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# PRELIMINARY NOTES CONCERNING MIDDLE BRONZE AGE POTTERY ANALYSIS FROM COSTIȘA-*CETĂȚUIA*, NEAMȚ COUNTY

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**Keywords:** Middle Bronze Age, Eastern Carpathians, pottery, archaeological records, macroscopic and microscopic analysis, SEM-EDS analysis.

**Abstract:** *The Costișa archaeological culture has been known for more than half a century and it has been categorized as belonging to the Middle Bronze Age in the Eastern Carpathian area. From the very beginning it was supposed to be the result of local connections with southern Monteoru-type elements and northern ones such as Komariw-Bialy-Potik. This assessment was made on the basis of a comparative analysis of the known archaeological investigation methods (stratigraphy and pottery typology). The present contribution employs another type of analysis of the pottery from the eponymous site. Thus, starting from the archaeological database consisting of seven pottery shards, the following scientific investigations were performed: SEM-EDS analysis, optical spectroscopy, and chemical modules analysis. The aim was to cover all the steps followed during modern pottery investigation, from the archaeological description of the artefacts and the initial macroscopic evaluation, to the integration by the archaeologist of the data obtained from the other types of analysis. The results of these analyses could provide multiple coherent answers regarding the history of a site, the ceramic technology, the relations between the local community and the Monteoru ones.*

**Rezumat**: *Cultura Costișa este cunoscută de peste o jumătate de secol. Aceasta a fost încadrată în perioada mijlocie a epocii bronzului din zona de răsărit a Carpaților Orientali. Încă de la debutul cercetărilor, cultura Costișa a fost considerată ca fiind rezultatul îmbinării unor elemente nordice de tip Komariw-*Bialy-Potok *cu elemente sudice de tip Monteoru. Această primă evaluare a fost făcută pe baza analizei comparative a rezultatelor aplicării metodelor de investigare arheologică (stratigrafie și tipologie ceramică). Contribuția actuală încearcă să utilizeze și alt tip de investigare a materialului ceramic din situl omonim. Astfel, pornind de la o bază de date arheologice formată din șapte fragmente de ceramică, au fost aplicate și următoarele tipuri de investigație*

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*științifică: macroscopie și microscopie optică, analiza SEM-EDS, spectroscopie optică, module de analiză chimică. Am dorit parcurgerea tuturor etapelor unui tip actual de investigare a olăriei, care începe cu descrierea arheologică a artefactelor și prima evaluare macroscopică până la integrarea de către arheolog a datelor rezultate ca urmare a utilizării analizelor multiple. Rezultatele acestor investigații ar putea oferi mai multe răspunsuri coerente cu privire la următoarele aspecte: istoria de unui sit, tehnologia ceramică, relațiile dintre comunitatea locală și comunitățile Monteoru.*

## Introduction

Within the Bronze Age framework in the area situated east of the Carpathians, the case of the Costișa culture requires a reassessment. Details concerning its origin, spreading area and its role in the cultural framework of that era need to be clarified. The first attempts at the research of this culture[2] as well as the most recent one[3] emphasized the blending of local components with different elements coming from the North or East. These first observations were made on the basis of a comparative analysis of the known archaeological investigation methods (stratigraphy, typology). The bulk of the research was dedicated to the pottery analysis, its presence in the archaeological layers, its frequency, techniques and decoration motifs.

Since the early 1960s up until recently, for this form of cultural representation the archaeologist did not manage to apply the current methods of investigating ceramic ware, which would have provided a more affluent range of answers. This shortcoming was due to the absence of adequate means of research and the steadfastness of the local archaeologists in a discourse that avoided the use of these means[4]. In this endeavour the inclusion and gradual diversification of investigating pottery can already speak of a long history of research from abroad as well as some very interesting local contributions.

This paper, although using a rather tenuous database, tries to bring forward other type of considerations on pottery from the eponymous site.

[2] VULPE 1961.
[3] MUNTEANU 2010.
[4] ANGHELINU 2012, 21.

This analysis is based on the use of physical and chemical analyses of the basic elements specific to this category of historical sources. To these analyses were added the archaeologist's naked-eye observations of the pottery, as well as details concerning the components of the prolonged technological process of manufacturing clay vessels.

All these factors are meant to promote, when the database and other means of investigation will be expanded, the diversification of the archaeological discourse and a necessary rewriting of the Costișa culture story.

**Explanatory elements on the history of an archaeological culture**

The Costișa archaeological culture is known for more than half a century. This material output of the communities who inhabited the western and southern Cracău-Bistrița basin during the Middle Bronze Age was investigated in two main stages. The first is represented by the contribution of Alexandru Vulpe and Mihai Zamoșteanu through the first research ever conducted at the eponymous site[5]. Within this stage should be included the contribution of Marilena Florescu, which extended the knowledge concerning the subject matter through investigations conductedat Borlești (Neamț County)[6]. As a result of these contributions, the Costișa culture was categorized as belonging to the Middle Bronze Age and was held to be the result of local connections with southern Monteoru-type elements and with northern ones such as Komariw-Bialy-Potik[7]. In this scenario it was assumed that, on its way northwards, the Monteoru culture overlapped/annihilated the Costișa communities. Marilena Florescu underlined the Costișa cultural history and considered, on the basis of the stratigraphic and comparative data, that the discovery from Borlești belongs to an earlier stage. This phase would correspond to the Monteoru IC3 phase. The Trzciniec and Monteoru features found in

[5] VULPE, ZAMOȘTEANU 1962.
[6] FLORESCU 1970, 78-79.
[7] VULPE 1962.

the Costișa pottery repertoire may be understood as the result of adaptation, or of the cultural receptivity of the Costișa culture[8].

A second phase of research began after 1990, when general studies[9] and monographs[10] were published, the research at older sites was resumed (Costișa-*Cetățuia*, Poduri-*Dealul Ghindaru* etc) and excavations at new sites were opened (Siliștea-*Pe Cetățuie*)[11]. Current contributions have followed a differentiated theoretical and methodological basis and provided new insight on the absolute chronology[12], on the relations between the Monteoru and the Costișa cultures[13], on the content of some earlier discoveries[14], and on other topics that have enriched the knowledge of the Bronze Age in this area. As a result of these contributions (radiocarbon dating), it was established that, at least for the Costișa-*Cetățuia* and Siliștea-*Pe Cetățuie* sites, the period of occupancy of the two sites can be traced throughout the 19th BCE to the 17th BCE centuries[15]. Equally important seems to be the comments on the possibility of some contributions from Central Europe or from Transylvania in fingerprinting the Costișa culture.

**Site informations**

The southern part of the Cracău-Bistrița basin was a densely populated geographical subunit in prehistoric times[16]. The two rivers that

[8] FLORESCU 1970.

[9] VULPE 2001, 248-249, Fig. 37/1-6.

[10] DUMITROAIA 2000, 127-156, fig. 93-115 and the chronological table from p. 324. CAVRUC-DUMITROAIA 2001; MUNTEANU 2010.

[11] Within this site has been examined a batch of 13 pottery fragments. Here, in order to achieve a coherent analysis I kept the same order of carrying out the scientific and archaeological investigations. The intention was to compare the results of pottery analysis of two archaeological cultures from two contemporary and neighboring sites. See BOLOHAN 2013. The results of a comparative study will be published after completing the data base and the structural analyses.

[12] BOLOHAN 2010.

[13] POPESCU 2003; 2006, POPESCU-BĂJENARU 2004.

[14] POPESCU 2000.

[15] BOLOHAN 2010, 237-240.

