Peruvian Black Pottery Production and Metalworking: A Middle Sicán Craft Workshop at Huaca Sialupe

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Introduction

The technical sophistication and virtuosity of prehispanic Andean ceramics are so often praised in the literature that it may appear that there is a large body of supportive, empirical findings. To the contrary, in-depth technical and more comprehensive technological studies have been rare. To achieve a comprehensive understanding of the many facets and stages of the technology and organization of craft production requires a correspondingly comprehensive, sustained effort—one built on interdisciplinary collaboration and long-term regional study of environmental, historical, social, and technological factors. A holistic and contextual approach has been used by the Sicán Archaeological Project that began in 1978 in its effort to understand the craft production, particularly ceramics and metallurgy, of the Middle Sicán culture that flourished on the northern coast of Peru some 1000 years ago.[1,2] This approach (Figure 1) has combined (1) archaeometry, the application of methods derived from the physical and natural sciences to archaeology; (2) archaeology, both regional surveys to establish resources and their human use and site excavations of ceremonial, residential, and workshop complexes; and (3) field and laboratory experimentation to recreate and test technology hypothesized with input and help from modern local artisans and experts with scientific and technological knowledge.[3]

The aim of this article is to present and interpret the emerging results of our ongoing analysis of the 1999 excavation of a Middle Sicán craft production site at Huaca Sialupe on the northern coast of Peru.

Research Issues

Among notable Middle Sicán legacies are its ceramic and metallurgical technologies. The metallurgy was characterized by unprecedented, large-scale production of arsenical bronze and *tumbaga,* low-karat alloys of gold, silver, and copper employing intentional surface corrosion or depletion processes to develop a rich silver or gold color.[4,5] The bronze replaced pure copper permanently as the utilitarian metal in northern Peru.

Following a trend set by the preceding Moche culture, Middle Sicán potters relied heavily on molds to produce diagnostic, decorated ceramics such as widely distributed, single-spout bottles.[6] These vessels were made using one or more pairs of molds. Our examination of broken and whole vessels from tombs and a wide range of other contexts indicates the pervasiveness of mold-made vessels. Middle Sicán pottery is also characterized by its preference for a black finish (Figure 2). Although blackware ceramics were made by earlier cultures, including the Cupisnique that dates back to the first millennium B.C., they had never attained the prominence or consistent blackness of their Middle Sicán counterparts. In fact, early Middle Sicán blackware (ca. A.D. 900–950) appears to have spearheaded an unprecedented “craze for monochrome blackware” that rapidly spread throughout much of the Peruvian coast.[7] Questions remain as to what accounts for this popularity and high quality.

