

Copper and Iron Production at Poggio Civitate (Murlo)

Analysis of Metalworking By-products from an Archaic Etruscan Site

P. G. WARDEN
ROBERT MADDIN
TAMARA STECH
JAMES D. MUHLY



1 Map - the Colline Metallifere.

Since 1966 excavations at Poggio Civitate (Murlo), a site in central Italy about twenty kilometers south of Siena (Fig. 1), have revealed an Etruscan habitation of the 7th and 6th centuries B.C. Heretofore our knowledge of the Etruscans, the inhabitants of central Italy during the Iron Age, had been based almost exclusively on funerary evidence, the rich and famous Etruscan tombs which have been avidly 'excavated' since the Renaissance. In the last two decades, with a new wave of archaeological interest in the economy and material culture of early Italy, the excavations at Poggio Civitate and at a number of other Etruscan habitation sites have radically altered our view of the Etruscans by providing timely evidence for daily life rather than for funerary ritual.

At Poggio Civitate the results have been rewarding (Nielsen and Phillips 1977: 73-100 with previous bibliography). Excavation has produced a large building complex, nearly square and about sixty meters on a side with a large porticoed courtyard, the whole richly embellished with terracotta architectural decoration which includes a number of life-size animal, human, and mythological figures placed along the ridge of the roof. This building was deliberately

dismantled in the second half of the 6th century B.C., judging by the latest pottery from the site. The rich architectural decoration was toppled, carted away, and buried. The site thereafter remained desolate. The reasons for this destruction remain a mystery, but the excavators, Kyle Phillips and Erik Nielsen, have suggested that the edifice, because of the nature of the destruction, the richness of its decoration, and certain aspects of planning, may have been a sanctuary.

Underneath this 6th century edifice a smaller but no less impressive building was found. It dates to the end of the 7th century B.C. and was destroyed violently by fire. Because of the suddenness of this destruction, the 7th century finds were much richer than those from the 6th century building. They include a large number of metal objects, imported Etruscan and Greek pottery, furniture, ivories, and so on, clearly the furnishings of an extremely wealthy Etruscan household. This earlier building, although relatively modest in scale, was also decorated with architectural terracottas.

The site of Poggio Civitate is admirably situated. It is a high hill at the eastern edge of a rough mountainous area known as the



2 Region of Murlo. Wooded hills of the Colline Metallifere in the background with agricultural land in the foreground.



Acknowledgments
We are grateful to Dr. Guglielmo Maetzke, formerly Soprintendente alle Antichità d'Etruria, and Prof. Francesco Nicosia, Soprintendente alle Antichità d'Etruria, for their generous permission to work on this material. Gratitude is also expressed to Kyle M. Phillips, Jr., Bryn Mawr College, and Erik Nielsen, Bowdoin College, Directors of the excavations at Poggio Civitate (Murlo), for permission to publish material from the site.

Elemental and metallurgical analyses of the slags were performed in the Laboratory for Research in the Structure of Matter, University of Pennsylvania. Special thanks are owed Alexander Vaskelis for photography, Robert White for scanning electron microscopy and Asha Varma for elemental analysis. The analysis of the charcoal samples was performed through the generosity of R. C. Koeppen of the Forest Products Laboratory of the United States Forest Service. Our greatest debt is to R. B. Haagen of A.S.A.R.C.O. for studying the slags and reporting them in detail.

Colline Metallifere, the metal-bearing hills (Fig. 2). Farther to the east is less rugged terrain which might have been agriculturally productive in antiquity; today this eastern area encompasses the rich agricultural valleys that undulate toward Arezzo and Chiusi as well as the picturesque Chianti valley to the north. From the top of Poggio Civitate it is possible to see all the way to Siena and far off to the east toward Chiusi. The site also controls the natural trade routes. It and the nearby citadel of Montalcino sit astride the valley of the Ombrone, a small river which traverses the Colline Metallifere and thus provides the major route between the Sienese interior and the coastal flatlands of the Maremma, site of the early and rich Etruscan cities of Populonia, Vetulonia, and Roselle.

