Analysis at microscope of some Gumelniţa pottery fragments from Borduşani *Popină* tell settlement

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Abstract: *In this paper, there are presented the main results obtained through the study of a batch of 18 ceramic fragments, analysed at binocular microscope and at optical microscope in polarised light. These sherds come from Chalcolithic pots found in the tell settlement from Borduşani* Popină, *Ialomiţa County, and attributed to Gumelniţa culture, phase A2. Thus, following the petrographic analysis three categories of ceramic fabric were confirmed, which were observed at macroscopic level and at stereomicroscope – fine, semi-fine and coarse – with some notable differences regarding the textural, of the microstructure, of the porosity and also compositional features.*

Rezumat: *În acest articol sunt prezentate principalele rezultate obţinute în urma studiului unui lot de 18 fragmente ceramice, analizate la microscopul binocular şi la microscopul optic cu lumină polarizată. Acestea provin din vase eneolitice descoperite în* tell*-ul de la Borduşani* Popină, *judeţul Ialomiţa, şi sunt atribuite culturii Gumelniţa, faza A2. Astfel, în urma analizei petrografice, au fost confirmate cele trei categorii de pastă observate la nivel macroscopic şi la lupa binoculară – fină, semifină şi grosieră – cu unele deosebiri notabile din punctul de vedere al caracteristicilor texturale, de microstructură, de porozitate şi chiar compoziţionale.*

Keywords: *Chalcolithic, Gumelniţa, pottery fabric, optic microscopy analysis.*
Cuvinte cheie: *Eneolitic, Gumelniţa, pastă ceramică, analiză la microscopul optic.*

◈ 1. Introduction

The archaeological site from Borduşani *Popină*, also known as Popina Mare, is situated at 2.5 km NE of the nearby village, in the forest district found in Balta Ialomiţei, at 800 m from Borcea branch of the Danube. The tell formed on an erosional remnant in the floodplain of the former lake Balta Ialomiţei and it reveals a complex stratigraphy exceeding 8 m in thickness.

In reverse order of deposition we can mention the discovery of artifacts belonging to a Getic settlement – La Tène period, with several levels of occupation, and Gumelniţa culture – phase A2, with numerous layers of occupation (S. Marinescu Bîlcu 1997).

Multidisciplinary research carried out here allowed for the observation of specific behavior patterns of these communities, in terms of resource management, mineral, animal and vegetable (D. Popovici *et alii* 2005).

◈ 2. Preliminary considerations

The main purpose of this article is to describe the types of pottery fabrics and the elements entailed by it, meaning the mineral composition and the nature of various

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inclusions, in order to understand the sourse of these materials as well as the treatment technique of the surfaces and the type of firing.

The term *fabric* was used in natural sciences in different ways. For instance, in petrography the term was chosen by some researchers to express the ensamble organisation of components, going beyond issues of structure and texture or their relative orientation. For some petrographic researchers the terms related to structure and texture are the same as the *fabric* (P. Bullock *et alii* 1985, p. 17).

Two elements must be taken into consideration when analysing pottery fabric: the matrix or the fine fraction consisting of clay, with mineral particles smaller than 0.002 mm and other larger inclusions (C. Orton *et alii* 1993, p. 67). Inclusions in the clay play an essential role, not only in the drying phase, but also during firing. They can already be naturally present in the paste or they can be added intentionally (P.M. Rice 1987 p. 93).

The two main components (the matrix and the inclusions) vary on the raw material selected by the potter and on the method of preparation. One must take into account the fact that both are more or less influenced by the combustion conditions (C. Orton *et alii* 1993, p. 67).

◈ 3. Methodology

For this study we selected pottery samples from five dwellings and one passage area. The pottery fragments were analysed using a binocular microscope in order to establish the main fabric types. In consequence, three main cathegories were identified and a total number of 18 ceramic fragments were attributed to fine paste (2), semi-fine paste (14) and coarse paste (2).

For the petrographic analysis an optical microscope with transmitted light in thin section was used. For obtaining the thin sections the samples were impregnated with a sintethic resin in a vaccum chamber. After polymerizing of the resin and its hardening, the samples passed trough a diamond disc cutting machine and a polishing device, in order to obtain the thin sections. Eighteen sections were obtained, with a thickness of 0.025 mm and perpendicular to the surface of the chosen pottery sherds.

The miscroscope analysis was done using a Olympus BX 60 device, at magnification of x50 - x500, in plane polarised light (PPL) and in crossed polarised light (XPL). The microscope study was performed in the laboratory of "Alexandra Bolomey" National Center of Pluridisciplinary Researches within the National Museum of Romania History.

