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STRUCTURAL ANALYSIS OF SOME POTTERY FRAGMENTS FROM THE ENEOLITHIC PERIOD BELONGING TO THE BOIAN CULTURE

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Abstract. *The paper presents a qualitative and quantitative structural analysis of some pottery fragments belonging to the Boian culture, discovered in the archaeological site of Galatui - Movila Berzei, in a dwelling - sanctuary. Six representative pottery fragments were used. To visualize some microscopic details of the surfaces of these pottery fragments, digital optical microscopy was used. Also, for the quantitative and qualitative analysis of the crystalline structure of the powder samples taken from the surfaces, X-ray diffraction (XRD) was used. The obtained results show that the ceramic mass has a high content of quartz, accompanied by various oxide compounds from the clay used, low in calcium but rich in iron. The analyzed pottery fragments present different decorative patterns, from parallel and broken lines, to checkerboard-type patterns that denote a special leaning towards aesthetics of the communities from Galatui - Movila Berzei.*

Keywords: *pottery, archaeometry, Eneolithic, pyrope, hematite, quartz.*

1. INTRODUCTION

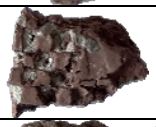
The pottery fragments studied were discovered in Galatui - Movila Berzei, Calarasi county and are part of the Collection of fragmentary potteries of the Lower Danube Museum in Calarasi. The archaeological site is located on the southern shore of Lake Galatui, on a high terrace, between the localities of Alexandru Odobescu and Galatui [1-3]. The site is structured on three layers located on three levels of housing: the first level was assigned to the Bolintineanu communities; the second was dated as belonging to the Boian - Giulesti communities; the last level was dated as belonging to the late stage of the Boian – Giulesti communities [1, 2]. The vessel fragments that we have subjected to our analysis come from this last level of living, from the so-called "sanctuary dwelling", which had considerable dimensions, the surface occupied by it being about 80 square meters [2, 3]. From a typological point of view, the pottery from this dwelling level can be dated to the end of the 5th - beginning of the 4th millennium BC. [1]

2. EXPERIMENTAL

2.1. Materials

Six pottery fragments were selected (Figure 1, Table 1) that have a variable thickness, but less than 1 cm. Samples B1.P6.2, B1.P6.4. and B1.P6.6. have decorative patterns of concentric circles. Samples B1.P6.1. and B1.P6.5. were decorated with broken lines, and the samples B1.P6.3. have chessboard-like patterns on their surfaces.

Table 1. Pottery fragments, front view

Sample	*Front view*
B1.P6.1.	
B1.P6.2.	
B1.P6.3.a	
B1.P6.3.b	
B1.P6.4.	

B1.P6.5.	
B1.P6.6.	

Regarding the colors used for decoration, the members of the Boian community of Movila Berzei used white paste and red paste, but none of the samples showed the presence of both pigments at the same time. The red paste is located in the inlays of B1.P6.1. and B1.P6.2., clearly highlighted under the microscope (Figure 3). Also, the ceramic is reddish in color, a fact due to the type of oxidizing firing. [4]

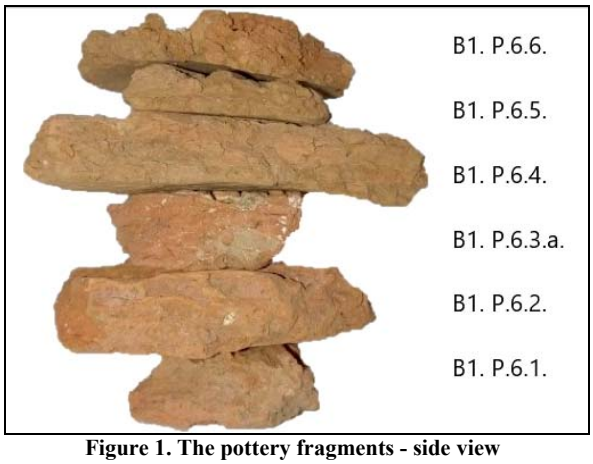


Figure 1. The pottery fragments - side view

2.2. Analysis methods and devices

This paper presents the quantitative and qualitative analysis of the crystalline structure of the pottery fragments. The experimental measurements were carried out in the Multidisciplinary Scientific and Technological Research Institute and in the Multifunctional Materials and Microfluidics Laboratory of the Materials and Mechanics Engineering Faculty of the "Valahia" University in Târgoviste.