The wealth of Poggio Civitate, manifest in the rich finds of the 7th century phase, the size of the 6th century complex, and the architectural decoration found on buildings of both periods, is difficult to explain. The strategic location of the site could have given it control of the trade routes, but we know little of this remote section of Etruria and cannot specify, yet, exactly what was being traded. Nor can we assess the locality's agricultural wealth

in the 6th century until faunal and floral studies are completed. However it is suggestive that the site is located at the edge of one of Europe's richest areas in metal ores.

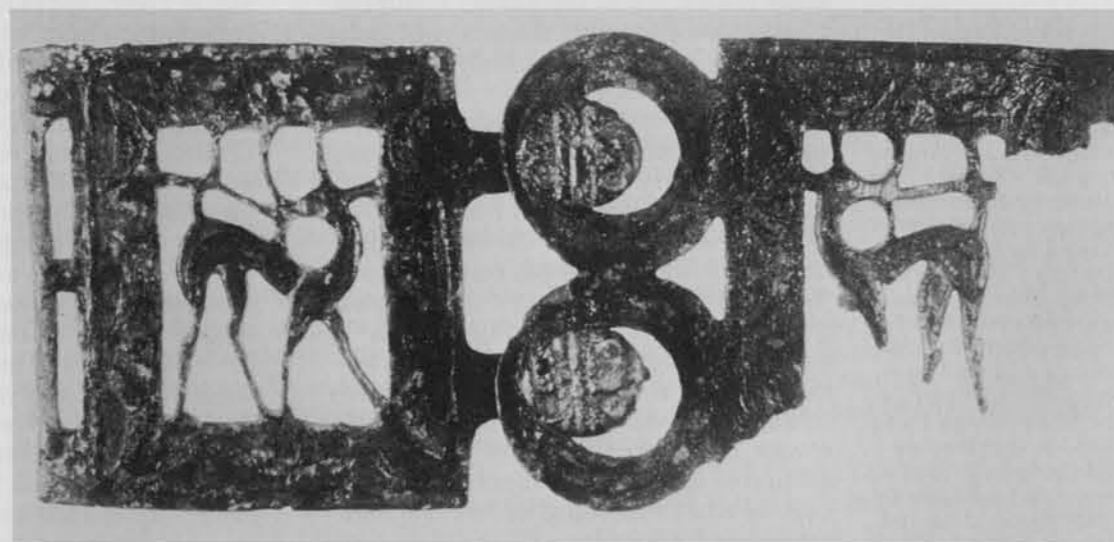
Near Murlo there are a number of copper deposits. There is copper in the Crevole lode at Vescovado di Murlo (about a kilometer from the site), as well as at Resi, Monte Pescini, Monte Acuto, and Santo, all in the immediate vicinity. In the nearby Merse river copper is so abundant that it is found as a precipitate along the banks of the stream. Traces of copper mining of undetermined date are found today in the hills immediately adjacent to Poggio Civitate. It seems certain that the Etruscans in this area would have been aware of these ores, especially given the evidence for metalworking at Poggio Civitate.

This all suggests another reason for the prosperity of the site. Thus the study of the metal objects found there, as well as the by-products of metalworking and ore refining, is particularly important. The metal finds were abundant and occasionally spectacular. They included objects of iron, lead, bronze, silver and gold. The artifacts range from mundane agricultural implements and household



3
The Merse River between Montieri and Murlo.

4
Bronze buckle with iron inlay. Mid 7th century B.C. Siena, Archaeological Museum Inv. no. 2837.



utensils to luxury items such as bronze cauldrons, figured bronze stands (Warden 1982), horse trappings (Fig. 4) and chariot fittings, as well as jewelry. Stylistic analysis of the objects has revealed that most were made locally; only a few pieces of gold jewelry are probable imports. Also, many of the objects are closely paralleled at the coastal site of Populonia, indicating that the metalworkers at Murlo had close ties to this famous Etruscan metallurgical center. From the 6th century period at Murlo we also have primary evidence for metalworking. Although no actual workshops have been found, there are slag and

metalworking by-products from stratified contexts, including a heap of slag just outside the northwestern corner of the building. Metallographic analysis of the objects themselves is currently being carried out by the Florence Archaeological Museum, while study of certain of the metalworking by-products has been carried out at the Laboratory for Research in the Structure of Matter at the University of Pennsylvania.