Using an optical microscope in order to perform the analysis of materials such as clay, adobe, mortar, plaster and other, obtained by means of a mixture preparation, one must take into consideration the main sedimentary characteristics, such as: texture, microstructure, porosity, composition, homogeneity and color (C. Haită 2012a, p. 87).

In order to properly characterize the texture, the dimensional categories were established on the basis of *Udden-Wentworth* grainsize scale, adapted to Romanian terminology (N. Anastasiu, D. Jipa 1983, p. 19), due to the fact that ceramic paste is based on a mixture of natural sediments. The texture analysis allows us not only the description of the granules from a sherd, but also their distribution and size, and to a lesser extent, the organisation of the material (C. Orton 1993, p. 141).

The microstructure observed in the microscope analysis represents a complex sedimentary characteristic, it express the disposition and the relative size of the constituents, the size and shape of pores, the ratio between the voids and the solid fraction, as well as the organization of the whole (C. Haită 2012a, p. 90).

Porosity is expressed by shape and size of the pores, their orientation and the ratio between their volume and the volume of the solid fraction. Porosity entails the physical and chemical changes undergone by the sediments over the preparation and firing. The vesicular porosity of materials prepared by mixing indicates the homogeneity of the material when wet, following the discharge of air bubbles, while channel porosity is noticed when dealing with paste mixed with vegetal materials, like straw or chaff. The cracks derived by firing transformation are easily recognised at microscope by their dimensions and orientation.

Composition refers to the whole of the organic and mineral compounds that can be identified at the microscopic level. The study of the compounds allows for identification of their origin, as well as the manner and the degree of transformation.

The degree of homogeneity is expressed by the relative proportion and the distribution of the sedimentary compounds. The homogeneity varies highly in archaeological materials. In the case of prepared materials we ussualy can notice a high degree of homogeneity, and only accidentally we can observe constituents outside of the "recipe" (C. Haită 2012a, p. 96).

The color expresses the whole composition, the nature of the compounds (rarely, with an interpretative meaning, like in the case of iron compounds or organic matter) and their distribution (discrete inclusions or oxides stains in the clay), but also the firing conditions (temperature, time, firing atmosphere). Though it is very important that the color description be based on the MunsellSoil Color Charts, this is an endevor made very difficult when using a microscope. Moreover, the color may vary on the same pottery sherd depending on the firing conditions. Thus, the color reflects not only the composition of the raw material, but also the firing technology of the artefact, as well as its post-deposional history (P.S. Quinn 2013, p. 42).

◈ 4. Description of the identified ceramic fabric categories

Macroscopic observations and at binocular microscope

Fine ceramic, the most spectacular, has an overall fine texture and is highly homogeneous. The fine matrix shows smashed pottery inclusions, with general dimensions under 1 mm, rare and very rare. The color of the fabric varies from black to dark gray (10YR 2/1 to 7.5YR 4/1). The firing is generally oxidizing, incomplete, but also, rarely, reductive. The surface is smooth or coverd with a fine textured slip.

Semi-fine ceramic entails medium texture fabric, good homogeneity and contains inclusions of smashed pottery, with dimensions between 1-2 mm, quite frequent. Moreover, white mica granules are noticeable, representing natural inclusions. Generally, the firing is incomplete and it leads to differences in color between the inside and outside surfaces and central area (the core) of the sherd. Thus, the color varies from reddish yellow to gray (7.5YR 6/6 to 2.5Y 6/1). The surface is generally smooth.

Coarse ceramic shows a rough texture, heterogeneous, even to a large extent. The prevailling inclusions consist of smashed pottery, with dimensions of up to 2 mm, they are very frequent, alongside with shell fragments. Most often, the firing is incomplete and the color varies from reddish yellow to dark gray (7.5YR 6/6 to 10YR 4/1). The surface is generally smooth.

Microscope observations

Fine ceramic shows a very fine texture characterized by a silty clay matrix, with silt with a frequency of 3-5%, very fine sand, up to 100 μm, with a frequency of approx. 1% and a few granules of medium sand, with a frequency of up to 1%. The degree of sorting of the granules is generally good and rarelly, very good. Homegeneity is very good (pl. I/1-2).

