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A GOLDEN DRACHMA FROM BRUTTÌA: COUNTERFEIT MONEY REVEALED BY SCANNING ELECTRON MICROSCOPY AND CATHODOLUMINESCENCE

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ABSTRACT

Diagnostic studies performed on an ancient coin are presented in order to find if the coin is authentic or is a coinage proof. Our investigation includes Scanning Electron Microscopy – Energy Dispersive X-ray (SEM-EDX) and Cathodoluminescence (CL). The coin is a Drachma representing on the obverse the portrait of Poseidon and, on the reverse the figure of Anfitrite riding a seahorse while Eros is shooting an arrow. The coin is well known in the numismatic studies and originals can also be found in Catanzaro, Naples or Milan museums. The EDX analysis, executed on narrow points of the surface, revealed Pb and Cu as main components of the coin on both sides: 51% of Pb and 35% of Cu their weight and surprisingly on both sides traces of gold was found. The maximum dimensions and the percentage in weight of the small revealed gold spots were respectively on the order of 20 μm and 95%. At the same time luminescence emission induced by electron bombardment (CL) on these spots was executed. This analysis confirmed SEM results, though the presence of Au was more evident than in SEM analysis. In fact CL analysis showed a little presence of Au throughout the sample surface.

KEYWORDS: drachma, Bruttia, golden coin, SEM-EDX and CL analysis

INTRODUCTION

This paper is a successful conclusion of an interdisciplinary work performed by scientists and technicians in Earth Science and Physics Departments at the "Università della Calabria". To our knowledge, this work is the first application of CL techniques to a metal coin, in literature we can find works (Linke et al., 2003) which make use of techniques like SEM, EDX or PIXE analysis but we didn't find any work in which such techniques are used in combination with CL (Cathodo - Luminescence) as in our case.

The object of the research was a coin recognized as a bruttian product of the first decades of 3rd century B.C. It was a single sample and so we had not information about the sequence of the coinage usually revealed by discovery of treasure chests. This difficulty was overcame by means of historical and macroscopic comparison with similar models kept in Catanzaro, Naples and Milan Museum.

Every observation and scientific analysis executed on this coin was put together in order to find its historical background and, at the same time, to obtain technological details about its production. In the following we describe all the research phases and specify the methodological criteria.

SAMPLING AND HISTORICAL BACKGROUND

The coin studied in this work has been offered by a private collector to see if the coin represents some valuable object and if so, to proceed to its transfer in a Museum by donation. The study refers to this sole coin because it has been difficult to obtain coins from national museum even if we submitted an official request ensuring and explaining in our request the proposed investigations were of non destructive and non invasive type.

The coin has the following characteristics:

- diameter: 15,8 mm
- thickness: 2 mm
- weight: 3,35 g
- Axes of the coin with orientation at 180° (Fig. 1)

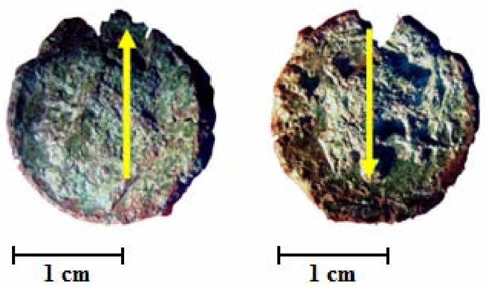

Fig. 1 Axes of the coin with orientation at 180°

At a first glance the coins looks already in a bad state of conservation so that it was impossible to see the graphical types by naked eye: different processes of corrosion had caused a loss of material (overall on the obverse of the coin) and a chromatic alteration of metals.

For this reason it was used a Stereo-Microscope, with enlargements from 1x to 2,5x, in order to define and reproduce the iconographical theme (Fig. 2).

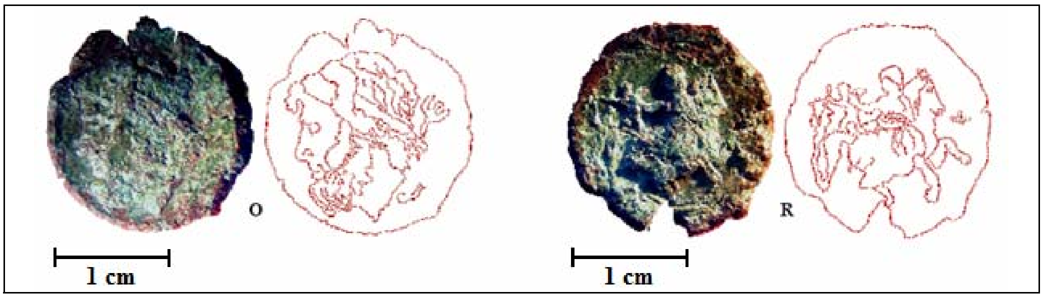

Fig. 2 Graphic and photographic representation of the drachma. O/ Head of Poseidon with diadem on the left. On the right a trident, below a dolphin; R/ On the left Amphitrite is riding a seahorse while Eros is shooting an harrow. On the right a star.

