Preliminary Report of the 2007 Field Season at Lamanai, Belize: The Lamanai Archaeological Project

by

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Introduction

This report presents the results of archaeological research in 2007 at the Maya site of Lamanai, located on the west bank of the New River Lagoon in the Orange Walk District of Belize (Figure 1). The work in 2007 was conducted as part of a long-term, on-going investigation of the site conducted by the Lamanai Archaeological Project under the direction of Drs. Elizabeth A. Graham and Scott E. Simmons, Co-Principal Investigators. The 2007 field season at Lamanai operated under permit number **IA/H/2/1/06 (05)**, which was issued by the Belize Institute of Archaeology, National Institute of Culture and History (NICH) to Dr. Scott E. Simmons.

The following report is comprised of four sections, each of which presents the research objectives, methods and results of the four discrete research endeavours undertaken at the site in 2007. These are presented in the following order:

- Lime Plaster Sampling at Lamanai by Isabel Villaseñor
- The Maya Archaeometallurgy at Lamanai by Scott E. Simmons and Aaron N. Shugar
- Style & Identity: The Ancient Maya Ceramics of Lamanai, Belize by James J. Aimers
- Ceramic Technological Studies at Lamanai by Linda Howie

In addition to the fieldwork relating to the four main research projects undertaken at Lamanai between May and August 2007 other work at Lamanai included:

1. the cataloging and curation of artifact collections recovered during restoration projects undertaken by NICH staff, January to May, 2007, which focused on the Spanish churches and the British sugar mill.
2. repair and maintenance of the previous on-site museum building (Museum of Pre-Columbian Art and Archaeology), which houses a range of special collections, including small finds, flint exotics and the extensive collection of whole and reconstructed ceramic vessels.
3. General upkeep and organization of on-site artifact collections housed in the bodega.

Each of these is discussed in the report by Linda Howie.

These particular activities focused on the curation of newly excavated collections (as part of restoration projects undertaken by NICH) and the ongoing organization and maintenance of the on-site artifact collections and storage facilities; they were coordinated by Dr. Elizabeth Graham, Dr. Linda Howie and Ms. Laura Howard. Repair and maintenance work done on the Museum of Precolumbian Art was undertaken in collaboration with Lamanai Park Managers Fernando Obando and Liston Armstrong. The structural repairs to the building were carried out by the Lamanai Archaeological Reserve staff and the cleaning of the building's interior and shelved collections was done by Dr. Howie and her field assistants.

Lime Plaster Sampling at Lamanai, Belize by Isabel Villaseñor

This report documents the second sampling of lime plaster materials carried out at the archaeological site of Lamanai, Belize. The sampling is part of a PhD research project by Isabel Villaseñor, with the supervision of Dr. Elizabeth Graham, Dr. James Aimers and Prof. Clifford Price, at the Institute of Archaeology, University College London.

The research aims to document diachronic technological changes in Lamanai. Since this site shows uninterrupted architectural programs for over 17 centuries, it constitutes a unique case in Maya archaeology for studying cultural changes through time. The sampling includes materials from ca. 100 BC (Structure N10-43), to the early 16th century (Spanish churches).

The first sampling was carried out on-site during March 2006 with the assistance of Dr. Scott Simmons and Ms. Laura Howard, whereas the second sampling was done with Dr. Graham. The second sampling aimed at complementing the first one, since no Early Classic samples were taken in 2006. Several other samples from other periods were also taken.

Samples were taken with scalpels or with a small hammer and a chisel, and they had a maximum size of 2 cm across. Samples were taken from edges or already damaged areas in order to minimize the damage inflicted to the structures. All of the samples were taken from floors, except Lam9, which was taken from a stucco sculpture (the Mask Temple), and the 16th century samples, which were taken from wall renders.

The samples are being analyzed at the laboratories of the Institute of Archaeology, University College London. The analytical work, which includes petrography, X-ray fluorescence, optical microscopy and scanning electron microscopy, aims to document the technological characteristics of the plasters through the elemental and mineralogical composition, and the micromorphological characteristics of the materials.

Sampling of Lam 3. Structure N10-18.

Sampling of Lam 7 and Lam8.
Str. P9-25, Holiday House

Below is a list of the samples taken in July 2007:

Sample	**Type of sample**	**Period**	**Structure**
Lam1	Wall render	16th century	Str. N12-13 (YDL II) South Wall
Lam2	Floor	Late Classic	Str. N10-18
Lam3	Floor	Late Classic	Str. N10-18
Lam4	Floor	Late Preclassic	Str. N10-4
Lam5	Floor	Early Classic	Str. P9-24 ("Holiday House")
Lam6	Floor.	Early Classic	Str. P9-24 ("Holiday House")
Lam7	Upper floor of Lam8	Late Preclassic/Early Classic	Str. P9-25 ("Holiday House", Hyatt floor)
Lam8	Lower floor of Lam 7 (compacted sascab)	Late Preclassic/Early Classic	Str. P9-25 ("Holiday House, Hyatt floor)
Lam9	Wall render/ stucco sculpture	Early Classic. Ca 450 AD	Str. N9-56 ("Mask Temple")
Lam10	Floor (upper layer)	Late Postclassic.	Str. N12-11, 2nd (YDLI). North façade.
Lam11	Floor (lower layer)	Late Postclassic	Str. N12-11, 2nd (YDLI). North façade.

The Maya Archaeometallurgy Project by Scott E. Simmons and Aaron N. Shugar

The 2007 field season comprised the seventh season of the Maya Archaeometallurgy Project (MAP), a research program aimed principally at illuminating the organizational structure and technological nature of Maya metallurgy as well as the roles metalworking played in Late Postclassic and Spanish Colonial Period Maya economies. The field component of the 2007 MAP lasted a total of just four days, consisting of mapping a portion of the Spanish Church Zone with a total station and checking ceramic artifacts recovered in previous field seasons for traces of use in copper metallurgy.

Objectives of the 2007 Field Season

The 2007 field season did not involve any excavations of any kind at Lamanai. Instead, research efforts of the Maya Archaeometallurgy Project were directed toward reaching two goals. The first of these was to map several portions of the Spanish Church Zone that had been the focus of field investigations in previous years, specifically during the 2002-2006 seasons. The second goal of the 2007 field season was the completion of a detailed metallurgical analysis of a sample of the copper artifacts that had been recovered archaeologically during those years.

While a detailed plan of structures identified during the 1974-1986 Royal Ontario Museum's Lamanai archaeological project had been created (see Pendergast 1981), several new structures had been identified as part of MAP research in the Spanish Church Zone and these structures needed to be added to the site plan. In addition, it was our intent to plot the locations of excavated areas on the Lamanai site plan, in part so that there would be a very accurate and complete digital record of all areas excavated under the MAP during the term of its work at the site, i.e., from 1999 to 2006.

A report on the results of metallurgical analyses of a sample of the copper artifacts recovered during the first two years to the MAP (1999 and 2001) was completed by Dr. Aaron N. Shugar, then of Lehigh University and the Smithsonian Center for Materials Research and Education (Simmons 2005). Excavations by the MAP in subsequent field seasons (in 2002, 2004, 2005 and 2006) had resulted in the recovery of additional copper artifacts, including bells, bell fragments, prills, casting reservoirs, fish hooks and axe fragments. The results of those analyses are reported here.

Research Methods - Mapping in the Spanish Church Zone

Mapping in the Spanish Church Zone, which is defined as that area of the site of Lamanai that lies in the immediate vicinity of Structures N12-11 and N12-13, informally referred to as YDL I and YDL II (Yglesia de Lamanai I and II). This was accomplished using a Topcon GTS 235 Total Station, which has a 10 second accuracy rating. A total of 513 separate survey points were plotted over the course of four days of mapping in the Spanish Church Zone. The computer software *Surfer* was used to create a map of a portion of the N11 and N12 grid blocks at the site (see following page).

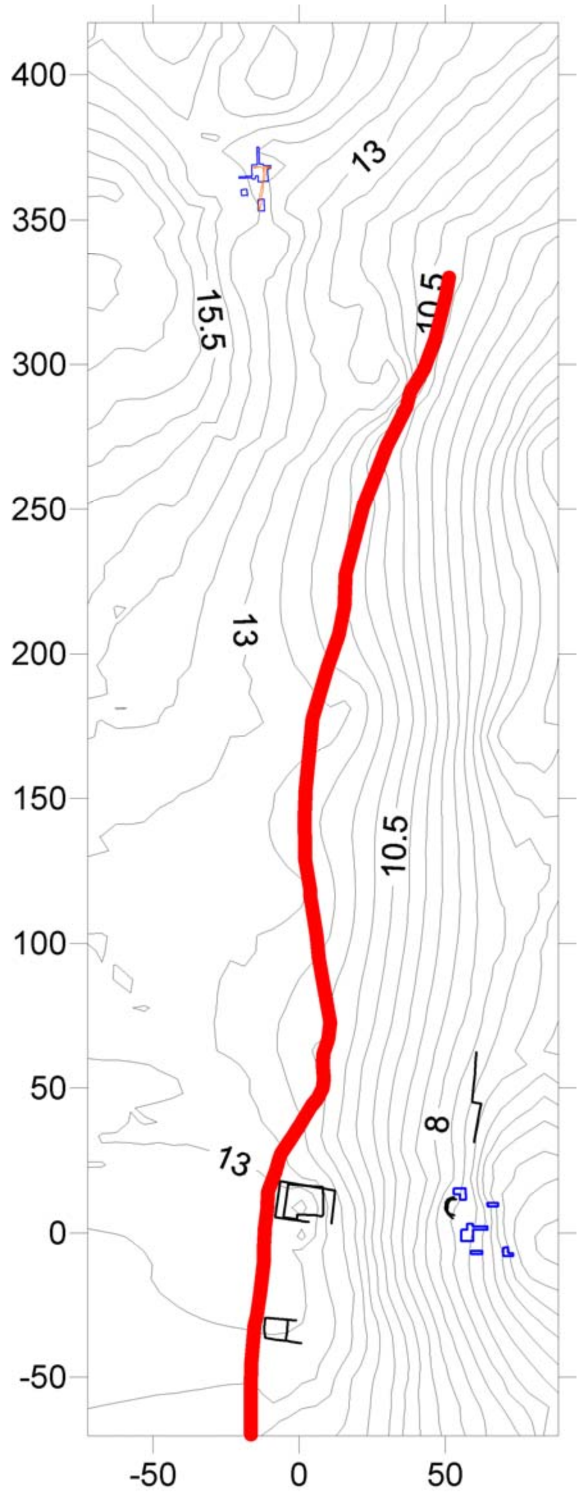

Figure 1. Preliminary plan of a portion of the Spanish Church Zone. The red line represents a modern road, blue outlined areas represent excavations in 2001-2005 (to the north) and in 2006 (to the south). Structures N12-13 and N12-11 are shown immediately to the east of the road to the north and south, respectively. Contour intervals are in meters above mean lagoon level (amll).

Microstructural and Chemical analysis of Copper Artifacts from Lamanai Belize by Aaron N. Shugar

This report comprises additional analyses of metal artifacts from Lamanai Belize and should be read in conjunction with the previous report entitled "Metallurgical Investigation of Metal Artifacts from Lamanai, Belize" (Shugar 2005).

Introduction

Several methods of analysis are used for the investigation of metals. These investigations typically focus on two main aspects of metal production. The first is the identification of forming technology; the process by which the metal artifact was made (casting, hammering, sharpening, and surface decoration). The standard method of analysis used for this identification process is optical light microscopy. This process of analysis entails removing a small piece of the artifact for sampling; this piece is then mounted in epoxy resin and ground and polished to a mirror-like finish. It can then be viewed under a microscope, and its revealing microstructure provides a clear indication of the manufacturing technology that formed the object. All samples discussed here were investigated using microscopy and were etched using alcoholic ferric chloride.

The second method of investigation is aimed at identifying the chemical composition of metal artifacts. Traditionally an object's chemical composition has been used to inform researchers of the source(s) of the original raw materials used in its production. This is an extremely important consideration when investigating an artifact, since not only can you determine the potential trade patterns that existed for the production of metal, but you can also compare the compositions of a collection of artifacts and see if their chemistry links them to a single casting or manufacturing center.

Typical methods of analysis used to identify chemical composition include scanning electron microscopy (SEM), atomic absorption spectroscopy (AAS), inductive coupled plasma spectroscopy (ICP), and X-ray fluorescence (traditional XRF and handheld portable XRF). For this report, we extended our analysis by using SEM for determining the chemical composition of artifacts recovered at Lamanai between 2001 and 2006 as well as determining the specific compositions of inclusions within the sample (see Appendix A). More detailed discussions of the results of both kinds of analyses will be presented in a forthcoming paper (Shugar and Simmons 2008).

For this report, the investigation into the manufacturing technology and chemistry of the metal artifacts uncovered at Lamanai Belize was broken down into material type and category. The artifacts will be discussed in their respective categories of bells, prills, sheet metal, axes, reservoirs (ingots) and needles and a discussion of the microstructure and chemistry is presented for each.

Bells

Limited sampling was done on the bells since the basic formation technology of using lost-wax casting is well documented and evidenced in previous samples (see Simmons 2005). In addition, visual investigations show the remnant down sprues on the loops of the bells, a clear indication of the lost-wax casting process. In any event, several bells were re-investigated with samples being taken for microstructural and chemical analysis. Bells LA 1238-1, LA 1240-1, LA 1243-1 and LA 1244-1 were sampled for analysis.

Bell Microstructure

All four bells showed a similar large grained microstructure typical of slow cooling. This is similar to other recorded bells produced through the lost-wax casting process (Hosler 1994:115). This slow cooled microstructure is likely due to the lost wax mold being contained in insulating sand. Cooling in open air would likely cause a smaller courser grain structure.

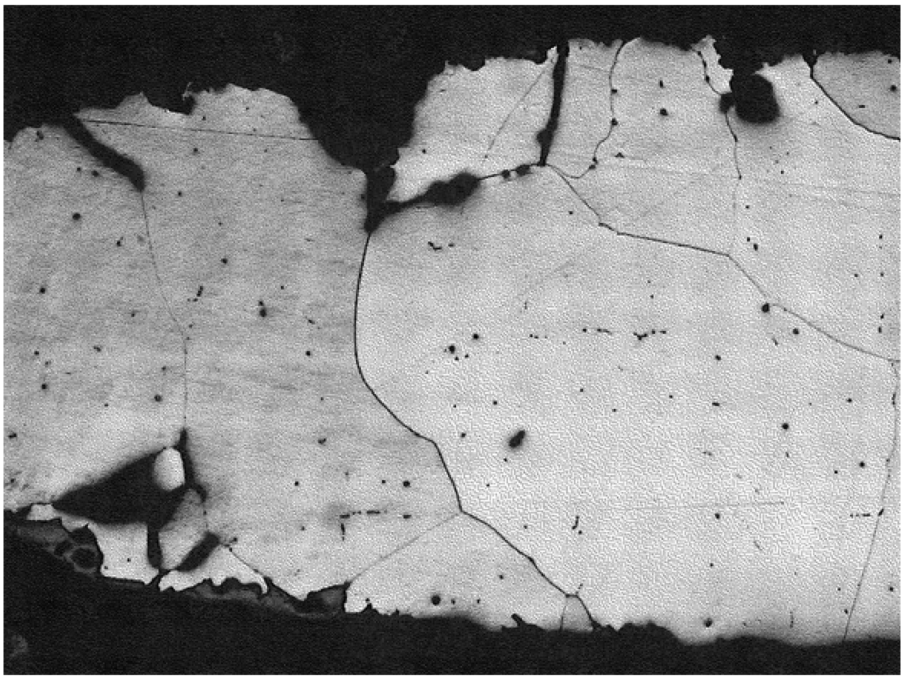

Figure 1: (Hosler 1994:Figure 7.8) Image showing similar large grained structure from a section of a filigree button from Lamanai. Small dark holes throughout the structure are pores due to shrinkage.

