The Characterisation of Lime Plasters from Lamanai, Belize: A Diachronic Approach to the Study of Architectural Practices

I. Villasenor, E. Graham, R. Siddall, and C.A. Price

1 Introduction

This paper presents the micromorphological and compositional characteristics of architectural plasters from Lamanai dating from ca. 100 BC to the sixteenth century AD, as well as non-archaeological local raw materials. The study made use of petrography and X-ray fluorescence (XRF) for the analyses of 45 samples.

1.1 Lamanai

The site of Lamanai is located in the Orange Walk District of northern Belize, along the western bank of the New River Lagoon. Archaeological investigations are currently directed by Elizabeth Graham, University College London, and Scott Simmons, University of North Carolina Wilmington.

Lamanai was first inhabited perhaps as far back as 1500 BC. In contrast to sites in the central Petén, Lamanai was not abandoned at the end of the Terminal Classic period (AD 770-950/1000) but continued as a vibrant centre with its inhabitants carrying out important architectural programs and expanding the scope of long-distance trade and exchange (Pendergast 1990; Graham 2004, 2006, 2007). The site remained inhabited after the Spanish conquest, with some parts of the site occupied until the nineteenth century (Graham 2008; Pendergast 1985).

1.2 Lime Production in the Maya Area

Lime has been used in the Maya area since ca. 1100 BC (Hammond and Gerhardt 1990) and continues to be widely used until the present day. Lime plasters were

I. Villasenor (✉), E. Graham, R. Siddall, and C. Price
University College, London, UK
e-mail: m.villasenor@ucl.ac.uk

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used abundantly in pre-Hispanic masonry architecture and most of the Maya Lowlands benefited from the availability of limestones in the Yucatan Peninsula.

Ethnohistorical accounts from the seventeenth century (Ruiz de Alarcón 1629), as well as recent ethnographic research (Schreiner 2002, 2003; Russell and Dahlin 2007), describe how lime production in Maya culture is associated with birth and fertility and lime itself is conceived as a young fertile woman. These studies also inform on the labour and material demands of this industry.

2 Characterisation of the Plasters

2.1 Early Plasters

The earliest lime plasters found at Lamanai date from the Late Preclassic, when the tallest structure, N10-43, was built. The bulk composition of these plasters, as obtained by XRF, proved to be highly calcareous, with more than 92% $CaCO_3$ in all cases, which corresponds to the composition of local limestones. The microscopic observation of samples from this period showed a calcareous non-hydraulic matrix with subrounded and angular particles of micritic calcite as the main aggregate material.

The subrounded aggregates correspond without any doubt to sascab, a calcareous sediment that comprises a range of particle sizes, from clays to boulders, which is formed by in situ weathering of limestones and which is abundant in the karstic terrain of the Maya lowlands. The microscopic examination of non-archaeological sascab collected from a quarry close to Lamanai showed the characteristic micritic nature of the sediments and their rounded edges. The same characteristics can be observed in the aggregates of the Lamanai plasters. The use of sascab as aggregate material in Maya plasters was also documented in the sixteenth century chronicles of Fray Diego de Landa (Pagden 1975).

The angular aggregates of micritic calcite observed in Late Preclassic plasters are probably fragments of crushed limestone that was incorporated in the plasters in order to obtain an interlocking effect, providing the plasters with better mechanical properties. Micritic limestones are found as raw materials in the site in the upper strata of the bedrock and date from the Upper Neogene or Lower Quaternary (McDonald 1978) (see Fig. 1).

Sascab continued to be used as the main aggregate material during the Early and Late Classic plasters, as can be seen by petrography. In addition to sascab, microscopic observations showed the clear presence of fragments of a previously painted plaster or stucco recycled as aggregate material in a Late Classic floor, sampled between Structures N10-78 and N10-79, both of which were part of Plaza Group N10[3]. The recycled fragments showed a red layer overlain by a blue/green layer, probably composed of Maya blue. Similar fragments of painted plasters have also been reported in fill material from the Terminal Classic and were originally part of a Late Classic stucco frieze that adorned Str. N10-28, which faced Str. N10-77 across the plaza (see Graham 2004).

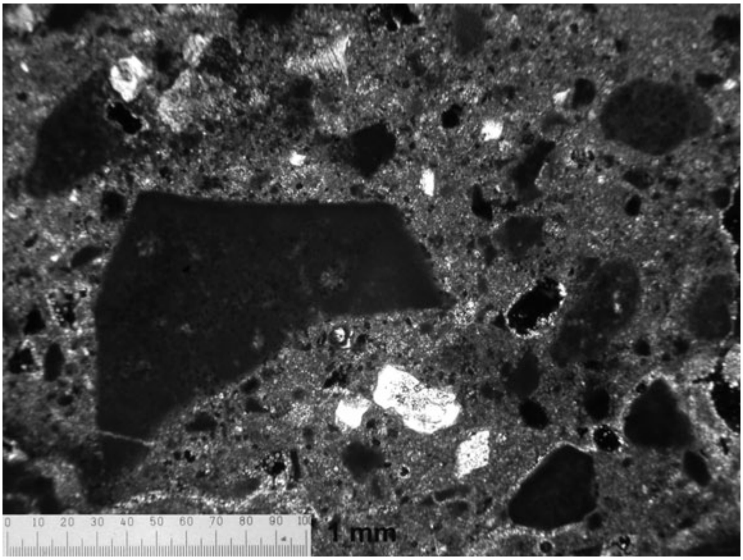

Fig. 1 Late Preclassic plaster showing small rounded aggregates of micritic calcite (sascab) to the *right*, and larger angular fragment (crushed limestone) at the *left*. Crossed polarised light, scale bar: 1 mm