The identified minerals are quartz, measuring 60-200 μm and a frequency of 3-5%, plagioclase feldspar measuring 10-200 μm and a frequency under 1% (pl. I/3), mica (pl. I/4) (muscovite, rarelly biotite), irregularly shaped carbonates, measuring up to 30 μm and a frequency of under 1%.

Iron oxides have been identified in the shape of ferruginous impregnations, reddish in color, rounded in shape, measuring between 20-50 μm and a frequency of 2-3%.

Anthropic inclusions consist of smashed pottery granules, under isomeric form, slightly irregular, generally angular, measuring 140-600 μm and a frequency of 2-3%, dark brown in color (pl. I/5). Alongside these, other organic inclusions were observed, consisting of fine vegetable remains, measuring 10-20 μm, with a frequency of 5-10%, mostly opaque, with irregular shape, and other with larger dimensions, of up to 100 μm, and a frequency of approx. 1% (pl. I/6). The degree of sorting is good.

The porosity is represented by vesicular voids and channels, measuring up to 2 mm and a variable frequency of 5-10%. Slightly irregular chambers can also be observed, measuring 1-2 mm and a frequency of 2-3%. Cracks are generally present at the edges of sherds, are cvasi-parallel, but rare (1-2%).

Rarely encountered is the treatment of the exterior surface with a fine layer of about 60 μm thickness, made out of clayey silt - silty clay (pl. II/1). Most often, both the outer and the inner surfaces are smoothed.

Firing was generally performed in an oxidizing ambiance and is incomplete.

Semi-fine ceramic is caractherized by a silty clay matrix, but also sandy clay with silt that contains medium and coarse silt, measuring up to 63 μm, with a frequency of 7-10%, fine sand measuring up to 100 μm, with a frequency of 3-5%, and rare medium sand granules, of up to 200 μm, with a frequency of 1-2%. The degree of sorting is generally good and rarely the sorting is moderate. The homogeneity of the prepared material is good (pl. II/2).

Like in the previous case, the minerals observed are frequent quartz grains, measuring 70-400 μm, with a frequency of 2-3%, monocrystalline grains of feldspar with a rounded contour, measuring 50-100 μm, mica (muscovite) measuring 50-200 μm and a frequency of 2-3% and brownish carbonates, with microcrystalinne calcite, measuring 40-200 μm and a frequency of about 1%, as well as a few granules measuring 0.7-1.6 mm.

Anthropic inclusions consist of smashed pottery fragments with isometric shape, angular, measuring up to 500 μm, with a frequency of 3-5% and rarely (under 1%) measuring 1-2 mm (pl. II/3). Reddish brown silty clay granules were rarely observed, rounded, measuring between 200 μm and 2 mm, with a frequency of 1-2%, generally poorly sorted. Moreover, just as rarely (about 1%) are also noticeable light brown flint fragments, measuring between 0.6 and 1.5 mm and medium brown shell fragments measuring 400-600 μm, with a frequency of 1% (pl. II/4). The degree of sorting is medium.

Organic inclusions consist of fine vegetable remains, measuring 10-20 μm and a frequency of 5-10%, generally opaque, irregular in form and rarely (2-3%) reaching 300 μm.

Porosity is expressed through isolated pores, vesicular and elongated, but also irregular, measuring 40 μm - 2.5 mm, with a frequency of 5-7%. Rarely, with a frequency of up to 1% we can notice channels with a maximal lenght of 1.7 mm (pl. II/5). Fine cracks were noticed cvasi-parallel with the edges of the pottery sherds, both exterior and interior.

Treatment of the surfaces was done by smoothing (pl. II/6), both interior and exterior.

Firing is generally oxidizing, but incomplete (pl. III/2), resulting in a yellowish brown or light brown color, and sometimes observing a gradual transition from outside towards the inner part.

Coarse ceramic is caractherised by a silty clay matrix containing 3-5% silt, very fine sand, measuring up to 80 μm and a frequency of up to 10%, and medium sand of up to 200 μm with a frequency of 2-3%. The degree of sorting of the granules is poor to medium. Uniformity is pretty low, the mixture is generally heterogeneous (pl. III/3).

As in the case of the other two types, the minerals observed are frequent monocrystalline quartz grains, measuring 200-400 μm, with a frequency of 3-5%, feldspars measuring 50-250 μm and a frequency of 1-2%, mica (muscovite, rarely biotite), measuring 50-200 μm and a frequency of 2-3%, rare carbonate granules measuring 60-120 μm and rarely up to 1.6 mm.

