. Secondly, there is no indication that economic interaction with this area of the lowland region became more intensive by Early Postclassic times. Hence a reorientation of the local ceramic economy towards the north in conjunction with a growing participation of the local community in maritime trade networks, as has been suggested for other sites in northern Belize (e.g. Progresso Lagoon, Caye Coco and Saktunja) (Masson and Mock 2004), is not demonstrated based on the ceramic evidence. The rarity of trade wares such as Slate ware, Fine Orange ware and Plumbate ware at Lamanai, the occurrence of which is generally seen as direct evidence of participation in trade networks driven by interests based in the northern lowlands, lends additional support to this conclusion. In fact, the ceramic evidence might also be viewed as a sign that Lamanai's commercial connections to the north operated on a relatively limited scale. What seems to be fairly clear is that the emergence and expansion of these new trade networks had little effect on local patterns of ceramic consumption and, hence, demand, at the very least as concerned the central precinct and adjacent residential areas.

11.4.2. Evidence of the Presence of Immigrants

The population movements that would have been triggered by ongoing conflicts and the economic decline of polities and city centres situated to the north, south, east and west of Lamanai, begs the question of whether the community accepted refugees. The strongest ceramic evidence that suggests the presence of immigrants at the site is the sudden appearance of a new tradition of coarse ware manufacture during the Terminal Classic period. There are two factors that suggest that the emergence of this new tradition relates to the influx of immigrants into the local community. Firstly, this approach to coarse ware manufacture involves raw material resources that had not been exploited previously by local potters, but similar clays were apparently used for coarse ware manufacture in other areas of northern Belize, particularly in inland areas adjacent to the Caribbean coast (as indicated by petrographic analysis). Secondly, the location of these clays in inland areas on the opposite side of the New River Lagoon, poses certain logistical challenges to their use. The successful manufacture of pottery using these new clays would have required knowledge of their behaviour at different stages of the manufacturing process, as well as how their natural properties could be altered and manipulated to best advantage. It is entirely possible that potters already working in the vicinity of Lamanai could have acquired this knowledge through experimentation. However, they would have had to have expended a considerable amount of time and effort to exploit these sources, when clays that they were already familiar with were abundant in the immediate vicinity of the settlement. It seems more likely, therefore, that the potters who used these particular clays chose them based on prior knowledge and experience with similar raw materials. Since these clays only occur in areas of Pine Ridge savannah, it would have been readily apparent where they occurred in the local area. It is well documented ethnographically that potters moving into a new area tend to seek out clay resources similar to those with which they are most familiar (e.g. Day 2004). Given the possibility that during the Terminal Classic period potentially large groups of people, which undoubtedly included potters, were in search of stable surroundings in which to re-establish themselves, the emergence of a significantly different way of producing utilitarian pottery at Lamanai might reflect this type of behaviour. This change in local patterns of pottery production, therefore, may reflect the influx of immigrants who brought with them a substantially different way of making coarse ware pottery.

11.4.3. Changes in Religious and Ceremonial Practice

The different ceramic depositional patterns that arise during the Terminal Classic period provide compelling evidence of a significant change in religious and ceremonial practices, particularly as concerned the appropriate treatment and function of the pottery used within different contexts of ritual and ceremonial activity. The rarity of the various trade wares postulated as material markers of participation in a regional cult driven by a network of elites dedicated to the proliferation of a new, formalized system of beliefs, practices, imagery and religious paraphernalia, suggests that these changes cannot be simply put down to a strong influence that came from outside of the local community. Rather, there are many aspects of the material record that suggest that this is a local phenomenon. For instance, the general focus of construction activities centred in the central precinct, as well as the accompanying changes in the patterns of use of communally-built structures and public areas, appear to have been predicated on the establishment and maintenance of physical links between the past and present, as well as the affirmation of traditional religious beliefs. The placement of new ceremonial structures and facilities, including a ball court, literally in the shadows of buildings that were major sites of ceremonial activity in the Classic period and earlier, would have generated a strong visual and psychological sense of continuity in the built setting of religious and ceremonial events, despite changes in the actual physical surroundings and specific aspects of ritual practice. Likewise, the interment of numerous burials within newly built ceremonial and administrative structures might be considered to reflect a particularly public form of ancestor veneration that, apparently, was not as prevalent in preceding time periods (c.f. McAnany 1995). Occupying a prominent place within the built environment, these interments are strong public expressions of the bonds between past and present members of the community, as well as the active role of the ancestors in perpetuating prosperity among their living descendants (Marcus 2000). The active creation and maintenance of such links through the built settings in which ceremonial and ritual activities took place can be viewed as a material manifestation of Lamanai's individual community history, fostering a sense of community identity deriving from shared experiences (past and present) and a common social memory (Joyce and Hendon 2000).

As the physical remains of the events and occasions through which shared experiences were created, ceramic depositional patterns provide additional insight into the motivations and concerns that lay behind certain changes in ritual practice. Viewed from this perspective the deliberate breakage of pottery used in religious and ceremonial events might be interpreted as acts of 'enchainment' – i.e. a means of creating and maintaining an active bond between people, places and a shared experience predicated on material culture (Chapman 2000:226). There is good evidence to suggest that within the contexts of burial and offertory ceremonies participants in these events retained or removed fragments of the pottery deliberately broken as part of associated rites. This practice might be viewed as a practical attempt to permanently rid the objects involved in religious acts of any potentially harmful powers they possess when complete. However, an integrating function would appear to be more in keeping with the considerable effort expended in establishing physical expressions of the important link between activities and people of the past and present through the manipulation of public architecture. Following Chapman's argument for the centrality of such acts in the creation and maintenance of a shared sense of community identity and history, the sudden appearance of large midden deposits dominated by deliberately broken pottery on the physical boundary between ceremonial structures and public plazas capable of accommodating large assemblies of people, might be viewed as another instance of enchainment. In this case, however, bonds are created through the intentional deposition of the remains of activities in which the wider community participated (either directly or indirectly) at strategic, highly visible locations. As permanent fixtures within public areas of the settlement set aside for ceremonial and ritual activity, these deposits would have served as a constant visual reminder of the shared experience of participating in religious and ceremonial events or, alternatively, of active efforts undertaken to protect or ensure the interests and wellbeing of the community.

Changes in local patterns in the production of the fine ware pottery used in ritual and ceremonial activities also suggest changes in practice, which might be considered to reflect a new emphasis or increased concern relating to the creation and active maintenance of a shared community identity. If manufacturing procedures can be regarded as material expressions of group identity, then changes in local patterns of fine ware production would appear to suggest a shift towards a community focus. The replacement of multiple distinct local approaches to fine ware production by a single, more generalized approach characterized by high internal variability is suggestive of a subsuming of individual expressions of group identity in favour of a shared community-level identity. From the standpoint of vessel design, the development of a more generalized approach to pottery production by Early Postclassic times would appear to reflect the emergence of a shared set of ideas not only with regard to what fine ware pottery ideally should look like, in terms of its colour and basic morphological and decorative characteristics, but also what their fabrics should contain. The inclusion of grog temper in all fine ware pottery produced locally by the Early Postclassic period might be considered to reflect new ideas concerning a vessel's 'substance'. Whilst the use of grog has several material advantages (e.g. if made from the same clay as the ceramic body it has the same thermal expansion rate, which has benefits during firing) (Rice 1987c:407; Arnold 1985: 24; Rye 1976: 114-115), it is also recognized as an important social practice. Chapman (2000: 54) describes the use of grog as a means of "presencing the past through the incorporation of old or ancestral material culture into currently used ceramics" (see also Rainbird 1999). The inclusion of grog, therefore, acts as another form of enchainment. The fact that grog does not replace other forms of temper, but instead, was added alongside tempering materials that have a long history of use at the site, provides some evidence that the choice to include grog may reflect ideological, as opposed to purely practical considerations. Observations made by early Spanish explorers that visited the Maya area lend some support to this interpretation. For example, Chuchiak (2004) reports that Captain Ruiz de Arce observed that Maya potters incorporated crushed fragments of censers deliberately broken as part of ancestor veneration rituals into the new censers they made for subsequent ceremonies. Chuchiak also reports that Captain Ruiz de Arce observed that potters did this because they believed that the new censers would not function properly in these rituals if they did not contain pieces of vessels used in previous rituals. Whilst it can not be demonstrated that this actual practice has roots in the Terminal Classic period, the fact that grog tempered fine ware becomes prevalent during the same time period that the deliberate breakage of pottery included in offerings and burials become the standard practice suggests a strong connection between this technological innovation and this change in ritual practice.

A final issue concerns the inception of new ideas surrounding the decorative treatment of fine ware vessels used in religious and ceremonial events, particularly those that took place at ceremonial structures. The shift towards the manufacture of orange-slipped fine ware with elaborate decorative embellishments marks the movement of decorative imagery from the interior surface of the vessel to the exterior surface. When decorative images are placed on the inside of a vessel they can only be fully appreciated by those who handle the vessel directly, whereas decoration placed on a vessel's exterior can be seen and appreciated by a wider audience. Accordingly, this change in the placement and nature of decorative images may reflect an important change in the nature of audience that was meant to see these images when the vessels were used in particular social and/or ritual contexts. The high visibility of the ideological information conveyed on these vessels, together with the formalized nature of decorative elements and their content, may suggest that an underlying intention (conscious or subconscious) was to enable a wider segment of the population to share and participate in the beliefs and ideas communicated through the use of pottery in particular events and activities, as well as the messages it communicated, both literally and symbolically. The introduction of ceramic instruments and a range of incense burning paraphernalia into these same contexts of religious and ceremonial activity might also be considered to suggest a new emphasis on large communal gatherings, reflecting an elaboration of ritual performance aimed at enhancing the personal and sensory experience of a wider audience of participants and observers.

11.5. Intra-Community Dynamics Contributing to Continuity and Change in the Local Material Record

When the ceramic evidence is situated within a broader framework and community-based activities and regional-level developments and potential pressures, there are two main factors that can be identified as contributing to changes in local patterns of production and consumption at Lamanai: 1) the movement of immigrants into the local area and 2) an intra-community dynamic relating to an ideological shift on the local-level. Changes in patterns of local pottery production and the use and depositional patterns of ceramics within contexts of ritual and ceremonial activity suggest an increased emphasis on creating and establishing bonds between the past and present, as well as between places, people and their shared experiences and social linkages. Material-human interactions, particularly with regard to ceramics, formed an important conduit through which these ideas and concern were expressed. It would appear that at the root of these community patterns lay a new concern for fostering and maintaining a shared community identity, history and social memory, which was enacted through both repeated practices and the manipulation of material culture and the built environment. The ceramic evidence suggests that pottery constituted an important medium through which these ideas were conveyed and perpetuated, and that large, public gatherings were perhaps a means through which they were communicated.