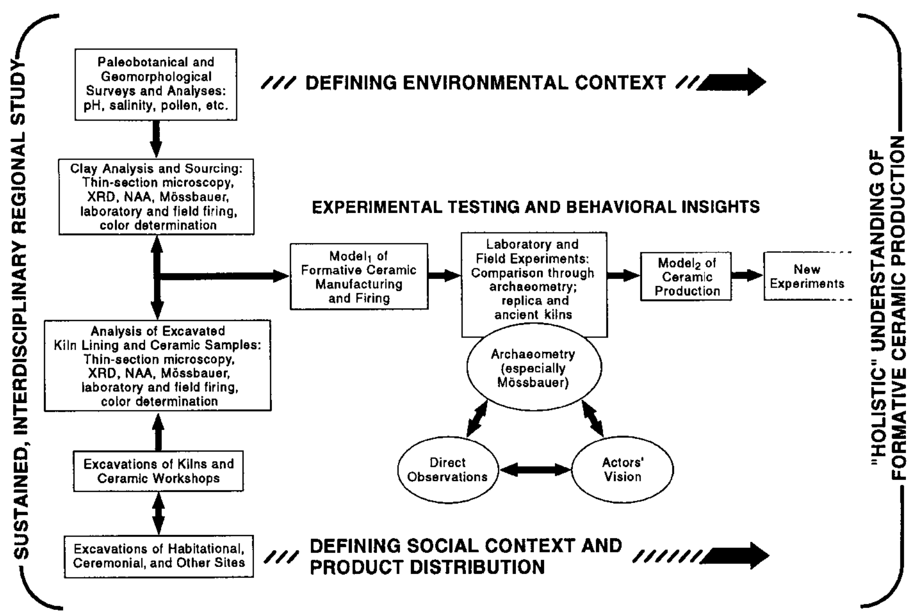

Figure 1. Graphic model of our sustained, interdisciplinary, regional study for attaining a holistic understanding of Sicán ceramic production. “Actors’ Vision” refers to the ideas and observations of those physically carrying out the manufacturing in the replication experiments. Diagram by Izumi Shimada and Steve Mueller.

Figure 2. Three blackware vessels accompanying a Middle Sicán commoner's burial, excavated in the east sector of Huaca Las Ventanas at the site of Sicán. Vessels shown are approximately 15 cm in height and 13 cm in width. Photo by Izumi Shimada.

Prior to the 1999 excavation of the Huaca Sialupe workshop, Middle Sicán blackware samples from non-workshop contexts were analyzed. Their chemical and mineral composition were determined through neutron activation analysis (NAA), x-ray diffraction (XRD), and thin-section microscopy (TSM). Firing conditions and temperatures were established by Mössbauer spectroscopy (MS).[8–10] These studies showed that the firing technology mostly involved a strongly reducing atmosphere and temperatures of about 700–800°C. Some of the specimens were reoxidized on the surface and, occasionally, throughout. About one-third of the sherds were only dried at temperatures below 400°C. The black surface color was caused by soot penetration.

The discovery of a well-preserved ceramic workshop at Huaca Sialupe provided an excellent opportunity to address questions of details of the technology, organization of production, and product inventory.

Archaeological Background

Sicán is the name given to a prominent regional culture that emerged in the Lambayeque region of the Peruvian north coast around A.D. 750–800 and persisted until about A.D. 1400, when it was conquered by the intruding Chimú Kingdom.[11] During the height of the Middle Sicán culture (A.D. 900–1100), its state-level polity dominated a 400-km stretch of the Peruvian north coast, and its sphere of influence reached some 1000 km north and south of Lambayeque.

Middle Sicán ceramic technology developed from a long tradition of over 2500 years of local pottery production. Excavation in 1989 at the bottom of the abandoned Poma Canal, about 25 km northeast of Huaca Sialupe, had revealed 57 Cupisnique kilns (ca. 1000–500 B.C.).[3,9] These kilns had a basic figure-eight or keyhole shape in plane view and incurving side walls to create a semi-closed, spherical firing chamber and firebox. They measured approximately 40–70 cm in width, 100–120 cm in length, and 35–45 cm in depth below the associated floor. The chamber had a prominent chimney at the far end and a capacity that ranged from about 0.20 to 0.45 m^3. Charcoal found at the bottom of the chamber indicates that the primary fuel was a local hardwood, *Prosopis pallida.*

Replicative firing experiments were conducted at Poma Canal (1990–1997) by professional potters using local clay, a full-scale replica kiln, and a 3,000-year-old Cupisnique kiln. The experiments were followed by archaeometric comparisons of the fired replica vessels with Cupisnique counterparts.[3,9,10,12] Our studies showed that these kilns were quite sophisticated, functioning in a highly predictable manner and attaining desired atmospheric conditions and firing temperatures of around 800°C. The knowledge and insights thus gained proved to be valuable in our study of the Huaca Sialupe workshop.

Excavation at Huaca Sialupe

Huaca Sialupe consists of a series of low, small mounds that together cover an area approximately 250 m × 400 m. The workshop occupies two contiguous, low mounds (Mound I and Mound II), approximately 120 m × 60 m overall, located in the eastern sector of the site. Sialupe is situated about 13.5 km southeast of the traditional pottery-making area of Mórrope, a village that suffers from interrelated problems of chronic water shortages, poor drainage, salinization of the soil, and encroachment of sand dunes, all caused by geological uplift.[13] Local prehistoric and historic potters have exploited clay deposits formed by the stagnation of floodwaters.