The Levenhuk DTX RC4 digital microscope was used for the microscopic study, using magnifications of approximately 40x. An additional cold light source with flexible arms was used, for a better orientation of the light to the areas of interest.

XRD analysis was performed using Rigaku Ultima IV X-ray diffractometer, Cu-Kα radiation with wavelength λ = 0.15406 nm. The interpretation of the results was done with the help of ICDD cards.

Sampling of the powder for XRD analysis was carried out with the help of a hand mill with a diamond tip, and the sampled powders were mortared. All sample preparation operations took into account precautions to avoid sample contamination or phase changes. The powder was deposited on glass slides for XRD analysis (Figure 2).

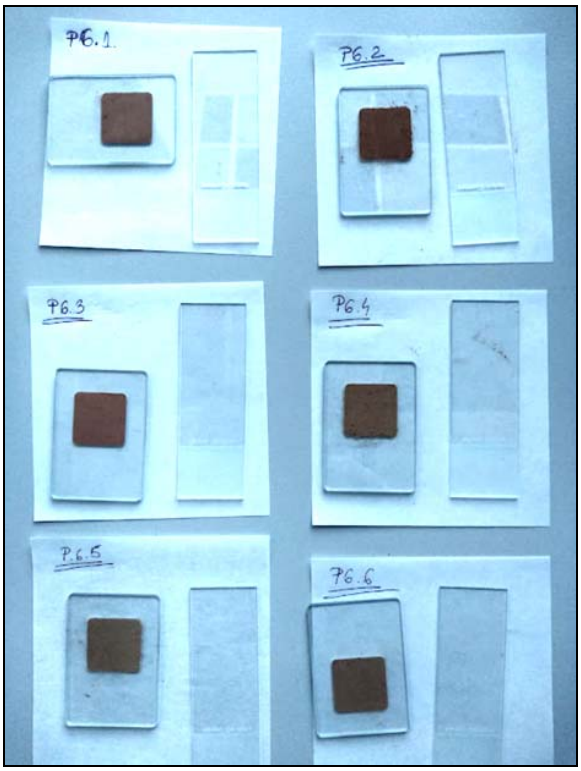


Figure 2. Ceramic powder samples deposited on glass slides for XRD analysis

3. RESULTS AND DISCUSSIONS

3.1. Digital optical microscopy

The microscopic images (Figure 3) highlighted various shades of colours and forms of their arrangement on the surfaces of the samples. Samples B1.P.6.1., and B1.P6.2. show traces of red pigment deposited in the incrustations.

It can be observed that the areas decorated in red were strongly affected by environmental factors. The white material deposited in the incrustations from samples B1.P6.4., B1.P6.5., B1.P6.6. it has a coarse structure that leads us to the hypothesis that very high-grained powder was used.

It is also noticeable the presence of some yellowish crystalline formations, which are nothing more than impurities deposited over time.



3.a. B1.P6.1.



3.b. B1.P6.2.



3.c. B1.P6.3.a



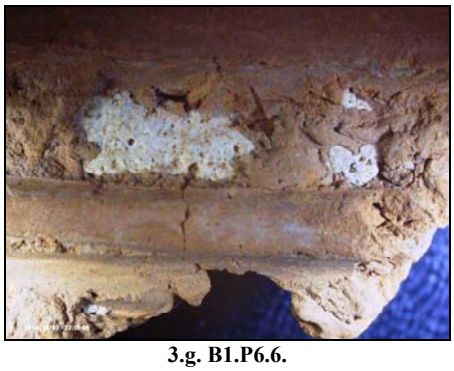
3.d. B1.P6.3.b



3.e. B1.P6.4.



3.f. B1.P6.5.



3.g. B1.P6.6.

Figure 3. Images obtained by digital optical microscopy (x40 magnification)

3.2. X-ray diffraction

The samples were investigated by X-ray diffraction to quantitatively and qualitatively identify the main crystallographic phases and the degree of crystallinity, shown in Figure 4. It should be noted that only the samples taken from fragments B1.P6.1 and B1.P6.6 they do not have a degree of crystallinity of 100%, probably due to amorphous impurities or incomplete structural transformations in the process of burning the vessels.

