SPRAWOZDANIA ARCHEOLOGICZNE 75/2, 2023
PL ISSN 0081-3834
DOI: 10.23858/SA75.2023.2.3674

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EARLY NEOLITHIC RED-PAINTED POTTERY FROM THE PRANDOCIN SITE, SOUTHERN POLAND. INDIRECT TRANSFER IN A TECHNOLOGICAL CONTEXT

ABSTRACT

Rauba-Bukowska A., Nowak M., Juźwińska G. and Moskal-del Hoyo M. 2023. Early Neolithic red-painted pottery from the Prandocin site, southern Poland. Indirect transfer in a technological context. *Sprawozdania Archeologiczne* 75/2, 251-283.

The paper presents the results of specialized research on a small collection of artefacts of the Linear Pottery Culture in southern Poland. Among the 27 pottery fragments discovered at the Prandocin Site 1, a few painted fragments were identified. Such kind of painting style directly relates to the Želiezovce group of this culture in western Slovakia. Painted vessels are rarely found in the context of the Linear Pottery Culture in Lesser Poland (Małopolska), which is why special attention was given to raw material and technological studies of the ceramics. The study aimed to answer the question of whether the painted vessel was produced locally or if it represents evidence of direct migration of people, objects, or ideas from the areas of present-day western Slovakia at the turn of the 6th and 5th millennium BC.

Keywords: Early Neolithic, red-painted ceramic, south-eastern Poland, Linear Pottery Culture, Transcarpathian contacts
Received: 11.12.2023; Revised: 11.12.2023; Accepted: 28.12.2023

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1. INTRODUCTION

The Linear Pottery Culture (LBK) in Poland is estimated to have emerged around 5350-5000 BC (Czekaj-Zastawny *et al.* 2020). This cultural unit is divided into three principal phases: early phase (phase I or Pre-Music-Note) spanning approximately 5300-5250 BC; a subsequent classic phase (phase II or Music-Note) lasting approximately from 5250-5100 BC, and a later phase (phase III or Želiezovce phase), occurring between 5100-5000 BC (Czekaj-Zastawny and Oberc 2021, 328, 329; Oberc *et al.* 2022; Moskal-del Hoyo *et al.* 2024, fig. 5, 6; Fig. 1). Generally, the cultural changes in the Lesser Poland (Małopolska) region during the evolution of the LBK followed a similar pattern to that in southwestern Slovakia (Czekaj-Zastawny 2017; Kadrow and Rauba-Bukowska 2017a).

Numerous objects made from obsidian and vessels with ornamentation reminiscent of Alföld Linear Pottery Culture (ALPC) discovered in southeastern Poland suggest direct interactions between communities on both sides of the Carpathian Mountains (Kaczanowska and Godłowska 2009; Czekaj-Zastawny and Rauba-Bukowska 2014; Kozłowski *et al.* 2014; Rauba-Bukowska 2014a; Czekaj-Zastawny 2017; Czekaj-Zastawny *et al.* 2017; Kadrow and Rauba-Bukowska 2017a; Rauba-Bukowska and Czekaj-Zastawny 2020). Around the transition between phases II and III, there was a significant influx of obsidian

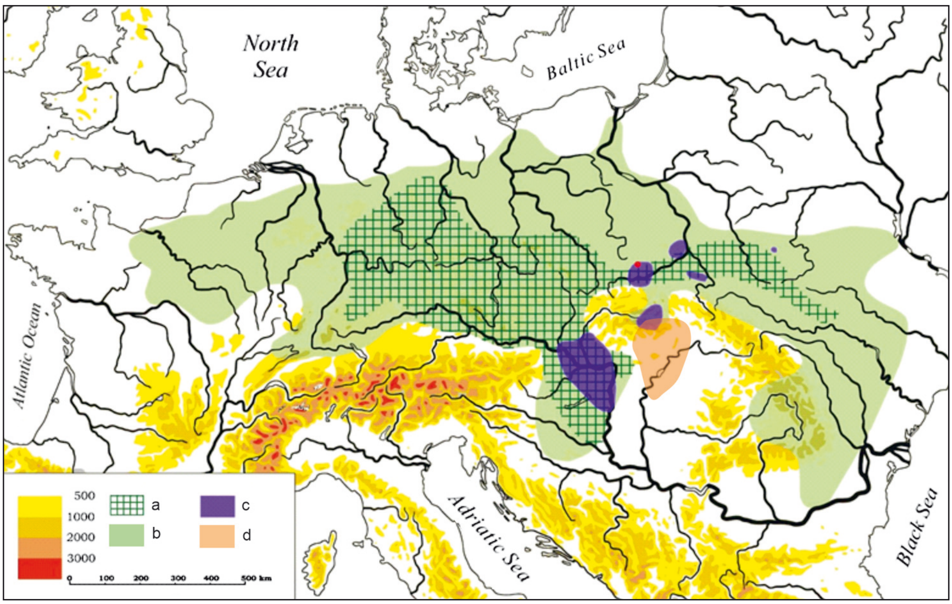

Fig. 1. Extent of the linear pottery culture (LBK) in Europe during the earliest phase (a); maximum extent (b); the Želiezovce group (in Slovakia and Pannonia), and clusters with pottery decorated in the Želiezovce style in south-eastern Poland and Volyn' (c); Bükk culture (d); location of the Prandocin site (red dot); (after Rauba-Bukowska and Czekaj-Zastawny 2020; Kadrow 2020). Drawing K. Juszczyk and A. Rauba-Bukowska

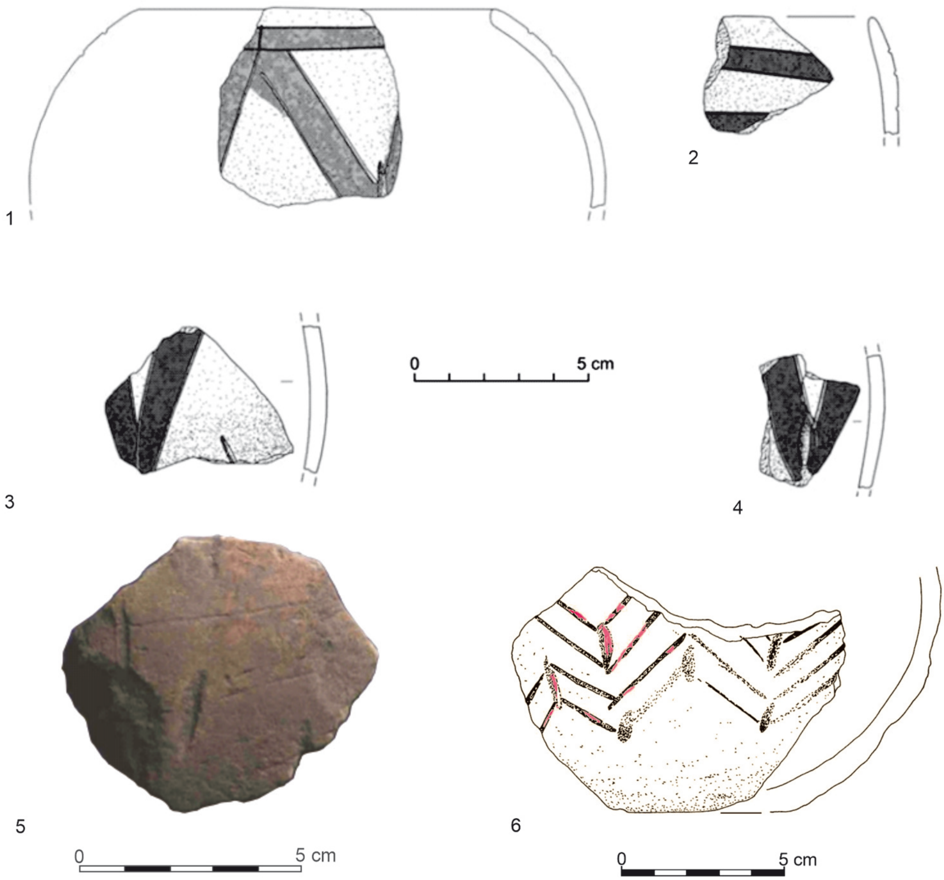

Fig. 2. Examples of Polish finds with red-painted pottery of the Linear Pottery Culture. 1-4 – Zwięczyca 3 (Dębiec 2014); 5 – Targowisko (Czerniak *et al.* 2006); 6 – Żerków (Valde-Nowak 2022). Prepared by M. Nowak

that was imported from the Carpathian Basin. This surge in new raw materials was especially noticeable in the southeastern Poland, particularly in the vicinity of Rzeszów (Kadrow 1990a, fig. 14 and 17c; 1990b, fig. 26c; Szeliga 2007, 295-297, fig. 1). Concurrently, there was a notable uptick in the importation of ceramic vessels or local replication of the patterns associated with the ALPC, primarily originating from the upper Tisza area and linked to the Bükk culture (Kadrow 1990a, 59-63, fig. 14; Kaczanowska and Godłowska 2009). This influx of ALPC ceramics brought about changes in the technology employed for locally manufactured pottery during the late (III) phase of the Linear Pottery Culture (Kozłowski *et al.* 2014, 70; Czekaj-Zastawny *et al.* 2017; Szeliga and Zakościelna 2019; Dębiec *et al.* 2021; Rauba-Bukowska and Czekaj-Zastawny 2020).

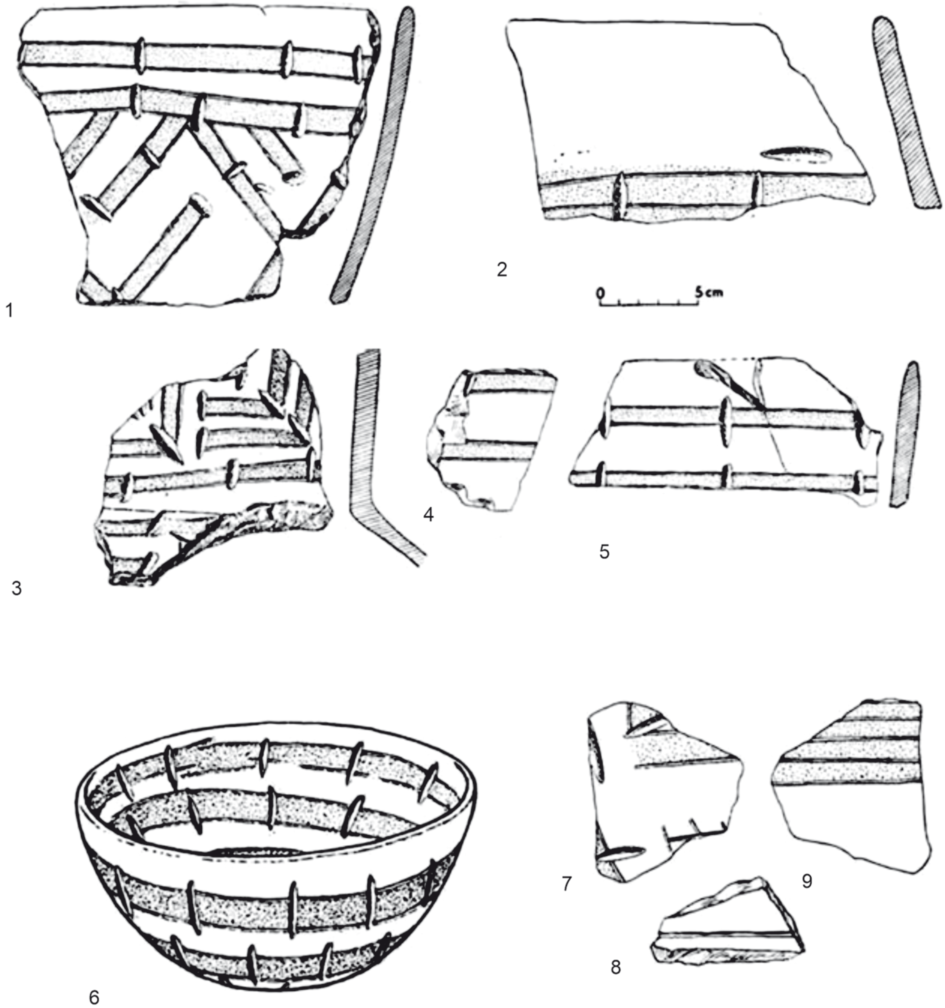

Fig. 3. Examples of finds with red-painted pottery of the Linear Pottery Culture from western Slovakia 1-9 (Štúrovo after Pavúk 1994). Prepared by M. Nowak

From the area north of the Carpathians in Poland, finds of Linear Pottery Culture (late phase/Želiezovce style) red-painted pottery fragments are known only from a few sites *i.e.*, Targowisko (Czerniak *et al.* 2006), Zwięczyca (Dębiec 2014), Kraków-Nowa Huta – Pleszów (Godłowska 1976), Żerków (Valde-Nowak 2022) and now from Prandocin (Fig. 2). In contrast, from the areas of southwestern Slovakia, this type of decoration is common on the sites of the contemporary Neolithic Želiezovce group (Pavúk 1969; 2009; Cheben 2000) (Fig. 3). Therefore, it can be assumed we are dealing with imports of ceramics or technology. In order to verify this issue, petrographic studies were carried out on the pottery samples from Prandocin. Raw material and technological analyses were conducted on pottery, and the results were compared with similar analyses of the pottery from the Želiezovce phase from Małopolska. Detailed analyses allowed for the determination of the mineral composition of ceramic fabrics. The arrangement of components, degree of clay processing, and approximate firing temperature were established. These data were correlated with geological information and the availability of suitable raw materials in the Prandocin site area. An approximate composition of the paint, which covered the surface of the vessel with a thin layer, was also determined.

