ARCHAEOMETALLURGY OF COPPER COINS RESCUED FROM A HISTORICAL SITE IN RIO DE JANEIRO. Guadalupe do Nascimento Campos and Guillermo Solórzano. Department of Materials Science and Metallurgy, PUC- Rio, Rua Marquês de São Vicente, 225 - Rio de Janeiro, 22453-900, RJ, Brazil, E-mail: guadalup@dcmm.puc-rio.br

Although archaeology is concerned with all material traces related with humankind, aiming to rescue their past, the analysis of metallic materials through metallographic procedures, with the objective of obtaining information regarding fabrication processes and the composition of these objects, has been rather limited. Due to the acquisition of a considerable heap of such objects, coming from different archaeological/historical sites, an inter-disciplinary approach combining scientific methods use in archaeological and metallurgical research is been undertaken. The present work has as objective a metallographic analysis of a metallic archaeological artifact using methods of light optical microscopy (LOM), scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) and transmission electron microscopy. The object of study corresponds to a cooper coin from the Brazilian Imperial period, dated 1823, removed from an archaeological site, Sitio Rochedo, in excavations conducted by researchers of the Brazilian Archaeological Institute. The site in question refers to "Sitio Rochedo" located in the city of Rio de Janeiro, where the excavations were conducted during the period of March and April of 2000 and February 2001, providing evidences of having hosted a sugar mill. Due to the corrosion processes accumulated over the years, the integrity of the objects was severely affected. The object microstructure is expected to be seriously modified, mainly due to the transformation of the metal into copper oxide which implies in delicate handling and metallographic manipulation of the objects. Sample preparation required a particular procedure in view of the fragility of the object that suffered a process of degradation due to the action of corrosion/oxidation for about two centuries in addition to the mechanism of impregnation of mineral sediments. After the manual and ultrasonic cleaning of the object, representative samples were removed by means of procession mechanical cutting. The metallographic sample preparation followed the conventional procedure of mechanical grinding and polishing. Special precautions were taken aiming to preserve the integrity of the sample. The final stage constituted in a chemical etching of the sample with a hidrogen peroxide solution. Microstructural studies were conducted with a metalolgraphic microscope (Zeiss Axioscop) operating light in bright field, dark field and differential interference contrast. Samples observed in the scanning electron microscope (SEM), Zeis DSM 960 used secondary electron and backscattered electrons detectors. The image acquisition and documentation was made through convetional photographic methodos as well as computer digital methods. Figure 1 show micrograph in bright field. This image correspond to alloy with α matrix of medium average grain size. The equiaxial grains reveal that, after mechanical processing, the material was annealed at a temperature high enough to promote recrystallization. The inclusions show the alignment and elongation of the slag particles. The micrographs also reveal twin interfaces typical of FCC metals. Figure 2a, a backscattered electrons (BSE) micrograph, shows the identification of a compositional difference, its contrast enhancing the inclusions; the position of the electron probe in three different areas are indicated: 1 corresponds to the matrix giving rise to the EDS spectra of Fig. 3a showing only an Cu peak; position 2 refers to the ligher region in the slag, revealing the presence of Ar, Cu, Bi and Pb; while the spectrum arising from position 3, the darker slag area, shows that it contains Cu and Pb. Figure 4 shows a bright field TEM micrograph. The contrast arises from the observed residual dislocations in tangles, typical of metal working involving plastic deformation, as in the final stamping of the coin. A detailed microstructural analysis of the coin indicated the absence of a texture in the polycrystalline alloy analyzed together with the rather large grain size observed. The alignment of prominent slag particles indicate that the coin was manufactured by hot working processes such as hammering or forging. However, is the not yet possible to precisily indicate the origin of the ore or the raw material, as this currently a source of controverse within the numismatic comunity, mainly due to falsification and and ilegal trade practice in early 19^{th} century[2].

