SOME ARCHAEOMETRICAL DETERMINATIONS ON A LOT OF CUCUTENIAN CERAMIC MATERIALS OF SITE FETEŞTI-LA SCHIT (ADÂNCATA COMMUNE, SUCEAVA COUNTY)

Mihai Gramaticu[1], Dumitru D. Boghian[2], Niculae Băncescu[1], Traian Lucian Severin[1], Silviu-Gabriel Stroe[3], Sorin Ignătescu[2]
[1] Mechanical Engineering, Mechatronics and Management Faculty;
[2] Faculty of History and Geography; [3] Food Ingineering Faculty,
"Stefan cel Mare" University, Suceava

Rezumat: *În vederea analizării probelor de ceramică preistorică, autorii au folosit un analizor cu dispersie spectrală de raze X, tip EDX 900 HS (Energy Dispersive X-ray Fluorescence (EDX) spectrometry), de mare sensibilitate si rezoluţie, pentru a evidenţia compoziţia chimică a acestor artefacte. În lucrare sunt prezentate rezultatele acestei cercetări experimentale, efectuate pe un lot de probe ceramice provenite din situl arheologic Feteşti-La Schit, judeţul Suceava. În această lucrare, autorii prezintă măsurătorile efectuate asupra unor fragmente ceramice eneolitice (Cucuteni A şi B), folosind testul Vickers pentru determinarea microdurităţii diferitelor tipuri de ceramică arheologică, ca indicator fizic şi mecanic al acestor artefacte. Porozitatea, împreună cu alte caracteristici fizico-chimice şi mecanice, poate fi folosită în evaluarea calităţii artefactelor arheologice. Autorii propun un număr mare de tehnici pentru analiza acestei caracteristici şi prezintă rezultatele analizei imaginii digitale folosind software specializat.*

Abstract*: In order to analyze prehistoric pottery samples, the authors used a X ray dispersal spectral analyser, EDX type 900 HS (Energy Dispersive X-ray Fluorescence (EDX) spectrometry), of high sensitivity and resolution, to highlight the chemical composition of these artefacts. In the paper are presented the results of this experimental research, performed on the batch of ceramic samples from the archaeological site Feteşti-La Schit, Suceava County. In this paper, the authors present the measurements made on some Copper Age ceramics (Cucuteni A and Cucuteni B), using Vickers hardness test to determine the hardness of different types of archaeological ceramics, as physical and mechanical indicator of these artefacts. Porosity, along with other physicochemical and mechanical characteristics, is a feature that can be used in evaluating the quality of archaeological artefacts. The authors propose a number of high techniques for the analysis of this characteristic and present the results of the digital image analysis using specialized software.*

Résumé: *En vue de l'analyse des preuves de céramique préhistorique, les auteurs ont utilisé un analyseur avec dispersion spectrale avec des rayons X, type EDX 900 HS (Energy Dispersive X-ray Fluorescence (EDX) spectrometry), de grande sensibilité et résolution, pour mettre en évidence la composition chimique de ces artefacts. On a présenté dans l'ouvrage ci-joint les résultats de cette recherche expérimentale, effectuée sur un échantillon de preuves céramiques provenues du site archéologique Feteşti-La Schit, département de Suceava. Dans cet ouvrage, les auteurs présentent les mesurages effectuées sur des fragments céramiques énéolithiques (Cucuteni A et B), tout en utilisant le teste Vickers pour déterminer la micro dureté des différents types de céramique archéologique, comme indicateur physique et*

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mécanique de ces artefacts. La porosité, ensemble à des autres caractéristiques physico-chimiques et mécaniques, peut être utilisée dans l'évaluation de la qualité des artefacts archéologiques. Les auteurs proposent un grand nombre de techniques pour l'analyse de cette caractéristique et présentent les résultats de l'analyse de l'image digitale tout en utilisant un software spécialisé.

Keywords: *archaeological ceramic, porosity, mechanical property, prehistoric pottery, spectral analysis, chemical composition, hardness, spectroscopy.*

1. INTRODUCTION

The multilayered archaeological site at Feteşti-*La Schit* (figure 1) is known in the archaeological literature for the results of systematic research carried out between 2000-2006, through which important clarifications have been made concerning the vertical and horizontal stratigraphy of the area, the traits of the occupation levels, the characteristics of the constructed and inhabited spaces, the layout and functionality of the archaeological complexes, for all the stages of evolution from this site (Cucuteni A_3, Cucuteni B_{1b}, Cucuteni B_{2a}, Horodiştea-Erbiceni II, Early Getic Latène, Late Middle Ages)[1].

There are three distinct categories of cucutenian pottery (painted, usual and "Cucuteni C"), each with its technological, typological and functional features, very important for the understanding of prehistoric life features of this site.

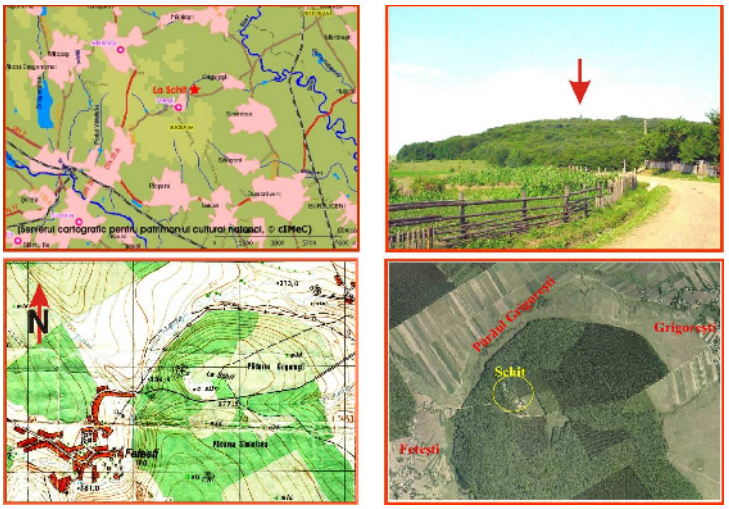


Fig. 1. The location of the Feteşti-*La Schit* settlement.

