A C T A A R C H A E O L O G I C A C A R P A T H I C A
VOL. XLIX, 2014 PL ISSN 0001-5229

JANUSZ K. KOZŁOWSKI, MAŁGORZATA KACZANOWSKA,
AGNIESZKA CZEKAJ-ZASTAWNY, ANNA RAUBA-BUKOWSKA,
KRZYSZTOF BUKOWSKI

EARLY/MIDDLE NEOLITHIC WESTERN (LBK) VS EASTERN (ALPC) LINEAR POTTERY CULTURES: CERAMICS AND LITHIC RAW MATERIALS CIRCULATION

ABSTRACT

J. K. Kozłowski, M. Kaczanowska, A. Czekaj-Zastawny, A. Rauba-Bukowska, K. Bukowski 2014. *Early/Middle Neolithic Western (LBK) vs Eastern (ALPC) Linear Pottery Cultures: ceramics and lithic raw materials circulation*, AAC 49: 37–76.

In this paper we focused on the relations between the north-eastern range of the Linear Bandkeramik (LBK) in the Upper Vistula basin and the area of Eastern (Alföld) Linear Pottery Culture (ALPC) in eastern Slovakia, separated by the main ridge of the Western Carpathians. Contacts between these two Early/Middle Neolithic cultural zones were manifested by the exchange of lithic raw materials (Carpathian obsidian from south-eastern Slovakia and north eastern Hungary vs Jurassic flint from Kraków-Częstochowa) and pottery. Ceramic exchange was studied by comparing the mineralogical-petrographic composition of the local LBK pottery from sites in the Upper Vistula basin and sherds from the same LBK sites showing ALPC stylistic features, and pottery samples from ALPC sites in eastern Slovakia. Observation under polarized light microscope and SEM-EDS analyses resulted in identification of a group of pottery samples with ALPC stylistic features which could be imports to LBK sites in southern Poland from Slovakia, and a group of vessels with ALPC decorations but produced in the Upper Vistula basin from local ceramic fabric, which were imitations by the local LBK population. The second group of pottery appears mostly in the pre-Notenkopf and Notenkopf phases of the LBK, correlated with Tiszadob-Kapušany Groups of ALPC, in contrast to the pottery imports attributed mostly to the Želiezovce group/phase, synchronous with the Bükk Culture/Group.

Key words: Neolithic, Western Linear Pottery Culture (LBK), Eastern Linear Pottery Culture (ALPC), pottery technology, pottery, obsidian and flint imports

Received: 10.12.2014; Revised: 15.02.2015; Revised: 16.03.2015; Accepted: 17.03.2015

INTRODUCTION

The process of Neolithization of Central Europe — notably, the expansion of the first farmers and breeders to the Middle Danube basin — would be reflected by the emergence of two cultural traditions with common roots in the Early Balkan Neolithic represented by the Starčevo-Körös-Criş complex. These two new cultural traditions were: the Western Linear Pottery Culture (Linear Bandkeramik

Kultur — LBK) which grew out of the Starčevo Culture in Transdanubia, and the Eastern Linear Pottery Culture (Alföld Linear Pottery Culture — ALPC) evolved from the Körös-Criş tradition in the Tisza basin (Fig. 1). The processes of the formation of the Linear complexes took place between 5 600 and 5 300 cal BC. The Western Linear Culture (LBK) spread northward along the Danube and with time crossed the Carpathians and the Sudetes and spread over almost the entire western part of the European Lowland. The diffusion of the Eastern Linear Culture (ALPC) had a much smaller range, limited in the main to the eastern and the north-eastern part of the Carpathian Basin. The two Linear cultures were directly adjacent only in the territory between the Tisza and the Danube rivers in a sparsely inhabited territory, and in the region of Spiš. However, the contacts of the two cultures, consisting in the lithic raw materials and ceramics exchange over great distances far exceeded the range of the above-mentioned adjacent zones.

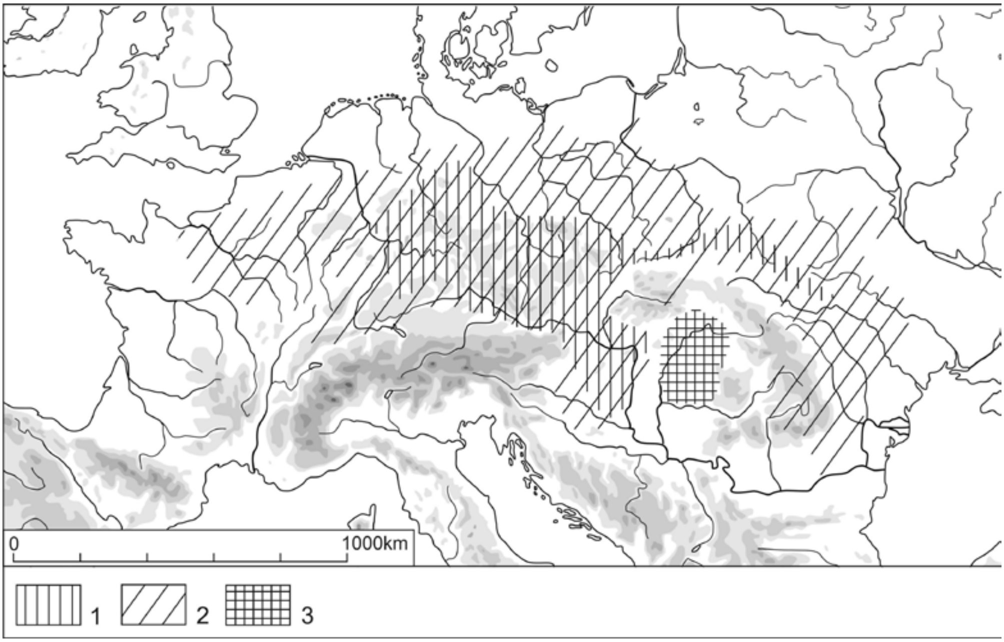

Fig. 1. Western LBK and Eastern ALPC.
1 — territory of the LBK earliest phase, 2 — major LBK extension, 3 — ALPC territory.

This paper offers new arguments concerning the long-distance contacts of the two Linear Cultures, some of them from an analysis of the provenance of ceramics which exhibit Eastern-Linear stylistics recovered from sites of the Western Linear Culture, first of all, in the Upper Vistula basin and in Spiš.

THE WESTERN LINEAR BAND POTTERY CULTURE (LBK)

The roots of the LBK are found in Transdanubia where the encounter took place between the Starčevo Culture and the — so-called — "Proto-Vinča" Phase (Kozłowski 1999, 158–160). The territories of Lower Austria, Moravia and eastern Slovakia also belong to the cradle regions of this culture. The formation of the LBK was related to complex processes of adaptation to environmental conditions in Central Europe. It was based on the elements of the Balkan-Danubian "Protolinear" Cultures together with strong influences from western Anatolia. Next to these factors, the impact of Mesolithic groups may also have played a role in the process of the regional evolution of the LBK (Czekaj-Zastawny 2008, 12, 13).

The fully mature LBK spread gradually north-west and north-east, mainly along the basins of the Danube, the Vah, the Morava, the Elbe, the Oder, and the Vistula rivers. Within between 300 and 400 years LBK settlement spread over a vast region between the Rhine and the Dnieper.

The main LBK expansion took place in the younger part of the older phase (Ib) synchronized in Western Slovakia with the Bíňa-Bicske or with the Milanovce horizons (Kulczycka-Leciejewiczowa 1964, 1979; Pavúk 2004) and lasted until about 5 400 cal BC. The next LBK expansion was during its Middle (Notenkopf) phase, lasting until about 5 000–4 900 cal BC (Bakels, Luning 1990; Pavúk 2004). At the beginning of the fifth millennium BC (4 900 cal BC) LBK occupied the European expanses from the Paris Basin as far as Ukraine and Moldavia, almost to the Black Sea.

As early as in Phase I the LBK reached Poland and spread to the west to the Upper Oder basin, and eastward as far as the Western Volhynian Plateau, northward to the region of Kuyavia and Chełmno Land. In all likelihood groups of LBK population had migrated to Poland from the territory of Slovakia, Bohemia and Moravia down two routes: via the Moravian Gate and via the Kłodzko Basin (Kozłowski 1999). So far a total of 29 sites dating to this early LBK phase have been identified in south-eastern Poland (Czekaj-Zastawny 2008; 2009; 2014).

Relative chronology of the LBK is based on the diagnostic features of ceramics correlated with the pottery seriation in south-western Slovakia that shaped the stylistic evolution of the LBK in south-eastern Poland (Fig. 2). The oldest, pre-Notenkopf, phase, is represented by assemblages of the Bíňa-Bicske phase (acc. to some researchers to the Milanovce horizon; Pavúk 2004) in south-western Slovakia and Austria (Kulczycka-Leciejewiczowa 1979, 51; Pavúk 1980, 7–90; Stadler, Kotova 2010), and it is divided into two sub-phases Ia (Gniechowice) and Ib (Zofipole) (Kulczycka-Leciejewiczowa 1964, 47–67; 1979, 19–164; 1983, 67–97). Phase II — Middle (the Notenkopf phase) has been sub-divided into three sub-phases: NI — the early sub-phase, NII — the classical sub-phase, NIII — the late sub-phase (Kadrow 1990, 9–76). In Phase III — Late (the Želiezovce phase) the sub-phases ŽI, ŽIIa, ŽIIb can be distinguished. Sub-phase ŽIIb has been registered only in the region around Kraków and in

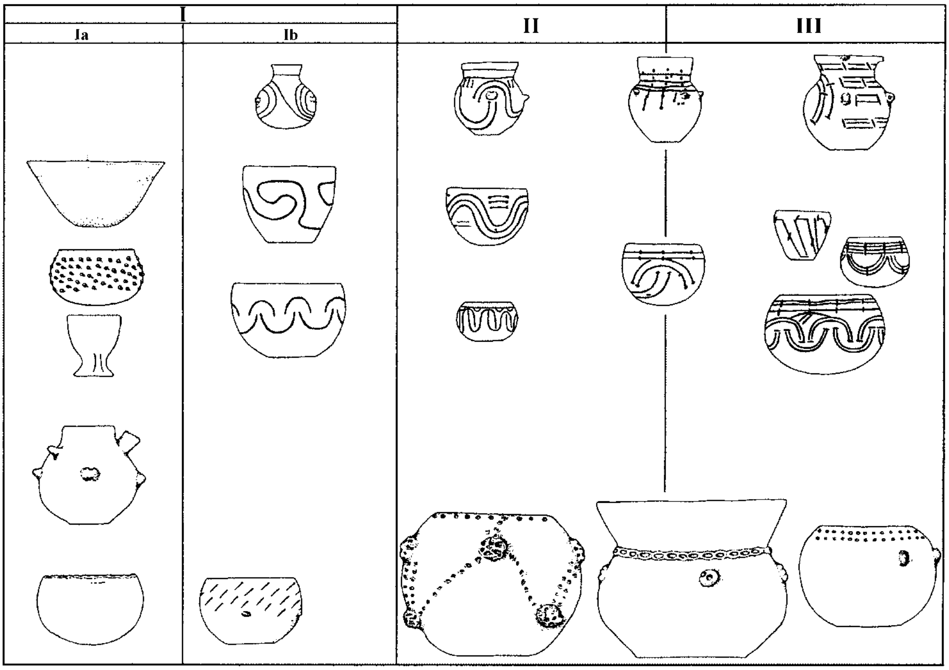

Fig. 2. Evolution of the pottery forms of the LBK in Lesser Poland.
Ia — Gniechowice phase, Ib — Zofipole phase, II — Notenkopf phase, III — Želiezovce phase.

Rzeszów. On the other hand, no characteristic finds of latest sub-phase ŽIII have been uncovered (G o d ł o w s k a 1982, 152–153; Kadrow 1990, 9–76). Absolute chronology indicates clearly that the beginnings of LBK settlement coinciding with the Gniechowice phase can be dated at 5 600/5 500 cal BC (K u k u ł k a 2001; C z e k a j - Z a s t a w n y 2008; 2014). Regretfully, C14 dates have not been yet obtained for Želiezovce IIb sub-phase which in south-eastern Poland defines the end of the LBK settlement. The latest dates for the Želiezovce phase were obtained from the settlement at Kraków-Pleszow 17 i.e. about 4 878–4781 cal BC (G o d ł o w s k a et al. 1987).

In the entire territory of south-eastern Poland about 800 LBK settlement points have been recorded (C z e k a j - Z a s t a w n y 2008; 2009), with two major identifiable concentrations of sites: a larger one to the left, and a smaller one to the right of the Upper Vistula River basin. In the light of evidence currently at hand we can say that the stimulus for the emergence of these settlement centres had come from specific environmental conditions, contacts and exchange. Other favourable factors were loess soils, well suited for the development of agriculture, the climate, and the well-developed river-network (C z e k a j - Z a s t a w n y 2008) but, even more importantly, the availability of lithic resources (mainly Jurassic flint) and, possibly, also the presence of salt springs (C z e k a j - Z a s t a w n y 2014).

Of major importance, moreover, was the fact that the LBK of south-eastern Poland was close to the northernmost range of the ALPC. In south-eastern Poland more than 50 all LBK sites with imports of Eastern Linear Pottery Culture (ALPC) have been registered (K a c z a n o w s k a, G o d ł o w s k a 2009). It seems that in the oldest LBK phase contacts between the two Linear complexes were sporadic; on the Poland area obsidian artefacts as well as pottery are practically absent, and on the southern side of the Carpathians early LBK sites with Jurassic and chocolate flint are rare (M a t e i c i u c o v á 2002). As the LBK further evolved exchange of goods between the two Linear Complexes gradually intensified. In the sites of the Notenkopf and and the Želiezovce phases more occupational episodes with ALPC imports have been registered (53 — the Notenkopf Phase, 51 — the Želiezovce Phase — K a c z a n o w s k a, G o d ł o w s k a 2009). The intensification of contacts between the LBK in south-eastern Poland and eastern Slovakia can be registered at most LBK sites in south-east Poland, notably from the end of the Notenkopf phase. First, of all, the quantity of imported obsidian increased up to more than 20% at the Želiezovce site of Rzeszów-Piastów; G o d ł o w s k a 1976, 89–92; K a c z a n o w s k a, G o d ł o w s k a 2009; K a d r o w 1990). The contacts between south-eastern Poland and eastern Slovakia ceased abruptly when the LBK and the Bükk Culture vanished. The following period on both sides of the Carpathians is characterized by a settlement hiatus, and the issue of the disappearance of both cultures is a current subject of discussion. Another colonization of these areas is associated with the second wave of expansion of the population from the south (K a c z a n o w s k a 1990; K a m i e ń s k a, K o z ł o w s k i 1990, 14–16; K o z ł o w s k i 2004).