Bell Chemistry

The chemistry of the bells varies as might be expected of objects from unknown origins (Table 1). The four bells may be divided into three types: first is a copper arsenic alloy with between 1.5 and 2.2 wt %. This composition is very clean with traces of Sn, Fe (likely due to dirt) and Ag seen in bells LA 1240-1 and LA 1244-1. In fact, the chemical compositions of these two artifacts are so similar they could have been produced in the same casting episode. The second type is a relatively pure copper with traces of Sn, and Fe with no As; bell LA 1238-1 is an example of this group. The inclusions are Pb rich. The third type appears to be more of a mixture of a purer composition, similar to the second type, and a more complex alloyed composition similar to the first type. The inclusions in this type are coppers sulfides (see Figure 2). Bell LA 1243-1 is an example of this third type.

			Chemical components								
Artifact No.	**Bell Type**	**Area sampled**	***Cu***	***Sn***	***As***	***Fe***	***Ag***	***Pb***	***S***	***Se***	***Ni***
LA 1238-1	pyriform	Body	98.9	0.5		0.3					
		Body	98.7	0.5		0.4					
		Avg Body	98.8	0.5		0.4					
		Inclusion	88.5	0.6		0.4		10.3			0.1
LA 1240-1	pyriform	Body	96.7	0.1	1.9	0.3					
		Body	95.4	0.2	2.9	0.4					
		Body	96.9	0.2	1.9	0.3					
		Avg Body	96.3	0.2	2.2	0.4					
LA 1243-1	pyriform	Body	97.7	1.0	0.9	0.3					
		Body	98.1	0.6	0.7	0.4			0.03		
		Body	98.7	0.8		0.3					
		Avg Body	98.2	0.8	0.8	0.3			0.03		
		Inclusion	82.9	0.6		1.3			11.6	2.7	
LA 1244-1	fragment	Body	97.6	0.2	1.4	0.5	0.1				
		Body	97.3	0.2	1.8	0.3	0.2				
		Body	97.2	0.5	1.2	0.4	0.3				
		Avg Body	97.3	0.3	1.5	0.4	0.2				
		Inclusion	84.9	0.5		1.0			9.4	3.9	

Table 1: Chemical composition of four bells analyzed by SEM-EDS.

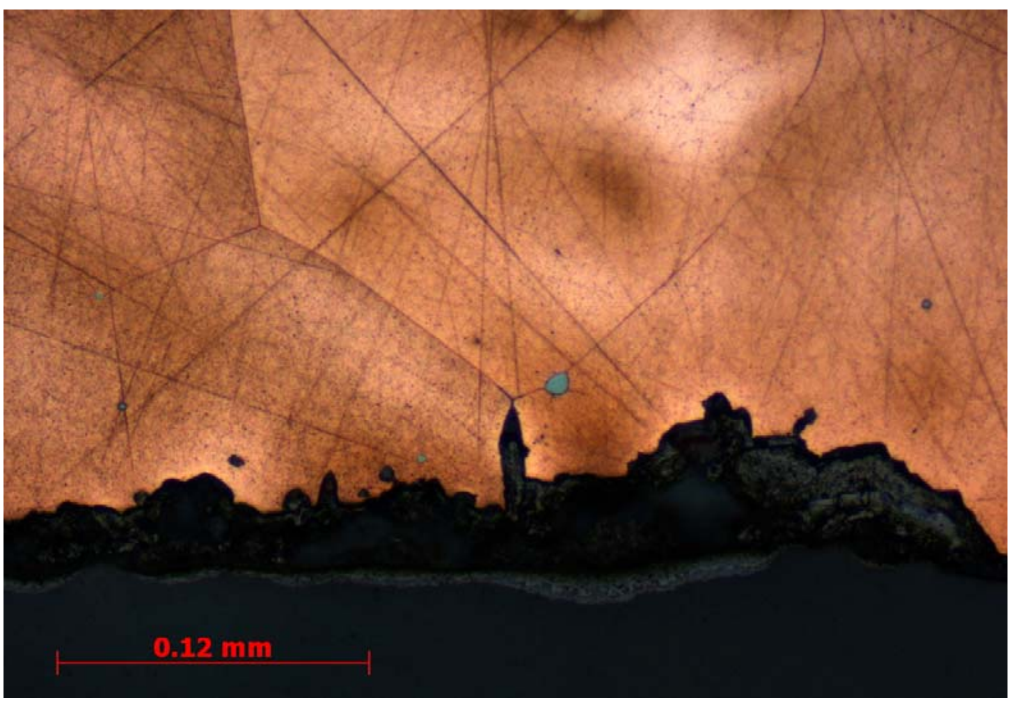

Figure 2: Sample LA 1243-1 showing large grains and surface corrosion. The small light blue inclusions are copper sulfides which form at the grain boundaries.

Prills

Prills are small, round balls of copper which can form during either the smelting process or the casting process. During casting, molten copper may bounce away from open molds and cool while traveling through the air. This action causes the metal to form into circular balls or prills, which typically fall to the ground and are found surrounding the metal casting area. Alternatively, if there is any wax remaining in the mold a violent reaction can occur, causing the molten metal to spurt out of the mold's pouring reservoir. This can also result in the creation of prills which can likewise be recovered archaeologically around the casting area. The nine prills found thus far in the Spanish Church Zone at Lamanai range from approximately 2-5 mm in diameter; those that are larger in size were ideal for use as bell clappers. In order to investigate the metallurgy of prills one must mount the entire prill. Since this was deemed to be too detrimental to the artifacts only two samples (see Figure 3) were chosen for microstructural and chemical analysis (LA 2081-2 and LA 2909-6).

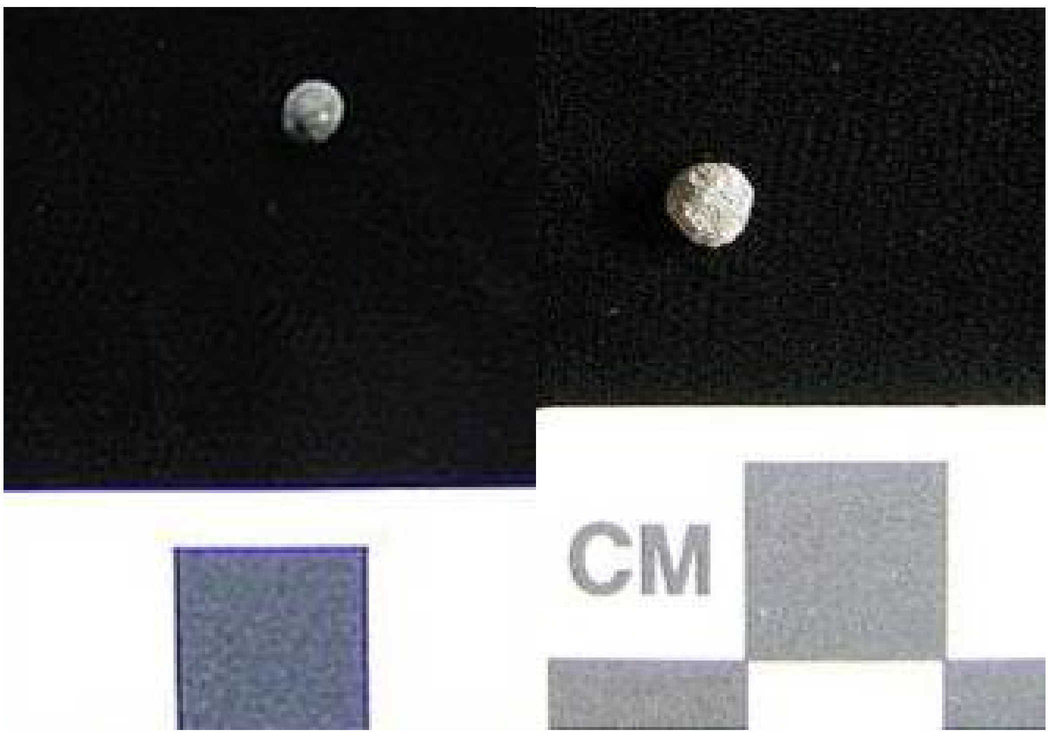

Figure 3: "Prills" investigated for microstructure and chemistry. Specimens LA 2909-6 (left) and LA 2081-2 (right).

Prill Microstructure

Copper prills are expected to have a specific microstructure based on their formation history. The microstructure should be a core dendritic with chill crystals at the surface of the prill and a relatively small grain structure (Figure 4). As expected, several of the prills we investigated showed this exact feature. LA 2909-6 is large grained, dendritic as-cast state with a fairly fast cooling rate allowing for some coring on the dendrites. Under cross polars copper oxide inclusions are visible due to the heavy amount of oxygenation during cooling.

In one unique case, LA 2081-2 (Figure 3), an entirely different microstructure was observed. For this one “prill” the microstructure shows evidence of heavy cold working. The grains are distorted, there are many working lines, and a clear indication of a fold indicative of a major reshaping of the metal exists (Figure 4). Initiation of corrosion is evident at the object’s weakest point, in the crack or fold with cuprite and malachite intergrowth. What originally appeared to be a prill appears now to represent a manufactured bell clapper. At this point in time it is impossible to determine whether this particular clapper was produced at Lamanai or arrived on site already in functional use.

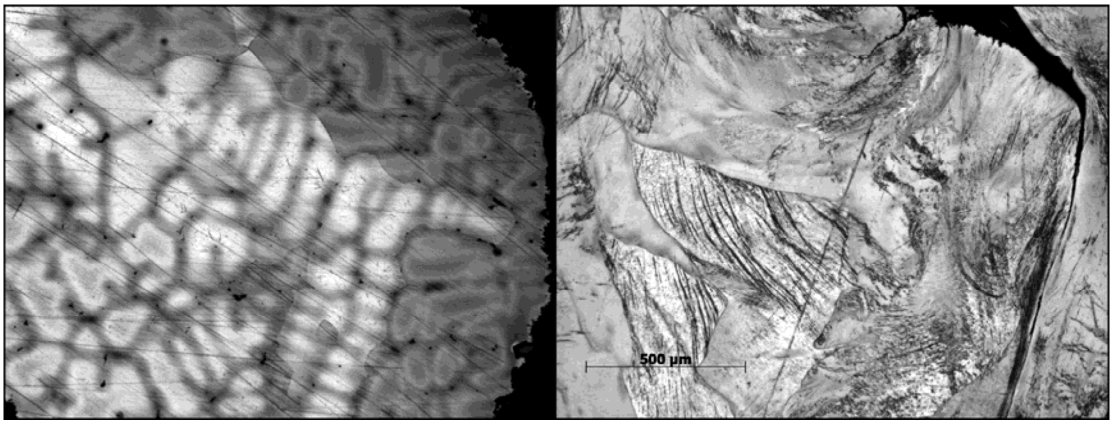

Figure 4: On the left (LA 2909-6) is a normal prill showing classic dendritic coring caused by fast cooling. On the right (LA 2081-2) is the formed bell clapper showing intense working with distorted slip lines, and a prominent fold in the metal to the right.

Prill Chemistry

The chemical composition of the prill and clapper are indicative of recycling. The high traces of Sn (0.5 and 0.4), As (0.7 and 0.5), and Ag (0.1 and 0.2) for LA 2909-6 and LA 2081-2 respectively, likely derive from the mixing of higher alloy artifacts (i.e. copper tin or copper arsenic alloyed artifacts) with more pure copper artifacts (see Table 2). The chemistry in association with the artifacts themselves and in conjunction with how prills are formed is strong evidence for a local recycling workshop at Lamanai.

			Chemical components						
Artifact Number	**Artifact type**	**Area sampled**	***Cu***	***Sn***	***As***	***Fe***	***Ag***	***Pb***	***S***
LA 2909-6	Prill	Body	99.1	0.3		0.5	0.1		
		Body	98.1	0.6	0.7	0.4	0.2		
		Avg Body	98.6	0.5	0.7	0.4	0.1		
		Inclusion	86.0	0.3		2.1			11.6
		Inclusion	44.6			0.5		54.9	
LA 2081-2	bell clapper/’prill’	Body	98.4	0.4	0.5	0.3	0.2		
		Body	98.2	0.5	0.5	0.3	0.3		
		Avg Body	98.3	0.4	0.5	0.3	0.2		

Table 2: Chemistry of copper prill LA 2909-6 and clapper LA 2081-2. Both have compositions indicative of remelted mixtures of more pure copper objects with alloyed objects.

Sheet metal

Several smaller samples of sheet metal have been found in recent years at Lamanai. Sheet metal production is rare in the Maya world and appears to have entailed a complicated manufacturing process involving multiple stages of hammering to flatten the metal as well as annealing to reduce brittleness and increase ductility. Three additional sheet metal samples have been investigated since the initial report (Simmons 2005). These are LA 1241-1, LA 2909-7, and LA 2924-12.

Sheet Metal Microstructure

The expected microstructure of sheet metal typically shows small equiaxed grains which typically are left in a worked stage showing working lines and bent annealing twins. In addition, any inclusions in the metal should be elongated and stretched out across the direction of flattening. Metal fragment LA 2924-12 shows these features showing flattened, mottled grains with elongated stretchers clearly visible in the SEM-BSE image (Figure 5). LA 2909-7 is a slightly thicker piece of metal. Under optical microscopy porosity shows no signs of working and has a dendritic structure with heavy porosity (Figure 6). Cuprite corrosion has formed at the center pores. This sample is more likely a thick blob that landed on the ground during casting, similar to forming of prills but a much heavier blob of metal that did not solidify until landing on the ground. Sample LA 1241-1 shows extensive working with small equiaxed grains, working lines and distorted annealing twins (Figure 7).

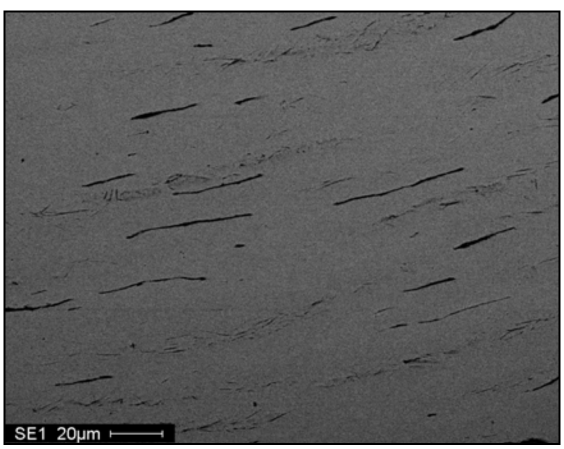

Figure 5: SEM-BSE image of LA 2924-12 showing elongated stringers (black) formed from extensive hammering and reduction in the metal's thickness.

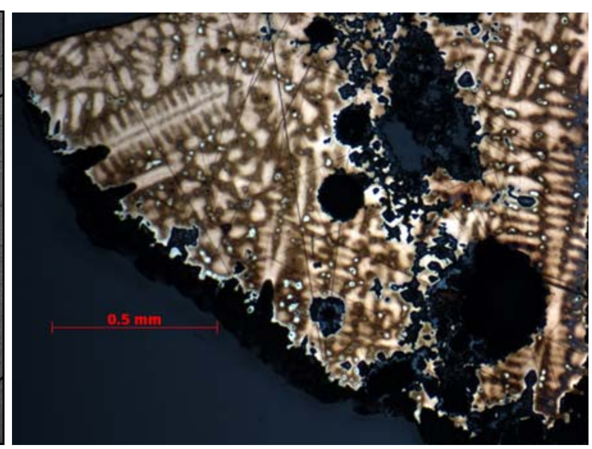

Figure 6: Thicker metal fragments LA 2909-7 showing a clear dentritic structure with heavy porosity.