[16] DUMITROAIA 2000, Map 6; CAVRUC-DUMITROAIA 2001, Map of discoveries.

drain the basin facilitated communication. In fact, the environmental conditions in the southern half were favourable to the development of relations between communities. By its geographical position, the Costișa-*Cetățuia* stronghold has an important place in the short- and medium-distance contacts specific of the period.

The Costișa-*Cetățuia* site is located in the Subcarpathian nappe and belongs to the Pietricica digitation. The soil consists of clay-siltite formations, grey-sands with brecciation and Carpathian conglomerates associated with rocks of chemical precipitation (rock salt, potassium salt, gypsum). The occurrence area of the peri-Carpathian nappe is marked by the presence of numerous mineralized springs (Rmn. *slatine*)[17]. For the present study of relevance are the Badenian deposits located between Buhuși and Mărgineni. Within these deposits there are yellowish grey marl, with rare intercalations of hard limestone and yellowish calcareous sandstones[18].

For the first time in 1937, then in 1959-1960, 1962, 2001-2008 and 2010 at Costișa-*Cetățuia*, Neamț county, was investigated an archaeological site, which by its characteristics unveiled the presence of two subsequent pottery groups, Costișa and Monteoru[19]. The settlement is located in the lower basin of the Bistrița River (Pl. 1) on a promontory of 75m altitude and 500m width (*Cetățuia*), but also in relation to the high terrace area located on the left side of the watercourse. A fortification was built by exploiting land conditions and by making three ditches. The forehead of the terrace is strongly carved and interrupted by stabilized landslides. The top of these terraces contain substantial deposits of loess. During the Bronze Age the Costișa community used these natural accidents, providing protection for each segment of the terrace, through the northern and southern ravines.

The living space was divided into two sections (A and B). The first is taller and has a visibility of up to 3-4 km by the lower basin of the

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[17] GRASU *et alii* 1999, 35-36; RUSU *et alii* 2002, 80.

[18] LUPAȘCU 1996, 20, COTOI, GRASU 2000, 14, 33-53, DONISĂ 1968.

[19] For references see *supra*, the chapter dedicated to the history of an archaeological culture.

Bistrița River. There is no visibility from the site towards the neighbouring and contemporary site of Siliștea-*Pe Cetățuie*.

The characteristics of pottery found in the lower layer indicates the presence of a pottery group to be called Costișa, with affinities in northern ceramic type groups alike Komariw and Bialy Potik, and in the top layer is present a pottery with different shapes, simple decoration, which belongs to the Monteoru group ceramic, phases IC3-Ib.

Based on these observations as well as on the stratigraphic features, the authors of the research talk about a period of contact/cohabitation of the two ceramic groups and about the "closing" of the Costișa-*Cetățuia* settlement by the Monteoru ceramic group[20].

**Cultural framing and archaeological taxonomy (introductory notes)**

Characteristic of the Middle Bronze Age in the researched area were the Costișa and Monteoru ceramic groups, specifically in the central and southern regions and the area of Trzciniec-Komariw, by the north-eastern outskirts. In the central area, as a consequence of connections with Eastern Transylvania, are present some artefacts belonging to the Wietenberg ceramic group. Until recently, the archaeological method of choice was the comparison of all cultural, chronological, technical and aesthetical delimitations in order to identify specific features of the pottery history within a site (Costișa-*Cetățuia*) and common features of contemporary pottery from several sites (Monteoru, Costișa, Borlești, Lunca, Siliștea etc.)[21].

Under these circumstances, framing in phases and stages the two pottery groups from which the bulk of the artifacts was collected, was made in reference to the stratigraphy from Sărata Monteoru (Monteoru pottery group) and based on the interpretation of differences or similarities of the pottery.

[20] See recently POPESCU-BĂJENARU 2009.

[21] See a recent critique concerning this kind of archaeology at ANGHELINU 2012, 17-20.

Thus, for the Costișa pottery group, on account of eye-naked observations made by the archaeologists[22], were identified the following ceramic categories:

A. Fine pottery
- Clay matrix
- Inclusions (small pebbles, mica, very well crushed shards)
- Dense, well prepared
- Well-burnt, uniformly-coloured core and surfaces

B. Coarse pottery
- Clay matrix
- pebbles, flint of angular shape
- Untidy worked
- Crumbly
- Greyish up to black core

C. A possible semi-fine intermediary pottery

For the Monteoru ceramic group, based on the same bulk of technical observations, the following ceramics groups were identified:

A. Very good paste
- Clay matrix
- Well mixed
- Well burnt
- Thin section
- No coloured core

B. Good paste
- Sandy clay matrix
- Crushed gravels uniformly sorted
- Well burnt
- Thin core section

C. Coarse ware
- Clay matrix
- Angular pebbles and poorly sorted flint

[22] For a detailed view concerning the pottery taxonomy specific for Monteoru and Costișa groups. See BĂRZU 1989; ZAHARIA 1990, 1991, 1993; DUMITROAIA 2001, 19-20; POPESCU 2006.

- Different coloured core

The arguments presented above were based on drawing a classification of pottery shapes, centred on the use of the aforementioned criteria. Technological, functional and aesthetic criteria were added to these. From here emerged two dominant ceramic categories, each with several variants and sub-variants: household vessels (food preparing, liquid storage, transport etc.) and special purpose vessels (funerary, ritual).

Thus, for the Costișa ceramic group was observed the preference for using differentiated ceramic paste for differentiated types of pottery. Therefore, cups and amphorae were made of good paste (A) and bowls and dishes-jars were made of coarse paste (B). For the Monteoru pottery group have been met same criteria. Difference was driven/determined by a larger classification of shapes as soon as the varied decorative techniques and models.

A first observation can be made about the uniformity of the pottery shape *repertoire* specific for the two pottery groups. The exceptions may be seen in the way of working the surfaces of the pots (techniques, motifs). The response was seen in the identification of the same pottery fashion specific for Middle Bronze Age or in the violent imposition of a community and the acceptance of its artefacts.

## Methodological issues

For this research it was processed the archaeological recording, observing and describing artefacts which were made on separate sheets. For each sample were applied some scientific investigation: chemical composition (SEM-EDS analysis, optical spectroscopy and chemical modules analysis), physical analysis (XRD)[23]. My aim was to complete the steps from archaeological description of the artefacts to the integration by the archaeologist of data from other types of analysis. The results of these analyses could provide multiple coherent answers regarding the history of a place, the pottery technology, the relations between the local community

[23] Unfortunatelly, by the time of writing these lines I have not received the results of XRD analysis, fact which has fragmented drawing the conclusions.

and the Monteoru communities. The archaeological research has made essential contributions concerning the stratigraphy, the artefact typology and the chronology. This step needs to be followed by a scientific verification of macroscopic observations, comparing data obtained from Costișa site with data from contemporary and neighbouring sites. A first step has been achieved through the publication of a first batch of ceramic artefacts from contemporary Bronze Age settlement at Siliștea-*Pe Cetățuie*, Neamț County[24].

In this context, the main goal is to attempt an overview and a detailed analysis of the pottery batch that originates from the Bronze Age level at Costișa-*Cetățuia*.