On the southern side of the Carpathians LBK sites datable to its earliest phase lie at a relatively great distance from the main ridge of the Carpathians, mainly between the Morava, the Vah, the Nitra and the Hron rivers. During the next phases of LBK the situation is different: especially in Spiš, in the Upper Hornad and the Upper Poprad basins, the Notenkopf and the Želiezovce occupation may be seen to enter the river valleys and move northward, towards the main ridge of the Carpathians (S o j á k 1999; 2000).

The question of the origins of the LBK south of the Tatra Mountains continues to be discussed. One model assumes that the LBK settlement in Spiš could have been the effect of a migration of LBK groups from the region of Kraków, via the Dunajec and the Poprad basins, across the Tatras, back to Spiš (P a v ú k 1969; S o j á k 1999). During the Notenkopf phase the two main river basins in Spiš i.e. that of the Upper Poprad and the Hornad, had already been settled. The two valleys exhibit a homogeneity of stylistic evolution.

A different model of the emergence of the LBK settlement in Spiš is based on the subsequent, specific evolution in the Hornad and in the Upper Poprad basins, observable in the Želiezovce phase (S o j á k 1999; 2001). In comparison to south-western Slovakia, the sites in the Upper Poprad basin have yielded rare Želiezovce forms and the style of ornamentation evolved more slowly. In the Upper Hornad basin, on the other hand, the pottery style suggests LBK connections with Western Slovakia.

Spiš is exceptional as a region of overlapping of influences of the Western (LBK) and the Eastern Linear (ALPC) complexes. Next to fairly numerous LBK sites also the Bükk Culture settlements, mainly in the Hornad basin and single sites in the Poprad basin, have been recorded (S o j á k 1999). ALPC finds (the Tiszadob Group and, later, the Bükk Culture) recorded in LBK sites are mostly intrusions.

In Spiš there are no sites attributable to Pre-Notenkopf settlement. The oldest LBK finds belong to the Early Notenkopf phase. Just as in the case of sites in the Upper Vistula basin the chronological seriation in Spiš is based on phases distinguished for LBK in south-western Slovakia, in particular, on finds attributed to Notenkopf phases I, II and III. They are recorded in association with Tiszadob pottery imports.

A similar clear-cut classification cannot be applied to the Želiezovce Phase (Culture). In its style the pottery from the Upper Poprad basin displays no features other than those of the classical Želiezovce phase (ŽK II; S o j a k 2000). Complete sequences of the Želiezovce phases (Ž I–Ž III) are observed only in the Upper Hornad basin. Next to the prevalence of classical Želiezovce elements (ŽK II) also in evidence are finds typical of the youngest phase of the Želiezovce Culture (ŽK III).

Simultaneously, the Bükk Culture phases I (phase I corresponds to the Tiszadob Group), II, and II/III, appear in this region.

Thus, the youngest LBK in Spiš exhibits stylistic features typical of Želiezovce III phase and of the younger phase of the Bükk culture.

Regrettably there are no absolute determinations for sites in Spiš, while the time-span for the Linear Complex settlement can be estimated only approximately as 5 300 to 4 900 cal BC.

THE EASTERN LINEAR POTTERY CULTURE (ALPC)

The process of formation of the ALPC took place in the territory on the Middle and the Upper Tisza as a result of northward expansion of the Körös Culture (D o m b o r ó c z k i, R a c z k y 2010; R a c z k y et al. 2010). As a result, two transitional units may be seen to take form between the Körös and the ALPC cultures, viz.: the Szatmar and the Méhtelek groups (D o m b o r ó c z k i 2009, K o z ł o w s k i, N o w a k 2007). Further diffusion of the ALPC is marked by the appearance of Proto-Linear or Early Linear sites in the Košice Basin (Košice-Červeny rak — K a m i n s k a et al. 2008) (Fig. 3–Ia), Eastern Slovakian Plain (Slavkovce, Zalužice, Zbudza, Moravany and others — K o z ł o w s k i ed. 1997; N o w a k et al. 2010), also in Transcarpathian Ukraine (Zastavne — P o t u s h- n i a k 1992; 1995). The transitional Körös/ALPC phase is dated to the period 5630–5470 cal BC; the early phase of the ALPC, to the period between 5470 and 5300/5200 cal BC. At the end of the early phase of the ALPC the division can still be seen within the ALPC in the Košice Basin with, predominantly, pottery decorated with incised linear ornaments (Barca III group) and the ALPC variant

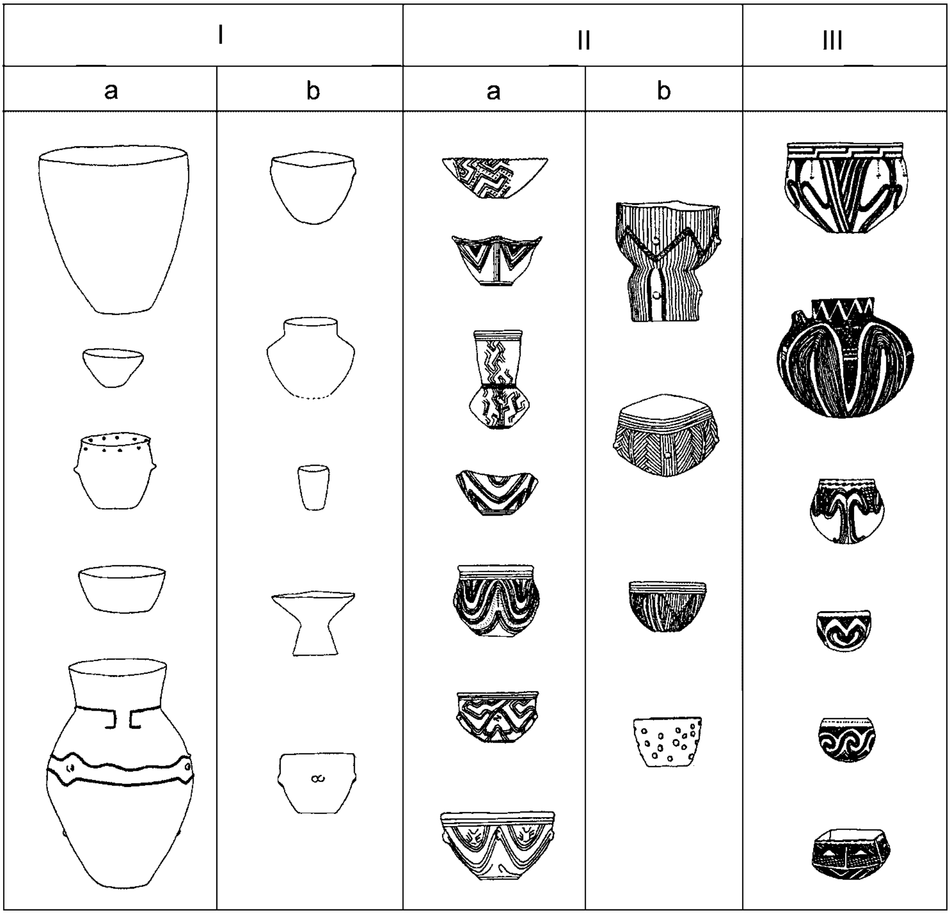

Fig. 3. Regional and diachronic variability of ALPC pottery.
I — the earliest phase (Ia — Košice-Červeny Rak group, Ib — Kopčany group); II — middle/younger phase (IIa — Tiszadob-Kapušany group, IIb — Raškovce group), III — Bükk Culture/group.

with black-painted pottery in Eastern Slovakia (Kopčany Group — Fig. 3–Ib) (Šiška 1989). Transcarpathian Ukraine belongs to the latter zone where M. Potushniak (1979) proposed to distinguish "the Painted Pottery Culture".

In sites of the transitional Körös/ALPC phase the lithic resource in use is always of local and mesolocal origin, mostly obtained in the Slovakian-Hungarian borderland (limnoquartzites, and Carpathian obsidian 2) and Transcarpathian Ukraine (mostly the stone used in the ground stone industry). In the Eastern Slovakian Plain during the early ALPC phase some imports of radiolarite from Šariš are recorded (Slavkovce — Kozłowski ed. 1997). The evidence for contacts with territories to the north and to the east of the Carpathians is exceedingly modest: some artefacts struck from Cretaceous flint from the Dniester basin were found at Zalužice and Moravany, and a trapeze struck from "chocolate" flint sourced in central Poland was discovered at Moravany (N o w a k et al. 2010). The occurrence of single artefacts struck from Cretaceous flint can hardly be explained in terms of exchange with the LBK population in the Dniester basin as it arrived in the Volhynian-Podolian Upland only later; moreover, at present there is no evidence on the presence of Late Mesolithic settlement on the Upper Dniester.

Imports of Transcarpathian raw materials in the early ALPC have no confirmed counterparts in the form of imports of raw materials from the Carpathian Basin in early LBK sites in the Upper Vistula basin. One possible import could be the trapeze struck from limnoquartzite discovered at Gwoździec in the Dunajec basin. The same site produced some early LBK pottery of Gniechowice and Zofipole type (K u k u ł k a 1997); this suggests a dating of 5400–5300 years cal BC. No other early LBK phase sites in south-eastern Poland has yielded raw materials that may be traced to the Carpathian Basin (C z e k a j - Z a s t a w n y 2008). Although obsidian artefacts are recorded at sites Mogiła 51 and 62, Rzeszów 3, Samborzec 1, in these sites pottery representing Gniechowice and Zofipole style was found in association with Notenkopf and Želiezovce style ceramics.

Subsequent evolution of the ALPC in the Carpathian Basin brings an expansion of this culture northward, along the Torysa River, towards the Šariš Basin (Š i š k a 1989). In the Sariš of the early phase of the Tiszadob Group (Fig. 3–IIa) were recorded in sites such as Prešov-Šarišske Luky. At the same time, the impulse from the Eastern Slovakian Plain reached the Šariš Basin by routes running in the Ondava and the Topla river valleys. These contacts are documented not only by the influx of obsidian to sites in the Šariš Basin (K o z ł o w s k i 1989) but also by the frequent use of black paint for pottery decoration which instead of the traditional curvilinear patterns is used to cover large areas of the vessel body and is often superimposed over the incised patterns.

In the Eastern Slovakian Plain during the same chronological horizon a local group with black-painted pottery may be seen to evolve, known as the Raškovce Group (Fig. 3–IIb; Š i š k a 1989). A similar style of pottery decoration is observed also in numerous sites in Transcarpathian Ukraine (P o t u s h n i a k 1995). The expansion of groups with painted ceramics came to a halt at the foot of the Vihorlat Mountains, although undoubtedly, this group had contacts with the Tiszadob area.

From the period when the Tiszadob Group was in existence contacts with the Transcarpathian region are confirmed by several finds of obsidian artefacts in Lesser Poland and — even a smaller number — of ceramic imports. One of them would be the vessel find from Kraków-Nowa Huta-Pleszów (K a c z a n o w s k a 1976; K a c z a n o w s k a, G o d ł o w s k a 2009, Fig. 2:3).

In the Košice Basin and in the Eastern Slovakian Plain the Bükk Culture evolved from the Tiszadob Group during the next chronological horizon of 5100–4900 cal BC. The Bükk Culture quickly spread across the whole Eastern Slovakia and expanded to the west along the Ipel River. The incised decorations and the technique of their execution employed in the Bükk (Fig. 3–III) Culture may be traced back to the Tiszadob Group, but painted decorations were used as well. Some role in the formation of the Bükk Culture was also played by local traditions deriving from other groups of the Late ALPC. The Bükk Culture achieved a very high standard of ceramic production. Moreover, this culture may have played a role in the distribution of Carpathian obsidian 2; the technology of processing of obsidian in specialized workshops is on a very high level (Šiška 1979).

Not only obsidian but also limnoquartzites were exploited in the Bükk Culture, worked in specialized workshops such as the one discovered at Boldogkőváralja (Vértes 1965), and radiolarites from the Šariš Basin (e.g. Šarišske Michalany with a deposit of radiolarite blades and cores, Kaczanowska, Kozłowski, Šiška 1993). Some Bükk Culture sites specialized in the production of ground and polished stone implements (Šiška 1984).

The most dense concentration of the Bükk Culture is seen in the territory previously occupied by the Late Eastern Linear groups; the Bükk Culture expanded more to the west, along the Ipel River as far as its upper basin. The Bükk Culture population also migrated to the north and entered the western part of the Šariš Basin, and even along the Hornad valley, as far as Spiš (Soják 1999). Individual Bükk Culture sites (but unrelated to the LBK) are recorded in the Poprad basin near Kežmarok. During this period the region of Spiš became a zone of contacts between the LBK and the Bükk Culture whose pottery occurs as an intrusion in LBK sites, mainly in the Hornad and the Poprad basins. The Bükk Culture is broadly distributed also outside the boundaries of the main concentration of its sites.

Ceramic imports of Bükk Culture and obsidian frequently occur at LBK sites of Western Slovakia (Pavúk 1969, 1994) and in Lesser Poland (Kaczanowska 1988; Kaczanowska, Godłowska 2009). The key territory for the contacts between the LBK and the Bükk Culture is western Spiš (Soják 2000). Investigations in the Upper Hornad and the Poprad basins should help us answer two questions essential for the relation between the LBK and the ALPC traditions:

a) was the origin of the LBK settlement south of the Tatras the effect of migrations from Lesser Poland down the valleys of the Dunajec and the Poprad (Pavúk 1969), or the consequence of the spread of LBK groups from Western Slovakia,

b) were southern contacts of LBK group established in Lesser Poland maintained only routes running down the Dunajec and the Poprad valleys, or did the mountain passes of the Eastern Beskidy Mountains also played a role?

A separate question are contacts between the Eastern and Western Linear Pottery Culture in Central and Western Slovakia and the role of these territories in the transmission of ALPC elements to Moravia and further to the west.

The question of the diffusion routes of the ALPC pottery and obsidian to the Upper Oder basin should be also looked into. Both routes: across the Little Poland as well as across the North-Western Slovakia are likely.

SELECTION OF POTTERY SAMPLES FOR MINERALOGICAL/CHEMICAL ANALYSIS

A series of seventeen sherd finds from LBK settlements found on the left bank terrace of the Vistula river, east of Kraków, were selected for analysis (Fig. 4). They display stylistic features not seen on LBK pottery but typical of the Eastern Linear Complex (Tiszadob and Bükk groups/cultures). The settlement sites which yielded these finds have a dating spanning the pre-Notenkopf phase, through the Notenkopf phase to the Želiezovce phase (Table 1, Fig. 5, 6). In 1957–1987 rescue excavations were conducted at these sites, their results published by M. Godłowska (1976; 1982; 1991; Godłowska et al. 1985).