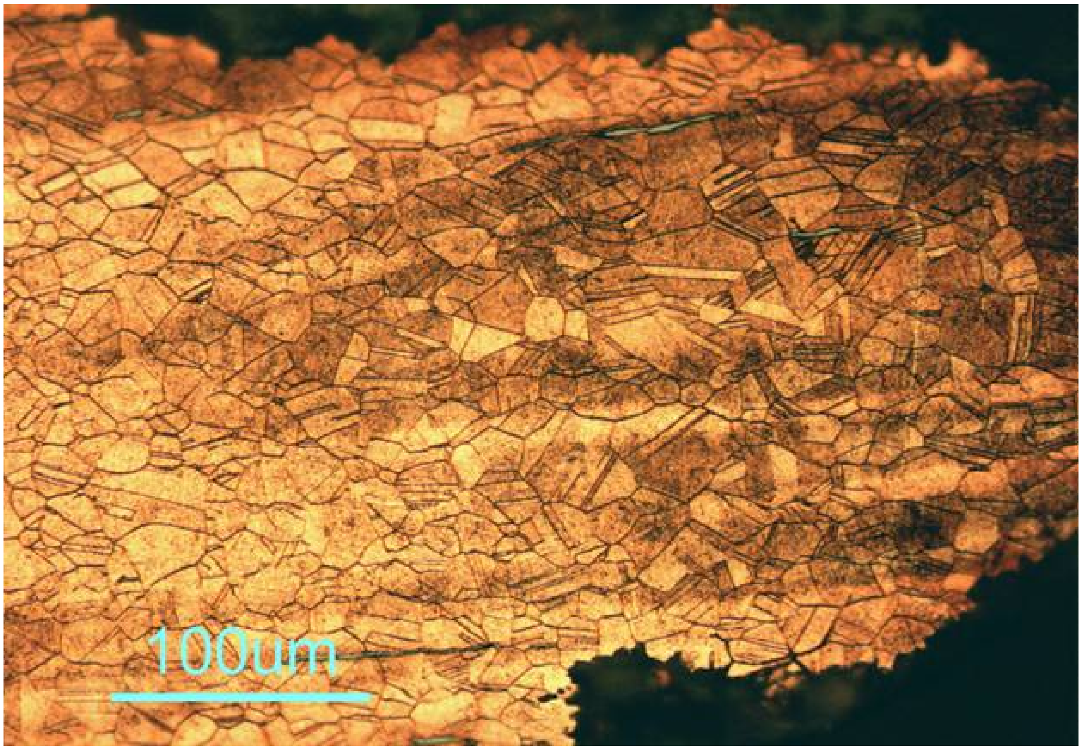

Figure 7: Exiaqued grains from LA 1241-1 showing heavily distorted annealing twins and working lines. Elongated inclusions are clearly seen in the upper right part on the micrograph.

Sheet Metal Chemistry

The composition of samples LA 1134-1 and LA 2909-7 are fairly similar in that their bulk chemistry is rather pure copper with traces of Sn, As, Fe, and Ag (see Table 3).

			Chemical composition							
Artifact number	**Artifact type**	**Area sampled**	***Cu***	***Sn***	***As***	***Fe***	***Ag***	***Pb***	***S***	***Se***
LA 1134-1	sheet fragment	Body	99.4	0.3		0.4				
LA 2909-7	sheet metal	Body	98.5	0.3	0.6	0.2	0.5			
		Body	98.1	0.3	0.9	0.3	0.4			
		Avg body	98.3	0.3	0.8	0.3	0.4			
		Inclusion	50.2					49.8		
		Inclusion	87.7						9.2	3.1
LA 2924-12	sheet metal	Body	95.4	0.1	4.0	0.5	0.1			
		Body	95.7	0.2	3.5	0.4	0.3			
		Avg body	95.5	0.1	3.7	0.4	0.2			

Table 3: Chemical compositions by SEM-EDS showing relatively pure copper for LA 1134-1 and LA 2909-7. LA 2909-7 does have lead inclusions (see Figure 9 below). Sample LA 2924-12 is a copper arsenic alloy.

LA 2909-7 does have clear lead inclusions as seen in an SEM-BSE image (see Figure 9). This sample was investigated further with concentration mapping done (see Figure 10) which revealed a complex compositional region showing increased amounts of Sn, As, and Pb. This sample does not resemble a recycled metal which would be more homogeneous in composition, and begs to question how such a complex compositional artifact arrived at Lamanai. LA 2924-12 is a clear copper arsenic alloy with an average arsenic content over 3.5 wt%. This is an original sheet fragment and does not come from recycled metal (see Figure 8).

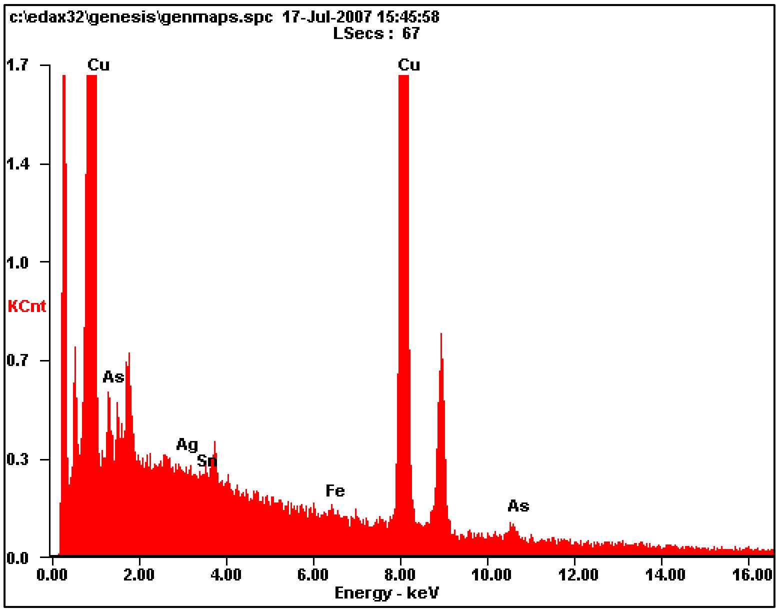

Figure 8: SEM spectrum showing high concentration of Cu and As with traces of Ag and Fe.

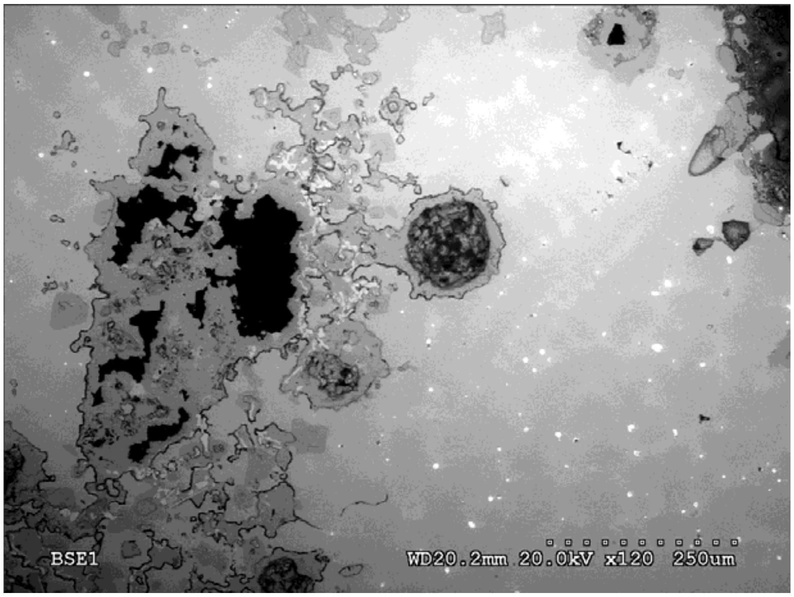

Figure 9: SEM-BSE image of LA 2909-7 showing a complex compositional structure. The bright dots are lead rich inclusions while the area surrounding the porosity (darker grey) is a complex mixture of tin, arsenic, and lead (Figure 10).

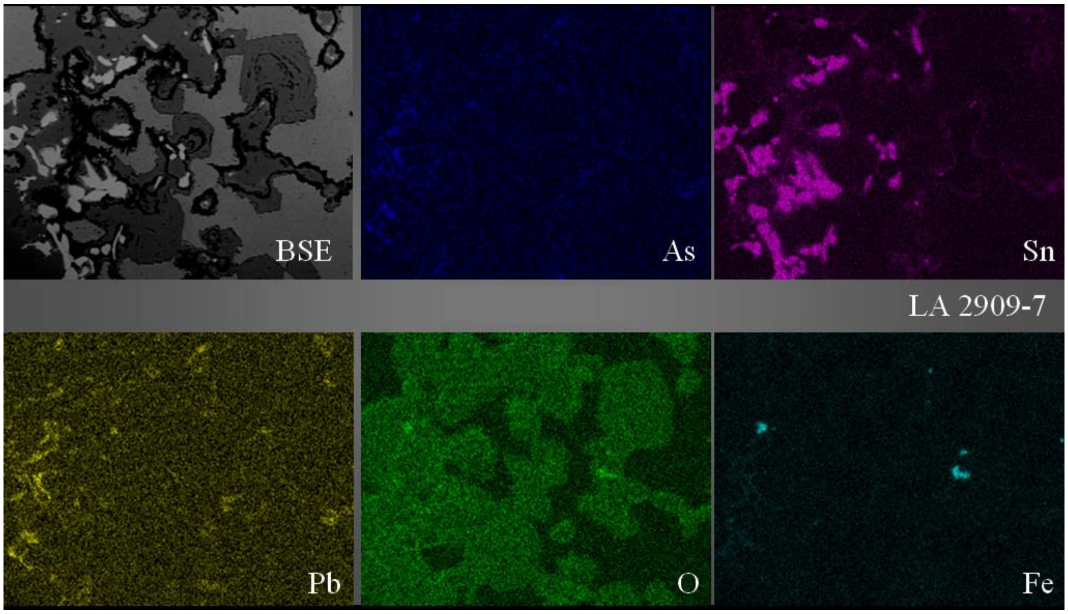

Figure 10: Compositional map of LA 2909-7 showing the varied distribution of As, Sn, Pb, O, and Fe.

Axes

Twenty-three axes and axe fragments have been found thus far at Lamanai (Simmons et al. 2008). Based on the limited ethnohistroic information currently available it appears that axes were produced by pouring molten metal into an open-shaped axe mold. The Florentine Codex shows a Mesoamerican metalsmith casting a metal axe into an opencast mold (Sahagún 1959:Folio 796). These castings, typically called blanks, needed to be heavily worked to achieve their final form. In many cases, such blanks have lips which form when the poured metal extends over the edges of the mold. These lips can be hammered back or filed to achieve the final axe shape.

The process of hammering and sharpening the bit edge of the blade increases the hardness of the metal but at the same time decreases the metal's ductility (Rothenberg et al. 1978). It would therefore be important for the metalsmith to occasionally anneal the object and re-crystallize the metal, which would restore its ductility (malleability) and decrease its hardness or brittleness. This process would leave a microstructure similar to that of the sheet metal, with small equiaxed grains, annealing twins, and if hammered into final shape, distorted twins and working lines (see Figure 11 for example).

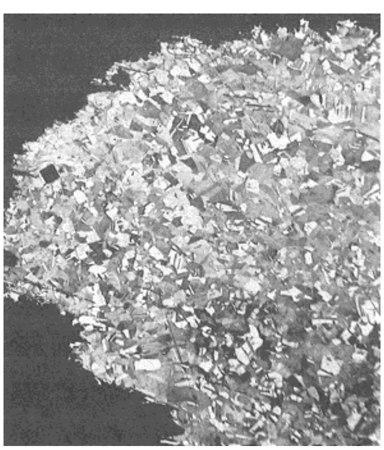

Figure 11: From Holser 1994 fig 3.14; showing typically axe blade microstructure with small equiaxed grains, and working lines and bent annealing twins.

Axe Microstructure

Examination of the microstructure of the blade of axe LA 2790-6 revealed a homogenous large grain structure with evidence of high porosity and heavy working near the tip of the blade (Figure 12). In addition, there was evidence for partial recrystallization of the metal. This may be due to either the axe being only partially annealed at lower than sufficient temperatures to allow for full recrystallization or the axe may have been partially hot worked. The back of this axe shows some minimal working and light annealing at the surface which would indicate only partial final shaping was done to complete this axe (Figure 13).

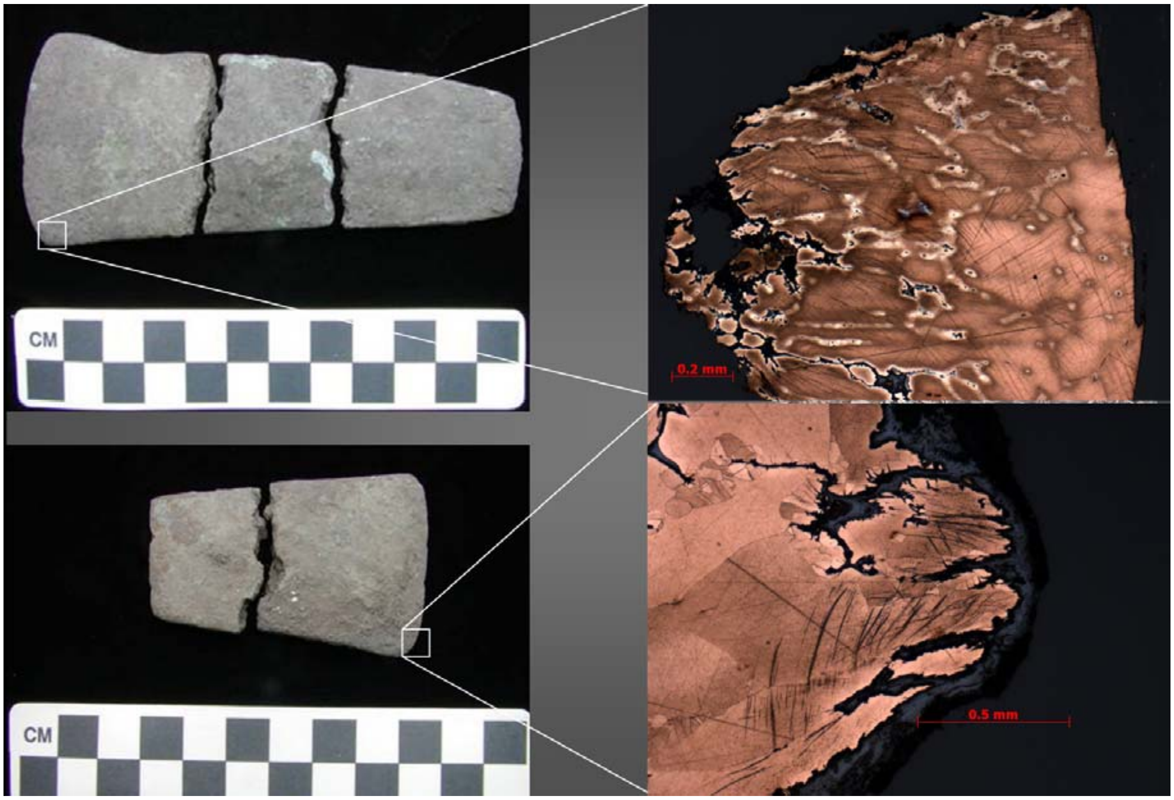

Figure 12: LA 2790-5 (blade of longer axe at top of image) and LA 2790-6 (blade of shorter axe at bottom of image) showing minimal annealing and heavy working lines near the blade tips. LA 2790-6 shows signs of partial recrystallization which may be due to under annealing (temperature) or hot working.

