

# Early Neolithic red-painted pottery from the Prandocin site, southern Poland. Indirect transfer in a technological context

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

### ABSTRACT

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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 6<sup>th</sup> and 5<sup>th</sup> millennium BC.

Keywords: Early Neolithic, red-painted ceramic, south-eastern Poland, Linear Pottery Culture, Transcarpathian contacts

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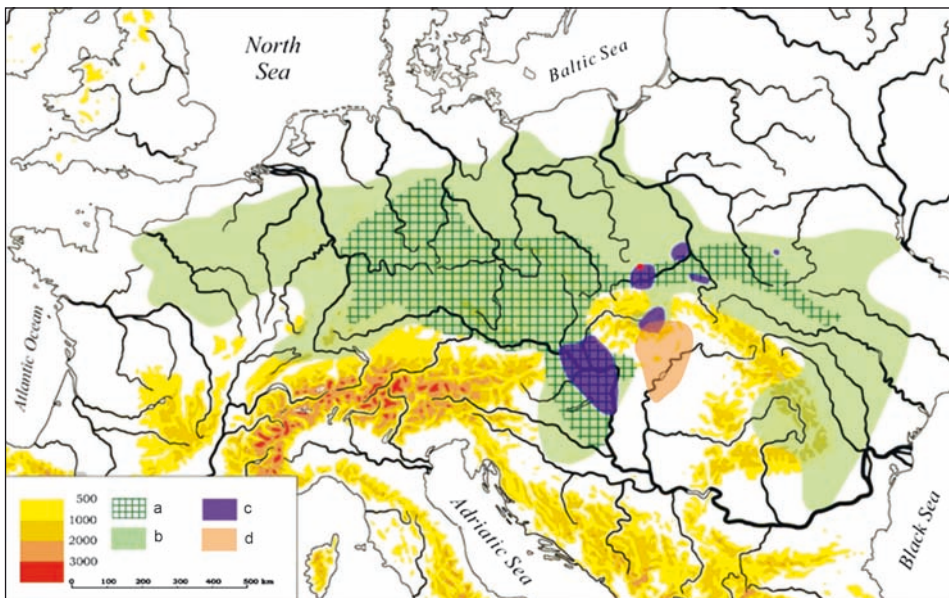
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## 1. INTRODUCTION

