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THE EARLY MEDIEVAL POTTERY WITH ADMIXTURE OF CALCIUM CARBONATE IN THE CERAMIC FABRIC (SAMPLES FROM HILLFORTS IN THE NIDA BASIN)

ABSTRACT

Tyniec A. 2022. The early medieval pottery with admixture of calcium carbonate in the ceramic fabric (samples from hillforts in the Nida Basin). *Sprawozdania Archeologiczne* 74/2, 317-336.

Among vessels used in the Early Medieval Ages in the area of western Lesser Poland, special attention should be paid to specimens made of ceramic fabric with a tempering agent composed of minerals containing calcium carbonate. Such vessels are usually labelled as Kraków "white" pottery. The "white" pottery from the area of the Nida Basin may be characterized on the basis of vessels made of clay with calcium carbonate admixture discovered in archaeological features. The most numerous materials derive from hillforts in Stradów and Szczaworyż. This pottery could have been some kind of a tribal emblem. For more than 200 years it was dominating among vessels in western Lesser Poland. The group producing vessels made of calcium carbonate fabrics may be the Vistulans mentioned in written sources.

Keywords: Early Medieval Ages, Lesser Poland, pottery, ceramic fabric with calcium carbonate, Kraków "white" pottery, hillforts in the Nida Basin

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INTRODUCTION

Among vessels used in the Early Medieval Ages in the area of western Lesser Poland, special attention should be paid to specimens made of ceramic fabric with a tempering agent composed of minerals containing calcium carbonate. Such vessels are usually labelled by archaeologists as Kraków "white" pottery. This name, deriving from the territorial scope of the first discoveries, was adopted in the archaeological literature but in fact it does not reflect the essence and specific characteristics of these early Medieval pottery materials (made of ceramic fabric tempered with crushed stones containing calcium carbonate). Vessels made of such ceramic fabric rarely have surfaces and fractures of "white" colour (typical of pottery made of kaolinite clays, in the Kraków region occurring often in the Late Medieval Ages – see below). The term "white" suggests as well that it is identical with the early medieval pottery made of white clay known from the areas of Sandomierz or the Opatów region (*cf.* Buko 2005, *passim;* older literature there). The definition "white" in the case of this recipe requires writing it consistently in quotation marks. Also the second part of the name "Kraków" is not fully adequate because the usage of carbonate admixture to ceramic fabric is noticeable in vessels discovered also at sites situated about 150-200

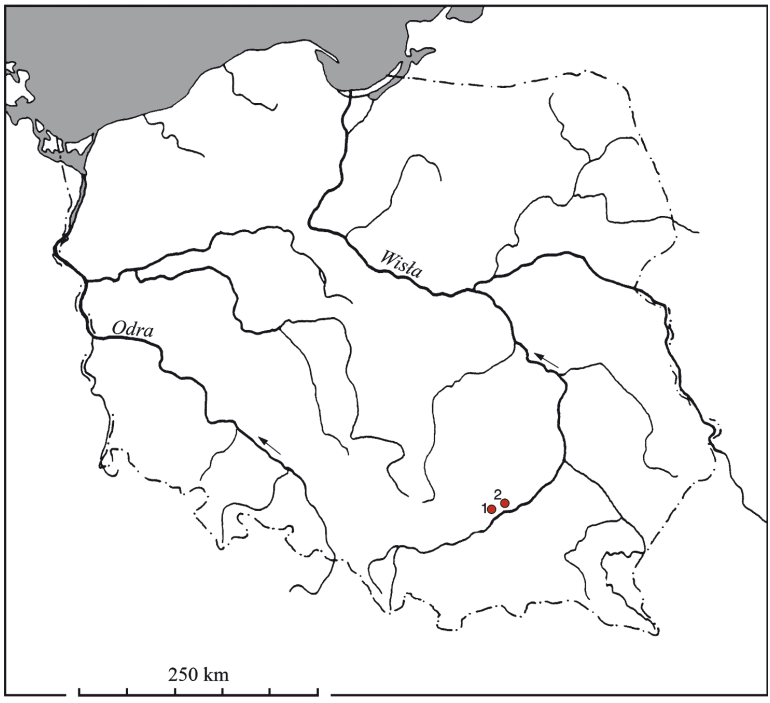

Fig. 1. Location of hillforts: 1 – Stradów, Kazimierza County, Świętokrzyskie Voivodeship, 2 – Szczaworyż, Busko County, Świętokrzyskie Voivodeship (drawing by B. S. Szmoniewski)

kilometres from Kraków (not only single potsherds – see below). The most completely analysed assemblages of vessels of this type of ceramics are materials registered in Kraków (Radwański 1968), Nowa Huta region of Kraków (Kubica-Kabacińska 2000; 2001) and in Mionów in Silesia (Parczewski 1977). Noteworthy are as well vessels made of this type of ceramic fabric deriving from the area of the Nida Basin – mainly from hillforts in Stradów and Szczaworyż (the author of this article obtained Professor Elżbieta Dąbrowska's written permission for use of unpublished materials from Szczaworyż) (Fig. 1).