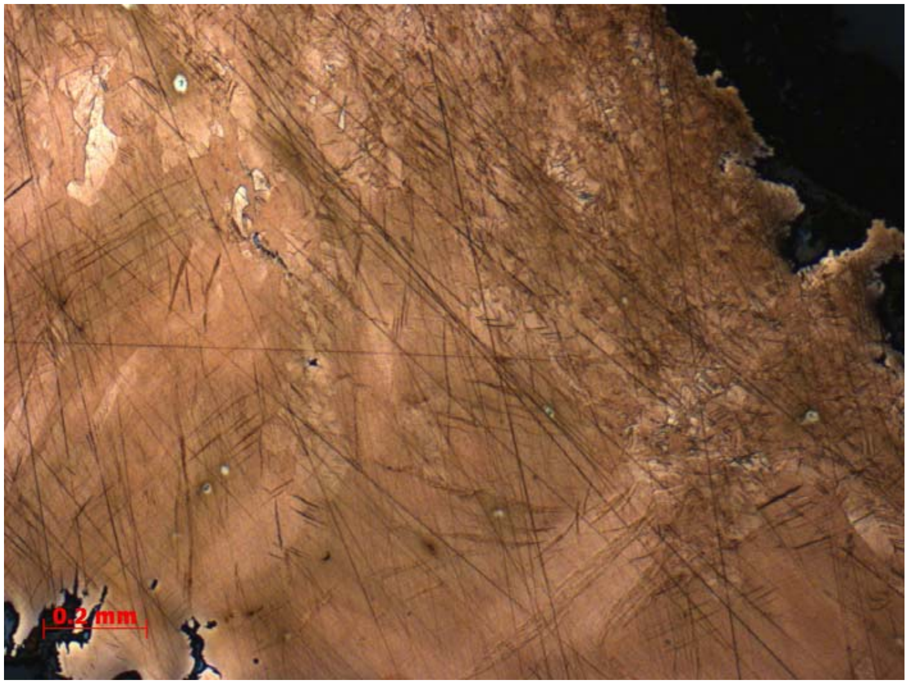

Figure 13: (LA 2790-7) Poll of the smaller axe showing grain distortion near the surface of the blade and minimal to no working at the central part of the blade. This is likely due to minimal final shaping of the axe by hammering.

Axe blade LA 2970-5 shows similar minimal working of the blade without repeated annealing and working. Heavy working lines near the tip may be from use or exclusively from final shaping (Figure 12). Close examination of the back of this longer axe (LA 2970-3) revealed additional information on Maya metalworking technology at Lamanai. Removal of some of the corrosion from the surface of this artifact revealed a roughly round-shaped, raised area located very close to the poll or haft end of the axe (Figure 14).

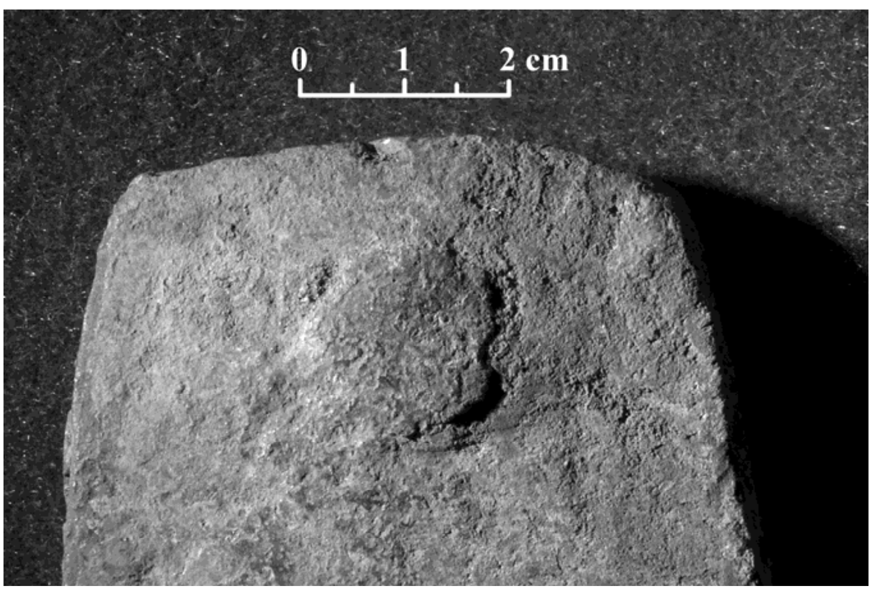

Figure 14: Pole of axe LA 2790-3 showing the remnants of a down sprue after cleaning. Photo courtesy of Dan Kushel.

Although no casting molds have yet been found at Lamanai the presence of this particular production feature on axe LA 2790-3 provides compelling evidence that some copper objects were most likely made in a bivalve or lost wax mold rather than being open cast. Since the Maya well understood the lost wax casting process (Hosler 1994) it is likely that the same technology was used to produce these axes. A mold was likely formed around a blank in wax, coated in clay, heated to remove the wax and filled with molten copper. Removal of the down sprue (similar to a funnel) would leave a small protrusion on the surface of the axe similar to the one seen in Figure 14. This is the first recorded occurrence of Maya copper axes being made in a bivalve molds.

Axe Chemistry

The chemical composition of the axes investigated reveals two separate production process (Table 4). The axe fragment LA 2790-5 (Figure 12) has a complex copper alloy of tin (1.5%) and arsenic (1.4%) as does axe fragment LA 1153-1 with 1.2% Sn and 1.0% As. Even though the alloy composition appears significant, these levels are almost certainly related to re-melting of higher alloyed metals as discussed by Hosler (1994). As suggested by microstructural analysis, this alloy composition would benefit the functionality of the axe by increasing the hardness of the metal, allowing for a sharper edge with greater longevity.

			Chemical composition								
Artifact Number	**Axe description**	**Area sampled**	***Cu***	***Sn***	***As***	***Fe***	***Ag***	***Pb***	***S***	***Se***	***Ni***
LA 1149-1	pig or axe/chisel blank	Body	96.5	1.0	1.3	0.3	0.5				0.4
		Body	97.7	0.6	0.7	0.4	0.4				0.2
		Avg body	97.1	0.8	1.0	0.4	0.4				0.3
		Inclusion	86.5	1.3		0.4		11.8			
		Inclusion	91.6	0.6		0.4	0.6		6.8		
LA 2790-5	Blade section long axe	Body	95.7	1.7	1.7	0.4	0.6				
		Body	96.4	1.4	1.2	0.3	0.6				
		Avg body	96.0	1.5	1.4	0.3	0.6				
		Inclusion	70.4		0.4	0.4	17.5	5.4		5.8	
LA 2790-7	Back section short axe	Body	98.5	0.3	0.6	0.2	0.5				
		Body	98.1	0.3	0.9	0.3	0.4				
		Avg body	98.3	0.3	0.8	0.3	0.4				
		Inclusion	50.2					49.8			
		Inclusion	87.7						9.2	3.1	
LA 2791-1	Axe fragment	Body	98.0		1.2	0.3	0.5				
		Body	98.7		0.6	0.3	0.4				
		Avg body	98.3		0.9	0.3	0.5				
		Inclusion	51.6	0.3		0.5		47.6			
LA 1153-1	Axe fragment	Body	96.7	1.6	1.1	0.2	0.3				
		Body	97.6	1.1	1.0	0.3	0.2				
		Body	97.5	1.0	0.8	0.3	0.3				
		Avg body	97.2	1.2	1.0	0.3	0.3				

Table 4: Chemical composition for several axes by SEM-EDS. Two main groups are seen; 1 pure copper axes and 2 low alloys of Sn and As.

Axe fragment LA 2790-7 has a very pure copper composition as does axe fragment LA 2791-1. The slightly higher lever of arsenic (0.8%) in axe LA 2790-7 likely resulted from the co-melting of pure copper objects with alloyed arsenic-rich copper objects, some of which may have been imported to the site in Early Postclassic times. This closely matches observed characteristics of other copper artifacts from Lamanai (Shugar and Simmons 2008).

Reservoirs ("ingots")

The two artifacts seen below in Figure 15, LA 2790-1 and LA 2790-4, were initially interpreted as ingots based on the characteristics of previously recovered artifacts of similar size and shape found at Lamanai (see Figure 16). It was assumed that these objects were produced as ingots for transport to re-melt and cast new objects. Upon closer inspection, these objects clearly match what should be termed "casting reservoirs."

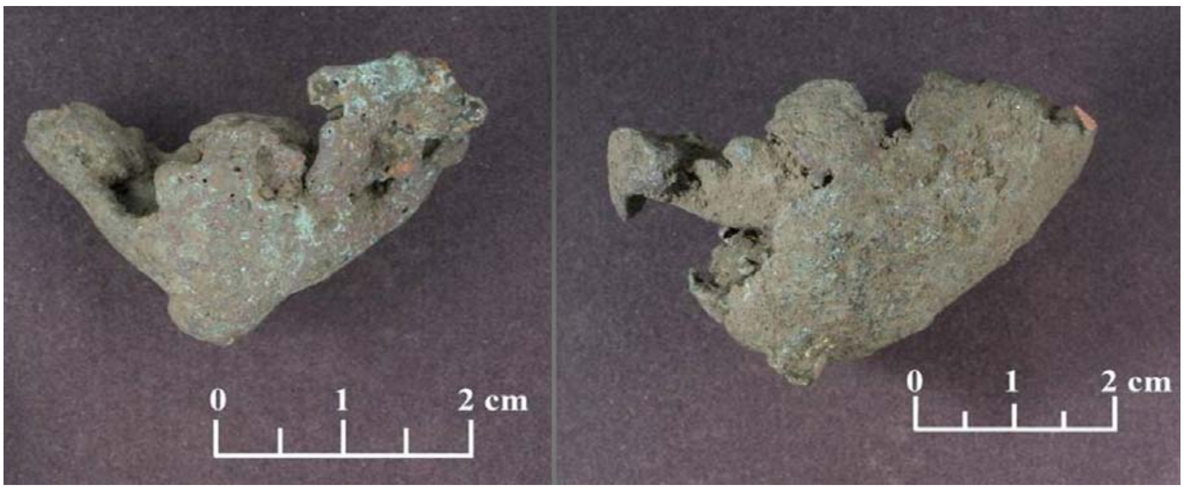

Figure 15: LA 2790-1 and LA 2790-4. These two previously termed 'ingots' are more likely pouring reservoirs from lost wax castings. Photo courtesy of Dan Kushel.

Figure 16: Samples of copper ingots or pigs. These might also represent poring reservoirs with down sprue remnants still attached.

These reservoirs are built into a lost wax cast mold and feed molten metal into the down sprue, which in turn fills the intended object to be cast (see Figure 17). Once this lost wax object has been formed the surrounding clay is broken away. Then the reservoir, down sprue, and the cast object are separated from one another. Removal of the down sprue from the reservoir would often leave a small protrusion on the reservoir surface similar to the protrusions observed on axe fragments and bell loops. Typically, these reservoirs could be used as a type of ingot or mass of raw material to be melted and cast into new objects.

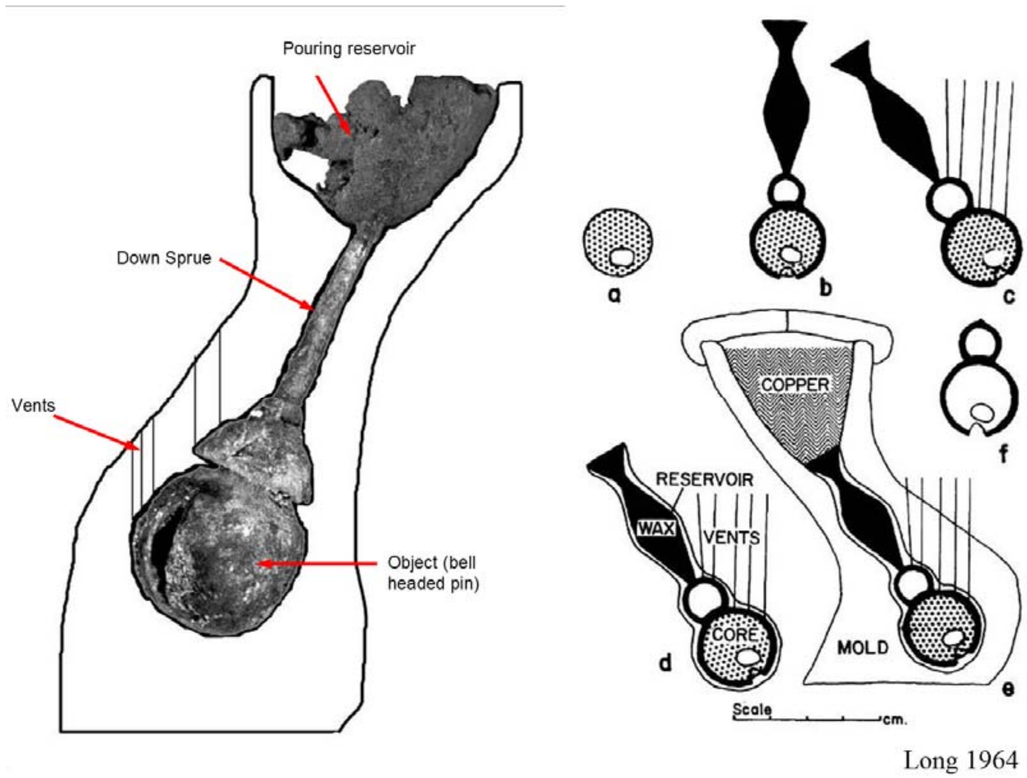

Figure 17: schematic of lost wax casting. On right, Long's (1964) description of the process. On the left, an example of LA 2790-4 with LA 91-1, a bell-headed pin.

Reservoir Microstructure

Both samples (LA 2790-1 and LA 2790-4) have extensive copper oxide inclusions which under cross polarizing light appear bright red. This extensive copper oxide environment is expected in an oxygen-rich environment, as is the case in an open casting reservoir. The grain formation is large and there are few annealing twins near the edges. These are most likely due to the sample being hammered or struck to separate it from the down sprue. There is no evidence for cold working in either sample. Reservoir LA 2790-4 has some inclusions at grain boundaries that represent copper sulfides.

Reservoir Chemistry

The two reservoirs have varied chemical compositions (see Table 5). The material observed in LA 2790-1 is a pure copper alloy with trace amounts of Sn. The limited inclusions in the metal are Sn rich. The material in LA 2790-4 is more complex in composition, more closely resembling recycled metals having both Sn and As. The inclusions are Pb rich and copper sulfides are present.

			Chemical composition								
Artifact No.	**Reservoirs**	**Area sampled**	***Cu***	***Sn***	***As***	***Fe***	***Ag***	***Pb***	***S***	***Se***	***Bi***
LA 2790-4	large reservoir	Body	98.2	0.8	0.7	0.3					
		Body	98.6	0.5	0.6	0.2					
		Body	95.5	2.9	1.5	0.2					
		Body	98.6	0.3	0.5	0.3	0.3				
		Body	98.6	0.4	0.5	0.2	0.3				
		Body	96.7	1.6	1.4	0.3					
		Avg body	97.7	1.1	0.9	0.2	0.3				
		Inclusion	86.8	0.5		0.3	0.4		9.8	2.2	
		Inclusion	88.7						11.3		
		Inclusion	43.6				1.9	19.7			30.7
LA 2790-1	small reservoir	Body	99.5	0.3		0.2					
		Body	99.2	0.3		0.3					
		Avg body	99.3	0.3		0.2					
		Inclusion	50.9	48.3		0.5					

Table 5: Chemical composition of the two casting reservoirs by SEM-EDS.

Needles and points

To date there have been 10 needles, 5 fishhooks, 2 pins, 2 pin heads, 2 pin tips, 2 bell-headed pins (one shown in Figure 17) found at Lamanai. These utilitarian artifacts are made by hammering out pieces of metal into longer shapes with rounded points. The process can be extensive and leave signature microstructures of heavy working and flow in one direction, very small equiaxed grains, heavy distortion to annealing twins as well as widespread working lines. These artifacts could also be produced in another way that has not yet been explored.