Inclusions consist of smashed pottery granules of isometric form, angular, measuring 600 μm - 1.4 mm, with a frequency of approx. 10% (pl. III/4). Medium brown flint fragments were present very rare (under 1%), measuring approx. 300 μm (pl. III/5). Alongside these, as in the cases of the other two fabric types, organic inclusions consist of fine vegetable remains, measuring 10-20 μm, with a frequency of 5-10%, generally opaque, irregular, but also encountering fragments of larger dimensions of up to 300-350 μm, with a frequency of 2-3%. The degree of sorting is poor.

Porosity is expressed through isolated pores, vesicular and elongated, but also irregular, as well as channels, measuring up to 1.4 mm, with a frequency of approx. 10%. Fine cracks, of about 200 μm, with a frequency of up to 1%, were noticed both in the exterior and the interior area of the sherd.

Surface treatment, both inside and outside, is generally done by smoothing.

Firing is generally oxidizing, incomplete (pl. III/6), with gradual transition from outside to inside.

◈ 5. General characteristics of the *fabric* in the analyzed ceramic batch

Texture

All 18 pottery sherds show a sedimentary matrix with a fine and medium texture, if we are to refer to the textural categories of sediments (Udden-Wentworth grainsize scale).

Fine ceramic fabric is made out of, for all the analyzed fragments, very fine silty clay. The coarse fraction is represented by silt, rarely (approx. 1%) by fine sand and medium sand granules, with a frequency under 1%. From a mineralogical point of view, this fraction is represented by monocrystalline quartz, poorly rounded, with good sorting, rare feldspar granules and well sorted mica granules.

The degree of sorting is good and very good, for all the analyzed cases, indicating a natural, non mixed sediment.

Semi-fine fabric consists of silty clay with fine silt and rarely of fine sandy silty clay, with silt (3-5%) and fine sand measuring 80-100 μm (1-2%). Sorting is medium and indicates most likely a natural sediment, without mixture.

Coarse fabric consists of sandy silty clay that contains silt (3-5%), fine sand, measuring 80-100 μm (10%), medium sand up to 200 μm (2-3%) and coarse sand up to 400 μm (2%). In this case sorting is weak, suggesting a mixture of sediments, probably intentionall, even if the mixture could have taken place at the moment of sampling from the contemporary alluvium.

Microstructure

All 18 fragments present an open porphyric microstructure, while the clay shows generally a chitonic relative distribution, being oriented around the granules.

Fine pottery has a very homogeneous microstructure with fine inclusions, and in the case of one fragment we could notice clay domains oriented oblique to the wall (pl. II/1).

Semi-fine ceramic presents a more complex microstructure, but homogeneous, presenting a porphiric distribution of burned, reddish brown clay fragments, measuring between 200 μm and 2 mm, and also birefringent clay domains oriented on two directions (pl. III/1).

Coarse ceramic present a heterogeneous porphyiric microstructure, expressed by the frequent crushed pottery inclusions.

Porosity

As observed in previous study, the porosity is essentially represented by two types of pores. The first type is represented by isolated pores, either circular, formed by mixing the wet material (air bubbles trapped in clay) or voids and channels resulted from burning the organic materials added to the mixture (C. Haită 2012b, p. 116).

The second type of porosity is represented by the fine cracks less than 1 mm wide parallel / cvasi-parallel to the wall of the pottery and relatively rare, with a frequency of 1-2%, observed in all the three categories of ceramics. These cracks are interpreted as formed during combustion by the rapide elimination of the water.

Composition

All pottery sherds contain in their compositon smashed pottery fragments and fine vegetable remains. It was noticed that some fragments of pottery include others in turn, this indicating reuse of ceramic material with size of approx. 400 μm and a frequency of no more than 1%. The degree of sorting of the inclusions is medium.

Reddish brown plant fragments were observed in the composition of all types of ceramic paste. In the case of fine ceramic these organic inclusions are very fine, with sizes of 10-20 mm and frequency of up to 10%. In the case of the other two catergories they are larger in size, up to 120 μm, less frequent (3-5%), and generally opaque (pl. I/6).

Semi-fine and coarse ceramic fabrics show very rare shell fragments, yellowish brown in color, measuring between 400 μm - 1.2 mm and a frequency under 1%.

In the case of two sherds of coarse and semi-fine categories, fragments of fine flint, light brown, rounded, with dimensions between 600 mm and 1.5 mm were identified. Few grains of charcoal have rarely been observed, accidentally integrated in the semi-fine paste.

Color

Fine pottery has a color ranging from yellowish to medium and dark brown, but it is uniform in the sherd's profile.