For setting up the database which made the object of this scientific analysis, I chose samples coming from the ceramic fragments excavated at Costișa-*Cetățuia,* Neamț County (Pl. 2/P1-P7)[25]. For the purposes of this analysis and interpretation, I chose the experience of a research centre with a longer tradition in the development of these initiatives. Thus, to the personal experience in describing and interpreting artefacts, I added the performance achieved by Prehistoric Ceramics Research Group (PCRG)[26] and some other recent contributions in the field[27]. For analysing the pottery shards I ordered in two steps the analysis. The first stage is represented by a naked-eye analysis performed by the archaeologist considering the following criteria:

- location (acronym), year of research, sample number
- photographs (original shard, front, back, drawing and thin section)
- spatial patterning
- fabric
- ingredients
- exterior colour (according to Munsell catalogue)

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[24] BOLOHAN 2013.

[25] In which P is the acronym for probe/sample.

[26] *Prehistoric Ceramics Research Group* available from: http://www.prehistoric-ceramics.org.uk

[27] MACKENZIE, ADAMS, 2013; QUINN 2009; QUINN 2013.

- wall thickness
- rim diameter
- ceramic group

In the second stage, this involved combining the results of macroscopic analysis with the thin-section microscopic analysis. I tried to identify and characterize the clay matrix, the elements of fabric and the elements observables by archaeologist and specialist in soil science and petrography. The following variables were used:

- place and (acronym) year of research; sample number
- photography (original shard, front, back, drawing and thin section)

Although the analysed database is not consistent, I tried to keep its diversity and a unique criterion for selecting samples from only the upper clay containers encompassing the main shapes and the main surface appearances stated above. They were selected from the whole assemblage of pottery. This allowed an easier reconstitution of the vessel forms subjected to structural analyses.

**The data base**

By using the criteria above, the technical equipment and the personal experience in archaeological investigation to which was added the experience of specialists in other fields, it was compiled a database containing the records of archaeological objects, the files resulting from macroscopic observations and the structural analysis. In this manner, I tried using all possible data, from the current state of ceramic fragments to the elemental analysis and observations of fabric.

Through operating with data from the site, I have found new features that were not visible to the archaeologists.

The samples have been numbered P1-P7, for which I have kept the logo specific for the Costișa-*Cetățuia* (Cos)[28].

All seven ceramic samples are coming from research conducted in 2001 (P4, P5, P6), 2003 (P7), 2007 (P1, P3) and 2008 (P2) originating in areas

[28] Pl. Archaeological records from Costișa-*Cetățuia* (P1-P7).

SI/2001 (P, 4, P5, P6), SIII/2003 (P7), SXIV/2007 (P1), S/XVII.I/2008 (P2) and *passim*/2007 (P3). These were associated with other different types of archaeological materials. The samples have been recovered from the same archaeological layer situated between 0.26 m (P1) and 0.40 m (P7)[29]. These data, together with architectural remains, attest the existence of an intense Bronze Age settlement. For the correct incorporation of the database, we chose to record data provided by the authors of the research: description of archaeological fragments, typological classification. To these data I added a specific set of naked-eye observations made during database creation. This step is necessary in attempting to identify possible ceramic groups in the study group[30]. In the later stage were tried some microscopic analyses, which gives multiple data on clay and temper as consequence of the chemical composition identification.

**Archaeological macroscopic observations**

Based on these criteria, the archaeological analysis led to the identification of two pottery groups: (A) coarse (P1, P4, P7) and (B) fine or semi-fine (P2, P3, P5, P6). For this step has been handled the observations on the vessel body colour, a very good indicator of the technology and used material[31]. For the group A the colour of the vessel body is much differentiated and is represented by red (2.5 YR 5/6) to very dark grey (5Y 3/1) and brown (7.5 YR 5/4). For group B the body colour is more uniform and is represented by brown (7.5 YR 5/2), light brown (7.5 YR 6/4), very pale brown (10YR 8/2) to grey (10YR 6/1). The differences observed in group A are due to the use of different sources of raw materials (clays, temper, fine calcium carbonate) or different temperatures during the combustion, the atmosphere. As it was found, the colour of pottery depends on the action of the iron oxides, hydroxides, trioxides in reducing

[29] These samples and the first preliminary data about the discovery context were provided for study by Dr. Anca Popescu, whom I warmly thank.
[30] This is quite difficult to achieve given that we had only seven shards. The situation will be improved and the degree of extrapolation of conclusions will gain consistency when the database will be expanded.
[31] RATHOSSI *et alii* 2004, 316.

or oxidizing conditions and the way they react with calcareous or non-calcareous clays. Since "firing at temperatures below 800°C does not produce any difference in the colour or the properties of the clay chemistry"[32] and the colour of fractures/cores is dark-grey, most of the shards (P3, P5, P6, P7) can be assigned to a reducing condition group. The P2 and P4 belong to a mixed category represented by an unoxidized core, oxidized exterior and oxidized interior. The only clear exception is the P1, which by its reddish colour belongs to an oxidising condition pottery.

Of the first group belong three bowls (P1, P4, P7) with a good amount of grog and gravel in the matrix. The second group is represented by two cups (P2, P3), two bowls (P4, P5) and an askos (P6). Based on these observations on the macrostructure to which were added some details of the surface treatment it may conclude that P4 and P6 belong to Monteoru culture and P1, P2, P3, P5, P7 belong to Costișa culture.

**Methodology of microscopic observations (Pl. 3/P1-P7)**

In a second phase of the microscopic observations, for a better visualization of non-plastic intrusion, was used a Zeiss Stemi 2000-C Stereo Microscope, which provide a magnification range from 1,95× to 250× and a field of view from 118 mm to 1.00 mm. Within the microscopic observations, in the last phase of the analysis was utilized a Celestron Deluxe Handheld Digital Microscope 44302 A (the microscope is equipped with a digital camera built-in 2MP for snapshot, images and videos and 10× to 40× and 150× magnification scale) which has helped in the identification of pottery technology and finding some petrographic features.

Sample preparation of fresh sections consisted of cutting slices of pottery fragments followed by three gradual grinding until a flat surface was obtained[33]. This stage was followed by dirt cleaning and washing these surfaces, drying and then preparing them for microscopic analysis. Each ceramic sample was recorded and photographed with a Canon camera attached to the microscope.

[32] MANIATIS 2009, 7-10, Fig. 9.

[33] Pl. 3. (P1-P7).

**Preliminary observations concerning the microstructure**

The clay and mineralogical naked-eye study confirmed the presence of at least two types of fabric for all the samples analysed, independently of their surface treatment, typology or cultural assignment. As far as the matrix is concerned, they showed abundant long, narrow and elongated or rounded pores which were usually oriented parallel to the surfaces (P1, P6, P7). This could be an indication of direction in which potters applied forces with their fingers to form the walls of the vessels. While this could also suggest a poor homogenization of the wet paste before firing, on the other hand, the paste seemed to be well homogenized or poorly homogenized since the inclusions appeared well distributed in the matrix for the category of the fine matrix or in a very chaotic distribution when looking to the so called coarse matrix (P7 is the most striking example).

A clean and uniform reddish surface, even though some of them are greyish stained, was observed in the samples at Costișa-*Cetățuia*, which indicates the oxidation condition for P1 or reducing conditions for P3, P5, P6, P7[34] maintained during the firing process or a sandwich like aspect which indicates an unfinished thermic process.

Most of the samples show textural and chromatic differences between the body and the surface. For some samples this aspect demonstrates that, prior to firing, separate layers or engobe were applied to the vessels in order to produce different surface structures, to protect the body or to improve the decoration of the body (see the P3 sample).

The ceramic batch from Costișa-*Cetățuia* is well burned, with a good to fine clay matrix while the paste is more crumbly and brittle. Macroscopic and microscopic observation of cut-sections reveal some differences among the samples from Costișa-*Cetățuia* (see the colour variations of the core, from greyish (P3, P5, P6, P7) with the intermediary sandwich aspect (P2, P4) to reddish colours (P1).