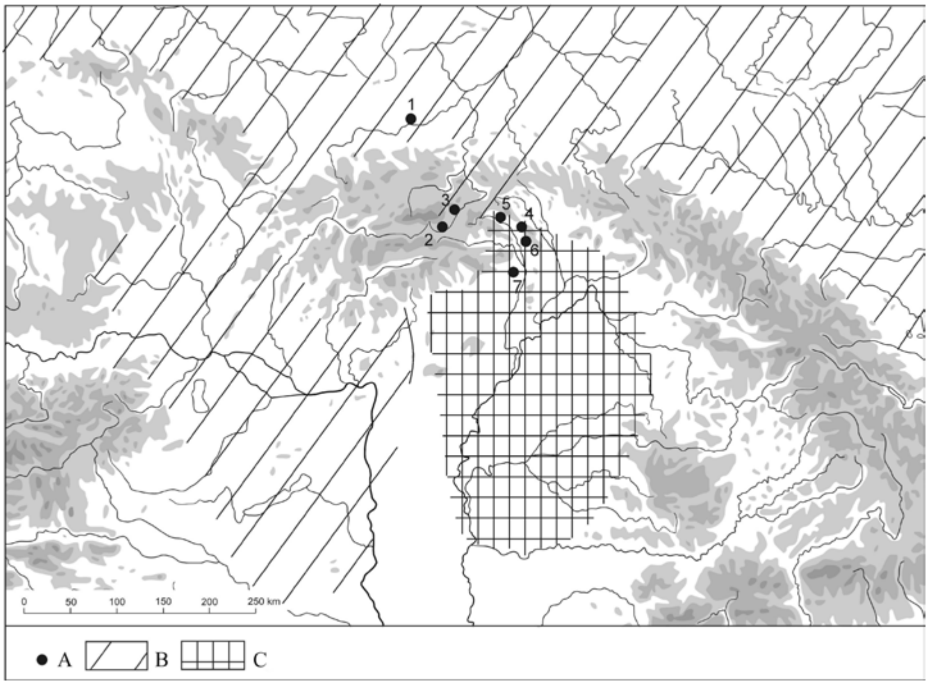

Fig. 4. Map of the sites from which pottery samples has been analyzed.

A — archaeological sites, B — major LBK extension, C — ALPC territory; 1 — LBK sites in the Upper Vistula basin, 2 — Matejovce (LBK), 3 — Stráne pod Tatrami (LBK), 4 — Vel'ký Šariš (ALPC), 5 — Smižany-Smižanska roveň (LBK/ALPC), 6 — Prešov-Solivar (ALPC), 7 — Košice-Galgovec.

Mineralogical-chemical examination of ceramics from LBK sites in western Lesser Poland helped in identifying the characteristic attributes of local raw materials used in the pottery manufacture (Rauba-Bukowska, Czekaj-Zastawny 2007).

In the present project ceramic samples representing the Bükk Culture from Eastern Slovakia (Spiš, Šariš and Košice Basin — Table 2, Fig. 7) were analyzed. In addition, a clay sample was obtained from the profile at Lipany in the territory of the Eastern Linear Pottery Culture.

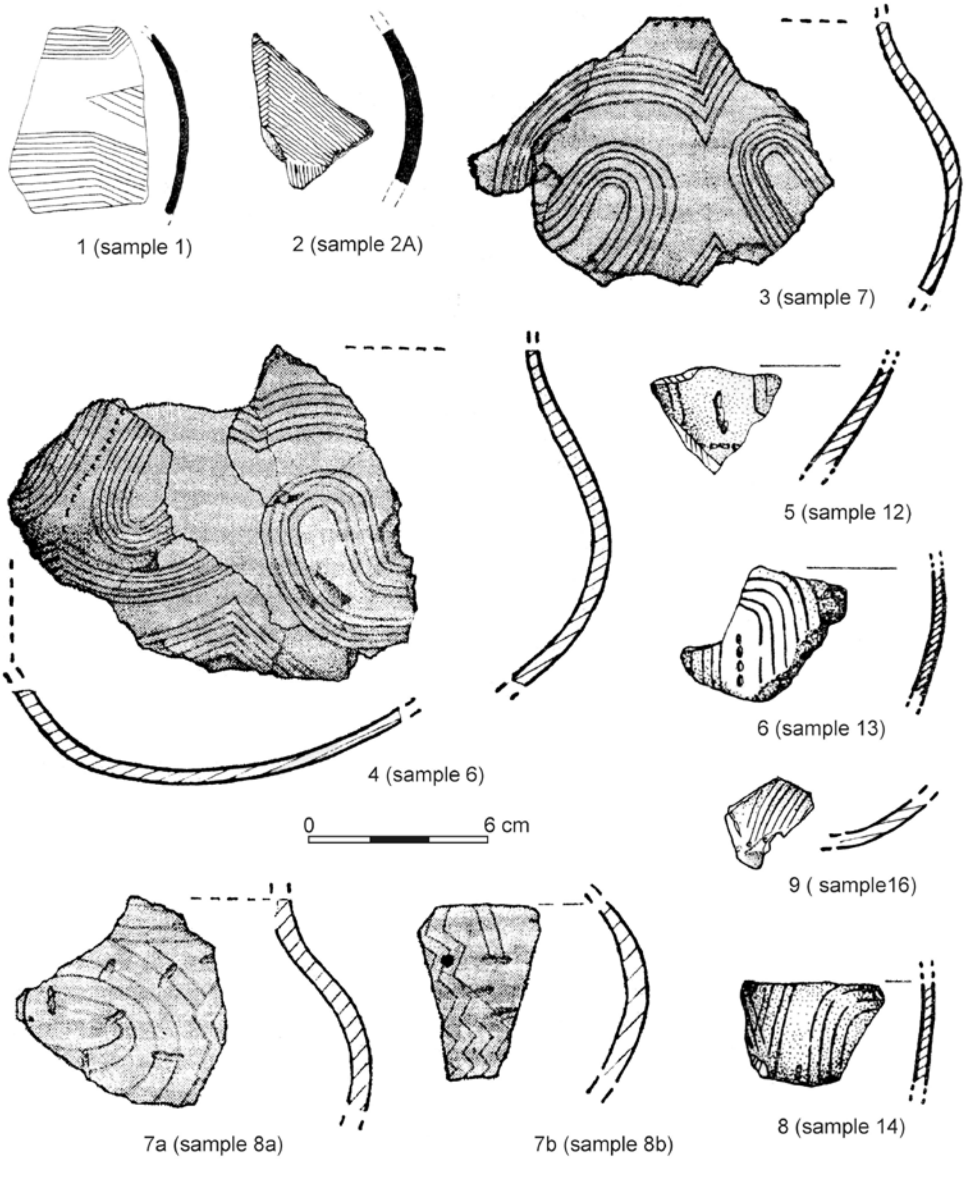

Fig. 5. Samples of pottery from LBK sites in the Upper Vistula basin, representing ALPC stylistics.

As a result, a mineralogical-chemical base was created to distinguish ceramics manufactured from local raw materials in the Upper Vistula basin which differ in their style from LBK pottery, and ceramics LBK stylistic forms and decorations imported from the region to the south of the Carpathians.

Table 1

Samples of pottery with Eastern Linear stylistics found in LBK sites in Lesser Poland

Samples	Site	Pit.	Ceramic context	Cultural attribution of the sample	Vessel type	Decoration	Fig
1	Kraków-Nowa Huta-Pleszów 17	605A	LBK Želiezovce Phase	Bükk Culture	Deep bowl	Incised and negative	5:1
2A	Pleszów 17	697	LBK Želiezovce Phase	Bükk Culture		Fine, deep incised lines	5:2
2B	Pleszów 17	697	LBK Želiezovce Phase			Double incised line „M" motif	6:1
3	Pleszów 18	35	LBK Notenkopf Phase			Incised lines	
4.	Kraków-Nowa Huta-Krzesławi-ce 41	5	LBK Želiezovce Phase			Four parallels incised lines in the shape of a bow	6:2
5	Krzesławice, 41	5	LBK Želiezovce Phase			Straight parallel incised lines	6:3
6	Krzesławice, 41	90	LBK Notenkopf Phase	Bükk Culture	Bowl with quadrangular body	Six parallel incised spiraloidal lines	5:4
7	Krzesławice 41	90	LBK Notenkopf Phase	Bükk Culture	Bowl with quadrangular body	Six parallel incised spiraloidal lines	5:3
8A and B	Krzesławice, 41	90	LBK Notenkopf Phase	Želiezovce Phase	Vessel with distiguished neck and globular body	Spiraloidal lines separated by vertical zigzag incised lines	5:7a, 7b
9	Kraków-Nowa Huta-Mogiła 55	125	Secondary deposit	LBK	Globula deep bowl	Irregular vertical zigzag incised lines	6:4

Samples	Site	Pit.	Ceramic context	Cultural attribution of the sample	Vessel type	Decoration	Fig
10	Mogiła 62	29A	LBK Želiezovce Phase	Bükk Culture	Deep bowl	8 parallel curvilinear incised lines	6:5
11.	Mogiła 62	49	LBK Želiezovce Phase		Bowl	Parallel double incised lines straight and zigzag; between lines 2–3 strokes.	6:8
12.	Mogiła 62	129	Secondary deposit	Bükk Culture	Bowl	Fine incised lines and strokes	5:5
13	Mogiła 62	151	LBK Notenkopf Phase	Bükk Culture	Deep bowl	Six fine incised parallel bow-shaped lines and four strokes	5:6
14	Mogiła 62	158	LBK Želiezovce Phase	Bükk Culture	Deep bowl	Four parallel finely incised lines	5:8
15	Mogiła 62	296	LBK Pre-Notenkpf Phase	Kapušany–Tiszadob Group	Funnel shaped neck fragment	Double zigzag incised line parallel to the rim and vertical zigzag line	6:6
16	Mogiła 62A	165	LBK Notenkopf Phase	Bükk Culture	Deep bowl	8 fine incised bow-shaped lines	5:9
17	Mogiła 62B	58	LBK Pre-Notenkpf Phase	Kapušany-Tiszadob Group	Body fragment	Double irregular incised line	6:7

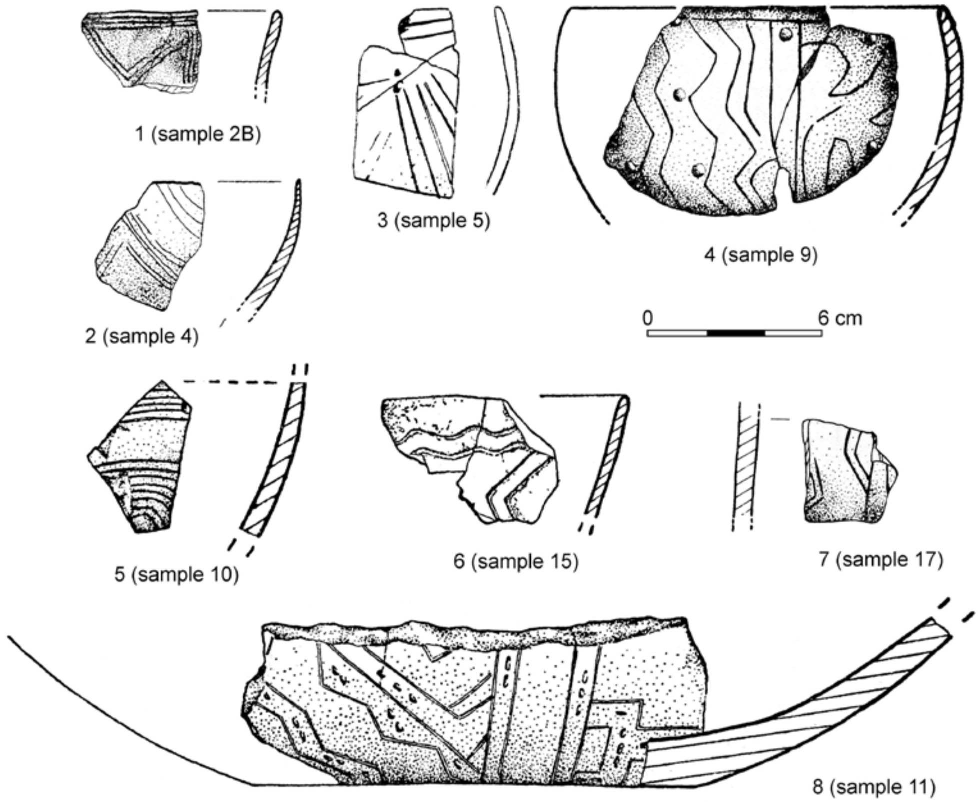

Fig. 6. Samples of pottery from LBK sites in the Upper Vistula basin, representing ALPC stylistics.

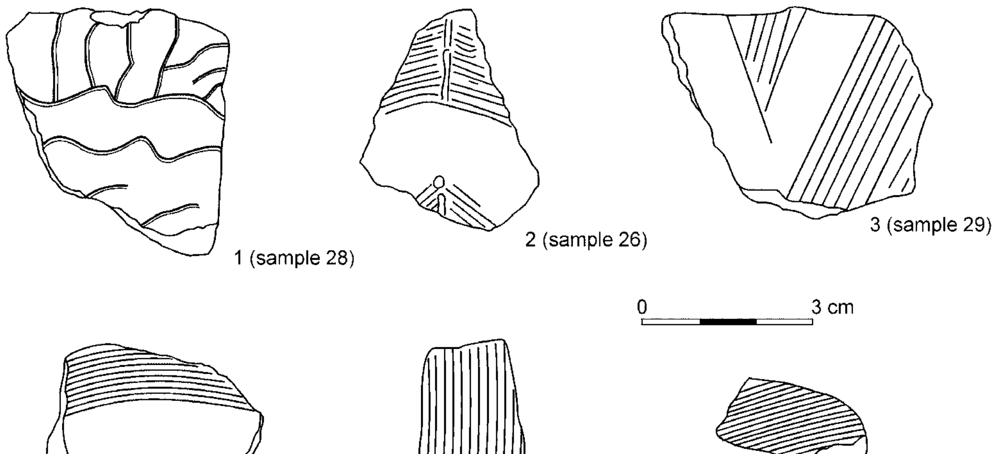

Fig. 7. Samples of pottery with Eastern Linear stylistics from Eastern Slovakian ALPC and northern Slovakian LBK sites.