Several metallurgical by-products were analyzed to determine the nature of the metals being smelted and of the metalworking activities at the site. The materials studied included slags and crucible or furnace fragments with slag adhering. Because bluish-green flecks were visible in two of the crucible slags, it was assumed that copper was being processed. Elemental analysis of seven specimens of slag revealed that iron was the major constituent of six of them, but a high iron content is to be expected of a copper smelting slag because iron in some form—either as part of the ore itself or added as flux—is needed to slag off the siliceous component of the copper ore. The only material analyzed which had a high copper content was a green speck entrapped in a crucible slag; it must represent a prill caught up in the slag or dross from refining, which has oxidized since the time of deposition.

Copper production at Murlo is not surprising given the great amount of bronze found at the site. Even though Murlo is an Iron Age site most of the artifacts are not of iron but of bronze. Here, at any rate, copper and bronze are of major economic importance at least through the 6th century B.C., a phenomenon which can be documented in other parts of Iron Age Italy as well.

Although iron objects have been found at the site, however, iron ores are not found in the immediate vicinity, and it remains to be explained how the iron at Poggio Civitate was obtained.

It is therefore of considerable significance, both economic and technological, that at least one of the slags analyzed, and probably another, can be connected with iron working. When sectioned, one slag was found to contain a metallic iron bar (Figs. 5, 6), rectangular in section (L. 1.17 cm., W. 0.5 cm., Th. 0.3 cm.). The metallurgical implications of the bar and the entrapping slag are discussed below, but it is worth noting at this point that the small iron bar must indicate that some sort of iron production was taking place at Murlo for the following reasons. The bar is probably a piece of scrap fed into the furnace with other materials which were known to yield metallic iron. Iron rods may have been used in copper production to stir the molten copper, but the Murlo bar is too small to have had any effect on molten metal. It is conceivable that the bar has partially melted; that is, it may have originally had a thickness sufficient to make it a useful stirring rod. The Murlo bar