The Bruttian coin was probably dated about 209 B.C., that is when archeologists put the beginning of the golden coinage of Brettii.

Historical sources (Diodoro Siculo, Libro XVI; Strabone, Libro VI) described this people as made up by raw and savage men, shepherds, Lucani's servants which in 356 B.C. created a succession's movement for the constitution of an autonomous Italian folk under the politic, economic and social profile.

Between the half of III century and the half of IV century they tried to claim the supremacy on Magna Grecian's coasts and so conquered Hipponion, Kroton and Consentia that were very important Greek towns: in this way they showed their own power as independent state of Bruttium (that is the current Calabria).

The importance of this new political reality was strengthened by the development of a coinage in gold, silver and bronze that was identified by the ethnic expression in Greek language βϱεττιων.

This system of coining was independent of the roman one even if these currencies remained simultaneous during the 2nd Punic War.

Because of the federal kind of Bruttian currency it's impossible to define clearly the sites of the Bruttian mint: Arslan et al. (1989) assumed that the first mint was Petelia for the bronze coinage, the second one Kroton for gold and silver and, at least, Consentia that helped Petelia.

The drachma had any reference nor graphic types but only symbols. The choice of a sea theme could refer to Kroton but the incrustation on the surface and the loss of metal made difficult reading the particulars of the coin or identifying "master symbols", useful for recognizing the authority which was responsible for that currency.

INSTRUMENTATION AND ANALYSIS

If compared to golden specimens found until now, this coin is macroscopically different for dimensions and weight. Even if it had a circular shape the coin showed visible cracks that caused a lack of integrity of the coin while thin layers of corrosion indicated the base metals. According to noninvasive and non-destructive principles the coin was studied by means of superficial technique of investigations that provided details concerning the chemical composition of the material and its alterations. For this purpose the coin was firstly studied with the help of Scanning Electron Microscopy (SEM), then through a more sensitive technique: the cathodoluminescence (CL).

Scanning Electron Microscopy can:

a) show the superficial texture of the sample until to nanometers,

b) reveal shape and dimensions of particles that constitute the layer of the surface,

c) perform chemical analysis if used with energy dispersion x-ray (EDX).

In this way it probes compositional and topographical properties of the material under qualitative and quantitative profile. Only after such investigations CL analysis was performed on both faces of our coin.

When a sample is excited electronically, thermally, optically, or by particle irradiation its deexicitation can occur through light emission. Luminescence permits sensitive, qualitative, and quantitative analysis of surface and bulk composition (Rotkin and Subramoney, 2004). Moreover, transition energies and intensities can yield detailed and valuable information about sample's electronic structure. In particular, cathode-luminescence (CL) spectro-scopy (where the sample is excited by electron irradiation) can provide information regarding quality of impurity and defect centre in the sample. For some insulators such as carbonate, CL analysis can detect the presence of defects at levels as low as 0.1 ppm (Habermann et al., 2000).

DISCUSSION

When a primary electron beam strikes a specimen, beam electrons will penetrate to a depth that is directly proportional to the energy of the primary beam and inversely proportional to the atomic number of specimen. The interactions between the specimen and the beam can be divided into two groups. In the first group, electrons suffer in the specimen a series of inelastic processes. Electrons emitted as a result of this interaction are called secondary electrons (SE) and generally are characterized as having energies less than 50 eV. Secondary electrons are produced by the primary beam which causes several interactions between the electrons moving in the specimen. Due to their low energy (relative to the beam energy) it is necessary to "collect" the electrons with a positively biased collector in order to form an image. The images, as it is know, are formed by differentiating the bright areas, which correspond to higher intensities of emitted electrons, from the areas of lower intensities. The bias on the collector enables a better collection of such electrons, which are low energy electrons, and the obtained image refers mainly to the morphology of the sample (Fig. 3).

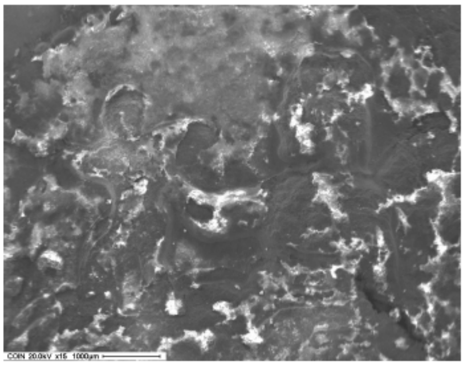

Fig. 3 On the reverse, detail in SE at 1000 μm.