Table 2

Samples from Eastern Slovakian sites

Sample	Site	Cultural attribution of sample	Vessel	Ornament	Fig.
18	Košice-Galgovec	Bükk Culture	Fragment	Undecorated body fragment	
19	Prešov-Solivar	Bükk Culture	Fragment	Undecorated	
20	Prešov-Solivar	Bükk Culture	Fragment	Undecorated	
21	Prešov-Solivar	Bükk Culture	Fragment	Undecorated	
22	Prešov-Solivar	Bükk Culture	Deep bowl fragment	10 fine incised bow-like lines	7:4
23	Prešov-Solivar	Bükk Culture	Deep bowl fragment	20 parallel fine incised	7:6
24	Prešov-Solivar	Bükk Culture	Fragment	Undecorated	
25	Vel'ky Šariš	Bükk Culture	Fragment	Undecorated	
26	Vel'ky Šariš	Bükk Culture	Bowl fragment	Angular decoration from 11 parallel fine incised lines	7:2
27	Vel'ky Šariš	Bükk Culture	Bowl fragment	14 parallel fine incised lines	7:5
28	Smižany-Smižanska roven	Kapušany- Tiszadob	Fragment	Horizontal and vertical undulated lincised lines	7:1
29	Stráne pod Tatrami	Bükk Culture	Deep bowl fragment	Angular negative decoration from finely incised lines	7:3
30	Matejovce	Bükk	Deep bowl fragment	Undecorated	
31	Lipany		Raw material (clay) sample		

GEOLOGY AND GEOMORPHOLOGY OF THE STUDY AREA

Study area in Poland

The archaeological sites of Pleszów, Mogiła, and Krzesławice are located to the north of the Vistula River Valley, in Nowa Huta, the easternmost district of Kraków, Poland. The sites of Brzezie and Targowisko lies to the south of the Vistula River Valley, between Kraków and Kłaj (Fig. 8).

In geological terms, the archaeological exploration area is located within the Carpathian Foredeep. The Miocene Carpathian Foredeep basin developed in front of the advancing Carpathians. Foredeep infill consists of the marine sedimentary

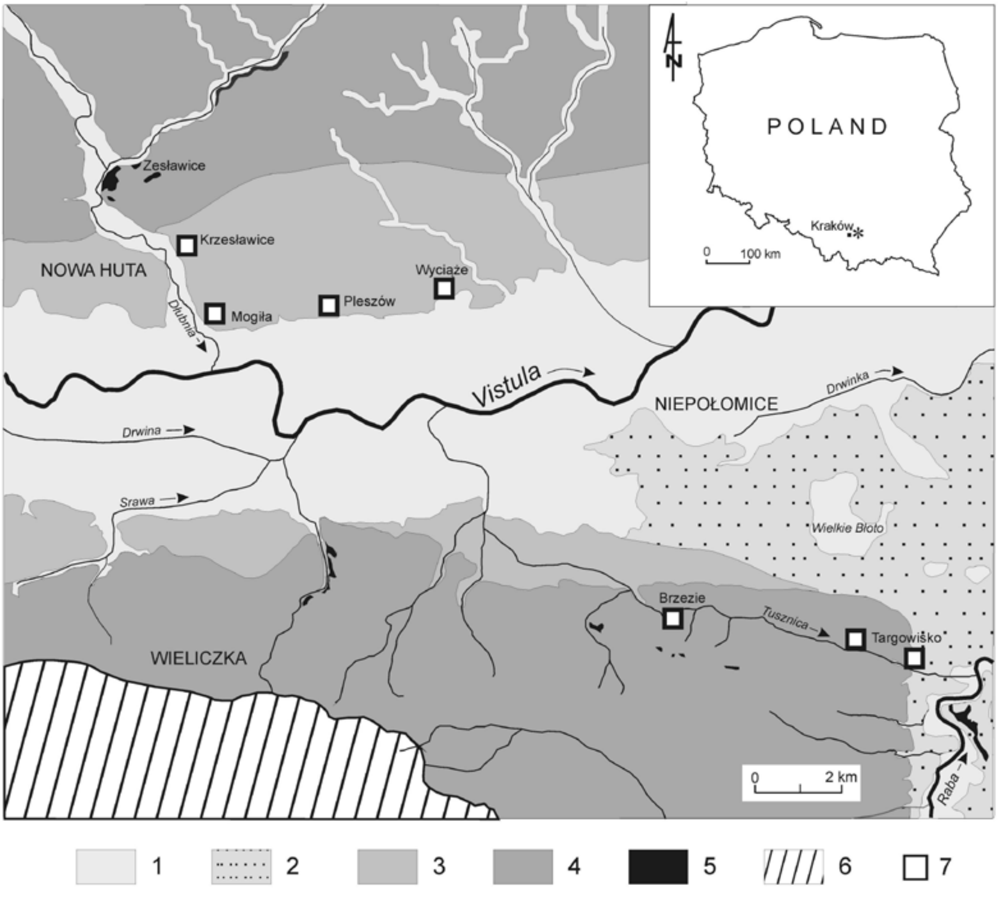

Fig. 8. Section of a covered geological map of the studied area showing relevant archaeological sites (simplified after Burtan 1954; Gradzinski 1955). Drawn by K. Bukowski.

1 — alluvial soils, sands, and gravels of the floodplain terraces of the Vistula and Raba rivers, Holocene; 2 — sands and gravels of the supra-floodplain terraces of the Vistula and Raba rivers, Pleistocene; 3 — loess covering the upper supra-floodplain terrace of the Vistula River Valley, Pleistocene; 4 — loess, Pleistocene; 5 — Chodenice and Grabowiec beds, Miocene; 6 — Carpathian flysch, Cretaceous-Paleogene; 7 — site locations.

sequence, clays and marly clays, interbedded with sandstone and locally, with characteristic tuffite levels, includes important evaporitic formation (salts, gypsum and anhydrites). These Miocene sediments are covered the Quaternary sediments (Pleistocene and Holocene sediments). The profiles of Miocene formations are known only from boreholes and rare open pits e.g. at the Zesławice Brickyard and small outcrops occur in areas where Quaternary sediments were eroded (e.g. scarps of rivers valleys). These outcrops are known from study area close to the excavation sites at Brzezie and Targowisko (Fig. 8).

The Quaternary deposits mostly contain alluvial sediments, including fluvioglacial sands and gravels which fill the Vistula River meltwater valley, loess deposits creating the cover of the upper terrace of the Vistula and occurring on elevations, as well as Holocene alluvial soils, sands, and gravels, deposited within the floodplain terrace of the Vistula River and its tributary valleys.

The excavation sites north of the Vistula River (Kraków-Nowa Huta-Krzesławice, Mogiła, Pleszów and Wyciąże) lies within the upper supra-floodplain terrace formations (Fig. 8), rising to the height of 6–25 m, composed of lime sands and gravels, sands and clays, all covered by a 10–15 m layer of loess.

The sites excavated to the south of the Vistula River (Brzezie and Targowisko) lie on loess deposits. The site at Brzezie is situated in the headwaters area of the Tusznica, minor left-bank tributary of the Raba River and occupies a small flatland, hemmed in by a steep slope. The site at Targowisko lies close to the edge of the left-bank supra-floodplain terrace of the Raba River. Loess is the soil bedrock at both sites (Fig. 8).

At the time of the expansion of Neolithic cultures the Vistula River was accumulating sediment in the lowlands (the remains of this process may be observed in the forest of Grobla near Niepołomice). The process was associated with high humidity periods at the beginning of the Atlantic period (Kalicki, Starkel 1989) and it left its traces in the form of the river bed avulsion in the Vistula River Valley. At the beginning of the Subboreal (ca. 3300 BC), the Vistula River started to cut through the bedrock. This was probably caused by climatic change and mounting anthropogenic changes in the Vistula catchment area, especially those caused by the arrival of humans in the Carpathian Mountains at the turn of the Neolithic and the Bronze Age (Valde-Nowak 1988).

Study area in Slovakia

The investigated material was selected from among ceramic artefacts excavated in sites in Northern and Eastern Slovakia (Fig. 9) lying within two regional geological units: the Paleogenic Inter-Carpathian Basin (Stráne, Matejovce, Smižany, and Veľký Šariš sites) and the Miocene East Slovakia Basin (Prešov-Solivar and Košice-Galgovec).

For the most part in the study areas older deposits (Paleogenic and Miocene) are buried under a compact layer of decayed Quaternary clays, 2–5 m thick.

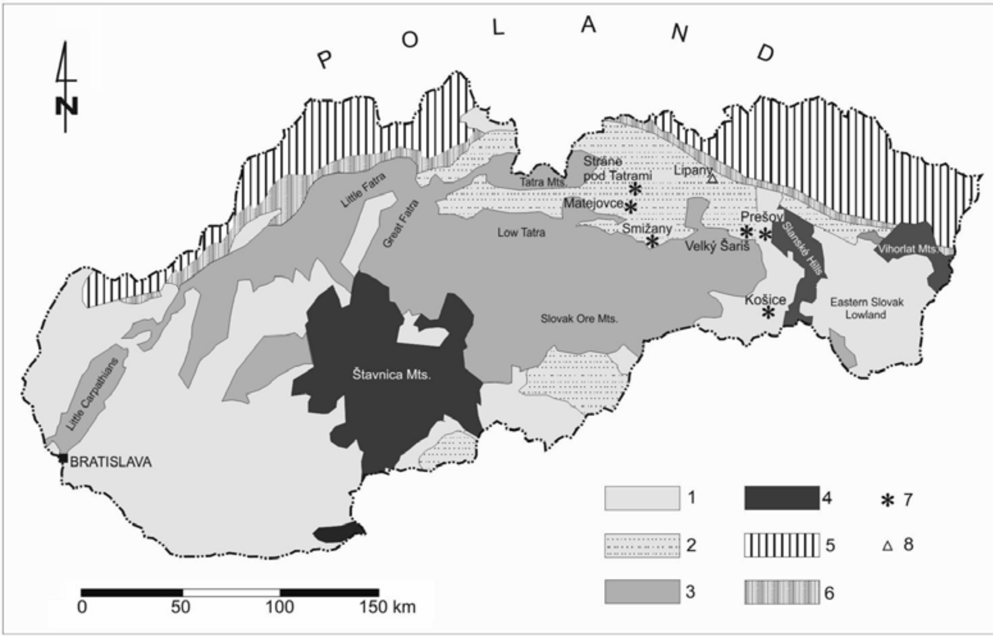

Fig. 9. Location of sites on the geological map of Slovakia (after M a h e l, B u d a y 1968). Drawn by K. Bukowski.

Legend: 1 — Neogene deposits (Miocene-Pliocene); 2 — Inter Carpathian Paleogene deposits; 3 — Palaeozoic and Mesozoic formations (not separated); 4 — Volcanic mountains, Neogene; 5 —Flysch Carpathians; 6 — The Pieniny Klippen Belt; 7 — archaeological sites; 8 — raw material sampling location.

River valleys are filled with Quaternary alluvial deposits, from several to about a dozen metres in thickness.

During the Quaternary the lithology and the genetic diversity of deposits, including those in the Carpathian region, reflected changes in relief and climate. In the lands of present-day Slovakia (differently than in Poland) the glaciations caused the development of mountain glaciers (in the Tatra and the Lower Tatra Mountains). Intense frost weathering occurring in the periglacial climate caused disintegration of rocks and the formation of wide alluvial fans and mudflows at the foot of mountains. Some of these proluvial deposits are found at the foot of the Tatra Mountains and of the Slanské Hills (Fig. 9). During the Pleistocene these fluvio-glacial systems of deluvial deposits and alluvial fans were covered by aeolian layers of loess. An unbroken loess cover and loess-like formations are present in most of the study area. Another characteristic feature of this part of the Carpathian Mountains is the presence of extensive volcanic mountains, which took form during the final (Badenian-Samratian) stage of the Carpathian orogeny. Built of andesites and, in part, of rhyolites, the Slanské Hills represent just such a type of formation in the area under study (M a h e l, B u d a y 1968).

When analysing the mineral composition of the raw materials used in ceramic production we need to consider the lithology of older (pre-Quaternary) rocks found in the study area, their transformations caused by erosion, and physical and chemical decay. Older rocks are often the sources of materials transported by rivers (alluvial deposits), mass movement diluvium or wind (loess).

MINERALOGICAL-PETROGRAPHIC ANALYSIS OF POTTERY FROM LBK SITES IN WESTERN LESSER POLAND AND THE QUESTION OF IDENTIFICATION OF CERAMIC IMPORTS

Materials and objectives of the research

The research objective was identifying the mineralogical-petrographic composition of pottery from LBK sites found on the left bank of the Vistula River to the west of Kraków. Analysis focused on 17 potsherds featuring stylistic elements attributed to Eastern Linear pottery found in LBK context (Table 3). For comparison, 13 fragments from Eastern Linear Pottery sites in eastern Slovakia (Table 4) were analyzed as well. Also addressed were crucial questions of similarities and dissimilarities of imported and locally produced pottery and the correlation of the analyzed materials with their counterparts from eastern Slovakia.

Research methods

Thin sections taken from pottery fragments were examined with a polarized light microscope. Next, methods of the quantitative petrographic analysis (point counting) were used to determine the percentage of individual components, such as clay minerals, quartz, alkali feldspars, plagioclases, muscovite, biotite, carbonates, grains of sedimentary, igneous and metamorphic rocks, grog fragments, and organic materials. Granulometric analysis was made to measure grain diameter of crystal grains and clay clasts. Calculation was made within the following ranges: 0.002–0.02 mm, 0.02–0.05 mm, 0.05–0.1 mm, 0.1–0.2 mm, 0.2–0.5 mm, 0.5–1 mm, 1–2 mm and Ø> 2 mm. Classification of the Polish Society of Soil Science from 2008 was used as a reference (Polskie Towarzystwo Gleboznawcze 2009). Samples were assigned to groups using the hierarchical cluster analysis and the formula of average taxonomic distance (ATD):

$$d = \sqrt{\frac{\sum_{k=1}^{m}(x_{ik} - x_{jk})^2}{m}}$$

where:
m = the number of features taken into account, x_{ik} and x_{jk} correspond respectively to value k — of specific feature for i — of this, and for j — of that structure.

The starting point in the analysis was the mineralogical-petrographic composition and content of grains with a diameter of 0.1 mm and more (Tables 3, 4).