Chapman (2000) and others (e.g. McAnany 1995, 1998; Brumfiel and Fox 1994) have observed that these kinds of emphases or strategies often come into view archaeologically at times of crisis and socio-political change. The function or intention of these acts and endeavours is to foster community integration and solidarity, constituting a symbolic breaking down of social differences (real or perceived) in favour of a common and shared identity. In state-level societies, such strategies are often employed by the ruling class or competing factions to legitimate, maintain and expand claims to authority, power, privilege and influence (c.f. Pohl and Pohl 1994). At Lamanai, however, the evidence suggests that the new emphasis on enchainment and community integration relates to other factors, which are at least partly tied to changes in the local population. For example, there is no compelling evidence that these efforts and concerns were motivated specifically by elite interests, as indicated by the striking pattern of socio-political and economic stability over the course of the Terminal Classic to Early Postclassic period. On the other hand, the ceramic data provides evidence of immigrants moving into the local area, as well as ongoing contacts with, if not the physical presence of, people/groups from other areas, as suggested by the occurrence of non-local pottery, particularly storage jars within the temple middens. The presence of outsiders, at least some of whom were new residents, suggests that the situations of crisis, instability, economic decline etc. faced by other communities would have been well known to the people living under comparatively stable and prosperous conditions at Lamanai. One way of responding to any perceived threat to the local community would have been to ensure a continuing mutual support of the gods, the ancestors and other members of the community (new and old) through ritual performance and through acts and endeavours directed at solidarity and enchainment. Set within this broader frame of reference, therefore, local shifts in ideology, ritual practice and the nature of associated material culture might be seen as a practical local response to changing community dynamics and shifting world conditions.

CHAPTER 12

CONCLUSIONS AND FUTURE RESEARCH

12.1. A SUMMARY OF RESEARCH AND MAIN CONCLUSIONS

This study has assessed the nature and interrelationships of physical, technological and functional variation among Terminal to Early Postclassic ceramics at the site of Lamanai, as well as their depositional patterns within contexts of ceremonial and ritual activity. It has examined the technological and provenance characteristics of different stylistic and functional categories of pottery comprising the Terminal Classic to Early Postclassic ceramic assemblage and has documented temporal trends in the stylistic and technological characteristics of locally manufactured and non-local pottery. This detailed examination of the physical evidence has been situated alongside a contextual analysis, on both the local and regional levels, of the wider cultural and environmental setting within which Terminal Classic to Early Postclassic pottery was made, circulated, used, and finally, deposited as part of religious and ceremonial activities and events that took place within the community at Lamanai. This contextualization of the material evidence within a wider framework of material-human interactions has enabled a comprehensive reconstruction of community-level patterns of ceramic production and consumption that is mindful of the synergistic relationship between creative processes, as learned practices, the material and social necessities of society and practical and environmental considerations and constraints. Integrating the physical, archaeological, environmental and cultural evidence has enabled a consideration of the material, economic and symbolic representational aspects of emergent patterns and variation in the local material record.

This study has demonstrated the high level of insight and interpretative resolution that can be achieved when multiple analytical techniques and independent lines of evidence are combined within a single research programme brought to bear on a specific archaeological problem. The results of the study have revealed that ceramic economic patterns at Lamanai during the Classic to Postclassic tradition depart significantly from conventional characterizations. Moreover, the material evidence has brought to light a significantly different picture of the nature of and factors contributing to ceramic change than is accounted for in current explanatory models.

The specific findings of different aspects of this study have been reported at the conclusion of each chapter. The following presents a summary of particular points of interest.

12.1.1. Pot-making within the Local Environment

The results of the geological survey of raw material resources available in the local area has revealed that significant compositional variation exists among local clays, as well as the existence of different forms of calcite and limestone. Clays formed in different geological and environmental contexts within the local area can be discriminated both petrographically and chemically and, therefore, provide a basis for differentiating ceramic fabrics based on their raw material ingredients. A thorough review of the geological literature concerning northern Belize and adjacent areas, viewed in concert with the results of the local geological survey and the thin-section analysis of the pottery, has demonstrated the potential for ceramics made using different raw materials to be discriminated, and their provenances, either identified or approximated through thin section analysis.

Considered in light of the information generated by the local geological survey, the results of the petrographic analysis demonstrate that ancient potters chose specific raw materials for pottery manufacture, indicating that they had considerable knowledge of environmental resources. It is also evident that they possessed in depth knowledge of the physical properties of local clays and how they could be manipulated and used successfully in combination with tempering materials, despite their more problematic natural properties.

12.1.2. Stylistic Trends within the Terminal Classic to Early Postclassic Ceramic Sequence

- Among the fine ware, there is a general loss of diversity in surface treatment. The early part of the sequence comprises multiple surface treatment groups, characterized by different slip colours and decorative techniques. By Early Postclassic times, however, all pottery is orange-slipped with primarily incised and hand-modelled decorative embellishments.
- There is a general increase in the morphological complexity of fine ware pottery. By Early Postclassic time vessel forms often display a complex body

geometry, further elaborated through the addition of appliqués, supports, appendages and flanges.

- New vessel forms are introduced into to the local ceramic repertoire (both fine ware and coarse ware) during the Terminal Classic period.

12.1.3. Paste Technology and Provenance

- The majority of vessels comprising the assemblage are of local manufacture.
- Four different local traditions of paste-making were identified: Crystalline Calcite-Tempered, Sandy-Sascab Tempered, Grog-Mixed Carbonate and Quartz-Sand, and the Crystalline Calcite-tempered tradition contains at least four slightly different approaches to paste preparation based on different raw material ingredients.
- Early pastes contain rock temper, whereas by Early Postclassic times they contain both rock temper and grog. Later pastes are also comparatively fine-textured, suggesting a more careful or rigorous processing of raw material ingredients by this time.
- Locally-manufactured and non-local pottery can be discriminated petrographically and, in some cases, chemically. The results of the study show, however, that the relationship between mineralogical, geochemical and stylistic variation within the assemblage is very complex.
- Only a small proportion of the ceramic comprising the assemblage analysed was found to be of non-local origin. During the early part of the sequence non-local pottery can be connected geologically to several different areas of the lowland region, including the Maya Mountains area, inland areas of northern Belize, extending into southern Yucatan, coastal areas to the north of the site and, possibly, Central Peten. By early Postclassic times non-local ceramics derive exclusively from areas to the north of the site, extending into southern Yucatan.
- Chemical variability within the local ceramic assemblage can be attributed to both provenance and technology. Discrimination of these two factors in the interpretation of the chemical data set would have been difficult, if not impossible, without a detailed knowledge of the geological and technological characteristics of the pottery, especially as concerns mineralogically similar fabrics.

12.1.4. Decorative and Firing Technology

- There is a general shift in the technology of decoration of fine ware pottery away from painting and the manipulation of slips to achieve desired colouring effects and towards a technology centred on the use of one colour and decorative embellishments achieved through post-slip-pre-firing incision and the addition of hand-modelled appliqués and appendages.
- All of the pottery analysed by SEM share two technological characteristics: 1) similar clays were used to make the ceramic body and the slip and 2) maximum firing temperatures rarely exceeded 850°C.
- Differences in decorative technology and firing methods tend to correlate with differences in composition, but often not with stylistic differences.

12.1.5. Shifts in Local Patterns of Ceramic Production and Consumption

- Multiple local approaches to pottery manufacture characterized by a high level of internal consistency give way to a more general approach that is characterized by a specific set of general stylistic and compositional traits, but also a high level of technological inconsistency.
- The Terminal Classic period marks the appearance of large midden deposits containing deliberately broken pottery in the immediate vicinity of ceremonial structures, indicating a significant change relating to modes of pottery consumption. This pattern of behaviour might have had a significant effect on demand and manufacturing priorities at certain times of the year.
- A shift towards the inclusion of deliberately broken pottery in burials and offerings as opposed to whole vessels, indicating changes in ritual practice.
- The emergence of new vessel forms during the Terminal Classic period and the predominance of fine ware pottery displaying a particular set of stylistic and, possibly, compositional characteristics by Early Postclassic times point to a significant shift in patterns of production and demand.
- There is a basic congruence in the fine ware pottery used in different kinds of religious and ceremonial activities and events.
- Nearly all of the non-local vessels used in local ceremonial and ritual activities are drinking vessels and storage jars.

- The results of the study reveal a significantly different picture of local ceramic economic activities and the factors influencing ceramic change during the Terminal Classic to Postclassic transition than current models maintain.
- There are two primary factors that appear to have contributed to shaping local patterns of ceramic production and consumption: firstly, the movement of immigrants into the local area and, secondly, a shift in local ideology reflecting a new emphasis on enchainment and community solidarity and integration.

12.2. FUTURE RESEARCH

The results of this study demonstrate the detailed information that potentially could be brought to light through similar studies of site assemblages, context-specific or otherwise, for all periods of Maya cultural development. Ceramic studies that incorporate an assessment of vessel technology using scientific techniques are slowly increasing in prevalence, and as the findings of the present study have indicated, there is still much to learn about myriad aspects of Maya ceramic technologies and manufacturing techniques. The level of insight that can be gained through such studies, however, would be enhanced greatly by a contextual approach to analysis and interpretation of the physical evidence. As this information base builds, a greater understanding of the spatial and temporal dimensions of ceramic variation at successively higher scales of analysis will be achieved, providing a powerful tool for investigating a range of issues concerning economic and social interactions among the lowland Maya, as well as the nature and technical logic of their material culture. Specific areas of research that arise directly out of the present study are as follows:

Concerning Local and Regional Patterns of Ceramic Production and Consumption

- Detailed studies aimed at the reconstruction of local patterns of ceramic production and consumption during the preceding Classic period at Lamanai, as well as time periods following the Early Postclassic, focussing on similar cultural contexts.
- A similarly detailed study of Terminal Classic to Early Postclassic ceramic deposits associated with elite and commoner domestic contexts at Lamanai.
- Regional-level studies focussing on the provenance and technology of specific styles (*types*) of Terminal Classic to Early Postclassic pottery. Based on the results of the current study, particularly significant insights could emerge

through studies focussing on Early Postclassic orange-slipped and incised pottery and coarse ware pottery (sandy-pasted and calcite-tempered). These studies should be undertaken in concert with a survey of the raw material resources, especially clays, available in the vicinity of the sites included in the study.

Specific Analytical and Experimental Research

- The results of this study suggest that local paste preparation techniques used in fine ware production were highly complex, possibly involving refinement of natural clays and, in some cases, the addition of multiple tempering materials. Our current understanding of these procedures and how they relate to the appearance of ceramic fabrics under the microscope, as well as their chemistry, would be advanced substantially by experimental studies on local raw materials aimed at the reconstruction of the specific techniques involved in the manufacture of different types of local fabrics. The results of such studies would be of great value as they have a direct bearing on our ability to interpret petrographic and chemical data sets.
- Decorative techniques and firing methods are two aspects of Maya ceramic technology that have been seldom investigated in detail using scientific techniques. SEM analysis of only a small sample of the Terminal Classic to Postclassic pottery at Lamanai has revealed that considerable variation exists in surface finishing techniques, paint and slip compositions and body microstructures, among both locally produced and non-local ceramics. In addition, our understanding of certain surface treatments, such as those involving a resist technique, would benefit greatly from more intensive and detailed examination by SEM.

BIBLIOGRAPHY

Adams, Richard E.W.

1971 *The Ceramics of Altar de Sacrificos, Guatemala*. Papers of the Peabody Museum of Archaeology and Ethnology Vol. 63, No. 1, Harvard University, Cambridge M.A.