A preliminary survey of Huaca Sialupe had revealed ceramic-production debris, primarily broken molds, heat-discolored soil, charcoal, and ash, concentrated on the downwind, northeast side of Mound I, the main conical mound, about 60 m in diameter and 5 m in height. The molds were overwhelmingly those for bottles, jars, flasks, and shallow and deep bowls that are diagnostic Middle Sicán in either form or decoration. The site was hypothesized to have been a settlement containing a workshop engaged in mold-based, fine blackware pottery production. It is further believed to have been a satellite settlement of the site of Huaca Pared-Uriarte, situated about 1 km to the south. The latter had an extensive Middle Sicán occupation (around 0.5 km^2) with an adobe platform mound complex built around a rectangular plaza, much like the Middle Sicán capital of Sicán in Poma, some 22 km to the northeast. Thus, Huaca Sialupe was thought to have housed artisans who were attached to the local elite to satisfy both their mundane and special needs.

Four partially preserved, ovate structures were found close together at the northern base of Mound I, along with large quantities of ash, charcoal, and intensely reddened adobe-brick fragments. These structures, which we hypothesize to be kilns, were built of adobe bricks set in mud mortar and placed in pits about 125 cm × 60 cm and 30–35 cm deep, dug into a sandy soil. One structure retained two superimposed, carefully smoothed interior clay linings. Poor preservation makes it difficult to fully reconstruct their original forms, but the preserved portions and scattered structural remains suggest that the kilns had in-curving walls that created semi-closed firing chambers. The consistent reddish coloring of these remains also suggests that the kilns were used primarily for oxidizing firing of relatively small vessels. A nearby oval bed of ash mixed with carbonized twigs is believed to have been used for preheating vessels to be placed in the kilns.

Some 20 m southeast of these kilns, three small oval- to teardrop-shaped kilns were found spaced about 1 m apart on a blackened earth floor (Figure 3), with the larger firing chamber oriented downwind. Their slightly concave, sloping (downward toward the firing chamber), clay-lined bottoms were 10–20 cm below floor level and measured 90–110 cm long and 40–50 cm wide (Figure 4). They were thoroughly coated with charcoal bits and powder, and one kiln had over 50 fine blackware vessel fragments mixed with compacted charcoal. Fallen lining fragments indicate that the kilns originally had in-curving side walls, creating a domelike firing chamber that reached an estimated 26 cm above the floor.

Immediately below the floor where these three kilns were found, two nearly identical inverted urn furnaces had been placed about 2.5 m apart. Additional urns appeared in the preceding floor and in the adjacent excavation area. The best preserved cluster of four inverted urns was found in Mound II. All of these urns seem to share a number of basic features. They measured 45–55 cm in diameter and about 45 cm high (Figure 5). Their mouths had been firmly set into the floor and their bottoms removed. Their exteriors had been covered with an insulating clay mixture, and their top openings had been reinforced by sherds. They contained a bed of charcoal inside and had an 8–9-cm round draft hole cut into the body near floor level, facing the prevalent wind direction.

Our excavation recovered a variety of metalworking remains from floors associated with the hypothesized furnaces and from overlying fill. The remains included small amorphous metal lumps (perhaps miscast arsenical bronze ingots or blanks), small chisels for sheet-metal cutting, sheet-metal scraps, slag lumps, ingot-mold fragments with arsenical bronze encrustation, a stone hammer fragment, and a broken tuyère (the ceramic tip of a blowtube).

Although the excavation data pointed to a metalworking function for the urns, we could not discount their possible use as a ceramics kiln, nor describe the specific metalworking process that may have been in use.