[1] D. Boghian, S. Ignătescu, I. Mareş, B. P. Niculică, *Les découvertes de Feteşti – La Schit parmi les stations cucuteniennes du nord de la Moldavie*, in *Cucuteni. 120 years of research. Time to sum up*, Piatra-Neamţ, 2005, p. 333-352; D. Boghian, S. Ignătescu, *Quelques considérations sur un vase Cucuteni B aux représentations anthropomorphes peintes, découvert à Feteşti – La Schit (Dép. de Suceava)*, in *Codrul Cosminului*, SN, 13 (23), 2007, p. 3-12.

Therefore, in this paper, we proposed to analyze the chemical composition (*X ray dispersal spectral analyser, EDX type 900 HS (Energy Dispersive X-ray Fluorescence (EDX) spectrometry*), hardness (*Vickers hardness*) and porosity (*system such as stereo-microscope OPTIKA that has a digital camera Q-IMAGING Go 3, connected to a PC*) of the nine ceramic fragments: six Cucuteni A phase - SV61, SV64, SV67, SV68, SV69, SV70, and three Cucuteni B phase - SV74, SV77, SV80 (table 1, figure 2), from the archaeological site of Fetesti-La Schit, representative for the Cucuteni culture (4500-3500 BC), in order to clarify elements of technology and functionality of Aeneolithic (Copper Age) pottery.

Table 1. Samples analyzed

No.	Code	Culture	No.	Code	Culture
1	SV61	Cucuteni A	7	SV74	Cucuteni B
2	SV65		8	SV77	
3	SV67		9	SV88	
4	SV68				
5	SV69				
6	SV70				

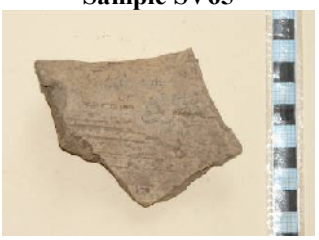
Fig. 2. Types of samples

Sample SV61

Sample SV65

Sample SV67

Sample SV68



Sample SV69

Sample SV70

Sample SV74

Sample SV77

Sample SV80

2. SPECTRAL ANALYSIS

Among the archaeological remains, pottery is the era of Copper Age largest category of artefacts[2]. For this reason it is a database of sufficient importance that can be studied from several perspectives.

One of the issues of concern related to ceramics is the chemical composition of the material from which they were modelled[3].

An advanced method to achieve quantitative and qualitative analysis of ceramics can be Roentgen radiation emission spectroscopy. Energy dispersive spectroscopy X-ray radiation (X rays) is an analysis technique used for analysis and chemical characterization of a sample in solid, powder or liquid[4].

Capability of the method is based on a fundamental principle which says that each chemical element has a unique atomic structure.

On the theory of X-rays production is done in high vacuum tubes containing a heat-emitting cathode and an anode metallic electrons on to download high-energy electrons gained by further accelerating voltage, the tens or hundreds Volts, applied between two electrodes.

So, to stimulate the emission of characteristic X radiation of a sample, a beam loaded with energy, such as electrons or protons, or a cannon X-rays, is directed towards the sample to be analyzed. Photons emitted by the sample are captured by a detector, a semiconductor silicon doped with lithium or SDD detector (silicon drift detector), cooled with liquid nitrogen or by modern Peltier effect. X photons produce a semiconductor ionization, free electron pairs in the electric field polarization effect causes current pulses whose size is proportional to the photon energy. If energy dispersive analysis, X photons of different wavelengths reach the detector, converting it each photon in a pulse of electric charge proportional to the photon energy[5].

All photons of the same radiation energy, radiation should be represented on the spectrum lines. However, for reasons of imprecision device, they appear as peaks

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[2] Mihai Gramaticu, Silviu-Gabriel Stroe, Dumitru Boghian, Sorin Ignătescu, *Spectral analysis on Copper Age ceramics of the site Feteşti-La Schit, Suceava county*, in *Annals of "Dunărea de Jos" University of Galaţi, Mathematics, Physics, Theoretical Mechanics*, Fascicle II, Year I (XXXII), 2009 (http://www.phys.ugal.ro/Annals_Fascicle_2/Year2009/summary%20Annals%20Fasc%202_2009%20CD_ROM.htm, accessed 15 November 2010).

[3] R. E. Mistier, *Tape Casting,* in *Ceramics and Glasses: Engineered Materials Handbook,* Vol. 4, S. J. Schneider Jr. (ed.), ASM International, Materials Park, Ohio, 1991, p. 161-165; I. Ruppel, *Extrusion*, in *Ceramics and Glasses: Engineered Materials Handbook,* Vol. 4, S. J. Schneider Jr. (ed.), ASM International, Materials Park, Ohio, 1991, p. 165–172.

[4] *Instruction Manual Shimadzu Energy Dispersion Fluorescence X-ray Spectrometer* (http://www.ssi.shimadzu.com/products/product.cfm?product=EDX; http://www.ssi.shimadzu.com/ products/literature/XRAY/edx_series.pdf, accessed 15 November 2010).