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

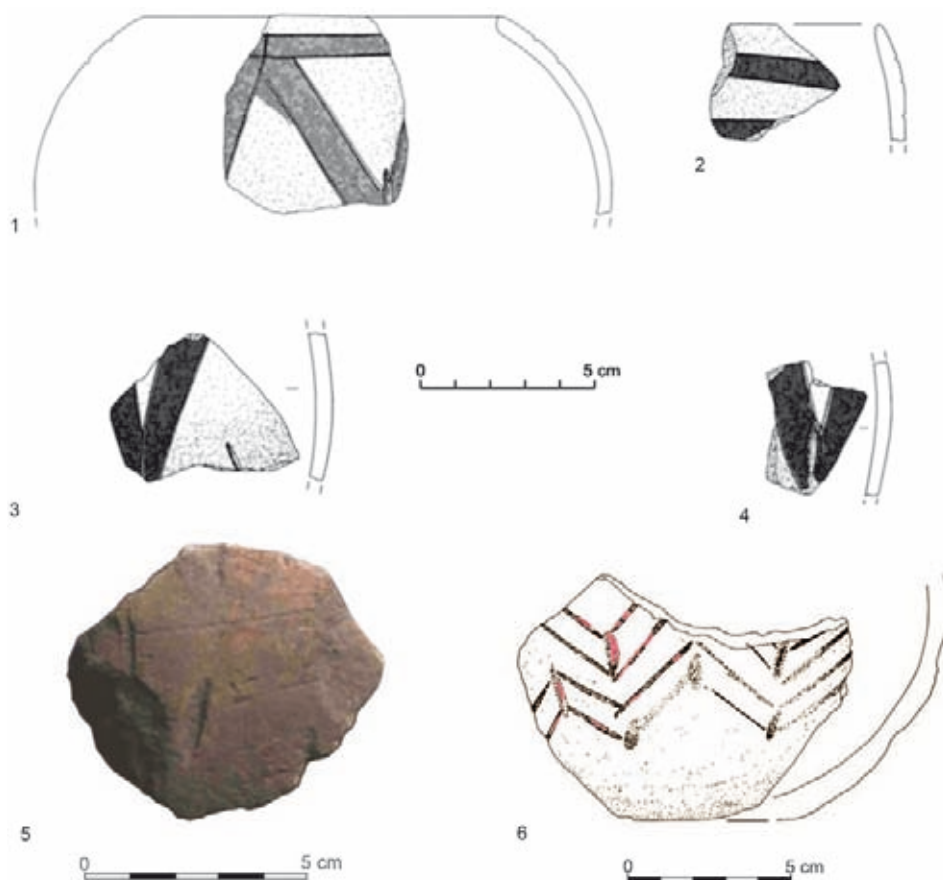


Fig. 2. Examples of Polish finds with red-painted pottery of the Linear Pottery Culture. 1-4 – Zwiężczyca 3 (Dębiec 2014); 5 – Targowisko (Czerniak *et al.* 2006); 6 – Żerków (Valde-Nowak 2022). Prepared by M. Nowak

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; Czekań-Zastawny *et al.* 2017; Szeliga and Zakościelna 2019; Dębiec *et al.* 2021; Rauba-Bukowska and Czekań-Zastawny 2020).

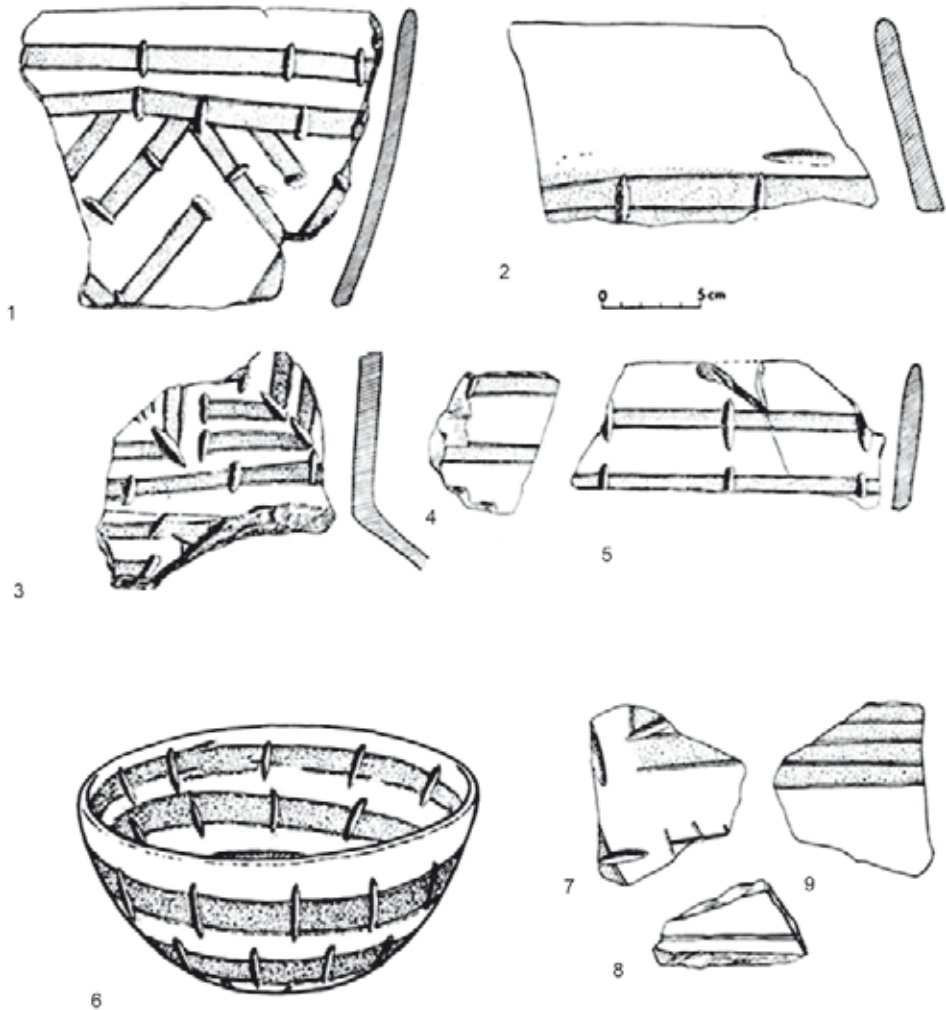


Fig. 3. Examples of finds with red-painted pottery of the Linear Pottery Culture from western Slovakia 1-9 (Štúrovo after Pavúk 1994). Prepared by M. Nowak