The color of semi-fine pottery ranges from reddish brown to dark brown and, in most cases, the color of the inside and outside surface of the sherd is different.

Coarse ceramic has a color that also shows variation of yellowish brown to dark brown, and the pottery fragments show color variations in the profile.

◈ 6. Conclusions

Microscopic analysis confirmed the paste types studied with the binocular microscope, but also brought important detailed information on both the sedimentary matrix and inclusions, and on how the mixture is achieved, the surface treatment and combustion conditions.

The texture and degree of sorting of the matrix indicates the use of naturally occurring sediments, generally without mixing. In the case of coarse paste, there may be a mixture, possibly intentionally, of fine sediments with fine to medium sands.

The inclusions are generally well sorted, with slightly larger dimensions where coarse paste is involved. It was noticed that some of the sherds contained crushed pottery fragment inside them, indicating ceramic material reuse. Moreover, it is expected that, in general, the resulting material is fine and well prepared.

Surface treatment – slip is very rare in the ceramic batch analyzed and present only in the case of the fine paste.

Firing is generally oxidizing, but incomplete, without identified changes in the minerals that might occur over 700° C. This is also indicated by the preservation of plant inclusions.

◈ Acknowledgments

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◈ Bibliography

N. Anastasiu, D. Jipa 1983	*Texturi și structuri sedimentare*, Editura Tehnică, București.
P. Bullock *et alii* 1985	P. Bullock, N. Fedoroff, A. Jongerius, G. Stoops, T. Tursina, *Handbook for soil thin section description*, Waine Research Publications, Wolverhampton.
C. Haită 2012a	*Sedimentologie și micromorfologie. Aplicații în arheologie*, ediția a II-a, Biblioteca Muzeului Național, Seria Cercetări Pluridisciplinare XII, Editura Cetatea de Scaun, Târgoviște.

C. Haită 2012b — Observations at microscope on pottery fabric of some ceramic fragments from Gumelniţa tell settlements Hârșova and Bordușani Popină, *SP*, 9/2012, p. 113-121.

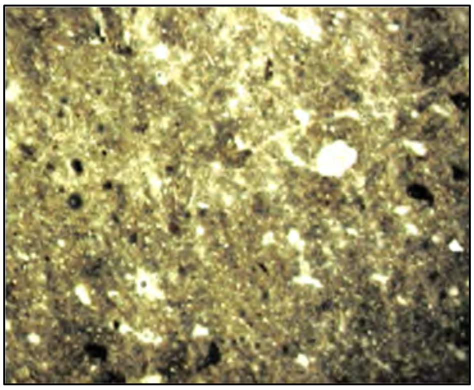
S. Marinescu-Bîlcu 1997 — Historical background, in S. Marinescu-Bîlcu *et alii*, Archaeological Researches at Borduşani Popină (Ialomiţa county). Preliminary report 1993-1994, *CA*, X, p. 35-38.

C. Orton *et alii* 1993 — C. Orton, P. Tyers, A. Vince, *Pottery in archaeology*, Cambridge Manuals in Archaeology, Cambridge University Press, Cambridge.

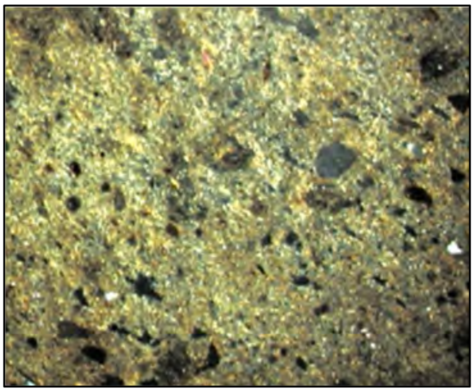
D. Popovici *et alii* 2005 — D. Popovici, F. Vlad, A. Nălbitoru, M. Mărgărit, *Cronica*, *Campania 2004*, http://cronica.cimec.ro/detaliu.asp?k=3074.

P.M. Rice 1987 — *Poterry analysis. A source book*, The University of Chicago Press, Chicago and London.

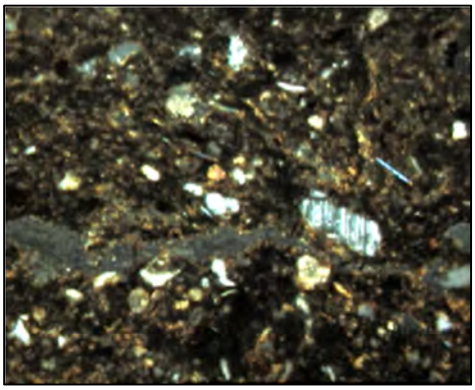
P.S. Quinn 2013 — *Ceramic petrografy. The interpretation of archaelogical pottery & related artefact in thin section*, Oxuniprint, Oxford.