[5] Gh. Gutt, D. D. Palade, Sonia Gutt, F. Klein, K. G. Schmitt-Thomas, *Încercarea şi caracterizarea materialelor metalice [Testing and characterization of metallic materials]*, Bucureşti, Editura Tehnică, 2001, *passim*.

in the form of a bell (Gaussian profile). The spectrum of X-rays emitted from the sample surface is characteristic of the sample composition, the spectrum analysis and could determine the elemental composition, in the mass concentrations of elements[6].

Analysis of samples was carried out in the Instrumental Analysis Laboratory within the Food Engineering Faculty Suceava, complex investigation of the samples being made on a spectrometer *Shimadzu EDX-900HS* (figure 3).

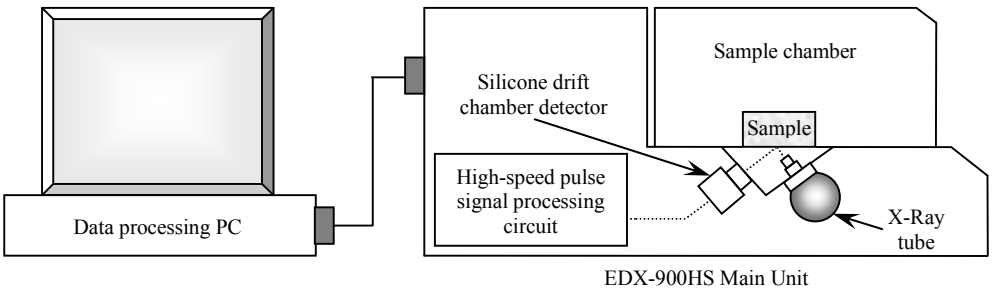

Figure 3. Configuration of EDX-900HS

With regard to equipment capabilities, spectrometer *Shimadzu EDX-900HS* is able to detect chemical elements from Na up to U.

The method allows a good separation of the mixture components and a precise identification of existing species.

The quantitative-qualitative analysis results have revealed a relatively uniform composition of chemical compounds with some variations from sample to sample (table 2).

Concentrations of the main metallic oxides are shown in figure 3. It can be seen that the oxides content is different for the studied samples due to the row materials involved and to the specific inorganic pigments used for the colours. Sample SV80 distinguish from the other seven having high Fe_2O_3, TiO_2, K_2O, P_2O_5 contents and a lower Al_2O_3 concentration. There is a possibility that this pieces might be from vessel with a different origin and to not be traditional to this archaeological site.

Table 2. Chemical composition of samples analyzed

Sample / Analyte	SV61 [%]	SV65 [%]	SV67 [%]	SV68 [%]	SV69 [%]	SV70 [%]	SV74 [%]	SV77 [%]	SV80 [%]
SiO_2	63.875	59.737	61.207	62.483	62.549	68.764	63.427	67.268	66.765
Al_2O_3	22.476	24.393	23.428	23.382	21.616	20.609	20.321	21.268	12.785
CaO	4.732	6.557	4.902	3.872	6.215	3.179	7.199	2.863	-
Fe_2O_3	4.801	5.140	5.064	5.008	4.953	4.015	4.738	4.654	7.102
K_2O	3.139	3.193	3.126	3.385	3.696	2.593	3.384	3.030	5.789
P_2O_5	-	-	1.354	0.914	-	-	-	-	6.254
TiO_2	0.582	0.548	0.572	0.593	0.618	0.554	0.638	0.594	0.745

[6] *Ibidem*.

BaO	0.161	0.130	0.139	0.172	0.150	0.152	0.088	0.143	0.141
MnO	0.123	0.186	0.099	0.090	0.084	0.062	0.074	0.062	0.282
Cr_2O_3	0.029	0.029	0.026	0.037	0.031	0.029	0.032	0.031	0.030
SrO	0.019	0.022	0.019	0.016	-	-	0.024	0.013	0.034
ZrO_2	0.019	0.016	0.017	0.016	0.021	0.014	0.021	0.024	-
SnO_2	-	0.018	0.018	-	0.018	-	0.020	0.018	0.023
Rb_2O	0.013	0.015	0.014	0.016	0.016	0.009	0.016	0.013	0.014
ZnO	0.011	0.008	0.012	0.012	0.010	0.007	0.012	0.015	-
Y_2O_3	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.004

3. HARDNESS DETERMINATION

The Vickers hardness test was developed in 1924 by Smith and Sandland. The test evaluates hardness in a manner similar to Brinell taking the ratio between the load applied and the surface area of the resulting impression[7]. Microindentation hardness is a measurement of the size of a microindentation made by a diamond pyramid-shaped indenter of specified size and shape pressed into a polished surface by a known load. The surface is normally not etched prior to the indentation. The Vickers indenter has four-fold symmetry but makes a deeper indentation and is more inclined to cause fractures in bridle materials than the Knoop indenter what has only two-fold symmetry and is commonly used on ceramics.

Although microhardness is a widely accepted term, the more accurate name is microindentation hardness. The emphasis on microstructure and microscopic indentation size is largely what distinguishes microindentation hardness from other hardness scales, such as Rockwell and Brinell. Microindentation hardness can he used to measure the hardness of individual grains, very small pieces, and thin layers[8].

Hardness is not a unique property but a measure of the reaction of the ceramic to the type of disturbing force imposed[9]. In addition to the indentation methods mentioned here, hardness has also been defined in terms of resistance to scratching (e.g. the Mohs scale), plowing, cutting, abrasion, erosion, damping, and rebound (e.g. Shore hardness). There is no definite numerical or even ordinal correspondence between one hardness scale and another.