1973a The Collapse of Maya Civilization: A Review of Previous Theories. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 21–34. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

1973b Maya Collapse: Transformation and Termination of the Ceramic Sequence at Altar de Sacrificios. In: *The Classic Maya Collapse*, edited by T Patrick Culbert, pp. 133–164. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Adams, R.E.W., H.R. Robichaeux, Fred Valdez Jr., Brett A. Houk, and Ruth Matthews

2004 Transformations, Periodicity and Urban Development in the Three Rivers Region. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation*, edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 324–341. University Press of Colorado, Boulder, Colorado.

Adams, Richard E.W. and Fred Valdez Jr.

1980 The Ceramic Sequence of Colha, Belize: 1979 and 1980 Seasons. In *The Colha Project: Second Season, 1980 Interim Report*, edited by Thomas R. Hester, Jack D. Eaton and Harry J. Shafer, pp. 15-40. Center for Archaeological Research, The University of Texas at San Antonio, San Antonio, Texas.

Aloupi, E. and Y. Maniatis

1990 Investigation of the Technology and Manufacture of Local LBA Theran Pottery: The Body and Pigment Analysis. In *Thera and the Aegean World III: Papers Presented at the Third International Scientific Congress, Santorini, Greece, 3–9 September 1989*, edited by D. A. Hardy, C. G. Doumas, J. A. Sakellarakis and P. M. Warren, pp. 459–469. Thera Foundation, London.

Andres, Christopher R. and Anne K. Pyburn

2004 Out of Sight: The Postclassic and Early Colonial Periods at Chau Hiix, Belize. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation*, edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 402–421. University Press of Colorado, Boulder, Colorado.

Andrews, E. and V. Wyllys

1973 The Development of Maya Civilization After Abandonment of the Southern Cities. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 243–268. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Andrews, E., V. Wyllys and Jeremy A. Sabloff

1986 Classic to Postclassic: A Summary Discussion. In: *Late Lowland Maya Civilization: Classic to Postclassic*, edited by Jeremy A Sabloff, V. Wyllys and E. Andrews, pp. 433–456. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Angelini, Mary L.
1998 The Potter's Craft: A Study of Formative Maya Ceramic Technology at K'Axob Belize. Unpublished Ph.D. dissertation, Graduate School of Arts and Sciences, Boston University, Boston.

Arnold, Dean E.
1971 Ethnominerology of Ticul, Yucatan Potters: Etics and Emics. *American Antiquity* 36(1):20–40.

1978 Ethnography of Pottery Making in the Valley of Guatemala. In *The Ceramics of Kaminaljuyu, Guatemala,* edited by Ronald K. Wetherington, pp.327–400. Monograph Series on Kaminaljuyu. The Pennsylvania State University Press, Pennsylvania.

1985 *Ceramic Theory and Cultural Process.* Cambridge University Press, Cambridge.

1987 Maya Pottery After 20 Years: Archaeological Implications. In *Maya Ceramics: Papers from the 1985 Maya Ceramics Conference, Part ii,* edited by Prudence M. Rice and Robert Sharer, pp. 545–561. BAR International Series 345(i). British Archaeological Reports, Oxford.

Arnold, D. E., H. Neff and R. L. Bishop
1991 Compositional Analysis and "Sources" of Pottery: An Ethnoarchaeological Approach. *American Anthropologist* 93:70–90.

Arnold, Dean E., Hector A. Neff, Ronald L. Bishop and Michael D. Glascock
1999 Testing Interpretative Assumptions of Neutron Activation Analysis: Contemporary Pottery in Yucatan, 1964–1994. In *Material Meanings: Critical Approaches to the Interpretation of Material Culture,* edited by Elizabeth S. Chilton, pp. 61–84. The University of Utah Press, Salt Lake City.

Arnold, Dean E. and Alvaro L. Nieves
1992 Factors Affecting Ceramic Standardization. In *Ceramic Production and Distribution: An Integrated Approach,* edited by George J. Bey III and Christopher A. Pool, pp. 93–114. Westview Press, Boulder CO.

Ball, Joseph W.
1983 Notes on the Distribution of Established Ceramic Types in the Corozal District, Belize. In *Archaeological Excavations in Northern Belize, Central America,* edited by Raymond V. Sidrys, pp.203–220. Monograph XVII. University of California, Los Angeles.

1993 Pottery, Potters, Palaces, and Polities: Some Socioeconomic and Political Implications of Late Maya Ceramic Industries. In *Lowland Maya Civilization in the 8th Century,* edited by Jeremy A. Sabloff and J. F. Henderson, pp.243–272. Dumbarton Oaks, Washington DC.

Bartlett, Mary Lee and Patricia A. McAnany
2000 Crafting Communities: The Materialization of Formative Maya Identities. In *The Archaeology of Communities: A New World Perspective,* edited by Marcello A. Canuto and Jason Yaeger, pp. 102–122. Routledge, London and New York.

Bartlett, M.L., Hector A. Neff and Patricia A. McAnany
2000 Differentiation of Clay Resources on a Limestone Plain: The Analysis of Clay Utilization During the Maya Formative at K'axob, Belize. *Geoarchaeology* 15(2):95–133.

Bateson, J. H.

1972 New Interpretation of Geology of Maya Mountains, British Honduras. *American Association of Petroleum Geologists Bulletin* 55:956–963.

Bateson, J. H. and I. H. S. Hall

1971 Revised Geologic Nomenclature for Pre-Cretaceous Rocks of British Honduras. *American Association of Petroleum Geologists Bulletin* 55:529-530

Beaudry, Marilyn P.

1984 *Ceramic Production and Distribution in the South-Eastern Maya Periphery : Late Classic Painted Serving Vessels.* BAR International Series 203. British Archaeological Reports, Oxford.

1991 New World Paste Compositional Investigations. In *The Ceramic Legacy of Anna O. Shepard*, edited by Ronald L. Bishop and Frederick W. Lange, pp. 224–256. University Press of Colorado, Niwot, Colorado.

Beaudry-Corbett, Marilyn

2003 A Social History of Archaeological Materials Characterization Studies. In *Patterns and Process: A Festschrift in Honor of Dr. Edward V. Sayre*, edited by Lambertus van Zelst, pp. 19–26. Smithsonian Center for Materials Research and Education, Suitland, Maryland.

Becker, Marshall J.

2003 A Classic-Period Barrio Producing Fine Polychrome Ceramics at Tikal, Guatemala. Notes on Ancient Maya Firing Technology. *Ancient Mesoamerica* 14:95-112

Bishop, Ronald L.

1980 Aspects of Compositional Modeling. In *Models and Methods in Regional Exchange*, edited by Robert Fry, pp. 46–67. SAA Papers No. 1. Society for American Archaeology, Washington, D.C.

1991 Anna O. Shepard: A Correspondence Portrait. In *The Ceramic Legacy of Anna O. Shepard*, edited by Ronald L. Bishop and Frederick W. Lange, pp. 42–87. University Press of Colorado, Niwot, Colorado.

1992 Instrumentation and the Future of Archaeology. In *Quandaries and Quests: Visions of Archaeology's Future,* edited by LuAnn Wandsnider, pp.160–169. Center of Archaeological Investigations Occasional Paper No.20. Southern Illinois University at Carbondale, Carbondale.

1994 Pre-Columbian Pottery: Research in the Maya Region. In *Archaeometry of Pre-Columbian Sites and Artifacts*, edited by D.A. Scott and P. Meyers, pp. 15–65. The Getty Conservation Institute, Los Angeles.

2003 Five Decades of Maya Fine Orange Ceramic Investigation by INAA. In *Patterns and Process: A Festschrift in Honor of Dr. Edward V. Sayre*, edited by Lambertus van Zelst, pp. 81–92. Smithsonian Center for Materials Research and Education, Suitland, Maryland.

Bishop, Ronald L. and Robert L. Rands

1982 Maya Fine Paste Ceramics: A Compositional Perspective. In *Excavations at Seibal: Ceramics,* edited by Jeremy A. Sabloff, pp. 283–314. Memoirs of the Peabody Museum of Archaeology and Ethnology Vol. 15, No. 2, Harvard University, Cambridge M.A.

Bishop, R.L., V. Canouts, P.L. Crown and S.P. De Atley
1990 Sensitivity Precision and Accuracy: Their Roles in Ceramic Compositional Databases. *American Antiquity* 55:537–546.

Bishop, Ronald L., Robert L. Rands and George R. Holley
1982 Ceramic Compositional Analysis in Archaeological Perspective. In *Advances in Archaeological Method and Theory,* Vol. 5, edited by Michael B. Schiffer, pp. 275–330. Academic Press: New York and London.

Braswell, Geoffry E., Joel D. Gunn, Maria del Rosario, Dominguez Carrasco, William J. Folan, Laraine A. Fletcher, Abel Morales López, and Michael D. Glascock
2004 Defining the Terminal Classic at Calakmul, Campeche. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 162–194. University Press of Colorado, Boulder, Colorado.

Brumfiel, Elizabeth M. and John W. Fox
1994 Factional Competition and Polical Development in the New World. Cambridge University Press, Cambridge.

Bullard, William R. Jr.
1973 Postclassic Culture in Central Peten and Adjacent British Honduras. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 221–242. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Buxeda I Garrigos, J., M.A. Cau Ontiveros and V. Kilikoglou
2003a Chemical Variability in Clays and Pottery from a Traditional Cooking Pot Production Village: Testing Assumptions in Pereruela. *Archaeometry* 45(1):1–18.

Buxeda I Garrigos J., R.E. Jones, V. Kilikoglou, S.T. Levi, Y. Maniatis, J. Mitchell, L. Vagnetti, K.A. Wardle and S. Andreou
2003b Technology Transfer at the Periphery of the Mycenean World: The Cases of Mycenaean Pottery Found in Central Macedonia (Greece) and the Plain of Sybaris (Italy). *Archaeometry* 45(2):263–284.

Chapman, John
2000 *Fragmentation in Archaeology. People, Places and Broken Objects in the Prehistory of South Eastern Europe.* Routledge, London.

Carmean, Kelli, Nicholas Dunning and Jeff K. Kowalski
2004 High Times in the Hill Country: A Perspective from the Terminal Classic Puuc Region. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 424–449. University Press of Colorado, Boulder, Colorado.

Carpenter, Andrea J. and Gary M. Feinman
1999 The Effects of Behaviour on Ceramic Composition: Implications for the Definition of Production Locations. *Journal of Archaeological Science* 26:783–796.

Chase, Arlen F.
1986 Time Depth or Vacuum: The 11.3.0.0.0 Correlation and the Lowland Maya Postclassic. In: *Late Lowland Maya Civilization: Classic to Postclassic*, edited by Jeremy A. Sabloff, V. Wyllys and E. Andrews, pp. 99–140. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Chase, Arlen F. and Diane Z. Chase
2004 Terminal Classic Status-Linked Ceramics and the Maya "Collapse": De Facto Refuse at Caracol, Belize. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 642–366. University Press of Colorado, Boulder, Colorado.

Chase, Arlen F. and Prudence M. Rice (editors)
1985 *The Lowland Maya Postclassic.* University of Texas Press, Austin.

Chase, Diane Z.
1982 Spatial and Temporal Variability in Postclassic Northern Belize. Unpublished Ph.D. dissertation, Department of Anthropology, University of Pennsylvania, Philadelphia.