5
Cross section of slag with iron bar embedded in it.

6
Iron bar.

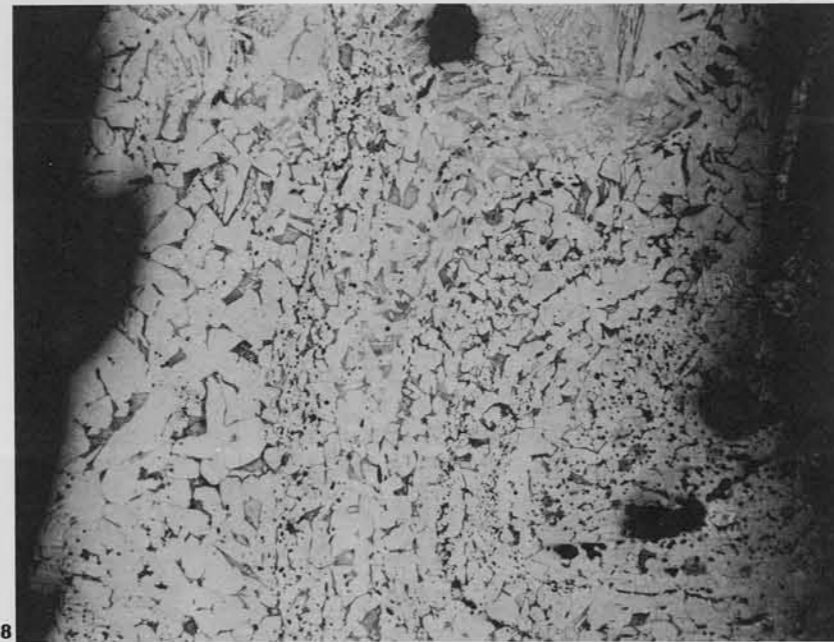
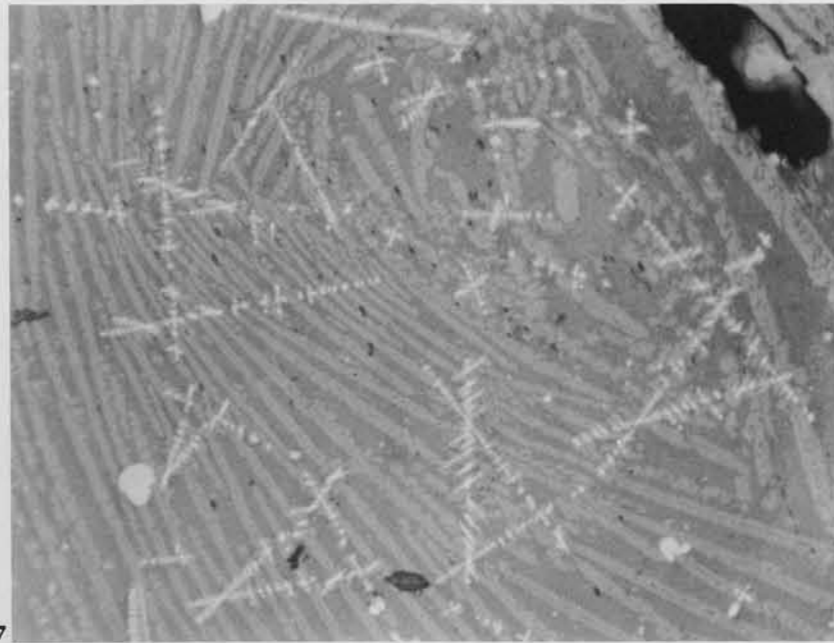


1 CM

shows little evidence of surface alteration; it retains a regular shape which indicates that it is a man-made product. It would not have contributed to copper production in any way, so it is likely that the slag from which it came is a residue of iron production.