The fresh-sections, however, revealed mainly two sorted fabric despite some differences in surface appearances. The first one consists of

[34] See *supra*, footnote 29.

mainly abundant large, angular and sub-angular (see P1, P4, P7). The second group is represented by few rounded and sub-rounded inclusions within a fine or coarse grained clay matrix (see P2, P3, P5, P6). These inclusions appeared to be uniformly distributed or, some of them, in a very ”chaotic” appearance in the clay matrix. The gradation of the inclusion are from few microns up to less than 1mm for the cups (P2, P3) and 2.5 mm within a bowl clay matrix (P4). Most of the grog inclusions are uniformly distributed in the clay- matrix.

**The manufacture**

The variety and the uniqueness of raw material sources as well as different technological approaches influenced the look and quality of the paste. Usually, local sources of clay were worked, a visible feature, made obvious by the natural inclusions which are the marker of clay deposit. However, the qualities of clay sources (plasticity, malleability) were tempered in accordance with the needs of manufacturing process. It requires a varied technological knowledge, such as identifying the source, extracting the suitable clay, primary processing, the transport, preparing for manufacturing, burning, drying. In this craft the natural transmission or cultural transfer of knowledge was equally important.

**Sources of clay**

Along the middle basin of the Bistrița River are typical recent Quaternary deposits consisting of stratifications of sands, silt and clays. This observation is the main indicator for recognizing local source of manufactured clay from the two sites. The exception consists of sample P6 from Costișa-*Cetățuia*, which through elemental analysis and through comparing the elemental module show a different type of material. However, even though I noted common aspects of studied pottery, can be observed differences between the pastes used to make pottery from the same site. Almost certainly, these manufacturing differences can be understood as a result of transformation or adoption/adaptation of new technological and cultural behaviours.

## Non-plastic inclusions

Adding plastic and non-plastic inclusions will change the original qualities of clay. In this respect, it was noted that the types of inclusions and their size are used differently. With some exceptions, for the shards under study, inclusions are present depending on vessel characteristics: the shape and thickness of the vessel walls. Temper was originally processed and its size enhanced the quality of pottery. Thus, well crushed temper increased the homogeneity of the paste and hardness of the vessel walls while coarse-looking temper (angular or sub-angular, poorly sorted) decreased the homogeneity but increased the porosity and the breaking degree. Moreover, different types of inclusions with large dimensions prevent the formation and dissemination of cracks[35], the array in the clay matrix which increases the hardness of the vessel; the same type of inclusion accelerates the drying vessel before firing[36]. The noticeable non-plastic inclusions are grog/crushed fired-pottery fragments, pellets of clay and quartz, and calcium carbonate. Distinguishing between these elements is very difficult[37]. Size inclusions show, at least for the group analysed, their deliberate choice. For example, the inclusions for the cups matrix are well rounded and sub-rounded of less than 1 mm. At the same time the size of the inclusions up to 2.5 mm are present in fragments originating from the bowls (P1, P4, P7).

## Crushed shards

Crushed shards were the most commonly temper in the analysed samples. The restricted use of grog only for specific ceramic vessels (P1, P4-P7) show particular technical and cultural behaviour that involve observation, selection and the use of the raw material.

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[35] The weathering, sintering, splitting of raw materials, the occurring of different types of cracks and the way they react in the matrix, according to application of SEM investigation, see Emami *et alii* 2011, 299.

[36] GARCIA-HERAS *et alii* 2008, 10.

[37] KREITER *et alii* 2007, 38.

**Methodology of structural analysis**

The involvement of multidisciplinary analysis in investigating the prehistoric archaeofacts begins to have consistency and provide new ways of interpretation. Considered until recently as the privilege of a small body of specialists such analyses are becoming a common good and a field of dialogue and interference. In these circumstances, the "archaeological monologue" built on standardized production or reproduction of the artefactual typologies needs to be reconsidered.

In this case study I started from enhancing the possibilities of approaching the archaeological monuments by using and merging non-destructive methods of investigation. These facts, in connection with the expertise and the personal observations on the ground, have suggested another "story" of the investigated place.

Reconstitution of the sites and artefacts history is, in recent years, a lifelong perspective challenge to which various fields are committed to provide an answer. Thus, the effort is concentrated on the reconstruction of 'histories' and not just on the mere enumeration of physical characteristics. The situation was encouraged by recent developments in the physical and chemical invasive or non-invasive analysis or by the gradual remodelling of PC technology.

The naked-eye observations and structural analysis (macroscopic evaluation, electron microscopy, SEM-EDX performed in specialized laboratories in Iași allowed the identification of some ceramic groups, the compositional differences, the ratio of elements, a situation which could be explained in the context of pottery technology and within the context of the Bronze Age contacts between the communities. These first considerations will be completed by petrographic analysis that will allow integrating data on the technology of pottery, identifying sources of raw materials and their circulation or the circulation of finished products.

**Chemical evaluation**

To confirm the macroscopic results I chose, according to local resources, to use a second method of investigation. Thus, scanning electron microscopy (SEM) in combination with energy dispersive X-ray spectrometry (EDX)[38] was further performed for microstructural and microchemical characterization (**Table 1-2**).

Personally, in line with the objectives of this case study I tried to profit of the researcher expertise from Iași who had experience in using SEM-EDX/EDS[39]. This is a technique with historical success for pottery examination and it was routinely employed for other samples in the same centre.

For compositional analysis was used a scanning electron microscope, SEM VEGA II LSH model, manufactured by the Czech company TESCAN coupled with an EDX detector type QUANTAX QX2, manufactured by BRUKER/ROENTEC Germany. The microscope, controlled entirely via a PC, has an electron gun filament of tungsten, which can achieve a resolution of 3nM to 30kV, with magnification of 30× and 1,000,000× operating mode "resolution" acceleration voltage from 200 V to 30 kV, scanning speed between 200 ns and 10 ms per pixel. Pressure is less than 1×10-2 Pa. The resulting image can be formed by secondary electrons (SE) and backscatter electron (BSE). Quantax QX2 is an EDX detector handled for qualitative and quantitative micro-analysis. EDX detector is a third generation, of X-flash type, which does not require liquid nitrogen cooling and is about 10 times faster than conventional detectors Si (Li).

Technique, along with the visualization of the microphotographs (Pl. 4), allows image exposure with the mapping/layout of the investigated surface atoms. Based on X-ray spectrum will be determined the elemental composition (in percent gravimeter or molar ratios) of a microstructure or of a selected zone as soon as the evaluation of the composition variation along a vector disposed in an area or a section subjected to analysis.

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[38] Some results of SEM-EDS analyses have been published without realizing, however a connection of all categories of results. In the same context I noted that the Nuclear Magnetic Resonance Spectroscopy investigations confirmed some of the archaeological observations. VASILESCU *et alii* 2012.

[39] All the SEM-EDX/EDS analysis has been carried out by dr. Viorica Vasilache and Professor Ion Sandu from Alexandru Ioan Cuza University of Iași, ARHEOINVEST Interdisciplinary Platform.

Structural analysis (SEM-EDX) has enabled the identification of compositional differences, the ratio of elements (Table 3-4), which could be explained in the context of pottery fabric technology as soon as within the contacts between communities during the Bronze Age. In this respect, I worked according to the following objectives: grouping the shards in relation to the weight of the chemical elements; watching for the elemental concentration; identifying the Caustic module (Si/Al), Alkaline-Earth module (Ca/Mg) and the Alkaline module (K/Na).