From the area north of the Carpathians in Poland, finds of Linear Pottery Culture (late phase/*Żeliezowce* style) red-painted pottery fragments are known only from a few sites *i.e.*, Targowisko (Czerniak *et al.* 2006), Zwiężczyca (Dębiec 2014), Kraków-Nowa Huta – Ple-szów (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 *Żeliezowce* 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 pot-

tery 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 Źeliezovce 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 ŹII 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	ŹIIb	Godłowska 1976; Godłowska <i>et al.</i> 1985
Targowisko	ŹIIb	Czerniak <i>et al.</i> 2006
Zwiężczyca	ŹIIb/ŹIII	Dębiec 2014
Źerków	ŹIIb	Valde -Nowak 2022
Prandocin	ŹIIb	

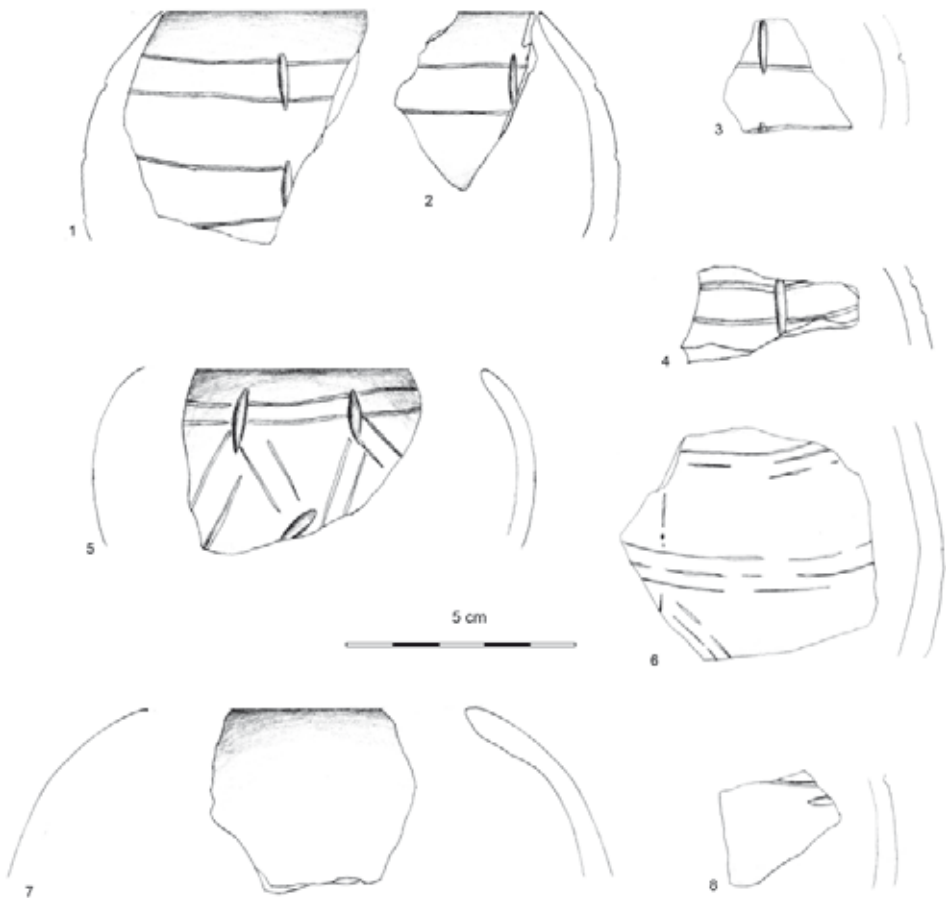


Fig. 4. Prandocin Site 1, Słomniki commune. Ceramic selection from Feature 54.

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 Zwiężyca (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 Źeliezowce 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 Żeliezovce 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 Vrábce 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*).