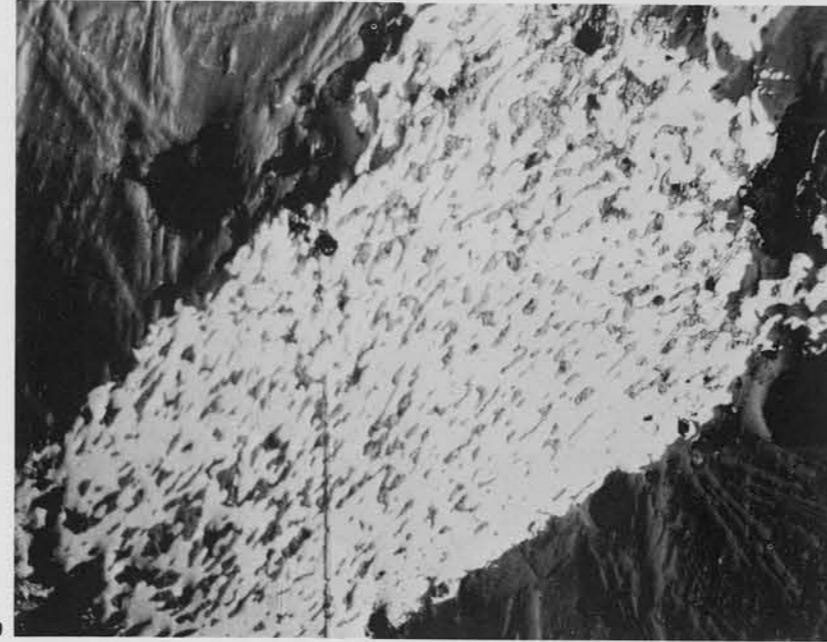
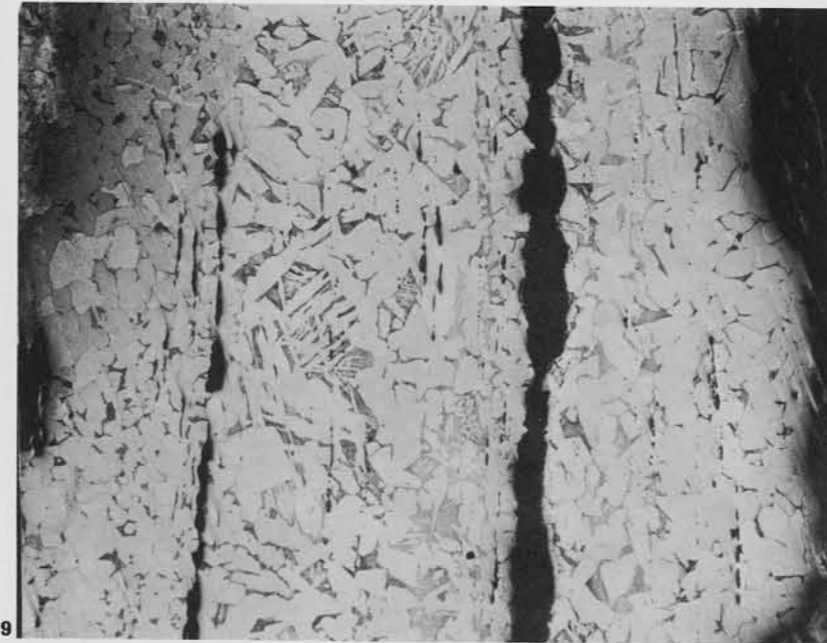
Analysis of the slag itself aids in understanding the process by which iron was produced. Microscopically, the slag shows well developed fayalite dendrites (Fig. 7), whose presence indicates that the slag was formed at a temperature greater than 1177° C. The microstructure of the iron bar supports this inference. The bar is made of partially carburized iron. A flow pattern (Fig. 8) and elongated slag stringers (Fig. 9) indicate that the bar had been forged. It therefore cannot be an accidental production and must have been added as scrap as part of an attempted recycling operation. In addition, there are concentrations of impurities and slag at the grain boundaries; these impurities must have precipitated while the slag was hot.

Several small areas of metallic iron were also visible in the polished cross section of the slag. These iron patches are concentrated at one edge of the slag chunk and consist of sponge iron with entrapped slag (Fig. 10). Therefore, they are representatives of the stage of the iron production process represented by this slag: metallic iron produced during the heat treatment. Although iron does sometimes occur in metallic copper (Cooke and Aschenbrenner 1975), and virtually always is the major constituent of copper slag (although not in metallic form), might it not be that at Poggio Civitate attempts were made to produce metallic iron from iron-rich slags, probably those that resulted from copper smelting?



7
Photomicrograph of slag shown in Fig. 5. The light tree-like patterns are fayalite dendrites. x500

8
Metallic iron bar, micrograph showing flow pattern produced by working the metal. x200



9
Metallic iron bar, micrograph showing slag inclusions (black areas) strung out by working. x200

10
Photomicrograph of sponge iron (white) with entrapped slag, (gray areas within white), at lower right of Fig. 5. Background is non-metallic slag matrix. x200

This suggestion finds support in another piece of slag from Murlo which in contrast to the one which contained the iron bar is non-magnetic, unlike other copper slags we have studied. It also shows signs of having been more strongly reduced, an indication that it may have yielded metallic iron, in a process in which the slag was 'resmelted.' This slag sample was taken from a heap of similar slag outside the northwestern corner of the 6th century building complex, an area which also produced the crucible or furnace fragments.