All pottery categories presented the following chemical elements: Si, Al, Fe, Ca, Mg, K, Na, P, Ti, and O (Table 1-2) In addition, there are small amounts of C in samples from Costișa-*Cetățuia*: (see the results for P1 engobe and structure, P3 engobe and P6 engobe. Mn has been positively tested in the engobe structure of the P1 sample[40].

For a finer interpretation of the test results, the elemental ratios of Si/Al (Caustic module) and Ca/Mg (Alkaline-Earth module), and the ratio K/Na (Alkaline module) were calculated (Table 3-4). These data are very important for finding the average value of the gravimetric concentration.

Thus, for the analysed samples from Costișa-*Cetățuia*, it was found that the Si/Al module calculated on the engobe is contained between 1.6 and 3.5, and for the structure analysis it is between 2.1 and 3.0.

When comparing the P3 engobe with the P3 structure samples from Costișa-*Cetățuia* it was noted that the engobe Caustic module (Si/Al) is lower than on the structure while the engobe Alkaline-Earth module (Ca/Mg) is higher. Changing of the Caustic module in favour of the Alkaline-Earth module shows that the artefact was buried for a long period in aggressive soil. When the Ca/Mg module is between 0.5 and 2.5,

[40] Two ceramic fragments belonging to Costișa culture and one belonging to Monteoru culture from the Eastern Carpathians area were analyzed in the Iași laboratory. Elemental analysis results show totally different by comparing with those obtained for the shards from Costișa-*Cetățuia*. This observation might suggest the use of different raw materials, different technology or just another cultural behavior. Unfortunately, the authors of the investigation have not referred to the place of provenance of the three pottery fragments to be able to carry out a comparative overview. SANDU *et alii* 2010, Table 1 and Table 3

it means that they are residual elements of combustion, and when the ratio is greater than 3 they are from contamination.

Whether the Ti and Fe are present in large quantities at the exterior surface of the pots is due to the exterior slip or of pigments. The presence of Mn on the outside surface of the samples P1 is due to the "painting" material structure.

The Carbon present in the engobe and the structure of the sample P1 from Costișa-*Cetățuia*, only in low concentrations, shows that the artefact was burned at temperatures around 850⁰C. The samples which do not contain C in the paste show that "the flue gases carrying the hydrocarbons that decomposed on the outer surface did not penetrate into the interior of the vessel"[41]. Obtaining this constant level of temperature for firing pottery shows good technical knowledge[42] visible from most of the samples subjected to the tests. The presence of the C on the outside of the pottery sample (P1, P3, P6) probably means that it is due to the contamination of the site.

Analysing these elemental compositions (Table 1-2) and the three module (Table 3-4) on the Costișa-*Cetățuia* samples, one may easily observe that the sample P6 shows more extreme values, suggesting the hypothesis that this object was made of different materials than the other six. Following the elemental composition of the samples from the interior side of the Costișa-*Cetățuia* samples, I am inclined to say that the artefact corresponding to the sample P6 is made of a different material than the other[43]. The assessment is supported by the overall appearance of the sample, the macroscopic observations and the cultural framing.

This thesis is further supported by the larger amount of P in the P6 vessel structure, compared to the other six samples coming from Costișa. This can be explained by the burning of pottery between 600⁰C and 800⁰C, as well as by maintaining a porosity of the structure that allowed organic

[41] Froh 2004, 171-172.

[42] ORTON *et alii* 1994, 68–69; GOFFER 2007, 237, 242–243 and Table 58; IORDANIDIS *et alii* 2009, 294–296 and fig. 3.

[43] The assesment is sustained by the analysis of the factor score saved using the regressive method. See, Plates 5-6.

liquids that contain P or phosphates to penetrate the fabric[44]. The burning of pottery at temperatures above 800⁰C would result in a decrease of the P concentration. The low concentration of P from outside the vessel was explained by their direct exposure to heat sources and repeated heating during use. Also, the P is up to six times higher in the basis of the vessel in respect to the rim of it[45]. No less important is the speculation that vessels which have a high content of P at the interior side could belong to the cooking vessel category (boiling wheat or beans!!!). According to archaeological typology the sample should come from a Monteoru askos-like vessel, which would suggest that the vessel was worked out for cooking certain products during some ceremonies. In the same context of analysis, could be interpreted the occurrence of P in the P3 Costișa-*Cetățuia*. The analysis of P3 samples from Costișa points out the existence of a large amount of P on the outside/engobe, which proves that the vessel was burned between 600⁰C and 800⁰C and also its contamination[46]. In such circumstances the sample could belong to a boiling/cooking pot or vessels with special purpose. To all these data the archaeological observation must be added: the latter reveals that the vessel in question belongs to the category of two handled cups from the Costișa ceramic group area.

Also, the sample P3 (Pl. 5-6) shows values much different than the average of other samples. The exterior side of the sample P3 should be subject to attention since the values content of the elements on the outside differs widely, which means that was contaminated from the soil, especially with P and Ca. Moreover, the presence of C, just on the exterior of the sample, show that here has been formed calcium carbonate due to moister environment in which it lay[47].

[44] CACKETTE *et alii* 1987, 122.
[45] Phosphorus is considered to be the most common element affected by different types of contamination The normal value of $P_2O_5$ concentration in the clay is between 0.1 and 0.5 wt. %. There were discovered at least five different conditions in which the Phosphorus may have high values. See, PFREUDIGER-BONZON 2005, 39.
[46] GARCIA-HERAS *et alii* 2008, 9.
[47] It still remains to explain the extreme position of the P7. See Pl. 6.

**Closing remarks**

This contribution was a challenge which I attempted to meet by combining the archaeological investigation methods with scientific analysis methods. As was stated above, even if these methods were applied to a small body of samples, the setting of a proper research design adequate to coherent questions can lead to consistent results. This attempt is an improved model that could provide answers to questions on technology, raw material origin, transmission of knowledge, relations between communities.

The pottery technology from Costișa-*Cetățuia* was quite uniform. The similarities of the pottery and the technological choices may suggest a ”common market” and the perpetuation of the household technology. The few differences may suggest an intra-site tradition[48] where the variations result from are given by the different treatment of two ceramic groups, coarse and fine, by the use of the temper, by certain accidents occurring during firing[49], or by the artefact history after leaving the site. Among the seven fragments stands out the P6 sample. This, by all its features is an intruder in the pottery from Costișa-*Cetățuia*. Within the same context I have noticed the association between P4 and P6 or the location to the extremities of the chemical identification data. Note that the two fragments were assigned to the Monteoru culture.

As I already said in another context[50], my impression is that, with very few exceptions, there are no major technological differences between the two ceramic groups (A and B). Proximity, contamination, cohabitation, all led to the transfer of knowledge and technology, as demonstrated through structural analysis[51].

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[48] KREITER *et alii* 2009, 114.

[49] For some indicators concerning the connections between clays and the thermal transformation, see at GARCIA-HERAS *et alii* 2008, 8. Analysing the magnification of the fresh fractures one can say that, at least for the analyzed seven shards, there`s no signs of vitrification. So, maybe, the clay crystals have not been completely destroyed. According to these observation the clays used for making pots at Costişa-*Cetățuia* belong to the illite category.

[50] BOLOHAN 2013.

[51] BOLOHAN 2013.

At the time being, we still have to answer some questions about the usefulness of this type of investigation where we have 'a bicycle made for two'[52]. The success, the degree of generalization and application of these investigations depend on openness and availability of both archaeologists and scientists, without building parallel discourses. My recent experiences have shown that, on a local scale, we have a long way to integrate the scientific investigation techniques in the archaeological interpretation. Certainly, the success of this approach should centre on the principle of ***do ut des***.

