Hematite Mining in the Ancient Americas: Mina Primavera, A 2,000 Year Old Peruvian Mine

Kevin J. Vaughn, Moises Linares Grados, Jelmer W. Eerkens, and Matthew J. Edwards

Mina Primavera, a hematite (Fe_2O_3) mine located in southern Peru, was exploited beginning approximately 2,000 years ago by two Andean civilizations, the Nasca and Wari. Despite the importance of hematite in the material culture of the ancient Americas, few hematite mines have been reported in the New World literature and none have been reported for the Central Andes. An estimated 3,710 tonnes of hematite were extracted from the mine for over 1,400 years at an average rate of 2.65 tonnes per year, suggesting regular and extensive mining prior to Spanish conquest. The hematite was likely used as a pigment for painting pottery, and the mine demonstrates that iron ores were extracted extensively at an early date in the Americas.

INTRODUCTION

Prehistoric mining of iron-containing materials is commonly thought to be exclusive to the Old World. Indeed, evidence for the mining of iron ores used to produce iron artifacts is found in Anatolia by 1,000 B.C.[1] and in southern Africa by A.D. 1.[2] However, oxides and hydroxides of iron such as hematite (Fe_2O_3), limonite (FeO(OH)), magnetite (Fe_3O_4), and goethite (FeOOH)—collectively referred to as ochres—were mined much earlier, possibly as early as 60,000,[3] 40,000,[2] and certainly by 28,000 years ago.[4]

Within the last few millennia, ochre mining was fairly extensive in the Old World. For example, L.H. Robbins et al. report a series of specular hematite (specularite) mines in Botswana varying in size and dating to approximately A.D. 800–1000.[3] Used as a body pigment, specularite was extracted by spalling rock through heating and then using hammerstones and stone wedges to further break up the iron ore. The authors estimate that 500 and 1,000 tonnes of specularite were removed from two of the largest mining complexes called Big Mine and Greenstone Mine, respectively.

While iron was never smelted in the ancient New World,[5] indigenous people of North and South America made extensive use of ochres as decorative pigments, preservatives, and abrasives for polishing bone and ivory.[6–8] In the Andes, a variety of native minerals were used by indigenous artisans as colorants.[9] In particular ochres, called tacu, taco, or llampi in the native Quechua, were commonly used to produce bright, vibrant colors to paint textiles,[10] wall murals,[11] and especially pottery.[9,12] Along the south coast of Peru, indigenous cultures such as the Paracas[13] (800 B.C.–A.D. 1) and Nasca (A.D. 1–750) processed native ochres for textile and pottery production. In particular, the Nasca mastered the use of mineral pigments in their colorful polychrome pottery (Figure 1),[14] and a range of ochres were important in creating vibrant shades of red and black on ceramic vessels.[12] Later, the highland Wari empire adopted many of the techniques of Nasca pottery production[15] and employed a variety of iron-based minerals for painting ceramics.

Despite their importance, however,

Figure 1. An example of a Nasca polychrome bowl recovered from excavations at Marcaya, a residential site located near Nasca, Peru.[27]

Over the last 40 years, there has been a discernible increase in the number of scholars who have focused their research on early industrial organizations, a field of study that has come to be known as Archaeotechnology. Archaeologists have conducted fieldwork geared to the study of ancient technologies in a cultural context and have drawn on the laboratory analyses developed by materials scientists as one portion of their interpretive program. Papers for this department are solicited and/or reviewed by Michael Notis, a professor and director of the Archaeometallurgy Laboratory (www.Lehigh.edu/~inarcmet) *at Lehigh University.*