OUTLINE OF THE STATE OF RESEARCH ON THE SO-CALLED "WHITE" POTTERY

The first complete definition of the "white" pottery was proposed by Elżbieta Dąbrowska (1963, 57, 58). The basic characteristics of these vessels as well as their dating frameworks defined by Dąbrowska have been so far only slightly modified. They were supplemented with physic-chemical data (Dereń *et al.* 1968; Radwański 1968, 14-16; Tyniec-Kępińska *et al.* 1996; Szmoniewski *et al.* 2006), chronological information (Radwański 1968, 24-31) and discussions on local concentrations of pottery registered beyond Lesser Poland (Parczewski 1977; Szuwarowski 1994), but in principle the definition has been so far positively verified. There is no doubt that the dissertation written by Kazimierz Radwański (1968) also remains the publication of fundamental significance for the majority of aspects of this pottery.

The "white" pottery was made of plastic, shale fabric (depending on its origin with various mineral admixtures), tempered with calcium carbonate or sometimes sand or mineral crushed stone. On the account of specific chemical processes occurring in this type of ceramic fabric under the influence of temperature, firing of vessels was taking place at a temperature below 900°C (at a higher temperature the carbonate compound is decomposed and the earthenware loses its functional qualities). The colour of the surfaces of vessels is diversified – from creamy, brown to grey – sometimes even at the surface of the same vessel – this may result from the course of post-depositional processes – mainly from the character of a deposit (Fig. 2).

The detailed studies on pottery have a great significance for issues connected with settlement – mainly for its dating. While it is true that the seminal publication of K. Radwański of early medieval Kraków pottery (1968) remains a fundamental basis for study of this material, the increase in number of materials and new methods used for research into pottery encourage taking up the matter again. Not surprisingly, this issue has been present among research postulates for many years (*e.g.*, Poleski 2004, 298) and it is the basis for interdisciplinary analyses, mainly in the field of "white" pottery (Dereń *et al.* 1968; Tyniec-Kępińska *et al.* 1996; Kubica-Kabacińska 2000; 2001; Pawlikowski 2000; 2001; Auch 2005; Szmoniewski *et al.* 2006). Alongside the such phenomena as the construction of

Fig. 2. Szczaworyż Busko County, Świętokrzyskie Voivodeship. The diversified colour of vessels surfaces (photo by B. Pilarski)

great strongholds of the tribal period or the practice of building huge barrow-graves, the specific recipe for this type of ceramic fabric for vessels, remains one of the distinguishing features of the material culture of early medieval western Lesser Poland (Radwański and Tyniec 2010). Use of clays with admixture of calcium carbonate resulted mainly from accessibility of raw material deposits. Despite the fact that this raw material caused numerous technological problems (for example this fabric required taking extra care during firing clay pots), such type of pottery in a short time became dominant (at sites in the area of contemporary Kraków) or constituted a very significant percentage share among pottery production of pre-craft character (for example in Kraków Nowa Huta-Mogiła, Kraków Kurdwanów or in hillforts in Stradów or Szczaworyż).

Did the idea of its production originate in this area or was it a result of some external impulse? Perhaps in the Early Medieval Ages, pottery production in the Kraków region was the inspiration to produce pottery including calcium carbonate for other areas? The answer for such question may contribute to our knowledge of the external contacts of early medieval Kraków. One of the possibilities is the assumption that it was the attempt to obtain ceramic fabric with parameters similar to products made of white kaolinite clays (*cf.* Buko 2005 or Hadamik 2005). In such a case, technological problems should stop fabric production of vessels with admixture of calcium carbonate as this had most probably happened in western Lesser Poland where traces of specific recipes for pottery were registered. In regions devoid of deposits of kaolinite clays or local outcrops of carbonate raw materials, different recipes are noticeable, possibly the effects of a search for a qualitatively similar ceramic fabric. There are vessels made of poorly noticeable temper, creamy in colour, fragile with soft surfaces – their fragments were discovered in features (nos 10, 23, 24, 33 and 57)

of the early medieval settlement at Site 20 in Brzezie, Kłaj community on the right of the Vistula River (Tyniec 2013 – this pottery at first glance is similar to "white" Kraków pottery with admixture of dusty calcium carbonate in ceramic fabric). Fragments of such vessels were discovered as well on the eastern peripheries of neighboring Site no. 37 (Tyniec 2012b). It is possible that vessels with admixture of dusty sand in the ceramic fabric discovered at the stronghold in Zawada near Tarnów also represent an attempt to obtain visibly similar pottery.

At this point, we should mention E.N. Simonowa's opinion on the issue of the early medieval white kaolinite pottery, *i.e.* technologically advanced, thick-walled vessels registered in the area of Poland, Moravia, Czech Republic, Slovakia, Hungary, northern Bulgaria, Romania and Crimea. The researcher links this pottery with Byzantine impulse reflected in ethnically different milieus. Simonowa considers the Kraków "white" pottery made of ceramic fabric with calcium carbonate as identical with pottery production made of kaolinite clays from areas mentioned above (Simonova 1996, 139; 2008, 39-45). The equality, however, should be made only as regards production of vessels in perfect white color.