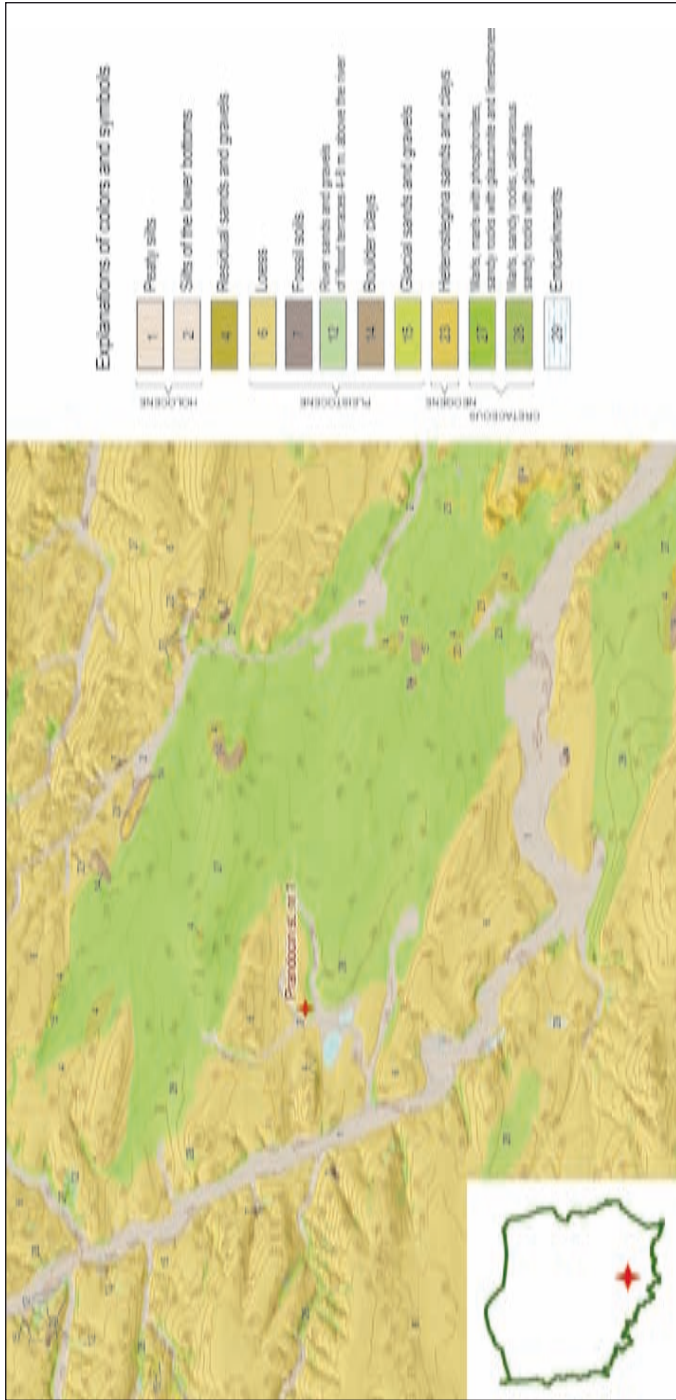


Fig. 5. Prandocin Site 1. Location against the geological background.  
Drawing K. Juszczyk, A. Rauba-Bukowska

## 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  $1.3 \times 1.3$  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. Spytowska, 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 I	Prandocin I	Prandocin I	Prandocin I	Prandocin I	Prandocin I	Prandocin I
Locality	Feature 54	Feature 55	Feature 56	Feature 57	Feature 58	Feature 59	Feature 61
Cultural affiliation	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-Zajac 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-Zajac 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