Microhardness tester is indispensable equipment for metallographic research, product quality control and research and development of new materials. This measurement should be made on a small area without defects, which can provide results with high precision. Most micro hardness testers can perform either Knoop or Vickers hardness tests, only the indenter needs to be changed.

Principle of Vickers hardness test method is forcing an indenter into the sample surface followed by measuring actual surface area of the indentation. Hardness is not

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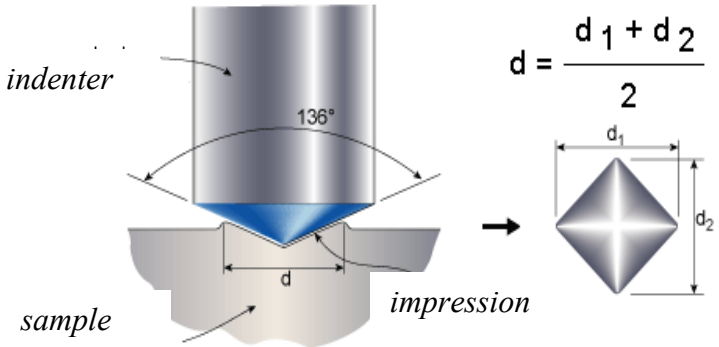
[7] R. L. Smith, G. E. Sandland, *An Accurate Method of Determining the Hardness of Metals, with Particular Reference to Those of a High Degree of Hardness,* in *Proceedings of the Institution of Mechanical Engineers*, London, 1922 (102), Vol. I (Jan.), p 623–641.

[8] Richard E. Chinn, *Ceramography. Preparation and analysis of ceramic microstructures*, ASM International, Materials Park, Ohio, 2002, p. 160-175.

[9] *Ibidem*, p. 160.

a fundamental property and its value depends on the combination of yield strength, tensile strength and the modulus of elasticity.



$$HV = \frac{1{,}8544 \cdot F}{d^2}$$

Fig. 4. Vickers hardness testing

The composition was made, as we saw, on a Shimadzu EDX-900HS spectrometer and for hardness determination was use a Shimadzu HMV micro hardness tester. This micro hardness tester can work with nine types of loads, belonging interval 98.07mN – 19.61 N. The automatic auto-load eliminates individual variations during loading, giving it a high precision[10].

The parameters set for to determine the hardness are action force F of indenter 980 mN and the loading time of 15s. For each sample were made 3 attempts at each hardness in areas that were not influenced by previous attempts.

In order to get good results from the hardness test of the surface preparation of analysis, samples were followed several stages according to the specifications ASTM C 1161[11]. Test results are presented in table 3[12]:

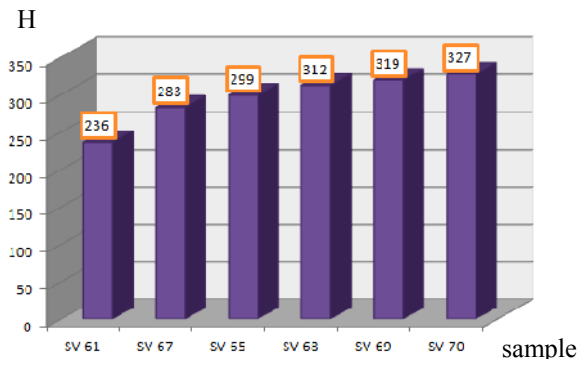
[10] M. A. Meyers, K. K. Chawla, *Mechanical Behaviour of Materials*, Cambridge, Cambridge University Pres, 2009, p. 214-228.

[11] ASTM C1161 Standards – *Standard Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature* (http://www.astm.org/Standards/C1161.htm, accessed 25 November 2010).

[12] Mihai Gramaticu, Traian Lucian Severin, Dumitru Boghian, Sorin Ignătescu, *Hardness determination of archaeological ceramics*, in *Annals of "Dunărea de Jos" University of Galați, Mathematics, Physics, Theoretical Mechanics,* Fascicle II, Year I (XXXII) 2009 (http://www.phys.ugal.ro/Annals_Fascicle_2/Year2009/summary%20Annals%20Fasc%202_2009%20CD_ROM.htm, accessed 15 November 2010).

Table 3. Hardness samples test

No.	Sample type	HV_1	HV_2	HV_3	HV
1	SV 61	230	246	234	**236**
2	SV 65	318	288	292	**299**
3	SV 67	291	286	273	**283**
4	SV 68	311	302	324	**312**
5	SV 69	325	339	293	**319**
6	SV 70	311	344	327	**327**
7	SV 77	318	337	359	**338**
8	SV 74	232	230	242	**244**
9	SV 80	213	205	195	**204**



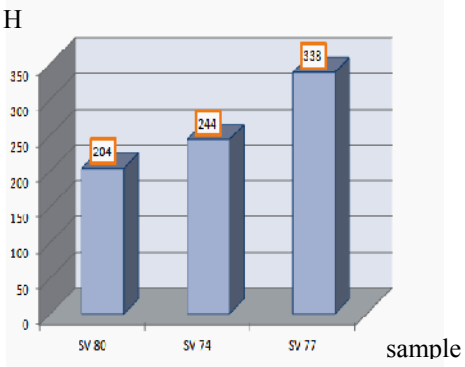


Fig. 5. Vickers hardness of Cucuteni A samples

Fig. 6. Vickers hardness of Cucuteni B samples

4. POROSITY DETERMINATION

Porosity, which can be considered as secondary "phase" indicates the degree of densification of a ceramic. As a rule of thumb, porosity less than approximately 8% (greater than 92% densified ceramic) means that the pores are discrete, while porosity greater than 8% indicates a continuous network of pores. Porosity measurements by some other methods, such as pycnometry or buoyancy, are sensitive only to open pores and exclude occluded (closed to the surface) pores. Thus, these other porosity methods do not necessarily agree closely with measurements by ceramographic techniques. Porosity decreases strength by two important mechanisms:

- Pores reduce the cross section area of a member.