Analytical Data

Archaeometry has been crucial in elucidating the technology of Middle Sicán craft production. Thus far, 208 samples from Huaca Sialupe have been studied. In our studies, NAA (neutron activation analysis) was used to determine element content, characterize the objects, and sort them into groups by statistical analysis.[9,10] NAA was also used in an effort to identify suspected traces of metals in charcoal samples taken from the inverted urns. MS yielded information on iron-bearing compounds in clays and ceramics; further, physical and chemical processes that occur during firing can be deduced from changes in the Mössbauer spectra.[9,10] Spectra measured for clay samples from Huaca Sialupe and Poma fired in laboratory and field model experiments were compared with spectra measured for excavated ceramic samples. In this manner, a reconstruction of the range of firing conditions (e.g., atmosphere, temperature) of ceramics production at Huaca Sialupe was achieved. XRD and TSM (thin-section microscopy) were used to supplement MS, since both are useful in recording mineral transformations that occur during firing. MS is applicable only to iron-bearing minerals and oxides. XRD allows an assessment of most other minerals, while iron oxides tend to escape detection by XRD because of their small particle size and low concentrations. Conversion-electron Mössbauer spectroscopy (CEMS) and scanning electron microscopy (SEM) were employed to study the black surface finish ubiquitous in Middle Sicán ceramics.

MS revealed that a substantial portion of excavated blackware sherds were fired typically around and above 900°C under reducing conditions, leading to the formation of gray Fe^{2+} silicates. Mössbauer spectra for two blackware sherds from Huaca Sialupe and a third found at the Middle Sicán elite tomb at Huaca Loro are shown in Figure 6, together with their respective

Figure 3. Photograph of one of three Middle Sicán kilns used for black pottery firing. Photo by Izumi Shimada.

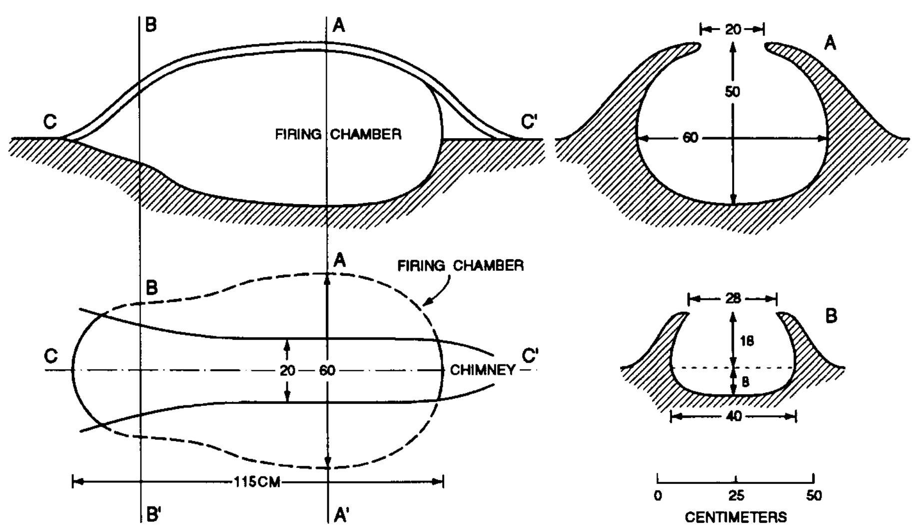

Figure 4. Plan and cross-sectional views of reconstructed Middle Sicán kiln used for black pottery firing. Drawing by Izumi Shimada and Steve Mueller.

