Baltic-Pontic Studies
vol. 3: 1995, 214-227
PL ISSN 1231-0344

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TECHNOLOGY OF THE SOFIEVKA TYPE POTTERY. PRELIMINARY REPORT ON PHYSICO-CHEMICAL EXAMINATIONS

This paper presents preliminary results of physical and chemical analysis of thirteen pottery fragments. These samples contain four fragments from a settlement and five fragments from a cemetery site (Sofievka type), as well as four potsherds belonging to the Mątwy group of Funnel Beaker culture.

The study was intended to give an answer to the questions of technological contrast between settlement and cemetery potsherds (Sofievka type) as well as to the relation between ceramics of the Sofievka type and the Mątwy group.

As a result of macroscopic analyses of technology of pottery connected with the Sofievka type a hypothesis was framed concerning the existence in its manufacture of two recipes: sepulchral and settlement [Kruts 1977:122]. The vessels found in graves would have a different pottery mass, to be more exact, together with the admixture of crushed shells there were also found organic fragments and ochre (which gave the vessels a characteristic red colour) and they also differ by their thin walls and „fragility". Taking into consideration the fact that similar observations were made on eneolithic cremation burial grounds from Moravia and Silesia [Medunová-Benešová 1967:374; Bukowska-Gedigowa 1975:15], the authors thought it useful to submit this, supposedly more extensive, „regularity" to physico-chemical verification.

This project was enlarged by submitting the „Sofievka" pottery to comparative analysis with the pottery connected with the so called Mątwy component (with the admixture of crushed shells, decorated with band-comb motives) of the Funnel Beaker culture, from Kuiavia (Inowrocław-Mątwy, Bydgoszcz voivodeship, site 5) whose origin is identified with the North Pontic environment [Kośko 1981:97-122] documents a weighty direction of the late Tripolye (phase C) contacts.

In order to answer these questions the following analyses were be done: colour analysis before and after refiring, X-ray diffraction, TG, DTG and DTA analysis, analysis of ceramic properties before and after refiring (apparent density, open porosity and water absorption), chemical analysis by XRF and microscopic studies of thin sections. Only colour analysis could be made of all thirteen ceramic fragments. This situation has made it difficult to find reasonable answer for all questions mentioned above (the authors hope to continue the research).

1. METHODS

1.1. COLOUR ANALYSIS

Determination of colour of cutting plane of ceramic fragments was done both before and after refiring in a laboratory chamber furnace. Refiring was done with the following parameters: atmosphere -air, heating rate - 200^{o}C/h, soaking time at the peak temperature -1h. The slices for colour analysis were cut perpendicularly to the vessel axis. The colours were identified according to the shade guide edited by the Federation Europeenne Des Fabricants de carreaux Ceramiques C.E.C..

1.2. X-RAY DIFFRACTION

Analysis was carried out with a DRON 1.0 X-ray diffractometer, and was performed with the following parameters: radiation -Co Kα conditions of Co lamp's work - U=34kV, I=20mA; form of work - step 0.04^o 2θ; radiation range - 1.5-70^o 2θ. The samples for measurement were grounded to a fine powder and sedimentated from water suspension on the thin glass plates. This kind of treatment was performed for five samples.

1.3. TG, DTG AND DTA ANALYSIS

Samples for measurement were milled in an agate mortar and passed through a 120-mesh sieve. Analysis was performed for air-dried samples. Examination was carried out with a Derivatograph-Q-1500D thermoanalyser with the following parameters: samples were heated to 1000^{o}C; heating rate - 10^{o}C/min; paper feed - 2mm/min; atmosphere - air, static; reference material - αAl_2O-3, crucible - platinum; sensitivity - TG 200mg, DTG 500uV, DTA 250uV. This analysis was made for eight samples.

1.4. CERAMIC PROPERTIES (APPARENT DENSITY, OPEN POROSITY AND WATER ABSORPTION) ANALYSIS

Ceramic properties were analyzed both before and after refiring. Samples cut out of the potsherds were refired in a laboratory chamber furnace. Refiring was done with following parameters: atmosphere - air, heating rate - 200°C/h, soaking time at the peak temperature - 1h. Ceramic properties were examined using the hydrostatic weighing method. Eleven samples were analyzed.