These are the first microscopic studies for the painted pottery of the LBK from Poland. Determining the technological and raw material characteristics of this pottery is of great importance for further considerations regarding the transfer of objects, people, or ideas in the Early Neolithic in southeastern Poland.

Additionally, archaeobotanical analyses were performed for the soil samples taken from the filling of the LBK feature. Archaeobotanical research was carried out as part of a larger research program dedicated to the study of Early Neolithic agriculture in southern Poland and long-term effects of human activities on the landscape (Moskal-del Hoyo 2021; Moskal-del Hoyo *et al.* 2017a). New excavations, such as in Prandocin, offer opportunities to gain new plant remains that may lead to better documentation of the interactions between human communities and their environment.

2. CHRONOLOGY

Radiocarbon dating was not conducted on the materials from Prandocin. Stylistic characteristics of the ceramics suggest a cautious dating to a later phase of ŽII according to J. Pavúk's system (1969), and for the Polish territory, according to Kadrow (1990a; 1990b; 2022). This is indicated by the presence of painted decorations as well as ornamentation in the form of double lines and notches in angular arrangement, along with a repetitive line motif (Fig. 4: 1, 2, 3, 5, 6, 8). The diversity of ceramic vessel forms from Prandocin aligns with the general development trends of the Linear Pottery Culture in southern Poland. Fragments of typical spherical bowls dominate.

Table. 1. Relative chronology of red-painted pottery assemblages from southeastern Poland

Site	Chronology	References
Pleszów	ŽIIb	Godłowska 1976; Godłowska *et al.* 1985
Targowisko	ŽIIb	Czerniak *et al.* 2006
Zwięczyca	ŽIIb/ŽIII	Dębiec 2014
Żerków	ŽIIb	Valde -Nowak 2022
Prandocin	ŽIIb	

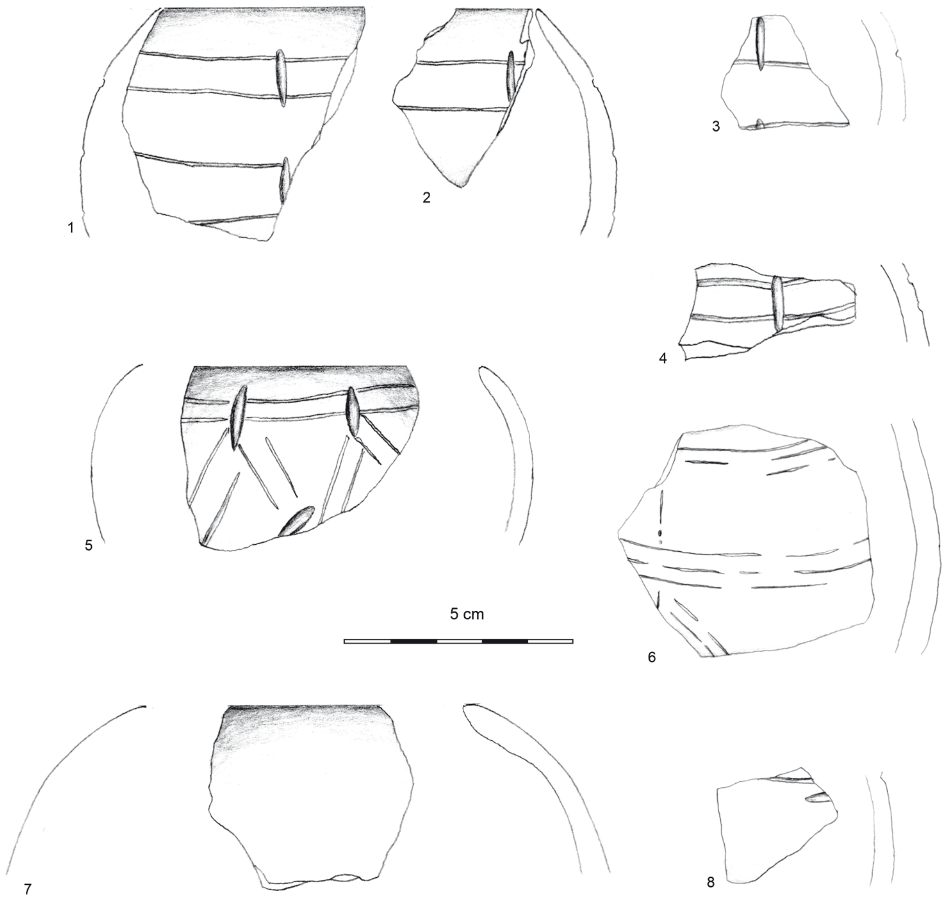

Fig. 4. Prandocin Site 1, Słomniki commune. Ceramic selection from Feature 54.
1, 2, 4, 5, 6 – thin sectioned fragments; 3, 8 – fragments of ornamented vessels; 7 – fragment of thin-walled vessels without ornamentation. Drawing W. Rumian and M. Nowak

As mentioned above, findings of ceramics with red painted decorations north of the Carpathians are only known from a few sites (Table 1). In Zwięczyca (Feature 661), fragments of vessels decorated with red paint, dated by the researcher (Dębiec 2014, 91) to the end of phase ŽIIb or even as a transitional phase between ŽIIb/ŽIII have been identified. However, it should be noted that, as of now, no material has been found in the Upper Vistula River basin that can be dated to phase ŽIII (Czekaj-Zastawny 2008a, 116; 2008b). Similarly, artefacts from Targowisko 3 (Czerniak *et al.* 2006), Kraków Nowa Huta – Pleszów (Godłowska 1976; Godłowska *et al.* 1985), and a vessel from Żerków are dated to phase ŽIIb, although the entire assemblage from which it comes is described as early Želiezovce phase (Valde-Nowak 2022).

For chronological assemblages in the Małopolska region, we have 21 radiocarbon dates from six sites. These sites include Biskupice 18 (Moskal-del Hoyo *et al.* 2024), Gwoździec 2 (Czekaj-Zastawny *et al.* 2020; Czekaj-Zastawny and Oberc 2021), Kraków Nowa Huta – Pleszów 17-20 (Oberc *et al.* 2022, 194), Łoniowa 18 (Valde-Nowak 2009, table 1, p. 23), Samborzec 1 (Kulczycka-Leciejewiczowa 2008, fig. 55, 104), and Żerków 1 (Valde-Nowak 2009, table 1, 23). Based on these data, sites in Małopolska with pottery decorated in the Želiezovce style are dated absolutely to a period beginning in the range of 5286-5216 BC (68.3%; 5339-5111 BC at 95.4%) and ending in the range of 5128-5022 BC (68.3%; 5175-4975 BC at 95.4%) (Oberc *et al.* 2022, 202). Similarly dated findings are from the Vráble site in western Slovakia (Furholt *et al.* 2020, 246). This confirms the contemporaneity of the development of the Linear Pottery Culture in Poland and western Slovakia.

3. THE SITE PRANDOCIN 1

The site was discovered in 1970 and later verified in 1997 during the survey within the Polish Archaeological Record (AZP) (Kruk 1970). The rescue excavations at site took place in spring 2021. In a trench 200 m long and 1.4 width, 74 features were revealed. Just one of them – Feature no. 54, is related to the LBK.

Prandocin Site 1 is situated in the Miechów Upland (Kondracki 2002, 264-265) within the drainage basin of a left bank tributary of the Szreniawa River (Fig. 5). The Miechów Upland is composed of hills with elevations ranging from 280 to 360 metres above sea level (50-100 metres in relative height), separated by basins and river valleys. The geological composition of the site's surroundings is dominated by Cretaceous and Quaternary formations. The prevailing features of the recent landforms are loess covers, sometimes forming loess plains. They are widespread in the discussed area, overlaying pre-existing landforms. Loesses represent the entire period of the North Polish glaciations, extending up to the Holocene, with a thickness reaching 20 metres (Boratyn and Brud 2001). In the immediate vicinity of the site, there are Holocene sediments of lower river valleys and peaty sediments, Pleistocene loesses, and Cretaceous marls, sometimes containing phosphorites, marls, sandy marls, glauconite-bearing sands, limestones, and glauconite-bearing limestones (Fig. 5).

The site is located in the temperate climate zone. In the Miechów Upland the mean temperature in January is between -4°C and -2°C, whereas in July the mean temperature is 17-18°C. The region is characterised by a relatively low average annual precipitation, which usually does not exceed 600 mm (Latałowa 1976; Pająk ed. 2012). The area of the archaeological site is deforested and urbanised, therefore, the current natural vegetation is strongly influenced by human presence. The maps of potential natural vegetation (Matuszkiewicz 2008) indicate that the main woodlands in this zone are oak-hornbeam forests (*Tilio-Carpinetum*) accompanied by patches of open oak forest (*Potentillo albae-Quercetum typicum*).

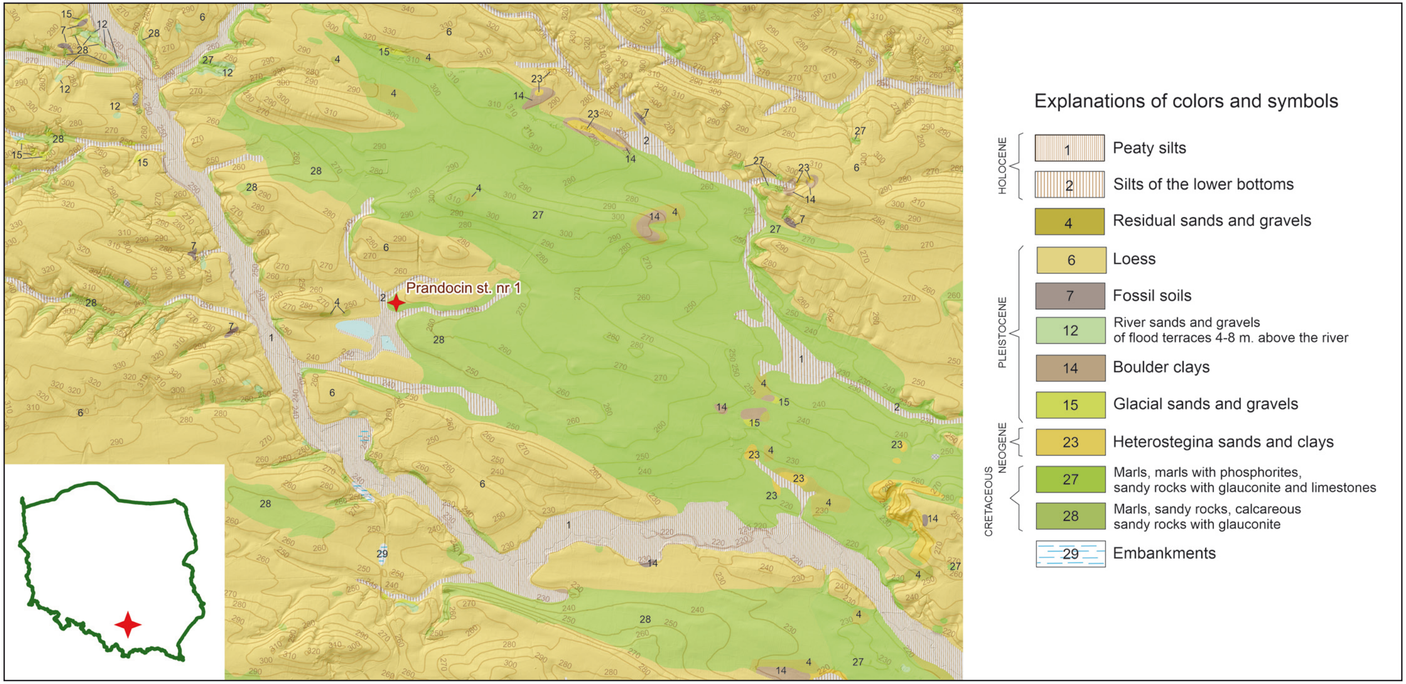

Fig. 5. Prandocin Site 1. Location against the geological background.
Drawing K. Juszczyk, A. Rauba-Bukowska

4. METHODS AND MATERIALS

4.1. Archaeology

The characterization of the pottery was conducted based on numerous publications, including synthetic works (*e.g.*, Kulczycka-Leciejowiczowa 1979; 1983; Kadrow 2020a; 2020b; 2020c) and site monographs (*e.g.*, Godłowska 1991; 1992; Kadrow 1991; Pavúk 1994; Czekaj-Zastawny *et al.* eds 2021). In its description, the state of preservation of the artefacts (size of fragments) was determined, vessel forms were reconstructed, and the dimensions of the diameter of the rims and bases were estimated. Regarding ornamentation, the decorative motifs and their execution were specified. Macroscopic observations were made, taking into account the surface colour, its character, fractures, visible impurities, and the thickness of the outer crust of the pottery. The artefacts were assigned to the technological groups distinguished in Małopolska.