In the second group, electrons are subject to scattering processes due to mainly elastic collisions in the specimen and lose loss energy in the process. These electrons are called backscattered electrons (BSE), typically have energies greater than 50 eV and generally have energies of approximately 80% of the electron beam energy (Olsen, 1988; Reimer, 1998; Seiler, 1983). This second group of more energetic electron are connected to the atomic number of elements partner in the collision process, so the obtained image in this case can be directly connected to the presence of heavier elements on the samples (Fig. 4). In particular in Fig. 6b the brighter zone is connected to Au particles.

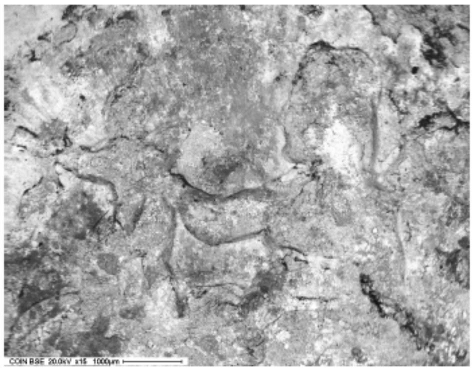

Fig. 4 On the reverse, detail in BSE at 1000 μm

In this work we used the CL spectroscopy to determine if the presence of gold particle in our sample can be localized, on the coin surface, in zones different from that were gold was detected by SEM. We obtained two different CL spectra, one (Fig. 5a) was attributed to a copper and lead matrix (Fig. 5b), because it was revealed from several points on sample and at this points the EDX spectroscopy revealed only the presence of Cu and Pb (Fig. 5c), while the second CL spectrum (Fig. 6a), as indicated in literature (Ma et al., 1999; Wing-Wah Yam et al., 2005; Wong et al., 1998), was attributed to gold particles (Fig. 6b) as successively confirmed by EXD spectroscopy (Fig. 6c). In order to detect if the presence of gold is diffused overall the coin surface, CL analysis was first carried on gold spots revealed by SEM. Then the CL beam was moved in various position on the sample and the same spectrum at 620 nm (attributable to gold) has been detected in several positions (eyebrows, beard, fork on the Head of Poseidon on the obverse of the coin, horse hoof on the verso), revealing that gold was probably covering all the surface coin on both sides.