1.5. CHEMICAL ANALYSIS

Analyses of six samples were made in the laboratory of the Arbeitsgruppe Archaometrie FU Berlin by WD-XRF (Dr.Gerwulf Schneider). It was performed of ignited samples. Loss of ignition was estimated after refiring in air at temperature 900°C (heating rate 200°C/h, soaking time at the peak temperature 1h).

1.6. MICROSCOPIC STUDIES OF THIN SECTIONS

Thin sections were prepared from the samples by the following method: a thin slice was cut from each sherds with a diamond-edged cutting wheel. One face of the slice was ground on a series of glass plates to a fine finish using 200-1000 grade carborundum powders. The slice was then mounted on a microscope slide and ground down to a thickness of ca 30um using various grades of carborundum powder (the lapping down was finished using 1200 grade carborundum). The cut sample was attached to the microscope slide as well as to the covering microscope glass was supported by means of Canada Balsam glue. All sections were examined on a Carl Zeiss Jena polarizing Amplival type microscope, equipped with a stepping stage. Estimations were made of the percentages of different clastic materials using (Eltinor type) integration stage (point-counting method). Granulometric analysis was made area-counting method. Thin sections of five samples were studied under polarizing microscope.

2. RESULTS

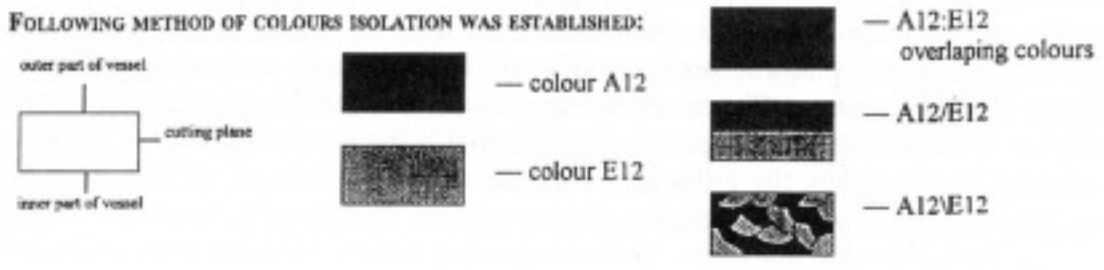
2.1. COLOUR ANALYSIS BEFORE AND AFTER REFIRING

Colour analysis was made at first. Colour of samples before and after refiring at temperatures range from 600 to 1100°C was shown in Table 1. This analysis was carried out to resolve the problem of similarity of raw material as well as to estimate original firing temperature approximately. Results are shown in Table 1.

Table 1

Colour analysis data

Sample number	Site	Colour before refiring	Temperature [°C]					
			600	700	800	900	1000	1100
			Colour after retiring					
1	Bortniche	A11/D11/F10	F10/D11/F10	D11/F10	F10	F10	F10	G12
2	Korarovche	A10	F10	F10	F9	F10	G10	G12
3	Evminka	E11\A10	F9	F9	F9	F9	F9	G11
4	Zazimye	D11/A12	D11	D11	D11	D12	D12	A9:C9
5	Zavalovka	E9/E9:A9\A9/E9	E9	E9	F8	F8	F8	F9
6	Krasny Khutor	A9:C9	D8	D8	D8	F7	E8	F8
7	Sofievka	A10:F10\F10:A10	F10	F10	F10	F10	F10	E10
8	Chernin	D8/A11\A10/F8	F8/D8	F9/D8	F9/D8	F9	F9	G12
9	Chernin	F8/A11\A10/F8	D8:A8/F9	F9/D8/F9	F9/D8/F9	F9	F9	G12
10	Mątwy	A10\A11	D10	D10	D11	F9	F11	F12
11	Mątwy	A10/A9/A12	C9	D9	D9	F8	F9	F12
12	Mątwy	A9	E7	F7	E8	F9	F9	F12
13	Mątwy	A11	A5\B5	A5\C5	D5	D7	E9	E10



a - the reaction of refiring at temperature 1100°C allowed to divide the samples into the so called „raw material" groups according to the colours of the clay matrix and to the vitrification stage of sample. On the basis of these analyses, samples were divided into six groups as following:

- G, sample No.1, 2, 3, 8 and 9
- A:C only sample No.4
- F,1, sample No.5 and 6
- F,2, sample No.10, 11 and 12
- E,1, sample No.7
- E,2, sample No.13

b - it is assumed that pottery made of the same body[1] and fired in the same conditions should change their colour in a similar manner with rising firing temperature. If a sample originally fired at a certain temperature is fired once again, then, if the original firing temperature is exceeded, the colour of the sample should change. If, however, the original firing temperature is higher than the temperature of refiring there will be no change in the sample's colour. This relation can be noticed only if the firing conditions of the original firing and refiring are the same, i.e. the soaking time at the peak temperature, the heating rate and particularly the gas atmosphere inside the kiln.

If investigated samples were not originally fired in air atmosphere changes in colour which can be observed after refiring at temperature of 600°C are not connected with exceeding of original firing temperature but with burned of unburned carbonized organic substance or changes in oxidation stage of iron.

On the basis of colour analysis original firing temperature can be estimated (approximately, only macroscopic examination) and together with results of another analysis gave information about the probable original firing temperature range.

2.2. X-RAY DIFFRACTION

X-ray diffraction, first of all, was conducted to check if the investigated samples contain clay minerals or not. The absence of clay minerals could suggest that during original firing the temperature of their decomposition was exceeded. The presence of clay minerals could help to speak about the type of raw material used. Another problem is the possible presence of aluminium silicates and calcium silicates phases. If their presence in examined, samples would be confirmed, it will be possible to draw conclusions concerning the original firing temperature. It is however necessary to remember the influence of chemical composition of ceramic body on the temperature at which particular phases appear. The possible rehydration and rehydroxilation of clay materials, in the case when sample contains carbonates the possible recarbonization also should be taken into account. The results of X-ray diffraction are presented in Table 2.

[1] It should be explained that the term body describes a raw material prepared through a speccial processes as for example weakening or washing (some times the raw material can also be used directly in production without any additional treatment).

Table 2

Sample number	Phases	Intensivity
1	quartz	major compound
	alkali feldspars	
	hematite	
	maghemite?	trace compound
	smectite	trace compound
3	quartz	major compound
	hematite	trace compound
	smectite	trace compound
	monohydrocalcite?	
4	quartz	
	calcite	
	smectite	trace compound
	monohydrocalcite?	
10	quartz	major compound
	plagioclase	
	alkali feldspars	
	smectite	trace compound
	sepiolite?	trace compound
	illite or micas	
13	quartz	
	calcite	
	plagioclase	trace compound
	illite	trace compound

2.3. TG, DTG AND DTA ANALYSIS

This analysis was carried out to check if the analyzed samples show effects of dehydration and dehydroxylation of clay minerals, decomposition of carbonates, burning of organic substance and growing of new phases. The results of TG analysis are shown in Table 3.

Table 3

TG analysis data

	Sample number								
1	Bortniche	T[°C]	20-240	240-600		600-700	700-900	900-1000	20-1000
		dm/m	12,11%	6,97%		0,26%	0,21%	0,06%	19,61%
3	Evminka	T[°C]	20-255	255-600		600-750	750-900	900-1000	20-1000
		dm/m	11,11%	5,86%		0,41%	0,09%	0,09%	17,56%
4	Zazimye	T[°C]	20-255	255-600		600-700	700-910	910-1000	20-1000
		dm/m	5,02%	3,98%		0,39%	8,10%	0,07%	17,56%
6	Kr. Khutor	T[°C]	20-225	225-400	400-570	570-700	700-900	900-1000	20-1000
		dm/m	9,02	3,94	2,4	0,48	0,19	0,29	16,32
7	Sofievka	T[°C]	20-200	220-345	345-600	600-700	700-900	900-1000	20-1000
		dm/m	12,9	4,22	4,48	0,32	0,35	0,13	22,4
9	Chernin	T[°C]	20-255	255-360	360-580	580-700	700-900	900-1000	20-1000
		dm/m	13,12	2,88	3,36	0,32	0,16	0,16	20
10	Mątwy-5	T[°C]	20-225	225-600		600-740	740-900	900-1000	20-1000
		dm/m	7,71%	4,72%		0,43%	0,25%	0,03%	10,14%
13	Mątwy-5	T[°C]	20-235	235-600		600-685	685-905	905-1000	20-1000
		dm/m	3,07%	3,11%		0,53%	11,65%	0,26%	18,62%