The outline of Feature no 54 had been identified after removing the topsoil approximately 50 cm thick. At this level, the pit was shaped like a rectangle with rounded corners. The preserved dimensions were 1.3 × 1.3 m, and its profile resembled a shallow basin (Fig. 6). In the feature's upper part, a concave layer was distinguished, associated with a younger,

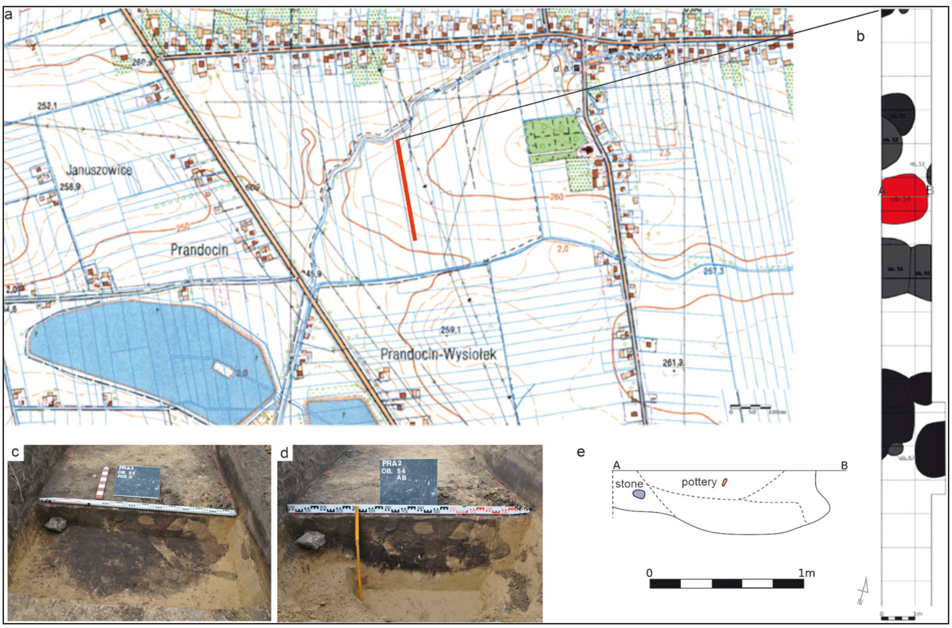

Fig. 6. Prandocin Site 1, Słomniki commune. Localization of the excavation site (a); excavation plan (b); photographs of the feature during excavation (c); cross section photographs (d) and drawing (e) of Feature 54. Drawing K. Spytkowska, prepared by A. Rauba-Bukowska and M. Nowak

Table 2. Prandocin 1. List of the samples and mineral composition; value in percentages

Symbol of the sample	**Pran01**	**Pran02**	**Pran03**	**Pran04**	**Pran05**	**Pran06**	**Pran08**
Site	Prandocin 1	Prandocin 1	Prandocin 1	Prandocin 1	Prandocin 1	Prandocin 1	Prandocin 1
Locality	Feature 54	Feature 55	Feature 56	Feature 57	Feature 58	Feature 59	Feature 61
Cultural afiliation	LBK III	LBK III	LBK III	LBK III	LBK III	LBK III	LBK III
Clay minerals	45.2	46.0	39.8	39.6	45.9	41.00	0.00
Carbonate mud	0.00	0.00	0.00	0.00	0.00	0.00	54.3
Glauconite	0	1.2	1.2	1.2	0.6	0	5.1
Grains of silt fractions	20.7	10.0	8.2	9.2	22.9	22.2	0.6
Quartz	27.9	32.2	34.7	38.0	21.7	24.6	4.8
Potassium feldspars	0.7	0.9	0.7	0.8	0.6	1.0	0.0
Flint / chalcedony	0.0	0.3	0.0	0.8	0.3	0.0	0.0
Fragments of sedimentary rocks	0.0	0.0	0.0	0.0	0.0	0.7	28.4
Fragments of igneous rocks	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragments of metamorphic rocks	0.0	0.0	0.2	0.0	0.6	1.0	0.0
Muscovite	1.4	0.6	1.2	1.6	1.9	1.7	0.0
Opaque minerals	0.0	0.3	0.7	0.4	0.0	0.0	0.0
Iron oxides and hydroxides	0.0	0.0	0.0	0.4	0.0	0.0	2.7
Grog	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clay pellet	0.0	0.0	0.0	0.0	0.3	0.0	1.2
Isotropic clasts	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Organic fragments	0.7	0.3	0.2	0.0	0.0	0.0	0.0
Carbonates	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Voids	3.4	8.0	12.6	8.0	5.1	7.5	2.7

settlement of the Lengyel culture. In total, 27 pottery fragments, 2 flint scales, an unmodified stone, and a bone awl were extracted from the feature. The homogeneous assemblage of the LBK materials comes from a depth of 70-90 cm and included 19 fragments of ceramic vessels.

4.2. Petrography

Thin sections were prepared from fragments of pottery for microscopic examination in transmitted polarized light. Through point-counting quantitative microscopic analysis, the percentage composition of various components, such as clay minerals, quartz, potassium feldspars, plagioclase, muscovite, biotite, carbonates, grains of sedimentary, igneous, and metamorphic rocks, fragments of secondarily used ceramics, as well as organic material, was determined. Petrographic descriptions of the ceramic sections were also carried out, considering the degree of consolidation of the fabrics, as well as firing atmosphere and temperature (Whitbread 2016; Reedy 2008, 109-210). The collected data were used for comparative studies and to determine petrographic and fabric groups. The approximate firing temperature was determined based on the thermal alteration of clay minerals – observing the degree of transformation into amorphous, isotropic substance, as well as the observation of minerals such as biotite, hornblende, and glauconite (Stoch 1974, 484; Bolewski and Żabiński 1988; Quinn 2013, 190-203). Grain size measurements were conducted using a micrometric scale under a polarizing microscope. The grain size classification followed the guidelines of the Polish Soil Science Society (Polskie Towarzystwo Gleboznawcze 2009).

Seven samples of the LBK ceramics were selected for petrographic studies, guided by technological characteristics of the ceramic mass, form, and decoration (Table 2). The investigations were carried out using a Nikon Eclipse LV100N POL polarizing microscope for transmitted light.

4.3. Archaeobotany

Archaeobotanical samples (13 litres) were floated with a mesh size of 1 mm and 0.5 mm at the W. Szafer Institute of Botany of the Polish Academy of Sciences (IB PAS). Only charred plant remains were taken into consideration as in dry archaeological sites uncharred material can be considered modern contamination (Lityńska-Zając and Wasylikowa 2005). Fruits and seeds were identified based on morphological features visible under a stereoscopic microscope at 10× and 16× magnifications, following keys, atlases, other publications (*e.g.*, Kulpa 1974; Cappers *et al.* 2009; Lityńska-Zając and Wasylikowa 2005) and the reference collection of the National Biodiversity Collection of Recent and Fossil Organisms at IB PAS. Charcoal fragments were studied with the help of a reflected light microscope with magnifications of up to 500×. They were analysed based on wood anatomy (*e.g.*, Schweingruber 2021). In Central Europe charcoal fragments are mostly identified to the genus level and species, *Pinus sylvestris*, has been indicated as it is the only possible pine species among native plants in the region. A Hitachi S-4700 scanning electron microscope (SEM) was used for micrographs at the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University (Kraków, Poland).

5. RESULTS

5.1. Pottery

Most ceramic fragments have their maximum size falling within the range of 1.7 to 6 cm. Only four are larger, falling within the range of 6 to 9.3 cm. The edges of breaks on the pottery are rounded, and their surfaces are relatively well-preserved. Distinctive features include fragments with black glossy surfaces indicating traces of paint, most likely originating from a single vessel (see below), as well as fragments with grey, greyish-white, and powdery-touch surfaces. The fractures in the pottery are uniform and monochromatic. In some fragments, a mineral admixture in the form of individual grains of coarse sand can be observed in the ceramic mass. The thickness of the pottery crust ranges from 5 to 11 mm. Most of them can be classified as tableware ceramics. They represent a typical for LBK vessel form, that is a spherical bowl.

The fragments probably originate from 3 to 4 vessels. The estimated diameter of the rims falls within the range of 6 to 7 cm. Decoration on the vessels was identified on six fragments. In terms of ornamentation, in addition to painting (see below), there are sets of double lines, including bands arranged horizontally with notches, in an angular arrangement, and a motif of decoration with multiple lines (Fig. 4: 1, 2, 3, 5, 6, 8). The presence of vessel fragments (with rims) without the customary engraved ornamentation, typical for LBK, is also noteworthy (one vessel; Fig. 4: 7).

5.2. Technology of the ceramics

Mineral composition

The primary components of the groundmass of the pottery fabrics are clay minerals (from approximately 40% to 47%), grains of the silty fraction (0.002-0.05 mm), fine mica flakes, concentrations and streaks of iron oxides and hydroxides, opaque minerals, and heavy minerals (*e.g.*, zircon, rutile, amphiboles; Table 2). Additionally, grains of thermally altered glauconite were identified. Inclusions are 0.05-1 mm composed of quartz grains (up to 38% in the Pran04 sample), feldspars, less commonly chalcedony, and fragments of sedimentary (*e.g.*, mudstones) and metamorphic rocks (*e.g.*, quartz-muscovite schists). The clastic material is well-rounded.

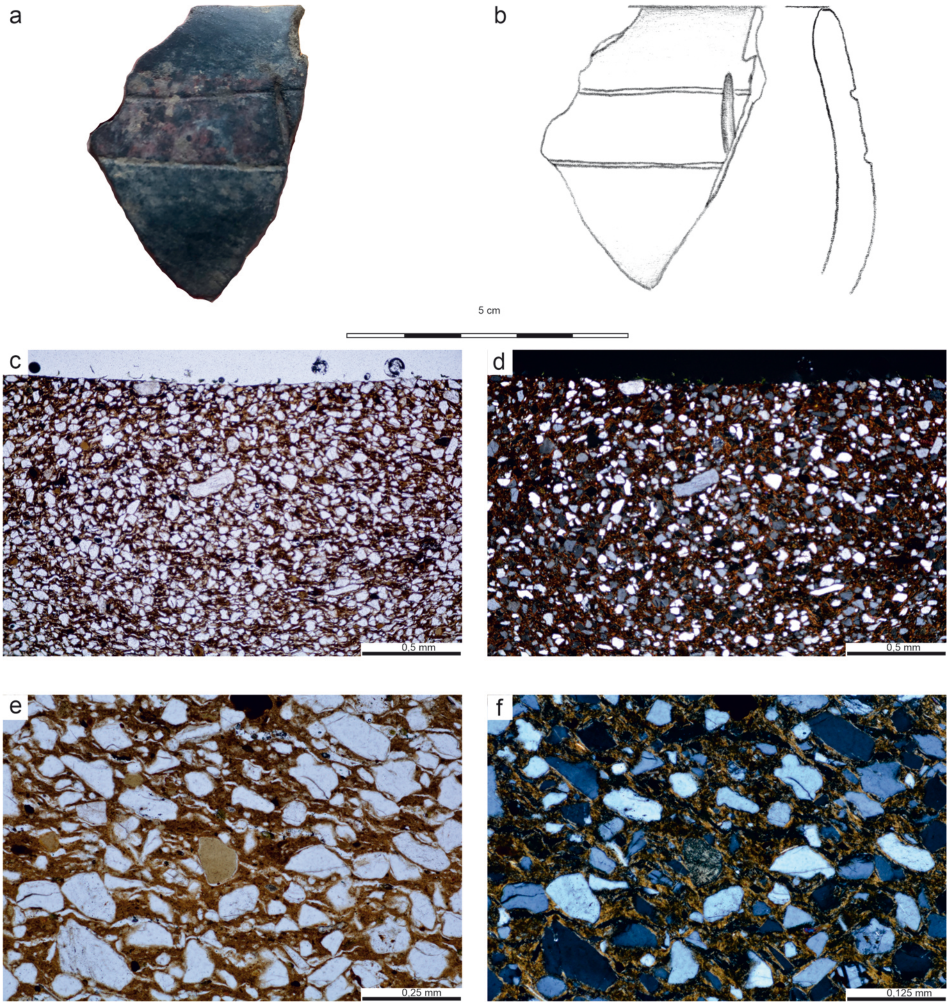

Fig. 7. Prandocin Site 1, sample Pran02; technological type II; photography (a) and drawing (b) of the fragment; microphotography of thin section (c-f); numerous grains of silt fraction (c, d); grain of thermal altered glauconite (e, f); plane polarized light (c, e); crossed polarized light (d, f). Photo A. Rauba-Bukowska, drawing W. Rumian

One sample (Pran08) contain numerous carbonate components. The primary component is carbonate mud (approximately 54%), in which there are numerous fragments of micrite-sparite limestone and thermally altered glauconite.

