Study of an Etruscan object composed of three metals

GIOVANNA SAVIANO\(^1\)*, FERDINANDO FELLI\(^1\), MAURO CAVALLINI\(^1\) and LUCIANA DRAGO\(^2\)

\(^1\) Dipartimento di Ingegneria Chimica, dei Materiali, delle Materie Prime e Metallurgia Università di Roma «La Sapienza», Italy.
\(^2\) Dip. di Scienze Storiche, Archeologiche, Antropologiche dell’Antichità Università di Roma «La Sapienza», Italy.

ABSTRACT. — This paper reports the results of preliminary research carried out on one of the many metal objects from excavations in the Sanctuary of Pyrgi (Santa Severa, Rome) near the port of Caere (Cerveteri), one of the main towns of Southern Etruria. The metal object, found in the southern area of the sanctuary consists of a cylinder, perhaps a handle, originally part of an object of indefinite shape and function. It consists of three different layers of metal: a central ferrous rectangular rod (10 × 8 mm), surrounded by a thick lead alloy ring 21 mm in diameter, and a 2-mm outer layer of copper alloy. SEM+EDS analyses were carried out on the three components.

It seems probable that the outer copper alloy sleeve was produced first. The inner iron rod was set in position and the Pb-Sn alloy was then cast to fix all three parts of the object together.

The ferrous rod was produced by deformation resulting from heating. Pb- and Cu-bearing alloys were cast in temperature ranges of, respectively, 350-300°C and 1100-800°C.

INTRODUCTION AND HISTORICAL BACKGROUND

This paper presents the results of preliminary research carried out on one of the numerous metal objects found in the excavations directed by Prof. Giovanni Colonna of the University of Rome «La Sapienza», in the southern area of the Etruscan Sanctuary of Pyrgi (Santa Severa, Rome), the main harbour of Caere (Cerveteri), as a contribution towards knowledge of metal production in South Etruria (Figs. 1, 2).

The findings in this area of the Sanctuary, which include a large number of votive offerings mainly dating from the 5th and 4th centuries BC, bear witness to constant worship up to the end of the 3rd century BC (Baglione, 1989-90; Colonna, 1992, 1996; Colonna and Baglione, 1998).

The object of this study, perhaps a handle with its ends missing, is part of an artefact, the shape and function of which cannot yet be identified. It is formed of a cylindrical part in lead in a bronze sleeve and an iron rod, with a
Fig. 1 – Aerial view of Sanctuary of Pyrgi.

Fig. 2 – Aerial view of southern part of Sanctuary of Pyrgi.
square cross-section, probably running from one end to the other. The rod is visible protruding from the end of the artefact. The detail of a lead core coated by a bronze sleeve is typical, for example, of the handles of round shields of rolled bronze, in use from a very advanced phase of the First Iron Age (second half of 8th century BC).

The technical characteristics of the object are extremely interesting, because it is an example of composite metallurgy, i.e., different metals and alloys in juxtaposition.

Its main interest lies not only in the use in the same object of three different metals but also of the alloy – iron, lead and bronze – mostly represented in the Sanctuary of Pyrgi in several kinds of materials, already extensively studied (Drago et al., 1999, 2000a, 2000b; Cavallini et al., 2000).

Among the iron objects there is also a large group of arrow-heads – more than five hundred – found in the fill of the square of the southern area of the Sanctuary, together with large numbers of Attic ceramics and other metal and ceramic findings. These objects form a sort of large secondary votive deposit, sealed at the latest at the mid-4th century BC, and have been related to the god Suri, corresponding to the Faliscan god Apollo Soranus, the Greek Hades, the Latin Dis Pater and the Roman Vediovis.

Among the findings, ten lead ingots are of particular interest. They are prismatic in shape, have a more or less regular trapezoidal cross-section, and weigh between 5,300-6,400 kg. and 21,750-38,500 kg. They were found in the southern area of the Sanctuary, under the foundations of altars and buildings dedicated to Suri in the 5th century BC. They are similar in composition but not in shape to the small lead ingots from the archaic wreck found at Campese Bay (Isola del Giglio) (Bound, 1991; Craddock and La Nieci, 1991; Cristofani, 1998).

Other lead objects found in the northern and southern areas of the Sanctuary are many clamps and lead pieces, partly used to fasten terracotta decorations to the wooden parts of the temples, and numerous «missili» (so called «ghiande missili»), dating from the 5th and 3rd centuries BC. Bronze goods include tools and vases. Among the findings in copper, most noteworthy is a significant group of pieces of aes rude, mainly found in the square of the southern area.

The aim of analyses, so far carried out on samples of the main categories of metal findings from both northern and southern areas (iron weapons, aes rude, ingots, clamps, lead missiles) and on a sample from the object examined here, is to gain information on metallurgy techniques and to determine the provenance of the raw materials, within the broader framework of a study on metallurgy, sources of supply, and circulation of raw materials in South Etruria (Tanelli, 1983, 1989; Zifferero, 1991, 1996; Carancini, 1996; Giardino, 1996, 1998; Boni et al., 2000; Brocato, 2000). Lead isotopes \(^{206}\text{Pb}/^{204}\text{Pb}, \(^{207}\text{Pb}/^{204}\text{Pb}, \(^{208}\text{Pb}/^{204}\text{Pb}\) have been analysed in many lead objects from various parts of the Italian peninsula. Etruscan lead ingots from the Pyrgi temple (Caere, 5th century BC) show isotopic fingerprints of the mining district of southern Tuscany (Boni et al., 2000).

