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PETROGRAPHIC CHARACTERIZATION OF PAINTED ENEOLITHIC CERAMICS

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Abstract

An efficient way to perform the petrographic characterization of painted Eneolithic ceramics is to study the thin and cross sections by using polarized and ultraviolet light microscopy. This is a very efficient approach to describe and to characterize the material properties and the manufacturing technique.
The samples analyzed in this study are cut from the red and black surface representing the typical decoration of the *Cucuteni* ceramic bodies. The thin sections of the samples were examined in transmitted polarized light microscopy, in order to investigate the texture and the mineralogical composition. The obtained petrographic results provide three types of information: i) the mineralogical composition of the inclusions, ii) the grain size, frequency, sphericity and sorting of the inclusions, as well as the frequency, size and shape of the pores, iii) the firing temperature by observing the transformations of the minerals, e.g. the transformation of biotite (black mica) into red hematite. The examination of the ceramic cross sections with optical polarizing microscope in visible light and under ultraviolet light revealed information on the layers' composition of the painted ceramic.
The results show that the matrix is Fe oxides rich clay and the texture is rather distinctly laminated, with evident iso-oriented inclusions, voids and cracks. Some voids are filled with carbonates of secondary crystallization. The inclusions are mineral fragments (quartz, feldspars, white mica, and black mica), characterized by low sphericity with sub-angular rounding. In conclusion, speculation about the region of origin and the pottery's techniques can be drawn.

Keywords: polarized and ultraviolet light microscopy, painted ceramics, mineral pigments

1. Introduction

An efficient way to perform the petrographic characterization of archaeological ceramics is to study the thin sections by using polarized light microscopy. This is a very efficient approach to characterize the material properties and to describe the manufacturing technique of ancient pottery [1, 2].

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The aim of this study was to perform the mineralogical and textural characterization of *Cucuteni* painted ceramic shards and derive unique attributes of these ancient ceramic objects.

The thin sections of the ceramic samples were first examined in transmitted polarized light microscopy. Two main properties can be investigated in thin sections, namely the mineralogical composition and the texture [2]. Secondly, the examination of the ceramic cross sections with optical polarizing microscope in visible light and under ultraviolet light revealed information on the layers' composition of the painted ceramic. The petrographic analysis was performed for samples taken from a number of eight *Cucuteni* shards.

The petrographic study of the *Cucuteni* Eneolithic ceramic has provided three types of information: i) the mineralogical composition of the inclusions; ii) the grain size, frequency, sphericity and sorting of the inclusions, as well as the frequency, size and shape of the pores [3]; iii) the firing temperature derived from the observed transformations of minerals [1], e.g. the transformation of biotite (black mica) into red hematite.

2. Materials and methods

2.1. Samples

The measurements were performed for a number of eight samples of painted ceramic shards originating from *Cucuteni* archaeological sites (Iaşi – Romania) and belonging to the Eneolithic period (four samples coded GA02[a], GA03[a], GA13[a], GA41[a] - *Cucuteni* phase A, about 3750–3200 BC, and four samples coded GA33[b], GA35[b], GA42[b], GA56[b] – *Cucuteni* phase B, about 3000–2700/2600 BC) [4], [http://www.phys.ugal.ro/Archaeopolice]. The sample GF66[a], obtained by experimental archaeology and by using raw material from the *Cucuteni* area, was also analyzed for comparison.

The thin and cross sections samples were extracted from the black and red surfaces representing the typical decoration of *Cucuteni* ceramic bodies. The thin sections were prepared in order to identify the minerals present in the clay matrix. The thin slices of ceramic shards were cut perpendicularly to the surface of the shard. Then they were polished on one side. This polished side was glued on a glass slide by using thermosetting epoxy resin. The thin sections were then ground to a uniform thickness of about 0.03 mm [1, 5]. The cross-sections were prepared by including the small shards in epoxy resin and then the obtained surfaces were polished.

2.2. Polarizing Microscopy

Polarizing microscopy was used to determine the mineral inclusions and the structure of the clay matrix. The thin sections of the *Cucuteni* ceramic samples have been examined in transmitted light using a petrographic–polarizing ZEISS RP48 POL microscope. At a thickness of about 0.03 mm, the mineral fragments present in the ceramic body show the interference colours that can be used for identification [1]. The minerals were also identified by observing the crystal shape, cleavage planes and optical properties (e.g. isotropy, pleochroism, and twinning) in plane polarized light. The extinction angle was observed by using cross polarization, because at this angle most light transmission is blocked by the polarized filters. Thus, birefracting samples are observed together with the changes of the colouration due to pleochroism [6].