The above composition of the samples corresponds to the local geological structure of the site of Prandocin (Fig. 5). It can be concluded that the vessels were made from raw materials readily available in the close vicinity.

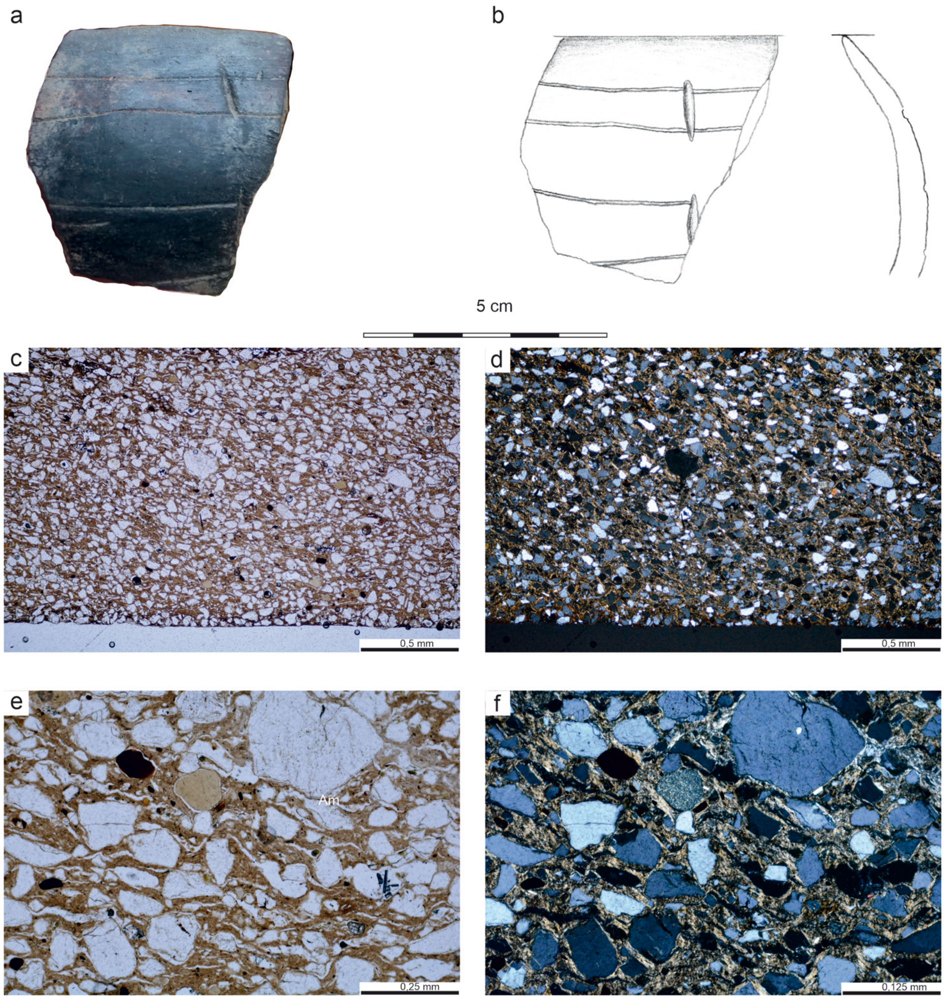

Fig. 8. Prandocin Site 1, sample Pran03; technological type II; photography (a) and drawing (b) of the fragment; microphotography of thin section (c-f); numerous grains of silt fraction (c, d); grain of thermal altered glauconite (e, f); plane polarized light (c, e); crossed polarized light (d, f).
Photo A. Rauba-Bukowska, drawing W. Rumian

Microstructure – granulation and sorting

The arrangement of mineral components and their quantitative relationships differ among the samples. Three basic ceramic fabrics can be distinguished.

The first type consists of fine-grained, well-sorted fabrics, represented by samples Pran02, Pran03, and Pran04. These are homogeneous fabrics that are well-mixed. Ceramic fabrics contain up to 10% of fine silt sized grains and between 32.2 to 38% very fine

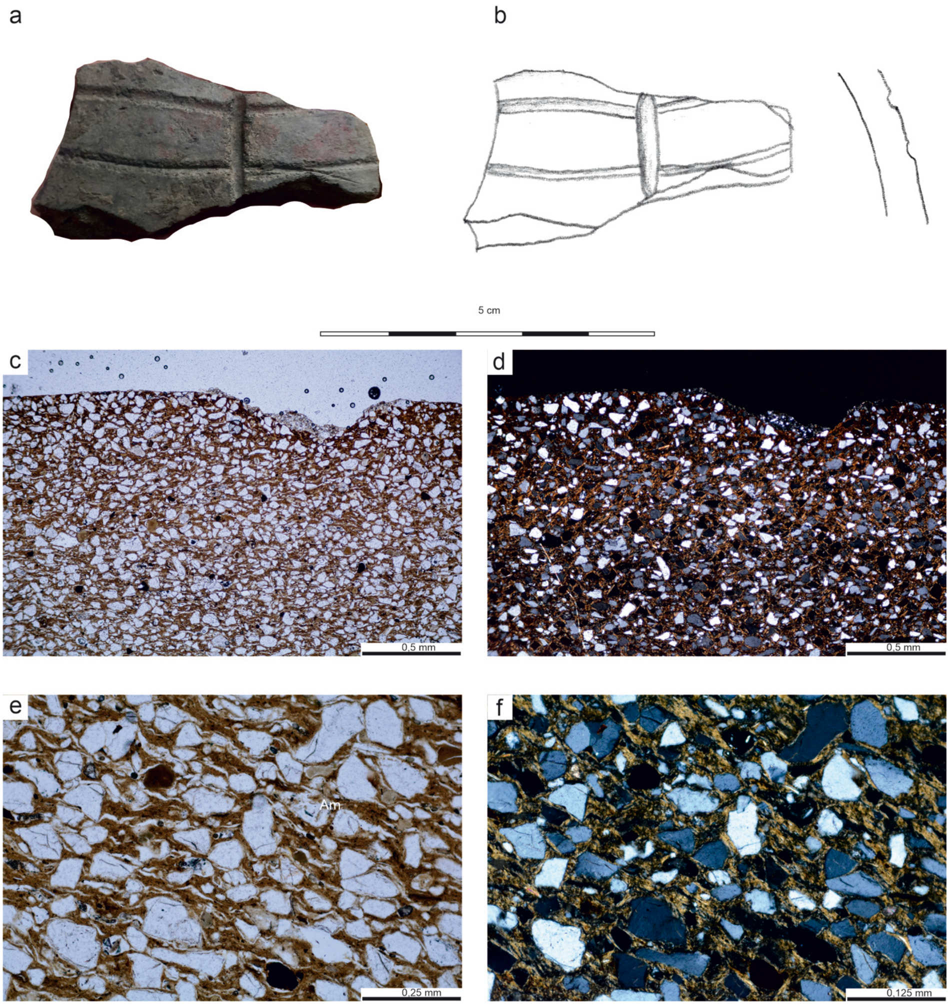

Fig. 9. Prandocin Site 1, sample Pran04; technological type II; photography (a) and drawing (b) of the fragment; microphotography of thin section (c-f); numerous grains of silt fraction, homogenous ceramic fabric (c-f); plane polarized light (c, e); crossed polarized light (d, f).
Photo A. Rauba-Bukowska, drawing W. Rumian

sand (Fig. 7; 8; 9). The components are evenly distributed in the mass, indicating good preparation of the pottery fabric. It can be inferred that these three fragments are made from the same ceramic mass and originate from the same vessel.

The second type consists of medium to coarse-grained fabrics, moderately sorted and well-mixed, represented by samples Pran01, Pran05, and Pran06 (Fig. 10; 11; 12). They are dominated by rounded grains of varying sizes, with a silty fraction ranging from 20 to 30%,

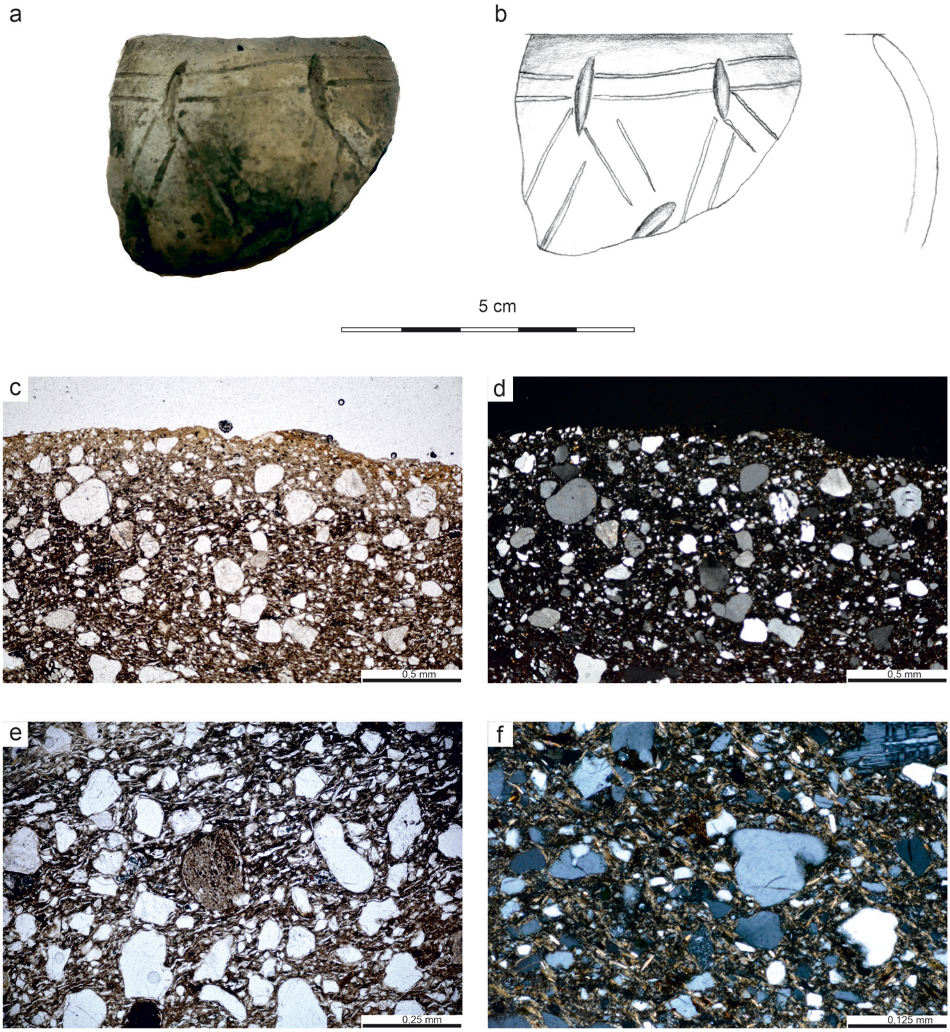

Fig. 10. Prandocin site 1, sample Pran01; technological type III; photography (a) and drawing (b) of the fragment; microphotography of thin section (c-f); numerous sand grains (c-f); plane polarized light (c, e); crossed polarized light (d, f). Photo A. Rauba-Bukowska, drawing W. Rumian

and a sand fraction from 20 to 28%. Grains and rock fragments are evenly distributed in the clay mass, indicating good preparation of pottery fabrics.

The third type is medium-grained, lumpy with numerous clasts of micrite and sparite limestones, represented by sample Pran08 (Fig. 13). The mass is heterogeneous, fine to medium-grained. The components are evenly distributed in the mass, indicating good preparation of the pottery fabric.