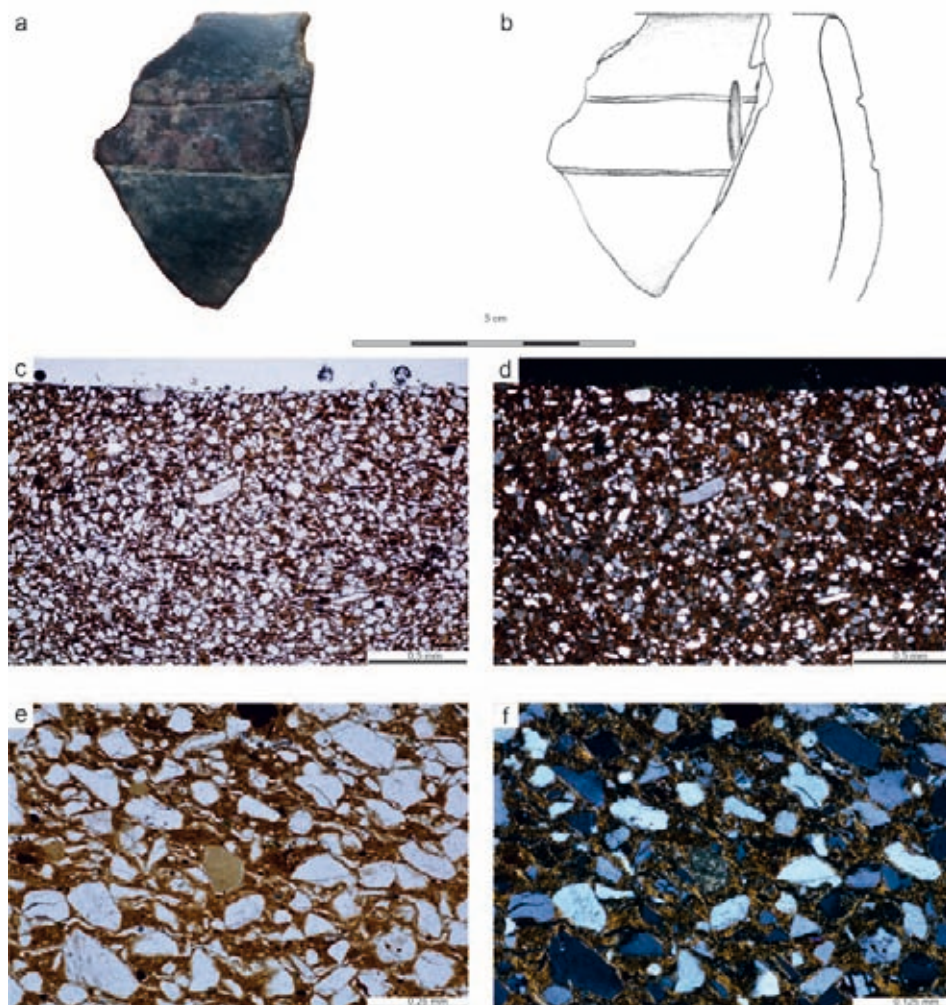
Most ceramic fragments have their maximum size falling within the range of 1.7 to 6 cm. Only four are larger, falling within the range of 6 to 9.3 cm. The edges of breaks on the pottery are rounded, and their surfaces are relatively well-preserved. Distinctive features include fragments with black glossy 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 Prano4 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 VV. Rumian

One sample (Prano8) 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.