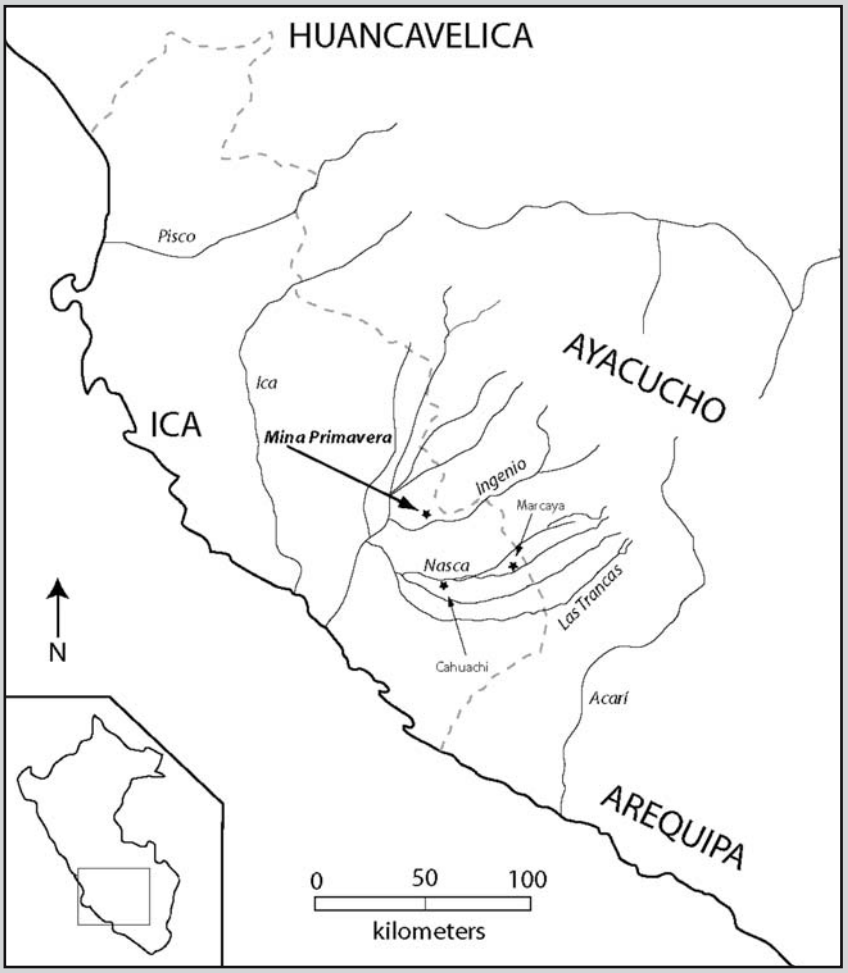

Figure 2. The south coast of Peru with sites mentioned in the text. The dotted line delineates the modern Department of Ica.

very little is known about the acquisition of the minerals used to create these pigments and with some notable exceptions,[8,16] few accounts of the mining of iron oxides in the New World have been reported. This article reports the results of investigations at Mina Primavera, a prehispanic hematite mine in southern coastal Peru that was exploited extensively for 1,400 years by the Nasca, Wari, and later civilizations.

The results of this work challenge traditional assumptions about the scale of iron extraction in the New World and reveal important clues about the organization of mining and iron ore acquisition by the ancient people of the Andes.

Mina Primavera

In an attempt to understand the sources of materials used in ancient pottery crafts, the authors have been conducting a reconnaissance of mineral and clay sources along the south coast of Peru, the heartland of the Nasca civilization and a region that was later incorporated into the Wari Empire (Figure 2). In 2004, with the aid of a local guide during a survey of the Ingenio Valley, the first author recorded a deep and apparently ancient ochre mine, Mina Primavera.

Mina Primavera was named after a recently abandoned barite ($BaSO_4$) mine, one of several contemporary mining operations for the extraction of barite and iron in the vicinity (Figure 3). The mine is located just north of the Ingenio Valley in the foothills of the Andes as they rise up from the flat desert plain of the south coast within the Portachuelo Formation, a formation composed of Cretaceous marine sedimentary deposits with intervals of intrusive volcanic pyroclastics. Mina Primavera is a small human-made cave in a cliffside located across the canyon from a modern ochre mine. The opening of the cave has been embellished recently by contemporary miners with masonry construction consisting of an artificial wall and door. According to local informants, miners used the cave to store their dynamite and tools and constructed a door so that they could secure their belongings while exploiting other nearby mines.

The prehispanic mine is approximately 500 square meters and 2 meters in height at the entrance. Inside, one encounters a deep crimson ceiling comprising a natural seam of iron oxide. Following this seam, the mine slopes steeply down toward the back of the cave and to the west. Worked into the mine floor are several large mortars used to process the extracted mineral into a powder (Figure 3).

Test excavations in 2004 and 2005 of 17 square meters of the mine's floor revealed diagnostic Early Nasca (A.D. 1–450), Middle Nasca (A.D. 450–550), and Wari (A.D. 750–1000) pottery, fragments of spondylus (Spondylus princeps) shell (a common offering in the ancient Andes linked to agricultural fertility and water[17–19]), stone and shell beads, flaked stone material, botanical remains, and plain textiles suitable for storing and transporting ground pigment (Figure 4). Flaked stone artifacts found are made primarily of chert and basalt. Included among the tool assemblage are several large basalt bifaces that the authors believe were used as axes and wedges to remove the native ochres. Battered hammerstones are not present in the assemblage. Very few flakes or chips that represent the by-product of tool manufacture or use were found, suggesting that tools were brought to the mine rather than being manufactured on site. The majority of the textiles were made of cotton (35 fragments, 89% of the total sample) while a few were made of wool and bast fibers. Many of the cloth fragments are stained red, while others are the original white or natural cream color. The staining on some of the fragments appears to have resulted from absorption of the mineral when cloths were used to store ground pigment and were abandoned in the cave following tearing/breakage.