The cross-sections have been studied with polarizing optical microscopy in visible light and under ultraviolet light. The analysis was performed by using a polarizing Olympus BX51M microscope.

3. Results and discussion

The petrographic study of ceramic shards allows the identification of the pottery paste types, based on the amount, nature, grain sizes, sorting, roundness, and sharpness of the inclusions [7]. The GA13[a], GA33[b], GA35[b], GA42[b] and GF66[a] samples of ceramic shards are presented in Figures 1–4. All the thin sections were photographed under plane-polarized light (see Figures 1a, 1c, 2a and 2c) and cross-polarized light (see Figures 1b, 1d, 2b and 2d). The inclusions found in the *Cucuteni* ceramic samples are mineral fragments including quartz, plagioclase and K-feldspar, white mica (muscovite) and black mica (biotite) (see Figures 1 and 2). The frequency of inclusions in the matrix varies from abundant (GA33[b]) to moderate (GA02[a], GA03[a], GA42[b] and GF66[a]) and sparse (GA13[a], GA41[a], GA35[b] and GA56[b]).

The size of the inclusions is fine, up to 0.1 mm, and the sorting is fair. The roundness of the inclusions is low spheroid and sub-angular. The texture is more or less distinctly laminated, with evident iso-oriented inclusions, voids and cracks. Some voids are filled with carbonates of secondary crystallization. The thin-sections present also elongate and regular voids of grass or straw (GA03[a], GA13[a]). In addition, the petrographic analysis revealed that the matrix is Fe oxides rich clay.

Although hematite, magnetite and ilmenite are abundant minerals in ancient ceramics, they are difficult to identify in thin sections, since they are opaque. Therefore, their optical properties cannot be detected under the transmission microscope [1]. In consequence, the thin section (Figure 3a) and cross sections of the micro samples (Figure 3b and 3c) were observed by optical microscopy under the ultraviolet light and in the visible light to reveal the colouring layers and the body (see Figures 3 and 4). A selection of cross-sectional microphotographs is shown in Figures 3–5.

The microphotograph of sample GA13[a] shows in visible light a very thin superficial layer of red pigment with a dimension of about 60 μm (see Figure 3a), which is applied directly on the underlying substrate. The layer contains red hematite [8-10]. The cross-section microphotograph of the GA35[b] sample reveals two superficial layers, the black one surfacing a red one (see Figure 4c). The black layer contains probably a variety of jacobsite phases or magnetite [8].

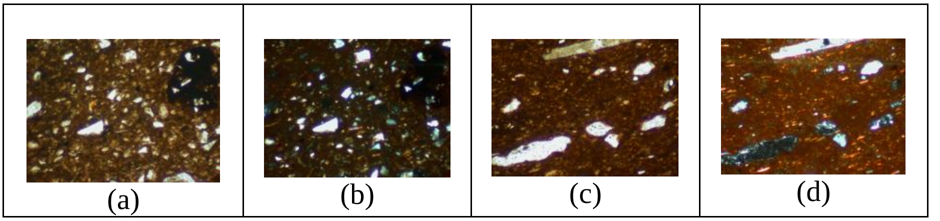

Figure 1. Polarizing microscopy views of thin-sections at ×125 magnification of samples: a) GA33^{b}, b) GA33^{b}, c) GA13^{a} and d) GA13^{a}.

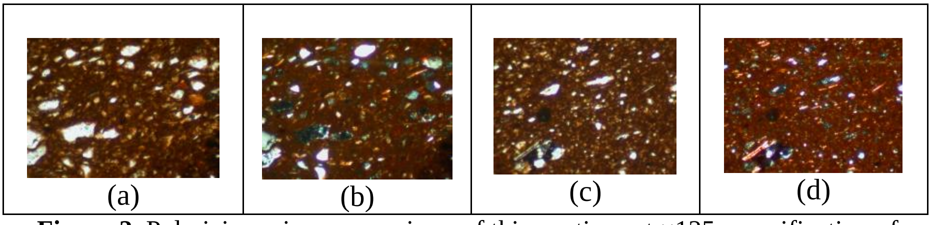

Figure 2. Polarizing microscopy views of thin-sections at ×125 magnification of samples: a) GA42^{b}, b) GA42^{b}, c) GF66^{a} and d) GF66^{a}.