**Methods and Techniques**

Fig. 3 shows the metal object. A transversal thin metallographic section was cut from it by a diamond saw and embedded in epoxy-type «Mecaprex MA2» cold mounting resin. Because of the great brittleness of the outer sleeve of the object, many chips were produced and lost during cutting.

Fig. 4 shows an overall view of the specimen, which was examined by optical microscopy. It was then sputtered with a thin film of carbon produced by evaporation, for Scanning Electron Microscopy (SEM) + Energy Dispersion Spectroscopy (EDS) analyses.

Quantitative analyses were carried out for information on the various components, impurities, and interphases between metals, where corrosion effects are more interesting.
Fig. 3 – Two aspects of studied object.
RESULTS

EDS analyses of the outer ring show that it is made of bronze, with the following composition: 84.1% Cu, 13.9% Sn, 1.8% Pb, 0.2% Fe. Corrosion morphology is clearly shown in fig. 5, in which a penetration of about 1 mm is evident. Metallographic examination reveals a heterogeneous pattern of dendrites ($\alpha_{Cu}$ solid solution) and $\alpha+\delta$ eutectoid areas. The darker constituent in fig. 6 is $\alpha_{Cu}$, with maximum Sn contents of 4%; the lighter constituent is an $\alpha+\delta$ eutectoid with Sn contents over 20%. Pb is associated mainly with the $\delta$ phase. The X-ray map of Cu and Sn is also shown in fig. 6. The dendritic structure clearly indicates that the sleeve was produced by a casting technique.

A thin layer of metallized iron was detected at the interface with the inner ring (fig. 5), which consists of a Pb-Sb alloy with 1.1% Sb and about 0.5% Cu.

The central ferrous rod appears to be fully mineralized, as usually occurs, and consists of various oxidation products (iron oxides, oxyhydroxides). The whole rod presents many cracks particularly at the Fe-Pb interface, as shown in fig. 7. Silicon and aluminium-rich inclusions are shown in fig. 8.

DISCUSSION AND CONCLUSIONS

Metallographic and analytical results suggest how the object was made. Some indications about ancient mines will also be discussed.
Fig. 5 – SEM micrograph of outer bronze ring. External surface shows corrosion products; internal interface towards Pb-Sb alloy is still metallic, with mineralized iron layer.

Fig. 6 – Micrograph of dendritic structure of bronze, and X-ray map of Cu and Sn.
The outer bronze ring was produced first. The presence of dendritic structures suggests casting of a (lost wax?) plane sheet with a rougher inner surface, worked while hot on a barrel to give a cylindrical shape. The loss of continuity in the cylindrical ring but the presence of an overlap along a generatrix, support this idea. The thin layer of mineralized iron, found at the bronze-lead interface, is probably due to deposits of iron-rich corrosion products from the inner rod or to corrosion of local residues from the working process.

The inner iron rod was set in position and the Pb-Sb alloy was then cast, to fix the parts of the whole object together.

As regards the metals:
- the outer bronze sleeve is a typical Cu-Sn alloy with low Pb contents. It appears to be homogeneous and has few inclusions. The alloy is quite different from the previously studied aes rude found in the same site (Drago et al., 2000 b), which consisted of metallic copper with mixed iron and copper sulphides, and other lead and bismuth impurities;
- the Pb-Sb alloy is very similar in composition to previously studied ingots (Drago et al., 2000 a), suggesting that its ore came from typical regional mineralized areas like the mountains of Tolfa or southern Tuscany, where galena with such a composition was mined (Rolandi, 1956; Tanelli, 1983, 1989; Zifferero, 1991, 1996; Carancini, 1996; Giardino, 1996, 1998; Saez et al., 1996; Brocato, 2000).
- the morphology of the mineralized iron is different from that of the iron arrow-heads from the same site (Cavallini et al., 2000), as its inclusion contents consist of Si- and Al-rich products, typical of local ores, instead of the puzzling Ca-rich inclusions of the arrow-heads (Panseri, 1957; Follo et al., 1988; Gauzzi et al., 1996; Mapelli and Nicodemi, 2000).
It should not be forgotten that the three alloys studied here differ greatly from the technological point of view: the iron rod was produced by hot deformation, whereas the Pb- and Cu-bearing alloys were cast in temperature ranges of, respectively, 350-300°C and 1100-800°C. The temperature of iron reduction was not higher than that of the copper alloy, because direct reduction was involved, with no need to reach melting temperature (1536°C for pure iron).

This study of an Etruscan object composed of three metals confirms the high metallurgical skills (Tylecote, 1988) of the old craftsmen, who were capable of handling different kinds of alloys. Knowledge of very different techniques and ores coming from several mines confirm the metallurgical and commercial ability of the Etruscans.

REFERENCES


(eds.) «La miniera, l’uomo e l’ambiente. Fonti e metodi a confronto per la storia delle attività minerarie e metallurgiche in Italia». All’Insegna del Giglio, Firenze: 53-76.


PANZERI C. (1957) — La tecnica di fabbricazione delle lame di acciaio presso gli antichi. AIM, Quaderno II, Milan.