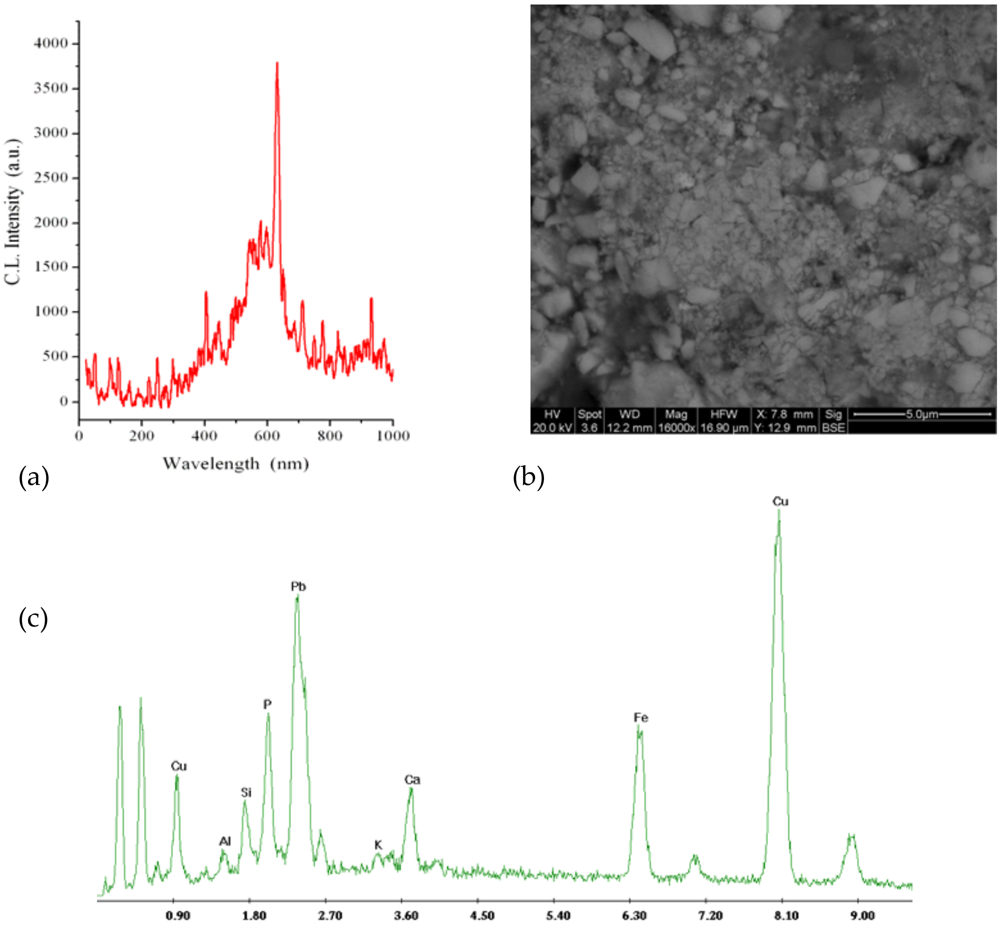

Fig. 5 a) CL spectrum was attributed to a copper and lead of matrix, b) SEM image of Cu-Pb matrix, c) EDX spectroscopy of Cu-Pb matrix

CONCLUSIONS

The presence of traces of gold on surface coin on both sides is in contrast with the fact that the coins of the same age present in museums are hard gold. Then our coin was probably only plated with gold and we can formulate the hypothesis that this coin is a counterfeit money of its age or it can also be supposed that the coin is a coinage proof contaminated by the residual gold in the cast. In our opinion we opt for the first hypothesis for several reasons: a. the coin weight and size are reduced with respect to the originals in hard gold; b. the coin matrix is in Pb and Cu, while the proofs are normally in bronze; c. the gold traces are on both sides (obverse and reverse); d. the styling of the coin is rather accurate in the details; e. some iconographic details are rather similar to other golden bruttian coinage.

NOTE: The coin studied in this work has been offered by a private collector to examine if the coin represents some valuable object and if so, to proceed to its transfer in a Museum by donation.

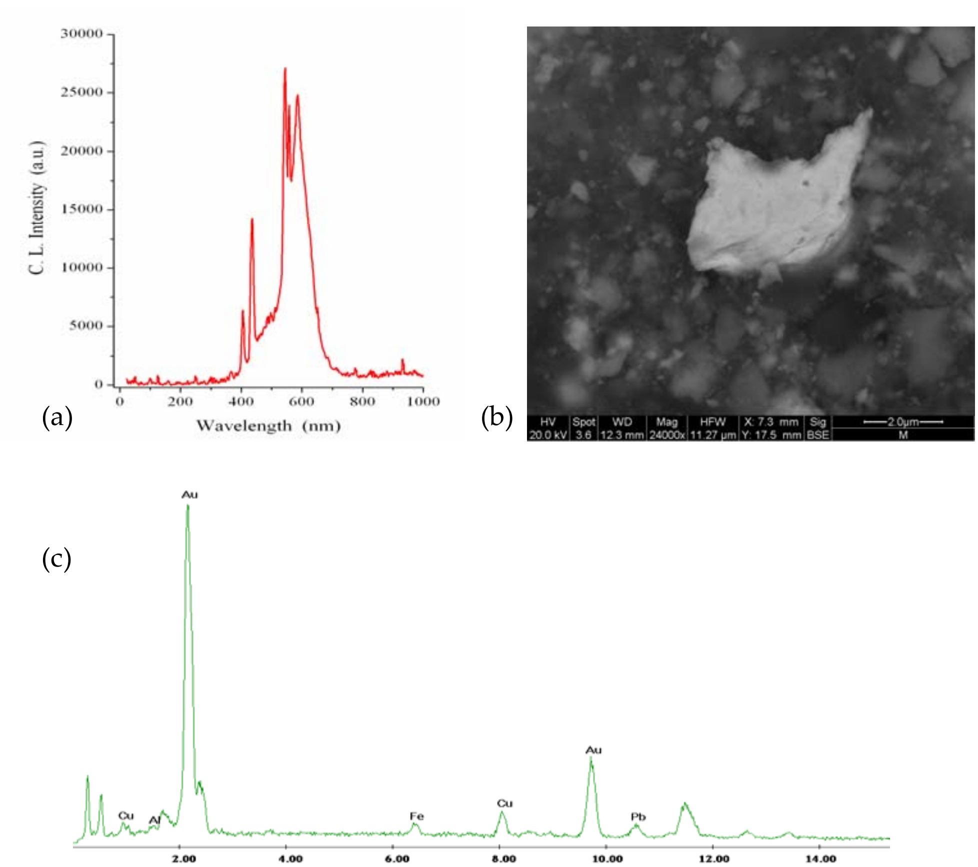

Fig 6 a) CL spectrum was attributed to gold particles, b) SEM image of Au particle, c) EDX spectroscopy of Au particle

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