The Nagsabaran Shell Midden Site: A Soil Micromorphological Approach

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Introduction

The extensive shell middens in the Municipality of Lal-lo in northeastern Luzon have been the subject of numerous archaeological research projects, especially since the 1970s, of the National Museum of the Philippines and Japanese archaeologists (Ogawa 2002; Aoyagi, Ogawa, and Tanaka 1997; Tanaka 2002, 1998). In general, the shell midden deposits contain black pottery C14 dated from c. 2,150 to 1,220 B.P. (Ogawa 2002; Tsang and Santiago 2001), whereas the silty clay sediments below the shell middens contain red slipped pottery generally dated in several sites to c. 3,800–2,500 B.P. (Tsang and Santiago 2001, Snow and Shutler 1986).

In 2000–2001, a joint National Museum of the Philippines and Taiwan archaeological team excavated the Nagsabaran site (Figure 1). Like the earlier Filipino and Japanese team, they exposed an upper shell midden layer with black pottery, and lower silty clay layer with red-slipped pottery (Tsang, Santiago, and Hung 2001; Hung 2005). A recent review of the pottery chronology for Cagayan Valley shows that few black pottery sherds were found within the silty clay layer dominated by red-slipped pottery (Mijares forthcoming).

There are different approaches to understanding site formation. The approach used here is soil micromorphology, seldom used in Southeast Asia until recently. It was first applied in the region at the Tingkayu site complex in Sabah

(Magee 1988) and at Gua Gunung Runtuh in Malaysia (Zauyah 1994). Recently, the approach has been applied at Niah Cave (Lewis 2003, Stephens et al. 2005). In the Philippines, initial applications of the soil micromorphology approach have been conducted by Helen Lewis at Tabon, Ille and Karangkarang Caves in Palawan (Lewis 2003, Lewis forthcoming), and by Mijares and Lewis for the Peñablanca cave sites (Mijares and Lewis forthcoming). These investigations have focused on understanding cave site formation.

In 2003, this author went back to Nagsabaran Site to collect undisturbed soil samples for micromorphological analysis. This study is the first application of the approach to an open archaeological site in the Philippines. The aim of this research is to understand the site formation processes in this area particularly the relation between the lower alluvial deposit and the upper shell midden layer. The second aim is to determine whether the black pottery found in association with red-slipped pottery within the silty clay layer were redeposited from the upper shell midden layers or were deposited *in situ*.

The Soil Micromorphology Approach

Soil micromorphological analysis is carried out on undisturbed soil samples in thin-sections, using a petrographic microscope. This is a relatively new approach in archaeology, although it has been used by soil scientists since the 1930s (Courty, Goldberg, and Macphail 1989; Bullock *et al.* 1985). The technique involves taking a sample of undisturbed soil using a tin box, impregnating it with resin, and then cutting a thin-section to 25–30 μm thickness (Murphy 1986). The thin-section is then examined under a petrographic microscope, and features are described. In order to standardize descriptions, Bullock *et al.* (1985) have published their *Handbook for Soil Thin-section Description*, augmented by a key to the handbook prepared by Stoops (1998, 2003).

These thin-sections were produced by Tony Phimphisane of the Geology Department, Australian National University, and described at the Archaeology and Natural History Department, Australian National University, using a Leica petrographic microscope at magnifications ranging from 10x to 50x, under plane polarized (PPL) and cross polarized (XPL) light.

Based on the description of the soil thin-sections, an analyst can then proceed to decipher different depositional and taphonomic processes. These include depositional and post-depositional, as well as geogenic, biogenic and anthropogenic processes responsible for site formation. Geogenic processes include diagenesis, weathering and erosion. Processes that are frequently seen include cementation with calcium carbonate minerals and movement of iron minerals through illuviation and eluviation leading to coating of voids and grains, and to a presence of iron-rich amorphous nodules.

Biogenic processes involve soil faunal activity as well as root movements that shape and reshape the structure of soil and sediments. Worms create channels as they move through the soil and at the same time deposit pellety excrement that can be identified in thin-sections. Anthropogenic processes are varied and different from site to site. They can be represented by living surfaces, hearths, artefacts, structures, and even plough marks (French 2003).