When lost wax casting, one has to remove the object from the down sprue. The remaining down sprue and casting reservoir could later be recycled and melted to produce other objects. But we have just seen several casting reservoirs without their attached down sprues (Figures 15, 16 and 17). If the down sprues were detached from both the object and the casting reservoir they would make excellent blanks for producing pointed objects of various types. In addition, we were able to record how the eye loops were produced with the needles from Lamanai. Several eye loop types have been recorded (Figure 18) and include a tucked type loop, a flap type loop and a punched type loop (also see Hosler 1994).

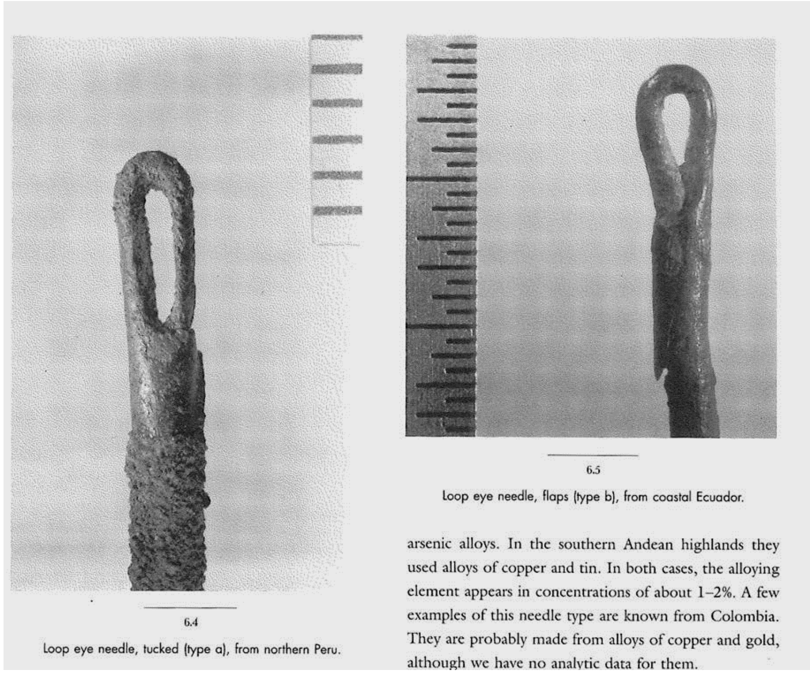

Figure 18: Examples of different eye loop construction. On the left is a tucked design from northern Peru and on the left is a flap type from Ecuador (Hosler 1994:175:images 6.4,6.5).

Two of the more complete needles in this assemblage show two of these techniques being used, the flap type and the punch type (Figure 19).

Figure 19: Two different eye loop types from needles found at Lamanai. On the left is a flap type design and on the right is a punch type (Photo courtesy of Dan Kushel).

For this investigation, two needles (LA 1580-18, and LA 1581-25) and a fish hook (LA 1575-2) were investigated for their microstructure and chemistry.

Needle and Fish hook Microstructure:

As expected the microstructures of the two needles and the fish hook all show extensive working and annealing. An excellent example of this is seen from the tip of one of the needles, LA 1581-25, which shows small equiaxed grains with heavily distorted annealing twins and many working lines, indicating the needle point was left in a final worked state (Figure 20).

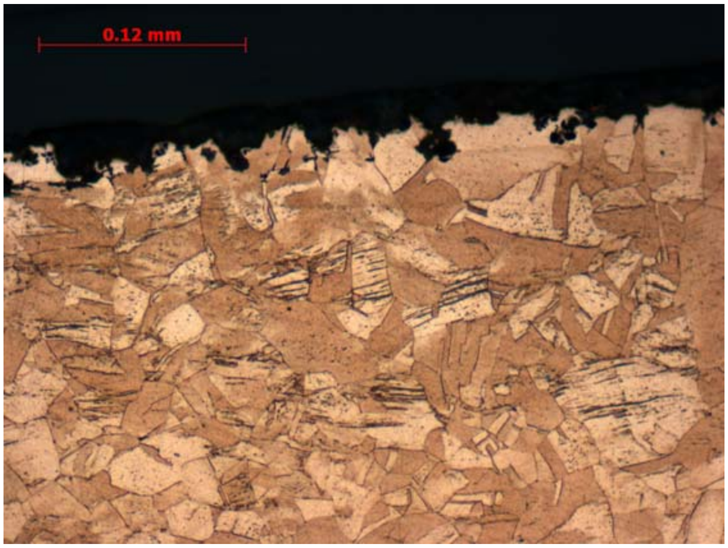

Figure 20: Needle LA 1581-25 showing small equiaxed grains with deformed annealing twins and working lines. Heavy annealing would result in giving the needle a stronger, harder point.

What was most interesting was investigating the eyeloop of sample LA 1580-18. The microstructure shows fine equiaxed grains with extensive annealing twins but no evidence of final working (see Figure 21).

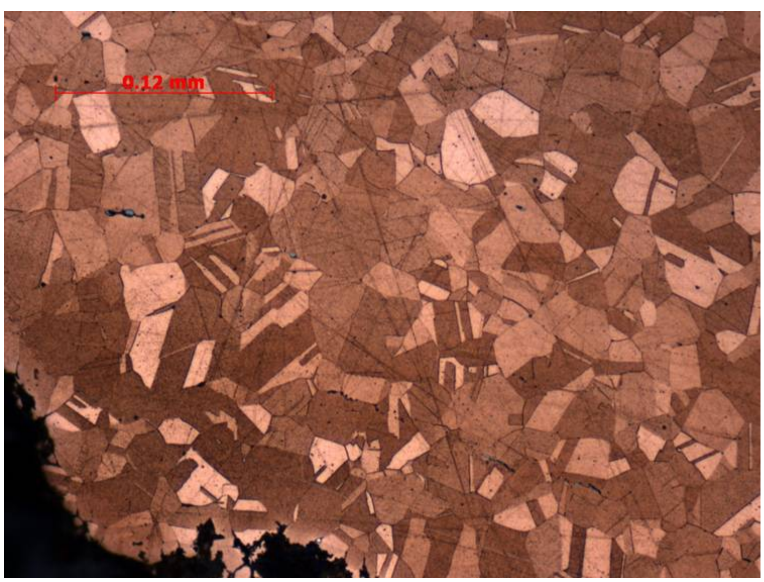

Figure 21: LA 1580-18: fine equiaxed grain structure with extensive annealing twins. No evidence of final working indicates that the last effective stage on this region of the point was annealing.

This is likely due to the fact the eye loop was made prior to the forming on the fine point. If this was the case, the annealing and working to shape the eye loop would reveal the microstructure that we see now but would likely have been finished with the final mechanical working of the eye loop. For the second part of a points' construction the tip would be hammered and worked. The process of repeatedly working and annealing the tip, would ultimately anneal the eyeloop leaving it as witnessed today.

Needle and Fish hook Chemistry

The chemical composition of the needles falls into two groups (see Table 6). First is a copper arsenic alloy. The fishhook LA 1575-2 has 1.8% As which is rather high in comparison to other utilitarian objects found. There are traces of Sn, Ag, and Fe but there is no indication that this composition represents a recycling of metals to produce this artifact. The second group is a relatively pure copper with approximately 0.4 % Sn, 0.5 % As and 0.5 % Ag. This composition is consistent with a recycling of metals with higher concentrations of Sn and As, respectively.

			Chemical Composition								
Artifact Numbers	**Artifact types**	**Area sampled**	***Cu***	***Sn***	***As***	***Fe***	***Ag***	***Pb***	***S***	***Bi***	***Se***
LA 1580-18	needle fragment	Body	98.0	0.5	0.5	0.3	0.7				
		Body	99.0	0.3		0.3	0.4				
		Avg Body	98.5	0.4	0.5	0.3	0.6				
		Inclusion	66.9			0.4	0.5	18.5		13.7	
		Inclusion	83.1	16.3		0.4	0.2				
LA 1581-25	needle	Body	97.9	0.4	0.8	0.2	0.5				
		Body	98.6	0.3	0.5	0.3	0.3				
		Avg Body	98.2	0.3	0.6	0.2	0.4				
		Inclusion	35.3			0.3	0.6	51.5		12.2	
LA 1575-2	fish hook	1575-2	96.9	0.7	1.7	0.3	0.4				
		1575-2	97.1	0.4	1.9	0.4	0.3				
		Avg Body	97.0	0.6	1.8	0.4	0.3				
		1575-2 inc	85.5			0.6			6.5		6.7

Table 6: Chemical composition of points by SEM-EDS.

Conclusions

The results of the chemical compositional and microstructural analysis reported here strengthen the argument for the localized re-melting and casting of copper based artifacts at Lamanai. Redefining specific ingots as casting reservoirs in conjunction with the presence of copper prills is a strong argument for localized recycling of metal artifacts. In addition, the variety of artifacts that show chemical compositions indicative of recycling fit well with previously observed accounts (Hosler 1994). What are needed now are more directed excavations to find additional specific evidence for localized production. Artifact types indicative of localized production would include more casting debris including prills, spills, mould fragments and perhaps most relevant, ceramic crucibles. Handheld XRF may be be used on site to help direct excavation and locate areas which may have higher concentrations of copper.

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Style and Identity: The Ancient Maya Ceramics of Lamanai, Belize by James J. Aimers

Abstract

My research during the summer of 2007 involved a stylistic analysis of ceramics from Lamanai. With assistance, I examined about 52 000 pottery sherds, mostly from the Postclassic period (ca. AD. 900- 1450). We also examined about 300 full or partial vessels. This large sample is already providing many insights into the local and intereregional role of the site. The research was also a test of a ceramic classification method that I have been developing for several years. Hopefully, in the long term this method will allow a more detailed and systematic discussion of interaction between sites and regions based on ceramic data. This research is directed toward an assessment of Lamanai's political, economic, and religious role in the Postclassic Maya world.

Account of Research

As planned, I conducted approximately 10 weeks of research from June 11 to August 19, 2007. I brought one recent graduate from the Institute of Archaeology, UCL (Stephen Merkel) as my research assistant. I also hired several local workers as assistants (George Melchor, Federico Tillett, Areli Ramos, Jorge Vasquez, Oscar Ruano, and Noel Vasquez). I have included copies of letters of recommendation for these people that I have also sent in an email message, and these letters note the duties and skills of each of these people. I was very pleased with all of their work.

During the field season we examined over 52 000 pieces of pottery and recorded approximately 500 000 qualitative observations and measurements. These were mostly from the Postclassic period, but I did examine sherds from an important Late Classic – Early Postclassic midden in order to understand the ceramics of the transition from Classic to Postclassic, and especially the Terminal Classic. All of these data were entered into a Microsoft Excel database in the evenings. We also took over 2100 digital photos of the ceramics. Overall, the research went very well and will form the basis of a number of planned articles, chapters, and books, some of which are already in preparation or in press. The season went smoothly and we accomplished more than I had originally planned.

Advances in Knowledge or Understanding Resulting from the Research

The research conducted last summer will advance knowledge in terms of theory, methodology, and basic culture-history. The Lamanai collection is the largest and most important collection of Postclassic ceramics in Belize, and one of the most important in the Maya region. This season I discovered that the collection is even larger than previously thought. For much of the season I worked alongside Dr. Linda Howie who, as you know, recently received SSHRC Canada funding for technological analysis of the ceramics (thin section petrography, neutron activation analysis, etc). My stylistic analysis along with Dr. Howie's ongoing work will produce comprehensive studies of the pottery of a sort that have not been attempted on this scale anywhere in the Maya area. Our research will investigate, problematize, and hopefully resolve a number of basic issues about pottery production and consumption at Lamanai, and these are relevant to all Maya pottery studies and to ceramic studies in other parts of the world. So, this summer's research allowed me to collect a very useful set of data.

In terms of methodology, this summer enabled me to test a version of type-variety classification that I believe will significantly facilitate the comparison of ceramics across broad areas without implicit and often untestable assumptions about where the ceramics were made. This sets the stage for classifications that more rigorously distinguish imports from locally-made, stylistically analogous ceramics. Interestingly, this methodological innovation has major repercussions for ceramic theory, as well as being a response to theoretical issues. For example, the method I used is clearer in indicating the direction of interaction between sites than standard methods, and this is already producing new theories and testable hypothesis about the nature of Postclassic Maya politics and economics (see below).

Findings from the 2007 season are helping to clarify the role of Lamanai in the Maya world after many southern lowland sites collapsed at the end of the Classic period around 900 AD. Pottery styles at Lamanai show that as sites to its south declined, Lamanai re-oriented its trade and interaction to newly emerging sites to the north. Despite this re-orientation, some southern pottery types—almost certainly imports-- continued to be present at Lamanai, suggesting that not all ties to the south were severed. I have also begun to assess the influence of the large site of Chichen Itza, thought by some to have been a conquest state in the Terminal Classic. Lamanai, surprisingly, showed virtually no ceramic connections to Chichen Itza. Instead, its alliances appear to have been with sites to the west of Chichen Itza, and along the east coast . In the Late Postclassic Lamanai shows strong and clear connections to the site of Mayapan to the northwest and I suspect that both of these sites prospered after the demise of Chichen Itza. There are indications that these connections have their roots in the Classic period. Thus, a picture of the site has emerged that shows it was interacting with sites across the peninsula yet it managed to avoid conquest by Chichen Itza—probably through strategic alliances, economic activity, and religious pilgrimage.

The great stylistic diversity I saw in ceramics from near the lagoon in particular strongly suggest that after the Classic Lamanai flourished as a cosmopolitan centre of trade and pilgrimage. Throughout the Postclassic period potters at Lamanai absorbed stylistic influences from as far away as the coast of Veracruz, yet there is unmistakable stylistic continuity through this 600 year period that argues against population change or invasion (as does other non-ceramic evidence). Detailed iconographic analysis of this rich corpus of ceramics will hopefully provide indications of how the people of Lamanai managed to occupy their site for about 3000 years until the Spanish arrived. Currently, trade and religion appear to be major factors as shown, for example, by depictions of the merchant god on funerary ceramics.

Dissemination of Results

The quantity of data collected this past summer will take months to organize and longer to analyse. I anticipate that it will take several years to fully convey in print the implications of my findings this year. The members of the Lamanai Archaeological Project will be submitting a general report on our 2007 research as a whole in the coming months. Some of my results will be published in a planned volume, to be edited by Dr. Elizabeth Graham and myself, tentatively titled *Lamanai Ceramic Methodology*, and a first chapter for that book is already completed. I have also submitted an article to *Mexicon* on the “Mayapán style” full-figure effigy censers (Chen Mul Modeled) from the Late Postclassic at Lamanai and elsewhere with Susan Milbrath, Carlos Peraza, and Lynda Folan. Much of the research will be published with Dr. Howie when her research is ready, as our work is complementary. Preliminary results will be presented at meetings and conferences.

Conclusions

Overall, the season was a great success. Because the sample is larger than I realized, there is still much more material that could be examined, but I am confident that valuable insights into ancient Maya life and cultural survival were gained in just 10 weeks. I'm looking forward to compiling and disseminating these data over the next several years. I am grateful to the Institute of Archaeology (Belize) for allowing me to conduct this research, and to the British Academy for funding it.