Dobruja in Romania has a special place on the map of distribution of pottery generally known as white – this is the area where both types of vessels made of pottery fabric with calcium carbonate admixture and with kaolinite clays have been registered (Szmoniewski and Voinea 2021, 119; Szmoniewski and Voinea 2020; Cursaru-Herlea 2016, 75-76). A special category there is white pottery made of kaolinite clays with red and brown-painted surfaces (Diaconu 1973, 209, 21; Stănică 2015, 219-222; Cursaru-Herlea 2016, 143-145).

It is a question that may be asked of this material whether for the inhabitants of western Lesser Poland (Vistulans) and their neighbours deriving from other cultures, these sets of forms, ornamentation program or technology of pottery production were the evident distinguishing features of the group. Such a situation was registered in case of the Pannonian Avars inhabiting the Carpathian Basin and their yellow pottery (Vida 1999; 2015) dated to the 8th-10th century that is the indicator of Avar burials (Bognar 2016). These vessels are thought to have their prototypes in vessels from Bulgarian Pliska (Henning 2007, Taf. 4, 5) or polished Carolingian pottery (Bognar 2016, 27). There is no doubt that yellow pottery is connected with the Avars.

In this respect, the set of vessels, technology of production and ornamentation would constitute a peculiar medium of ideas/culture and constitute a tribal determinant. Did in case of Vistulans the pottery with calcium carbonate in ceramic fabric (or other experimental recipes mentioned above) play the role of the emblem? Vessel type ceramics on the account of their impermanence offer the opportunity for frequent changes. The attachment to a tradition of making of pots from material creating problems or requiring special attention at the stage of production (mainly firing) noticeable in western Lesser Poland, proves the creation and cultivating there of a specific style and a consciousness of its integrating meaning inside the group. Outside, it confirms membership to this group (*cf.*

Niewęgłowski 1992, 289, 292-294; earlier literature in the volume). In this case, the group making vessels with admixture of calcium carbonate may be the Vistulans mentioned in written sources.

The chronology of the Kraków "white" pottery was designated by E. Dąbrowska as the period from the 8th to 11thcentury with the possibility of its appearance in small quantities even up to 13th century (Dąbrowska 1963, 58). K. Radwański dated this type of pottery based on stratigraphy analyses and coexistence in assemblages (1968, 24-31). The source material deriving from the research from Kraków before and after its chartering ensured his publication a permanent place in discussion on the early medieval pottery production and its chronology. Radwański located the period of domination of the Kraków "white" pottery between the 8th and 12th centuries and its mass appearance in Kraków assemblages since the half of the 9th century. A similar situation is seen nearby in assemblages from Nowa Huta-Mogiła where the appearance of the "white" pottery is dated to the turn of the 7th and 8th century on the base of findings of hooked spurs with hooks bent inwards (Radwański 1968, juxtaposition at p.27, subsequent literature in the volume). Despite serious concerns over the correctness of dating of these artefacts (*cf.* Poleski 1992, 24 and footnote 7; 1993-1994, 238, 239; further literature in the volume), Radwański's findings are not contested. At the turn of the 10th and 11th centuries and at the beginning of the 11th century, a significant drop in quantity of the "white" pottery occurred in assemblages from Kraków region. Single fragments still appeared in materials from mixed and backfill layers up to the beginning of the 13th century (which could be the result of post-depositional processes). Kazimierz Radwański considered as well that introduction on a massive scale of the "white" ceramic fabric was connected with technological improvements (including: coil-building with clay strips [*technika ślizgowo-taśmowa*]) and changes in organization of pottery production (Radwański 1968, 30). This led to the increased frequency in the pottery assemblages in early medieval Kraków of, pottery vessels made of clay marls with admixture of calcium carbonate ($CaCO_3$) so-called white pottery and made of ferruginous clays with an admixture of alluvial sand (group VI). Generally speaking, without details concerning chronology, changes in technology and typology, it should be stated that white pottery prevails (up to 90% of all findings of pottery) in undisturbed or weakly disturbed structures constructed before the 11th century. Pottery from group VI constitutes sometimes even 100% of finds in later assemblages dated from the 11th to the middle of the 13th century (Radwański 1968). The research confirms that in areas where white pottery was discovered, traces of settlement dated before the 11th century are noticeable. Radiocarbon dating for part of the Wawel Castle fortifications confirm the correctness of this chronological position (Kukliński 1995, 247, 251; 2005 *passim*; 2017; Firlet 2003 *passim*). It should be taken that the period of actual use of the "white" pottery ends in the first decades of the 11th century and finds deriving from younger layers are the accidental components.

It seems that the centre of production of pottery with ceramic fabric with admixture of calcium carbonate was situated in Lesser Poland in the Kraków region (*cf.* Dąbrowska 1963, 58; Radwański 1968, 37). Its percentage share in early medieval material was low in areas located further from this region but also its local centres of production for local purposes are noticeable also there. A particular place in this group has pottery production in the Nida Basin in hillforts in Stradów (*cf.* Maj 1990, group I) and Szczaworyż (Dąbrowska 1965; 1973).