All samples belonging to the cemetery ceramic group have two effects of loss of mass in the temperature range of ca 200-600°C correspond with wide exotherm with several maxima. These effects are not observed in the rest of the samples. Only for two samples thermal decomposition of calcite can be observed (sample No.4 and 13).

Gain in weight connected with the oxidation of Fe_{2+} to Fe_{3+} was not observed.

2.4. ANALYSIS OF CERAMIC PROPERTIES BEFORE AND AFTER REFIRING (APPARENT DENSITY, OPEN POROSITY AND WATER ABSORPTION)

This kind of analysis, first of all, was made to determine the original firing temperature. While during refiring the original firing temperature is increased, in the first, there are changes in the pore structure and after them changes of the open porosity and, therefore, of the apparent density and water absorption are observed. Results of analysis of ceramic properties are presented in Table 4.

Table 4

Ceramic properties analysis (apparent density – g/cm^3, open porosity – %, water absorption – %) before and after refiring

Sample number		Temperature [°C]											
		20	400	600	700	750	800	850	900	950	1000	1050	1100
1	dv	1,42	1,49	1,48	1,47	1,43	1,46	1,53	1,51	1,53	1,52	1,53	1,57
	P	48,1	44,6	45,9	44,3	44,2	43	42,9	42,6	41,5	40,9	40,7	39,1
	N	34	29,8	31	30	30,9	29,4	28,3	28,2	27,2	26,9	26,7	24,8
2	dv	1,35	1,39	1,36	1,31	1,29	1,32	1,33	1,2	1,15	1,19	1,17	1,16
	P	50,3	49,1	49,8	48,3	49	48,6	47,4	43,7	50,9	55,6	55,7	57,3
	N	37,3	35,2	36,7	36,8	38	36,7	35,6	36,3	44,2	46,6	47,5	49,1
3	dv	1,28	1,29	1,29	1,27	1,27	1,29	1,32	1,33	1,34	1,35	1,37	1,36
	P	51,7	52,2	53,2	52,7	52,3	51,9	49,2	48,2	48,2	47,9	47,2	46,4
	N	40,3	40,4	41,2	41,5	41,1	40,3	37,4	26,3	35,9	35,4	34,5	34
4	dv	1,99	1,99	1,91	1,85	1,72	1,68	1,68	1,46	1,42	1,39	1,37	1,37
	P	23,6	24	27,1	28,6	32,5	33,2	32,9	36,3	39,4	42,1	43,9	44,3
	N	11,9	12,1	14,2	15,5	18,9	19,8	19,7	24,9	27,7	30,3	32,1	32,4
5	dv	1,19	1,2	1,2	1,19	1,15	1,18	1,19	1,19	1,16	1,21	1,21	1,24
	P	55,6	55,5	56,2	55	56,9	56,3	56,2	56,6	57,7	56,6	56,1	56,6
	N	46,7	46	46,8	46,3	49,7	47,6	47	47,4	49,9	46,9	46,2	45,7
6	dv	1,3	1,33	1,31	1,31	1,28	1,3	1,31	1,32	1,31	1,33	1,35	1,37
	P	51,3	50,6	51,4	50,1	51,9	50,7	50,7	50	51,2	50	49,4	50,1
	N	39,6	37,9	39,2	38,2	40,8	39	38,6	37,9	39,1	37,5	36,6	36,6
7	dv	1,37	1,45	1,44	1,42	1,57	1,51	1,42	1,4	1,43	1,45	1,45	1,47
	P	47,6	45,3	46,9	46,2	47,1	41,3	44,2	44,4	45,8	44,7	44,6	45,1
	N	34,7	31,2	32,7	32,4	33,3	27,4	31,1	31,7	31,9	30,7	30,7	30,7
10	dv	1,81	1,8	1,78	1,77	1,77	1,76	1,77	1,78	1,92	1,97	2,04	2,2
	P	30,7	31,1	32,2	32,3	33	31,9	31,7	30,5	25,2	22,6	17,9	8,4
	N	16,9	17,3	18,1	18,2	18,7	18,1	17,9	17,2	13,1	11,5	8,8	3,8
11	dv	1,82	1,78	1,74	1,73	1,69	1,67	1,69	1,71	1,7	1,71	1,7	1,82
	P	30,7	32,8	34,2	34,2	36,3	35,4	35,7	34,1	34,5	33,9	34	30,1
	N	16,9	18,4	19,6	19,7	21,4	21,1	21,1	20	20,2	19,8	20	16,5
12	dv	1,74	1,74	1,71	1,67	1,56	1,53	1,52	1,59	1,57	1,5	–	–
	P	33,1	34,4	35,3	36,3	39,6	39	39	33,4	33,7	35,7	–	–
	N	19	19,8	20,7	21,7	25,4	25,5	25,6	21	21,4	23,8	–	–
13	dv	1,76	1,75	1,71	1,61	1,67	1,51	1,48	1,46	1,43	1,41	1,39	1,37
	P	33,6	34	35,4	38,7	38,9	39,8	41,6	41,4	43,1	44,3	44,1	46,8
	N	19	19,5	20,7	23,9	24,8	26,4	28,2	28,6	30,1	31,1	31,7	34,1