- Pores act as stress-concentrating notches[13].

Although several methods are known for determining the porosity[14], for the study of archaeological ceramics porosity from Feteşti-La Schit, we made the analysis in the Materials Science Laboratory of Faculties of Mechanical Engineering, Mechatronics and Management of the „Ştefan cel Mare" University of Suceava, using an optical system such as stereo-microscope OPTIKA that has a digital camera Q-IMAGING Go 3, connected to a PC[15]. This system has a 254 pixels/inch resolution that allows jpg image capture with 4915200 pixels size. The total image magnification (stereo-microscope + camera) is 100. For accurate determinations those parameters have been kept to the same level during researches.

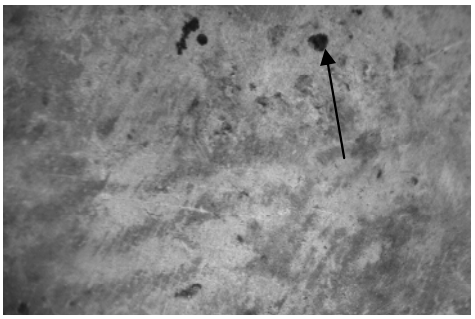


Fig. 7. Zone and/or interesting details identification

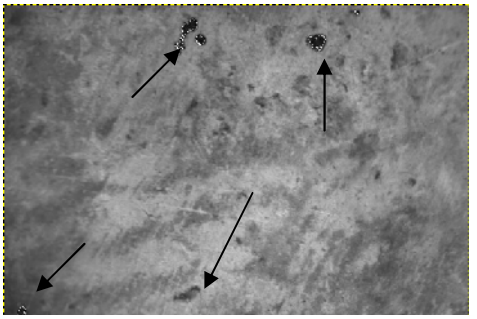


Fig. 8. Marking the elements of the same type on photography

Each ceramic sample has been photographed on both surfaces (exterior and interior of the ceramic recipient) and in transversal section in representative zones for the sample. The image analysis has been obtained using specialized software, graphic imaging editory program GIMP 2.6.6 (open) and a program for analysis, management and archive of metallographic structures with IQmaterials Media Cybernetics license.

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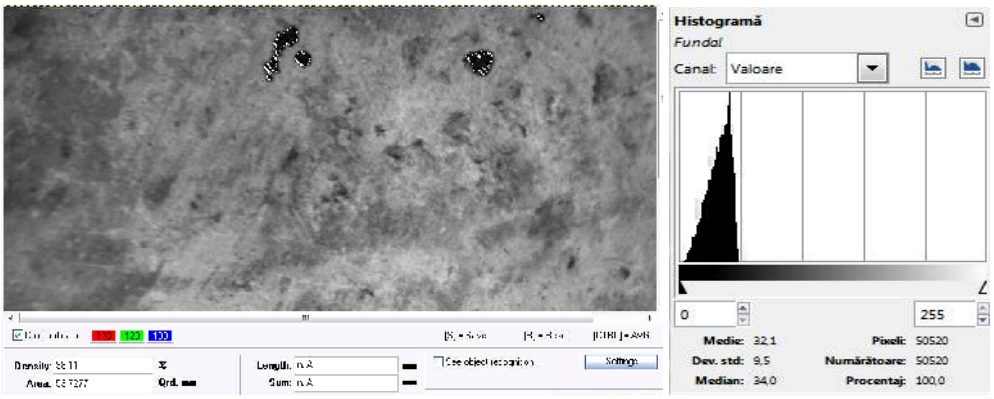
[13] Richard E. Chinn, *Ceramography…*, ASM International, 2002, p. 159.

[14] Lee E. William, W. Mark Rainforth, *Ceramic Microstructures*, University Press Cambridge, Great Britain, 1994, *passim*; Karen G. Harry, Allen Johnson, *A non-destructive technique for measuring ceramic porosity using liquid nitrogen*, in *Journal of Archaeological Science*, Vol. 31, No. 11, November 2004, p. 1567-1575; Gregory C. Rutletge, Joseph L. Lowery, Chia-Ling Pai, *Characterization by Mercury Porosimetry of Nonwoven Fiber Media With Deformation*, in *Journal of Engineered Fiber and Fabrics*, Massachusetts, USA, Vol. 4, No. 3, 2009, p. 1-13.

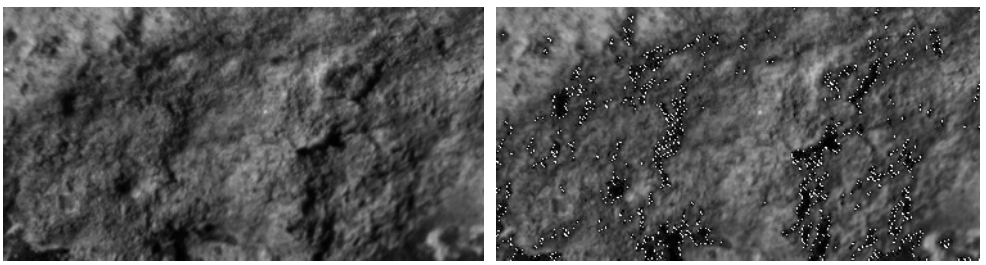
[15] Mihai Gramaticu, Niculae Băncescu, Dumitru Boghian, Sorin Ignătescu, *About some methods of determining the porosity and specific structural constituents in archaeological ceramics*, in *Annals of "Dunărea de Jos" University of Galaţi, Mathematics, Physics, Theoretical Mechanics*, Fascicle II, Year I (XXXII), 2009 (http://www.phys.ugal.ro/Annals_Fascicle_2/Year2009/summary%20Annals%20Fasc%202_2009%20CD_ROM.htm, accessed 15 November 2010).