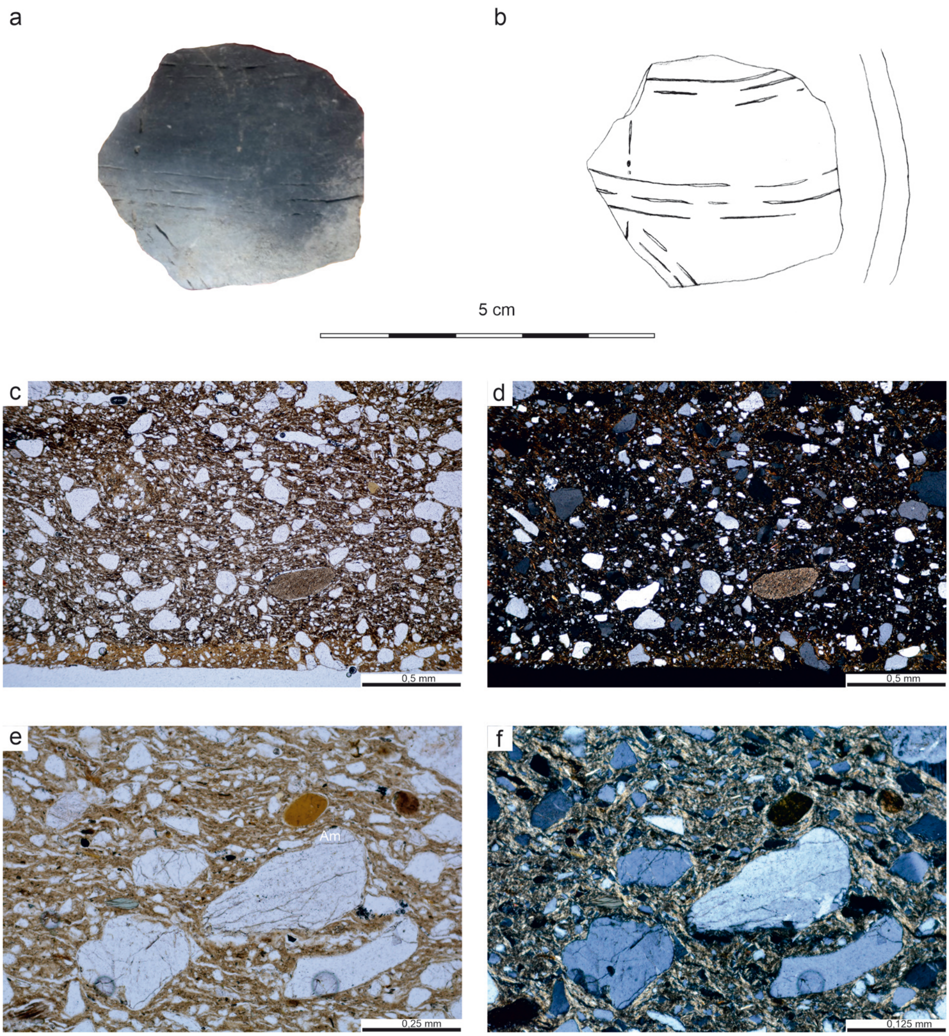

Fig. 11. Prandocin Site 1, sample Pran05; technological type III; photography (a) and drawing (b) of the fragment; microphotography of thin section (c-f); numerous grains of silt and sand fraction (c, d); grain of thermal altered glauconite (e, f); plane polarized light (c, e); crossed polarized light (d, f). Photo A. Rauba-Bukowska, drawing W. Rumian

Temperature and atmosphere of firings

All examined fragments show traces of firing under a mixed reducing-oxidizing atmosphere. Within the clay minerals, no glassy phase was observed, which starts forming above 800-850 Celsius degrees. The observation of thermally induced changes and the microstructure of the clay bodies indicate firing temperatures at approximately 700-750°C

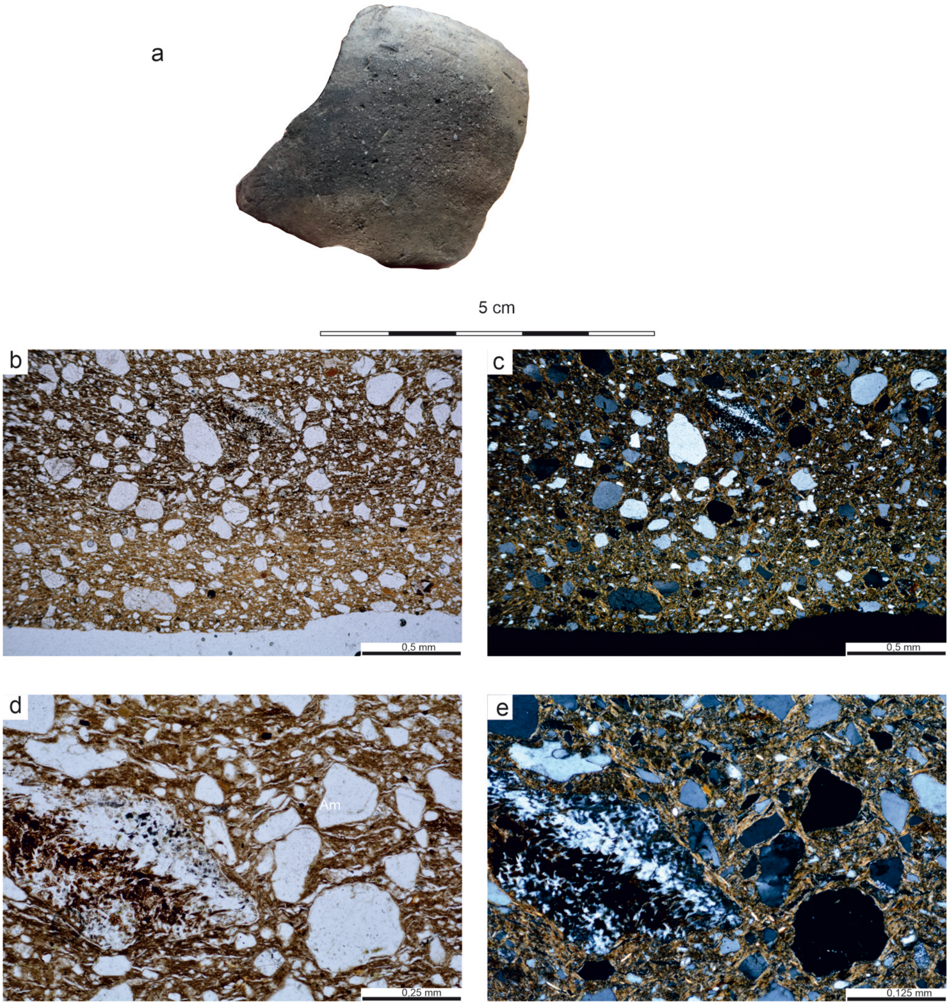

Fig. 12. Prandocin Site sample Pran06; technological type III; photography (a) of the fragment; microphotography of thin section (b-e); numerous grains of silt and sand fraction (b, c); grain of chalcedony (d, e); plane polarized light (b, d); crossed polarized light (c, e).
Photo A. Rauba-Bukowska, drawing W. Rumian

(Stoch 1974, 484; Quinn 2013, 190-200; Whitbread 2016; Daszkiewicz and Maritan 2016; Czekaj-Zastawny *et al.* 2021, 109).

Observations of the painted area

Macroscopically, the painting is visible on fragments in the form of a horizontal band running along two incised lines. On the cross-section of the vessel wall, a thin layer (approximately 0.03 mm) of dye is visible. It is likely composed mainly of iron oxides and

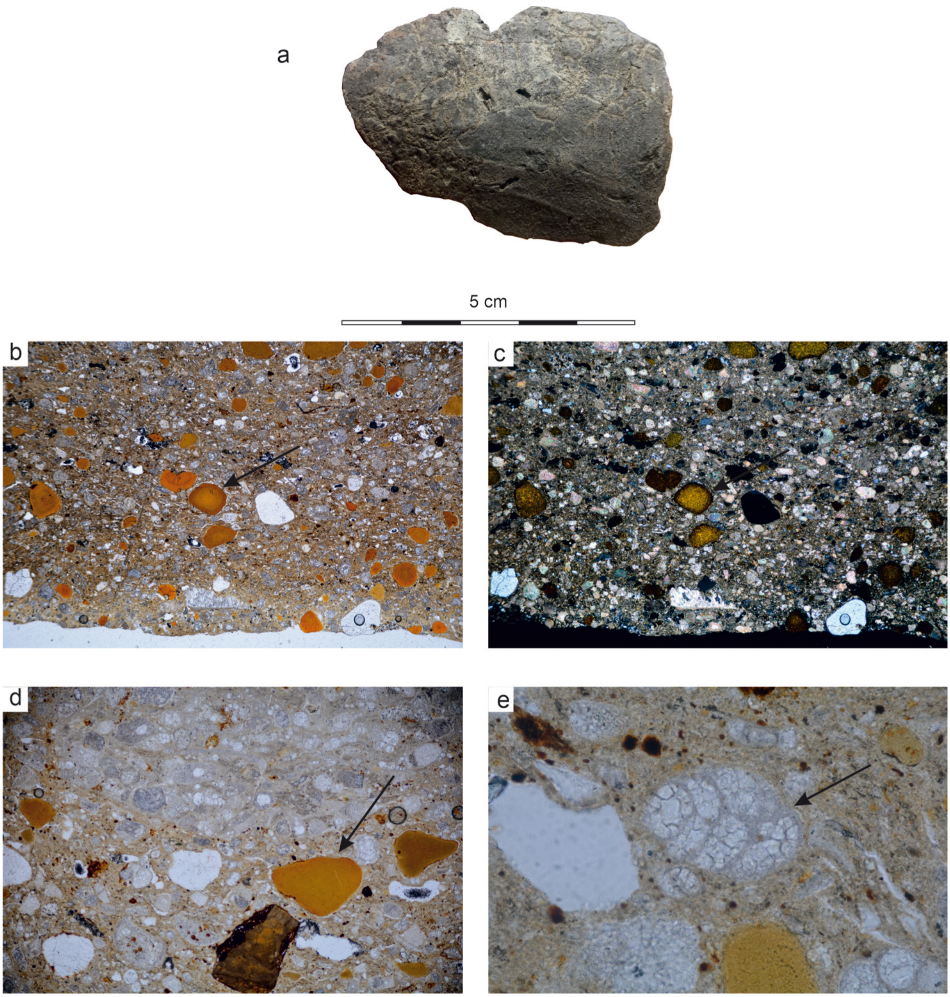

Fig. 13. Prandocin Site 1, sample Pran08; technological type IV; photography (a) of the fragment; microphotography of thin section (b-e); numerous grains of thermal altered glauconite (b, c, d, arrows); grains of carbonate rock (d) and microfossils (e, arrow); plane polarized light (b, d, e); crossed polarized light (c). Photo A. Rauba-Bukowska, drawing W. Rumian

hydroxides, no other clastic components, such as silty grains, were observed in this pigment.

The paint adheres to the smoothed surface of the vessel. The same treatment of the vessel wall is observed on the remaining surface that is not covered by red dye. There are no visible signs of intentional roughening or preparation of the surface covered by pigment. On one fragment, the red colour extends beyond the area delimited by two lines.

Intentional roughening of the surface, which was painted after the firing of the vessel is a common and standard practice in the ceramics of the Želiezovce group in western Slovakia (Pavúk 1994; Cheben 2000). This characteristic distinguishes the ceramics from Prandocin, as well as from other Polish sites, from the ceramics in Slovakia.

Interpretation on the background of state of research

The basic types of ceramic fabrics of the LBK in Małopolska have been established during extensive studies of this pottery. The research indicated that specific structural and physical characteristics of ceramic fabrics were employed to create vessels for various purposes. Based on the analysis of over 300 ceramic thin sections, it was also determined that the methods of preparing ceramic fabrics varied for each stylistic phase (*e.g.*, Rauba-Bukowska *et al.* 2007; Czekaj-Zastawny and Rauba-Bukowska 2013; Rauba-Bukowska 2014a; 2014b; 2014c; 2014d; Rauba-Bukowska 2016; Kadrow and Rauba-Bukowska 2017a; 2017b; Czekaj-Zastawny *et al.* 2017; Czekaj-Zastawny *et al.* 2021; Rauba-Bukowska and Czekaj-Zastawny 2020; Rauba-Bukowska 2021).

In summary, fine-grained, compact fabrics (types I and II) were used for forming thin-walled vessels. On the other hand, thick-walled vessels were crafted from fabrics with a higher sand content (type III) or fragments of sedimentary rocks (type IV). All mentioned types of ceramic fabrics contained a varying amount of plant admixture (Moskal-del Hoyo *et al.* 2017b; Czekaj-Zastawny *et al.* 2017; Rauba-Bukowska and Czekaj-Zastawny 2020).

Differences in technology have been observed between vessels from the Music-Note and Želiezovce phases. These changes involve the use of intentional additives, such as plant material and grog. In the early and classical phases (Music-Note phase), plant additives were commonly used, and no evidence of ceramic grog was found. However, vessels decorated in the Želiezovce style were made from ceramic fabrics with the addition of grog. At the same time, the proportion of organic additives decreased (Kozłowski *et al.* 2014; Czekaj-Zastawny *et al.* 2017; Rauba-Bukowska and Czekaj-Zastawny 2020; Rauba-Bukowska 2021). Grog is a new type of additive in the LBK pottery tradition. It was particularly abundantly mixed into clays used for crafting thick-walled vessels. This technological innovation was likely adopted in the LBK tradition through Transcarpathian contacts, possibly from the Bükk culture (Czekaj-Zastawny and Rauba-Bukowska 2014; Kadrow and Rauba-Bukowska 2016; Kadrow and Rauba-Bukowska 2017b; Kadrow 2020; Rauba-Bukowska and Czekaj-Zastawny 2020).

