

ANALYSIS OF GOLD COINS OF THE XIX CENTURY BY PORTABLE XRF

**Marcelo O. Pereira¹, Valter de S. Felix², Paula de J. M. Aranha³, Pedro C. S. Heringer³,
Renato P. Freitas²**

¹ Coordenação de Disciplinas Básicas – campus Nova Iguaçu
Centro Federal de Educação Tecnológica Celso Suckow da Fonseca (CEFET/RJ)
Estrada de Adrianópolis, 1317
26041-271, Nova Iguaçu, RJ
marcelocefetrij@gmail.com

² Laboratório de Instrumentação e Simulação Computacional (LISCOMP/IFRJ - CPAR)
R. Sebastião de Lacerda s/n
26600-000 Paracambi, RJ
renato.freitas@ifrj.edu.br

³ Museu Histórico Nacional – IBRAM
Praça Marechal Âncora s/n
20021-200 Rio de Janeiro, RJ
Pedro.Heringer@museus.gov.br
Paula.Aranha@museus.gov.br

ABSTRACT

Coins are cultural symbols and reflect important historical events through of the history. Archeologists, historians and other experts make use of the study of coins (Numismatics) to reconstruct the economy, forms of commerce, customs, religion, political history and art of people and region throughout the globe. The knowledge about the composition of the metal alloy of coins is essential to characterize the fabrication in a historical period and identify possible falsifications. The X-ray Fluorescence (XRF) is a technique of analysis spectroscopic widely used in archaeometry to investigate the elemental composition of pigments, ceramic objects, metal alloy. In this work were XRF analyzes used in a rare coin of the coronation of the emperor D. Pedro I in 1822, Brazilian coins of 1816 and a Portuguese coin of 1823 from the collection of the Museu Histórico Nacional of Rio de Janeiro (MHN). The XRF analyzes were performed using a portable Bruker TRACE IV model system, the spectra operation at a voltage of 40 keV and electric current of 10 uA in acquisition time of 60s. The results indicated the presence of Au, Ag, Cu. The portable X-ray system was shown to be powerful tool in the investigation of metallic alloys with high concentration.

Keywords: XRF, coins, gold, archaeometry

1. INTRODUCTION

Analysis of the elemental composition of numismatic collections has become an area of great importance, since it can provide information on the manufacturing process [1], source of raw material [2], geographical distribution of old mints and period of coinage [3]. This information is of great value to archaeologists and historians, since it makes it possible to

correlate the chemical composition of the coins with the political, social and economic context of the regions.

The National Historical Museum, in Rio de Janeiro, presents one of the largest numismatic collections in Latin America with about 150,000 pieces in technical reserve. In its extensive collection, there is a select group of rare coins. Among them, gold coin entitled "Piece of Coronation", from 1822, which alludes to the rise of D. Pedro I to the throne of the Brazilian Empire.

To commemorate the occasion, the Mint of Rio de Janeiro produced 64 copies of a coin of 6400 réis, with the stamp signed by the engravers Zeferino Ferrez (obverse) and Thomé Joaquim da Silva Veiga (reverse).

The emperor, however, was not at all satisfied with the result of the work, especially for having had his bust portrayed to the mold of the ancient Roman emperors: bare-breasted and wearing a laurel wreath. In addition, the presence of the royal crown, to the detriment of the imperial crown, as well as the omission of the words *CONSTITUCIONALIS* and *ET PERPETUUS BRASILIAE DEFENSOR* that, in his view, could convey the idea of a desire for absolutist power [4].

The production was discontinued. Of the 64 coins produced, there are now only 16 original copies known in collections of museums and private collectors. The rarity and historical particularities of the "Piece of Coronation" make these coins, the most valuable of Brazilian numismatics [5].

The application of analytical techniques in archeology raises a great problem when it comes to precious objects because cuts, polishes or any kind of modification is unacceptable. Consequently, a non-destructive analysis is the only possible approach.

Currently X-ray fluorescence (XRF) is the most used analysis technique in the study of artifacts with historical-cultural value. The frequent application of this technique is due in particular to the technological innovations that have occurred in the last decade, which enabled the construction of portable XRF systems that allow non-destructive and *in situ* elemental analyzes of works of art with good precision [6]

This work identified the elemental concentration of the material that composes this artifact by XRF. The mean density of the material was also calculated as a function of the determined elemental concentrations. In addition, the applied technique to a gold coin of 4000 réis produced in the state of Bahia in 1816 and a gold coin produced in Portugal in 1823. These gold coins served to evaluate the percentage of gold in the Piece of Coronation.