Pottery Production and Exchange in the Aftermath of the Maya Collapse: A Technological Study of Postclassic to Spanish Colonial Ceramics at Lamanai, Belize
by Linda Howie

Field Assistants: a) ceramic analysis and data collection - Jorge Vasquez, Oscar Ruano and Nadia Charest

b) geological prospection – Jorge Vasquez and Oscar Ruano

c) mapping – Merle Alfaro and Oscar Ruano (in consultation with Jorge Can)

Funding Body: Social Sciences and Humanities Research Council of Canada (Postdoctoral Fellowship)

University Affiliation: The University of Western Ontario, London, Ontario, Canada

Project Summary:

This research project investigates continuity and change in the manufacture, origins, use and deposition of pottery at Lamanai during the Postclassic to Spanish Colonial period (c. A.D.1050 - A.D.1535). A central aim of this research is to identify the kinds of factors and pressures, internal and external to the community that contributed to shaping local patterns of ceramic production and consumption at this time. Current models and understanding of Maya culture and society during the Postclassic period, which emphasize the central role of regional economic and political restructuring in shaping patterns in the production and consumption of material culture items, rely heavily on the ceramic record at different sites. These models, however, are based on an incomplete knowledge of the nature and potential significance of community-level variability in the ceramic record, as well as of the technology and origins of different stylistic (and typological) classes of pottery across time and space. Since detailed local and regional studies of the compositional and technological characteristics of Postclassic pottery are entirely absent, little is actually known about the origins of manufacture of different kinds of pottery, as well as the technical practices of the groups of potters who produced them.

The study adopts an approach to ceramic analysis that is targeted ultimately at illuminating the human behaviours and motivations that underlie patterns and variability in the Postclassic to Spanish Colonial ceramic record at Lamanai. It uses stages of the manufacturing process as a conceptual tool to facilitate the comparison of pottery vessels according to their raw materials, forming and decorative techniques and firing. The stylistic and technological characteristics and origins of the Lamanai pottery will be examined in detail using a combination of traditional methods of macroscopic analysis and scientific techniques, including thin section petrography (geological), neutron activation analysis (chemical) and scanning electron microscopy (structural and chemical). This physical examination of the pottery will be situated along a detailed study of ceramic depositional patterns within different domestic and ceremonial contexts, as well as the environmental and cultural setting within which the pottery was manufactured and used and deposited. This information will provide a framework within which to

situate and interpret the physical ceramic evidence, in order to reconstruct and characterize community-level patterns of ceramic production and consumption.

The new information generated by this study will provide important insight into the pottery-making practices of the Postclassic Maya, as well as trade and interaction in the Maya lowlands in the centuries following the ‘collapse’ of Classic period civilization. The analytical work proposed will generate a lasting comparative data base that can be used by future researchers and, for the first time, will enable conventional models of Postclassic Maya economic institutions to be tested using empirical evidence.

Summary of Fieldwork undertaken May-July 2007

Introduction

The fieldwork undertaken at Lamanai in 2007 constitutes the first of two phases of ceramic analysis that will be conducted on site. This research focuses on documenting and describing the macroscopic attributes of the different pottery comprising selected Postclassic to Spanish Colonial sherd assemblages according to visual characteristics of their form, surface treatment and decoration and pastes, as well as determining the range and frequency of the different stylistic and functional categories of pottery represented within these assemblages. A main objective was to establish groups of ‘like vessels’ based on stylistic and functional criteria and study stylistic and paste variability within these groups on the macroscopic level so that a sample of vessels representing the range of variation observed could be selected and sampled for petrographic and chemical analysis. These scientific techniques enable detailed examination of variability in vessel technology (how vessels were made) and provenance (where vessels were made), generating information essential to the reconstruction of patterns of ceramic production and consumption.

The analyst’s ability to ascribe provenance and to document and describe technical practices relating to raw material resource selection and their manipulation in the creation of the paste out of which pottery vessels are made depends heavily on a comprehensive understanding of the raw material resources available to local potters, both compositionally and geologically. This comparative baseline of information enables discrimination of vessels consistent and inconsistent with local clay deposits and rock formations, and aids the study and documentation of raw material processing techniques and paste recipes. A central component of the author’s work at Lamanai has been building a comparative data base of compositional information (chemical and petrographic) about local clays and rocks to enable this level of investigation into paste technologies. A second major component of the fieldwork undertaken at Lamanai this year, therefore, was the prospection of local geological environments and contexts not surveyed previously, for the identification and sampling of additional clay deposits and rock outcrops that might have been exploited by local potters. The focus of the geological survey was on sampling raw material resources that occur in three principal areas: 1.) in the vicinity of Barber Creek, which defines the northern boundary of the Lamanai Archaeological Reserve, 2.) in association with a fresh water spring situated south of the site, just inland from the New River Lagoon, and 3.) clayey soils that occur between Barber Creek and the Fireburn savannah (situated north of the site).

Pottery Collections Examined

The sherd assemblages analysed during the 2007 field season derive from three different excavation projects:

1.) clearing activities and excavations conducted by the Tourism Development Project (TDP) as part of the construction of the new Tourist Centre Area facilities at Lamanai (completed in 2003)

2.) excavations of Late Postclassic to Spanish Colonial house lots undertaken by Darcy Wiewall as part of her Ph.D. research (ongoing)

3.) 3.) clearing activities and excavations conducted by NICH in the vicinity of the Spanish churches as part of the restoration project completed in the spring 2007

In all cases, the sherd lots selected for detailed analysis were processed is the same manner and according to the same set of procedures. Detailed surface treatment, morphological and frequency data, however, were only collected for the Tourist Centre Area pottery and the Late Postclassic to Spanish Colonial house lot material. The underlying objectives of the analysis were to identify and describe the different stylistic and functional categories of vessels represented within each sherd assemblage, to determine their temporal association and to document variation in vessel surface treatment, morphological and macroscopic paste attributes for the different stylistic groups identified, within both individual lots of material and the different assemblages analysed. The analytical procedures employed, including the method used to sort/group the sherds, the categorical and metric attributes recorded and the way in which these attributes were recorded, follow the standard methodology developed by the author for ceramic studies focusing on variability in vessel technology and provenance (detailed in Howie 2005).

Once all the sherd lots had been examined, a sample of vessels capturing range of variation observed in the way of surface treatment, morphological and macroscopic paste attributes was selected for analysis using scientific techniques so that variation in vessel technology and provenance within and among the different pottery assemblages can be studied in detail. This sampling was conducted on an assemblage by assemblage basis, for each of the different archaeological contexts examined. The pottery assemblage associated with the two Spanish churches, however, was not sampled for further analysis since the lots proved to be temporally 'mixed' deposits (see below). A photographic catalogue of all of the sherds sampled for microscopic and chemical analysis (N=642) has been provided on the accompanying CD.

Tourist Centre Area Sherd Assemblages

The sherd lots analysed from the Tourist Centre Area are associated with three distinct structural and archaeological features that were identified during the Tourism Development Project's investigation and archaeological mitigation of the selected area of the site to be developed for tourism purposes. These features include: structure N11-30, a cobble surface feature situated just to the south of the Lamanai Visitor's Centre, and a sheet midden accumulation and associated subsurface pit features occurring in the vicinity of the Visitor's Centre restroom facilities (Figure 1). The sherd lots recovered from these different areas that were examined in the present study are listed in Figure 2.

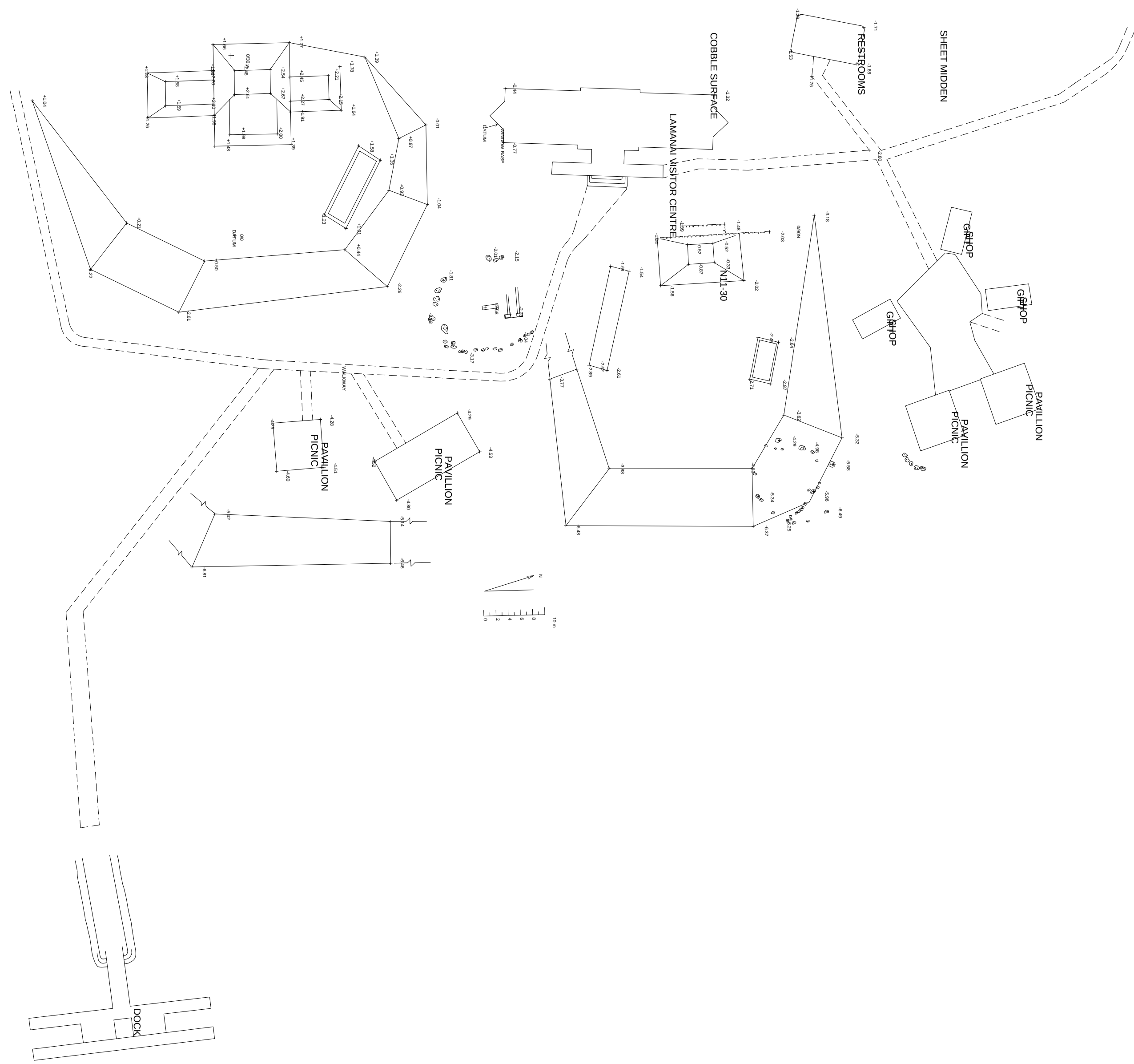

Figure 1: Map of the Tourist Centre Area showing the location of associated archaeological features and structures and modern buildings.

Structure/Cultural Feature	Associated Sherd Lots Analysed
Structure N11-30	LA1911, LA1912, LA1930, LA1931, LA1933, LA1935, LA1936, LA1937, LA1938, LA1943, LA1944, LA1945, LA1947, LA1952, LA1959
Cobble feature	LA1979, LA2051, LA2052, LA2048, LA2055, LA2053
Sheet midden and associated subsurface pit features	LA1969, LA1970, LA1971, LA1972, LA1973, LA1976

Figure 2: Sherds lots analysed from the Tourist Centre Area, listed by associated structure or cultural feature.

Structure N11-30

Structure N11-30 is a small structure of unknown function situated north east of the Lamanai Visitor's Centre, approximately 200m inland from the New River Lagoon. TDP excavations of this structure identified two construction phases as well as middden accumulations abutting the building's south west corner and east side (Graham and Howard 2002 a; 2002b).

Examination of the pottery deriving from structure N11-30, as well as the associated midden deposits, revealed a range of different serving and utilitarian wares and the presence of well-recognized stylistic types that are considered markers of the Terminal Classic, Early Postclassic, Middle Postclassic and Late Postclassic periods. The absence of Middle Classic and earlier stylistic types, even in the core fill of the earliest construction phase identified (e.g. lot LA1935), suggests that the first phase of construction could not have occurred earlier than the Late Classic period. In all of the lots examined, the earliest stylistic types are comparable to known pottery types that are typical of late Late Classic to Terminal Classic occupations in northern Belize (e.g. Achote Black pottery, red slipped and resist bichrome basal break dishes, polychrome and red to orange slipped rounded dishes, large storage jars with red-slipped rims, red ware storage jars with a ridge on the rim area and striated bodies). In addition, the repertoire of Late Classic to Terminal Classic stylistic types that were observed to occur together in different lots, is equivalent to that observed in presumably contemporaneous deposits found in other areas of the central precinct at Lamanai, such as the Ottawa Group elite complex and the midden abutting structure N10-27.

The structural remains associated with the earliest construction phase identified for N11-30 are abutted by midden deposit, which occurs on the building's south west corner (lots LA1944 and LA1945). The predominant stylistic types that occur in this deposit are well-recognized markers of late Late Classic to Terminal Classic period (e.g. Achote Black Group vessels, red slipped and bichrome basal break dishes and polychrome rounded dishes). A small quantity of Early Postclassic (e.g. Buk phase gouge-incised orange slipped vessels [Zakpah Orange Red Group]) and Middle Postclassic (Cib phase incised and plain red-slipped vessels comparable to Payil Red and Mama Red pottery) pottery, however, also occurs in the deposit. Based on the vessel styles represented and their frequency it would appear that accumulation/deposition of the midden primarily occurred during the late Late Classic to Terminal Classic Period, with only minor amounts of pottery being deposited in the area later in time.

The pottery assemblage recovered from the core of the second construction phase (e.g. lots LA1936 and LA1937) comprises a range of stylistic types that date to the Terminal Classic to Middle Postclassic period. Terminal Classic to Early Postclassic stylistic types, however, clearly dominates the assemblage. Late Postclassic and later stylistic types (e.g. Yglesias phase wide-mouth jars with groove incision on the rim area and associated utilitarian dish and bowl styles) are completely absent in these lots, but do occur in small quantities in the stratum of soil and cultural remains overlaying the structure, as well as in the possible sheet midden deposit abutting the structure on its east side (lot LA1959). This evidence suggests that the later structural modification of the building could have taken place as late as the Middle Postclassic period, but certainly not later. The occurrence of Late Postclassic pottery in the stratum overlying the architectural remains suggests the area was still in use in Late Postclassic times, although the structure itself had fallen into disuse or, at the very least, was no longer being activity maintained.

Cobble Feature

TDP investigations of the area to by impacted by the construction of the Lamanai Visitor's Centre led to the identification of an organized cobble surface that was interpreted as a house floor or some other living surface that likely constituted an exterior and probably formerly roofed surface that would have served a variety of functions related to households centered nearby – e.g. the plazuela group associated with structure N11-30 (Graham and Howard 2002 a; 2002b).

Examination of the pottery assemblage associated with the cobbled surface revealed a range of Postclassic serving and utilitarian ware pottery styles, with stylistic types considered typical of the Early, Middle and Late Postclassic periods of occupation at Lamanai. For example, serving ware vessels include Early Postclassic 'Buk' gouge-incised and plain orange-slipped vessels, including chalices and grater bowls (Zakpah Orange Red Group), Middle Postclassic 'Cib' incised and plain red slipped tripod bowls with cylindrical feet and pedestal-based jars (comparable to Payil Red), and Late Postclassic red-slipped tripod bowls with a notched medial ridge and conical, slit-vented feet. Also present are Yglesias phase unslipped wide-mouth jars with groove-incised bands on the rim area and associated utilitarian bowl, plate and dish forms typical of the Late Postclassic to Spanish Colonial periods at Lamanai. As the TDP excavations of the cobble surface did not produce any material culture items of European origin, such as olive jar fragments or Majolica, however, there is some evidence that area might have fallen into disuse, or was abandoned by the Spanish Colonial period. Based on the ceramic evidence, the earliest possible date for the construction of the cobble surface is the Early Postclassic period.