The analyzed assemblage of ceramics from Prandocin includes ceramic fabrics with a significant sand content and lacks additives typical for LBK in Małopolska, such as organic (plant) material and grog. The sand grains mainly consist of quartz and feldspar, occasionally chalcedony, corresponding to local deposits. Various granulations were observed; the fabrics of vessels Pran02, Pran03, Pran04, and Pran08 are fine-grained and well-sorted, while the fabrics of vessels Pran01, Pran05, and Pran06 are poorly sorted and contain grains of different sizes. Based on mineral composition and granulation, the fabrics can be assigned to several technological types distinguished for the LBK. Samples Pran02, Pran03, Pran04 (fragments with painting) correspond to Type II, characterized by fine-grained, very well-sorted, homogeneous, and compact fabrics. These three samples show significant similarity, suggesting they originate from the same vessel. Samples Pran01, Pran05, and Pran06 correspond to Type III with a high sand content. The fabric of vessel Pran08 is challenging to classify within the existing division due to its atypical carbonate composition and the presence of fragments of micritic limestones. However, because of the content of sedimentary rock fragments and its lumpy structure, it can be assigned to Type IV ceramic fabrics (*e.g.*, Rauba-Bukowska 2021, table 5).

A unique feature of the examined vessels is the absence of additives typical for LBK pottery, such as organic material and grog additives.

5.3. Archaeobotanical analysis

The results of the archaeobotanical analysis are presented in Table 3. Among fruits and seeds, there were six taxa identified to species (*Anthemis arvensis* – Fig. 14: c and *Chenopodium album* type – Fig. 14: a), genus (*Galium* sp. and *Stipa* sp. – Fig. 14: d) and family (Caryophyllaceae – Fig. 14b – and Chenopodiaceae). Also, two fragments of caryopsis were documented, which represented badly preserved cereal grains (Cerealia indet.). The carpological material was very scarce. Fruits of *Anthemis arvensis* (field chamomile) and awns of *Stipa* sp. (feather grass) were the most abundant, while other diaspores appeared

Table 3. Archaeobotanical analysis

Name of a taxon	Kind of remains	Number of specimens/fragments
Carpological material		
Anthemis arvensis	fruit	7
Chenopodium album type	seed	2
Galium sp.	fruit	1
Stipa sp.	awn	4
Caryophyllaceae	seed	1
Chenopodiaceae	seed	1
Cerealia indet.	caryopsis	2
Undetermined		7
Anthracological material		
Pinus sylvestris	charcoal	2
Alnus sp.	charcoal	2
Quercus sp.	charcoal	26
Broad-leaved	charcoal	1

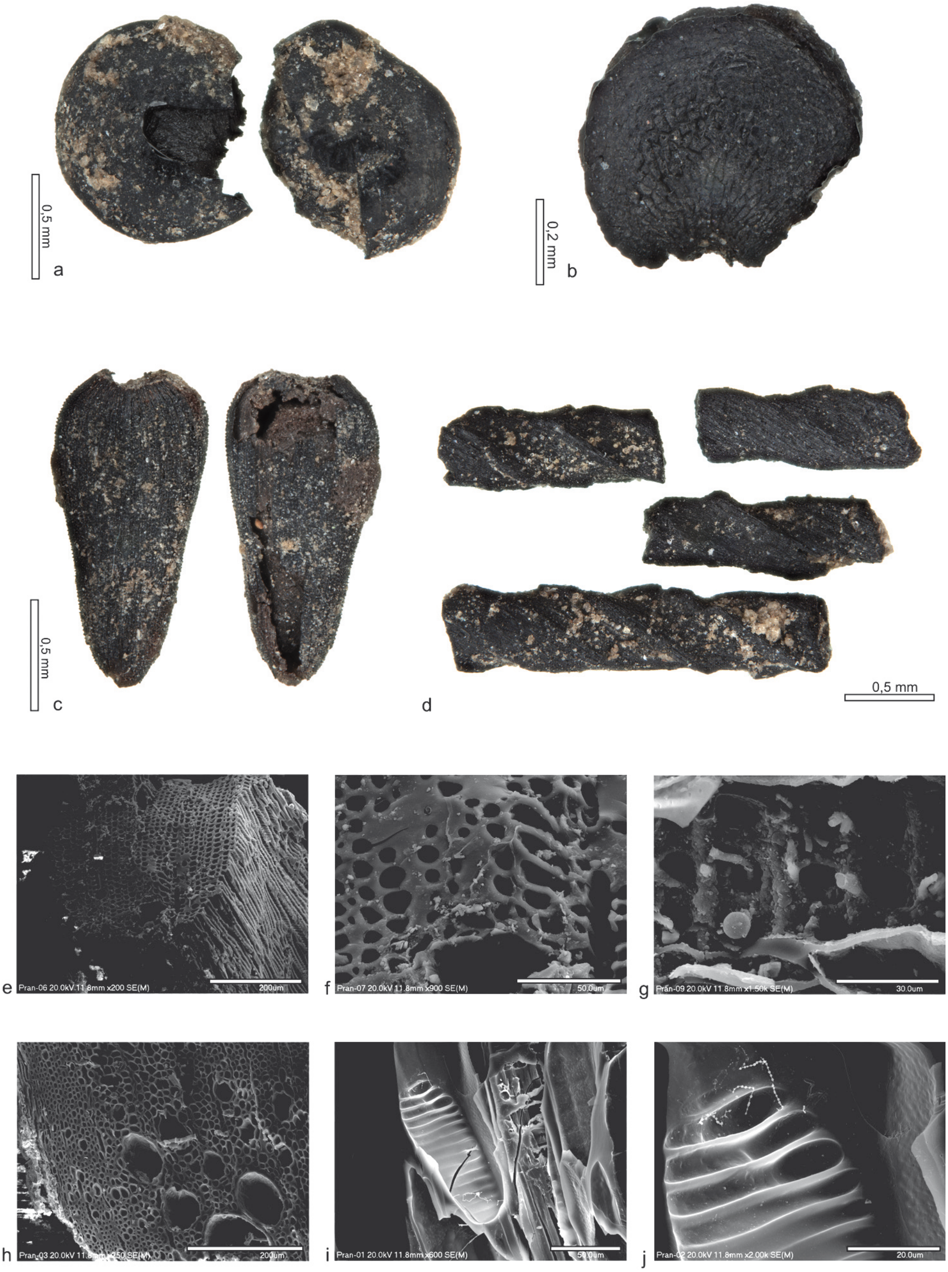

Fig. 14. Charred plant remains from Prandocin site 1: taxa of wild herbaceous (a-d) and woody plants (e-j); a. *Chenopodium album* type; b. Caryophyllaceae; c. *Anthemis arvensis*; d. *Stipa* sp.; e-g. *Pinus sylvestris*; h. *Quercus* sp.; i-j. *Alnus* sp. Scale-bar: 0.5 mm (a, c-d); b. 200 µm (b, e, h); 50 µm (f, i); 30 µm (g); 20 µm (j). Photos K. Stachowicz, Micrographs M. Moskal-del Hoyo

Fig. 15. Photographs of the red-painted vessels from Prandocin (a, b, c) (Poland) and Štúrovo (d, e) and Bajč (f) (Slovakia). Photo A. Rauba-Bukowska

as one or two specimens. Among cultivated plants, only two fragments of cereal caryopses (Cerealia indet.) were found.

In the group of wood charcoal remains, there were three taxa identified to species (*Pinus sylvestris* – Fig. 14: e-g) and genus (*Alnus* sp. – Fig. 14: i-j – and *Quercus* sp. – Fig. 14: h). They were preserved as very small fragments (<2 mm, Fig. 14: e, h), were vitrified (Fig. 14: f, i-j) and were characterised by a presence of microorganisms and fungi (Fig. 14: f, g, j), which suggests that they might have come from deadwood (Moskal-del Hoyo *et al.* 2010). Remains of *Quercus* sp. (oak) clearly predominated, whereas *Pinus sylvestris* (Scots pine) and *Alnus* sp. (alder) were less frequent.

6. DISCUSSION

The presence of finds of ceramics with red painting in areas north of the Carpathians fits into the discussion about the penetration of patterns and influences from Transcarpathia into the Upper Vistula River basin. Studies in this area have primarily addressed the issue of the presence of “imports” (both ceramics and mineral resources) from the East Linear Pottery circle (*e.g.*, Kaczanowska and Godłowska 2009; Czekaj-Zastawny and Rauba-Bukowska 2014; Kozłowski *et al.* 2014; Rauba-Bukowska 2014a; Czekaj-Zastawny 2017; Czekaj-Zastawny *et al.* 2017; Kadrow and Rauba-Bukowska 2017a; Rauba-Bukowska and Czekaj-Zastawny 2020; Szeliga and Zakościelna 2019; Dębiec *et al.* 2021). Studies are also focused on the dissemination of new patterns from a southern origin, manifested in changes in the ornamentation of vessels referred to as the Želiezovce style or phase (Kadrow 2020).

The Slovak Želiezovce group (phase), according to J. Pavúk (1969; 2009), originates from the local substrate of the LBK in the late Music-Note phase, influenced by the Eastern Linear Pottery circle (Alföld Linear Pottery Culture). In terms of ornamental motifs, it is characterized by the presence of oval impression located on two or three parallel engraved lines or long incisions cutting of transversely through multiple engraved lines. Technique of finishing vessels consists of placing appropriate motifs made up of engraved lines and smoothing the surface. However, the surface between the lines was specially roughened. After firing, these rough surfaces between the lines were covered with red or yellow dye (Fig. 15: d, e, f). In some cases, the red color is visible only inside the engraved lines. This is probably related to the state of preservation of the ceramics. Painting was present in this group from its very beginning, and it shares several analogies with the Szakalhat group of the Eastern Linear Pottery circle (Pavúk 1969, 295-297).

The Małopolska assemblages with ceramics decorated in the Želiezovce style are considered the result of interactions with the territory of Slovakia, involving the rapid absorption of new ideas and patterns (Kulczycka-Leciejowiczowa 1979, 60). The spread of this new ornamentation could have occurred through contacts associated with the exchange of goods and ideas (*e.g.*, Kadrow 2020a; 2020b; 2020c; Kozłowski *et al.* 2014; Czekaj-

Table. 4. Prandocin Site 1. Technological features of the LBK pottery – Želiezovce phase Poland (Rauba-Bukowska 2021) in comparison to Želiezovce group material from western Slovakia (Pavúk 1969; 1994; 2009; Cheben 2000); (+) – present; (-) – lack

Technological features of the pottery	Dominant admixture			Paint	Correlation of ceramic fabric to vessel type
	Plant	Grog	Sand		
Music-Note phase LBK	++		+	-	+
Želiezovce phase LBK	+	+	++	very rare	+
Ceramics from Prandocin site	-	-	++	+	-
Želiezovce group from western Slovakia (Pavúk 1969; 2009; Cheben 2000)	-	-	?	very often	?

Zastawny 2014; 2017; Rauba-Bukowska 2014a; Czekaj-Zastawny and Rauba-Bukowska 2014; Czekaj-Zastawny *et al.* 2017). Typical Želiezovce assemblages in Poland (*e.g.*, sites like Rzeszów 16 – Kadrow 1990a; Nowa Huta – Godłowska 1991; 1992) are primarily characterized by the presence and high frequency of basic decorative elements such as groups of notches and engraved lines, often accompanied by imports of obsidian artefacts and pottery of the Eastern Linear circle. The inspirations from the areas south of the Carpathians continue until the period associated with phase ŽIIb. To date, there is no evidence of interaction with the youngest stylistic phase of the Želiezovce group from Slovakia, namely ŽIII (Godłowska 1982, 152, 153; Kadrow 1990a; Czekaj-Zastawny 2008a; Pavúk 2009).

The results of the presented research are particularly interesting in the above context. In Prandocin, ceramics with ornamentation characteristic for the Želiezovce phase in Małopolska were discovered. Petrographic studies indicate that the vessels were made from locally available raw materials. The forms do not deviate from typical assemblages from southeastern Poland. However, the manufacturing technology clearly differs from the technology of Małopolska pottery (Table 4). This is evidenced, among other things, by the absence of typical additives, such as organic material and grog. In these aspects, it is similar to the ceramics of the Želiezovce group in Slovakia, where no organic additives or grog were noted (Pavúk 1994; Furholt *et al.* 2020). The technology used in crafting the vessels from Prandocin also does not precisely replicate patterns from Slovakia. This is indicated, for instance, by the method of preparing the surface to be painted. In the case of vessels from sites such as Štúrovo or Bajč, they have a specially prepared surface intended to be covered with pigment (Pavúk 1994; Cheben 2000; I. Cheben personal communication). This preparation was not observed in the examined assemblage from Prandocin. A unique blend of technological features in the ceramics was observed, which cannot be explained solely by the migration of the creator or the idea. According to Olivier Gosselain (2000), features such as surface ornamentation can easily transfer to other areas or to another human group. However, the choice of raw material or the preparation of ceramic fabric requires a more in-depth knowledge of the production process. The vessels found in

Prandocin could have been made by someone familiar with the Želiezovce ceramic-making techniques. However, their knowledge was not precise enough to replicate the method of painting ornamentation (Fig. 15). It is possible that the creator had not acquired knowledge about pottery production methods directly from the Želiezovce group. The Bükk culture environment can also be excluded as a transmitter. In Bükk culture ceramic materials, grog additives are often present, as well as organic (plant) fragments (Czekaj-Zastawny *et al.* 2018, 354-358).

