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Classification of Neolithic Ceramics and Clays According to Their Morphological Characteristics

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Abstract

In this study the eight bowls having different shapes, sizes and grades from the Vinča II period were chosen for the examination of ceramic body morphology. The morphology of ceramic pads, prepared in the laboratory using clays that were sampled nearby the excavation site, were also considered. The optical microscopy images of the pottery ceramic body and test pads were analyzed using the ImagePro plus 4 software package. Multivariate statistical analysis was employed to classify pottery sherds and clays according to their morphology.

The obtained results show that morphological characteristics of the minerals can be considered as viable in recognition of the clay source.

Introduction

Following one of main goal in archaeological research, a series of multidisciplinary approaches can result in reconstruction of techniques that were the characteristics of technology of ancient people. It was proven many times that applying different (in most cases only available) analytical techniques helped with statistical analysis tools can solve many secrets. In this study, the same steps were followed to reach the answer on the question about clay source that was used for pottery production.

Materials & Methods

The bowls that were excavated at the site of Pločnik (south part of Serbia) were chosen for this study. The bowls had different finesse of production judged by wall thickness and they were classified as fine, medium and coarse structures. Clay samples were taken on four locations nearby excavation site. The locations were selected using geological maps, in contacts to local people that indicated the points where the usable clay can be find and on the locations where the clay is exploited nowadays for brick production. Those samples were used to prepare test pads.

The bowls ceramic body and the test pads were photographed using the optical microscopy technique. On the base of optical characteristics, mineral identification in polarized light microscope was done, using maximum magnification of 1200 x. Four digital images of the test pads and 32 for the bowls ceramic body were made, and further analyzed using the ImagePro plus 4 software package.

Image analysis was used to obtain morphological parameters of minerals in the composition of the examined bowls and test pads. Among the observed minerals, three characteristic minerals – quartz grains, mica and metamorphic rocks, were chosen for further analysis.

The procedure described above generates sufficiently enough data to employ pattern recognition techniques to gain a better insight into the possible hidden regularities. The dataset was formed from the 656x21 matrix, consisting of 21 measured morphological parameters (selected so as to enable shape characterization - diameters, perimeter, axis major and minor, then the optical density of objects and their colour) of 656 selected minerals in ceramic body and test pads (previously examined by the means of XRD). Principal Component Analysis (PCA) was applied as dimension reduction technique to explore the classification possibilities. Scattering matrices based dimension reduction technique was applied for more detailed examination of the classification.

Results

The PCA was applied to the dataset formed of standardized data from training dataset. The first three PCs (corresponding to three eigenvalues higher than 1) explained 89.34% of the total variance among 21 variables, where the first component (PC1) contributed 53.6% and the second component (PC2) contributed 25.2% of the total variance. The result obtained after applying PCA is presented in Fig. 1. As it can be seen groups denoted as Quartz-clay and Quartz-ceramic are well defined and separated from others, and were chosen for more detailed analysis. In that manner new training dataset was formed from the 252x10 matrix, which consists of 10 morphological parameters of 252 quartz grains in four test pads. Ten morphological parameters were chosen as most discriminant in previous step. Following the goal, which is the classification, scattering matrices based dimension reduction technique was applied to explore its possibilities. The results are presented in Fig 2. Four test pads (from clay sampled on four different locations) were classified according to the morphological characteristics of quartz grains. As it can be seen in Fig 2a groups denoted as 1 and 2, can be used for classification purpose. Next step was to apply the classification result obtained in previous step to test dataset formed from the 84x10 matrix, which consists of same morphological parameters of 84 quartz grains in eight ceramic bowls. The results are presented in Fig 2b and c. The

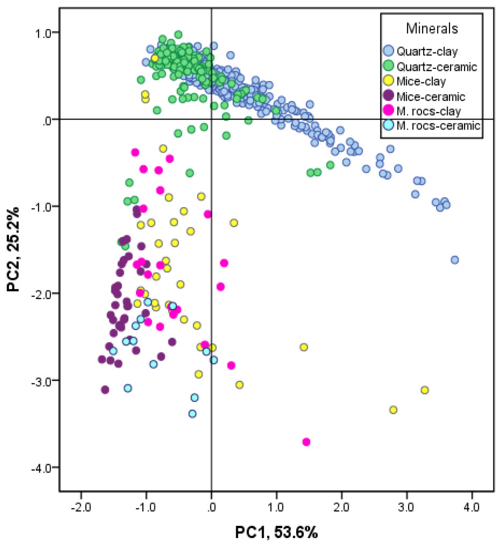

Fig. 1; Score plots of PC1 and PC2 illustrating classification ceramics minerals according to its morphological characteristics

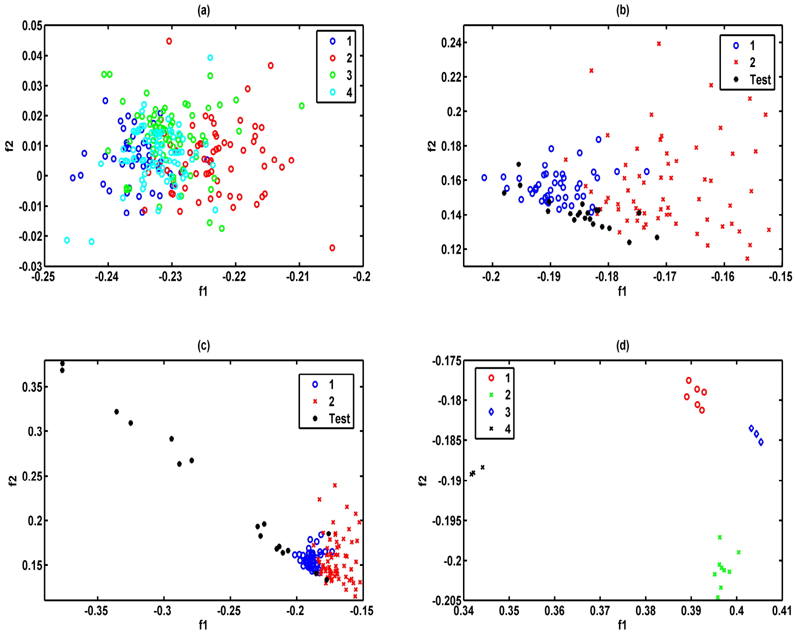

Fig. 2; Classification result based on scattering matrices dimension reduction technique

result of classification according to mica morphological characteristics, the same four test pads prepared of clay from different sampling locations is presented in Fig 2d.

Conclusions

Based on morphological parameters observed in petrographic images of ceramic artefacts and their comparison to the same parameters observed in the test pads, the origin of the raw materials used for their preparation can be envisaged using properly chosen pattern recognition techniques.

References

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