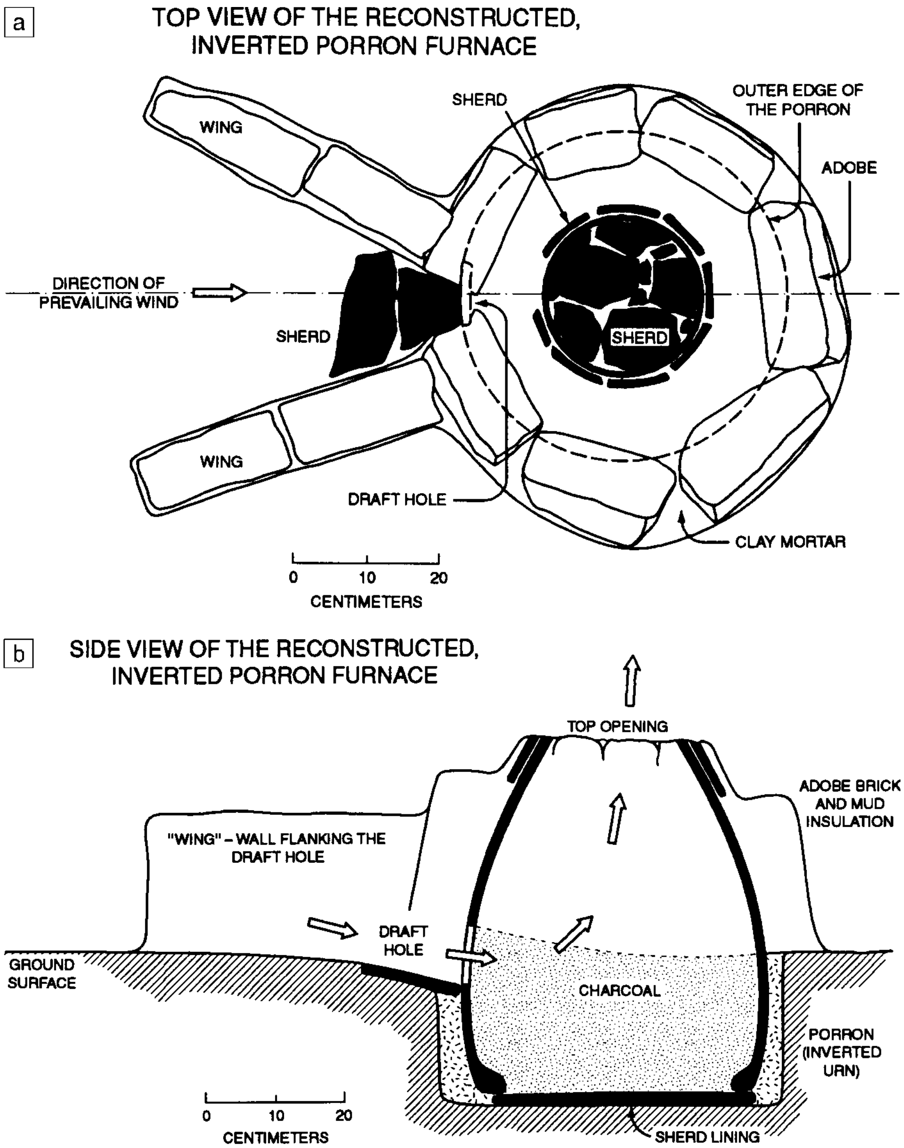

Figure 5. (a) Top and (b) side cross-sectional views of hypothesized metalworking furnace made from an inverted urn. Drawing by Izumi Shimada and Steve Mueller.

XRD scans. The XRD scans of Sherds 1 and 2 do not exhibit any sheet silicates except for mica, which proved stable up to temperatures of 930–950°C. The Mössbauer spectra of the core and surface do not show any significant differences, indicating that the reducing atmosphere was maintained throughout the firing and no reoxidation of the surface layer took place at the end of the firing. Even though the iron-bearing compounds show that the firing conditions were strongly reducing, the observed black surface coloration is not caused by magnetite formation but by graphite deposition. Hexagonal graphite plates and layers of graphite were observed by SEM on a polished surface (Figure 7). The presence of graphite accounts for the prominent metallic sheen. Carbon is also predominant in energy-dispersive x-ray analyses of the surface layer. The presence of magnetite on the surface as the cause for the black color was independently excluded by backscattering Mössbauer experiments (Figure 8).