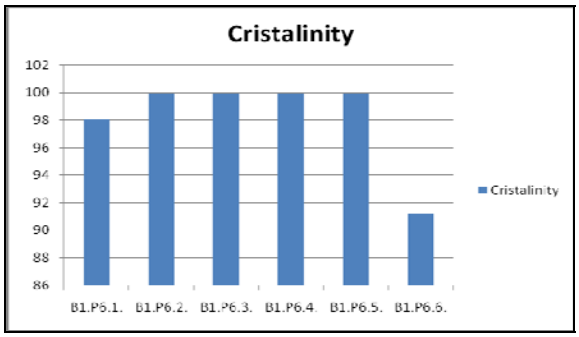


Figure 4. Cristalinity of the samples analyzed by XRD

The following crystalline compounds were identified: quartz (mostly) accompanied by sodalite, muscovite, feldspars, donpeacorite (mostly in sample B1.P6.3.), enstatite, rutile and hematite. No sample contains the phosphate group, so neither does hydroxyapatite (calcium phosphate). Iron is present both in the form of hemaitite and into complex oxide structures. The pyrope and especially the hematite give the pottery its reddish color. The causes of this color are the nature of the clay used, rich in iron, and the oxidizing burning conditions. [4]

In the six samples investigated, calcium is present in very low concentrations, identified only in the samples decorated with white paste, in the crystalline form of calcite.

Pyrope ($Mg_3Al_2(SiO_4)_3$, determined in percentage of 9.4% only in sample B1.P6.1.), is a reddish colored mineral related to garnet. Garnets are compounds commonly found in the earth's crust and formed through high pressure and temperature processes. [6]

Hydrated sodium magnesium sulfate ($Na_2Mg(SO_4)_2(H_2O)_4$) is a saline efflorescence suitable for marine and lake environments. [7] The presence of this compound is probably due to the transfer of saline substances due to the water circuit in nature.

Sodalite ($Na_{7.7}(MnO_4)_{1.7}(H_2O)_{0.8}\cdot(AlSiO_4)_6$) is a blue silicate, but sometimes it can have greenish, even reddish or yellowish tints. [8, 9]

Deonpeacorite (Mn^{2+},Mg)$Mg[SiO_3]_2$ (yellow-orange) is a silicate of manganese and magnesium, with a yellowish-orange color.[10] Donpeacorite is accompanied by enstatite ($MgSiO_3$) (yellow), a magnesium silicate, both of which are glassy in appearance. [11]

Muscovite in polymorphism 2M1 (mica, $KAl_2(AlSi_3O_{10})(F,OH)_2$) is present in samples B1.P6.4. and B1.P6.5. (approximately 15%) and is a compound of the chromatic spectrum of red, as shown by the XRD analyzes of some pottery fragments discovered at Radovanu [12] and Cascioarele [13].

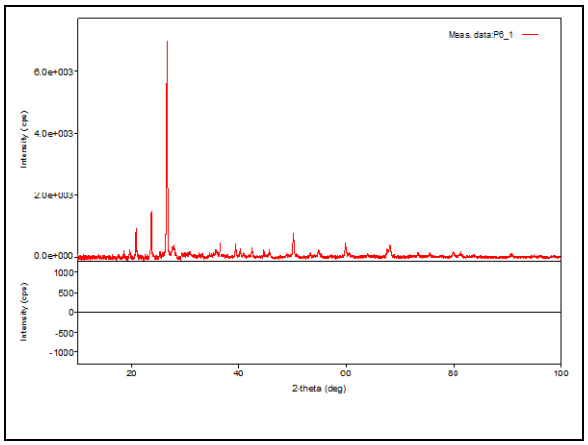


Figure 5. The diffractogram of the sample B1.P6.1.

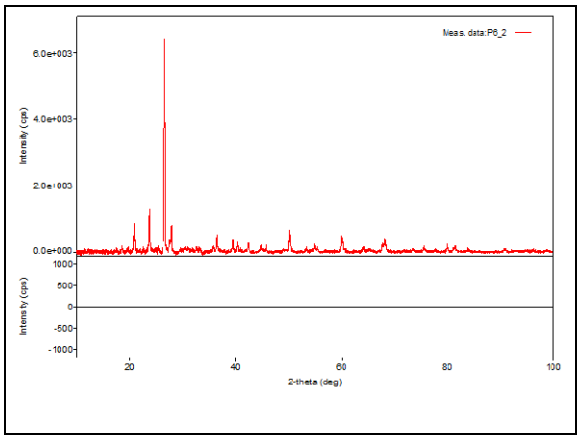


Figure 6. The diffractogram of the sample B1.P6.2.