1985 Ganned But Not Forgotten: Late Postclassic Archaeology and Ritual at Santa Rita Corozal, Belize. In *The Lowland Maya Postclassic,* edited by Arlen F. Chase and Prudence M. Rice, pp.104–125. University of Texas Press, Austin.

1986 Social and Political Organization in the Land of Cacao and Honey: Correlating the Archaeology and Ethnohistory of the Postclassic Lowland Maya. In: *Late Lowland Maya Civilization: Classic to Postclassic,* edited by Jeremy A. Sabloff, V. Wyllys and E. Andrews, pp. 347–378. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

1988 Caches and Censerwares: Meaning from Maya Pottery. In *A Pot for All Reasons: Ceramic Ecology Revisited,* edited by Charles C. Kolb and Louana M. Lackey, pp.81–104. Papers Dedicated to Frederick R. Matson, 1986, A Special Publication of Ceramica de Cultura Maya et al., Muriel Kirkpatrick, general editor, Laboratory of Anthropology, Temple University, Philadelphia, PA.

Chase, Diane Z. and Arlen F. Chase
1982 Yucatec Influence in Terminal Classic Northern Belize. *American Antiquity* 47(3):596–613.

1988 *A Postclassic Perspective: Excavations at the Maya Site of Santa Rita, Corozal, Belize.* Monograph 4. The Pre-Columbian Art Research Institute, San Francisco..

Closs, Michael P.
1988 The Hieroglyphic Text of Stela 9, Lamanai, Belize. *Research Reports on Ancient Maya Writing* 21. Center for Maya Research, Washington, D. C.

Chuchiak, John F.
2004 De Descriptio Idolorum: An Enthnohistorical Examination of the Production, Imagery and Functions of Colonial Yucatec Maya Idols and Effigy Censers, 1540-1700. Paper presented at the 69th Annual Meeting of the Society for American Archaeology, Montreal.

Cobos Palma, Rafael
2004 Chichén Itzá: Settlement and Hegemony during the Terminal Classic Period. In *The Terminal Classic in the Maya Lowlands: Collapse, Transition, and Transformations,* edited by Arthur D. Demarest, Prudence M. Rice and Don S. Rice, pp.517–544. University Press of Colorado, Boulder, Colorado.

Coe, William R.
1965 Caches and Offertory Practices of the Maya Lowlands. In *Archaeology of Southern MesoAmerica Part 1,* edited by G. R. Willey, pp.462–468. Handbook of Middle American Indians, Vol. 2, Robert Wauchope, general editor, The University of Texas Press, Austin.

Cornec, J. H.
1985 *Note on the Provisional Geological Map of Belize at the Scale of 1:250,000.* Petroleum Office, Belmopan.

Cresswell, R.
1983 Transferts de techniques et chaînes opératoires. *Techniques et Culture* 2:145–164

Culbert, T. Patrick (editor)
1973a *The Classic Maya Collapse.* School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

1973b Introduction: A Prologue to Classic Maya Culture and the Problem of Its Collapse. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 3–20. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

1977 Maya Development and Collapse: An Economic Perspective. In: *Social Processes in Maya Prehistory: Essays in Honor of Sir J Eric Thompson*, edited by Norman Hammond, pp. 509–530. Academic Press, New York.

1988 The Collapse of Classic Maya Civilization. In: *The Collapse of Ancient States and Civilizations*, edited by Norman Yoffee and George L. Cowgill, pp. 69–101. University of Arizona Press, Tuscon.

Darch, Janice P.
1981 The Characteristics and Origins of Sascab in Northern Belize, Central America. In *Zeitschrift für Geomorphologie,* edited by Göttingen H. Mortensen, pp. 400–419. Neue Folge Band 25. Gebrüder Borntraeger, Berlin, Stuttgart.

Darch, Janice P. and P. A. Furley
1983 Observations on the Nature of Sascab and Associated Soils in Cayo and Orange Walk Districts, Belize and in El Peten, Guatemala. In *Resources and Development in Belize: An Account of the University of Edinburgh Expedition to Central America, 1981*, edited by G. M. Robinson and P. A. Furley, pp. 179–222. Department of Geography, University of Edinburgh, Edinburgh.

Day, Peter M.
1989 Technology and Ethnography in Petrographic Studies on Ceramics. In *Archaeometry: Proceedings of the 25th International Symposium*, edited by Y. Maniatis, pp. 139–147. Elsevier, Oxford and Amsterdam.

1995 Pottery Production and Consumption in the Siteia Bay Area during the New Palace Period. In *Achladia: Scavi e Richerche della 'Missione Greco-Italiana in Creta Orientale (1991–1993),* edited by M. Tsipopoulou and L. Vagnetti, pp. 148–175. CNR/GEI, Rome.

2004 Marriage and Mobility: Traditions and the Dynamics of the Pottery System in Twentieth Century East Crete. In *Pseira VIII: The Archaeological Survey of Pseira Island Part 1*, edited by P.P. Betancourt, C. Davaras and R. Hope Simpson, pp. 105–142. INSTAP Academic Press, Philadelphia.

Day, P.M., E. Kiriatzi, A. Tsolakidou and V. Kilikoglou
1999 Group Therapy: A Comparison between Analyses by NAA and Thin Section Petrography of Early Bronze Age Pottery from Central and East Crete. *Journal of Archaeological Science* 26:1025–1036.

Day, Peter M. and David E. Wilson
1998 Consuming Power: Kamares Ware in Protopalatial Knossos. *Antquity* 72:2.

Demarest, Arthur A., Prudence M. Rice and Don S. Rice (editors)
2004a *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation*. University Press of Colorado, Boulder, Colorado.

2004b The Terminal Classic in the Maya Lowlands: Assessing Collapses, Terminations and Transformations. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 545–572. University Press of Colorado, Boulder, Colorado.

Dickerson, R. E. and N. E. Weisbord
1931 Cretaceous Limestone in British Honduras. *Journal of Geology* 39:483–486.

Dixon, C.G.
1956 *Geology of Southern British Honduras.* Belize Government Printing Office, Belize.

Dobres, Marcia-Ann
2000 *Technology and Social Agency.* Blackwell Publishers Inc., Malden.

Eaton, J. D.
1982 Colha: An Overview of Architecture and Settlement. In *Archaeology at Colha, Belize: the 1981 Interim Report,* edited by Thomas R. Hester, Harry J. Shafer and Jack D. Eaton, pp. 11–20. Center for Archaeological Research, The University of Texas at San Antonio and Centro Studi e Ricerche Ligabue, Venezia and San Antonio.

Faber, E.W., V. Kilikoglou, P.M. Day and D.E. Wilson
2001 A Technological Study of Middle Minoan Polychrome Pottery from Knossos, Crete. In *Modern Trends in Scientific Studies on Ancient Ceramics: Papers Presented at the 5th European Meeting on Ancient Ceramics, Athens 1999*, edited by V. Kilikoglou, A. Hein and Y. Maniatis, pp. 129–142. BAR International Series 1011. Archaeopress, Oxford.

Fash, William L., E. Wyllys Andrews and T. Kam Manahan
2004 Political Decentralization, Dynastic Collapse and, the Early Postclassic in the Urban Center of Copán, Honduras. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 260–287. University Press of Colorado, Boulder, Colorado.

Flores, G.
1952 Geology of Northern British Honduras. *American Association of Petroleum Geologists Bulletin* 36(2):404–409.

Foias, Antonia E. and Ronald L. Bishop
1997 Changing Ceramic Production and Exchange in the Petexbatun Region, Guatemala: Reconsidering the Classic Maya Collapse. *Ancient Mesoamerica* 8:275–291.

Folk, Robert L.
1974 *Petrology of Sedimentary Rocks.* Hemphill Publishing Company, Austin, Texas.

Ford, Anabel, Nicole Woodman and Lisa Lucero
1992 Review and Revision of Ceramic Analysis: Results of the 1991 Maya Ceramic Workshop. *Ceramicas de Cultural Maya et al.* 16:24–29.

Fox, John W.
1987 *Maya Postclassic State Formation: Sedimentary Lineage Migration in Advancing Frontiers*. New Studies in Archaeology, C. Renfrew and J.A Sabloff, general editors, Cambridge University Press, Cambridge.

Fox, Richard G.
1977 *Urban Anthropology: Cities in their Cultural Settings*. Prentice-Hall, Inc., Englewood Cliffs.

Franklin, U.M. and V. Vitali
1985 The Environmental Stability of Ancient Ceramics. *Archaeometry* 27(1):3–15.

Freidel, David A.
1985 New Light on the Dark Age: A Summary of Major Themes. In *The Lowland Maya Postclassic,* edited by Arlen F. Chase and Prudence M. Rice, pp. 285–310. University of Texas Press, Austin.

1986 Terminal Classic Lowland Maya: Success, Failure and Aftermaths. In: *Late Lowland Maya Civilization: Classic to Postclassic*, edited by Jeremy A. Sabloff and E. Wyllys Andrews V, pp. 409–432. School of American Research Advanced Seminar Series, Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Freidel, David A. and Justine Shaw
2000 The Lowland Maya Civilization: Historical Consciousness and Environment. In *The Way the Wind Blows: Climate, History, and Human Action,* edited by Roderick J. McIntosh, Joseph A. Tainter and Susan Keech McIntosh, pp. 271–300. The Historical Ecology Series, William Balée and Carole L. Crumley, general editors, Columbia University Press, New York.

Freidel, David A., Kathryn Reese-Taylor and David Mora-Marín
2002 The Origins of Maya Civilization: the Old Shell Game, Commodity, Treasure, and Kingship. In *Ancient Maya Political Economies,* edited by Marilyn A. Masson and David A. Freidel, pp. 41–86, Altamira Press, New York.

Freestone, Ian C.
1991 Extending Ceramic Petrology. In *Recent Developments in Ceramic Petrology*, edited by Andrew Middleton and Ian Freestone, pp. 399–410. British Museum Occasional Paper No. 81. British Museum, London.

Fry, Robert E.
1979 The Economics of Pottery at Tikal, Guatemala: Models of Exchange for Serving Vessels. *American Antiquity* 44:494–512.

1980 Models of Exchange for Major Shape Classes of Lowland Maya Pottery. In *Models and Methods in Regional Exchange*, edited by Robert Fry, pp. 3–18. SAA Papers No. 1. Society for American Archaeology, Washington, D.C.

1981 Pottery Production-Distribution Systems in the Southern Maya Lowlands. In *Production and Distribution: A Ceramic Viewpoint*, edited by H. Howard and E. L. Morris, pp. 145–167. BAR International Series 120. British Archaeological Reports, Oxford.

1989 Regional Ceramic Distribution Patterning in Northern Belize: The View from Pulltrouser Swamp. In *Research in Economic Anthropology, a Research Annual: Prehistoric Maya Economies of Belize,* edited by Patricia A. McAnany and Barry L.

Isaac, pp. 91–111. Research in Economic Anthropology, Supplement 4, JAI Press Inc., Greenwich, Connecticut and London.

Furley, P. A. and A. J. Crosby
1974 Geography of Belize. Collins, London.

Gifford, James C.
1960 The Type-Variety Method of Ceramic Classification as an Indicator of Cultural Phenomena. *American Antiquity* 25(3):341–347.