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[52] POLLARD, BRAY 2007.

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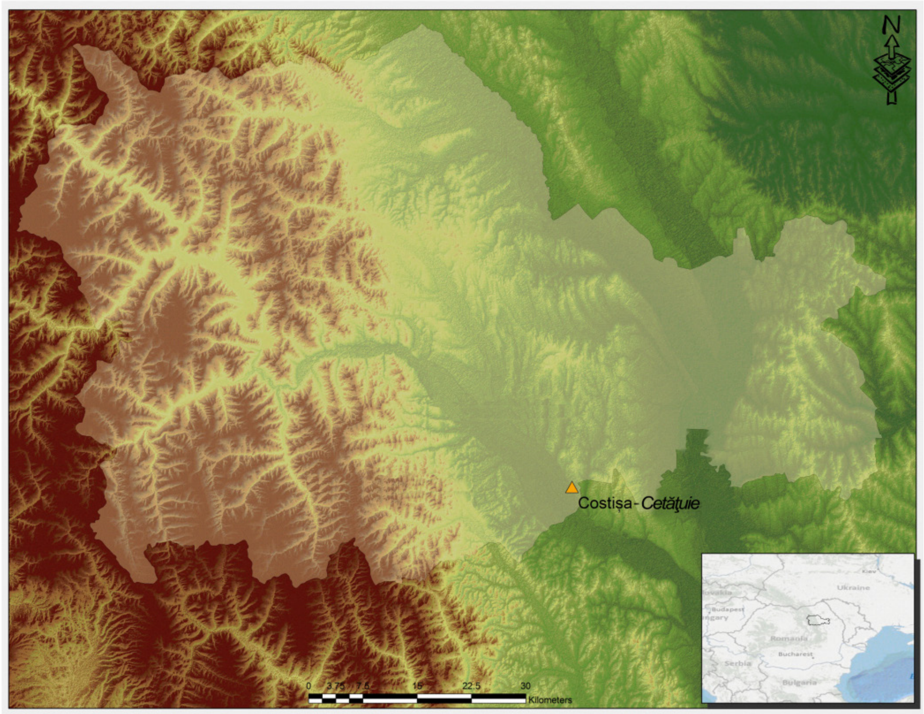
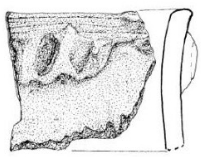
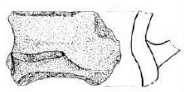
Archeometriai Műhely
Hyperfine Interactions
IJCS
Material Characterization



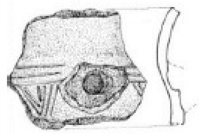

Cracău-Bistrița depression and the placement of the Costișa-*Cetățuie* site

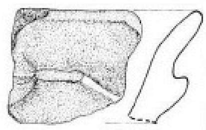
| COS-P1 | | | |
|---|---|---|---|
| Original Sherd (front and back sides) | | Drawing | Original Sherd (thin section) |
|  |  |  |  |

| | |
|---|---|
| Stratigraphy and spatial patterning | Plateau B, S XIV, squares 2-3/b-c, -0,18-0,26 m, Costișa ground layer (the area with broken pottery) |
| Surface treatment, firing conditions | Coarse, Oxidation |
| Ingredients | Grog, Gravels |
| Exterior color | 2.5 YR 5/6 |
| Wall thickness | 7,26 mm |
| Diameter of rim | 20 cm |
| Vessel type and ceramic group | Bowl, Costișa Group |

| COS-P2 | | | |
|---|---|---|---|
| Original Sherd (front and back sides) | | Drawing | Original Sherd (thin section) |
|  |  |  |  |

| | |
|---|---|
| Stratigraphy and spatial patterning | Plateau B, S XVIII, square 6a, -0,25 m, second layer of stones |
| Surface treatment, firing conditions | Fine, Reduction |
| Ingredients | Carbonates |
| Exterior color | 7.5 YR 6/4 |
| Wall thickness | 5,52 mm |
| Diameter of rim | – |
| Vessel type and ceramic group | Cup, Costișa Group |

| COS`07-P3 | | | |
|---|---|---|---|
| Original Sherd (front and back sides) | | Drawing | Original Sherd (thin section) |
|  |  |  |  |
| Stratigraphy and spatial patterning | | No. 427 Costişa 2007 | |
| Surface treatment, firing conditions | | Fine, Reduction | |
| Ingredients | | – | |
| Exterior color | | 10 YR 8/2 | |
| Wall thickness | | 6,97 mm | |
| Diameter of rim | | – | |
| Vessel type and ceramic group | | Cup, Costişa Group | |

| COS-P4 | | | |
|---|---|---|---|
| Original Sherd (front and back sides) | | Drawing | Original Sherd (thin section) |
|  |  |  |  |
| Stratigraphy and spatial patterning | | Plateau A, S I, squares 3-4, -0,30 m | |
| Surface treatment, firing conditions | | Coarse, Reduction | |
| Ingredients | | Grog, Gravels, Quartz | |
| Exterior color | | 5 Y 3/1 | |
| Wall thickness | | 11,47 mm | |
| Diameter of rim | | 30 cm | |
| Vessel type and ceramic group | | Bowl, Monteoru Group | |

<table>
<tr><th colspan="4">COS-P5</th></tr>
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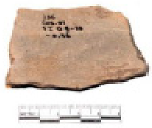
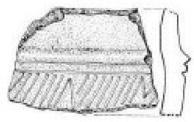
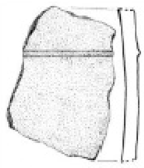
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Stratigraphy and spatial patterning</td><td colspan="2">Plateau A, S I, squares 9-10, -0,36 m, Costişa ground layer</td></tr>
<tr><td colspan="2">Surface treatment, firing conditions</td><td colspan="2">Fine, Reduction</td></tr>
<tr><td colspan="2">Ingredients</td><td colspan="2">Grog, Quartz</td></tr>
<tr><td colspan="2">Exterior color</td><td colspan="2">10 YR 6/1</td></tr>
<tr><td colspan="2">Wall thickness</td><td colspan="2">10,00 mm</td></tr>
<tr><td colspan="2">Diameter of rim</td><td colspan="2">–</td></tr>
<tr><td colspan="2">Vessel type and ceramic group</td><td colspan="2">Everted Bowl, Costişa Group</td></tr>
</table>

<table>
<tr><th colspan="4">COS-P6</th></tr>
<tr><td colspan="2">Original Sherd<br>(front and back sides)</td><td>Drawing</td><td>Original Sherd<br>(thin section)</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Stratigraphy and spatial patterning</td><td colspan="2">Plateau A, S I, squares 7-8, -0,32 m</td></tr>
<tr><td colspan="2">Surface treatment, firing conditions</td><td colspan="2">Semi fine, Reduction</td></tr>
<tr><td colspan="2">Ingredients</td><td colspan="2">Grog, Limestone</td></tr>
<tr><td colspan="2">Exterior color</td><td colspan="2">7.5 YR 5/2</td></tr>
<tr><td colspan="2">Wall thickness</td><td colspan="2">6,98 mm</td></tr>
<tr><td colspan="2">Diameter of rim</td><td colspan="2">–</td></tr>
<tr><td colspan="2">Vessel type and ceramic group</td><td colspan="2">Askos (?), Monteoru Group</td></tr>
</table>