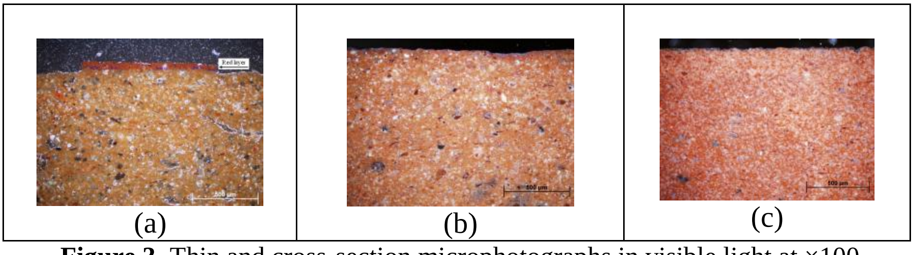

Figure 3. Thin and cross-section microphotographs in visible light at ×100 magnification of samples a) GA13^{a}; b) GA33^{b}; c) GF66^{a}.

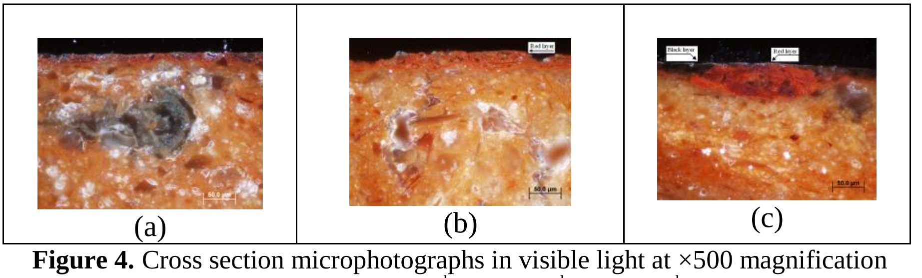

Figure 4. Cross section microphotographs in visible light at ×500 magnification of samples a) GA33^{b}; b) GA42^{b}; c) GA35^{b}.

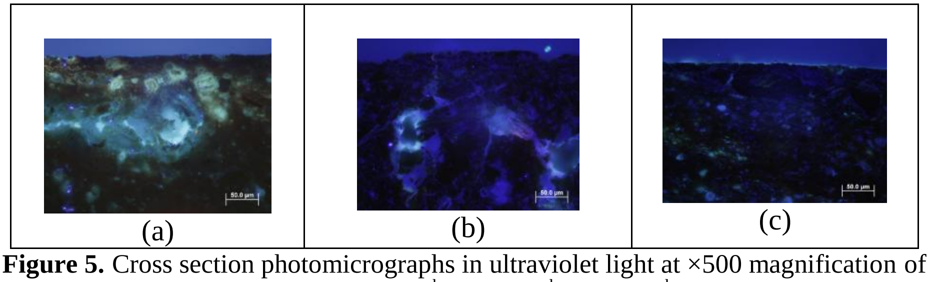

Figure 5. Cross section photomicrographs in ultraviolet light at ×500 magnification of samples a) GA33^{b}; b) GA42^{b}; c) GA35^{b}.

The cross section of the sample GA33[b] reveals some fluorescence in ultraviolet light (see Figure 5a).

4. Conclusions

The results show important mineralogical similarities between the investigated *Cucuteni* ceramic artefacts and the sample made experimentally by using raw material from the area where the *Cucuteni* samples were found. The matrix of the ceramic samples is Fe oxides rich clay and the texture is more or less distinctly laminated, with evident iso-oriented inclusions, voids and cracks. Some voids are filled with carbonates of secondary crystallization. The inclusions are mineral fragments (quartz, feldspars, white mica, and black mica) of low sphericity with sub-angular rounding.

In conclusion, the petrographic analysis, applied for the characterization of the paste of the ceramic body, has shown that the *Cucuteni* potters used the clay that can be found in the region. In other words, this indicates that the Eneolithic ceramic bodies were indeed made with local row material (Cucuteni, Iaşi County, Romania).

However, these are preliminary interpretations. Further analysis carried out on ceramic shards of the same Eneolithic period found in other sites and burial environments are needed in order to derive a general conclusion regarding their origin, manufacturing techniques and trade habits of the *Cucuteni* population.

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