1963 A Statement Concerning the Ceramic Group. *Ceramica de Cultura Maya et al.* 2–3:23–25.

1976 *Prehistoric Pottery Analysis and the Ceramics of Barton Ramie in the Belize Valley.* Papers of the Peabody Museum of Archaeology and Ethnology Memoir 18. Harvard University, Cambridge.

Gill, Richardson B.
2000 *The Great Maya Droughts: Water, Life, and Death.* University of New Mexico Press, Albuquerque.

Gischler, E. and A. J. Lomando
1999 Recent Sedimentary Facies of Isolated Carbonate Platforms, Belize-Yucatan System, Central America. *Journal of Sedimentary Research* 69(3 PtA):747–763.

Glascock, Michael D.
1992 Characterization of Archaeological Ceramics at MURR by Neutron Activation Analysis and Multivariate Statistics. In *Chemical Characterization of Ceramic Pastes in Archaeology*, edited by Hector Neff, pp. 11–26. Monographs in World Archaeology No. 7. Prehistory Press, Madison, Wisconsin.

Glascock, M.D., H. Neff, and K.J. Vaughn
2004 Instrumental Neutron Activation Analysis and Multivariate Statistics for Pottery Provenance. *Hyperfine Interactions* 145:95–105.

Gosselain, Oliver P.
1998 Social and Technical Identity in a Clay Crystal Ball. In *The Archaeology of Social Boundaries*, edited by M.T. Stark, pp. 78–106. Smithsonian Institution Press, Washington D.C.

Graham, Elizabeth
1985 Facets of Terminal to Postclassic Activity in the Stann Creek District, Belize. In: *The Lowland Maya Postclassic,* edited by Arlen F. Chase and Prudence M. Rice, pp. 215–230. University of Texas Press, Austin.

1987 Terminal Classic to Early Historic Period Vessel Forms from Belize. In *Maya Ceramics: Papers from the 1985 Maya Ceramics Conference, Part i*, edited by Prudence M. Rice and Robert Sharer, pp. 73–98. BAR International Series 345(i). British Archaeological Reports, Oxford.

2002 Perspectives on Economy and Theory. In *Ancient Maya Political Economies,* edited by Marilyn A. Masson and David A. Freidel, pp. 398–418. Altamira Press, New York.

2004 Lamanai Reloaded: Alive and Well in the Early Postclassic. In *Archaeological Investigations in the Eastern Maya Lowlands*, edited by J. Awe, J. Morris, & S. Jones, pp. 223-241. Research Reports in Belizean Archaeology, Volume 1. Institute of Archaeology, National Institute of Culture and History, Belmopan, Belize.

Graham, Elizabeth and David M. Pendergast
1989 Excavations at the Marco Gonzalez Site, Ambergris Cay, Belize, 1986. *Journal of Field Archaeology* 16(1):1–16.

Gregg, Jay M., Scott A. Howard and S. J. Mazzullo
1992 Early Diagenetic Recrystallization of Holocene (<3000 Years Old) Peritidal Dolomites, Ambergris Cay, Belize. *Sedimentology* 39:143–160.

Gunn, Joel D. and William J. Folan
1981 Climatic Change, Culture and Civilization in North America. *World Archaeology* 13:87–100.

1996 Tres ríos: una superficie de impacto climatológico global interregional par las tierras bajas de los mayas del suroeste. In *Los investigadores de la cultura maya*. Universidad Autónoma de Campeche, México.

2000 Three Rivers: Subregional Variations in Earth System Impacts in the Southwestern Maya Lowlands (Candelaria, Usumacinta, and Champotón Watersheds). In *The Way the Wind Blows: Climate, History, and Human Action,* edited by Roderick J. McIntosh, Joseph A. Tainter and Susan Keech McIntosh, pp. 223–270. The Historical Ecology Series, William Balée and Carole L. Crumley, general editors, Columbia University Press, New York.

Hall, I. H. S. and J. H. Bateson
1972 Late Paleozoic Lavas in Maya Mountains, British Honduras, and Their possible Regional Significance. *The American Association Of Petroleum Geologists Bulletin* 56(5):950–963.

Hamblin, Robert L. and Pitcher, Brian L.
1980 The Classic Maya Collapse: Testing Class Conflict Hypotheses. *American Antiquity* 45(2):246–267.

Hammond, Norman
1974 The Distribution of Late Classic Maya. Major Ceremonial Centres in the Central Area. In *Mesoamerican archaeology – New Approaches : Proceedings of a Symposium on Mesoamerican Archaeology held by the University of Cambridge Centre of Latin American Studies, August 1972*, edited by Norman Hammond, pp. 313–334. Duckworth, London.

1982 *Ancient Maya Civilization.* Rutgers University Press, New Brunswick, New Jersey.

Hammond, Norman and Gair Tourtellot
2004 Out with a Whimper: La Milpa in the Terminal Classic. In *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 288–301. University Press of Colorado, Boulder Colorado.

Hammond, N., G. Harbottle and T. Gazard
1976 Neutron Activation and Statistical Analysis of Maya Ceramics and Clays from Lubaantun, Belize. *Archaeometry* 18(2):147–168.

Harbottle and Sayre
1975 Appendix: Current status of examination of sherds of Fine paste ceramics from Altar de Sacrificio and Seibal and their comparison with other Maya Fine paste ceramics. In *Excavation at Seibal, Vol. 2: Ceramics*, edited by Jeremy A. Sabloff, pp. 241–253.

Memoirs of the Peabody Museum of Archaeology and Ethnology, Vol. 13, No. 2. Harvard University, Cambridge, Massachusetts.

Harrison, Peter D.
1977 The Rise of the Bajos and the Fall of the Maya. In *Social process in Maya prehistory : studies in honour of Sir Eric Thompson,* edited by Norman Hammond, pp. 469–508. Academic Press, London.

Hein, A., A Tsolakidou, I. Illiopoulos, H. Mommsen, J. Buxeda i Garrigos, G. Montana and V. Kilikoglou
2002 Standardization of elemental analytical techniques applied to provenance studies of archaeological ceramics: and Inter laboratory calibration study. *The Analyst* 127: 542–553.

Hein, A., P.M. Day, P.S. Quinn and V. Kilikoglou
2004a The Geochemistry of Neogene Clay Deposits in Crete and Its Implications for Provenance Studies of Minoan Pottery. *Archaeometry* 46(3): 357–384.

Hein, A., P.M. Day, M.A. Cau Ontiveros and V. Kilikoglou
2004b Red Clays from Central and Eastern Crete: Geochemical and Mineralogical Properties in View of Provenance Studies of Ancient Ceramics. *Applied Clay Science* 24: 245–255.

Hester, Thomas R., Harry J. Shafer and Jack D. Eaton
1982 *Archaeology at Colha, Belize: the 1981 Interim Report.* San Antonio: Center for Archaeological Research, The University of Texas at San Antonio and Centro Studi e Ricerche Ligabue, Venezia.

Hosler, Dorothy, Jeremy A. Sabloff and Dale Runge
1977 Simulation Model Development: A Case Study of the Classic Maya Collapse. In *Social process in Maya prehistory: studies in honour of Sir Eric Thompson,* edited by Norman Hammond, pp. 553–590. Academic Press, London.

Houston, Stephen D., Hector Escobedo, Mark Child, Charles Golden and Réne Muñoz
2001 Moral Community and Settlement Transformation Among the Classic Maya: Evidence from Piedras Negras, Guatemala. In *Social Construction of Ancient Cities,* edited by M. L. Smith. Smithsonian Institution Press, Washington DC.

Howie, Linda A., Peter M. Day and Elizabeth Graham
2004 Late Classic Maya Paste Recipes at Altun Ha, Belize and the Meaning of Paste Variability. Paper presented at the 69th Annual Meeting of The Society for American Archaeology, Montreal.

Howie, Linda A., Terry Powis and Elizabeth Graham
2005 Can you Judge a Pot by Its Colour? Typological Groupings Under the Microscope at Lamanai, Belize. *Yuk'ab': An Online Journal of Maya Material Culture* 1. www.units.muohio.edu/mcs/mediaservices/webdev/portal/index.php

Howie-Langs, Linda A.
1999 Ceramic Production and Consumption at Altun Ha, Belize: A Petrographic Study. Unpublished Masters Thesis, Department of Archaeology, University of Sheffield, Sheffield, U.K.

Howry, Jeffrey
1978 Ethnographic Realities of Maya Prehistory. In Cultural *Continuity in Mesoamerica,* edited by David Browman, pp. 239–257. World Anthropology Series. Mouton Publishers, Paris.

Iceland, H.B. and Goldberg, P

1999 Late-Terminal Classic Maya Pottery in Northern Belize: A Petrographic Analysis of Sherd Samples from Colha and Kichpanha. *Journal of Archaeological Science* 26:951–966.

Jones, Lea, D.

1986 *Lowland Maya Pottery: The place of petrological analysis*. BAR International Series 288, Oxford, U.K.

Joyce, Rosemary A. and Julia A. Hendon

2000 Heterarchy, History, and Material Reality: "Communities" in Late Classic Honduras. In The Archaeology of Communities, edited by Marcello A. Canuto and Jason Yaeger, pp. 143-160. Routledge, London.

Kepecs, Susan

1998 Diachronic Ceramic Evidence and its Social Implications in the Chikinchel Region, Northeast Yucatan, Mexico. *Ancient Mesoamerica* 9:121–135.

Kesler, Stephen E., J. Howard Bateson, William L. Josey, George H. Cramer and Weldon A. Simmons

1971 Geological Notes: Mesoscopic Structural Homogeneity of Maya Series and Macal Series, Mountain Pine Ridge, British Honduras. *The American Association of Petroleum Geologists Bulletin* 55(1):97–123.

Kesler, S. E., C. F. Kienle and J. H. Bateson

1974 Tectonic significance of Intrusive Rocks in the Maya Mountains, British Honduras. *Geological Society of America Bulletin* 85:549–552.

Kilikoglou, V.

1994 Scanning Electron Microscopy. In Ceramic Regionalism in Prepalatial Central Crete: The Mesara Imports at EM I to EM IIA Knossos (D.E. Wilson and P.M. Day). *The Annual of the British School at Athens* 89:70–75

Kilikoglou, V., Y. Maniatis and A.P. Grimanis

1988 The Effect of Purification and Firing of Clays on Trace Element Provenance Studies. *Archaeometry* 30(1):37–36.

King, R. B., I. C. Ballie, T. M. B. Abell, J. R. Dunsmore, D. A. Gray, J. H. Pratt, H. R. Versey, W. A.C.S. and S. A. Zisman

1992 *Land Resource Assessment of Northern Belize (Vol.1 and Vol. 2)*. Natural Resource Institute. Bulletin 43.

Lemonnier, Pierre

1980 *Les Salines de l'Ouest: Logique technique, logique sociale*. Editions de la Maison de sciences de l'homme, Presses Universitaires de Lille, Paris, Lille.

1986 The Study of material Culture Today: Toward an Anthropology of Technical Systems. *Journal of Anthropological Archaeology* 5:147–186.

1993 Introduction. In *Technological Choices: Transformation in materials cultures since the Neolithic*, edited by Pierre Lemonnier, pp. 1–35. Routeledge, London.