<table>
<tr><th colspan="4">COS-P7</th></tr>
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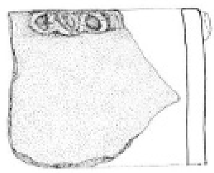
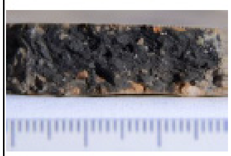
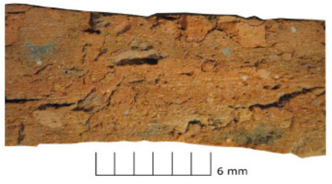
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Stratigraphy and spatial patterning</td><td colspan="2">Plateau A, S III, square 5b, -0,40 m, under the stones</td></tr>
<tr><td colspan="2">Surface treatment, firing conditions</td><td colspan="2">Coarse, Reduction</td></tr>
<tr><td colspan="2">Ingredients</td><td colspan="2">Grog, Gravels</td></tr>
<tr><td colspan="2">Exterior color</td><td colspan="2">7.5 YR 5/4</td></tr>
<tr><td colspan="2">Wall thickness</td><td colspan="2">10,22 mm</td></tr>
<tr><td colspan="2">Diameter of rim</td><td colspan="2">43 cm</td></tr>
<tr><td colspan="2">Vessel type and ceramic group</td><td colspan="2">Everted bowl, Costișa Group</td></tr>
</table>

Plate 2. Costișa-*Cetățuia*. The archaeological database (P1-P7)

| COS – P1 |
| --- |
| Original Sherd (thin section) |
|  |
| Fabric: |

| | |
| --- | --- |
| Dominant grain types: | Grog |
| Relatively few grain types: | Gravels |
| Sporadically occurring grain types: | Calcite |
| Shapes of the dominant grains: | Sub-angular |
| Sizes of the dominant grain: | 1mm ≤ 2,5 mm |
| Total quantity of grains: | 30% |
| Matrix/pores: | Coarse |
| Sorting: | Moderate |
| Remarks: | Reduction and no added surface; Costişa Group |

| COS – P2 |
| --- |
| Original Sherd (thin section) |
|  |
| Fabric: |

| | |
| --- | --- |
| Dominant grain types: | Carbonates (?) |
| Relatively few grain types: | – |
| Sporadically occurring grain types: | – |
| Shapes of the dominant grains: | Well rounded |
| Sizes of the dominant grain: | >1 mm |
| Total quantity of grains: | 15-20% |
| Matrix/pores: | Fine |
| Sorting: | Good |
| Remarks: | Reduction, greyish core and reddish surfaces; Costişa Group |

| COS – P3 |
|---|
| Original Sherd (thin section) |
|   |
| Fabric: |

| | |
|---|---|
| Dominant grain types: | Carbonates |
| Relatively few grain types: | Gravels |
| Sporadically occurring grain types: | – |
| Shapes of the dominant grains: | Sub-rounded |
| Sizes of the dominant grain: | >1mm |
| Total quantity of grains: | 15 % |
| Matrix/pores: | Fine |
| Sorting: | Good |
| Remarks: | Reduction, greyish core and yellow-reddish surfaces; Costișa Group |

| COS – P4 |
|---|
| Original Sherd (thin section) |
|   |
| Fabric: |

| | |
|---|---|
| Dominant grain types: | Grog |
| Relatively few grain types: | Gravels |
| Sporadically occurring grain types: | Carbonates, Quartz/Feldspar (?) |
| Shapes of the dominant grains: | Sub-angular |
| Sizes of the dominant grain: | 2,5 mm |
| Total quantity of grains: | 35-40 % |
| Matrix/pores: | Coarse, porosity |
| Sorting: | Bad |
| Remarks: | Reduction, thin greyish core, yellow-reddish surfaces, poor fabric; Monteoru Group |

| COS – P5 |
|---|
| Original Sherd (thin section) |
|  |
| Fabric: |

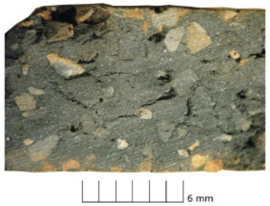


| | |
|---|---|
| Dominant grain types: | Grog |
| Relatively few grain types: | Quartz |
| Sporadically occurring grain types: | Carbonates |
| Shapes of the dominant grains: | Sub-rounded |
| Sizes of the dominant grain: | 1,5 mm |
| Total quantity of grains: | 15-20% |
| Matrix/pores: | Semi fine, porosity/cracking |
| Sorting: | Bad |
| Remarks: | Reduction, greyish core and thin yellowish surfaces; Monteoru Group |

| COS – P6 |
|---|
| Original Sherd (thin section) |
|  |
| Fabric: |



| | |
|---|---|
| Dominant grain types: | Grog |
| Relatively few grain types: | Calcite |
| Sporadically occurring grain types: | Feldspar |
| Shapes of the dominant grains: | Sub-rounded |
| Sizes of the dominant grain: | 1,5 mm |
| Total quantity of grains: | 40% |
| Matrix/pores: | Semi fine, Porosity/cracking |
| Sorting: | Moderate |
| Remarks: | Reduction, greyish color, no added surfaces; Monteoru Group |

| COS – P7 |
|---|
| Original Sherd (thin section) |
|  |
| Fabric: |

| | |
|---|---|
| Dominant grain types: | Grog |
| Relatively few grain types: | – |
| Sporadically occurring grain types: | Carbonates |
| Shapes of the dominant grains: | Sub-angular |
| Sizes of the dominant grain: | 2mm |
| Total quantity of grains: | 45-50% |
| Matrix/pores: | Coarse, porosity/cracking |
| Sorting: | Bad |
| Remarks: | Reduction, mosaic like fabric, greyish core; Costișa Group |

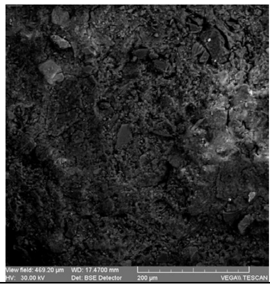
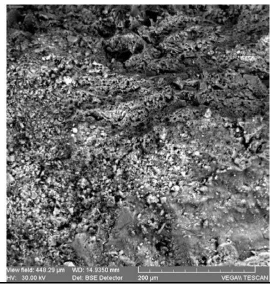
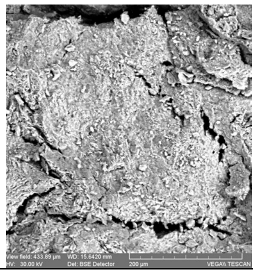
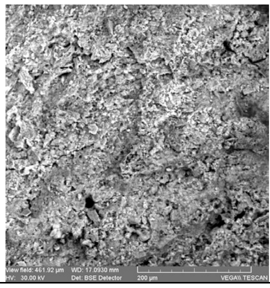
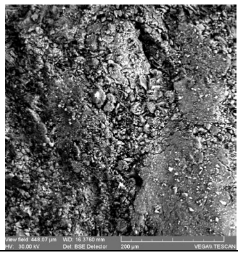
Plate 3. Costișa-C*etățuia*. The archaeological database. Fresh cut sections (P1-P7)

| Cos Samples | Si | Al | Fe | Ph | Ca | K | Ti | Mg | Na | C | Mn | O | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 engobe | 28.040 | 10.953 | 7.708 | 1.938 | 2.548 | 2.835 | 1.188 | 1.737 | 0.506 | 0.970 | 0.434 | 41.143 | 100 |
| P3 engobe | 17.456 | 10.615 | 5.532 | 5.493 | 5.939 | 1.713 | 0.890 | 1.214 | 0.456 | 1.229 | | 46.966 | 100 |
| P4 engobe | 36.592 | 10.320 | 6.047 | 0.541 | 1.255 | 2.861 | 0.662 | 1.143 | 0.874 | | | 39.705 | 100 |
| P5 engobe | 28.267 | 10.633 | 5.890 | 2.603 | 3.041 | 2.461 | 0.902 | 1.829 | 0.551 | | | 43.824 | 100 |
| P6 engobe | 27.701 | 10.223 | 5.252 | 3.417 | 1.743 | 2.865 | 0.925 | 0.986 | 0.998 | 1.594 | | 44.297 | 100 |
| P7 engobe | 29.182 | 10.963 | 5.202 | 3.325 | 2.515 | 2.259 | 0.959 | 1.027 | 0.794 | | | 43.774 | 100 |