The principal paleobotanical remains recovered from the mine were composed of a variety of native New

World domesticates including fragments of bottle gourd (Lagenaria siceraria) and maize (Zea mays) cobs. Cord strung through drilled holes suggests the gourds were used as receptacles. Other floral remains included the Andean domesticates cotton (Gosyppium barbadense) used for cloth, achupalla (Tillandsia spp.) probably used as a bast fiber, and comestibles including lúcuma (Lucuma bifera), pacay (Inga feuillei), and common beans (Phaseolus vulgaris). Calibrated[20] radiocarbon dates using accelerator mass spectrometry (AMS) of five maize cobs recovered in excavations reveal that the mine was exploited in the first few centuries A.D. and later between approximately A.D. 900–1500 (see Table I on page 19).

X-ray diffraction (XRD) analysis of sediments demonstrates that the primary mineral within the mine is hematite (Fe_2O_3). Parallel analyses on pigments from ceramic artifacts at archaeological sites in the surrounding region has determined that black and red pigments used by potters in the Nasca culture (A.D. 1–750) were hematite, while later potters appear to have used manganese oxides (MnO) and ilmenite ($FeTiO_3$) for blacks and hematite for reds. Provenance analysis of Nasca pigments has determined that reds and blacks had very high concentrations of iron.[12] Analysis of Wari pigments suggest that reds were high in iron and blacks had lower concentrations when compared to Nasca pigments. While we cannot yet unambiguously determine that the hematite from this particular mine matches the hematite used as pigments on Nasca and Wari artifacts, the evidence suggests that this is one likely source exploited by Nasca and Wari artisans. Future research incorporating analysis of stable isotope ratios may more firmly establish the connection between Mina Primavera deposits and the red and black pigments on prehispanic ceramics.