López Varela, Sandra L., Patricia A. McAnany and Kimberly A. Berry

2001 Ceramics Technology at Late Classic K'axob, Belize. *Journal of Field Anthropology* 28:177–191.

Loten, S.
1985 Lamanai Postclassic. In *The Lowland Maya Postclassic*, edited by Arlen F. Chase and Prudence M. Rice, pp. 85–90. University of Texas Press, Austin.

Lucero, Lisa J.
1992 Problems in Identifying Ceramic Production in the Maya Lowlands: Evidence from the Belize River Area. *Memorias del Primer Congreso Internacional de Mayistas: Mesas Redondas, Arqueologia, Epigrafia* II:143–154.

Mahias, Marie-Claude
1993 Pottery techniques in India: Technical variants and social choice. In *Technological Choices: Transformation in materials cultures since the Neolithic*, edited by Pierre Lemonnier, pp. 157–180. Routeledge, London.

Maniatis, Y and M.S. Tite
1981 Technological examination of the Neolithic-Bronze Age pottery from Central and Southeast Europe and the Near East. *Journal of Archaeological Science* 8: 59–76.

Marcus, Joyce
2000 Toward an Archaeology of Communities. In The Archaeology of Communities, edited by Marcello A. Canuto and Jason Yaeger, pp. 231-242. Routledge, London.

Martin, Simon and Nikolai Grube
2000 *Chronicle of the Maya Kings and Queens: Deciphering the Dynasties of the Ancient Maya.* Thames and Hudson Ltd, London.

Masson, Marilyn A.
2000 *In the Realm of Nachan Kan: Postclassic Maya Archaeology at Laguna de On, Belize.* University Press of Colorado, Boulder, Colorado.

2002 Community Economy and the Mercantile transformation in Postclassic Northeastern Belize. In *Ancient Maya Political Economies,* edited by Marilyn A. Masson and David A. Freidel, pp. 335–364. Altamira Press, New York.

Masson, Marilyn A. and Robert M. Rosenswig
n.d. The Evolution of Postclassic Maya Pottery Traditions in Northern Belize. Submitted to *Latin American Antiquity* in February 2003 (accepted, in revision).

Masson, Marilyn A. and Shirley Boteler Mock
2004 Ceramics and Settlement Patterns at Terminal Classic-Period Lagoon Sites in Northern Belize. In *The Terminal Classic in the Maya Lowlands: Collapse, Transition, and Transformation,* edited by Arthur A. Demarest, Prudence M, Rice and Don S. Rice, pp.367–401. University Press of Colorado, Boulder.

Mazzullo, S.J., and A.M. Reid
1988 Sedimentary textures of Recent Belizean peritidal dolomite. *Journal of Sedimentary Petrology* 58:479–488.

Mazzullo, S.J., W.D. Bischoff, and C.S. Teal
1995 Holocene shallow-subtidal dolomitization by near- normal seawater, northern Belize; *Geology*, 23:341–344.

Mock, Shirley Boteler
1994 Yucatecan Presence in Northern Belize as Seen in the Postclassic Ceramics at Colha. In *Continuing Archaeology at Colha, Belize,* edited by Thomas R. Hester, Harry J. Shafer

and Jack D. Eaton, pp. 233–243. Studies in Archaeology 16. Texas Archaeological Research Laboratory, The University of Texas at Austin, Austin.

1998 Prelude. In *The Sowing and the Dawning: Termination, Dedication, and Transformation in the Archaeological and Ethnographic Record of Mesoamerica,* edited by Shirley Boteler Mock, pp. 3–20. University of New Mexico Press, Albuquerque.

McAnany, Patricia A.
1995 Living with the Ancestors: Kinship and Kingship in Ancient Maya Society. University of Texas Press, Austin.

1998 Ancestors and the Classic Maya Built Environment. In *Function and Meaning in Classic Maya Architecture*, edited by Stephen D. Houston, pp. 271-298 . Dumbarton Oaks, Washington, D.C.

Molloy, John P. and William L Rathje
1974 Sexploitation among the Late Classic Maya. In *Mesoamerican archaeology – New Approaches : Proceedings of a Symposium on Mesoamerican Archaeology held by the University of Cambridge Centre of Latin American Studies, August 1972*, edited by Norman Hammond, pp. 431–444. Duckworth, London.

Morley, Sylvanus G. (revised by G. W. Brainerd)
1956 *The Ancient Maya* (3rd Edition). Stanford University Press, Stanford.

Neff, Hector
1989a Origins of Plumbate Pottery Production. In *Ancient Trade and tribute: Economies of the Soconusco Region of Mesoamerica*, edited by B. Voorhies, pp. 175–193. University of Utah Press, Provo.

1989b The Effect of Interregional Distribution of Plumbate Pottery Production. In *Ancient Trade and tribute: Economies of the Soconusco Region of Mesoamerica*, edited by B. Voorhies, pp. 249–267. University of Utah Press, Provo.

2000 Neutron Activation Analysis for Provenance Determination in Archaeology. In *Modern Analytical Methods in Art and Archaeology*, edited by Enrico Ciliberto and Giuseppe Spoto, pp. 81–143. Chemical Analysis Series, Vol. 155. John Wiley & Sons, Inc., New York.

2001 Sources of Raw Material Used in Plumbate Pottery. In *Incidents of Archaeology in Central America and Yucatan*, edited by M. Love, M.P. Hatch and H. Escobedo. University Press of America, Lanham, M.D.

2003 Analysis of Mesoamerican Plumbate Pottery Surfaces by Laser Ablation Inductively-Coupled Plasma-Mass Spectrometry (LA-ICP-MS). *Journal of Archaeological Science* 30:21–35.

Neff, H. and R.L. Bishop
1988 Plumbate Origins and Development. *American Antiquity* 53:505–522.

Neff, Hector, Ronald L. Bishop and Edward V Sayre
1988 A Simulation Approach to the Problem of Tempering in Compositional Studies of Archaeological Ceramics. *Journal of Archaeological Science* 15:159–172.

1989 More Observations on the problem of Tempering in Compositional Studies of Archaeological Ceramics. *Journal of Archaeological Science* 15:57–69.

Neff, Hector and Frederick J. Bove
1999 Mapping Ceramic Compositional Variation and Prehistoric Interaction in Pacific Coastal Guatemala. *Journal of Archaeological Science* 26:1037–1051.

Noll, W.
1978 Material and Techniques of the Minoan Ceramics of Thera and Crete. In *Thera and the Agean World II: papers presented at the Second International Scientific Congress, Santorini, Greece, August 1978,* edited by C. Doumas, pp. 493–505. Thera and the Aegean World,London.

Noll, Walter, Reimer Holm and Liborius Born
1975 Painting of Ancient Ceramics. *Angewandte Chemie* 14(9):602–613.

O'Mansky, Matt and Nicholas P. Dunning.
2004 Settlement and Late Classic Political Disintegration in the Petexbatun Region, Guatemala. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 83–101. University Press of Colorado, Boulder Colorado.

Ower, Lesley H.
1926 Geology of British Honduras. *Imperial Geologist, Belize City* :494–509.

1927 Features of British Honduras. *Geographical Journal* 70:372–386.

1928a Geology of British Honduras. *Journal of Geology* 36:494–509.

1928b The Silica Lines of British Honduras. *Geological Magazine* 65:507–509.

Peacock, D.P.S.
1970 The Scientific Examination of Ceramics: A Review. *World Archaeology* 1:375–389.

Pendergast , David M.
1975 Lamanai 1975: The Goods Are Oft Interr'd With Their Bones. *ROM Archaeological Newsletter*, New Series, No. 122.

1978 Lamanai 1978, Part II: Crocodiles and Crypts. *ROM Archaeological Newsletter*, New Series, No. 163.

1979 *Excavations at Altun Ha, Belize, 1964-1970.* Archaeological Monograph 1. The Royal Ontario Museum, Toronto, Canada.

1980 A Dusty Tunnel. *ROM Archaeological Newsletter*, New Series, No. 176.

1981a Lamanai, Belize: Summary of Excavation Results, 1974–1980. *Journal of Field Archaeology* 8(1):29–53.

1981b A Regular Three-Ring Circus. ROM *ROM Archaeological Newsletter*, New Series, No. 192.

1981c The 1980 Excavations at Lamanai, Belize. *Mexicon* 2(6):96–99.

1981d Lamanai, Belize: 1981 Excavations. *Mexicon* 3(4):62–63.

1982 Lamanai, Belice, durante el Post-Clásico. *Estudios de Cultura Maya* XIV:19–58. Seminario de Cultura Maya, Universidad Nacional Autónoma de México, Mexico City.

1984 Excavations at Lamanai, Belize, 1983. *Mexicon* 6(1):5-10.

1985 Lamanai, Belize: An Updated View. In *The Lowland Maya Postclassic*, edited by Arlen F. Chase and Prudence M. Rice, pp. 91–103. University of Texas Press, Austin.

1986 Stability through Change: Lamanai, Belize, from the Ninth to the Seventeenth Century. In *Late Lowland Maya Civilization: Classic to Postclassic*, edited by Jeremy A Sabloff and E Wyllys Andrews V, pp. 223–250. School of American Research Advanced Seminar Series. Douglas W Schwartz, general editor, University of New Mexico Press, Albuquerque.

1988 Lamanai Stela 9: The Archaeological Context. *Research Reports on Ancient Maya Writing* 20. Center for Maya Research, Washington, D. C.

1990 Up from the Dust: The Central Lowlands Postclassic as Seen from Lamanai and Marco Gonzalez, Belize. In *Vision and Revision in Maya Studies*, edited by Flora Clancy and Peter D. Harrison, pp. 169–177. University of New Mexico Press, Albuquerque.

1992 Noblesse Oblige: The Elites of Altun Ha and Lamanai, Belize. In *Mesoamerican Elites: An Archaeological Assessment*, edited by Diane Z. Chase and Arlen F. Chase, pp. 61–79. University of Oklahoma Press, Norman.

1998 Intercessions with the Gods: Caches and Their Significance at Altun Ha and Lamanai, Belize. In *The Sowing and the Dawning: Termination, Dedication, and Transformation in the Archaeological and Ethnographic Record of Mesoamerica,* edited by Shirley Boteler Mock, pp. 55–63. University of New Mexico Press, Albuquerque.

Pohl, Mary and John Pohl
1994 Cycles of Conflict: Political Factionalism in the Maya Lowlands. In *Factional Competition and Political Development in the New World*, edited by Elizabeth M. Brumfiel and John W. Fox, pp. 138–157. Cambridge University Press, Cambridge.

Powis, Terry G.
2002 An Integrative Approach to the Analysis of the Late Preclassic Ceramics at Lamanai, Belize. Unpublished Ph.D. dissertation, Department of Anthropology, University of Texas, Austin.

Powis, Terry and Linda Howie
n.d. Compositional and Stylistic Variability of Late Preclassic and Protoclassic Ceramics at Lamanai, Belize. In *Archaeological Investigations in the Eastern Maya Lowlands: Papers of the 2005 Belize Archaeology Symposium*, edited by Jaime Awe, John Morris and Sherilyne Jones. Research Reports in Belizean Archaeology Volume 3.

