Categorization of archaeological ceramics based on their elemental composition using self organizing maps (SOM)

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Abstract

The categorization of archaeological ceramics based on their elemental composition has a long tradition in ceramic provenance studies. The compositional differences between ceramics manufactured at different production sites are essentially related to the use of geochemically diverse raw material sources providing, thus, distinct compositional patterns. For this, the manufacture of ceramics of unknown origin can be localized by means of reference data of specific production sites, Hence, the dissemination and trading of ceramic wares or commodities transported in them can be investigated. In order to determine the elemental composition of archaeological ceramics commonly laboratory methods with high precision and accuracy, such as neutron activation analysis (NAA) or wavelength-dispersive X-ray fluorescence spectrometry (WD-XRF), are applied in view of minimizing analytical uncertainties, which could obscure the natural variation of the determined compositional patterns. During the last 20 years, however, portable energy dispersive XRF (pXRF) has been introduced in the study of archaeological materials, providing fast and non-invasive measurements of their elemental compositions. In the case of pottery analyses, though, several issues arise. The method is extremely surface sensitive, which has to be considered for measurements of slipped, painted or weathered surfaces. The determined element concentrations are commonly less precise and accurate than compositional data collected with laboratory measurements and also the suite of elements, which can be potentially be measured, is smaller. In the case of trace elements the concentrations are furthermore frequently below the lower limit of determination. Eventually, also the sample geometry affects the measurements as the systems are calibrated for measurements of plane surfaces in direct contact. All these issues impede the statistical evaluation of pXRF data following traditional approaches of multivariate statistics, such as hierarchical cluster analysis or principal component analysis, applied commonly to data collected by laboratory analyses. As the pXRF data are considerably fuzzier their categorization requires a more flexible approach based on the actual data structure rather than on assumptions regarding geochemistry. For this the application of artificial neural networks (ANN) is tested and the multivariate data are evaluated with self organizing maps (SOM). Supervised as well as unsupervised learning is applied on different data sets, considering varying element suites. The resulting categories are compared with traditional multivariate data evaluation.