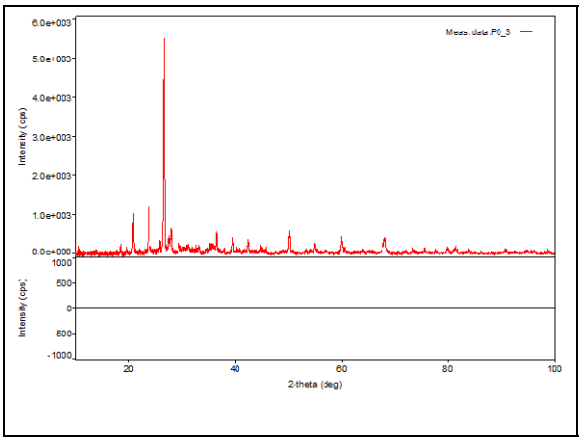


Figure 7. The diffractogram of the sample B1.P6.3.

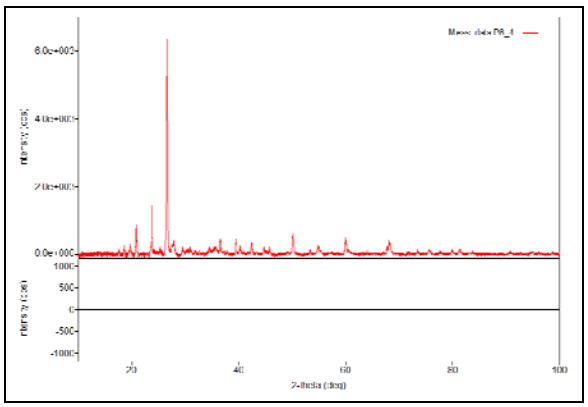


Figure 8. The diffractogram of the sample B1.P6.4.

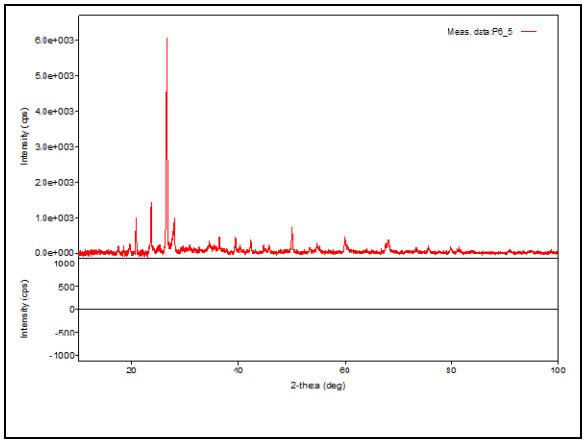


Figure 9. The diffractogram of the sample B1.P6.5.

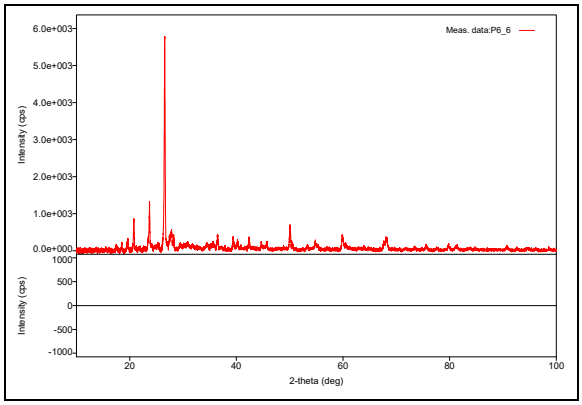


Figure 10. The diffractogram of the sample B1.P6.6.

4. CONCLUSIONS

The archaeometric analyzes carried out on the pottery fragments from the settlement of Boian de la Galatui - Movila Berzei, show that the ceramic mass has a majority 100% crystallinity, resulting from an oxidizing firing that had the effect of a red-brown coloring due to the presence of hematite and pyrope.

The obtained results (XRD) show that the ceramic mass has a high content of quartz (approximately 70% in each sample), accompanied by various oxide compounds from the clay used (sodalite, muscovite, feldspars, donpeacorite, enstatite, rutile), low in calcium but rich in iron.

Some compounds are the result of physical-chemical processes due to climate changes, the transfer of saline substances due to the water circuit in nature. An example would be hydrated sodium magnesium sulfate.

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