CARBONATE POTTERY FROM STRADÓW AND SZCZAWORYŻ

The "white" pottery from the area of the Nida Basin may be characterized on the basis of vessels made of clay with calcium carbonate admixture discovered in archaeological features. The most numerous materials derive from hillforts in Stradów and Szczaworyż (Fig. 1). Also at the settlement site in Szarbia, one such vessel was registered (*cf.* Baczyńska and Maj 1982, 175, fig. 8a). The remaining fragments of "white" pottery were registered in layers or as stray finds at archaeological sites. It should be mentioned that the "white" pottery find at the hillfort in Szczaworyż has provided only a limited set of data deriving from macroscopic observation. This is the result of the specific state of preservation of this material. The surfaces of vessels discovered there – made of clay with admixture of calcium carbonate – are worn or have distinct grooves (Fig. 3). These changes result from the character of soil in the Szczaworyż area (Szwarczewski 2006) – the high acidity causes damage to the surfaces of this kind of pottery.

Pottery with calcium carbonate admixture was discovered at the site in Stradów in 87 settlement features. Its percentage share in pottery materials was as follows (calculations based on Maj 1990, Tables):

– 0-25% in Features: 103 – 5%; 26 – 9%; 11 – 17%; 106 – 18%; 90 – 20%; 57 – 22%; 32/B – 23%; 7, 9/B – 24%; 10a, 3/M – 25%;

– 26-50% in Features: 49 – 29%; 20, 29, 46, 63, 65, 112, 6/B, 7/B, 33/B – 33%; 25 – 34%; 17, 44a, 56 – 36%; 45, 55, F/W – 38%; 61, 79 – 40%; 14/B, 4/M – 42%; 18, 5/B, 17/B – 43%; 1/B, 2/M – 44%; 111 – 45%; 1002/B – 46%; 21 – 47%; 33 – 48%; 3,4 – 49%; 16, 27, 50,78, 81, 93a, 98, 4/W , 4/B, 16/B, 30/B, 39/B, 1/M – 50%;

– 51-75% in Features: 52 – 52%; 41 – 53%; 73 – 56%; 62, 20/B- 60%; 88, 12/B, 38/B – 63%; 25/B – 64%; 44, 101, 11/B, 13/B – 67%; 14 – 69%; 8/B – 70%; 24 – 75%;

– more than 76% in Features: 2 – 78%; 77 – 86%; 20a, 35, 44c, 59, 63a, 66, 71a, 77a, 97, 129, 1b/W, 23/B, 35/B – 100%.

From a comparison of these data and the dating of the features in Stradów based on typological determinations for pottery materials and stratigraphic relations (Maj 1990, table II), we may conclude that pottery made of ceramic fabrics with carbonate admixture

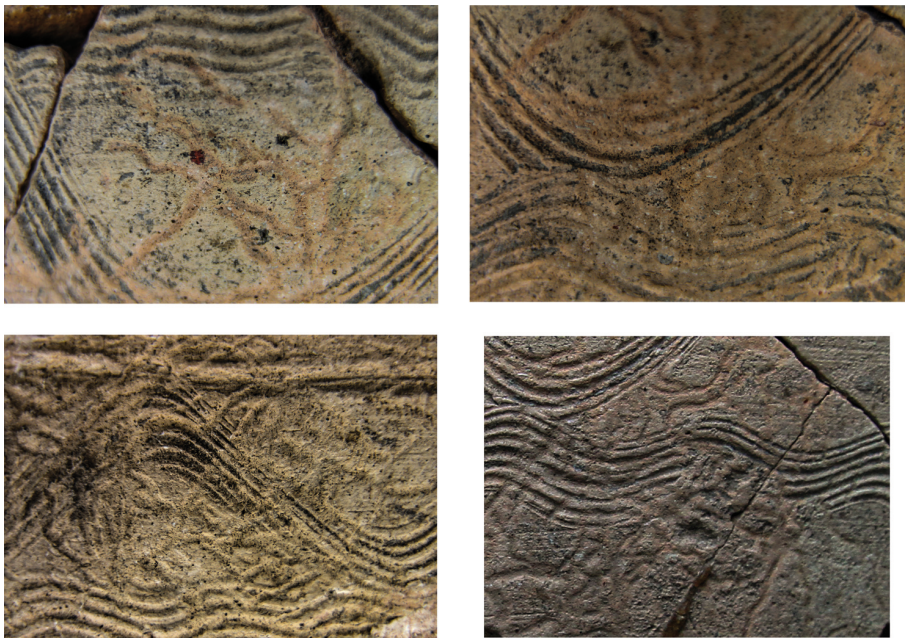

Fig. 3. Szczaworyż, Busko County, Świętokrzyskie Voivodeship. Damage to surfaces of pottery (photos by B. Pilarski)

is a constant component in the set of vessels in use at this site. Features comprising low (and high) percentage of pottery with calcium carbonate are dated to phase II and phase III of Stradów pottery. Phase II is dated from the second half of the 9th up to the middle of the 10th century (Szmoniewski and Tyniec 2010, 13), and Phase III – about the middle of the 10th up to the middle of the 11th century (Maj and Zoll-Adamikowa 1992; Tyniec-Kępińska 1996; 2007, 103-105).

In the set of pottery deriving from 12 features at the site in Szczaworyż the percentage of vessels made of ceramic fabric with calcium carbonate is lower than at Stradów. It may be presented as follows (calculations based on author's research):

– 0-25% in Features: 13 – 3%; 10 – 4%; 3 – 5%; 6, 22 – 6%; 9 – 7%; 1 – 9%; 20 – 11%; 15 – 12%; 5 – 14%; 16 – 22%;

– 26-50% in Features: 14 – 26%.

