Nondestructive analysis of an ancient artefact with X-ray fluorescence technique

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Abstract

In this paper, we present the qualitative and quantitative analysis of an ancient artifact recovered from the Acropolis site in the city of Durrës. This artifact, an earring, was discovered by restoration specialists and archaeologists in an ancient grave and from archeological estimation it belongs to VI-VII AD. The primary aim of this research is to determine whether the separate pieces of the earring belong to the same object or if they are fragments from different items. By utilizing the X-ray fluorescence (XRF) technique, we performed a detailed compositional analysis of each piece of the artifact. The XRF instrument used for this study is the ARTAX µ-XRF spectrometer, manufactured by Bruker. This device is equipped with a Rhodium (Rh) anode material and operates in direct excitation mode, ensuring precision in the detection process. The X-ray detection is carried out using a silicon drift detector (X-Flash 1000B), which provides a resolution of 146 eV FWHM at 10 kcps. This is coupled with a digital signal processor for accurate processing of the collected data.

For the qualitative analysis, we employed two different software platforms: the ARTAX SPECTRA 7 software from Bruker and the QXAS software developed by the International Atomic Energy Agency (IAEA). These tools allowed us to interpret the spectral data effectively and identify the elemental composition of the artifact. For the quantitative analysis, we used the M-Quant software from Bruker, which relies on the fundamental parameter approach for accurate measurements. This method is recognized for its high reliability in determining precise concentrations of elements, particularly in historical artifacts where precision is critical.

To ensure the accuracy of our measurements, we calibrated the XRF instrument using a brass standard from the IAEA proficiency test in 2013. Calibration is a crucial step in any scientific analysis, as it provides a reference point for the measurements. Each measurement was further

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processed in the QXAS software provided by the IAEA, using the Full Fundamental Parameters (FFP) approach. This comprehensive method ensures that the results are as accurate as possible, considering all relevant factors in the measurement process.

The analysis was carried out at multiple points across the surface of the artifact. Specifically, we analyzed 3-4 points on each of the nine pieces that make up the earring. This thorough examination was essential to ensure that the results were consistent across the entire artifact and to verify whether the different pieces could be conclusively linked.

Our results indicate that all the pieces of the earring are indeed part of the same object. This conclusion is based on the fact that the elemental analysis revealed nearly identical chemical compositions across all the pieces. In particular, the ratios of copper (Cu) and tin (Sn), the two primary components of bronze, were consistent across the different parts of the earring. This uniformity in composition strongly supports the hypothesis that the separate pieces were originally part of a single, unified object.

In conclusion, the use of X-ray fluorescence for both qualitative and quantitative analysis has allowed us to make significant progress in understanding the artifact's origins and structure. This research not only confirms that the earring fragments belong to the same object but also provides valuable insights for future studies on ancient artifacts in Albania.

Keywords: X-Ray Fluorescence, Spectroscopy, Artefacts, Qualitative analysis.

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