The Geomorphology of the Cagayan Valley

The north-flowing Cagayan River dissects the Cagayan Valley. The valley itself is an inter-arc basin, 250 km long and about 80 km wide. It is circumscribed by the inactive Sierra Madre volcanic arc in the east, the volcanically active Cordillera Central in the west, and the Carraballo Mountains in the south (Durkee and Pederson 1961; Mathisen and Vondra 1983; Mijares 2002). The valley contains about 900 m of Plio-Pleistocene fluvial and non-marine pyroclastic deposits, the latter originating in the Cordillera Central according to Mathisen and Vondra (1983).

The Lal-lo formation has been described by Durkee and Pederson (1961:158) as:

> ...a topographically resistant escarpment trending northwest along the northeast flank of the Lucban nose. The escarpment is composed of arenaceous, tuffaceous claystones and argillaceous, tuffaceous, fine grained, sandstones.

In the lower reaches of the Cagayan River, overlying this fluvial and pyroclastic deposit, there is a thick shell deposit consisting of *Batissa* sp., as thick as 3 meters in some areas and covering a distance of about 40 km inland from the mouth of the river (Ogawa 2002).

Nagsabaran Site Stratigraphy

Three stratigraphic layers were identified during the excavation of Nagsabaran (Figure 2). These are the upper shell midden deposit containing the black pottery sherds; a brown silty clay deposit with no archaeology; and at the base a very dark brown silty clay deposit, which contains the red-slipped and black pottery sherds. These lower silty clay deposits have a pH of 5.5, which is moderately acidic.

Soil Micromorphology at Nagsabaran

One of the 2000-2001 squares at Nagsabaran was re-opened in 2003, and two Kubiena tins were driven into the profile in order to get undisturbed soil samples. Nagsabaran sample 1 was taken across the interface between layers 1 and 2, and Nagsabaran sample 2 was taken to intersect layers 2 and 3 (Figure 2). This section will describe each thin-section following the Bullock *et al.* (1985) approach.

Nagsabaran sample 1 (Plate A1) contains the base of the bivalve shell midden (Layer 1: Plate A4) and the top of a lower massive sediment deposit (Layer 2). This lower deposit is of a lighter colour on the left hand side (brownish under PPL and gray under XPL), and darker on the right, here being a strong brown colour under PPL (Plate A2) and grayish brown under XPL (Plate A3).

Layer 2 was identified in the field as silty clay, but size grain analysis under the petrographic microscope indicates that it is silty clay loam with a coarse to fine ratio (C:F) of 5:95, with moderate sorting. Birefringence of the ground mass is moderate, and it has a stipple-speckled fabric. A stipple-speckled fabric indicates that there are small patches of oriented clay, which are randomly distributed (Bullock *et al.* 1985).

The lower part of the section has a moderately developed blocky angular structure, with porosity estimated at five percent, and partially accommodating channels, vughs, and accommodating intra-pedal cracks. This sediment primarily contains igneous minerals: quartz (80–170 μm), plagioclase (100–350 μm), muscovite (250 μm), biotite (100 μm) and amphibole (40–150 μm). Roots (2%) and charcoal particles (Plate A5) about 200–1000 μm in size were also identified.

Two fabric pedofeatures were observed in thin-section. The first comprises yellow to orange sub-rounded nodules (100 μm), and the second comprises rounded red nodules. Both of these feature sets appear to be made of clean clay. Recurrent iron rich amorphous nodules are also distributed through the thin-section. These are about 40–170 μm in size and occupy an estimated five percent of the sub section area.

Nagsabaran sample 2 (Plate B1) contained a massive sedimentary deposit, yellowish red under PPL (Plate B2) and dark reddish gray under XPL (Plate B3). The thin-section shows a weakly developed sub-angular blocky structure with about five percent porosity. There are channels that are partially accommodated or unaccommodated, and intra-pedal cracks that are accommodated. "Accommodation of aggregates to each other is a measure of the degree to which adjacent faces are mould of each other" (Bullock *et.al.* 1985: 42). An unaccommodated nature, such as granular peds indicates particular depositional or post-depositional processes.