2.2 The Terminal Classic Period: Quarrying Activities

In contrast to earlier periods, considerably larger aggregates made up of crystalline calcite prevailed over micritic calcite in the plasters from the Terminal Classic period onwards, as observed with microscopic examinations. These crystalline aggregates are probably related to the quarrying activities that took place during this period for the infilling of Plaza Group N10[3], which exploited hard crystalline limestones from the Cretaceous period, and which have been reported by Pendergast (1985) and Graham (2004). The numerous fragments of crystalline calcite, therefore, probably represent quarrying waste from these building works.

Considerable amounts of quartz are also visible in the plasters from the Terminal Classic period onwards, indicating a change in the procurement of raw materials in comparison to earlier plasters; quartz is however a common constituent of many types of stones and is therefore not diagnostic of any particular geology.

2.3 Postclassic and Spanish Colonial Periods

From the Late Postclassic period onwards, plasters show a higher content in silicon and aluminium in their bulk composition (up to 12% of SiO_2 and 6% in Al_2O_3), as shown by XRF analyses. This characteristic may indicate the deliberate exploitation of siliceous materials in order to obtain moderate hydraulicity in the lime mixtures. Hydraulicity is the formation of calcium silicate and aluminate hydrates in the plasters, which result in increased mechanical properties, reduced porosity, and the ability of the plasters to set under water (see Moropoulou et al. 2000).

The deliberate production of moderately hydraulic plasters is also suggested by the observation of isotropic phases and angular fragments of devitrified glass, as well as a higher hardness in comparison to earlier plasters. The likely incorporation of volcanic materials to the plasters bespeaks an empirical knowledge of materials, while the exploitation of these deposits may have been favoured by the increased trade during the Late Postclassic period.

Principal component analyses of XRF data show that Late Postclassic and Early Spanish Colonial samples are dissimilar to the plasters of earlier periods and are located away from the local raw materials, which is most probably related to the incorporation of non-local raw materials in the plaster mixtures.

2.4 *The Use of Tamped Sascab*

In addition to the use of sascab as aggregate materials in the plasters, the silt and clay-size fractions of sascab were also used as tamped powder for the laying of floors during the Preclassic, Early and Late Classic periods at Lamanai. The characterisation of non-burnt tamped sascab is based on the microscopic examination of

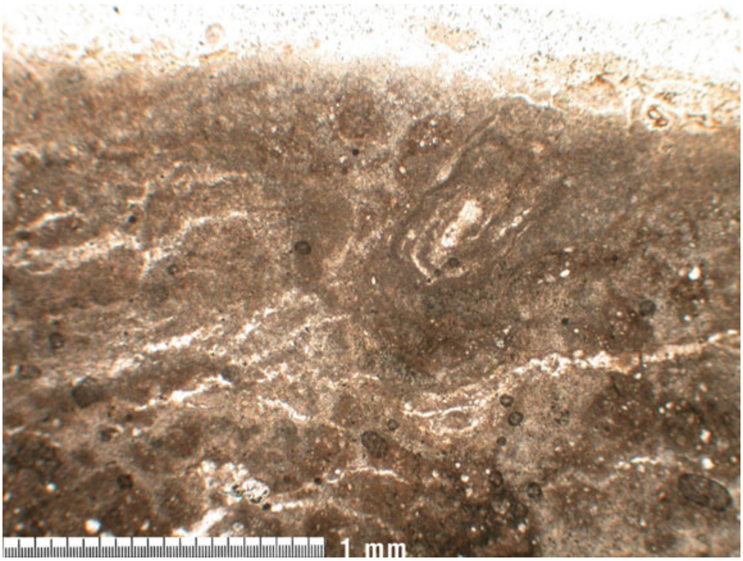

Fig. 2 Late Classic floor characterised as tamped sascab (unburnt calcareous sediments). Plane polarised light, scale bar: 1 mm

the samples, which showed masses of micritic calcite with cracks running parallel to the surface of the floors, and without the clear presence of aggregates or lime lumps (see Fig. 2). The construction of non-burnt sascab floors was apparently carried out without the use of burnt lime, and hardness was probably obtained solely by tamping the fine calcareous sediments when wet, as is still practiced today in the region for the construction of sascab roads.

The use of tamped sascab was observed only in floors, most likely because this material provides adequate performance characteristics for floors but not for wall renders or sculptures. The use of sascab represented a less energy-intensive construction technique for floors in comparison to lime plasters. Tamped sascab has also been reported by Brown (1986).

3 Conclusions

Lime plasters were used in Lamanai since the Late Preclassic period. During early periods, plasters were characterised by the use of local raw materials, such as sascab and crushed limestone.

From the Late and Terminal Classic periods, there is an increase in the size of aggregates and in the prevalence of crystalline calcite, which is probably related to the quarrying activities that were taking place at that time.

During the Late Postclassic and Spanish Colonial periods, volcanic materials seem to have been exploited deliberately, probably to obtain hydraulic properties in the plasters.

Compacted sascab (unburnt calcareous sediments) was also used as an alternative to lime plasters for the laying of floors, which was observed in many chronological periods.

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