Results of chemical analysis give information on major and trace elements of the samples investigated. These elements are connected with the ceramic body, the clay matrix as well as the clastic admixtures. The results of this analysis sometimes is influenced by secondary effects from burial. Results of this analysis are presented in Table 5.

Table 5.

Chemical analysis. Analyses were made in the laboratory of the Arbeitsgruppe Archaometrie FU Berlin by WD-XRF (Dr.Gerwulf Schneider). Analysis of ignited samples, major elements in percent by weight, normalized to a constant sum of 100%. the original total is given in the column „Total", loss of ignition at 900°C is given in column „LOI", traces are in ppm, elements in brackets are determined with lower precision

A. major elements

Sample number	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	(S)	(Cl)	LOI [%]	Total
	% by weight													
1	51,14	0,96	23,60	16,01	0,050	0,21	2,32	0,07	0,30	5,34	0,02	0,01	19,55	99,71
3	64,37	1,18	18,59	7,30	0,032	0,28	2,40	0,04	0,11	5,65	0,00	0,00	12,20	98,57
4	61,30	0,81	14,30	4,64	0,043	0,29	17,18	0,22	0,54	0,68	0,04	0,01	17,40	100,40
7	58,66	1,14	26,41	12,43	0,042	0,17	0,40	0,03	0,11	0,60	0,02	0,00	12,68	100,84
10	62,88	0,85	17,45	7,72	0,085	2,23	2,78	0,65	3,78	1,58	0,00	0,01	10,11	99,57
12	50,53	0,68	17,42	4,90	0,054	1,44	21,41	0,22	1,94	1,41	0,04	0,00	17,39	99,66

B. traces elements

Sample number	V	Cr	Ni	(Cu)	Zn	Rb	Sr	(Y)	Zr	(Nb)	Ba	(La)	(Ce)	(Pb)	(Th)
	ppm														
1	220	174	40	24	43	13	228	17	188	22	1972	7	31	42	27
3	149	112	44	31	111	20	205	25	227	19	1690	10	44	18	22
4	97	90	19	5	26	26	232	16	181	17	1150	9	38	19	15
7	254	181	47	22	28	17	24	16	238	19	217	9	31	22	22
10	114	116	44	21	112	150	211	35	203	17	1542	42	82	23	24
12	142	114	52	28	108	107	299	32	117	9	1223	60	125	23	18

It is clear that from only six analyses very preliminary interpretations can be made. Due to the variation of composition within one group of pottery, comparisons must be made on a statistical basis which needs at least about twenty samples for one group to be compared with another group of a similar size. Anyhow, some observations are clear. All samples from Ukraine are made from a clay extraordinary low in sodium and potassium and thus very different from the samples from Mątwy.