Inspection through the microscope indicates that Nagsabaran sample 2 has a C:F ratio of 2:98, with a silty clay loam texture. The grain inclusions are poorly sorted. Birefringence is medium with a stipple-speckled fabric. This thin-section also contains primarily igneous minerals, which are sub-angular to sub-rounded in shape and consist of quartz (50–850 μm), biotite (60–100 μm), amphibole (50–350 μm), muscovite (150 μm) and plagioclase (40–500 μm). A number of altered minerals were also observed. An earthenware sherd 2 cm long was observed in the lower end of the section. This contains plagioclase, quartz, amphibole and biotite grains (Plate B5). Plant residues in the form of charcoal (50–200 μm) were also identified.

Similar to Nagsabaran sample 1, this thin-section also contains 100–600 μm iron-rich amorphous nodules, estimated to occupy five percent of the section area. Two fabric features were detected. The first comprised nodules (1,360–3,600 μm) of yellowish red colour under PPL and dark reddish brown under XPL (Plate B4), with igneous and amorphous minerals and a rare coating of limpid clay in two voids. The second fabric pedofeature comprises rare limpid red clay aggregates 140 μm in size.

Discussion and Interpretation

As stated above, the geology of the area is based primarily on a fluvial pyroclastic deposit. This can be clearly seen in the thin-sections, which contain primarily igneous minerals such as quartz, plagioclase and amphibole. These minerals, generally of a fine sand grain size, were probably deposited in a low energy environment. The coarse fractions of the sediments are mostly sub-angular in shape and not rounded, which means they were probably transported from a not to distant source through fluvial action.

The main difference between Layers 2 and 3 (Nagsabaran sample 2) is that the former has a lighter colour than the latter. Such a difference can be attributed to greater oxidization of the lower layer, making it darker. No traces of the processes of eluviation and illuviation, for instance clay or iron coatings or infillings, which might have accounted for the differences in colour, could be observed in the thin-section.

The weak to moderately developed sub-angular blocky structure with channels, vughs, and cracks that characterises Layers 2 and 3 can be attributed to alternating wetting and drying of the sediments (Courty, Goldberg, and Macphail 1989:151). This process creates a massive structure under wet conditions, but will form a blocky to prismatic structure when dry. These wetting and drying events are also the reason for the abundance of iron rich amorphous nodules (French 2003).

The pH testing of the Nagsabaran sediments shows that they are moderately acidic, perhaps due to a presence of quartz-rich minerals derived from igneous rocks. Acidic sediments are not good for bone or organic preservation. Soil microfauna also prefer a neutral soil (pH = 6–7), although fungi could be present in acidic soils (French 2003). Fungi with bacteria are responsible for splitting proteins and cellulose essential for humus production.

Anthropogenic deposits, except for the earthenware sherd, could not be detected in the thin-sections. Although a few charcoal fragments were identified, they could not easily be associated with human activity. The charcoal estimate in the thin-section is only about two percent. No fragments of burnt sediment or ash that could be related to a hearth were found in the thin-sections. Besides pottery and the shell midden no other features like floors, hearth, or workshops formed through human action were seen.

There is no evidence that the black pottery sherds found in the silty clay layer were redeposited from the above shell midden layer. There was minimal bioturbation activity in the lower sitly clay layer that could account for any movement of materials from above layer into the lower strata. These can be seen in the blocky structure of the sediment as oppose to a crumbly or granular structure normally associated with bioturbation such as faunal (worm) activity.

The shell midden deposit is widely thought to be of human cause. The shell deposit unconformably overlay the silty clay deposit below. It was difficult getting intact layers of the shell deposit since they tend to loosen up and pluck out of the thin-section during processing. This created a large void in the upper layer of Nagsabaran sample 1 section. Future soil micromorphology research in shell midden should try to address this problem. This could then be tackled by partially impregnating the layer with resin before a bulk sample could be taken. We could then try to understand how the midden was deposited and formed through time.

This first attempt to apply soil micromorphology in an open site in the Philippines has shown that understanding site formation could help test the validity of chronological models such as those on pottery. The previous pottery chronology for Cagayan Valley of red-slipped followed by black pottery (Ogawa 2002) is no longer tenable. Black pottery sherds are associated with red-slipped pottery in the lower silty clay layer dating to c. 3800 BP (Mijares forthcoming). The same association of black and red-slipped pottery sherds is also observed in nearby Peñablanca Caves (Mijares 2005).

The red-slipped and black pottery styles both occurred in the silty clay layer in these sites. Though the red-slipped pottery tends to be more frequent in this early stratigraphic context, black pottery is already present. The black pottery became dominant during the shell midden period, and red-slipping declined in popularity.