A parallel situation seems to have existed at 13th and 12th century Kition, on the eastern shore of Cyprus. Most of the slags studied appear to be of the type expected to result from copper smelting, while several are of the strongly reduced type which, on analogy with similar slags from Murlo, might have been used to produce metallic iron (for detailed reports see Stech, in press, and Maddin, Muhly, and Stech, forthcoming). Cyprus is a land poor in iron ores, yet we know that production of iron artifacts had begun there by 1220 B.C. Therefore some source of iron was available. It could have been imported as ore, but the possibility that the iron-rich copper slags were processed to obtain iron cannot be dismissed and indeed has been suggested previously by both Muhly and Frank Koucky. Of significance in this connection is documentary evidence for the export of Cypriot copper slags to France during the Ottoman period to be used as sources of iron (Steinberg and Koucky 1974: 178).

One of the slag specimens from Murlo yielded large enough pieces of charcoal for the wood from which it was made to be identified. The wood is an oak (*Quercus*) of the ring-porous red oak type. In modern



Italy the most common oak of that type is *Q. Cerris*, sometimes called the turkey oak. Even today the hill of Poggio Civitate is covered with scrub oak which is periodically harvested as fuel, and the Colline Metallifere are also covered with scrub oak as well as scrub pine. In 1937, analysis of slag from furnaces at Campiglia, on the coast near Populonia, also revealed the presence of charcoal made from *Q. Cerris* as well as from another type of oak, *Q. Robur* (Tongiorgi 1937: 332-3).

Iron ores are not found near Poggio Civitate. The nearest iron ores are at Montieri, more than thirty kilometers away, a site which also has the richest silver ores in Europe. At Montieri the iron ores are found in small quantity and there is no evidence for ancient exploitation; it is doubtful that the inhabitants of Poggio Civitate would have had access to these ores. Apart from Montieri the nearest iron ores in any quantity are on the coast, in the region around Populonia and on the island of Elba (Fig. 1). Here the iron ores are very abundant and were undoubtedly known to the Etruscans. By the end of the 6th century Elban ores were transported to the mainland to be smelted at Populonia where over the next few centuries slag heaps accumulated over the 7th century cemeteries. In some cases the tumuli were used as furnaces, showing, if nothing else, a certain ingenuity on the part of the Etruscan metalworkers but also rather a casual attitude toward the tombs of their ancestors. What is strange is that at



11
A 7th century B.C. rein ring (P.C. #71-706) from Poggio Civitate. The ring, decorated with two bull head finials, is for attachment to a chariot pole. Maximum Diameter: 5.5 cm.

12
A 7th century B.C. bronze figure of a wrestler (P.C. #71-105), was probably an attachment for an elaborate bronze stand. Stylistically this figure can be associated with bronzes produced in Populonia. Height: 9.5 cm.

Populonia we have no evidence for extensive iron smelting much before the middle of the 6th century B.C., while at nearby Campiglia there is only evidence for the smelting of copper ores (Warden, in press). In view of the close connection between the metal assemblages of Poggio Civitate and Populonia, the evidence for smelting at Murlo at the same date or at an earlier date is interesting. There is clearly a connection between the two sites, but at Murlo, it would seem, iron ore was more difficult to obtain and iron metal had to be extracted

from copper slags.

This brings up a number of questions. If, as now seems likely, the wealth of the site at least partially resulted from metal trade and metal exploitation, could it also be possible that the decline or destruction of the site might also have partially resulted from economic factors? Also, is there any connection between the destruction of Poggio Civitate—with the resulting/termination of metal production and trade in the eastern part of the Colline Metallifere—and the sudden rise of iron production at

13a-c
A 7th century B.C. iron adze (P.C. #71-97). a underside; b top; c side view. Length: 18 cm.



14

A bronze tack with gold foil crimped over the head (P.C. #71-629) from the 7th century B.C. At Murlo some thirty-seven tacks with gold or silver heads have been found. They appear to have been used as decorative fasteners for elaborate wood and ivory furniture. Length: 1.4 cm.



15

A 6th century B.C. bronze furniture attachment in the form of a double lotus ending in a five-petaled palmette (P.C. #67-56). A number of these plaques, which probably served as decorative attachments for wooden furniture, have been found. Height: 5.5 cm.