Table 1. Costișa-*Cetăţuia*. Elemental composition for the engobe samples (SEM-EDS analysis)

| Cos Samples | Si | Al | Fe | Ph | Ca | K | Ti | Mg | Na | C | O | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 struct. | 29.619 | 10.752 | 5.275 | 2.037 | 1.932 | 3.154 | 0.778 | 1.532 | 0.782 | 1 562 | 42.577 | 100 |
| P1 struct. | 31.361 | 11.807 | 4.861 | 2.380 | 2.525 | 3.195 | 0.751 | 1.217 | 0.392 | | 41.509 | 100 |
| P1 struct. | 33.475 | 11.811 | 5.829 | 2.433 | 1.863 | 2.567 | 0.661 | 1.299 | 0.524 | | 39.539 | 100 |
| P1 struct. | 33.389 | 10.995 | 5.246 | 1.452 | 2.092 | 2.926 | 0.699 | 1.356 | 0.736 | | 41.108 | 100 |
| P1 struct. | 30.470 | 11.708 | 4.822 | 2.292 | 2.894 | 2.716 | 0.654 | 1.477 | 0.654 | | 42.313 | 100 |
| P1 struct. | 25.273 | 11.969 | 6.523 | 6.507 | 2.531 | 2.423 | 1.048 | 0.901 | 0.604 | | 42.221 | 100 |
| P1 struct. | 31.300 | 10.078 | 4.728 | 1.944 | 2.826 | 2.786 | 0.878 | 0.965 | 0.728 | | 43.768 | 100 |

Table 2. Costișa-*Cetățuia*. Elemental composition for the structure samples (SEM-EDS analysis)

| Cos samples | Engobe | Structure |
|---|---|---|
| P1 |  |  |
| P2 | |  |
| P3 |  |  |
| P4 |  |  |

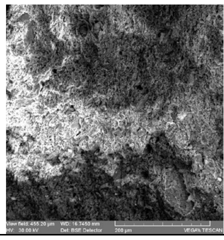
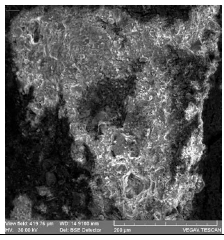
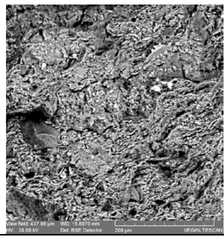
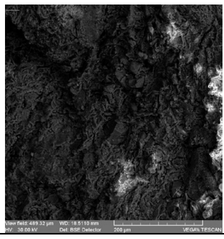
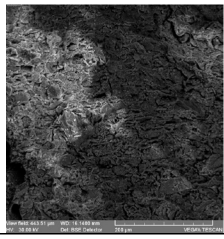
| | | |
|---|---|---|
| P5 |  |  |
| P6 |  |  |
| P7 |  |  |

Plate 4. Costișa-*Cetățuia*. BSE microphotographs for P1-P7 samples

| Module | Si/Al | Ca/Mg | K/Na |
|---|---|---|---|
| P1 engobe | 2.56 | 1.47 | 5.60 |
| P3 engobe | 1.65 | 4.90 | 3.76 |
| P4 engobe | 3.55 | 1.10 | 3.27 |
| P5 engobe | 2.66 | 1.66 | 4.47 |
| P6 engobe | 2.71 | 1.77 | 2.87 |
| P7 engobe | 2.66 | 2.45 | 2.84 |

Table 3. Costișa-*Cetățuia*, SEM-EDS analysis. Molar Ratio for engobe

| Module | Si/Al | Ca/Mg | K/Na |
|---|---|---|---|
| P1 structure | 2.75 | 1.26 | 4.03 |
| P2 structure | 2.67 | 2.07 | 8.15 |
| P3 structure | 2.83 | 1.43 | 4.90 |
| P4 structure | 3.07 | 1.54 | 3.97 |
| P5 structure | 2.60 | 1.96 | 4.15 |
| P6 structure | 2.11 | 2.81 | 4.01 |
| P7 structure | 3.10 | 2.93 | 3.83 |

Table 4. Costișa-*Cetățuia*, SEM-EDS analysis. Molar Ratio for structure

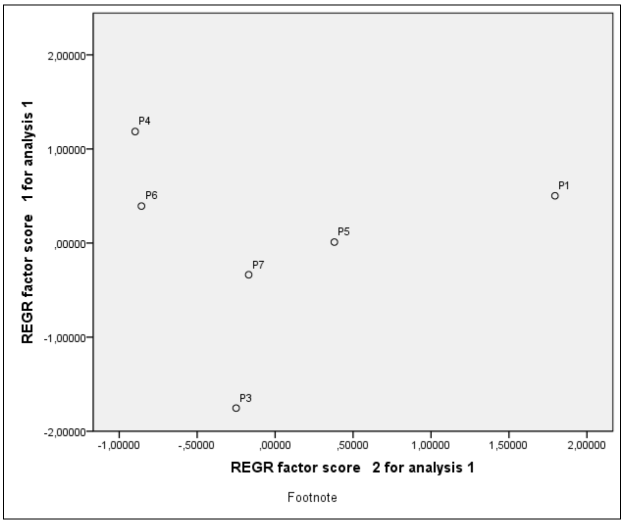



Plate 5. Plotting based on the chemical analysis of the Costișa-*Cetățuia* sample by SEM-EDX. The samples are marked according to the archaeological data base (engobe).

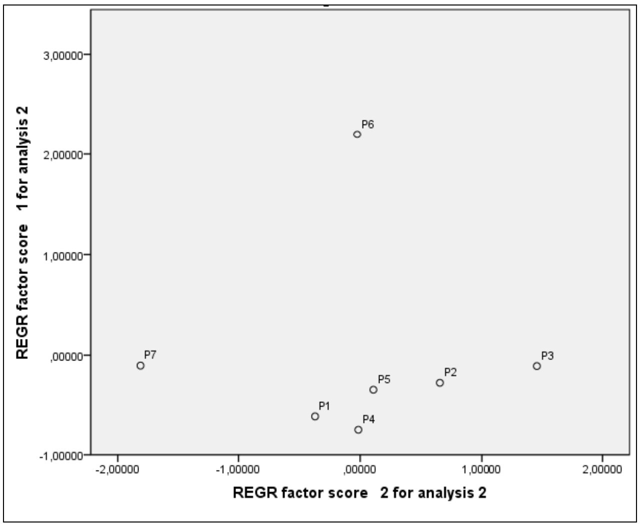



Plate 6. Plotting based on the chemical analysis of the Costișa-*Cetățuia* sample by SEM-EDX. The samples are marked according to the archaeological data base (structure).