To resolve the question regarding the original use(s) of the aforementioned inverted urns, 13 batches of charcoal from different depths of the charcoal bed at the bottom of Urns 5 and 19 were collected for NAA. The intention was to look for any traces of metals that might have spilled or sputtered during metalworking. The sample volume had to be reduced by oxidizing the charcoal in order to fit enough material in the quartz vials used for NAA. Five samples of ash from the charcoal collected from Urn 19 contained about 200–400 ppb (parts per billion by weight of ash) of gold, while charcoal collected from Urn 5 yielded no trace of gold. Naturally occurring gold concentrations in uncontaminated soil are typically around 1–3 ppb, values that were indeed found in bricks and clays from different parts of the workshop. In addition, gold traces of 15–100 ppb were observed in six blackware sherds (Table I).

Behavioral and Organizational Implications

Archeometry has played a critical role in elucidating the nature of craft production at Huaca Sialupe. While metallurgical debris recovered from the excavation suggested only arsenical bronze-working (reported elsewhere), archaeometry provided not only a confirmation of this suspicion, but also additional evidence for precious metalworking. A replicative field experiment conducted in 2000 using a full-sized inverted urn provided important additional data. It was filled with charcoal from local hardwood (*Prosopis pallida*) up to the top of the draft hole. Using only natural draft, the temperature of the charcoal bed reached over 1100°C, as measured by a Ni/CrNi thermocouple. The air exiting from the furnace top readily surpassed 700°C, more than adequate for annealing, yet the furnace exterior, with its thick mud insulation, remained safe to touch at about 60°C. These lines of evidence together argue that the inverted urns were efficient updraft furnaces used perhaps for gold alloying and annealing to make arsenical bronze and *tumbaga* sheets. The presence of at least two separate areas in Mounds I and II, each with at least three regularly spaced furnaces, suggests at least two distinct groups of a half dozen or so metalworkers. Earlier excavation of non-production sites, including many tombs, have shown that arsenical bronze objects were widely accessible to the masses, but *tumbaga* and other precious-metal items were restricted to the social elite, such as those who presumably lived at the nearby sites of Huaca Pared-Uriarte.

Well-fired, shiny blackware sherds were common at the Huaca Sialupe workshop, and archaeometry revealed the chemistry behind this popular finish. The intriguing metallic sheen depended on the degree of surface polishing that, being rather labor-intensive, was predominantly found on high-status, decorated bottles and flasks. For example, highly polished, black, double-spout bottles were found only in