The last program called GSA (Geometrical Surface Analyze) actually analyses geometrical structures.

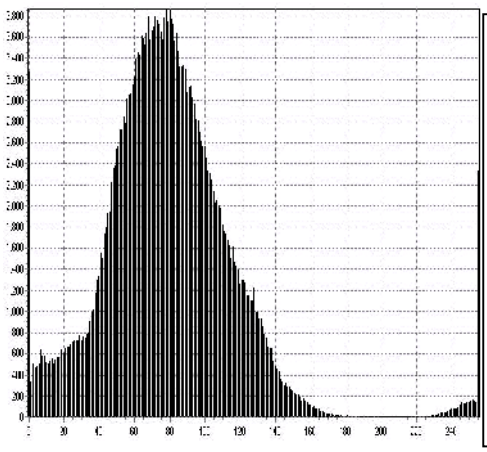


a **b**

Fig. 9. The analysis chart obtained by GSA program (a) and example of histogram obtained by GIMP program (b)



a **b**



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Resolution:	**254x254 ppi**
Color space:	**RGB color**
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File type:	**JPEG image**
Size in memory:	
Undo steps:	**None**
Redo steps:	**None**
Number of pixels:	**4915200**

c

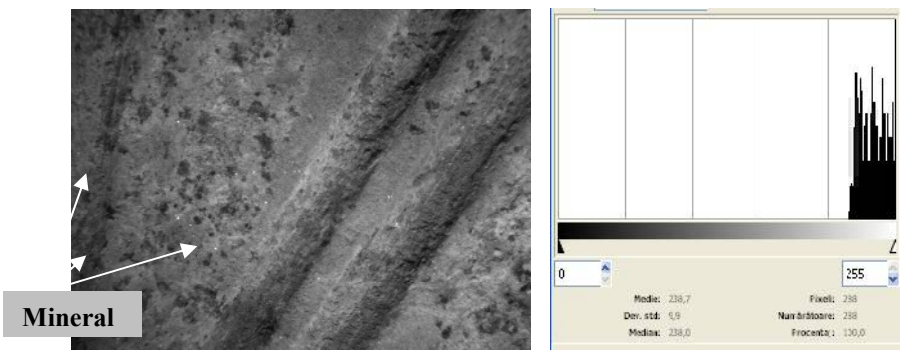
Fig. 10. Sample SV61. Section view. a – appearance in section as shown in stereomicroscope; b – highlighting porosity using graphical analysis program; c – highlighting porosity using graphical analysis program

GIMP program is used to simplify some GSA program manoeuvres and to make simple analysis. The photographic images obtained are optical analyzed during which are identified the interest zones.

As an example, in figure 7 has been chosen an area of interest containing a pore. In order to determinate the distribution of porosity surface and its size, and to statistically analyze the measurements, it requires marking this type of detail on sample photography. The easiest method in this case has been offered by GIMP program which helps in pointing out the elements of the same type by marking them on photography (figure 8). Next step regards analysis by established criteria (area, medium diameter, dispersion, etc.). For area calculation it have been applied the GSA program facilities. Due to this purpose the marked detail image is imported in GSA program which sets the analysis criteria. In figure 9 is presented the area analysis chart.

By analysis chart data can be calculated the numerical distribution values, it can be drawn the colour or distribution frequencies histogram, it can be determined the hefts, etc. For example, for percentage distribution calculation can be used the areas estimated in mm^2 or pixels, applying the same formula: $D = V_1*100/V$ where V_1 represents the value determined by analysis, and V is the total value, an image characteristic, constant and dependent of the set value for camera resolution. Same calculation can also be made for chart analysis obtained, values easily obtained by GIMP program, by mentioning that, in this case, calculations can only be made to pixel values. We analyzed same two groups of samples from the cucutenian site Feteşti – La Schit and they were called Cucuteni A and Cucuteni B, according to the chronological phase to which they belong. Each sample was analyzed on both surfaces and in section and for each sample was made one sheet. In the following we present one sheet for each group and the final synthesis. Porosity for sample SV61 from Cucuteni A group is presented in figure 10.

Using the porosity evaluation methods we can determine several structural constituents or foreign ingredients from ceramic composition. Examples are given in figures 11 for mineral inclusions, figure 12 for adhesions and figure 13 for deposits.



a **b**

Fig. 11. Sample SV61, exterior side the arrow marks a mineral inclusion, probably sand (a) and histogram distribution of mineral inclusions in the surface layer (b).

Calculation area occupied by inclusions, in pixels, for the area leads to:

$$S = 100 \cdot A_i/A_t = 288*100/4915200 = 0,0058\ \%$$

where: A_i – inclusions area; A_t – total area.

High density and compact ceramic, made perhaps using the wheel or rotating equipment. On the exterior side presents decoration in relief of the Cucuteni specific type. On the interior side it has a layer of carbon black colour like edge. Over this layer can be observed are clay like deposits.

Similarly it has been measured the samples porosity from group Cucuteni B, the given example being onto sample SV74 (figure 14-16).