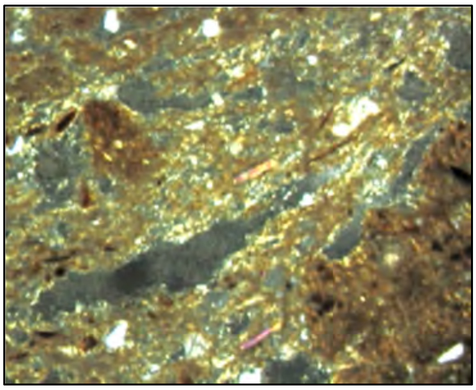
1. Fine fabric. PPL, f.w. 2 mm.
Pastă fină. PPL, l.i. 2 mm.



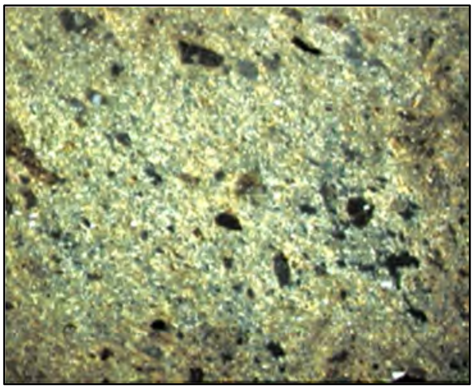
2. Fine fabric. XPL, f.w. 2 mm.
Pastă fină. XPL, l.i. 2 mm.



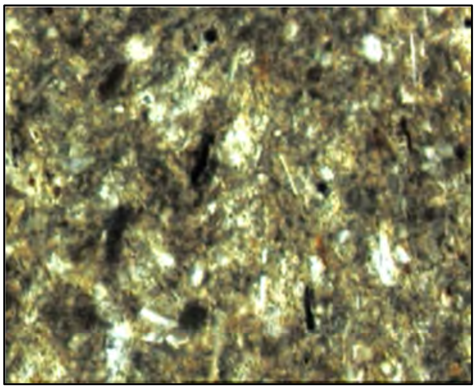
3. Fine fabric with grains of quartz and plagioclase. XPL, f.w. 0.5 mm.
Pastă fină cu granule de cuarț și feldspat plagioclaz. XPL, l.i. 0,5 mm.



4. Fine fabric with grains of muscovite. XPL, f.w. 0.5 mm.
Pastă fină cu granule de muscovit. XPL, l.i. 0,5 mm.

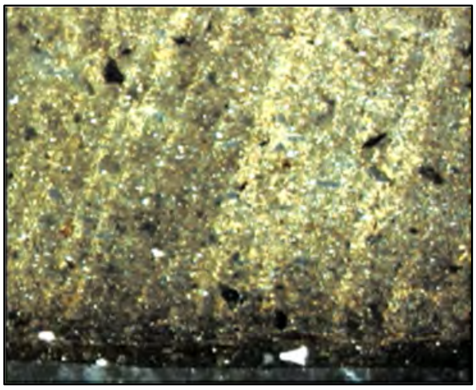


5. Fine fabric with fine inclusions of pottery fragments. XPL, f.w. 0.5 mm
Pastă fină cu incluziuni fine de fragmente ceramice. XPL, l.i. 0,5 mm.

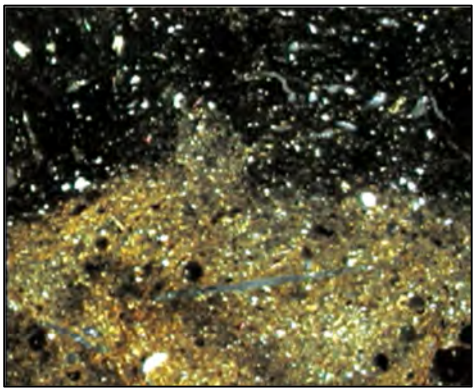


6. Fine fabric with fine opacitised vegetable fragments. PPL, f.w. 0.2 mm.
Pastă fină cu fragmente vegetale fine, opacizate. PPL, l.i. 0, 2 mm.