Table 3

Mineralogical composition od samples. Value in percentages

Samples	Clay minerals	Quartz Pelit	Quartz	Flint/ chalce dony	K-feld- spars	Plagio clases	Crumbs of sedimen tary rocks	Crumbs of igneous rocks	Crumbs of metamorphic rocks	Musco vite	Biotite	Opaque minerals	Clay clasts	Grog	Organic fragm.	Voids	Others
1	56.7	18.3	8.8						2.3	8.2		1.3	3.1		0.3	0.3	0.7
2A	51.0	19.2	4.7			0.6			7.9	13.0		1.5	0.6		0.6	0.9	
2B	52.8	9.0	8.3	0.4						1.2	0.4		2.0	20		5.9	
3	76.5	8.2	5.5		0.4					1.2		1.9	1.2		1.6	3.5	
4	83.6	8.0	1.7							0.3		2.7	2.7			1.0	
5	73.7	8.7	5.0		0.6					0.9		2.5	3.4		0.9	3.4	0.9
6	55.1	20.7	10.8	1.0	0.7				0.0	3.6			1.3			6.3	0.5
7	60.5	19.2	9.2	0.5	0.3	0.2			0.8	3.6		0.8	0.8		0.5	3.3	0.3
8	48.4	25.6	5.8		0.7				0.0	6.9		1.4	9.4			1.8	
9	62.7	1.9	1.3							0.0		0.6	9.8		12.3	11.4	
10	71.6	10.2	9.0							1.3		0.3	3.0		3.6	1.0	
11	49.3	19.0	9.7		1.1					0.0		1.1	2.8		9.4	7.4	0.2
12	49.3	19.5	16.3		1.4				0.4	5.3	0.4	3.2	1.4			2.8	
13	47.1	18.4	18.4	0.2	1.0	0.2			0.6	5.5	0.3	2.3	1.9			3.5	0.6
14	52.4	21.5	12.3		1.2				1.2	2.2		2.4	0.0			6.5	0.3
15	69.7	5.8	2.2		0.7					0.4		1.5	0.4		10.2	8.4	0.7

Samples	Clay minerals	Quartz Pelit	Quartz	Flint/ chalce dony	K-feld-spars	Plagio clases	Crumbs of sedimen tary rocks	Crumbs of igneous rocks	Crumbs of metamorphic rocks	Musco vite	Biotite	Opaque minerals	Clay clasts	Grog	Organic fragm.	Voids	Others
16	51.0	23.8	12.2		1.0				0.3	5.1	0.6	1.6	0.0			3.8	0.6
17	51.4	11.1	3.8							0.7		0.3	11.5		18.1	3.1	
18	48.3	19.4	13.8		0.9		0.4	0.9		5.6	0.4	4.3	0.4			2.2	0.8
19	42.0	14.0	11.1	0.3					1.3	5.6	0.3	1.0	16.0			8.5	0.3
20	46.8	14.3	12.3	0.6	1.3				1.0	5.8		1.3	16.0			0.3	0.3
21	52.4	15.0	10.0		0.4				1.1	0.0		0.7	16.9			3.4	0.1
22	47.4	8.6	11.0		0.3			0.7	0.3	0.7		0.0	24.5			6.5	
23	50.0	9.5	8.1		1.4				1.0	0.0		1.0	27.0		1.0	1.0	
24	54.9	12.2	13.5					0.7	0.3	1.4		1.4	14.2			1.4	
25	56.7	7.3	8.4	0.4	0.4	0.4		14.6		1.0	0.1	0.8	3.4			6.5	
26	48.6	20.0	14.5					1.0		5.9		0.7	4.5			4.5	0.3
27	46.2	16.1	22.1	0.1	1.7	0.1			3.0	3.3		1.66	4.3		1.0	0.3	0.3
28	56.8	21.2	5.7		1.1	0.1			5.3	6.1		1.9	0.8		0.8		0.4
29	60.8	16.7	8.4		1.1	0.1			0.8	7.2	1.1	1.1	1.1			1.5	0.1
30	50.0	19.0	9.1		1.2				0.4	8.7	1.2	4.8	3.2			2.4	0.1
31	46.2	13.8	14.8		3.1		0.9	0.3	7.9	2.5		2.2	6.3			1.9	0.1

Table 4

Individual grain size mesurements of the sample. Value in percentages

Samples	<0.002 mm clay	0.002–0.02 mm silt	0.02–0.05 mm silt	0.05–0.1 mm sand	0.1–0.2 mm sand	0.2–0.5 mm sand	0.5–1 mm sand	1–2 mm sand	–
1	56.7	19.26	20.21	3.19	0.53	0.11	0.00	0.00	0
2A	51.0	22.97	18.99	5.80	1.14	0.11	0.00	0.00	0
2B	52.8	19.15	19.54	6.38	1.93	0.19	0.00	0.00	0
3	76.5	9.37	11.27	2.51	0.26	0.09	0.00	0.00	0
4	83.6	7.76	6.72	1.70	0.22	0.00	0.00	0.00	0
5	73.7	11.59	10.79	3.40	0.53	0.00	0.00	0.00	0
6	55.1	18.41	21.47	4.09	0.84	0.09	0.00	0.00	0
7	60.5	17.78	16.65	3.80	1.20	0.07	0.00	0.00	0
8	48.4	25.00	23.28	2.98	0.34	0.00	0.00	0.00	0
9	62.7	19.52	12.90	4.53	0.35	0.00	0.00	0.00	0
10	71.6	11.54	14.66	2.02	0.18	0.00	0.00	0.00	0
11	49.3	24.30	21.56	3.14	1.05	0.65	0.00	0.00	0
12	49.3	21.93	23.96	4.18	0.63	0.00	0.00	0.00	0
13	47.1	21.88	25.70	4.63	0.69	0.00	0.00	0.00	0
14	52.4	17.15	22.05	6.30	1.75	0.35	0.00	0.00	0
15	69.7	11.65	16.32	2.07	0.26	0.00	0.00	0.00	0
16	51.0	20.97	22.43	4.82	0.78	0.00	0.00	0.00	0

Samples	<0.002 mm clay	0.002–0.02 mm silt	0.02–0.05 mm silt	0.05–0.1 mm sand	0.1–0.2 mm sand	0.2–0.5 mm sand	0.5–1 mm sand	1–2 mm sand	–
17	51.4	21.20	20.64	5.07	1.69	0.00	0.00	0.00	0
18	48.3	18.59	24.14	8.05	0.92	0.00	0.00	0.00	0
19	42.0	23.92	25.21	7.12	1.75	0.00	0.00	0.00	0
	46.8	22.57	22.94	6.56	1.13	0.00	0.00	0.00	0
21	52.4	19.99	22.68	4.18	0.60	0.00	0.15	0.00	0
22	47.4	21.44	21.22	6.96	2.32	0.66	0.00	0.00	0
23	50.0	19.15	23.39	5.44	2.02	0.00	0.00	0.00	0
24	54.9	16.93	19.77	7.04	1.22	0.14	0.00	0.00	0
25	56.7	19.24	16.84	3.21	2.94	1.07	0.00	0.00	0
26	48.6	23.84	22.35	4.10	0.93	0.19	0.00	0.00	0
27	46.2	21.78	25.14	6.37	0.52	0.00	0.00	0.00	0
28	56.8	21.37	18.09	2.96	0.78	0.00	0.00	0.00	0
29	60.8	20.23	15.97	2.37	0.56	0.07	0.00	0.00	0
30	50.0	20.73	21.50	6.14	1.45	0.17	0.00	0.00	0
31	46.2	23.81	21.13	6.09	2.33	0.45	0.00	0.00	0

For visualization, dendrogram in MATLAB R2007b software was adopted. The results of granulometric analyses were presented using GRAPHER 3 software. The research was carried out at the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology in Kraków.

Following the preliminary thin section analysis twenty-one samples were selected for examination under scanning microscope (SEM-EDS) to observe "fresh" pottery breaks at higher magnification using X-ray analysis. This study was made at the Laboratory of Scanning Microscopy of the Institute of Geological Sciences Jagiellonian University using HITACHI S-4700 microscope with NORAN Vantage microanalysis system.

Laboratory research results

Observations under polarized light microscope

The first series of examinations were applied to samples from the following archaeological sites: Kraków-Nowa Huta-Pleszów 17 and 18, Kraków-Nowa Huta-Krzesławice 41, and Kraków-Nowa Huta Mogiła 55, 62 and 62a (Tables 3–4, Fig 5, 6). The analyzed pottery fragments have distinctive decorative motifs not typical for LBK.

Resulting microscopic observation of samples, preliminary division into raw-material and technological groups was made. The obtained data on the structure and texture of the analyzed samples confirmed the use of two types of raw material and different methods of preparing the ceramic paste.

The first raw material type is marked by a low content of the silty fraction and a high percentage of clay minerals (62.7–83.6%). It is represented by samples nos. 3, 4, 5, 9, 10, and 15. Their mass contained small amounts of coarse quartz (up to 9%) and muscovite (0–1.3%), but also traces of clay clasts. In samples nos. 4, 5, 10, 15, and 17 there were also relics of sea plankton, mainly *Foraminifera, Diatom* or *Radiolaria*. The examined fragments were made of heavy fine-grained clays, not very well mixed (Fig. 10). All potter's pastes were tempered by a significant amount of organic material. The shape and inner structure of these organic remains suggest that they came from plants. In sample no. 4 the presence of organic remains was intimated by empty spaces.

The second raw material type had a higher content of the silty fraction and a lower content of clay minerals than in the first group (47.1–60.5%). It is represented by samples nos. 1, 2A, 6, 7, 8, 12, 13, 14, and 16. Some larger grains were also observed. Clastic elements include grains of quartz, feldspar and fragments of metamorphic rocks (0–7.9%). The muscovite content is higher than in the first group (from 2.2% to 13%) while fragments of clay clasts are less frequent. Due to the presence of basic grain fractions (clayey, silty and sandy) the samples in question represent heavy clay (no. 7), clay (nos. 1, 6, 14) and silty clays (nos. 2A, 8, 12, 13, 16). The potter's pastes are well mixed with only a small amount

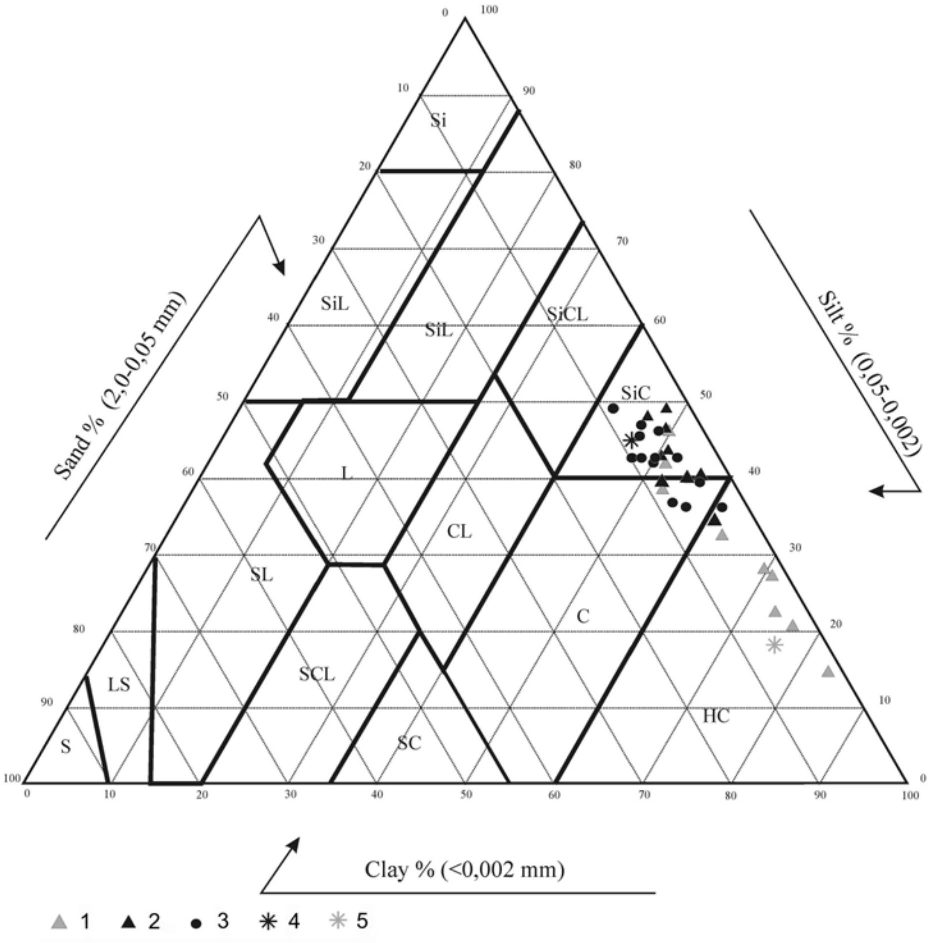

Fig. 10. Triangular diagram showing the clay : silt: sand ratio for the analyzed samples. Note, the both imported Bükk culture pottery and pottery from Slovakia mostly represent silty clay and clay. Local imitations usually are made from heavy clay. Drawn by A. Rauba-Bukowska.

1 — local imitations of ALPC vessels, 2 — imported ALPC vessels, 3 — ALPC (Bükk Culture) pottery from north-eastern Slovakia, 4 — sample of raw material from Slovakia, 5 — samples of raw material from the right bank of the Vistula river; C — clay, HC — heavy clay, Sc — silty clay, SC — sandy clay, Si — slit, SiCL — silty clay loam, SiL — silty loam, L — loam, CL — clay loam, S — sand, LS — loamy sand, SL — sandy loam, SCL — sandy clay loam.

of larger grains. A very small amount of organic material was observed in only a few samples (nos. 1, 2A, 7).

Fragments nos. 2B, 11 and 17 cannot be classified to either of the two groups described above. Sample 2B contains small amount of clay minerals but has a high content of clay clasts and grog particles. There is also — as in the first raw material type, a small content of silt and muscovite. While organic material is absent some well rounded quartz grains (admixture of sand?) were observed.

Although mineralogically this sample is close to samples of the first type of raw material its technological features are different.

Sample no. 11 is marked by a very low content of clay minerals and a high content of silty fraction, typical for the second raw material type. At the same time, it also contains some organic admixture and very rare mica flakes.

Sample no. 17 (like sample no. 2B) contains less clay mineral and clastic materials. In the clay matrix some rare mica flakes were observed. A diagnostic element (indicating local origin of the raw material) is the significant percentage of sea plankton remains (mainly siliceous). Also observed are numerous fragments of unmixed clay (also with plankton) and a significant percentage of organic admixture (18.1%).

The next stage of analysis focused on pottery fragments of the Linear Pottery Culture from eastern Slovakia: from the vicinity of Košice (Galgovec), Prešov-Solivar, Veľký Sariš, and from Spiš: the vicinity of Spišská Nová Ves (Smižany) and Poprad (Matějovce, Stráne pod Tatrami), a total of 13 fragments.