One of the three samples from the settlement has a high content of calcium which is explained by a different temper consisting of calcite. This sample has also a lower iron content connected with lower contents of titanium, vanadium, chromium and nickel. This may indicate a different clay source within the same area. Because of the large variation within the four samples from Ukraine nothing can be said about the difference between the samples from the settlement and the one from the cemetery. The high phosphorus contents of two samples from the settlement, as usual connected with elevated barium and strontium contents, probably are secondary effects from burial. The large variations in iron may be another typical feature of the clays used in that area.

The two samples from Mątwy are clearly different in composition from all Ukrainian samples. The clay is lower in titanium and much higher in sodium, potassium and magnesium than the clay used at the Ukrainian site. One of the two samples form Mątwy is high in calcium due to a different temper.

2.6. MICROSCOPIC STUDIES OF THIN SECTIONS

Examination of thin sections under polarizing microscope was performed to speak about type of matrix and first of all to estimate clastic admixtures. It means type of minerals, their percentage, percentage of particular grain fractions as well as percentage of matrix and clastic material in sample's area. Results of these analysis give information about formula. The term formula describes the specific combination of matrix and clastic material which, for example, could depend on the function of vessels. On the basis of the same clay material ceramic bodies with the same matrix but with different clastic material can be formed (intentional admixtures of clastic material). The results of thin section analysis are shown in Table 6, 7, 8, 9, 9a and 10.

Table 6

Matrix and clastic material in particular fraction

Sample number	Matrix	Clastic material			
		Total	grains diameter [mm]		
			[0,01–0,1]	(0,1–0,5]	> 0,5
	% of area				
1	57,8	42,2	9,8	32,4	–
3	62,5	37,5	2,7	27,4	7,4
4	59,5	40,5	1,4	28,9	10,2
10	68,6	31,4	12,9	18,5	–
13	53,5	46,5	1,1	12,1	33,3

Table 7

Granulometric analysis data

Sample number	Clastic material		
	grains diameter [mm]		
	[0,01–0,1]	[0,1–0,5]	> 0,5
	% of whole clastic material		
1	80	20	–
3	73	25	2
4	57	40	3
10	90	10	–
13	71	25	4

Table 8

Maximum grains diameter

Sample number	Clastic material		
	grains diameter [mm]		
	[0,01–0,1]	[0,1–0,5]	> 0,5
	maximum grains diameter [m]		
1	0,1	0,3	–
3	0,1	0,5	0,6
4	0,1	0,5	0,8
10	0,1	0,15/0,4	–
13	0,1	0,5	2,0

Pseudomorphs after bioclasts[2] can be observed in sample No.4 and 13. These, however, seem not to be from the same origin. In sample No.1 and 3 the pores have the same shape like the bioclasts in sample 4. At the rims of some of these pores unidentified material (relics from bioclasts or contamination from burial ?) can be observed.

Samples from Mątwy ceramic group are different from the rest (Sofievka type), but are not similar to each other. Sample No.10 is very decisively different, without any traces after bioclasts, is very well sorted (only several well rounded grains of quartz were added). In the next sample (sample No.13) admixtures of bioclasts are observed.

Unfortunately for the samples of cemetery ceramic group thin sections could not be made.

[2] The attribution of the clasts is not quite clear because of untypical shape. It could be also calcareous shale.