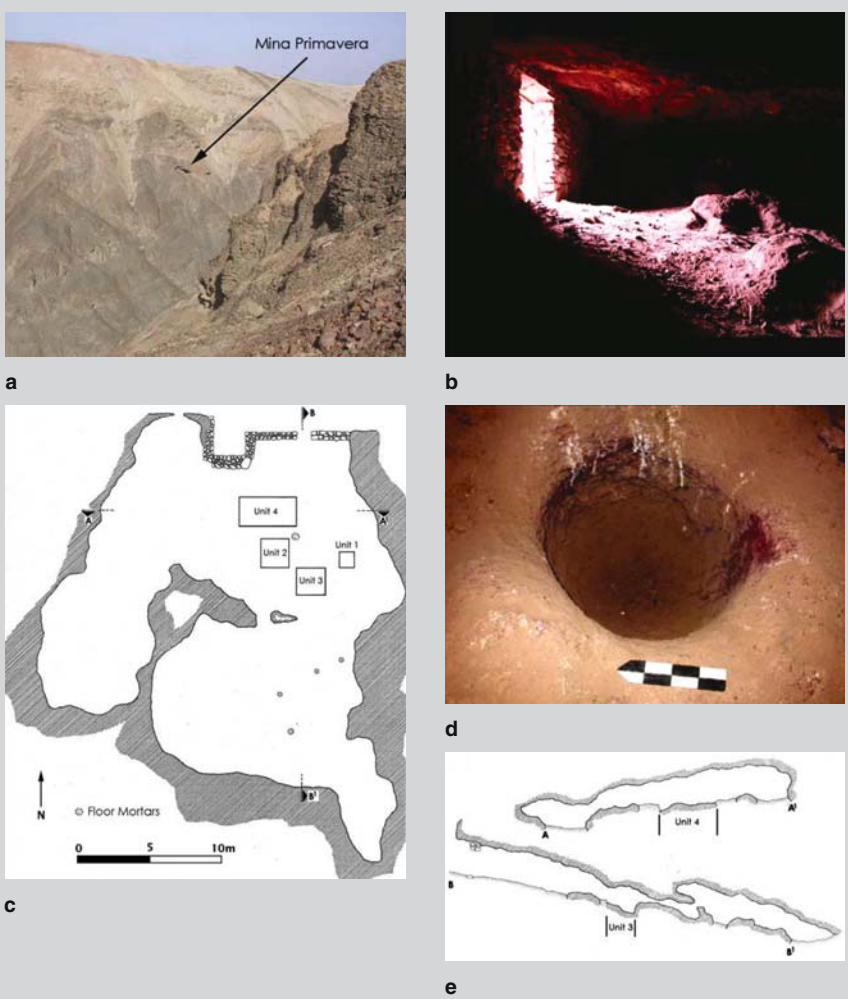

Figure 3. Mina Primavera. (a) The mine is located on a steep cliffside. (b) The mouth of the cave has been augmented with modern construction (note the hematite seam that comprises the ceiling of the cave); the height of Mina Primavera at its entrance is approximately 2 meters. (c) Planview of Mina Primavera with units excavated and location of floor mortars. (d) Detail of floor mortar used to grind hematite. (e) Cross section of the mine showing elevations. Scale is the same as in (c).

The Organization and Scale of Mining at Mina Primavera

The authors' findings reveal important clues regarding the organization of prehispanic mining of hematite in the Nasca region and provide evidence for the mining of iron in the ancient Andes. The range of artifacts and features in the cave suggest that by 2,000 years ago miners were bringing food, offerings, and other items with them to the mine. The domestic refuse recovered in excavations indicates the miners camped in the mine itself. A follow-up survey during 2007 in the immediate vicinity of Mina Primavera revealed several ancient temporary encampments consisting of small artificial terraces with hammerstones, flaked stone, and broken pots. Though these encampments could have been used to stage mining activities in the region, they are small compared to other temporary mining camps in nearby valleys.[21] Thus, most staging activities appear to have taken place in Mina Primavera itself.

While camping at the mine, miners extracted native rock using basalt and other hard stone tools (evidence for fire-spalling rock was not found), processed hematite in mortars on the mine floor, and transported the ground mineral in plain textile bags to some external location, where it was likely further processed to be used as a pigment for pottery, textiles, and potentially body paint and other uses.

Mina Primavera is large, indicating that the scale of prehispanic mining operations was extensive. Based on the size of the mine, nearly 700 cubic meters (roughly 3,710 tonnes at 5.3 g/cc) of hematite are estimated to have been removed to create the cave. For comparison, this is over three times the amount extracted from the specularite mines reported from Botswana, and the scale of iron mining at Mina Primavera is surprising given that there are no reports of this kind of mining in the An-

des and few in the ancient Americas.

Assuming that the radiocarbon dates in this study bracket the dates when the mine was utilized, a 1,400 year span, an average of 0.5 cubic meter (2.65 tonnes) of hematite was removed per annum. Of course, actual rates of removal were higher during certain time periods and lower during others. The presence of ceramics from the Nasca and Wari cultures and the radiocarbon dates suggest particularly heavy exploitation during the first millennium.

Mining in the Ancient Andes

While the findings at Mina Primavera may provide the first evidence of iron mining in the Andes, mining of other materials is well documented. For example, a well-known ancient mine in South America is the Restauradora copper mine located in Chuquicamata, Chile, and discovered in 1899.[22] Restauradora was made famous by the discovery of the mummified remains of a miner found within the mining tunnel. Radiocarbon dating of human tissue and textiles from the miner demonstrates that he lived around A.D. 550 (equivalent to the Middle Nasca period, and a time that the Mina Primavera was exploited). The artifacts associated with "Copper Man," as he became known, are similar to those found at Mina Primavera and included hammerstones and plain textiles used as bags.[23]

Other evidence for mining in ancient South America is a series of cinnabar (HgS) mines in Huancavelica, Peru, roughly 200 km to the north of the Mina Primavera.[24] Cinnabar, used as a body and textile pigment in the ancient Andes, including the south coast of Peru,[25] was also important in silver production during the colonial period. Spanish documents indicate that over 19 years in the late 16th century 4,000 people working at a cinnabar mine in Huancavelica extracted over 47,000 tonnes of mercury from cinnabar for use in silver processing.[24] In prehispanic times cinnabar was extracted at the mine using wooden stakes and deer antlers, though it is unknown how extensively the mine was exploited prior to Spanish conquest.