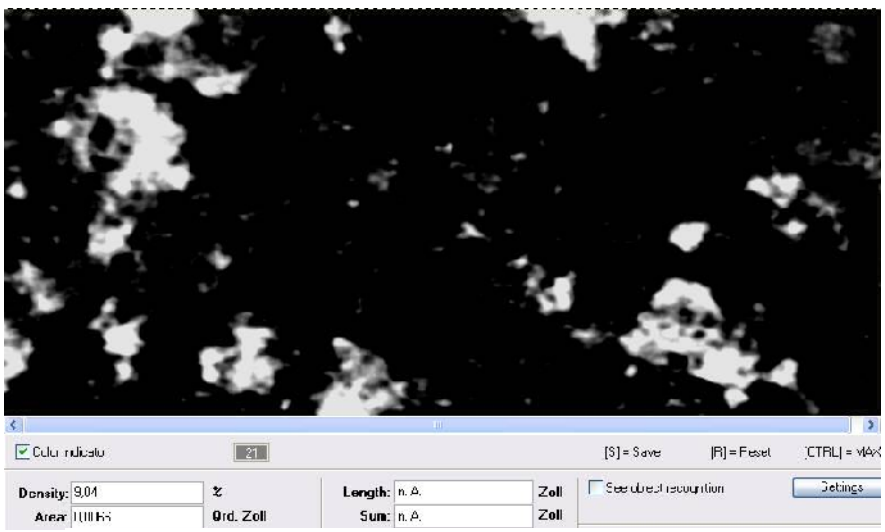


Fig.12. Calculation of the surface occupied by adhesions. After processing images with image analysis program resulted an area occupied by 0,001%

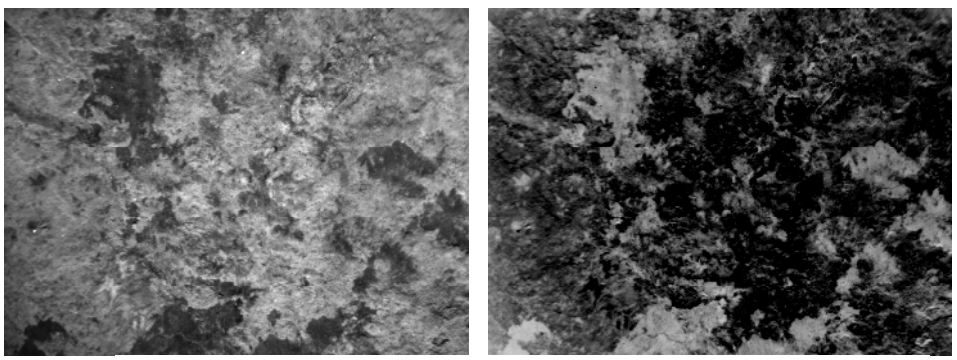


Fig. 13. Highlighting clay deposits by inversion of color in monochromatic light. Black is the deposition.

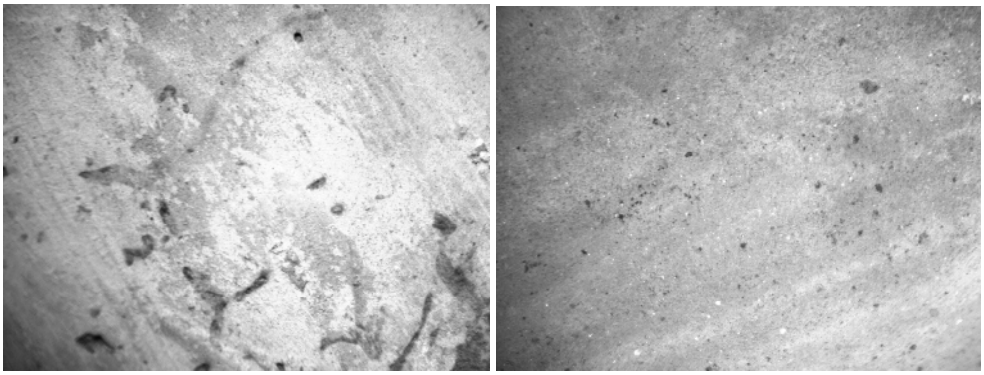


Fig. 14 The general appearance of the outer surface (a) and inside (b) of sample SV74. It is noted that the areas are well finished, clean, relatively small pore inserts minerals, probably sand. The inner surface of the dish was better finished than the outer surface. On the exterior sedimentary limestone deposits can be observed.

Fig.15. Identification of porosity on the outer surface of the sample 74 and determine their distribution using the program GIMP. P = 8, 126 % calculated in pixels at a resolution of 254 pixels an at an increase order 100.

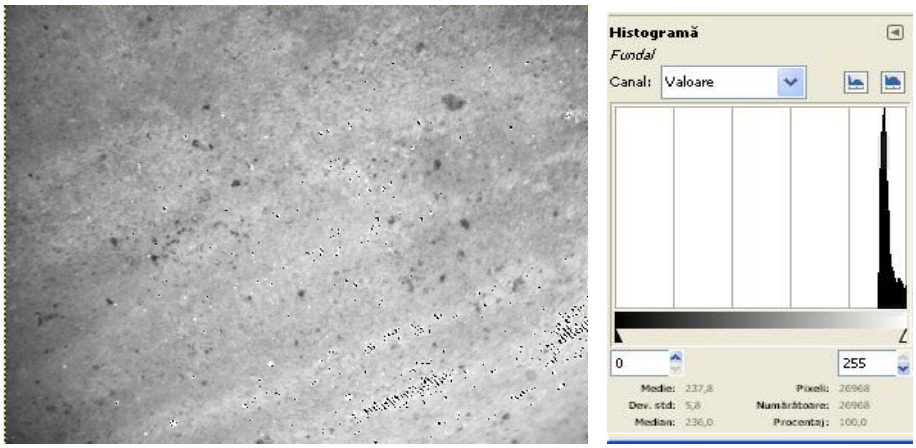


Fig.16. Marking the inner surface porosity of the sample and determine their distribution using the program GIMP. P = 0.5486% calculated in pixels at a resolution of 254 and an increase order of 100.