Table 9

Planimetric analysis data

A - 100% clastic material

Sample number	Clastic material										
	Q	Pl	Af	Car	Bio	Mus	Px	Om	Rf	Bioc	
	% of area										
1	66,7	–	1,3	0,6	–	–	–	16,0	–	15,4	*
3	78,6	–	–	–	–	–	1,6	6,3	2,4	11,1	*
4	51,8	1,2	–	–	1,2	–	–	22,3	–	23,5	
10	78,2	–	1,0	3,0	–	2,0	2,0	9,9	3,9	–	
13	55,7	3,8	3,3	6,3	–	1,0	–	7,6	1,0	21,4	

B - 100% matrix and clastic material

Sample number		Clastic material									
	MATRIX	Q	Pl	Af	Car	Bio	Mus	Px	Om	Rf	Bioc
	% of area										
1	57,8	28,1	–	0,5	0,3	–	–	–	6,8	–	6,5	*
3	62,5	29,5	–	–	–	–	–	0,6	2,4	0,9	4,2	*
4	59,5	21,0	0,5	–	–	0,5	–	–	9,0	–	9,5	
10	68,6	24,6	–	0,3	0,9	–	0,6	0,6	3,1	1,2	–	
13	53,5	25,9	1,8	1,5	2,9	–	0,5	–	3,5	0,5	10,0	

Q – quartz
Pl – plagioclase
Af – alkali feldspars
Car – carbonates
Bio – biotite
Mus – muscovite
Px – pyroxenes
Om – opaque minerals
Rf – rocks fragments
Bioc – pseudomorphs after bioclasts
* – pores after bioclasts

Table 10

Results of thin section analysis

Sample number	grains size [mm]		
	[0,01–0,1]	[0,1–0,5]	> 0,5
	type of clastic material		
1	Q Om Af Car Por	Q Por	
3	Q Om	Q Om Px Rf Por	Q Por
4	Q Om B	Q Om Pl B Ps	Ps
10	Q Om Af Mus Car Px Rf	Q Om Af Mus Car Px Rf *	
13	Q Om Af Pl Mus	Q Om Pl Car Rf Ps	Ps

Q – quartz
Om – opaque minerals
Af alkali feldspars
Pl – plagioclase
Mus – muscovite
B – biotite
Car – carbonates
Px – pyroxenes
Rf – rock fragments
Por – pores after bioclasts
Ps – pseudomorph after bioclasts
* – grains diameter up to 0,15 mm, only well rounded quartz up to 0,4 mm

3. CONCLUSIONS

1. For all investigated samples the colour is due to unburned carbonized organic substance and only to a less extend to Fe_{2+}. Firing was done in a more or less reducing atmosphere connected with fumigation.

There are two groups connected with clearly(!) another type of substance responsible for fumigation. All samples of the cemetery pottery group belong to the one group, to the second one the rest of sample.

2. In the case of technological parameters samples were decidedly divided into three groups:

- sample No.4, the best parameters (lowest open porosity and water absorption)
- all samples belonging to the cemetery ceramic group (sample No.5, 6 and 7) and three samples belonging to the settlement ceramic group (sample No.1, 2 and 3)
- all samples belonging to the Mątwy ceramic group

3. In the case of original firing temperature samples were divided into the following groups:

- 600-700°C sample No.13 and 4
- 700-800°C sample No. 10, 12 and 1
- 800-900°C sample No.11, 2 and 3
- 900-950°C all samples of cemetery ceramic group

4. Pseudomorphs after bioclasts only can be are observed in samples originally fired in lower temperature than the samples with pores after bioclasts[3].

5. Clearly differs the formula of sample No.10. In the rest of samples, Mątwy and settlement group, admixtures of bioclasts can be observed (cemetery ceramic group could not be studied). Samples Mątwy group are not of the same origin as the rest.

6. Samples were buried in other conditions, clearly another:

- two samples of cemetery ceramic group (sample No.1 and 3)
- samples Mątwy group
- samples No.7 (cemetery ceramic group) and 4 (settlement)

7. In chemical analysis two samples from Mątwy are clearly different in composition from all Ukrainian samples.

8. It is very important to continue these analysis and to make all kind of analysis for every type of ceramic group (and for more ceramic samples) to be sure that the described above results are representing particular groups.

[3] It is the typical behavior for bioclasts during firing [see Daszkiewicz, Raabe, Jelitto 1996].

ACKNOWLEDGMENT

I am indebted to Dr.Gerwulf Schneider for his kind permission to make the chemical analysis in his laboratory.

Translated by authors