18

This hollow convex pendant, a 7th century B.C. bronze bulla (P.C. #71-120), was popular throughout Etruria during the Iron Age. Such bullae were often used as amulets or tintinnabula, sometimes containing small stones which were meant to create a ringing sound. Length: 3.1 cm.



Populonia, production of such great scale that it surely must have affected the economy of all the minor metalworking centers in the interior?

The revised dating for the beginnings of iron smelting at Populonia and the suggestion that iron ore from Elba was not being shipped to the mainland before the end of the 6th century, also calls into question the theory that Greek colonists came to western Italy (Pithecosa and Cyme) in search of new sources of iron ore as early as the mid-8th century. The evidence presented here certainly supports the argument that, at least in its early phases, Greek colonization represented a search for fertile land, not mineral resources (see Graham 1982: 102-3).

The problem is tantalizing but the solution will have to await a careful assessment of all the economic factors. In the end this may have to include study of the entire Colline Metallifere and neighboring sites, but this has already proven itself an area in which metallurgy and archaeology together provide answers to crucial historical problems.

Gregory Warden received his B.A. in Anthropology from the University of Pennsylvania and his Ph.D. in Classical Archaeology from Bryn Mawr College in 1978. He has taught at Bowdoin College and the University of Pennsylvania and is currently teaching at Southern Methodist University. He has excavated in Italy (eight seasons at Poggio Civitate) and has published on Etruscan archaeology and Roman architecture. He is presently working on the publication of the small finds from The University Museum excavation at Cyrene.



The archaeometallurgical research team of Tamara Stech, James D. Muhly and Robert Maddin continues its work on early copper and iron metallurgy in the Eastern Mediterranean and is working in collaboration with MASCA on the Sumerian Metals Project. Recently Tamara Stech presented her research

results at a conference, in Larnaca, Cyprus, entitled *Early Metallurgy on Cyprus: 4000 B.C.-500 B.C.* James Muhly has just returned from a year as a National Endowment for the Humanities/American Schools of Oriental Research Fellow in Jerusalem where he concerned himself with early metallurgy in the

Levant. *Early Metallurgy in China* was the title of a recent conference held in Beijing (Peking) organized by Robert Maddin, who reported on his study of Southeast Asian bronzes, and by Tsun Ko of the Beijing University of Iron and Steel Technology.

Bibliography

Cooke, S. R. B., and S. Aschenbrenner
1975

"The occurrence of metallic iron in ancient copper," *Journal of Field Archaeology* 2: 251-266.

Graham, A. J.
1982

"The Colonial Expansion of Greece," in *Cambridge Ancient History* second edition, Vol. III/3, 83-182. Cambridge, England: Cambridge University Press.

Maddin, R., J. Muhly, and T. Stech
Forthcoming
"Metalworking at Kition," in *Kition V*.

Nielsen, E., and K. M. Phillips, Jr.
1977

"Bryn Mawr College Excavations in Tuscany," *American Journal of Archaeology* 81: 75-100.

Stech, T.
In press

"Urban Metallurgy in Late Bronze Age Cyprus," *Acts of the International Symposium "The Ancient Metallurgy of Cyprus, ca. 4000-500 B.C."* Nicosia: Department of Antiquities.

Steinberg, A., and F. Koucky
1974

"Preliminary metallurgical research in the ancient Cypriot copper industry," in *American Expedition to Idalion, Cyprus*, edited by L. E. Stager, A. Walker, and G. E. Wright, pp. 149-178. Cambridge, Massachusetts: American Schools of Oriental Research.

Tongiorgi, E.
1937

"Ricerche archeologico-minerarie in Val Fucinaia. Esame dei carboni provenienti dallo scavo dell'impianto metallurgico," *Studi Etruschi* 11:331-333.

Warden, P. G.
1982

"An Etruscan Bronze Group," *American Journal of Archaeology* 86: 233-238.

Forthcoming
"The Colline Metallifere: Prolegomena to the Study of Mineral Exploitation in Central Italy," in *Crossroads of the Mediterranean*, edited by R. Holloway. *The Metal Artifacts from Poggio Civitate (Murlo) 1966-1978*.