While the mining activity at Mina Primavera is not quite at the scale of the post-colonial cinnabar mines of Huancavelica, the documentation of a prehispanic hematite mine has important implications for the understanding of iron mining in the ancient Americas and clarifies understanding of the prehispanic Nasca and Wari civilizations. For the Nasca, brilliantly painted pottery was an important artifact in ritual, in daily life, and in death. Nasca pottery was used in large gatherings at ceremonial centers such as Cahuachi,[26] as well as in smaller, more humble settlements such as the small village Marcaya.[27] Additionally, Nasca pottery was used extensively in burial caches.[28] Finely painted polychrome pottery continued to play an important role in the emergence and dominance of the Wari empire,[15] although patterns for the consumption of the finest polychrome pottery became increasingly restricted to elite contexts and political events such as state-sponsored feasts.[29] Thus, understanding the ways in which the raw materials used for this pottery were extracted, processed, and transported to eventually be used as a paint remains an important question in understanding the ancient Andes and one of its most important artisan crafts. Furthermore, Mina Primavera, the first prehispanic hematite mine reported in the Andes,

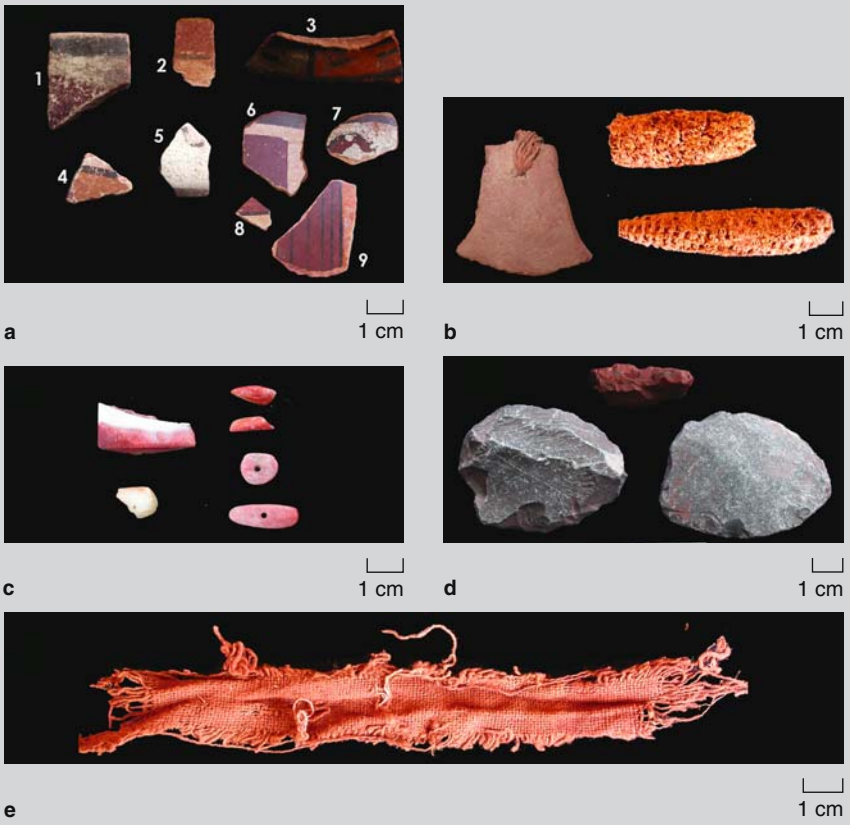

Figure 4. Examples of artifacts recovered in excavations at Mina Primavera. (a) Diagnostic Early Nasca (A.D. 1–450, fragment numbers 1, 2, 4, 6–9), Middle Nasca (A.D. 450–550, #5), and Wari (A.D. 750–1000, #3) ceramics; (b) botanical remains including Lagenaria siceraria and Zea mays; (c) Spondylus princeps (left) and beads; (d) flaked stone material; and (e) stained plain cotton textile.

Table I. Radiocarbon Dates from Mina Primavera*

Sample #	Context (Unit)	Depth Below Surface (cm)	^{14}C yr B.P.	Calibrated Calendar Years[20]
AA72022	2	0–20	505 ± 43	A.D.1316–1455
Beta 195717	1	20–60	990 ± 70	A.D. 900–1200
AA72023	2	20–60	1901 ± 44	A.D. 17–230
AA72024	3	0–60	1951 ± 35	38 B.C.–A.D. 26
AA72021	1A	20–60	1961 ± 43	48 B.C–A.D.128

*All dates are on maize cobs; ^{14}C yr B.P. = radiocarbon years before present.

and one of only several reported in the New World, compels archaeologists to reconsider the extent and importance of iron mining in the ancient Americas.

ACKNOWLEDGEMENTS

This study was supported by the National Science Foundation and the Heinz Foundation. We thank the Instituto Nacional de Cultura of Lima and Ica, especially Rubén Garcia and Susana Arce. We also thank Grace Katterman, Jose Sereveleón, Gonzalo Valencia, Roberto Quispe, Enrique Narciso, Gabi Brockman, Ryan Snodgrass, Miriam Pike, Luz Bautista, and Dawn Vaughn. Funds to print in color were provided by the Research and Discovery Support Program Grant, College of Liberal Arts, and Department of Sociology and Anthropology at Purdue.

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