This lower rate of "white" pottery at the hillfort in Stradów does not result from its state of preservation because even among destroyed potsherds it is still possible to distinguish fragments made of this material (Fig. 3). It therefore does not seem that the relative paucity of this material at this site can be explained by environmental factors (acidity of soils). At the site in Szczaworyż, pottery of fabric with calcium carbonate did not play a major part in the assemblage of vessels in use at the site.

POTTERY WITH ADMIXTURE OF CRUSHED *INOCERAMUS* SHELLS

The specific variant of „white" pottery are vessels made of clay including admixture of crushed *Inoceramus* shells – the extinct genus of fossil marine pteriomorphian bivalves dated to the Jurassic and Cretaceous periods (Fig. 4). In Stradów pottery this admixture was identified by U. Maj (1990, 15). She described this type of ceramic fabric as her II variant. Distinction of vessels made of clay with admixture of crushed fragments of shells is no doubt reasonable.

It is still an open question whether the admixture of crushed *Inoceramus* shells is the potential source of calcium carbonate in "white" pottery as it was suggested in a footnote (*op. cit.*, footnote 12). The lack of published information on observations of such remains in assemblages of "white" pottery deriving from other regions and their presence in the ceramic fabric at two sites from the Nida Basin (Stradów and Szczaworyż) may testify the local character of this phenomenon. It turns out that crushed *Inoceramus* shells in ceramic fabric are also present in pottery from Kraków (for example inventory reports on

Fig. 4. Proszowice, Proszowice County, Lesser Poland Voivodeship. Pottery with admixture of crushed *Inoceramus* shells (photo by A. Tyniec)

Table 1. Szczaworyż. Fragments of pots with an admixture of Inoceramus shells in the ceramic fabric

SZCZAWORYŻ						
feature no.	Inv. No.	Edge	Ornament	Rolling area	Smudging	Percentage pots with carbonate admixture in the facility
9	200/63		e_5	2-4	-	7%
	201 /63	J_1	f_3	2	-	
			a_2	?	?	
	203/63		B	-	+	
	211/63	H_1	-	2	-	
13	9/65		b_3	-	+	3%
	12/65 2 fragm.		?	?	?	
20	41/66		-	-	+	11%
	52/66 5 fragm.		-	4	-	

materials deriving from trenches in the Dominican or Franciscan monasteries, gardens of the Archaeological Museum in Kraków or from Kraków-Kurdwanów) and for example in Zofipole or Proszowice. This admixture is rather the effect of its presence in deposit just like fragments of snail shells in vessels from Slovakia and northern Hungary (Fusek 1994, 16).

Tables 1 and 2 presented below contain basic information regarding known fragments of pottery with crushed *Inoceramus* shells in the ceramic fabric.

In Stradów, the rims of vessels with admixture of crushed *Inoceramus* shells in the ceramic fabric are qualified as of type D (according to the typology of U. Maj 1990, supplemented by the author of the article); the remaining rims are qualified as of types G, J, B and F. The majority of vessels was slipped in the upper parts of the belly and on the neck. The remaining rims were examples characterized by more elaborate working. The ornamentation of these vessels is the equivalent of a trend observed in the whole collection of the "white" pottery. It is noteworthy that all the vessels with admixture of crushed shells were discovered in features linked by U. Maj (1990, table II) to phase III of technological development of Stradów pottery (except for Feature 7 – phase II and Features 79 and 16/B – phase II or III).

The rarity of potsherds with admixture of crushed *Inoceramus* shells at the hillfort in Szczaworyż is indicative of the transfer of items rather than of some manufacturing idea. Regardless of both mentioned possibilities, this type of pottery proves the existence of some undetermined but direct contacts between the inhabitants of hillforts in Szczaworyż and Stradów.

Table 2. Stradów. Fragments of pots with an admixture of Inoceramus shells in the ceramic fabric

STRADÓW 1						
Feature no.	Pot no.	Edge	Ornament	Rolling area	Smudging	Percentage pots with carbonate admixture in the facility
2	11		g_{1-4}	3	-	45%
3	12		c_{3-6}	-	+	39%
4	13	D_2	e_6	4	-	49%
	18	D_2	E	3	-	
	23	G_4	-	2	-	
7	7	D_5	-	2	-	24%
14	15		$b_{3?}$	3	-	69%
17	6		i_6	4	-	36%
41	40		-	6	+	53%
44	19	D_6	-	3		67%
	39		-	?	?	
45	17	D_4	-	2	-	35%
61	2	F_2	e_5	3	-	40%
62	6	D_6	-	2	-	60%
	7	D_5	-	2	-	
	11		E	?	?	
73	3		c_3	3	+	56%
77	3	J_8	E	3	-	86%
	5		-	-	?	
	6		-	5	+	
	7		H	3	-	
79	4		E	5	+	40%
81	24		-	5	+	50%
88	8	G_1	e_6	3	-	63%
4/W	2		-	5	+	50%
9/B	8	B_2	E	2	-	24%
16/B	2		-	-	+	50%
25/B	5	D_3	-	2	-	55%
	8		-	5	-	
38/B	3	J_3	-	3	-	63%
	7	D_7	-	2	-	
	8	G_4	e_1	3	-	
	13		c_{3-4}	3	-	
1002/B	2	D_5	g_1	4	-	45%

CALCIUM CARBONATE INCLUSIONS IN POTTERY FROM STRADÓW AND SZCZAWORYŻ IN THE LIGHT OF SPECIALIST ANALYSIS

Pottery with calcium carbonate admixture in the ceramic fabric at sites in Stradów and Szczaworyż was distinguished on the basis of macroscopic observations proved with use of hydrochloric acid causing noticeable effervescence on the surfaces of potsherds). Physico-chemical research was also conducted in the case of a few potsherds (fragments made of clay with calcium carbonate admixture as defined by U. Maj, 1990).