The pottery samples from Slovakia vary in their mineralogy and petrography. In all of them the percentage of clay minerals is relatively low (42–60.8%). The material of samples nos. 24, 25, 28, 29, 30 with a small amount of the silty fraction, may be classified as typical clay. At the same time, most samples represent silty clays (Table IV). Clastic elements observed include alkali feldspars, a small amount of plagioclases and fragments of igneous and metamorphic rocks. Many grains, due to their very small dimension, could not be identified. One sample (no. 25) is marked by the presence of coarse grains of volcanic rocks — 14.6%, small flint fragments and a small amount of muscovite. The other pottery fragments, from Veľký Sariš (26, 27) and Košice-Galgovec (18), have similar characteristics. Their fine pelite mass contains grains of rocks (mainly metamorphic) and muscovite flakes. The clay matrix was contains small clay clasts, especially visible in samples from Veľký Sariš (nos. 26, 27).

The series from Prešov Solivar (nos. 9–24) is set apart by its fairly high content of clay clasts (between 14.2 and 27%). Samples nos. 21, 22, 23 and 24 contain a negligible amount of mica flakes (0–1.4%). In samples nos. 19 and 20 there were fragments of clay clasts with volcanic glass, grains of thermal altered glauconite, small amphiboles and muscovite (a few percent).

Three samples from Spiš (28, 29, 30) are more clayey. Their pastes are homogenous and fine grained, with a small amount of rock fragments and muscovite (6.1–8.7%).

The pottery fragments from Slovakia contain only a very small amount of organic material, insignificant from the technological point of view. No plankton remains were observed. In general, their fabric are homogenous (except for the specimens from Prešov Solivar), practically with no admixture, well made, and of low porosity.

The raw material from the area of Lipany (sample no. 31) was collected from colluvial sediments at the base of an escarpment. It was fired in electric kiln in a temperature of 700°C, for 12 hours. It is composed of a clayey matrix (46.2%)

and fine-grained clastic material, sub-rounded and moderately sorted, features that suggest not very distant transportation. In its clay matrix there are mainly quartz grains but also alkali feldspars and rock fragments (in most part metamorphic). Also observed are infrequent mica flakes, glauconite, precipitations of iron oxides and hydroxides, and crumbs of ferruginous clay clasts. The material belongs to silty clays.

All the pottery fragments described above are fine-grained, with a silty fraction dominant in detritic material. Some of the ceramic finds from Poland (samples nos. 3, 4, 5, 9, 10, and 15) contain only a small amount of silt (up to 32%) and a corresponding higher percentage of clay minerals. The other vessels from Poland, and also from Slovakia, are marked by containing a high amount of silt. A feature characteristic for most of the samples is well sorted material. In samples nos. 2A, 2B, 14, 18, 19, 20, 22, 23, 24, 25, 30, and 31, an increased amount of coarser fraction can be observed. Visible are bigger grains and fragments of clay clasts, including chamotte. By correlating the three major grain fractions the analyzed material may be divided into: heavy clays — samples nos. 3, 4, 5, 7, 9, 10, 15, and 29, clays — samples nos. 2B, 1, 6, 14, 24, 25, 28, and silty clays, samples nos. 2A, 8, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27, 30, 31 (Table 3, 4; Fig. 10).

Scanning microscopy (SEM-EDS analyses)

EDS analysis of the clay matrix revealed the presence of MgO, K_2O, CaO (Table V, Fig. 11A). Samples from sites in the vicinity of Kraków and Veľký Sariš have a higher content of CaO, while those from Prešov Solivar, Košice, Smižany and Strána have a lower content of CaO and MgO. The fragment from Matějovce is marked by its low content of CaO content and the highest content of MgO. Samples from vicinity of Lipany are made exceptional by a marked percentage of MgO and K_2O, and no CaO content.

The examined samples may be divided into a number of groups shown in the diagram (Fig. 11A):

1. Group I — samples nos. 26, 27 (Veľký Sariš), 2B (Kraków Nowa Huta-Pleszów), 9, 10 (Kraków Nowa Huta-Mogiła) with high content of CaO.

2. Group II — samples nos. 1 (Krakow-Nowa Huta-Pleszów), 6, 7, 8 (Krakow-Nowa Huta-Krzesławice), 14 (Kraków-Nowa Huta-Mogiła), 25 (Veľký Sariš) and 28 (Smižany). They have a slightly lower content of CaO and a higher content of K_2O.

3. Group III — samples nos. 18 (Košice-Galgovec), 29 (Stráne), and 20, 22 and 23 (Prešov-Solivar). They have higher content of K_2O at the expense of calcium, and a higher content of MgO.

Sample no. 30 (Matějovce), made exceptional by its high magnesium content, and sample nos. 31 (raw material from Lipany) containing no calcium, are unique. A loam sample collected near to the site at Brzezie was found to be relatively similar to samples taken at Prešov Solivar (Rauba-Bukowska 2009, 238).

Table 5

Geochemical analysis of Neolithic pottery from Poland and Slovakia by EDS. Value in percentages

Samples	Site	Magnification	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3
1	Pleszów	×50	0.86	1.17	20.42	49.42	9.07	3.56	4.64	1.00		9.87
2B	Pleszów	×50	0.23	0.97	17.17	58.59	7.70	1.98	4.09	1.11		8.16
6	Krzesławice	×50	0.56	1.04	19.25	53.67	11.74	2.67	2.44	1.35		7.29
7	Krzesławice	×50	0.74	1.34	18.16	53.90	9.24	3.30	3.32	1.45		8.56
8	Krzesławice	×50	0.62	1.02	17.80	54.56	10.86	1.93	2.03	1.07		10.12
9	Mogiła	×50	0.59	1.95	17.30	40.47	9.39	2.00	3.36	0.68	2.90	21.35
10	Mogiła	×50	0.17	1.00	19.31	44.89	16.75	1.76	2.98	0.79		12.35
12	Mogiła	×50	0.51	1.12	18.78	47.14	14.00	2.20	2.43	1.44		12.38
13	Mogiła	×50	0.00	1.26	20.08	50.24	10.94	3.14	2.56	0.76		11.02
14	Mogiła	×50	0.63	1.20	18.93	49.32	13.62	2.64	2.71	1.01		9.94
18	Koszyce	×50	0.59	0.77	22.26	42.87	10.81	3.41	1.73	0.73		16.84
20	Presov Solivary	×50	0.48	0.77	21.97	54.33	3.83	2.84	0.44	1.13		14.21
22	Presov Solivary	×50	0.71	1.61	21.09	53.64	5.77	2.65	0.75	1.19		12.59
23		×50	0.26	0.93	23.11	51.75	6.34	2.68	0.33	0.72		13.89
25	Velki Saris	×50	0.57	1.08	19.44	46.57	13.26	3.19	4.55	0.81	0.43	10.09
26	Velki Saris	×50	0.58	1.61	15.99	54.24	11.02	2.95	4.31	1.26	0.48	7.56

Samples	Site	Magnification	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3
27	Velki Saris	×50	0.55	1.52	17.85	51.97	11.68	2.91	4.50	0.97		8.05
28	Spisz	×50	0.78	1.16	16.16	61.52	5.57	2.82	3.21	0.69		8.10
29	Spisz	×50	0.46	1.13	23.43	53.86	7.50	4.07	2.04	0.77		6.75
30	Spisz	×50	0.39	2.84	27.68	39.44	10.12	1.77	0.73	1.31		15.73
31	Lipany	×50	0.79	3.94	17.24	63.31	0	4.07	0.00	0.82		9.83
BVI- -miocene clay. Poland	Brzezie	×50	0.59	2.22	18.03	66.13	0	3.30	0.88	0.84		8.01

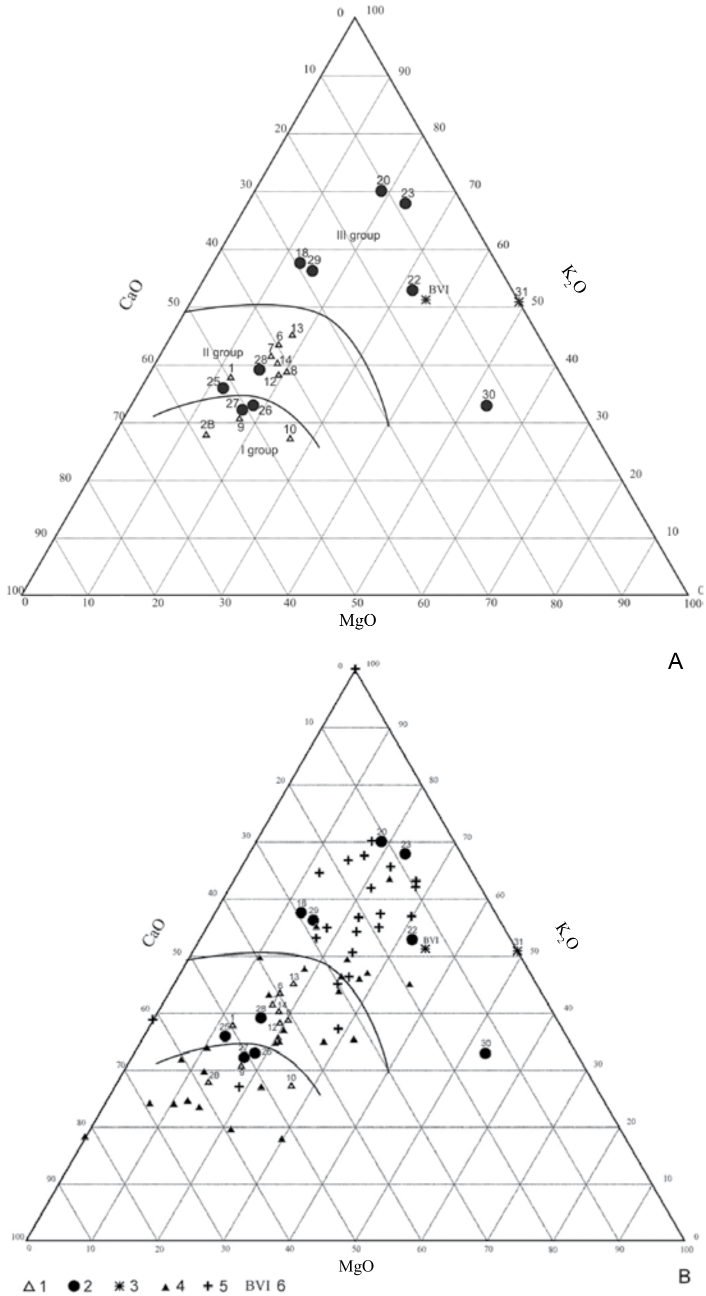

Fig. 11. Triangular diagram showing MgO : K_2O : CaO ratio. Drawn by A. Rauba-Bukowska.
A — samples analyzed in this article can be divided into three classes; B — comparison with LBK pottery samples from left and right bank of Vistula river. 1 — pottery samples from Lesser Poland (ALPC imports and imitations), 2 — pottery samples from ALPC sites in Slovakia, 3 — sample of raw material from Slovakia (Lipany), 4 — LBK pottery samples from sites on the left bank of Vistula river, 5 — LBK pottery samples from sites on the right bank of Vistula river, 6 — sample of raw material from the right bank of Vistula river (Brzezie).

DISCUSSION

The general picture of the potter's paste is formed by utilized raw materials, temper and their preparation. Some of these elements can be analyzed, others — like the degree of its working-out escaped objective assessment. Not all of the analyzed elements can be correlated. Furthermore, identification of raw material sources can be hindered by the complexity of local geology and geomorphology of a given site and, especially, by cover uniformity on vast areas.

Taking into account the geological setting and, especially, the Quaternary sediments found in Poland and Slovakia, it is possible to suggest a number of source areas for the analyzed raw materials. Samples from Poland (nos. 3, 4, 5, 9, 10, 15, 17) contained skeletons of sea plankton known to occur in Miocene clays of the Carpathian Foredeep. Thin-walled pottery from Slovakia (samples nos. 18, 26, 27, 28, 29, 30) and Poland (1, 2A, 6, 7, 8, 11, 12, 13, 14, 16) was produced from fine-grained silty (loess-like) material. Within them were found fragments of metamorphic rocks. Mineralogical and petrographic tests confirmed that some of the rock debris found within the silt in areas of Slovakia in question reflects the local nature of the geological structure of bedrock. In the case of the sites located in the Tatra Mountains foothills region (samples nos. 28, 29 and 30), one can find debris of crystalline rocks (e.g. granite or gneiss), quartz and sandstone, with silica cement. In the case of the ceramic artefacts from the Prešov area (samples nos. 25, 19, 20), where intensive volcanic processes were essential for the development of the geological structure of the region, they included fragments of volcanic rocks and volcanic glass, as well as single pyroxenes and amphiboles (main minerals in andesites). It is noteworthy that such evident indicators appear often in the coarse pottery.

For comparing materials from Poland and Slovakia, and for distinguishing local imitations from imports, several analytical steps have been taken, in the first place — the comparison of series of vessels with each other versus raw materials available locally (Lipany — Spiš region). The analysis of the mineralogy and content of grains >0.1 mm in samples suggest the following classification (Fig. 12):

1. The first and the most frequent group includes samples from Polish sites (which on the basis of microscopic observations have been classified into second raw material group) and also vessels from Slovakia sites. This group may be divided further into two sub-groups:

1a. This sub-group includes potsherds from Krakow-Nowa Huta-Krzesławice (samples nos. 6, 8), Krakow-Nowa Huta-Mogiła (nos. 11, 12, 13, 14, 16), Košice-Galgovec (no. 18), Veľký Sariš (nos. 26, 27), Matějovce (no. 30) and Lipany (no. 31). They are marked by a high content of the silty fraction and a low percentage muscovite. Sample no. 11 is exceptional as it contains no muscovite but has a high amount of organic admixture.

1b. This sub-group includes samples no. 1 and 2A from Poland, nos. 7, 28 and 29 from Slovakia, and differs from sub-group 1a by having a lower content of quartz.