Porosity of samples analyzed is summarized in table 4.

Table 4. Porosity of samples analyzed

Group	Sample no.	Porosity [%]		
		Exterior surface	Interior surface	Section
Cucuteni A	SV61	0,00586	7,268	6,07
	SV65	0,31878	5,406	10,22
	SV67	1,126	6,00	2,889
	SV68	2,53	10,531	19,2
	SV69	0,76	7,5966	1,381
	SV70	0,91	3,749	4,05
Cucuteni B	SV74	8,126	0,00292	1,274
	SV77	11,438	4,705	2,426
	SV80	3,623	27,606	2,7689

5. CONCLUSIONS

Our approach is included in the archaeometric research that seeks to multilateral know archaeological ceramics, in this case the Cucuteni culture (Middle Aeneolithic/Copper Age), and complement other such concerns[16].

Spectral analysis of samples from the archaeological site from Feteşti-La Schit revealed differences in terms of proportion regarding oxide compounds. These differences may be explained by the choice of different sources of clay for modelling various types of ceramics (pottery incised, painted, usual, "type C")[17]. Another possible explanation that should be further investigated is that the vessels from which the samples analyzed were not implemented all the archaeological site has been discovered, but they arrived from the exchange.

Verifying such assumptions would require additional spectral analysis performed and the sources of clay in the archaeological site in question.

Establishing the exact characteristics of the ceramic samples provide a database that can be compared with samples that could be false.

Analysis results suggest that the different kinds of pottery from both phases: Cucuteni A and B have been obtained using different manufacturing technologies for ceramics. Stages of implementation of product ceramics: selection of the clay, ingredients, modelling, and combustion were outstanding, leading to different values

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[16] Linda Ellis, *Analysis of Cucuteni-Tripolye und Kurgan Pottery and the Implications for Ceramic*, in *Journal of Indo-European Studies*, 8, 1980, 1-2; Eadem, *A Study in Technology and Origins of Complex Society*, BAR, International Studies, 217, Oxford, 1984; Eadem, *Analysis of Precucuteni Ceramics from Târgu Frumos, Romania*, in vol. *Scripta Praehistorica. Miscellanea in honorem nonagenarii magistri Mircea Petrescu Dîmboviţa oblata*, Ediderunt Victor Spinei, Cornelia-Magda Lazarovici and Dan Monah, Iaşi, 2005, p. 261-270; D. Anghel, *Aspecte generale ale tehnologiei prelucrării ceramicii*, *[General aspects of ceramics processing technology]*, in *Buletinul Cercurilor Ştiinţifice Studenţeşti*, Alba Iulia, 4, 1998; Gh. Gâţă, *A Technological Survey of the Pottery*, in Silvia Marinescu-Bâlcu, Alexandra Bolomey, *Drăguşeni. A Cucutenian Community*, Bucureşti, Editura Enciclopedică – Wasmuth Verlag, Tübingen, 2000, p. 111-130; ****Ceramica neolitică. O lecţie de istorie. Catalog de expoziţie*, *[Neolithic pottery. A history lesson. Exhibition catalog]*, Alba Iulia, Editura Aeternitas, 2007; Ovidiu Cotoi, *Comments regarding the techniques and materials used in the preparation of ceramic paste of the ceramic category "Cucuteni C"*, in *Annales Universitatis Apulensis*, Series Historica, 11/I, 2007, p.153-160; George Bodi, *Hoiseşti-La Pod. O aşezare cucuteniană pe valea Bahluiului [Hoiseşti-La Pod. A Cucuteni settlement in the floodplain of the Bahlui river]*, Iaşi, Editura Pim, 2010, p. 127-147. See also Marino Maggetti, *Phase Analysis and its Significance for Technology and Origin. Archaeological Ceramics*, Washington, Smithsonian Institution, 1982, p. 121-133; Idem, *Il contributo delle analisi chimiche alla conoscenza delle ceramiche antiche*, in T. Mannoni, A. Molinari (Eds.), *Scienze in Archeologia*, Firenze, Edizioni all'Isegna del Giglio, 1990, p. 65-88.

[17] C. H. Schilling, I. A. Aksay, *Slip Casting. Ceramics and Glasses*, Vol. 4, *Engineered Materials Handbook*, C. A. Dostal (ed.), ASM International, Materials Park, Ohio, 1991, p. 153-160.

of hardness, identified by this analysis. Complex study of these samples helps us understand the causes of these values of hardness, setting the ratio between hardness microstructure and composition.

The values obtained for porosity occupies a very wide range, from 0.00292 and 27.606. At least at this stage we can not use this criterion to identify the origin of the samples. Statistical processing of a much larger number of samples may refute this conclusion in the future. Porosity values are highly dependent on raw material quality and processing so that may be used as a criterion for quality assessment. We believe that this criterion could differentiate ceramic materials and crafts areas.

Porosity ranges quite much on the surface. It is a natural phenomenon related to differences between surface roughness inherent to processing and pottery techniques. On the other hand, the section analysis was made in areas unprepared, which greatly influenced the results.

Finally, through further research, we intend to continue archaeometrics investigations for ceramics of the site Fetesti-La Schit, in order to more fully knowing it, in terms of compositional, structural, technological and functional.