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Abstract

Soil micromorphological analysis was applied to the sediment samples taken from the archaeological site of Nagsabaran, Northern Luzon, Philippines. The first sample comes from the interface of a bivalve shell midden deposit and a massive layer of silty clay loam; the second was taken from the latter layer and the third, which is a dark brown silty clay deposit. Analyses of the two samples show that the pedology of the area is based on a fluvial pyroclastic deposit. The particles are sub-angular, indicating that they were transported from a short distance. Thin-sections from the lower layer show geogenic formation. Charcoal was observed in the thin-sections but this could not be associated with human activity. Particles of black pottery were also observed in this silty clay layer. These results have great implications in understanding the chronological relationship between black and red-slipped pottery in the area.

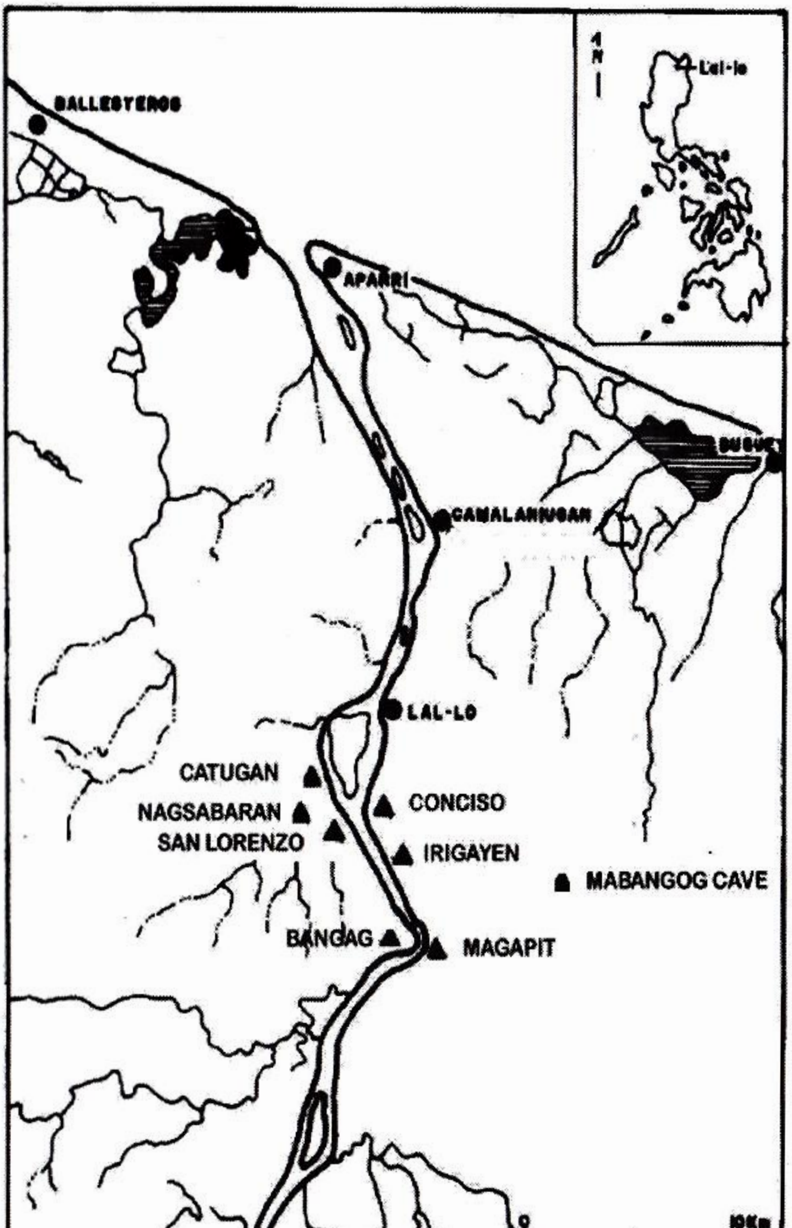


Figure 1
Map of major shell midden sites in north-eastern Luzon

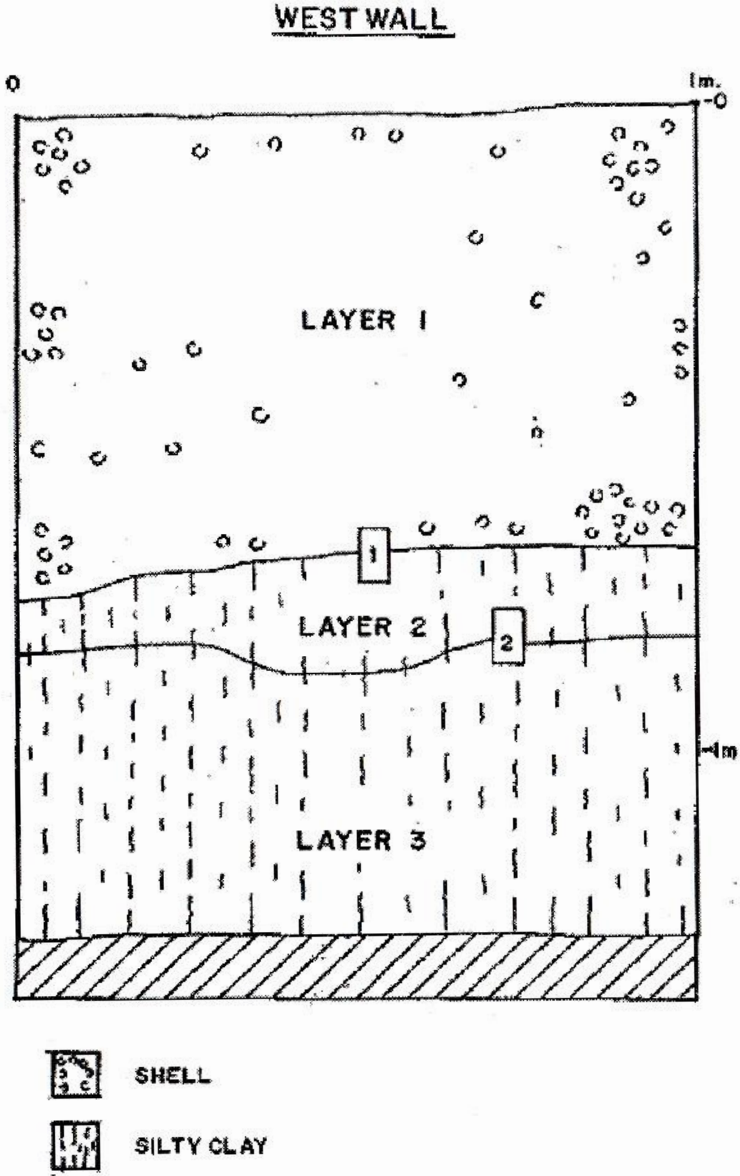
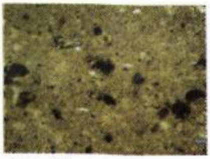


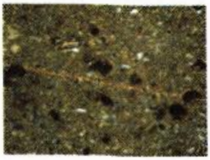
Figure 2
Stratigraphic profile of the Nagsabaran site

Plate A (bar=200 μm)

A1. Nagsabaran 1 (6 x 4 cm scanned image)



A2. Ground mass in PPL with the iron nodules

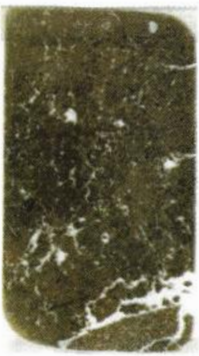


A3. Same as above in XPL

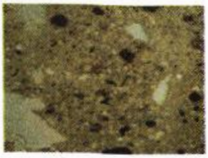
A4. Shell in XPL

A5. Charcoal in PPL

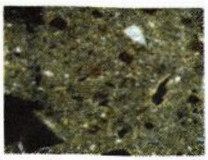
Plate B



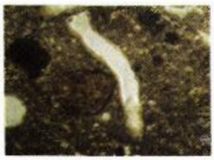
B1. Nagsabaran 2 (6 x 4 cm scanned image)



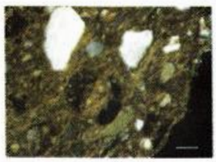
B2. Groundmass in PPL with iron nodules and limpid clay



B3. Same as above in XPL



B4. Fabric Pedofeature 1 in PPL



B5. Earthenware in XPL