Analyses of six fragments of vessels deriving from Feature 32/B (Barzyńskie settlement) in Stradów were performed at the Lviv Polytechnic and Lviv National Academy of Arts (Tyniec-Kępińska *et al.* 1996), including two macroscopic analyses confirming usage of calcium carbonate to "white" pottery production.

X-ray and structure research were conducted with the use of a DRON X-ray diffractometer. Their result is a conclusion that even samples where macroscopic observations do not indicate any presence of calcium compounds, there were trace amounts deriving from feldspars. The analysis of microstructures confirms that firing of vessels had taken place in relatively low temperatures (below 850-900°C).

Potsherds deriving from vessels made of ceramic fabric with admixture of calcium carbonate discovered at the site in Stradów were subjected to multilateral analyses in laboratories of the AGH University of Science and Technology in Kraków in the scope of the grant of the State Committee for Scientific Research nr 2H01H02623 (agreement no. 1056/H01/2002/23) under the title: *"The early medieval settlement complex in Stradów – specialist analyses of findings from the years 1956-1963"* (Szmoniewski *et al.* 2006).

The research at the AGH University of Science and Technology in Kraków was conducted in the scope of project "The characterisation of textures and structures of samples of ceramics from Stradów" implemented by a team under the supervision of Prof. A. Kielski and Dr K. Wodnicka (Szmoniewski *et al.* 2006).

Twelve samples of vessels were subjected to tests – samples were assigned by U. Maj (1990) to fabrics made of variations of carbonate admixtures: PR. 1 (Id), PR. 2, PR. 7 (Ia) (fragments of two different vessels), PR. 3 (If), PR. 4 (Ie), PR. 5 (Ib), PR. 6 (Ig), PR. 8 (Ic), PR. 9 (Il), PR. 10, PR. 11 (Ik), PR. 12 (Ih). The basic goal of these tests was to determine the technological characteristics of samples aimed at identifying methods of their production (*cf.* Szmoniewski *et al.* 2006). The results are as follows: all examined samples are distinguished by relatively high total porosity about 30%, characteristic for sherds. This porosity in conjunction with usually high values of specific surface area proves that the vessels were fired at relatively low temperatures. In some samples this conclusion is confirmed as well by presence of illite that would have been degraded in higher temperatures.

Vessels were made of marl clays, which is testified by their phase composition shown in X-ray research. In the majority of samples, calcite is present next to quartz as the main

phase, in several samples (nos. 1, 5, 6, 12) it is the main phase. Only in the case of a few samples (nos. 2, 4, 7, 8, 9) X-ray research did not reveal any presence of calcite. Accompanying phases are: microcline, albite and in single cases diopside and gehlenite. Such phase composition is fairly typical for aluminosilicate ceramic materials produced by firing marl clays. It is characterized by a high variability affecting the textural properties of examined vessels. Also, the helium density of examined samples is typical of aluminosilicate ceramics materials – it ranges between 2.6-2.7 g/cm^3. Assuming the lack of closed porosity on account of the low temperature of firing, density should be considered as equivalent to density of solid particles (specific gravity). Against this background, sample no. 8 stands out due to its elevated density plausibly as a result of organic admixture. The apparent density of the samples is considerably lower in comparison to their density due to significant porosity. The porosity is also characterized by the total amount of pores expressed in cm^3/g of material. The specific surface area is characterized by fluctuating numerical values which results from the presence of very small pores in the form of micropores and mesopores. The high values of the specific surface area prove the relatively low temperatures of firing vessels because these small pores disappear in the course of firing. Changeable numerical values are a consequence of changeable phase composition and presumably changeable conditions of firing of the vessels. It is worth noting that particularly high values of the specific surface area are usually connected with presence of illite. These samples, as it results from their macroscopic description, are characterized by increased fragility. The presence of illite may result from the low temperature of firing or process of rehydroxylation facilitated by low temperatures of firing.

Furthermore, some of the samples (ten, with three potsherds from Kurdwanów and one from Szczaworyż) were subjected to tests in the laboratory of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in Warsaw (Auch 2005). This research was aimed at getting information on the composition of the fabric of carbonate pottery. Samples were tested on the account of their absorbability, density of fabrics, non-elastic tempering admixtures and chemical composition of fabrics (the analyses were conducted with use of scanning microscope VEGA TS5135MM manufactured by Tescan company and optical spectrometer of X-ray fluorescence EDAX PV 9800).