2. MATERIALS AND METHOD

2.1. Coins

The Piece of Coronation of the National Historical Museum has the following characteristics: 32 mm in diameter and mass of 14.32 g. The gold coin of 1823 presents mass of 14.28g,

while the coin of 1816 is lighter with mass of 7.95g. Figures 1 and 2 show the photos of the obverse and reverse of the Piece of Coronation, respectively.



Figure 1: Obverse of the Piece of Coronation.



Figure 2: Reverse of the Piece of Coronation.

2.2. Experimental

The XRF measurements were performed in the Numismatic Department of the National Historical Museum using a Bruker TRACER IV portable system, which has an X-ray tube with Rh anode, which can operate at maximum voltage and current of 40 kV and 60 μ A. The

system is equipped with an X-ray detector, model XFlash® (10 mm²) SDD, thermoelectrically cooled to -15 ° C, whose resolution for the Mn-K α energy is 145 eV and can realize up to 10 kcps. The XRF spectra were acquired by positioning the system vertically and placing the coin on the support. Three points were scored on each side of the coin for 60 seconds. The X-ray tube operated at 40 kV and 10 μ A. Figure 3 shows a photo of the portable system. Figure 4 shows the spectrum obtained at one point on the obverse of the coin.



Figure 3: Portable System of XRF.

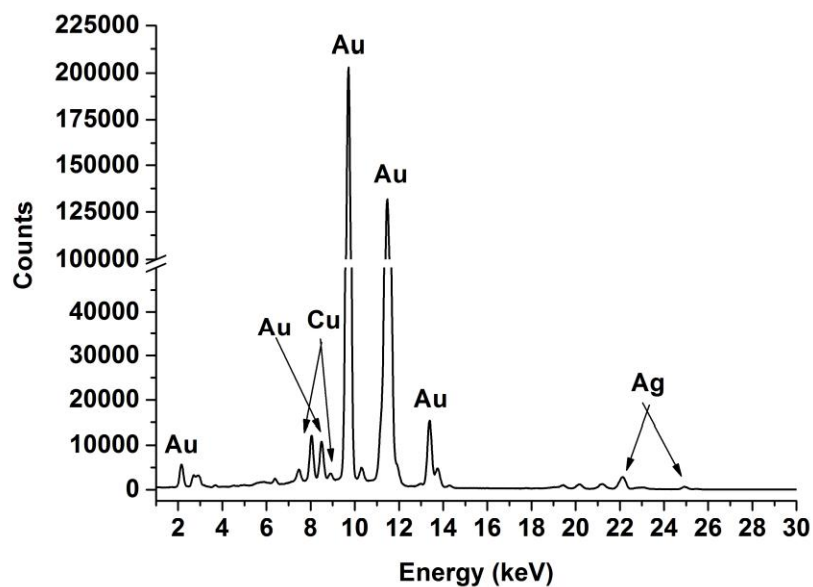


Figure 4: Spectrum of the obverse of the Piece of Coronation.

3. RESULTS

The obtained spectra were analyzed in the free software PyMCA, developed by the European Synchrotron Radiation Facility (ESRF). To quantify the elementary concentrations the fundamental parameters method was applied and the relative values were obtained, based on works described in the literature [7, 8, 9]. The results obtained in this work are described in table 1. It is also possible to find the average density of the coins obtained second the average concentrations of each coin

Table 1: Concentrations of Au, Ag and Cu of each coin

Elements	Piece of Coronation		Gold coin (1816)		Gold coin (1823)	
	Reverse	Obverse	Reverse	Obverse	Reverse	Obverse
Au%	97.8	98.0	95.9	96.1	94.2	94.0
Ag%	0.4	0.4	0.6	0.6	0.5	0.5
Cu%	1.8	1.6	3.5	3.3	5.3	5.5
Density	19.1 g/cm ³		18.9 g/cm ³		18.7 g/cm ³	

Studies found in the literature describe the concentrations in Brazilian gold coins of 4000 réis between the years 1695-1702 by XRF. These studies present Au levels between 95.7% and 98.8% [10] and 92.6% to 93.2% [11]. While Cu concentrations between 0.67% to 2.19% [10] and 2.60% to 2.82% [11]. The values presented in this work for the Brazilian currencies describe Au concentrations between 95.9% and 98.0%, and between 1.6% and 3.5%, respectively.

4. CONCLUSIONS

The results in this work for the concentrations of Au and Cu in Brazilian currencies are equivalents to the results found in other studies. The mean densities of these coins are close to the densities of pure gold (19.3 g / cm³). The Portuguese currency has a higher concentration of copper, which may show an indication of the addition of this material to pure gold for the currency.

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