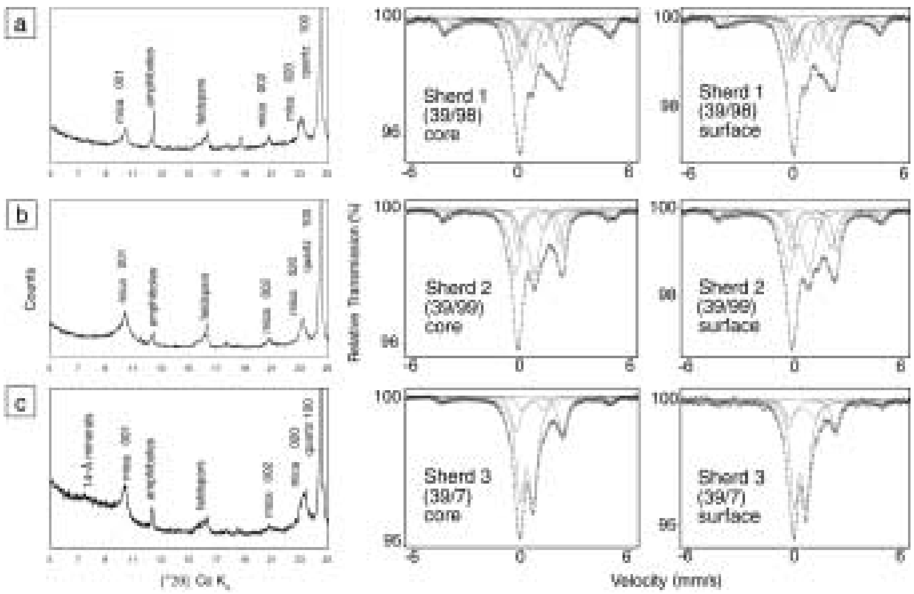

Figure 6. (a), (b) Room-temperature Mössbauer spectra of material from the cores (center column) and the surface (right column) of two well-reduced sherds of Sialupe blackware. The components with the large quadrupole splitting are dominant and characterize Fe^{2+} silicates. No difference between core and surface material is observed. (c) Mössbauer spectra from the core and the surface of an underfired sherd from a shaft tomb in Huaca Loro. Fe^{3+} species that exhibit a small quadrupole splitting and a small isomer shift are the main components in these spectra. The respective x-ray diffraction scans of the core samples are shown in the left column. Only mica (which is stable up to 930°C), feldspars, and amphiboles are observed in (a) and (b), while the presence of the 14-Å minerals in (c) supports the notion that the sherd was indeed underfired. For further explanation, see Reference 9.

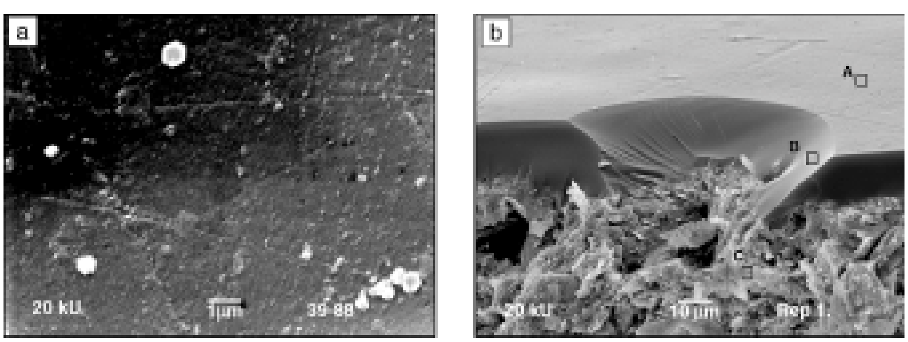

Figure 7. Scanning electron micrographs showing the shiny surface of a sherd from a replica vessel. The hexagonal graphite plate in (a) is 3000 unit cells wide; the surface layer in (b) is 10–20 μm thick. Ratios of C/(C + O) and Al/(Al + Si), as observed by electron-dispersive x-ray analyses in (b), are as follows: Spot A: C/(C + O) = 0.93, no Al, traces of Si, and Fe were observed in this weathered surface layer. Spot B: C/(C + O) = 0.94, no Al, traces of Si. Spot C: C/(C + O) = 0.1, Al/(Al + Si) = 0.3.

four elite tombs out of over 50 Middle Sicán tombs of varied social status excavated outside of Huaca Sialupe.

The pottery recovered at the Huaca Sialupe workshop, however, may not accurately reflect the range and quality of production, as they were predominantly "wasters" (pottery discarded due to some defect). In this regard, results of our replicative ceramic firing experiments in 2000 and the analysis of ceramics from non-production sites provide important insights. A professional potter, working with a full-scale replica of a teardrop-shaped kiln excavated at Huaca Sialupe, 30 burnished replica vessels, and using local fuel, performed three reduction firings that yielded a wide variety of finishes, ranging from well-reduced, shiny black to partially reduced, shiny gray.

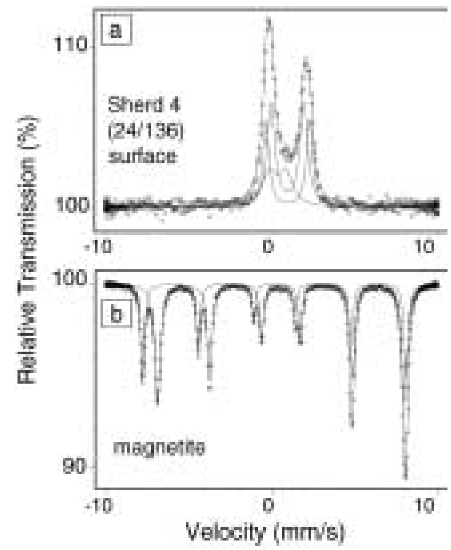

Figure 8. (a) Backscattering Mössbauer spectrum probing a depth of about 10 μm of the shiny black surface of a replica vessel. Nonmagnetic divalent and trivalent iron is present in the surface of the sherd, but no magnetite can be detected. (b) A transmission spectrum of magnetite is included for comparison.