Sheet Midden and Associated Subsurface Pit Features

As part of the construction of the Visitor's Centre restroom facilities, three 1.5m x 6m trenches were dug to bed rock to serve as soak away ditches. These trenches are oriented in a north-south direction and are situated between the restroom building and the main road into the archaeological reserve. At the time of their excavation, a cross sectional plan of the west side of the westernmost trench (that situated closest to the main access road) was drawn and clay samples were taken from three different subsurface soil horizons (Figure 3). The decision to document the trench profile was based on the occurrence of a thick black clayey soil horizon

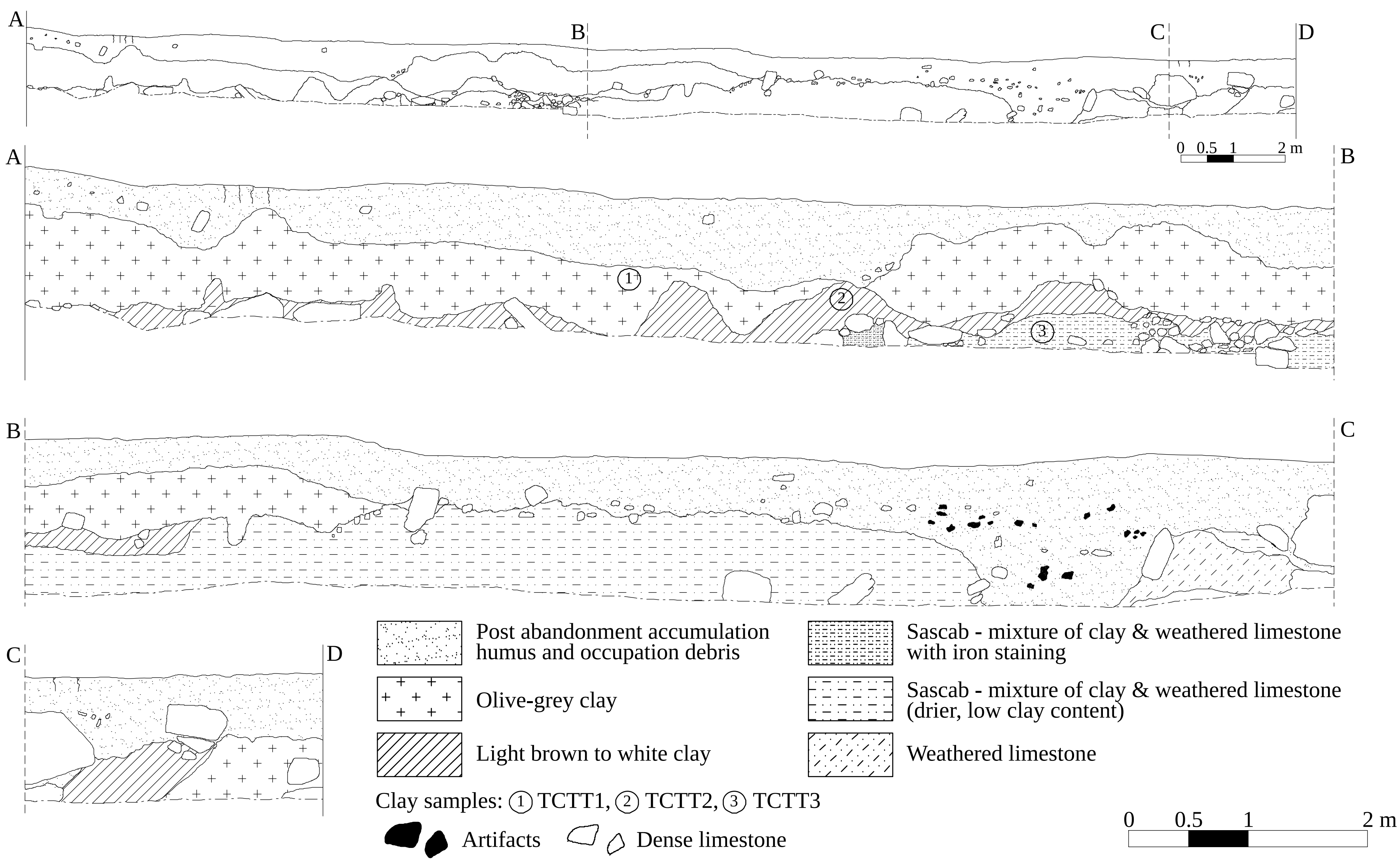

Figure 3: West section of North-South trench showing subsurface soil horizons and clay sampling locations.

lying directly below the ground's surface that contained abundant artifacts, as well as at least one pit feature, dug to bedrock, that also contained a large quantity of artifacts. In addition, a thick black horizon containing ubiquitous artifacts was consistently encountered in all excavations that were undertaken in the general area of the planned restroom building. Given the extent of the deposit, the limits of which were not determined by the TDP's investigations, and the fact that the black clayey matrix is typical of midden deposits that occur elsewhere at the site, the general area has been interpreted as a sheet midden (of unknown extent) relating to the nearby plazuela groups. At present it is not known how the subsurface pit feature observed in the trench profile relates to the midden deposit.

The ceramics contained in the sheet midden date to the Terminal Classic to Late Postclassic period, with a range of different serving ware and utilitarian stylistic types represented. In all of the sherd lots except LA1969, however, Early Postclassic and Middle Postclassic stylistic types clearly predominate numerically. Terminal Classic and Late Postclassic stylistic types are represented by only a handful of sherds. In comparison, lot LA1969 exclusively comprises Middle Postclassic stylistic types.

Other Significant Observations about the Tourist Centre Area Pottery Assemblages

The detailed macroscopic assessment of the pottery recovered from different archaeological contexts within the Tourist Center Area has also yielded evidence that ceramic production/consumption patterns for this particular area of the site may be significantly different than those that have been defined for other areas of the central precinct (Howie 2005). Of particular interest is the high incidence of vessels that, based on the macroscopic assessment of paste attributes, are potentially of non-local origin. The author's previous work on Terminal Classic to Early Postclassic pottery deposited in caches, burials and middens abutting ceremonial and elite residential and administrative structures indicated a strong localized pattern of production and consumption, with non-local pottery comprising less than 10% of the assemblages analysed. In contrast, in many of the lots examined from the Tourist Center Area 50% or more of the vessels appear to be potentially of non-local origin. These vessels include decorated serving ware forms and unslipped utilitarian ware forms, as well as special purpose vessels such as comals, griddles and incense burning paraphernalia. Also significant is that several stylistic categories or 'types' of pottery are represented by vessels displaying different compositional attributes, quite likely related to differences in provenance. For some vessel categories, at least some vessel pastes are macroscopically consistent with local paste types identified previously by the author. Their occurrence alongside often multiple potentially non-local pastes, that themselves display compositional differences, in vessel categories that are characterized by a high level of stylistic uniformity is very interesting.

The provenance and paste technology of the potentially non-local, as well as locally produced pottery will be investigated in greater depth through petrographic and chemical analysis of a sample of vessels selected to capture the range of variation observed in macroscopic paste attributes, within and across functional and stylistic categories of vessels, as well as within and among the different assemblages analysed.

Another significant characteristic of the Tourist Center Area pottery assemblages is that they contain a seemingly disproportionate amount of storage jars, which in most cases account for nearly half of the individual vessels represented. All of the assemblages contain several different stylistic types of jars. These often have different temporal associations, but in many instances different jar styles are undoubtedly contemporaneous. When considering that utilitarian pottery in general – i.e. all forms including jars -

normally makes up about 20% of domestic midden assemblages (c.f. Fry 1980), the quantity of storage jars that occurs in the Tourist Center assemblages is unquestionably high. Their frequency may relate, at least in part, to the function of this particular area of the site, or of some of the buildings or plazuela groups situated in this area. This issue will be investigated in greater depth in future, in order to better contextualize and understand the patterns of pottery consumption associated with this area of the site and how they compare to those associated with other areas and social contexts within the community at Lamanai.

Late Postclassic to Spanish Colonial House Lots

The examination and sampling of sherd assemblages deriving from commoner house lots dating to the Late Postclassic to Spanish Colonial period was undertaken as part of a collaborative study with Darcy Wiewall that is investigating aspects of continuity, change and variation in household-level patterns of pottery production and consumption during this time period. A central aim of this study is to examine the impact of the Spanish State on household economic patterns relating to the manufacture and acquisition of pottery vessels. The pottery assemblages that are the focus derive from commoner house lots (N25, N425, N11-16 and N12-4) identified by Wiewall in 2003 through intensive survey, post hole sampling and chemical analysis of soils in the N11 and N12 grid blocks at Lamanai (Wiewall 2005). A detailed assessment of the surface treatment, morphological and macroscopic paste characteristics of the pottery comprising the different house lot assemblages, as well as the relative frequency of different functional categories of pottery, was conducted by Wiewall, in collaboration with the author between 2004 and 2005. These aspects of the house lot assemblages will be initially documented and described in Wiewall's forthcoming Ph.D. dissertation. During the initial macroscopic assessment of the house lot assemblages, different paste types, including both those appearing to be geologically consistent and inconsistent with local raw material resources and fabric/paste types known to have been produced locally, were identified but not examined in detail or sampled for petrographic analysis. This part of the assessment was conducted by the author during the 2007 field season, resulting in the selection and sampling of 217 individual vessels (represented by diagnostic sherds) for petrographic study to examine intra- and inter-household variation in vessel provenance and paste technology.

Spanish Churches

The examination of the sherd lots recovered from the area in which the two Spanish churches are situated focused on the materials recovered during the excavations and clearing activities undertaken by NICH, and partly funded by FAMSI in 2007, as part of the restoration of this area for tourist viewing. A central aim of the ceramic analysis was to determine the temporal associations of the pottery recovered from different archaeological contexts within the area under investigation and to identify any instances of variation in this regard. All of the sherd lots examined were found to contain a mixture of Classic, Postclassic and Spanish Colonial stylistic types. What can be considered as the 'earliest' pottery that occurs within these sherd lots is comparable to Early Classic, and possibly Terminal Preclassic vessel styles in terms of their morphology and surface treatment characteristics. Also present are a range of stylistically different serving and utilitarian ware vessels displaying stylistic conventions typical of later time periods, with clear ceramic typological markers of the Terminal Classic and Early, Middle and Late Postclassic periods. European pottery is extremely rare. In all of the lots examined, the majority of the Maya sherds derive from serving ware vessels, with far fewer storage jars and other utilitarian forms represented, an assemblage composition typical of standard domestic refuse (c.f. Fry 1980). This pattern coupled with the diverse temporal associations of the vessel styles represented, as well as the small size and often heavily eroded condition of the pottery fragments, strongly suggests that the material constitutes secondary deposits, likely of standard domestic refuse that was brought to the area for use a construction material.

Mapping of the Tourist Center Area

The TDP investigations of the Tourist Centre Area involved only limited mapping of the structural and other cultural features that occur within this area. Such features were only recorded for the specific land areas that were to be directly impacted – e.g. covered over - by the construction of the various tourist facilities, such as the Visitor's Centre, the restrooms and the picnic pavilions. The archaeological structures and features that were identified were mapped onto the architectural drawings of the area, recording their spatial relationship to the planned buildings and well as to each other. However, neither the newly identified archaeological features nor the modern buildings were tied into an existing site datum, enabling this new information to be added to the existing site map. As a result, up until the 2007 field season, there was no record of the geographical relationships of the archaeological features and new tourist facilities to the adjacent plazuela groups situated north and north east of the Tourist Centre Area. These plazuela groups were principal sites of ceremonial and religious activity during the same time period that structures were built and in use in the Tourist Centre Area. In addition, since the TDP's mapping efforts focused exclusively on the specific land areas to be directly impacted by their construction activities, no attempt was made to systematically record the structural features that occur outside of these areas. The absence of this critical contextual information has direct implications for any studies focusing on the artifact assemblages that were recovered from the Tourist Centre Area: the archaeological contexts of these assemblages remain poorly and only ambiguously defined, in terms of the potential function of this particular area of the Central precinct, as well as and the nature of its relationship to the contemporaneous adjacent plazuela groups, hindering cultural interpretations of any emergent patterns the artifactual evidence.

In an effort to learn more about the context of both the artifact assemblages and their associated structural remains, NICH employee Merle Alfaro and Oscar Ruano were hired to map all architectural features, archaeological and modern, lying between the main access road to the site and the lagoon edge. Prior to mapping, a survey of the area was conducted by the author, Jorge Can, of NICH, and Claude Belanger, who oversaw the TDP investigations of the area, to identify structural remains relating to the Maya settlement that would be included in the map and to distinguish these from more recent disturbances and alterations of the landscape caused by British Colonial and various modern construction activities in the area. Once all of the Maya structural features had been flagged, both these and the modern structures and pathways comprising the Tourist Centre facilities were mapped according to standard NICH procedures at 200:1 scale, using the north east corner of a modern concrete building foundation that appears on the existing site map and the south east corner of the Lamanai Visitor's Centre as the primary data.

Mapping the Tourist Centre Area has greatly increased our understanding of this area of the site, in terms of the structural remains that occur there and has led to the discovery of specific structures that are of particular cultural and historical significance (Figure 1). In brief, rising up from the lagoon edge, the area can be described as comprising a long, flat, man-made terrace that leads up to two large platforms. Atop each of the platforms sits a plazuela group consisting of a principal building situated on the eastern edge of the platform and multiple, comparatively ephemeral, structural remains which are likely the foundations of buildings that had perishable super-structures. Structure N11-30 is the principal building of the plazuela group situated north east of the Visitor's Centre building. Situated at the base of north east corner of both of the platforms are the remains of a circular structure, an architectural type of considerable cultural significance during the Terminal Classic to Postclassic period that has not been identified previously at Lamanai. To the north of the plazuela group that includes structure N11-30, underlying and directly behind the Visitor's Centre building, are at least two cobble surface features (see above). A sheet midden, of unknown extent (described above), occurs directly north of the cobble surfaces. It is hoped that future excavations in the area will help to clarify the nature, temporal associations and interrelationships of the structural features that have been identified and mapped thus far, shedding new light on the function of this particular area of the central precinct and its relationship to adjacent areas of ceremonial and religious importance that were in use during the same time period.

Remaining Fieldwork

Of the sherd lots that were examined in the 2007 field season, those deriving from the Tourist Centre Area comprise the most extensive assemblages representative of the Postclassic ceramic repertoire at Lamanai. These assemblages, however, contain an abundant Early to Middle Postclassic component and only a small quantity of material representative of Late Postclassic to Spanish Colonial period. Although Late Postclassic to Spanish Colonial pottery clearly predominates the four houselot assemblages that were examined, these assemblages are comparatively small, containing only small quantities of diagnostic pottery fragments. As a result, the distinguishing properties and attributes of what might be considered as a 'Late Postclassic' vs. a 'Spanish Colonial' ceramic assemblage remain only ambiguously defined. A main focus of the 2008 field season, therefore, will be to examine additional and more extensive assemblages that have been dated to these time periods based on the archaeological context from which they were recovered. The two assemblages that have the greatest potential to yield this information are those deriving from structure N11-18 (the *Cacique's* House), which is an elite residence, and structure N12-12 (the Rectory), a building situated just to the north of the Spanish Churches that is abutted by an extensive deposit of primary refuse. Although the exact function of this building is unclear at present, its close proximity to the churches clearly links it to the activities that took place in this particular area.

Additional material that will be examined in 2008 will include the pottery assemblages recovered from the numerous caches and burials interred in structures N10-2 and N10-4. These assemblages span the Terminal Classic to Middle Postclassic period. Since the stratigraphic relationships of these assemblages are well defined, they offer a rare opportunity to study microtemporal variation in vessel style and technology.

