

## **Advantages and Disadvantages of Micro-XRF Spectrometry in Numismatic Research**

Marta Matosz, Julio M. del Hoyo-Meléndez

Laboratory of Analysis and Non-Destructive Investigation of Heritage Objects, The National Museum in Krakow, ul. Piłsudskiego 14, 31-109 Krakow, Poland

X-ray based techniques continue to be the preferred method of analysis for the study of material composition and technology of fabrication. Within this group, X-ray fluorescence (XRF) is probably the most popular and well-established method in the cultural heritage field. Although qualitative XRF analyses are an important and essential component of current numismatic research, there is an increasing interest in obtaining quantitative information that can be used towards a better understanding of metallic objects. As a consequence, improvements have been recently observed in areas such as instrument development, analytical methodologies, calibration, and quantification methods. Nevertheless, various factors such as the irradiation geometry as well as irregular and non-homogeneous surfaces, typically found in historic coins, have a negative impact on the consistency of quantitative XRF analysis. XRF analyses of coins may contribute to the better understanding of the manufacturing process, the provenance of raw materials, and in some cases the geographical distribution of mints.

Silver denarii from medieval (10-11<sup>th</sup> centuries AD) Poland belonging to Central European collections have been characterized using micro-X-ray fluorescence spectrometry and the results have been evaluated in the context of published data on coins from this region and from this time period. The research has focused on evaluating the use micro-XRF as a screening tool for elemental surface characterization of the alloys. The denarii are made of Ag and Cu, with minor amounts of Pb, Fe, Au, Bi, and Zn. Semi-quantitative analyses have revealed silver contents in the 86-97 % range for the surveyed coins. The results have allowed to determine the advantages and limitations of the technique when examining numismatic collections. For example, two groups of coins were clearly identified after studying the Pb/Ag and Cu/Ag ratios. Nevertheless, it is important to point out that a known drawback of this method is silver surface enrichment, which is a common process observed in archaeological silver-copper alloys sometimes leading to incorrect interpretation of the data. Preliminary data from complementary techniques like neutron activation analysis (NAA) and proton-induced X-ray emission (PIXE) are very promising in accounting for some of these surface effects. This study has the goal of providing elemental information, which will serve to enhance the current knowledge about geographical and chronological diversification of Polish numismatic collections.