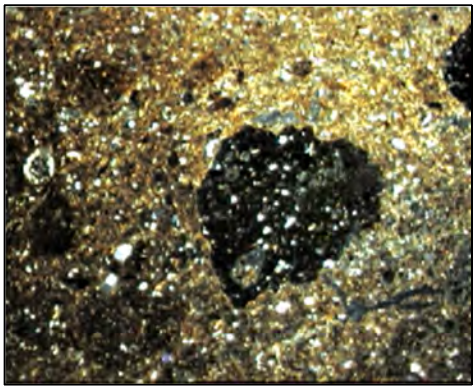
Pl. I. Photos at microscope. PPL – plane polarised light; XPL – crossed polarised light; f.w. – frame width.
Imagini la microscop. PPL – lumină plan polarizată; XPL – lumină polarizată încrucișat; l.i. – lățime imagine.



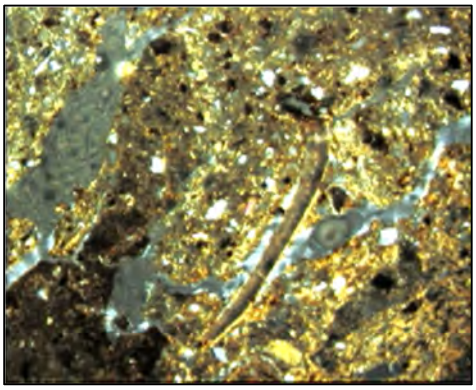
1. Fine fabric – oblyque orientation of clay and the surface finishing. XPL, f.w. 2 mm.
Pastă fină – orientarea oblică a argilei și finisarea suprafeței. XPL, l.i. 2 mm.



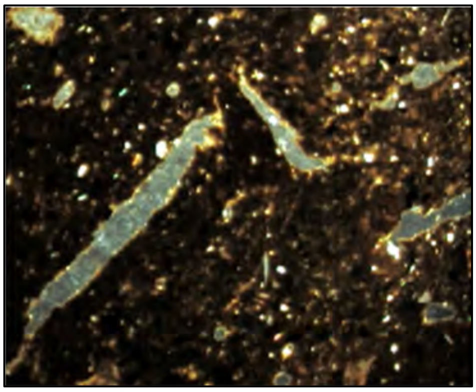
2. Semi-fine fabric. XPL, f.w. 2 mm.
Pastă semifină. XPL, l.i. 2 mm.



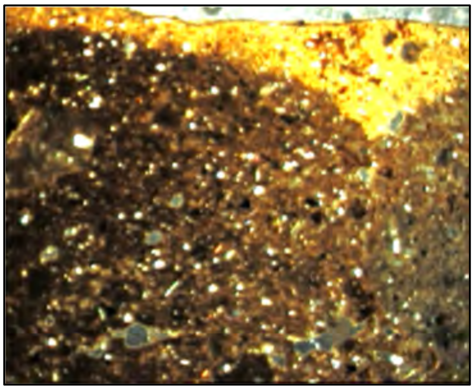
3. Semi-fine fabric. Pottery fragment inclusion. XPL, f.w. 2 mm.
Pastă semifină. Incluziune de fragment ceramic. XPL, l.i. 2 mm.



4. Semi-fine fabric with shell fragment inclusion. XPL, f.w. 2 mm.
Pastă semifină cu incluziune de fragment de scoică. XPL, l.i. 2 mm.

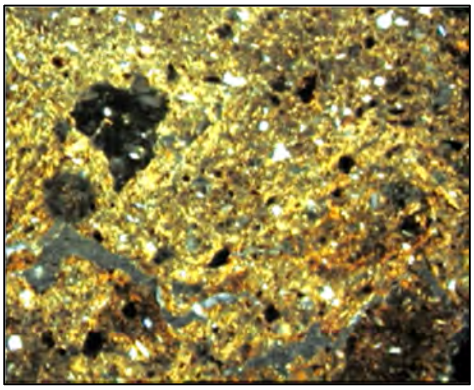


5. Semi-fine fabric with porosity with channels. XPL, f.w. 2 mm.
Pastă semifină cu porozitate cu canale. XPL, l.i. 2 mm.

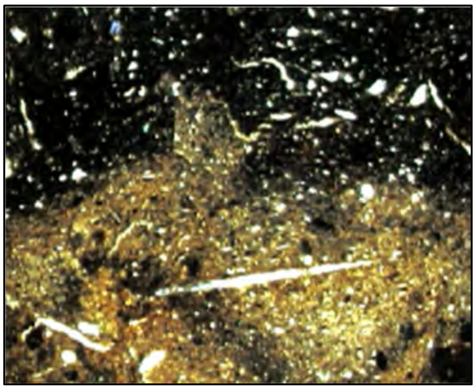


6. Semi-fine fabric. Surface treatment by smoothing. XPL, f.w. 2 mm.
Pastă semifină. Tratarea suprafeței prin netezire. XPL, l.i. 2 mm.