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References:
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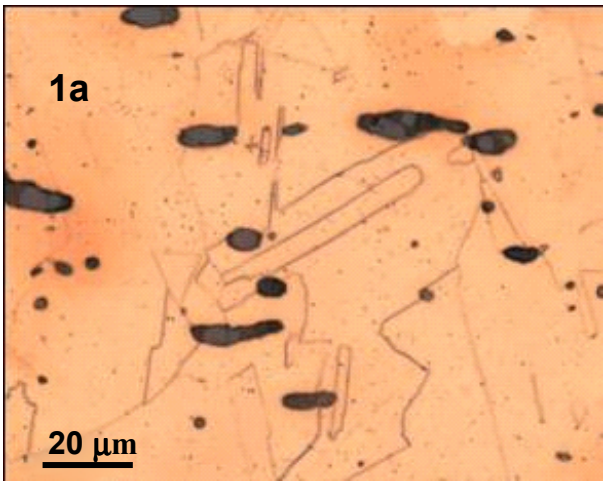
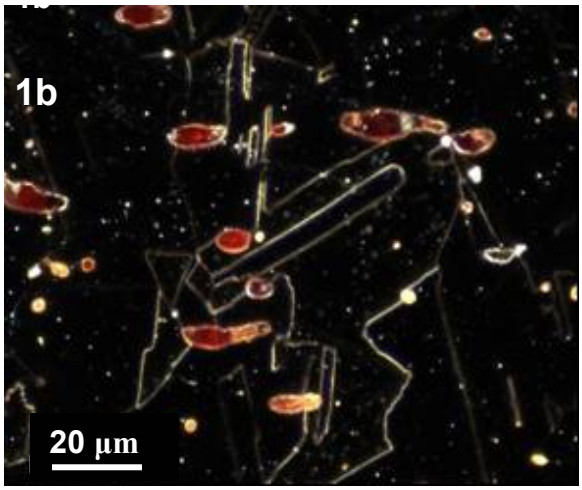
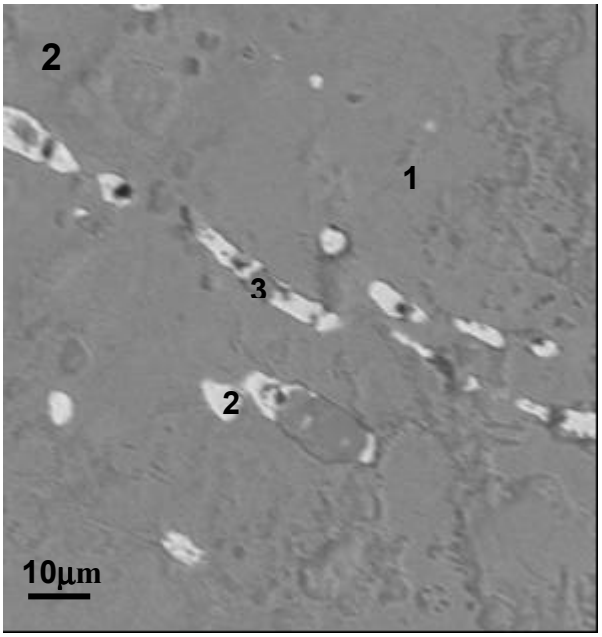
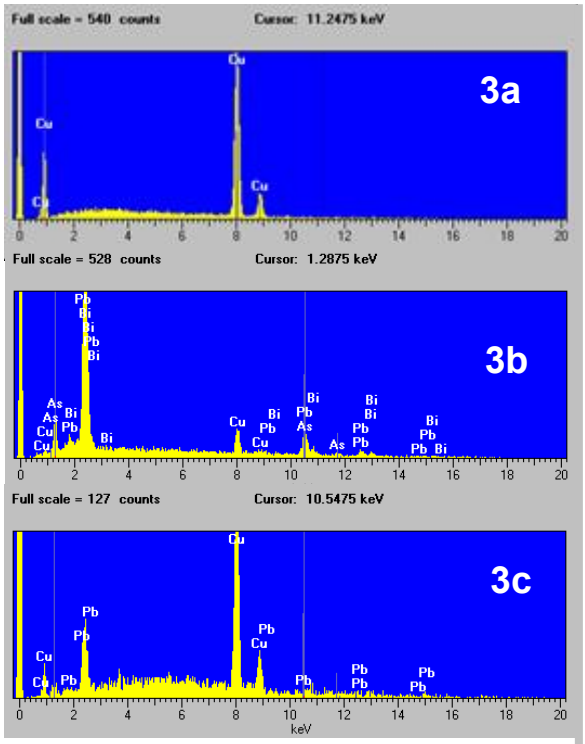
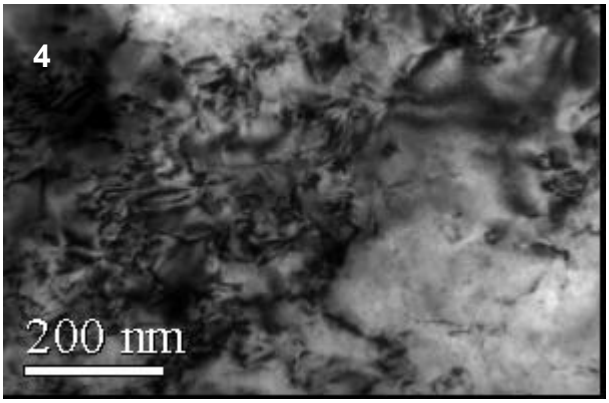
[2] Tylecote, R.F.; Metallurgy in Archaeology. Ed. Edward Arnold, London, 1962.











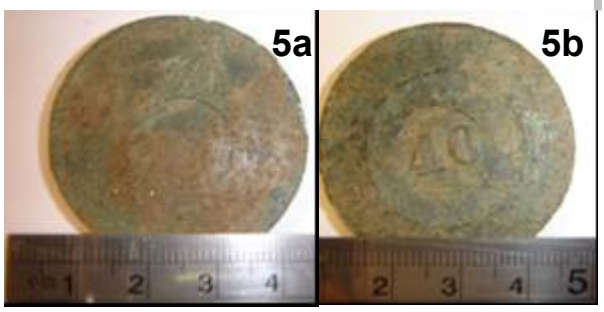


Figure 1 – Light optical micrograph of equiaxed Cu coin (a) in bright field , (b) in dark field
Figure 2 - BSE - SEM micrograph labeling electron probe position on elongated inclusions and matrix.
Figure 3 – EDS spectra of the (a) alloy matrix, (b) the dark slag area and (c) the lighter slag area.
Figure 4 – TEM micrograph in bright field with residual dislocations in tangles
Figure 5 – Cooper coin from the Brazilian Imperial Period