Tests proved that samples from the Stradów vessels are of sufficient absorbance to enable their usual kitchen usage – in contrast to the fragments of vessels from Kraków-Kurdwanów (CL13436-13438 – Auch 2005, 89) where their permeability renders them unsuitable for any kitchen or table usage.

Analyses of the non-elastic tempering admixtures have shown that their macroscopic assessment sometimes is deceptive because the part of the analysed fragments did not in fact consist of fabrics with carbonate admixture (samples: CL 13427 kaolinite clay, CL 13428 ferruginous clay with a high amount of quartz pelite – *cf*. Auch 2005, 90).

The characterisation of pottery with calcium carbonate should be initiated with determination of macroscopic composition of ceramic fabrics. Often, mainly in materials from

Szczaworyż, the only admixture to clay is dusty calcium carbonate (for example: material from Features no.1 and 3) sometimes with noticeable uncrushed lumps of limestone (for example in Feature no.9 in Szczaworyż). A specific type of aggregate are fragmented shells of *Inoceramus* bivalve (see below). Potsherds made of such raw material usually are characterized by fine, dusty surfaces (see above: Sites 20 and 37 in Brzezie, Kłaj commune, to the right of the Vistula River – Tyniec 2012a, 65, 66; Tyniec 2012b, and the hillfort in Zawada near Tarnów – Okoński 1989, 128). A part of pottery with admixture of calcium carbonate has ceramic fabric with different kinds of crushed minerals (grains with a diameter up to 0.2 cm). The fabric of the "white" pottery from Stradów (as well as the vessels from Szarbia) also contain grains of sand (diameter up to 0.1 cm). The physic-chemical research shows that some vessels with different fabric than in case of "white" pottery also reveal the presence of carbonates in their composition. This results from the fact that they were produced with the use of feldspars. Similar "reflexes" may also result from the use or accidental addition of organic matter to the ceramic fabric. This type of pottery does not have any connection with the pottery defined as "white" (*cf.* Tyniec-Kępińska *et al.* 1996). Vessels made of ceramic fabric with admixture of calcium carbonate are absorbent which had impact on their functionality. Fragments of vessels were subjected to a simple test – they were soaked in water for 72 hours. Samples were weighed before and after soaking and then their weights were compared (*cf.* Auch 206, 87-89). The same test for kaolinite artefacts proved their better parameters.

Among fragments of "white" pottery from Stradów (518 artefacts), 239 rims of vessels were registered (this description of pottery is based on typology of rims and ornaments by U. Maj 1990). The vast majority of them are straight rims: 24% of type D (1-12, 16), 21% of type G (1-9), 16% of type F (1-9, 11, 13), 13% are of type J (1-10), 9% of type B (1-4), 4% of type A (1-4), type C (1-2) and type E (2-6, 8). The least numerous rims are of type M (expanded rims: 2-4, 6, 8, 10, 13) and type AB (1, 3). The best represented are variants: F_4 (15 artefacts), J_1 (13 artefacts), G_4 (12 artefacts), D_6 (10 artefacts), D_5 (8 artefacts), B_2 (8 artefacts), B_3 (8 artefacts).

In features in the hillfort of Szczaworyż, 178 potsherds with admixture of calcium carbonate were discovered, including 10 fragments of rims: 2 specimens of variant $F_{7,}$ G_4 and single fragments of variants AB_7, D_{14}, H_1, H_2, J_1 (according to classification of pottery for site in Stradów, Maj 1990).

Bases of vessels made with clay with calcium carbonate admixture are: flat (Szczaworyż, Features nos 1 and 13), with circumferential rings (for example: Stradów- Feature 11, vessel 4; Feature 18, vessel 14; Feature 24, vessel 7; Feature 26, vessel 28 *etc.* – *cf.* Maj 1990) or with impression of the axle of a wheel (Stradów, Feature 88, vessel 52; Feature 129, vessel 1 – *cf.* Maj 1990). There were also discovered bases with traces of sand (Stradów Feature 44, vessel 33 – *cf.* Maj 1990, 89, fig. 32: 33). Some bases are characterized by noticeable two layers (for example: Stradów, Feature 45, vessel 34 – *cf.* Maj 1990, 93, fig. 26: 34). Also bottoms with potter's marks were registered (for example Stradów, Feature 18, vessel 13; Feature 41, vessel 24 and 25 – *cf.* Maj 1990, 86, fig. 29: 24, 25).

The grade of slipping of the surfaces of vessels made of ceramic fabric with admixture of calcium carbonate should be investigated on the basis of the assemblage from Stradów. As it has been already mentioned, potsherds of "white" vessels are characterized by the very poor state of preservation resulting from conditions of the soil from which they were recovered. Traces of slipping in this material may be observed only on the basis of structuring of grains of the ceramic admixture. In the case of "white" pottery, it is not always possible on the grounds of macroscopic analyses (particularly in the absence of other admixtures). Damage to the surfaces make impossible determination of traces of slipping in the case of 38% fragments; a further 17% did not bear such traces. A significant part of the slipping on potsherds (26%) is linked with zone 4. The fragmentation of 12% of potsherds makes impossible precise identification from which part of the belly they came from. Generally these potsherds derive from vessels slipped in zones 2-4. A minimum percentage of potsherds (in total 5%) derive from vessels slipped in zones 2, 3 and 5.