Powis, T., L.A. Howie and E. Graham
2002 The Style and Petrography of Late Preclassic and Protoclassic Pottery at Lamanai, Belize. Paper presented at the 67th Annual Meeting of The Society for American Archaeology, Denver.

Purdy, E.G., W.C. Pusey III, and K.F. Wantland
1975 Continental Shelf of Belize: regional shelf attributes. In *Belize Shelf-Carbonate Sediments, Clastic Sediments and Ecology*, edited by K.F. Wantland and W.C. Pusey, pp. 1–39. American Association of Petroleum Geologists, Studies in Geology 2.

Pusey, W. C.
1975 Carbonate sedimentation on northern Belize shelf. In *Belize Shelf-Carbonate Sediments, Clastic Sediments and Ecology*, edited by K.F. Wantland and W.C. Pusey, pp. 131–233. American Association of Petroleum Geologists, Studies in Geology 2.

Rainbird, Paul

1999 Entangled Biographies: Western Pacific Ceramics and the Tombs of Pohnpei. *World Archaeology* 31(2):214-224.

Rands, Robert L

1973 The Classic Maya Collapse: Usumacinta Zone and the Northwestern Periphery. In *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 165–206. School of American Research Advanced Seminar Series. Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

1991 The Intellectual Development of Mesoamerican Archaeology and an Assessment of Shepard's Influence. In *The Ceramic Legacy of Anna O. Shepard*, edited by Ronald L. Bishop and Frederick W. Lange, pp. 154–176. University Press of Colorado, Niwot, Colorado.

Rands, Robert and Ronald Bishop

1980 Resource Procurement Zones and Patterns of Ceramic Exchange in the Palenque Region, Mexico. In *Models and Methods in Regional Exchange*, edited by Robert Fry, pp. 19–46. SAA Papers No. 1, Society for American Archaeology, Washington, D.C.

Rands, Robert L., Ronald L. Bishop and Jeremy A. Sabloff

1982 Maya Fine Paste ceramics: An archaeological perspective. In *Excavation at Seibal: Ceramics*, edited by J. A. Sabloff, pp. 315–338. Memoirs of the Peabody Museum of Archaeology and Ethnology, Harvard University, Vol. 13, No. 2, Harvard University, Cambridge, Massachusetts.

Rathje, William L.

1972 Praise the Gods and Pass the Metates: A Hypothesis of the Development of Lowland Rainforest Civilizations in Mesoamerica. In *Contemporary Archaeology: A Guide in Theory and Contributions*, edited by Mark P. Leone, pp. 365–392. Southern Illinois University Press, Carbondale, Illinois.

1973 Classic Maya Development and Denoument: A Research Design. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 405–456. School of American Research Advanced Seminar Series. Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

1975 The Last Tango in Mayapán: A Tentative Trajectory of Production-Distribution Systems. In *Ancient Civilization and Trade*, edited by Jeremy A. Sabloff and C. C. Lamberg-Karlovsky, pp. 409–448. A School of American Research Book. University of New Mexico Press, Albuquerque.

Rathje, William L and Jeffrey A. Sabloff

1973 Ancient Maya Commercial Systems: A Research Design for the Island of Cozumel Mexico. *World Archaeology* 5: 221–231

1975 *A Study of Pre-Columbian Commercial Systems: The 1972–1973 Seasons at Cozumel, Mexico*. Peabody Museum of Archaeology and Ethnology. Harvard University, Cambridge, Massachusetts.

Reents-Budet, Dorie

1988 The Iconography of Lamanai Stela 9, Center for Maya Research, *Research Reports on Ancient Maya Writing* 22. Center for Maya Research, Washington, D. C.

1994 *Painting the Maya Universe: Royal Ceramics of the Classic Period.* Duke University Press, Durham, NC.

Reents-Budet, Dorie and Ronald L. Bishop
2003 More than Methodology: INAA and Classic Maya Painted Ceramics. In *Patterns and Process: A Festschrift in Honor or Dr. Edward V. Sayre*, edited by Lambertus van Zelst, pp. 93–108. Smithsonian Center for Materials Research and Education, Suitland, Maryland.

Reents-Budet, Dorie, Ronald L. Bishop, Jennifer T. Tascheck and Joseph W. Ball
2000 Out of the Palace Dumps: Ceramic production and Use at Buenavista del Cayo. *Ancient Mesoamerica* 11:99–121.

Reid, R. P., I. G. Macintyre and J. E. Post
1992 Micritized Skeletal Grains in Northern Belize Lagoon: A Major Source of Mg-Calcite Mud. Journal of Sedimentary Petrology 62(1):145-156.

Reina, Ruben F. and Robert M. Hill, II
1978 The Traditional Pottery of Guatemala. University of Texas Press, Austin.

Rice, Prudence M.
1976 Rethinking the Ware Concept. *American Antiquity* 41(4):538–543.

1980 Peten Postclassic Pottery Production and Exchange: A View from Macanche. In *Models and Methods in Regional Exchange*, edited by Robert Fry, pp. 67–82. SAA Papers No. 1, Society for American Archaeology, Washington, D.C.

1987a Lowland Maya Pottery Production in the Late Classic Period. In *Maya Ceramics: Papers from the 1985 Maya Ceramic Conference*, edited by P.M. Rice and R.J. Sharer, pp. 525–543. BAR International Series no. 345(ii). Oxford, U.K.

1987b *Macanche Island, El Peten, Guatemala: Excavations, Pottery and Artifacts.* University of Florida Press, Gainesville.

1987c *Pottery Analysis: A Sourcebook.* University of Chicago Press, Chicago.

Rice, Prudence M. and Don S. Rice
2004 Late Classic to Postclassic Transformations in the Petén Lakes Region, Guatemala. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 125–139. University Press of Colorado, Boulder Colorado.

Rice, Prudence M., Arthur A. Demarest and Don S. Rice
2004 The Terminal Classic and the "Classic Maya Collapse" in Perspective. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 1–11. University Press of Colorado, Boulder Colorado.

Rice, Prudence M. and D. Forsyth
2004 The Terminal Classic-Period Lowland Ceramics. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 28-59. University Press of Colorado, Boulder Colorado.

Ringle, William M., Tomás Gallareta Negrón and George J. Bey III
1998 The Return of Quetzalcoatl: Evidence for the Spread of a World Religion during the Epiclassic Period. *Ancient Mesoamerica* 9:183–232.

Ringle, William M, George A Bey III, Tara Freeman Bond, Craig A. Hanson, Charles W Houck and Gregory J. Smith.

2004 The Decline to the East: The Classic to Postclassic Transition at Ek Balam, Yucatán. In *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation*, edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 485–516. University Press of Colorado, Boulder Colorado.

Robinson, G. M.

1983 The agricultural geography of Belize. In *Resources and Development in Belize: An Account of the University of Edinburgh Expedition to Central America, 1981*, edited by G. M. Robinson and P. A. Furley, pp. 21–74. Department of Geography University of Edinburgh, Edinburgh.

Robinson and Furley

1983 *Resources and Development in Belize: An Account of the University of Edinburgh Expedition to Central America, 1981*. Department of Geography University of Edinburgh, Edinburgh.

Rouse, Irving

1960 The Classification of Artifacts in Archaeology. *American Antiquity* 25(3):313-323

Ruz, Alberto L.

1965 Tombs and Funerary Practices in the Maya Lowlands. In *Archaeology of Southern Mesoamerica Part 1,* edited by G. R. Willey, pp.441-461. Handbook of Middle American Indians, Vol. 2, Robert Wauchope, general editor, The University of Texas Press, Austin.

Rye, Owen S.

1976 Keeping Your Temper Under Control: Materials and the Manufacture of Papuan Pottery. *Archaeology and Physical Anthropology in Oceania* 11:106-137.

1981 Pottery Technology: Principles and Reconstruction. Manuals on Archaeology 4. Taraxacum, Washington, D.C.

Sabloff, Jeremy A.

1973 Continuity and Disruption During Terminal Late Classic Times at Seibal: Ceramic and Other Evidence. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 107–132. School of American Research Advanced Seminar Series. Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

1975 *Excavations at Seibal, Department of Peten, Guatemala: The Ceramics*. Memoirs of the Peabody Museum of Archaeology and Ethnology, Vol. 13, No. 2. Harvard University, Cambridge, Massachusetts.

Sabloff, Jeremy A and E. Wyllys Andrews V

1986 Introduction. In: *Late Lowland Maya Civilization: Classic to Postclassic*, edited by Jeremy A. Sabloff and E. Wyllys Andrews V, pp. 3–16. School of American Research Advanced Seminar Series. Douglas W Schwartz, general editor, University of New Mexico Press, Albuquerque.

Sabloff ,Jeremy A. and William L. Rathje

1975 The Rise of a Maya Merchant Class. *Scientific American* 233:72–82.

Sabloff, Jeremy A., William L Rathje, David A. Friedel, Judith G. Connor and Paula LW. Sabloff

1974 Trade and power in Postclassic Yucatan: initial observations. In *Mesoamerican archaeology – New Approaches : Proceedings of a Symposium on Mesoamerican*

Archaeology held by the University of Cambridge Centre of Latin American Studies, August 1972, edited by Norman Hammond, pp. 397–416. Duckworth, London.

Sabloff, J.A. and G.R. Willey
1967 The collapse of Maya civilization in the southern lowlands: a consideration of history and process. *Southwestern Journal of Archaeology* 23:311–336.

Sanders, William T.
1973 The Cultural Ecology of the Lowland Maya: A Reevaluation. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 325–366. School of American Research Advanced Seminar Series. Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Sellett, F.
1993 Chaîne Opératoire: The Concept and Its Applications. *Lithic Technology* 18:106–112.

Sharer, Robert J.
1977 The Maya Collapse Revisited: Internal and External Perspectives. In *Social process in Maya prehistory: studies in honour of Sir Eric Thompson,* edited by Norman Hammond, pp. 531–552, Academic Press, London.

1994 *The Ancient Maya*, 5th edition. Stanford University Press, Stanford.

Shaw, Joseph W., Aleydis Van de Moortel, Peter M. Day and Vassilis Kilikoglou
2001 *A LM IA Ceramic Kiln in South-Central Crete: Function and Pottery Production.* Hesperia Supplement 30. American School of Classical Studies at Athens, Princeton, New Jersey.

Shaw, Justine M.
2003 Climate Change and Deforestation. Implications for the Maya Collapse. Ancient Mesoamerica 14:157-167

Shelby, Thomas Mark
1999 Report of the 1998 and 1999 Investigations on the Archaeology and Iconography of the Polychrome Stucco Façade of Structure N10–28, Lamanai, Belize. FAMSI Report No. 98037. Electronic document, http://www.famsi.org/reports/98037/index.html, accessed December 10, 2005.

Shepard, Anna O.
1939 Technological Notes of the Pottery of San Jose. In *Excavations at San Jose, British Honduras*, edited by John Eric Thompson, pp. 251–277. Carnegie Institution of Washington, Washington.

1948 *Plumbate: A Mesoamerican Trade Ware.* Carnegie Institution of Washington Publication 573. The William Byrd Press, Inc., Richmond, Virginia.

1956 *Ceramics for the Archaeologist.* Carnegie Institution of Washington Publication 609. Washington, DC.