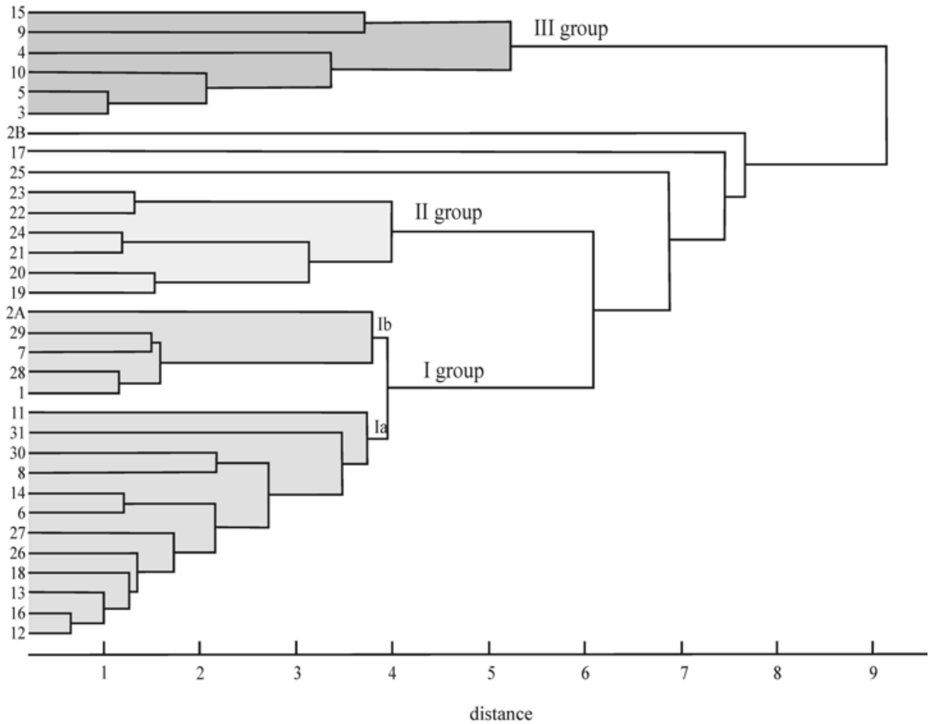

Fig. 12. Hierarchical cluster analysis of the analyzed samples. Dendrogram reveals three main clusters (colored) and three samples weakly correlated with them. Drawn by A. Rauba-Bukowska.

Both subgroup contain no organic admixture and only a small quantity of sub-rounded fragments of metamorphic rocks. The paste is homogenous and carefully prepared.

2. This group includes all samples from Prešov Solivar (nos. 9–24) and a pottery fragment from Krakow-Nowa Huta-Pleszów (no. 2B). They contain a smaller quantity of quartz pelite and a high amount of detritus of clay clasts and grog. No organic admixture.

3. This group includes samples from Polish sites classified to first raw material type, as identified by microscopic observation (samples nos. 3, 4, 5, 9, 10, 15). They contain only small amounts of quartz pelite and muscovite. Organic admixture appears relatively often. The texture can be described as loamy, with visible hollows and defoliations.

The analysis of thin sections of local pottery from sites in Kraków Nowa Huta-Mogiła (R a u b a - B u k o w s k a 2007; R a u b a - B u k o w s k a et al. 2007) indicates that Miocene clays, probably from the Dłubnia River valley, were the main raw material used in pottery production. They contain a high amount of clay minerals (heavy clay) and only a small amount of detritic material — quartz and feldspars. Rock fragments are rare and muscovite content low. Visible are relics of sea plankton: *Foraminifera, Diatom* and *Radiolaria*. Such features can

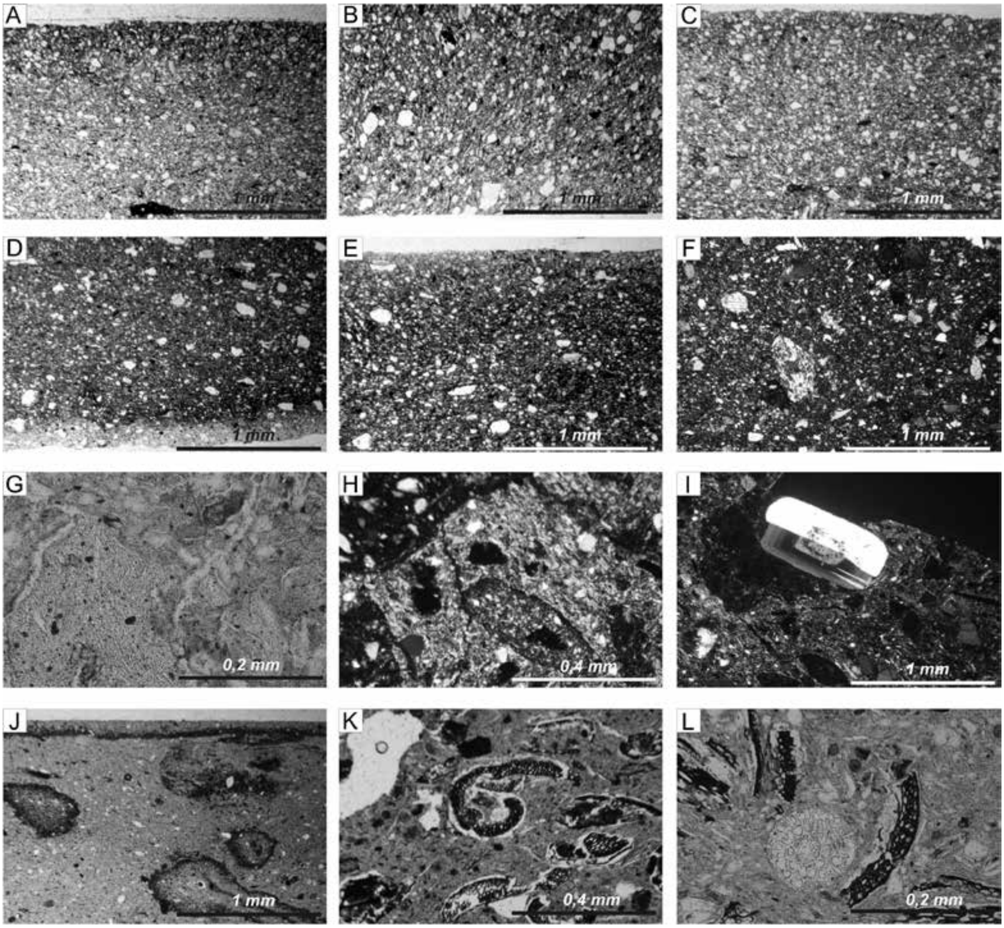

Fig. 13. Thin section micrographs of Neolithic pottery from Poland and Slovakia. Photo by A. Rauba-Bukowska.

A–F — samples attributed to the first group in the hierarchical cluster analysis; A — sample 16, PPL; B — sample 18, PPL; C — sample 27, PPL; D — sample 2A, PPL; E — sample 28, PPL; F — sample 31, XPL. These samples are made of fine grained, homogeneous clay matrix with a negligible amount of coarse grains; Samples G–I attributed to the second group in hierarchical cluster analysis: G — sample 19, PPL, tuff inclusion (indicated) and small grain of amphibole (Am) are visible in silty matrix; H — sample 22, XPL, in silty clay there are dark grains of grog and a grain of siliceous rock; I — sample 25, XPL, zoned plagioclase feldspar crystal in volcanic rock; J–L — samples attributed to the third group in hierarchical cluster analysis: J — sample 4, PPL, opaque substance, surrounds organic fragments — post depositional process; K — sample 9, PPL, great number of plant fragments in the clay matrix, on the left are visible voids (light area); L — sample 17, PPL, in the middle there is siliceous microfossil inclusion also visible are plant remains (black).

be observed in the raw material of the first type identified by microscopic observation of the Polish samples. In the light of hierarchical cluster analysis and mineralogical research it is justified to say that the pottery in question (samples nos. 2B, 3, 4, 5, 9, 10, 15, 17) was produced from local raw materials. Still open is the question of the origin of sample no. 11 (Kraków-Nowa Huta-Mogiła). The probability analysis and granulometry point towards silty clay. The low muscovite content and the small amount of rock fragments and the presence of organic elements suggest local origin.

To identify the source of raw material the chemical composition of the analyzed samples was compared to the composition of pottery from nearby sites lying on both banks of the Vistula River (Rauba-Bukowska 2007; 2014a, b, c). The results of this comparison are rather unexpected. It appears that the division presented on the triangular diagram (Fig. 11A) reflects the division into the left- and the right-bank of the Vistula River (Fig. 11B). This may be understand to correspond to the nature of the sediments from which the potsherds were recovered rather than to the raw materials used in pottery production.

To determine the origin of the analyzed potsherds they were compared with pottery finds of the LBK Želiezovce phase from the Upper Vistula basin. Mineralogical examination of the pottery from western Lesser Poland (also from sites named in this paper) was made for close to 300 samples (Rauba-Bukowska 2007). It was established that the ceramic fabric of most thin-walled vessels of the Želiezovce phase is very close to that of imported vessels — a homogenous, silty material with a varying content of mica minerals and infrequent larger (0.1–0.4 mm) rock grains. Organic remains are very rare. Similar features were observed in imported vessels from the Eastern Linear Culture in Brzezie 17 (Czekaj-Zastawny 2014; Rauba-Bukowska 2014b; Czekaj-Zastawny, Rauba-Bukowska 2014).

The research indicates that in Lesser Poland during the transition period between the Notenkopf and the Želiezovce phases there was a change in the raw material supply: intentional selection of silty, fine grained material, probably obtained from river alluvia (in contrast to earlier phases of LBK, when fine material, often Miocene clay, was dominant), and careful preparation of potter's paste.

CONCLUSIONS

Using the results from the mineralogical-chemical and technological analysis we propose to distinguish the pottery samples into three groups:

1. Pottery without mineral temper; particles of metamorphic rocks are small, sub-rounded and well-sorted. This group includes samples nos. 1, 2A, 6, 7, 8 (8a, 8b), 12, 13, 14 and 16 from the territory of Poland (Fig. 5:1–8) and samples from Slovakia, namely: from the Košice Basin, Šariš and the Poprad valley: samples 18, 26, 27, 28, 29, 30 (Fig. 7:1–6). The properties of the clay fabric indicate that the pottery with Eastern Linear technological features found in LBK sites in Lesser Poland are imports. This is confirmed further by the stylistic features of the decoration of this pottery which attributes it to the Bükk Culture. The pottery is thin-walled, well fired, from a carefully pugged fabric. The decorations on the body of vessels are carefully arranged, executed with a toothed implement (4 to 10 thin parallel lines), sometimes in combination with stabs

typical of the Bükk Culture. One of the imports (sample 8) was a sherd from a vessel with stylistic features of the early phase of the Želizovce group/phase. We wish to emphasized also that the decorative motifs on this sherd are not known from pottery recovered from sites of the Želiezovce phase/group in Lesser Poland.

2. This group are sherds from sites in Lesser Poland, their fabric greasy clay with a low quartz or muscovite content. A component of sea plankton was identified. The temper is organic. These are samples 3, 4, 5, 9, 10, 15, 17 (Fig. 6:2–7). A similar composition of the ceramic fabric was identified in the LBK vessels from sites on the left-bank terrace of the Vistula River (R a u b a - B u k o w s k a 2011). The pottery from local clay is poorly fired, its surface soft, and decorations mostly abraded. There is evidence on the use of gravers or single toothed tools but the quality of the decoration is inferior to the original Bükk or Tiszadob ceramics. In this group samples 15 and 17 were found in the context of the pre-Notenkopf or the Notenkopf phase (sample 3), but also in the context of Želiezovce phase (samples 4, 5, 10). Of interest is sample 10: a sherd found in a Želiezovce phase/group context, with a ceramic fabric of local origin. At the same time, the decoration was carefully executed using a multiple toothed tool (8 parallel lines) and carefully planned out. Its style is very close to the one known from Bükk Culture pottery. In the case of this particular pot we may assume that the potter came from Eastern Slovakia and made the pot at the site in Lesser Poland, imitating, however, the original, familiar style.

3. This group includes sample 2B from Kraków-Nowa-Huta-Pleszów, site 17 (Fig. 6:1). This sherd was made from clay similar to samples from Prešov-Solivar (samples 19–24); it is marked by a fairly high component of silty clast and chamotte. The Slovak samples contained a small admixture of metamorphic rock, whereas sample 2B contained sand temper. The style of sherd 2B suggests imitation of foreign motifs of the Bükk Culture or, possibly, the Szakalhat Group (the letter “M” motif — cf. Virag 2009), perhaps handed on through the Želiezovce group.

The question of sample 11 from Kraków-Nowa Huta-Mogiła, site 62 (Fig. 6:8) has not been resolved. Granulometric analysis indicates the component of loamy silts, while the low muscovite content and a component of rock particles suggest local origin and technique of manufacture. This specimen is exceptional in the examined pottery sample; the sherd comes from a thick-walled, bowl-like vessel made from a fabric with abundant organic temper, which makes the identification of its provenance difficult. The decoration is also anything but typical, consisting of double incised lines, straight or zig-zag, alternating with groups of stabs, possibly an influence of the eastern Linear Complex style.

On the basis of the analyses of ceramics from LBK sites in Lesser Poland exhibiting the features of the Eastern Linear Pottery Culture, the following conclusions have been formulated:

1. The assemblages attributed to the Notenkopf phase of the LBK included, as a rule, pottery representing the style of the Kapušany-Tiszdob Group: both

imports as well as imitations. Sherds of this sort were discovered within the early Notenkopf features at Targowisko I (Kulczycka-Leciejewiczowa 1973), Samborzec (Kulczycka-Leciejewiczowa 2008), and Kraków-Nowa Huta-Pleszów, site 18, pit 35. At Rzeszów-Osiedle Piastów (Kadrow 1990) similar sherds were found in association with the late Notenkopf phase.

2. Some Notenkopf assemblages included pottery in the Bükk Culture style (Olszanica pits 13, 71; Krakow-Nowa Huta-Mogiła, site 62, pit 151, site 62A, pit 165; Kraków-Nowa Huta-Krzesławice, site 41, pit 90).

3. Most inventories of the Želiezovce phase from Lesser Poland where Eastern Linear pottery was retrieved the stylistic motifs represent the Bükk Culture exclusively (Kraków-Nowa Huta-Mogiła, site 62, pit 29A and 158; Kraków-Nowa Huta-Pleszów, site 17, pits 605, 697; Olszanica, pits 27, 28, 68, 73; Gwoździec, pit 10B; Kraczkowa, pit 6).

ACKNOWLEDGMENTS

A study completed with the financial support of the Polish National Science Center (NCN) grants no 2085/B/H03/2011/40 and N N109 181040 (2011–2013).

REFERENCES

Bakels B., Lüning J.

1990 *Pioneer farmers*, [in:] N. Calder (ed.), *Scientific Europe*, Maastricht, p. 132–139.

Burtan J.

1954 *Szczegółowa mapa geologiczna Polski w skali 1:50000. Arkusz Wieliczka (M34-77A)*, Warszawa.

Czekaj-Zastawny A.

2008 *Osadnictwo społeczności kultury ceramiki wstęgowej rytej w dorzeczu górnej Wisły*, Kraków.

2009 *Settlement of the Linear Pottery Culture in Southeastern Poland*, [in:] J. K. Kozłowski (ed.), *The First Neolithic Sites in Central/South-East European Transect*, vol. 5, BAR S2049, Oxford.

2014 *Brzezie 17. Osada kultury ceramiki wstęgowej rytej*, Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce, Kraków.

Czekaj-Zastawny A., Rauba-Bukowska A.