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Curation of Recently Excavated Artifacts

Work undertaken by: Linda Howie, Laura Howard and Elizabeth Graham

The restoration projects undertaken by NICH of the Spanish Churches and the British Sugar Mill and associated buildings produced impressive artifact assemblages that will add substantially to current knowledge of these areas of the site. In both cases, the resulting artifact collections were recovered as part of limited excavations of the structural remains of buildings that were conducted so that they could be restored for tourist viewing, and during surface clearance of the immediate surrounding area. All artifacts were recovered by hand and bagged according to their structural association, such that the artifacts deriving from different areas of particular buildings, different construction phases or from different localities within the surrounding area were separated into different lots of material. Individual artifact lots were then assigned an I.D. number or code and these I.D. numbers/codes were recorded on a map of the area, documenting either the specific locality or general area from which they were recovered. All artifacts were then washed, dried and returned to their bags to await cataloguing according to the LAP system.

Both restoration projects were assigned an LAP 'operation number' and all of their associated lots of artifacts were assigned LAP lot numbers. Operation records and lot records summarizing important contextual and descriptive information were then filled out and filed in the on-site archives. The operation and lot numbers that were assigned in each case are recorded in the Lamanai 'Master Lot List', a copy of which is kept on site.

In the case of the 'Spanish Churches' artifact lots, artifact count sheets, which are organized by artifact category, were filled out for each lot. All 'Small finds' and complete pottery vessels, including figurines, were assigned specific catalogue numbers and detailed descriptive information was recoded on the standard forms. For each lot of artifacts, photographs were taken of the diagnostic pottery and all complete vessels and figurines were illustrated (this work was done by Louise Belanger).

Due to the unique character of the Sugar Mill artifacts, many of which constitute metal industrial debris deriving from a range of machinery and tools, count sheets and small finds records were not completed for the different artifact lots. A more detailed cataloguing of the material from this area will require a knowledgeable individual who is familiar with the machinery and implements used in the British Colonial sugar industry, and thus can identify and differentiate the corroded and often fragmentary metal artifacts.

The collections deriving from both restoration projects have been stored in labeled plastic containers, which are currently housed in the north side room of the bodega building. Many of the larger metal artifacts deriving from machinery used in the Sugar Mill, however, have been left *in situ* for tourist viewing. Since the corrosion crusts on these artifacts act as a protective coating, preserving the underlying metal body, it is not anticipated that exposure to the elements will cause any significant damage in future.

Maintenance of the Onsite Collections and Storage Facilities

Structural repair to the old museum building undertaken by**:** Lamanai Reserve staff, Oscar Ruano and Jorge Vasquez, under the supervision of Park Manager Fernando Obando

Cleaning of museum's interior and shelved collections undertaken by: Linda Howie, Jorge Vasquez and George Melchor, under the supervision of Park Manager Fernando Obando

The Lamanai Museum of Precolumbian Art and Archaeology, currently houses an extensive collection of artifacts that require special storage conditions (i.e. on shelves), including complete and reconstructed pottery vessels, chert eccentrics, painted pieces of stucco deriving from building facades and large carved wood and bone artifacts. A variety of small find artifacts, such as beads, figurines, jewelry and clothing facets, recovered as part of Pendergast's excavations at the site from 1974 to 1986 are also stored in wooden and zinc oxide shelving units in this building.

The Museum was open to the public until 2003, when the current Visitor's Centre was completed, and since then has served principally as a storage facility for the collections described above. Some sherd assemblages that were stored previously on the floor of the bodega are also kept in the bathroom facilities of this building (these are no longer in use), to safe guard against potential damage due to flooding during the hurricane season.

Although the LAP has endevoured to maintain both the building and the collections it houses, the museum has not enjoyed a regular regime of cleaning and general upkeep since it was closed to the public in 2003. As a result, by the 2007 field season, both the interior and exterior of the building had experienced a certain amount of deterioration, most of which can be described as natural wear and tear that would be expected to occur in a sub-tropical, forested environment.

The roof of the Museum, however, had suffered more extensive deterioration. The zinc oxide roofing panels had corroded in numerous places, in many instances to the extent that sizable holes had formed (Figure 4). The portion of the roof that had been most severely affected covers the northwest corner of the main room of the building and, unfortunately, is situated directly above an uncovered display of artifacts as well as the shelving units that contain the small finds collection.

Figure 4: Photograph of the interior of the Museum roof showing an extensively corroded panel containing numerous large holes just prior to replacement.

The problematic state of roof was noted by the Park Manager, Fernando Obando, in 2006, at which time he recommended to NICH that structural repairs should be carried out as soon as possible to avoid any additional deterioration or damage to the Museum's interior, including the artifact collections. The situation was subsequently brought to the attention of LAP director Dr. Elizabeth Graham and plans were made to conduct the necessary repairs during the 2007 field season. This work was carried out by Lamanai Reserve staff and LAP staff in July, under the supervision of Mr. Obando and involved the following:

1.) Work done to exterior

The roof was first cleared of leaves and other debris and the most extensively corroded roofing panels were replaced (both the panels and nails were supplied by NICH). The entire roof was then cleaned with dilute muriatic acid solution and less severely corroded areas were patched using zinc oxide and tar flash stripping. Finally, the entire roof was painted with a protective paint for zinc oxide structures. To minimize the accumulation of leaves and other matter on the roof in future, all overhanging branches were removed from the surrounding trees.

2.) Work done to interior

Dust, cobwebs and insects (both dead and alive) were cleared from the shelved collections, walls, rafters and floor and rodents' nests were removed the reconstructed vessels as necessary (Figure 5). All drawers in the shelving units containing the small finds collection were cleaned to remove insect and rodent nests and related debris and damaged artifact bags and labels were replaced.

Figure 5: Photographs of the Museum' interior showing the general condition of the room and shelved collections prior to being cleaned.

Recommendations:
The repair and maintenance of the Old Museum building during the 2007 field season constitutes a temporary solution to an inevitably ongoing problem. Other aspects of the building's general condition that require fairly immediate attention include:

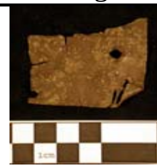
1. The wooden roof beam and other structural supports urgently require termite treatment as several are already infested and consequently deteriorating.
2. The door frames and door of both the main room and the men's restroom, in which some assemblages are currently stored, are decaying and need to be replaced so that a proper pad-locking system s can be installed on both (both doors are currently boarded, impeding access).
3. The bat-proofing is starting to deteriorate in some areas and will require replacement.
4. Additional roof panels, will have to be replaced as they deteriorate, including those covering the restroom portion of the building.
5. The area above the partition wall between the main Museum room and the adjoining restrooms should be screened to prevent rodents from nesting in the shelving units.
6. The restroom portion of the building should be bat-proofed (an openings screened in).

Appendix A

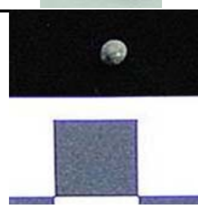
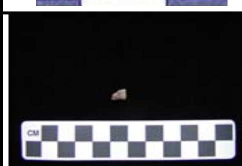
Analytical Methods used in the Analysis of Copper Artifacts from Lamanai

Small Find No.	Group	Object	Technique of analysis				
	Analytical		Optical	SEM -Smith	SEM-Lehigh	ICP	Handheld XRF
LA 1123-1	1		X	X			
LA 1131-1	1	Sheet Fragment	X	X		X	
LA 1134-1	1 and 2	Sheet fragment	X		X	X	
LA 1136-1	1	Sheet Fragment				X	
LA 1137-1	1 and 2	Lead Ingot	X		X		
LA 1149-1	1 and 2	Pig or axe/chisel blank	X		X	X	
LA 1153-1	1 and 2	Axe fragment	X		X	X	
LA 1179-1	1	Sheet Fragment	X				
LA 1230-1	1	Ring				X	
LA 1232-1	1	Pyriform bell				X	
LA 1234-1	1	Pyriform bell				X	
LA 1236-1	1	Needle	X				
LA 1238-1	1 and 2	Pyriform bell	X		X	X	
LA 1240-1	1 and 2	Pyriform bell	X		X	X	
LA 1241-1	1 and 2	Sheet fragment	X	X	X	X	
LA 1242-1	1	Globular bell				X	
LA 1243-1	1 and 2	Pyriform bell	X	X	X	X	
LA 1244-1	1 and 2	Bell fragment	X	X	X	X	
LA 1246-1	1	Globular bell				X	
LA 1575-2	2	Fish hook	X		X		X
LA 1580-18	2	Needle	X		X		X
LA 1581-25	2	Needle	X		X		X
LA 2070-5	2	Globular bell					
LA 2081-1	2	Prill					
LA 2081-2	2	Prill	X		X		
LA 2373-3	2	Needle					X
LA 2567-1	2	Pig/Ingot					X
LA 2568-1	2	Pig/Ingot					X
LA 2790-1	2	Small reservoir	X		X		X
LA 2790-2	2	Mid section long axe	X		X		X
LA 2790-3	2	Back (poll) of long axe	X				X
LA 2790-4	2	Large reservoir	X		X		X
LA 2790-5	2	Blade (bit) section long axe	X		X		X
LA 2790-6	2	Blade (bit) of short axe	X				X
LA 2790-7	2	Back section (poll) short axe	X		X		X
LA 2791-1	2	Back section (poll) of axe	X		X		X
LA 2909-6	2	Prill	X		X		

Small Find No.	Group	Object	Technique of analysis				
	Analytical		Optical	SEM -Smith	SEM-Lehigh	ICP	Handheld XRF
LA 2909-7	2	Sheet metal	X		X		
LA 2924-12	2	Sheet metal	X		X		
LA 2932-1	2	Prill					
LA 2936-7	2	Prill					

Small Find No.	Object	Image	Technique of analysis														
		Image	Optical	SEM		***Cu***	***Sn***	***As***	***Fe***	***Ag***	***Pb***	***S***	***Se***	***Bi***	***Ni***	***Zn***
LA 1134-1	sheet fragment		X	X	1134-1	99.4	0.3		0.4							
LA 1149-1	pig or axe/chisel blank		X	X	1149-1	96.5	1.0	1.3	0.3	0.5					0.4	
					1149-1	97.7	0.6	0.7	0.4	0.4					0.2	
					1149-1 inc	86.5	1.3		0.4		11.8					
					1149-1inc	91.6	0.6		0.4	0.6		6.8				
LA 1153-1	axe fragment		X	X	1153-1	96.7	1.6	1.1	0.2	0.3						
					1153-1 area	97.6	1.1	1.0	0.3	0.2						
					1153-1 area	97.5	1.0	0.8	0.3	0.3						
LA 1238-1	pyriform bell		X	X	1238-1	98.9	0.5		0.3							
					1238-1	98.7	0.5		0.4							
					1238-1 inc	88.5	0.6		0.4		10.3				0.1	
LA 1240-1	pyriform bell		X	X	1240-1	96.7	0.1	1.9	0.3							
					1240-1	95.4	0.2	2.9	0.4							
					1240-1	96.9	0.2	1.9	0.3							
LA 1241-1	sheet fragment		X	X	1241-1	95.6	1.8	1.4	0.4	0.4						
					1241-1	95.6	1.4	2.0	0.4	0.2						
					1241-1	79.0	1.4	0.8	0.6		18.1					
					1241-1 inc	88.2	0.9		1.0			7.0	2.6			
LA 1243-1	pyriform bell		X	X	1243-1	97.7	1.0	0.9	0.3							
					1243-1	98.1	0.6	0.7	0.4			0.03				
					1243-1	98.7	0.8		0.3							
					1243-1 inc	82.9	0.6		1.3			11.6	2.7			
LA1244-1	bell fragment		X	X	1244-1	97.6	0.2	1.4	0.5	0.1						
					1244-1	97.3	0.2	1.8	0.3	0.2						
					1244-1	97.2	0.5	1.2	0.4	0.3						
					1244-1 inc	84.9	0.5		1.0			9.4	3.9			

Small Find No.	Object	Image	Optical	SEM		Cu	Sn	As	Fe	Ag	Pb	S	Se	Bi	Ni	Zn
LA 1575-2	fish hook		X	X	1575-2	96.9	0.7	1.7	0.3	0.4						
					1575-2	97.1	0.4	1.9	0.4	0.3						
					1575-2 inc	85.5			0.6			6.5	6.7			
LA 1580-18	needle		X	X	1580-18	98.0	0.5	0.5	0.3	0.7						
					1580-18	99.0	0.3		0.3	0.4						
					1580-18 inc	66.9			0.4	0.5	18.5			13.7		
					1580-18 inc	83.1	16.3		0.4	0.2						
LA 1581-25	needle		X	X	1581-25	97.9	0.4	0.8	0.2	0.5						
					1581-25	98.6	0.3	0.5	0.3	0.3						
					1581-25 inc	35.3			0.3	0.6	51.5			12.2		
LA 2081-2	prill		X	X	2081-2	98.4	0.4	0.5	0.3	0.2						
					2081-2	98.2	0.5	0.5	0.3	0.3						
LA 2790-1	small reservoir		X	X	2790-1	99.5	0.3		0.2							
					2790-1	99.2	0.3		0.3							
					2790-1 inc	50.9	48.3		0.5							
LA 2790-2	Mid section long axe		X	X	2790-2	98.5	0.5	0.4	0.3	0.3						
					2790-2	98.2	0.5	0.7	0.3	0.4						
					2790-2	98.0	0.6	0.9	0.2	0.4						
					2790-2 inc	93.6	6.4									
LA 2790-3	Poll of long axe		X													
LA 2790-5	Blade section long ax		X	X	2790 - 5 blade	95.7	1.7	1.7	0.4	0.6						
					2790 - 5 blade	96.4	1.4	1.2	0.3	0.6						
					2790 - 5 blade incl	70.4		0.4	0.4	17.5	5.4		5.8			

Small Find No.	Object	Image	Optical	SEM		Cu	Sn	As	Fe	Ag	Pb	S	Se	Bi	Ni	Zn
LA 2790-4	large reservoir		X	X	2790-4 2nd	95.6	0.8	0.7	0.3							2.6
					2790-4 2nd	98.6	0.5	0.6	0.2							
					2790-4 2nd	95.5	2.9	1.5	0.2							
					2790-4 2nd	86.8	0.5		0.3	0.4		9.8	2.2			
					2790-4 inc	88.7						11.3				
					2790-4 matrix	98.6	0.4	0.5	0.2	0.3						
					Incusion	43.6				1.9	19.7			30.7		
					2790-4 grain boundray	96.7	1.6	1.4	0.3							
					2790-4 area	98.6	0.3	0.5	0.3	0.3						
LA 2790-6	bit of short axe		X													
LA 2790-7	poll of short axe		X	X	2790-7	98.5	0.3	0.6	0.2	0.5						
					2790-7	98.1	0.3	0.9	0.3	0.4						
					2790-7 incl	50.2					49.8					
					2790-7 incl	87.7						9.2	3.1			
LA 2791-1			X	X	2791	98.0		1.2	0.3	0.5						
					2791	98.7		0.6	0.3	0.4						
					2791 inc	51.6	0.3		0.5		47.6					
LA 2909-6	prill		X	X	2909-6	99.1	0.3		0.5	0.1						
					2909-6	98.1	0.6	0.7	0.4	0.2						
					2909-6 incl	86.0	0.3		2.1			11.6				
					2909-6 incl	44.6			0.5		54.9					
LA 2909-7	sheet metal		X	X	2790-7	98.5	0.3	0.6	0.2	0.5						
					2790-7	98.1	0.3	0.9	0.3	0.4						
					2790-7 incl	50.2					49.8					
					2790-7 incl	87.7						9.2	3.1			
LA 2924-12	sheet metal		X	X	2924-12	95.4	0.1	4.0	0.5	0.1						
					2924-12	95.7	0.2	3.5	0.4	0.3						