1964 Temper Identification: "Technological Sherd-Splitting" or an Unanswered Challenge. *American Antiquity* 29:518–520.

Sidrys, Raymond V.
1983 *Archaeological Excavations in Northern Belize, Central America.* Monograph XVII. Institute of Archaeology, University of California, Los Angeles.

Simmon, M. and G.F. Brem
1979 The analysis and Distribution of Vocalic Ash-Tempered Pottery in the Lowland Maya Area. *American Antiquity* 44:79–91.

Shotton, F.W. and G.L. Hendry
1979 The Developing Field of Petrology in Archaeology. *Journal of Archaeological Science* 6:75–84.

Smith, Robert E.
1955 *Ceramic Sequence at Uaxactun Guatemala, Vol. 1.* Middle American Research Institute Publication No. 20. Tulane University, New Orleans.

1971 *The Pottery of Mayapan Including Studies of Ceramic Material from Uxmal, Kabah, and Chichen Itza, 2 vols.* Peabody Museum of Archaeology and Ethnology Papers vol. 66. Harvard University, Cambridge, Massachusetts.

Smith, Robert E., Gordon R. Willey and James C. Gifford
1960 The Type–Variety Concept as a Basis for the Analysis of Maya Pottery. *American Antiquity* 25(3):330–340.

Smyth, Michael P., Christopher D. Dore, Hector Neff and Michael D. Glascock
1995 The Origin of Puuc Slate Ware: New Data from Sayil, Yucatan, Mexico. *Ancient Mesoamerica* 6:119–134

Stanchly, N.
2001 Preliminary Observations: The Faunal Assemblage from Structure N10-9 (2000, 2000, 2001 Field Seasons). Ms. On file with the author.

Stuart
1993 Historical Inscriptions and the Maya Collapse. In *Lowland Maya Civilization in the Eighth Century A.D.*, edited by Jeremy A. Sabloff and John S. Henderson, pp. 321–354. Dumbarton Oaks, Washington, D.C.

Suhler, Charles, Traci Arden, David Freidel and Dave Johnstone
2004 The Rise and Fall of Terminal Classic Yaxuna, Yucatán, Mexico. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation,* edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 450–484. University Press of Colorado, Boulder Colorado.

Sullivan, Lauren A.
2002 Dynamics of Regional Integration in Northwestern Belize, In *Ancient Maya Political Economies,* edited by Marilyn A. Masson and David A. Freidel, pp. 197–222. Altamira Press, New York.

Thompson, John Eric
1939 *Excavations at San Jose, British Honduras.* Carnegie Institution of Washington, Washington.

1954 *The Rise and Fall of Maya Civilization.* University of Oklahoma Press, Oaklahoma.

Tite, M.S.
1995 Firing temperature determinations – how and why? In *The Aim of Laboratory Analysis of Ceramics in Archaeology,* edited by A Lindahl and O. Stilborg, pp. 37–42. Kungl. Vitterhets Historie och Antikvitets Akadamien Konferenser 34, Stockholm.

1999 Pottery Production, Distribution and Consumption – Contribution of the Physical Sciences. *Journal of Archaeological Method and Theory* 6(3):181–233.

Tite, M.S. and Y. Maniatis
1975 Scanning Electron Microscopy of Fired Calareous Clays. *Transactions and Journal of the British Ceramic Society* 74:19–22.

Tite, M.S., I.C. Freestone, N.D. Meeks and M. Bimson
1982 The Use of Scanning Electron Microscopy in the Technological Examination of Ancient Ceramics. In *Archaeological Ceramics*, edited by J.S. Olin and A.D. Franklin, pp. 109–120. Smithsonian Institution Press, Washington, D.C.

Tomkins, Peter, Peter M. Day and Vassilis Kilikoglou
2004 Knossos and the earlier Neolithic landscape of the Herakleion Basin. In Knossos: Palace, City State: Proceedings of the Conference in Herakleion organized by the British School at Athens and the 23rd Ephoreia of Prehistoric and Classical Antiquities of Herakleion, in November 2000, for the Centenary of Sir Arthur Evans's Excavations at Knossos, edited by Gerald Cadogan, Eleni Hatzaki and Adonis Vasilakis. British School at Athens Studies 12, Athens.

van der Leeuw, Sander

1993 Giving the Potter a Choice: Conceptual aspects of pottery techniques. In *Technological Choices: Transformation in materials cultures since the Neolithic*, edited by Pierre Lemonnier, pp. 238–288. Routeledge, London.

van der Leeuw, Sander E., Dick Papousek and Anick Coudart
1991 Technical Traditions and Unquestioned Assumptions: The Case of Pottery in Michoacan. *Techniques et culture* 17–18:145–173.

Valdez Jr., Fred
1987 The Prehistoric Ceramics of Colha, Northern Belize. Unpublished Ph.D. dissertation Department of Anthropology, Harvard University, Cambridge M.A.

1994 The Colha Ceramic Complexes. In *Continuing Archaeology at Colha, Belize,* edited by Thomas R. Hester, Harry J. Shafer and Jack D. Eaton, pp. 9–16. Studies in Archaeology 16. Texas Archaeological Research Laboratory, The University of Texas at Austin, Austin.

Valdez Jr., Fred and Richard.E.W. Adams
1982 The Ceramics of Colha after Three Field Seasons, 1979–1981. In *Archaeology at Colha, Belize: The 1981 Interim Report*, edited by Thomas R. Hester, Harry J. Shafer, and Jack D. Eaton, pp. 21–20. Center for Archaeological Research, The University of Texas at San Antonio, San Antonio, Texas.

Versey, H.R.
1972 Karst in Jamaica. In *Karst: Important Karst Regions of the Northern Hemisphere*, edited by M. Herak & V.T. Springfield, Amsterdam and New York: Elsevier.

Vinson, G. L.
1962 Upper Cretaceous and Tertiary Stratigraphy of Guatemala, *Bulletin of the American Association of Petroleum Geologists* 46:425–456.

Walker, S. H.
1973 *Summary of Climatic Records for Belize.* Land Resource Division, Supplement No.3, Surrey, England.

Walker, Debra Selsor
1990 Cerros Revisited: Ceramic Indicators of Terminal Classic and Postclassic Settlement and Pilgrimage in Northern Belize. Unpublished Ph.D. dissertation, Graduate Faculty of Dedman College, Southern Methodist University, Dallas, Texas.

Webb, Malcolm C.
1973 The Peten Maya Decline Viewed in Perspective in the Perspective of State Formation. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 367–404. School of American Research Advanced Seminar Series. Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Webster, David L.
1998 Warfare and Status Rivalry: Lowland Maya and Polynesian Comparison. In *Archaic States*, edited by G. M. Feinman and J. Marcus, pp. 311–351. School of American Research Press, Santa Fe, New Mexico.

Webster, David, AnnCorinne Freter and Rebecca Storey.
2004 Dating Copán Culture-History: Implications for the Terminal Classic. In: *The Terminal Classic in the Maya Lowlands: Collapse Transition and Transformation*, edited by Arthur A. Demarest, Prudence M. Rice and Don S. Rice, pp. 231–259. University Press of Colorado, Boulder, Colorado.

Weigand, P.C., G. Harbottle and E.V. Sayre
1977 Turquoise sources and source analysis: Mesoamerica and the Southwestern U.S.A.. In *Exchange Systems in Prehistory*, edited by T.K. Earle and J.E. Ericson, pp. 15–34. Academic Press, New York.

Welsh, W. Bruce M.
1988 *An Analysis of Classic Lowland Maya Burials*. BAR International Series 409. British Archaeological Reports, Oxford.

West, Georgia
2002 Ceramic Exchange in the Late Classic and Postclassic Maya Lowlands: a Diachronic Approach. In *Ancient Maya Political Economies*, edited by Marilyn A. Masson and David A. Freidel, pp. 140–196. Altamira Press, New York.

Wheat, Joe Ben, James C. Gifford, and William W. Wasley
1958 Ceramic Type, Type Cluster, and Ceramic System in Southwestern Pottery Analysis. *American Antiquity* 24(1):34-47.

Whitbread, I.K.
1986 The Characterisation of Argillaceous Inclusions in Ceramic Thin Sections. *Archaeometry* 28:79–88.

1989 A Proposal for the Systematic Description of Thin Sections Towards the Study of Ancient Ceramic Technology. In *Archaeometry: Proceedings of the 25th International Symposium*, edited by Y. Maniatis, pp. 127–138. Elsevier, Amsterdam.

1995 *Greek Transport Amphorae: A Petrological and Archaeological Study*. The British School at Athens Fitch Laboratory Occasional Paper 4. The Short Run Press, Exeter.

1996 Detection and Interpretation of Preferred Orientation in Ceramic Thin Sections. In *Imaging the Past: Electronic Imaging and Computer Graphics in Museums and Archaeology*, edited by Janet Lang, Peter Main , Tony Higgins, pp. 413–425. The British Museum, Department of Scientific Research, Occasional Paper 114, London.

White, Christine D.

1997 Ancient Diet at Lamanai and Pacbitun: Implications for the Ecological Model of Collapse. In *Bones of the Maya: Studies of Ancient Skeletons*, edited by Stephen L. Whittington and David M. Reed, pp. 171–180. Smithsonian Institution, Washington D.C.

Whitelaw, T.M., P.M. Day, E. Kiriatzi, V. Kilikoglou and D.E. Wilson

1997 Ceramic traditions at EM IIB Myrtos, Fournou Korfi. In *TEXNH. Craftsmen, Craftswomen and Craftsmanship in the Aegean Bronze Age (Aegaeum)*, edited by R. Laffineur and P.P. Betancourt, pp. 265–275. Liege and Austin.

Willey, Gordon R.

1974 The Classic Maya hiatus: a 'rehearsal' for the collapse? In *Mesoamerican archaeology – New Approaches : Proceedings of a Symposium on Mesoamerican Archaeology held by the University of Cambridge Centre of Latin American Studies, August 1972*, edited by Norman Hammond, pp. 417–430. Duckworth, London.

Willey, Gordon R., T. Patrick Culbert and E.W. Adams

1967 Lowland Maya Ceramics: A Report from the 1965 Guatemala City Conference. *American Antiquity* 32:289–315.

Willey, Gordon R and Demitir B. Shimkin.

1973 The Maya Collapse a Summary View. In: *The Classic Maya Collapse*, edited by T. Patrick Culbert, pp. 457–502. School of American Research Advanced Seminar Series. Douglas W. Schwartz, general editor, University of New Mexico Press, Albuquerque.

Wilson, D.E. and P.M. Day

1994 Ceramic Regionalism in Prepalatial Central Crete: The Mesara Imports at EM I to EM IIA Knossos. *The Annual of the British School at Athens* 89:1–95.

Wright, A. C. S., D. H. Romney, R. H. Arbuckle and V. E. Vial

1959 *Land in British Honduras: Report of the British Honduras Land Use Survey Team.* Colonial Office, Colonial Research Publications No. 24, D. H. Romney, general editor, Her Majesty's Stationary Office, London.

Yaeger, Jason and Marcello A. Canuto

2000 Introducing an archaeology of communities. In *The Archaeology of Communities*, edited by Marcello A. Canuto and Jason Yaeger, pp. 1–15. Routledge, London.