2014 *Technology of the earliest vessels in the upper Vistula River basin — imports against local pottery*, [in:] T.L. Kienlin, P. Valde-Nowak, M. Korczyńska, K. Cappenberg, J. Ociepka (eds.), *Settlement, Communication and Exchange around the Western Carpathians. International Workshop held at the Institute of Archaeology, Jagiellonian University, Kraków, October 27–28, 2012*, Oxford, p. 95–107.

Domboróczki L.

2009 *Settlement structures of the Alföld Linear Pottery Culture (ALPC) in Heves County (North-Eastern Hungary): development models and historical reconstructions on micro, meso and macro levels*, [in:] J.K. Kozłowski (ed.), *Interactions between different models of neolithization north of the Central European Agro- Ecological Barrier*, Prace Komisji Prehistorii Karpat PAU 5, Kraków, p. 75–127.

Domboroczki L., Raczky P.
2010 *Excavations at Ibrány-Nagyerdő and the northernmost distribution of the Körös Culture in Hungary*, [in:] J.K. Kozłowski, P. Raczky (eds.), *Neolithization of the Carpathian basin: northernmost distribution of the Starčevo-Körös Culture*, Kraków-Budapest, p. 191–218.

Godłowska M.
1976 *Próba rekonstrukcji rozwoju osadnictwa neolitycznego w rejonie Nowej Huty*, Mat. Arch. NH 5, p. 7–180.
1982 *Nowohucki zespół osadniczy na tle wpływów południowych we wczesnym i środkowym neolicie Małopolski*, WA 17:2, p. 143–160.
1991 *Osada kultury ceramiki wstęgowej rytej w Krakowie-Nowej Hucie na stan. 62 (Mogiła)*, Mat. Arch. NH 14, p. 7–44.

Godłowska M., Rook E., Drobniewicz B.
1985 *A settlement of the Linear Pottery Culture at Pleszów*, Prz. Arch. 33, p. 57–103.

Godłowska M., Kozłowski J. K., Starkel L., Wasylikowa K.
1987 *Neolithic settlement at Pleszów and changes in the natural environment in the Vistula valley*, Prz. Arch. 34, p. 133–147.

Gradziński R.
1955 *Szczegółowa mapa geologiczna Polski w skali 1:50000. Arkusz Niepołomice (M34-65C)*, Warszawa.

Kaczanowska M.,
1976 *Sprawozdanie z badań wykopaliskowych prowadzonych w roku 1971 r. w Nowej-Hucie na stanowisku 18 (Nowa Huta-Pleszów)*, Spraw. Arch. 28, p. 243–255.
1988 *Materiały neolityczne ze stanowiska 41 w Nowej Hucie-Krzesławicach*, Mat. Arch. NH 12, p. 27–72.
1990 *Uwagi o wczesnej fazie kultury lendzielskiej w Małopolsce*, AAC 29, p. 71–97.

Kaczanowska M., Godłowska M.
2009 *Contacts between the Eastern and Western Linear Cultures in South-Eastern Poland* [in:] J.K. Kozłowski (ed.), *Interactions between different models of Neolithization North of the Central European Agro-Ecological Barrier*, Kraków, p. 137–150.

Kaczanowska M., Kozłowski J. K., Šiška S.
1993 *Neolithic and Eneolithic chipped stone industries from Šarišské Michal'any, Eastern Slovakia*, Kraków.

Kadrow S.
1990 *Osada neolityczna na stan. nr 16 w Rzeszowie na Osiedlu Piastów*, Spraw. Arch. 41, p. 9–76.

Kalicki T., Starkel L.
1989 *Utwory czwartorzędowe doliny Wisły na wschód od Krakowa*, [in:] J. Rutkowski (ed.), *Przewodnik LX Zjazdu Polskiego Towarzystwa Geologicznego, Kraków 14–16 IX 1989*, Kraków.

Kamieńska J., Kozłowski J. K.
1990 *Entwicklung und Gliederung der Lengyel- und Polgar- Kulturgruppen in Polen*, Zeszyty Naukowe Uniwersytetu Jagiellońskiego 925, Prace Archeologiczne, Kraków.

Kaminská L'., Kaczanowska M., Kozłowski J. K.
2008 *Košice-Červený rak and the Körös/Eastern Linear transition in the Hornád basin (eastern Slovakia)*, Přehled výzkumů 49, p. 83–91

Kozłowski J.K.
1989 *The lithic industry of the Eastern Linear Pottery Culture in Slovakia*, Slov. Arch. 27:2, p. 377–410.
1999 *Rozprzestrzenianie się gospodarki wytwórczej z pierwotnych centrów neolityzacji obszaru Starego Świata i jej adaptacja do warunków środowiskowych umiarkowanej strefy w Eurazji*, [in:] J.K. Kozłowski (ed.), *Encyklopedia historyczna Świata, vol. I, Prehistoria*, Kraków, p. 151–172.

2004 *Problem kontynuacji rozwoju pomiędzy wczesnym i środkowym neolitem oraz genezy „cyklu lendzielsko-polgarskiego" w basenie górnej Wisły*, Mat. Arch. NH 24, p. 11–18.

Kozłowski J. K. ed.

1997 *The Early Linear Pottery Culture in Eastern Slovakia*, Prace Komisji Prehistorii Karpat PAU 1, Kraków.

Kozłowski J. K., Nowak M.

2007 *Neolithization of the Upper Tisza Basin*, [in:] J. K. Kozłowski, M. Nowak (eds.), *Mesolithic / Neolithic interactions in the Balkans and in the Middle Danube Basin*, BAR International series 1726, p. 77–102.

Kukułka A.

1997 *Badania sondażowe w Gwoźdźcu stan. 2, gm. Zakliczyn, woj. tarnowskie*, MSROA 18, p. 161–167.

2001 *Wczesnoneolityczna osada w Gwoźdźcu, gm. Zakliczyn, stan. 2 na Pogórzu Wiśnickim*, [in:] J. Gancarski (ed.), *Neolit i początki brązu w Karpatach polskich*, Krosno, p. 11–40.

Kulczycka-Leciejewiczowa A.

1964 *Materiały kultur z cyklu wstęgowych z badań ratowniczych w Targowisku, pow. Bochnia*, Mat. Arch. 5, p. 103–115.

1973 *Niektóre problemy osadnictwa kultury ceramiki wstęgowej rytej w dorzeczu górnej Wisły*, APolski 18, p. 73–90.

1979 *Pierwsze społeczeństwa rolnicze na ziemiach polskich. Kultury kręgu naddunajskiego*, [in:] W. Hensel, T. Wiślański (eds.), *Prahistoria ziem polskich, vol. 2. Neolit*, Wrocław-Warszawa-Kraków-Gdańsk, p. 19–164.

1983 *O zofipolskim stylu ceramiki wstęgowej rytej w Polsce*, APolski 28, p. 67–97.

2008 *Samborzec. Studium przemian kultury ceramiki wstęgowej rytej*, Wrocław.

Maglay J., Pristaš J., Kučera M., Ábelová M.

2009 *Quaternary geological map of Slovakia at scale 1 : 500 000*, Bratislava.

Mahel M., Buday T.

1968 *Regional Geology of Czechoslovakia, Part 2: The West Carphathians*, Praha

Mateiciucová I.

2002 *Štipaná kamenná industrie z pohřebiště v "Široké u lesa"*, [in:] V. Podborský (ed.), *Dvě pohřebiště neolitického lidu s lineární keramikou ve Vedrovicích na Moravě*, Brno, p. 217–234.

Nowak M., Kozłowski J. K., Kaczanowska M., Kalicki T. Moskal-del Hoyo M., Budek A. Litviniuk G., Lityńska-Zając M., Stobierska E., Wyszomirski P.

2010 *Early Neolithic In the Upper Tisza Basin: New data from Moravany, Eastern Slovakia*, Eurasian Prehistory 7:1, p. 159–219.

Pavúk J.

1969 *Chronologie der Želiezovce-Gruppe*, Slov. Arch. 17, p. 269–367.

1980 *Ältere Linearkeramik in der Slowakei*, Slov. Arch. 28:1, p. 7–90.

1994 *Šturovo — Ein Siedlungsplatz der Kultur mit Linearkermik und der Želiezovce-Gruppe*, Nitra

2004 *Early Linear Pottery Culture in Slovakia and the Neolithisation of Central Europe*, [in:] A. Lukes, M. Zvelebil (eds.), *LBK Dialogues. Studies in the formation of the Linear Pottery Culture*, BAR International Series 1304, Oxford, p. 71–82.

Polskie Towarzystwo Gleboznawcze

2009 *Klasyfikacja uziarnienia gleb i utworów mineralnych PTG 2008*, Roczniki Gleboznawcze 60:2, p. 5–16.

Potushniak M.

1979 *Neolit Zkarpattia: kultury Krish i raspisnoy keramiki. Polgarskaya i Badenskaya kultury Zakarpattia, Archeologia Ukrainskoy SSSR*, vol. I. Kiev, p. 139–150.

1992 *Do pitannya neolitizatsii verkhviya r. Tisi*, Novi materiali z archeologii Prikarpattia i Volhyni 2, p. 15–17.

1995 *Deyaki naslidki doslidzhennya serednoneolitichnogo sharu na bagatosharovomu posielenni Zastavne-Kovo Domb u Zakarpatti*, Problemi archeologi skhidnikh Karpat, Uzhorod, p. 51–66.

Raczky P., Sümegi P., Bartosiewicz L., Gál E., Kaczanowska M., Kozłowski J. K., Anders A.

2010 *Ecological barrier vs mental marginal zone? Problems of the northernmost Körös Culture settlements in the Great Hungarian Plan*, [in:] D. Gronenborn, J. Petrasch (eds.), *Die Neolithisierung Mitteleuropas*, Mainz, p. 147–174.

Rauba-Bukowska A.

2007 *Charakterystyka mineralogiczno-petrograficzna ceramiki z epoki wczesnego neolitu z wybranych stanowisk w okolicy Krakowa*, PhD thesis, typescript in AGH University of Science and Technology.

2009 *Bone temper in early Neolithic vessels from southern Poland. Examinations using scanning microscopy*, [in:] D. Hofmann, P. Bickle (eds.), *Creating Communities. New Advances in Central European Neolithic Research*, Oxford, p. 235–248.

2011 *Wyniki analiz mikroskopowych naczyń oraz przedmiotów wykonanych z gliny z epoki neolitu ze stanowiska 5 w Modlnicy, pow. krakowski*, [in:] J. Kruk, A. Zastawny (eds.), *Modlnica st. 5 pow. krakowski - od środkowego neolitu po wczesną epokę brązu. Via Archaeologica, Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce*, Kraków, p. 311–383.

2014a *Wyniki badań mineralogiczno-petrograficznych naczyń kultury ceramiki wstęgowej rytej ze stanowiska Brzezie 17, gm. Kłaj*, [in:] A. Czekaj-Zastawny, *Brzezie 17. Osada kultury ceramiki wstęgowej rytej*, Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce, Kraków, p. 437–458.

2014b *Wyniki badań mineralogiczno-petrograficznych naczyń importowanych kręgu wschodnio-linearnego, odkrytych na stanowisku Brzezie 17, gm. Kłaj*, [in:] A. Czekaj-Zastawny (ed.), Brzezie 17. *Osada kultury ceramiki wstęgowej rytej*, Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce, Kraków, 459–468.

2014c *Wyniki badań mineralogiczno-petrograficznych surowców ceramicznych z okolicy stanowiska Brzezie 17, gm. Kłaj*, [in:] A. Czekaj-Zastawny (ed.), *Brzezie 17. Osada kultury ceramiki wstęgowej rytej*, Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce, Kraków, p. 469–479.

Rauba-Bukowska A., Czekaj-Zastawny A., Grabowska B., Zastawny A.

2007 *Wyniki badań mineralogiczno-petrograficznych naczyń kultury ceramiki wstęgowej rytej i malickiej ze stanowisk Brzezie 17 i Targowisko 11, gm. Kłaj, woj. Małopolskie, Results of mineralogical and petrographic research on vessels of Linear Band Pottery Culture and Malice Culture from sites Brzezie 17 and Targowisko 11, Kłaj commune, Małopolska province*, Spraw. Arch. 59, p. 63–113.

Soják M.

1999 *Neolitizácia Spiša a kultúrne vztahy s Małopolskom*, [in:] I. Kuzma (ed.), *Otázky Neolitu a Eneolitu naših krajin*, Nitra, p. 197–202.

2000 *Neolitické osidlenie Spiša*, Slov. Arch. 48:2, p. 185–314

2001 *Osidlenie Spiša v obdobi stredneho neolitu*, [in:] J. Gancarski (ed.), *Neolit i początki epoki brązu w Karpatach polskich*, Krosno, p. 41–56.

Šiška S.

1979 *Die Bükker-Kultur in der Ostslovakischen Tiefebene*, Slov. Arch. 27, p. 245–290.

1984 *K výrobe kamenných brúsených nástrojov*, [in:] A. Habovštiak, L. Kraskovská (eds.), *Zbornik prác L'udmile Kraskovskej*, Bratislava, p. 20–29.

1989 *Kultúra s východnou lineárnou keramikou na Slovensku*, Bratislava.

Stadler P., Kotova N.

2010 *Early Neolithic settlement from Brunn Wolfholz in Lower Austria and the problem of the origin of (Western) LBK*, [in:] J. K. Kozłowski, P. Raczky (eds.), *Neolitthisation of the Car-*

pathian Basin: northernmost distribution of the Starčevo/Körös culture, Kraków-Budapest, p. 325–348.

Valde-Nowak P.
1988 *Etapy i strefy zasiedlania Karpat polskich w neolicie i na początku epoki brązu*, Kraków.

Vértes L.
1965 *The depot of silex blades from Boldogkőváralja*, AAHung. 17, p. 129–136.

Virág Z.
2009 *The eastern periphery of the Central European LPC in the region of Budapest (connections between the Transdanubian LPC and the Alföld LPC)*, [in:] J.K. Kozłowski (ed.), *Interactions between different models of Neolithization north of the Central European Agro- Ecological Barrier*, Kraków-Budapest, p. 9–30.

Addresses of the Authors
Janusz K. Kozłowski,
Małgorzata Kaczanowska
Institute of Archaeology
Jagiellonian University
Gołębia 11
31-007 Krakow, Poland
e-mail: janusz.kozlowski@uj.edu.pl

Agnieszka Czekaj-Zastawny
Institute of Archaeology and Ethnology
Polish Academy of Sciences
Sławkowska 17
31-016 Kraków, Poland
e-mail: aczekajzastawny@gmail.com

Anna Rauba-Bukowska
Archeometria
Staszica 10/7
31-162 Kraków, Poland
e-mail: a.rauba@yahoo.pl

Krzysztof Bukowski
AGH University of Science and Technology
Mickiewicza 30
30-059 Krakow, Poland