

## **The application of total reflection x-ray fluorescence analysis (TXRF) to archaeometric ceramic research at the Goethe-University of Frankfurt.**

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In the last ten years new methods of geochemical analysis that aim to determine the provenance of archaeological ceramics have been introduced in archaeometry. Apart from the well-established methods of instrumental neutron activation analysis (INAA) and wavelength dispersive X-ray fluorescence analysis (WD-XRF), the inductively coupled plasma-mass spectrometry (ICP-MS) is currently also used to detect 30 or more trace and rare elements for a better and more exact determination of the provenance of sherds in comparison to reference groups (Tite 1999, Mommsen 2007, Swart 2005). Because of the high cost and time-consuming procedures for sample preparation and analysis, archaeologists were on the lookout for faster methods with reduced costs so as to be able to get larger sample series, and in so doing to have a stronger basis for statistical examinations. Especially for large-scale economic studies looking at production and consumption it is necessary to have series with more than 50 or 100 vessels. For this reason, the portable energy dispersive X-ray fluorescence analysis (P-EDXRF) was developed and has already been in use for the measuring of ceramic samples for five years. Different studies have discussed this new method in archaeology and its possibilities (e.g. Morgenstern/Redmount 2005, Potts/West 2008, Helfert et al. 2011).

Comparable to the technical components of P-ED-XRF (X-ray tubes and detectors) and its rapid development in the last years the well-known method of total reflection X-ray fluorescence analysis (TXRF) comes in the focus of archaeometrical investigations. In addition to traditional X-ray fluorescence analysis it is now possible to gain measurements with a high degree of accuracy and precision in the region of parts per billion (ppb) and to have quantitative multielemental determinations for ca. 30 elements. The method was first introduced to archaeometry by García-Heras et al. 1997 but not adopted by laboratories to characterise ceramics. In the course of the developing the Ceramics Research Centre in the Institute for Archaeological Sciences at the University of Frankfurt, TXRF has been used since 2011, beside other analytical methods. Founded on the fundamental work of M. García-Heras, R. Fernández-Ruiz and J. D. Tornero (García-Heras et al. 2001, Fernández-Ruiz/García-Heras 2007), an evaluation study for different types of ceramics is currently underway and has been providing information on new possibilities for archaeological research.

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