

# ECASIA'13

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on Applications of Surface  
and Interface Analysis**

**13 – 18  
October 2013  
«Forte Village»,  
Cagliari,  
Sardinia (Italy)**

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## Spectroscopic characterization of Phoenician-Punic coins

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### 1. Introduction

Sardinia hosted many Phoenician and Punic communities, as integrated forms of pacific cohabitation with the Lebanese merchants or actual colonies for the exploitation of the rich mines and wealthy coastal emporia under the Carthaginians (750-250 B.C.). One of their most important settlements is that of Mount Sirai, in the south west of the island, whose excavation revealed a complex structure of the site and allowed the discovery of excellent finds, as steles, everyday-life objects and tools, grave goods, amulets and coins. Punic coins were made by gold, electrum or, more commonly, by bronze. The first coin mintage from Carthage dates back to the IV century B.C. Whether the mintage was exclusive to Carthage or permitted outside the city too is still a matter of debate.

There is the possibility that mintages were allowed in Sardinia (320-238 B.C. as well as in 216), in Spain (237-209 B.C.) and Southern Italy (216-203 B.C.).

We have analyzed ten of these bronze coins (Fig. 1) to unveil the secrets of their mintage, origins and inner structure.

Some traditional spectroscopic techniques such as X-ray diffraction (XRD) and fluorescence (XRF) have been used for this purpose, allowing us to learn about their mineral content (XRD) and elemental composition (XRF) [1,2]. Here we report about these findings.



Figure 1: Bronze coins in our study

### 2. Results

The ten coin studied feature a head of the Tanit Goddess looking leftwards on the obverse, and a horse on the reverse.

XRD analysis (Fig. 2) showed they are composed by bronze (a copper-rich alloy), with the presence of Cuprite (copper(I) oxide,  $\text{Cu}_2\text{O}$ ) and 10% of Sphalerite (a mixed sulfide of zinc and iron). The Rietveld fit allows a careful evaluation of the lattice parameter of the FCC Cu-based phase.

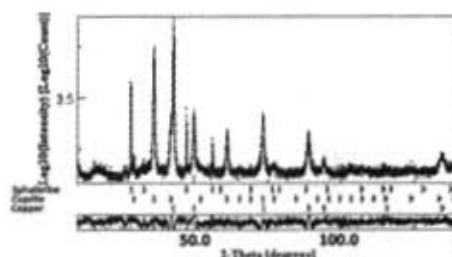


Figure 2 XRD spectra of one coin

Fluorescence spectra (XRF), on the other hand, gave information about the elemental constitution of the coins. In this way we found out that copper is the main component, but also that tin, arsenic (or lead), zinc, iron and nickel are present in the alloy.

The coin patina is mainly made of copper oxide phases, like Cuprite ( $\text{Cu}_2\text{O}$ ) and Tenorite ( $\text{CuO}$ ). Sphalerite and Paracatamite are also present, together with mixed copper and zinc chlorides. Very likely, the formation of Paracatamite is due to the presence of chlorides in the nearby environment. The presence of  $\text{ZnS}$ , instead, may be traced back to the ancient metal extraction procedure.

After scratching this layer off, the contribution of the Cu-based bronze phase increases, while that of Cuprite decreases. Traces of Sphalerite are still observable, as shown by XRD analysis.

### 3. Conclusions

Taking pure Copper as the reference, from lattice parameter expansion we have estimated the Tin content (Vegard's law) of these bronze coins, which varies between 2 and 6 %. This implies that the coins here examined are not belonging to one specific mintage.

Such a hypothesis is also supported by the different weight of the coins, together with the different head fashion of the Tanit Goddess and horses represented on both coin sides.

### References

- [1] Carter, Giles F., "Analysis of Copper and Brass Coins of the Early Roman Empire", *Science*, 151 (1966): 196-97.
- [2] Calliari, I., M. Magrini, A. Zambon, P. Guerriero, and R. Martini, "Microstructural and Compositional Characterization of Roman Coins", *X-ray Spectrometry* (1999): 86-90.

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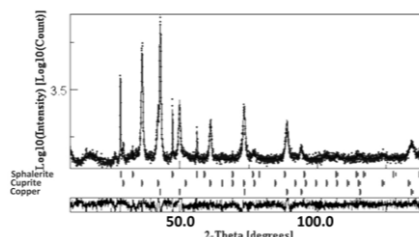


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