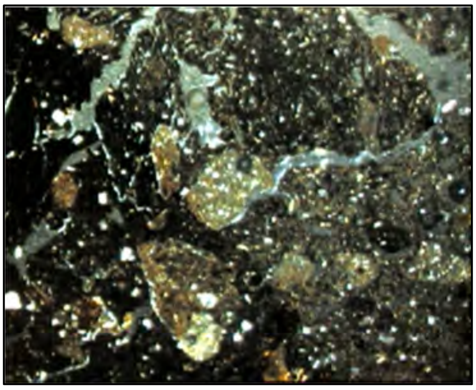
Pl. II. Photos at microscope. PPL – plane polarised light; XPL – crossed polarised light; f.w. – frame width.
Imagini la microscop. PPL – lumină plan polarizată; XPL – lumină polarizată încrucișat; l.i. – lățime imagine.



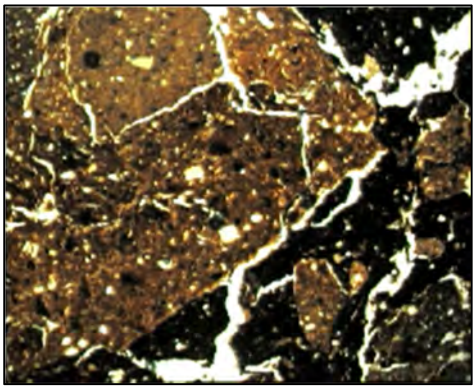
1. Semi-fine birefringence fabric – clay oriented on two directions. XPL, f.w. 1 mm.
Pastă semifină cu argilă birefringentă orientată pe două direcții. XPL, l.i. 1 mm.



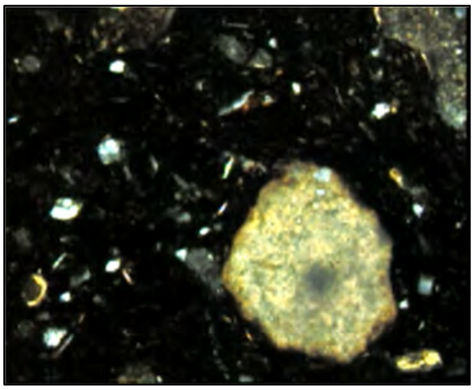
2. Semi-fine fabric, limit of zones with different burning. PPL, f.w. 2 mm.
Pastă semifină, limită a unor zone cu ardere diferită. PPL, l.i. 2 mm.



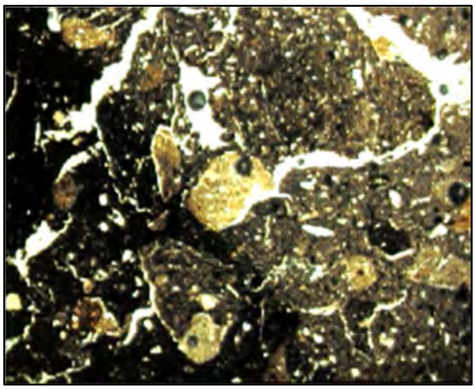
3. Coarse fabric. XPL, f.w. 2 mm.
Pastă grosieră. XPL, l.i. 2 mm.



4. Coarse fabric with large inclusions of pottery fragments. PPL, f.w. 2 mm.
Pastă grosieră cu incluziuni mari de fragmente ceramice. PPL, l.i. 2 mm.



5. Coarse fabric with flint fragment inclusion. XPL, f.w. 0.5 mm.
Pastă grosieră cu incluziune de silex. XPL, l.i. 0,5 mm.



6. Coarse fabric with frequent ceramic inclusions. PPL, f.w. 2 mm.
Pastă grosieră cu frecvente incluziuni ceramice. PPL, l.i. 2 mm.

Pl. III. Photos at the microscope. PPL – plane polarized light; XPL – crossed polarized light; f.w. – frame width.
Imagini la microscop. PPL – lumină plan polarizată; XPL – lumină polarizată încrucișat; l.i. – lățime imagine.