Much the same variable quality was found among Middle Sicán "black" ceramics excavated or surface-collected from other sites. In an earlier MS study,[8] many of the "black" and "gray" ceramic vessels that accompanied 18 women, buried within a gigantic Middle Sicán elite shaft tomb in Poma about 22 km northeast of Sialupe, were found to have been only heated to 400°C or less, the black coloration being due to varying degrees of soot deposition. A Mössbauer backscattering spectrum of a replica sherd is shown in Figure 8a. These vessels were possibly made in haste to satisfy immediate funerary needs. Thus, factors affecting *both* the consumers and the producers need to be considered in order to understand why and how certain craft products were made the way they were. Just as in our society today, these factors include the potential and limitations of available raw materials, of the technology, and the producers (e.g., their skill level), as well as the social or symbolic values of the products and expectations and preferences of the consumers. Archaeometric data need to be contextual-

Table I: Concentrations of Au Determined by Neutron Activation Analysis in Blackware Sherds and Charcoal Samples from a Metalworking Furnace Excavated at the Huaca Sialupe Workshop.

Sherd Number	Au (ppb)*	Charcoal Batch Number	Au in Ash of Charcoal (ppb)
39/112	18	39/87	237
39/119	50	39/123	92
39/94	50	39/124	315
39/96	23	39/125	377
39/98[a]	23	39/126	292
39/103	15	39/127	215
		39/128	159
		39/129	161

* The natural level of Au in Sialupe clay is 1–3 ppb.
[a] Sherd 1 in Figure 6.

ized in order to establish their behavioral and cultural significance. However, these lines of evidence taken together suggest that while Sialupe potters were capable of producing well-fired, true blackware, they did not *consistently* obtain the desired finish.

The clusters of similar kilns, together with the observed stylistic and technical variation in molds and matrices, suggest that ceramic production at Huaca Sialupe was based not on economic efficiency, mass production, or complementary task differentiation, but rather on the largely redundant and parallel efforts of semi-autonomous, "modular" groups of potters. This organization is akin to that seen in Sicán arsenical bronze production[5] and, earlier, in urban Moche craft production.[14]

The coexistence of metalworking and pottery making in the same workshop brings up an important point regarding our current thinking on and approaches to ancient technology and craft production. Our perceptions of both are overly influenced by medium-specific analytical distinctions, and we tend to project these preconceptions onto the practices of past cultures without examining their validity. Archaeologists and others think of a workshop in terms of a single, specific craft or medium, be it ceramics, weaving, or metalworking, without considering potential interaction among concurrent and nearby crafts. Metalworking, for example, relied on a knowledge of ceramics and on ceramic tools such as ingot molds, crucibles, and tuyères, as well as furnaces. In addition, metalworkers and potters may have coordinated the procurement of fuel or negotiated for advantageous apportionment of high-quality fuels. In other words, more attention needs to be paid to multicraft organization and inter-craft interaction in the investigation of workshop sites such as Huaca Sialupe.[14–16]

Conclusion

This article demonstrates the critical role played by archaeometry in the holistic study of ancient technology and craft production. The active participation of archaeometrists and pertinent craft specialists in the field is important not only for the examination of archaeological remains in their proper contexts, but also for the selection of specific samples and analytical techniques and for subsequent experimental testing and refinement of interpretive models. This holistic approach has yielded an in-depth technological and organizational understanding of 1000-year-old Middle Sicán black pottery production that in many ways diverges from currently popular views of ancient craft production.

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