To sum up, technologically the assemblage from Prandocin is closer to the Želiezovce group. It should be noted that the small collection from Prandocin certainly does not reflect the entire range of diversity in ceramic fabrics at this site. It is only a limited glimpse into the working methods of the pottery workshop. Nevertheless, due to the rarity of findings of painted ceramics from the LBK, it deserves special attention and in-depth analysis.

The plant assemblage from Prandocin is very scant, partly because it comes only from one archaeological feature. However, a scarcity of plant remains at Early Neolithic sites is typically observed in Linear Pottery Culture sites (*e.g.*, Lityńska-Zając*et al.* 2017; Mueller-Bieniek *et al.* 2019; Moskal-del Hoyo *et al.* 2023). Only two fragments of cereals represent cultivated species, which probably belonged to wheat species (emmer *T. dicoccum* and einkorn *Triticum monococcum*) or barley (*Hordeum vulgare*), crops typically found in LBK sites in southern Poland (Lityńska-Zając *et al.* 2017). Among wild herbaceous plants, taxa indicating segetal and ruderal communities appeared (Lityńska-Zając 2005), while a presence of feather grass indicates steppe-like vegetation or open canopy forests (Ceynowa-Giełdon 2001). This kind of woodland might be suggested by a dominance of oak followed by pine in the charcoal assemblage, which is in accordance with the results obtained in other LBK sites in loess areas of southern Poland (Moskal-del Hoyo 2021).

7. CONCLUSION

The vessels were made from clay, whose characteristics correspond to the local geological structure of the area. Microscopic examinations were used to determine the quantitative relationships of mineral components in the ceramic fabrics. Comparisons with other studies conducted in the same way revealed that the ceramics were produced using a technology different from that of the LBK vessels in Małopolska. Primarily, no organic additives and grog were identified in the pottery fabrics (*e.g.*, Rauba-Bukowska *et al.* 2007; Rauba-Bukowska and Czekaj-Zastawny 2020; Rauba-Bukowska 2014b; Rauba-Bukowska 2021). Especially, the presence of organic additives is a distinctive feature of LBK ceramics in general (Moskal del-Hoyo *et al.* 2017b). Thus, its absence is an atypical characteristic for the LBK. Additionally, the presence of ceramics with a high content of sand is also atypical.

Previous detailed studies of LBK ceramics have shown a significant change in the composition of ceramic fabrics between vessels with Music-Note and Želiezovce ornamentation

(Czekaj-Zastawny *et al.* 2017; Rauba-Bukowska and Czekaj-Zastawny 2020; Czekaj-Zastawny *et al.* 2021). Primarily, the addition of grog began to be used in the production of vessels with thicker walls. Meanwhile, the use of organic additives, which dominated in the pre-Music-Note and Music-Note phases, became less frequent in the Želiezovce phase (Moskal del-Hoyo *et al.* 2017b). However, these changes in the technology of LBK vessel production between pots with Music-Note and Želiezovce ornamentation styles are less radical than those observed in Prandocin. The materials from Prandocin exhibit a unique blend of characteristics from the Želiezovce group ceramics from Slovakia and the ceramics of the Želiezovce style and phase from Małopolska.

Finally, it is worth noting that even if the plant material is not very abundant, it contains plants that have been documented from the Early Neolithic sites in Poland, showing a high match with other LBK sites, documenting the presence plants of segetal and ruderal communities, open oak-pine woodland, and likely steppe-like grasslands.

Aknowledgements

We would like to express our gratitude to Professor Agnieszka Czekaj-Zastawny for her valuable insights during the writing of this article. Our thanks also go to Dr. Ivan Cheben for his expert consultation on painting techniques specific to the Želiezovce pottery. Special appreciation is extended to Professor Juraj Pavúk for facilitating access to ceramic materials within the resources of the Academy of Sciences in Nitra. I would also like to thank my father – Jacek Nowak for his support and help during the research in Prandocin. The studies were made possible with financial support from the Institute of Archaeology and Ethnology PAS, Departments of Mountain and Highland Archaeology. Archaeobotanical analysis was funded by the statutory research fund of the Institute of Botany, Polish Academy of Sciences.

References

Bolewski A. and Żabiński W. eds 1988. *Metody badań minerałów i skał*. Warszawa: Wydawnictwo Geologiczne.

Boratyn J. and Brud S. 2001. *Objaśnienia do szczegółowej mapy geologicznej Polski, 1:50 000. Arkusz Słomniki (947)*. Warszawa: Ministerstwo Środowiska, Państwowy Instytut Geologiczny.

Cappers R. T. J., Neef R. and Bekker R. M. 2009. *Digital Atlas of Economic Plants. Parts 1, 2a, 2b* (= *Groningen Archaeological Studies* 9). Groningen: Barkhuis.

Ceynowa-Giełdon M. 2001. *Stipa joannis Čelek*. Ostnica Jana. In R. Kazimierczakowa and K. Zarzycki (ed.), *Polska czerwona księga roślin. Paprotniki i rośliny kwiatowe*. Kraków: Instytut Botaniki im. W. Szafera PAN, Instytut Ochrony Przyrody PAN, 461-463.

Cheben I. 2000. *Bajč – eine Siedlung der Želiezovce-Gruppe: Entwicklungsende der Želiezovce-Gruppe und Anfänge der Lengyel-Kultur* (= *Universitätsforschungen zur prähistorischen Archäologie* 68). Bonn: Rudolf Habelt GmbH.

Czekaj-Zastawny A. 2008a. *Osadnictwo społeczności kultury ceramiki wstęgowej rytej w dorzeczu górnej Wisły*. Kraków: Instytut Archeologii i Etnologii PAN.

Czekaj-Zastawny A. 2008b. Linear Band Pottery Culture in the upper Vistula river basin. *Sprawozdania Archeologiczne* 60, 31-72.

Czekaj-Zastawny A. 2014. *Brzezie 17. Osada kultury ceramiki wstęgowej rytej* (= *Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce*). Kraków: Krakowski Zespół do Badań Autostrad.

Czekaj-Zastawny A. 2017. The first farmers from the South – Linear Pottery culture. In P. Włodarczak (ed.), *The Past Societies. Polish Lands from the First Evidence of Human Presence to the Early Middle Ages* 2. *5500-2000 BC*. Warszawa: Instytut Archeologii i Etnologii PAN, 21-62.

Czekaj-Zastawny A., Rauba-Bukowska A. and Hreha R. 2018. Colorants used for decoration of the Bükk Culture vessels. In P. Valde-Nowak, K. Sobczyk, M. Nowak and J. Źrałka (eds), *Multas per gentes et multa per saecula. Amici magistro et collegae suo Ioanni Christopho Kozłowski dedicant*. Kraków: Jagiellonian University in Kraków, Alter, 351-359.

Czekaj-Zastawny A. and Rauba-Bukowska A. 2013. *Technologia i chronologia najstarszych naczyń glinianych w dorzeczu górnej Wisły (VI/V tys. BC). Report of the project number N N109 181040*. Kraków: unpublished manuscript for the National Centre of Science (Narodowe Centrum Nauki).

Czekaj-Zastawny A. and 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 and 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: Archaeopress Archaeology, 95-107.

Czekaj-Zastawny A., Kadrow S. and Rauba-Bukowska A. 2017. Ceramic raw material acquisition and transfer of technological ideas among the Early Neolithic communities around the Western Carpathians. In L. Burnez-Lanotte (ed.), *Matières à Penser: Raw materials acquisition and processing in Early Neolithic pottery productions. Matières à penser: sélection et traitement des matières premières dans les productions potières du Néolithique ancien. Proceedings of the Workshop of Namur (Belgium) Actes de la table ronde de Namur (Belgique) 29 et 30 mai 2015 – 29 and 30 May 2015* (= *Séances de la Société Préhistorique Française* 11). Paris: Société Préhistorique Française, 81-91.

Czekaj-Zastawny A., Rauba-Bukowska A., Kukułka A., Kufel-Diakowska B., Lityńska-Zając M., Moskal-del Hoyo M. and Wilczyński J. 2020. The earliest farming communities north of the Carpathians: The settlement at Gwoździec site 2. *PLoS ONE* 15/1, e0227008. https://doi.org/10.1371/journal.pone.0227008

Czekaj-Zastawny A. and Oberc T. 2021. Chronologia osady/Chronology of the settlement. In In A. Czekaj-Zastawny, A. Rauba-Bukowska and A. Kukułka (eds), *Najstarsza osada kultury ceramiki wstęgowej rytej z terenu Polski. Gwoździec stan. 2, gm. Zakliczyn*. Kraków: Instytut Archeologii i Etnologii PAN, Muzeum Okręgowe w Tarnowie, 313-334.

Czekaj-Zastawny A, Rauba-Bukowska A. and Kukułka A. eds 2021. *Najstarsza osada kultury ceramiki wstęgowej rytej z terenu Polski. Gwoździec stan. 2, gm. Zakliczyn / The earliest settlement of* *the Linear Pottery Culture from the territory of Poland. Gwoździec site 2, com. Zakliczyn.* Kraków: Instytut Archeologii i Etnologii PAN, Muzeum Okręgowe w Tarnowie.

Czekaj-Zastawny A, Rauba-Bukowska A., Kukułka A. and Bochnia M. 2021. Ceramika naczyniowa kultury ceramiki wstęgowej rytej / Ceramic vessels of the Linear Pottery Culture. In A. Czekaj-Zastawny, A. Rauba-Bukowska and A. Kukułka (eds), *Najstarsza osada kultury ceramiki wstęgowej rytej z terenu Polski. Gwoździec stan. 2, gm. Zakliczyn.* Kraków: Instytut Archeologii i Etnologii PAN, Muzeum Okręgowe w Tarnowie, 63-124.

Czerniak L., Golański A., Jóźwiak B. Kadrow S., Rozen J. and Rzepecki S. 2006. Sprawozdanie z archeologicznych badań wykopaliskowych przeprowadzonych w latach 2003-2004 na stanowiskach 3, 12-15 i 34 w Targowisku, gm. Kłaj, woj. małopolskie. In Z. Bukowski and M. Gierlach (eds), *Raport 2003-2004. Wstępne wyniki konserwatorskich badań archeologicznych w strefie budowy autostrad w Polsce za lata 2003-2004.* Warszawa: OODA, 541-554.

Daszkiewicz M and Maritan L. 2016. Experimental Firing and Re-firing. In A. M. W. Hunt (ed.), *The Oxford Handbook of Archaeological ceramic Analysis.* Oxford: Oxford University Press, 487-508, Plates 5-9.

Dębiec M. 2014. *Zwięczyca 3. Eine bandkeramische Siedlung am Wisłok.* Rzeszów: Zimowit.

Dębiec M., Saile T., Alagierski T. and Rauba-Bukowska A. 2021. Ein Ungarn in Polen. Zu einer frühneolithischen Statuette aus Kosina 62 bei Łańcut im südöstlichen Polen. *Archäologisches Korrespondenzblatt* 51/1, 23-35.

Furholt M., Cheben I., Müller J., Bistáková A., Wunderlich M. and Müller-Scheessel N. (eds) 2020. *Archaeology In The Žitava Valley I. The LBK and Želiezovce settlement site of Vráble* (= *Scales of Transformation in Prehistoric and Archaic Societies* 9). Leiden: Sidestone Press.

Godłowska M. 1976. Próba rekonstrukcji rozwoju neolitycznego w rejonie Nowej Huty. *Materiały Archeologiczne Nowej Huty* 5, 7-180.

Godłowska M. 1982. Nowohucki zespół osadniczy na tle wpływów południowych we wczesnym i środkowym neolicie Małopolski. *Wiadomości Archeologiczne* 47, 143-159.

Godłowska M. 1991. Osada kultury ceramiki wstęgowej rytej w Krakowie-Nowej Hucie na stan. 62 (Mogiła). Część I. Materiały. *Materiały Archeologiczne Nowej Huty* 14, 7-68.

Godłowska M. 1992. Osada kultury ceramiki wstęgowej rytej w Krakowie Nowej-Hucie na stan. 62 (Mogiła). Część II. Analiza materiałów. *Materiały Archeologiczne Nowej Huty* 15, 7-52

Godłowska M., Rook E. and Drobniewicz B. 1985. A Settlement of the Linear Pottery Culture at Pleszów. *Przegląd Archeologiczny* 33, 57-103.

Gosselain O. 2000. Materializing Identities: An African Perspective. *Journal of Archaeological Method and Theory* 7/3, 187-217.

Kaczanowska M. and 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 Neolithisation North of the Central European Agro-Ecological Barrier.* Kraków: Polska Akademia Umiejętności, 137-149.

Kadrow S. 1990a. Osada neolityczna na stan. nr 16 w Rzeszowie na osiedlu Piastów. *Sprawozdania Archeologiczne* 41, 9-76.

Kadrow S. 1990b. The Rzeszów Settlement Microregion in Neolithic. *Acta Archaeologica Carpathica* 29, 33-70.

Kadrow S. 1991. *Iwanowice. Stanowisko Babia Góra* 1. *Rozwój przestrzenny osady z wczesnego okresu epoki brązu*. Kraków: Instytut Historii Kultury Materialnej PAN.