The collection of so-called "white" pottery from Stradów is easier to identify and describe. Of the sherds of pottery made of ceramic fabric with calcium carbonate, 8% of the assemblage have destroyed surface, 10% have no traces of slipping. Of the remaining fragments of vessels: 35% have traces of slipping in zone 3, 17% fragments in zone 2, 17% fragments in zone 4, 9% in zone 5 and 4% in zone 6.

The ornamentation of vessels made of clay with admixture of calcium carbonate is diversified. The use of decorative motifs may be analysed on the basis of the pottery from Stradów. Just as in the case of determination of zones of slipping, the material from Szczaworyż may not be fully presented due to significant damage to the surfaces. There is no doubt that deepened ornamentation had a greater chance to be preserved than delicate surface traces of slipping, this is why this collection is interpreted as a random collection. In Stradów (according to the typology by U. Maj 1990), vessels were more often decorated with ornamentation included in her group e (38%), group b (18%) and group c (14%). Decoration of group g (9%), f (7%) and group a (5%) are less frequent. Decorative motifs of group h were determined in the case of 3% of the vessels, groups: k (3%), m (2%), d and l – less than 1%. In case of Szczaworyż, the percentage share of individual decorative elements is slightly different. Group e decisively outweighs the others (49%), with a high rate of groups a (20%) and b (12%). Decoration of the remaining groups: c (5%), g (5%), f (3%), k (3%), h (2%) were present only in the case of few vessels. Differences in selection of decorative motifs on vessels made of pottery fabric with calcium carbonate admixture result from tendencies noticeable at the described sites. Just as in the case of vessels made of other ceramic fabrics they are related to chronological transformations of ornamentation of vessels. It cannot be excluded that ornamentation was not only used to meet aesthetic expectations but it was also an element of a system of signs and performed some magical functions.

As discussed above, the temperature of firing (below 900° C) for potsherds with calcium carbonate admixture was confirmed in a laboratory and this proves the high proficiency of

the producers of this "white" pottery in selection of means of production. The chosen temperature of firing guaranteed obtaining durable vessels with high performance characteristics.

CONCLUSIONS

The appearance of well-dated pottery with calcium carbonate at sites in the Nida Basin is a very beneficial phenomenon for chronologic considerations regarding the development of pottery production in this region. In regards to the limited number of better dated examples (so-called "selected" artefacts), mainly these found in archaeological features, until we obtain new (non-archaeological) dates for some sites, this type of pottery remains an indicator of determined chronological period and the reference point for technological and stylistic transformations of the pottery.

The potsherds subjected to analyses have provided much information. Despite application of different methods of research and testing devices, it turns out that their results are convergent and comparable – at least at a general level. Analyses of the vessels proved also that their producers had working knowledge of secrets of pottery production resulting in vessels with the highest performance characteristics.

The research permits drawing several conclusions and suggestions. Parameters connected with absorbability substantiate the statement that whilst vessels made of carbonate ceramic fabrics at sites in Kraków, Nowa Huta and Stradów were typical utility (serving or cooking) vessels, at site in Kraków Kurdwanów they were numerous but of little use (*cf.* Auch 2005, 89). So the question is what motivated their producers and users? It seems that their absorbability made these vessels functioned as prestigious goods, or were related in some way with tradition (sort of an "ancestral porcelain"). It is similar to the situation in Szczaworyż where acidic soil and water damaged the vessels but despite this, they were still produced and carefully decorated. It is noteworthy that their ornamentation is similar to vessels deriving from the cemetery in Nitra Lupka.

Analyses on non-elastic tempers indicate that their macroscopic assessment can sometimes be deceptive and the part of fragments originally assigned to this fabric did not in fact come from vessels made with carbonate admixture (*cf.* Tyniec-Kępińska *et al.* 1996; Auch 2005, 90).

In the course of analyses into the chemical composition of fabrics, it turned out that samples deriving from two vessels form Stradów (*cf.* Auch 2005, 91: CL 13433 and CL13434: no. 6 from feature 45 and no. 11 from feature 88) are similar to vessels known from Bulgaria (including some from Pliska – Henning 2000; 2007). Significantly, it includes younger (*sic*!) carbonate pottery form Stradów dated to phase III with vessels strongly wheel-formed and slipped with low absorbability. It is possible that the direction of diffusion of ideas could have been opposite to that indicated by M. Auch (2005, 93). In the 8th and 9th century this type of pottery was developing in western Lesser Poland and in

the 10th century, the period of its prosperity, it was an inspiration to potters to the south of the Carpathian Mountains who so far had been using kaolinite clays (producing white and red-painted vessels)?

Finally, there is the matter of whether pottery calcium carbonate temper could have been some kind of a tribal emblem. It seems that it could. For more than 200 years, this product so sensitive to changes (see above), impermanent and challenging was dominant among vessels in western Lesser Poland. The attachment to tradition of production of vessels from such a challenging material requiring attention at each stage of production (mainly firing) testifies to the creation and maintenance of a specific style and consciousness of its integrating meaning inside a group. From the outside it indicates affiliation with the group. The group producing vessels made of calcium carbonate fabrics may be the Vistulans mentioned in written sources.

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