Kadrow S. 2020a. Faza i styl żeliezowski kultury ceramiki wstęgowej rytej w Polsce południowo-wschodniej. In M. Dębiec and T. Saile (eds), *A planitiebus usque ad montes. Studia archaeologica Andreae Pelisiak vitae anno sexagesimo quinto oblata*. Rzeszów: Wydawnictwo Uniwersytetu Rzeszowskiego, Fundacja rzeszowskiego Ośrodka Archeologicznego, 143-152.

Kadrow S. 2020b. Macro and Micro Scale Neolithisation Process in south-eastern Poland against the background of central-eastern Europe. *Lietuvos Archeologija* 46, 171-189.

Kadrow S. 2020c. Innovations in ceramic technology in the context of culture change north of the Carpathians at the turn of the 6th and 5th millennia BCE. In M. Spataro and M. Furholt (eds), *Detecting and explaining technological innovation in prehistory* (= *Scales of Transformation* 8). Leiden: Sidestone Press, 85-105.

Kadrow S., Forysiak J., Okupny D., Saile T., Posselt M., Rauba-Bukowska A., Wąs M., Twardy J., Golański A. and Abramów J. 2022. The Early Neolithic Cultural Transformation in the Targowisko Settlement Region, SE Poland. *Praehistorische Zeitschrift* 97/2, 409-446

Kadrow S. and Rauba-Bukowska A. 2016. Ceramics Technology and Transfer of Ideas in the West Carpathian Region in Neolithic. In S. Terna and B. Govedarica (eds), *Interactions, Changes and Meanings. Essays in honour of Igor Manzura on the occasion of his 60th birthday*. Kishinev: High Anthropological School University, 65-72

Kadrow S. and Rauba-Bukowska A. 2017a. The selection of ceramic raw material: convenience or a technological idea? A case study of the Danubian cultures north of the Carpathians. *Archeologické rozhledy* 69, 261-280.

Kadrow S. and Rauba-Bukowska A. 2017b. The Technology of Neolithic Pottery North and South of the Western Carpathians. In T. Pereira, X. Terradas and N. Bicho. (ed.), *The Exploitation of Raw Materials in Prehistory: Sourcing, Processing and Distribution*. Cambridge: Cambridge Scholars Publishing, 414-431.

Kondracki J. 2002. *Geografia regionalna Polski*. Warszawa: Wydawnictwo Naukowe PWN

Kozłowski J. K., Kaczanowska M., Czekaj-Zastawny A., Rauba-Bukowska A. and Bukowski K. 2014. Early/Middle Neolithic Western (LBK) vs Eastern (ALPC) Linear Pottery Cultures: Ceramics and Lithic Raw Materials Circulation. *Acta Archaeologica Carpathica* 49, 37-76

Kulczycka-Leciejewiczowa A. 1979. Pierwsze społeczeństwa rolnicze na ziemiach polskich. Kultury kręgu naddunajskiego. In W. Hensel and T. Wiślański (eds), *Prahistoria ziem polskich* 2. *Neolit*. Wrocław: Ossolineum, 19-164.

Kulczycka-Leciejewiczowa A. 1983. O zofipolskim stylu ceramiki wstęgowej rytej w Polsce. *Archeologia Polski* 28, 67-97

Kulczycka-Leciejewiczowa A. 2008. Samborzec. Studium przemian kultury ceramiki wstęgowej rytej. Wrocław: Instytut Archeologii i Etnologii PAN

Kulpa W. 1974. *Nasionoznawstwo chwastów*. Warszawa: Państwowe Wydawnictwo Rolnicze i Leśne.

Kruk J. 1970. Badania poszukiwawcze i weryfikacyjne w górnym i środkowym dorzeczu Szreniawy. *Sprawozdania Archeologiczne* 22, 271-301.

Latałowa M. 1976. Diagram pyłkowy osadów późnoglacjalnych i holoceńskich z torfowiska w Wolbromiu. *Acta Palaeobotanica* 17/1, 55-80.

Lityńska-Zając M. 2005. *Chwasty w uprawach roślinnych w pradziejach i wczesnym średniowieczu*. Kraków: Instytut Archeologii i Etnologii PAN.

Lityńska-Zając M. and Wasylikowa K. 2005. *Przewodnik do badań archeobotanicznych* (= *Vademecum Geobotanicum*). Poznań: Sorus.

Lityńska-Zając M., Czekaj-Zastawny A. and Rauba-Bukowska A. 2017. Utilisation of cultivated and wild plants in the economy of the Linear Pottery culture in the Upper Vistula Basin. *Sprawozdania Archeologiczne* 69, 271-296.

Matuszkiewicz J. M. 2008. *Potencjalna roślinność naturalna Polski*. Warszawa: Instytut Geografii i Przestrzennego Zagospodarowania PAN.

Moskal-del Hoyo M. 2021. Open canopy forests of the loess regions of southern Poland: A review based on wood charcoal assemblages from Neolithic and Bronze Age archaeological sites. *Quaternary International* 593-594, 2021, 204-223. DOI: 10.1016/j.quaint.2020.11.013

Moskal-del Hoyo M., Wachowiak M. and Blanchette R. A. 2010. Preservation of fungi in charcoal. *Journal of Archaeological Science* 37/9, 2106-2116.

Moskal-del Hoyo M., Mueller-Bieniek A., Alexandrowicz W. P., Wilczyński J., Wędzicha S., Kapcia M. and Przybyła M. M. 2017a. The continuous persistence of open oak forests in the Miechów Upland (Poland) in the second half of the Holocene. *Quaternary International* 458, 14-27.

Moskal-del Hoyo M., Rauba-Bukowska A., Lityńska-Zając M., Mueller-Bieniek A. and Czekaj-Zastawny A. 2017b. Plant materials used as temper in the oldest Neolithic pottery from south-eastern Poland. *Vegetation History and Archaeobotany* 26, 329-344.

Moskal-del Hoyo M., Kapcia M., Salavert A., Alexandrowicz W. P., Saile T., Kiosak D. and Dębiec M. 2023. Archaeobotanical and palaeoenvironmental analyses from the easternmost Early Neolithic sites at Kamyane-Zavallia (Ukraine) and Nicolaevca V (Moldova). *Vegetation History and Archaeobotany*. DOI: 10.1007/s00334-023-00944-y

Moskal-del Hoyo M., Korczyńska-Cappenberg M., Kenig R., Rauba-Bukowska A., Roffet-Salque M., Maule C. A., Werra D. H., Hughes R. E., Kapcia M., Wilczyński J., Czekaj-Zastawny A. and Nowak M. 2024. An Early Neolithic House in the Foothills: A Case Study of Pottery and Lithic Artifacts from the Biskupice Site 18 (Wieliczka Foothills, Southern Poland). *Journal of Archaeological Science: Reports* 53, 104346. doi.org/10.1016/j.jasrep.2023.104346

Mueller-Bieniek A., Bogucki P., Pyzel J., Kapcia M., Moskal-del Hoyo M. and Nalepka D. 2019. The role of *Chenopodium* in the subsistence economy of pioneer agriculturalists on the northern frontier of the Linear Pottery culture in Kuyavia, central Poland. *Journal of Archaeological Science* 111, 1-11.

Oberc T., Czekaj-Zastawny A. and Rauba-Bukowska A. 2022. ^{14}C dating for the Linear Pottery Culture from the territory of Poland – research problems. In M. Grygiel and P. Obst (eds), *Walking among ancient trees. Studies in honour of Ryszard Grygiel and Peter Bogucki on the 45th anniversary of* *their research collaboration*. Łódź: Fundacja Badań Archeologicznych Imienia Profesora Konrada Jażdżewskiego, Muzeum Archeologiczne i Etnograficzne w Łodzi, 183-212.

Pająk B. (ed.) 2012. *Raport o stanie środowiska w województwie małopolskim w 2011 roku. Wojewódzki Inspektorat Ochrony Środowiska w Krakowie*. Kraków: Biblioteka Monitoringu Środowiska.

Pavúk J. 1969. Chronologie der Želiezovce-Gruppe. *Slovenská Archeológia* 17/2, 269-367.

Pavúk J. 1994. *Štúrovo* (= *Archaeologica Slovaca Monographiae. Studia* 4). Nitra: Archäologisches Institut der Slowakischen Akademie der Wissenschaften.

Pavúk J. 2009. Die Entwicklung der Želiezovce-Gruppe und die Entstehung der Lengyel-Kultur. In A. Zeeb-Lanz (ed), *Krisen-Kulturwandel-Kontinuitäten. Zum Ende der Bandkeramik in Mitteleuropa. Beiträge der internationalen Tagung in Herxheim bei Landau (Pfalz) vom 14.-17. 06. 2007* (= *Internationale Archäologie. Arbeitsgemeinschat, Symposium, Tagung, Kongress* 10). Rahden/Westf.: Verlag Marie Leidorf GmbH, 249-266.

Polskie Towarzystwo Gleboznawcze 2009. Klasyfikacja uziarnienia gleb i utworów mineralnych PTG 2008. *Roczniki Gleboznawcze* 60/2, 5-16.

Quinn P. S. 2013. *Ceramic Petrography. The Interpretation of Archaeological Pottery and Related Artefacts in Thin Section*. Oxford: Archaeopress.

Rauba-Bukowska A. 2014a. Wyniki badań mineralogiczno-petrograficznych naczyń importowanych kręgu wschodniolinearnego, odkrytych na stanowisku 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: Krakowski Zespół do Badań Autostrad, 459-468.

Rauba-Bukowska A. 2014b. 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. Żródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce*). Kraków: Krakowski Zespół do Badań Autostrad, 437-458.

Rauba-Bukowska A. 2014c. Wyniki badań mineralogiczno-petrograficznych surowców ceramicznych z okolicy 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: Krakowski Zespół do Badań Autostrad, 469-480.

Rauba-Bukowska A. 2014d. Rozpoznanie składu mineralnego i petrograficznego mas ceramicznych kultury ceramiki wstęgowej rytej i kultury malickiej ze stan. 10, 11 w Targowisku, pow. Wielicki. In A. Zastawny (ed.), *Targowisko, stan, 10, 11. Osadnictwo z epoki kamienia* (= *Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce*). Kraków: Krakowski Zespół do Badań Autostrad, 585-606.

Rauba-Bukowska A. 2016. Analiza mineralogiczno-petrograficzna i technologiczna fragmentów naczyń ceramicznych kultury ceramiki wstęgowej rytej ze stanowiska Zagórze 2, gm. Niepołomice. *Raport* 11, 7-22.

Rauba-Bukowska A. 2021. Technological indicators in the pottery production of the late Linear Pottery culture and the Malice culture. *Sprawozdania Archeologiczne* 73/1, 119-151.

Rauba-Bukowska A., Czekaj-Zastawny A., Grabowska B. and 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. *Sprawozdania Archeologiczne* 59, 63-113.

Rauba-Bukowska A. and Czekaj-Zastawny A. 2020. Changes in the pottery production of the Linear Pottery Culture – origins and directions of ideas. In M. Spataro and M. Furholt (eds), *Detecting and explaining technological innovation in prehistory* (= *Scales of Transformation* 8). Leiden: Sidestone Press, 73-83.

Reedy Chandra L. 2008. *Thin-Section Petrography of Stone and Ceramic Materials*. London: Archetype Publications.

Schweingruber F. H. 1990. *Anatomie Europäischer Hölzer*. *Ein Atlas zur Bestimmung europäischer Baum-, Strauch- und Zwergstrauchhölzer*. Bern-Stuttgart: Verlag Paul Haupt.

Stoch L. 1974. *Minerały ilaste*. Warszawa: Wydawnictwa Geologiczne.

Szeliga M. 2007. Der Zufluss und die Bedeutung des Karpatenobsidians in der Rohstoffwirtschaft der postlinearen Donaugemeinschaften auf den polnischen Gebieten. In J. K. Kozłowski and P. Raczky (eds), *Lengyel, Polgar and Related Cultures in the Middle/Late Neolithic*. Kraków: Polish Academy of Sciences and Arts, 295-307.

Szeliga M. and Zakościelna A. 2019. Transcarpathian intercultural relationships of the LBK communities from the Sandomierz settlement cluster in the light of new findings. *Sprawozdania Archeologiczne* 71, 167-195.

Valde-Nowak P. 2009. Early farming adaptation in the Wiśnicz. Foothills in the Carpathians. Settlement at Łoniowa and Żerków. *Recherches Archeologiques Nouvelle Serie* 1, 15-35.

Valde-Nowak P. 2022. Early Želiezovce site in Żerków in the West Carpathian Foothills in the light of the lithic industry. In M. Dębiec, J. Górski, J. Müller, M. Nowak, A. Pelisiak, and T. Saile (eds), *From farmers to heroes? Archaeological Studies in Honor of Sławomir Kadrow* (= *Universitätsforschungen zur prähistorischen Archäologie* 376). Bonn: Rudolf Habelt, 85-94.

Whitbread I. K. 2016. Fabric description of Archaeological Ceramics. In A. M. W. Hunt (ed.), *The Oxford Handbook of Archaeological ceramic Analysis*. Oxford: Oxford University Press, 200-216.