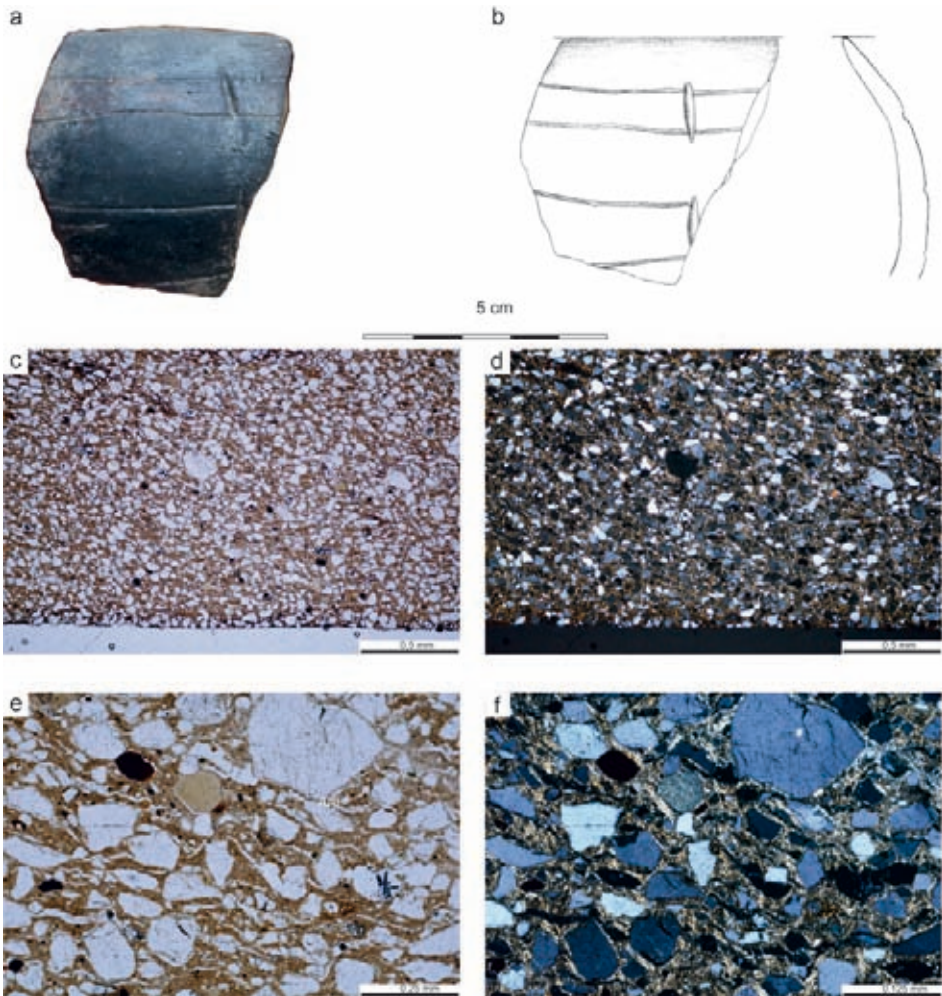


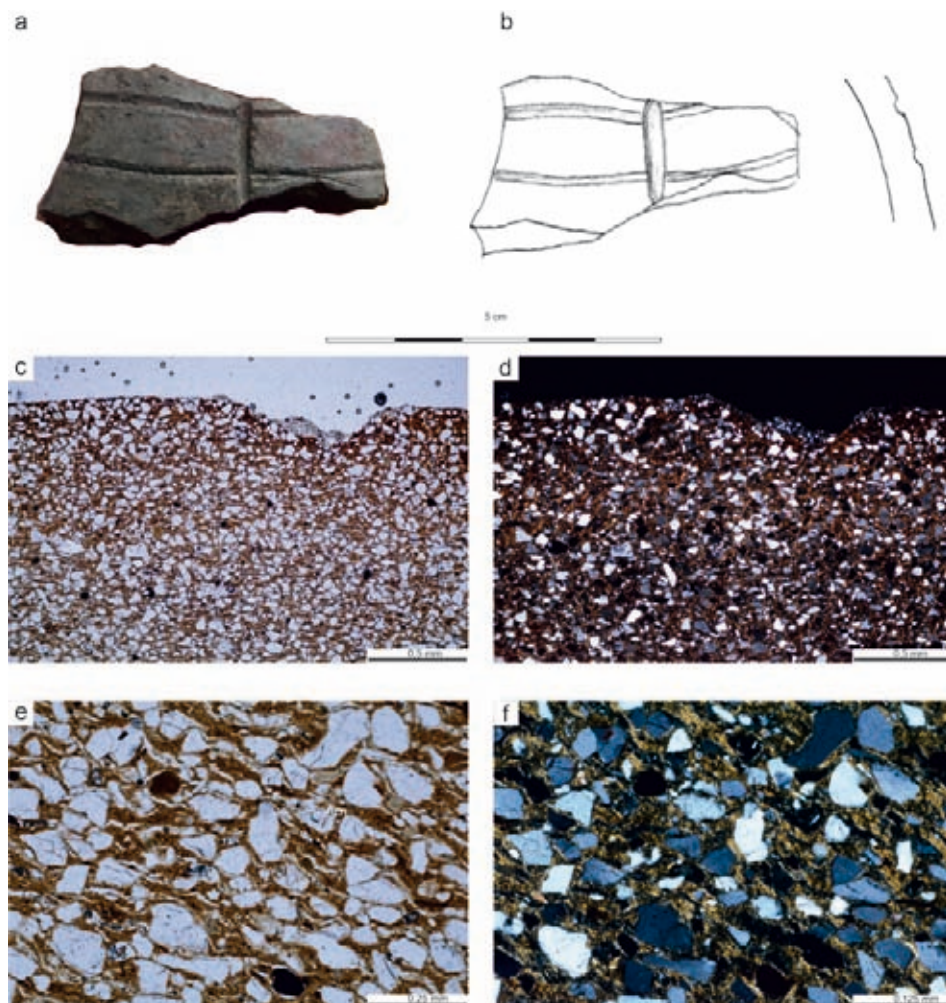
Fig. 8. Prandocin Site 1, sample Pran03; technological type II; photography (a) and drawing (b) of the fragment; microphotography of thin section (c-f); numerous grains of silt fraction (c, d); grain of thermal altered glauconite (e, f); plane polarized light (c, e); crossed polarized light (d, f).

Photo A. Rauba-Bukowska, drawing VV. 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 Prano2, Prano3, and Prano4. 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 VV. 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%,



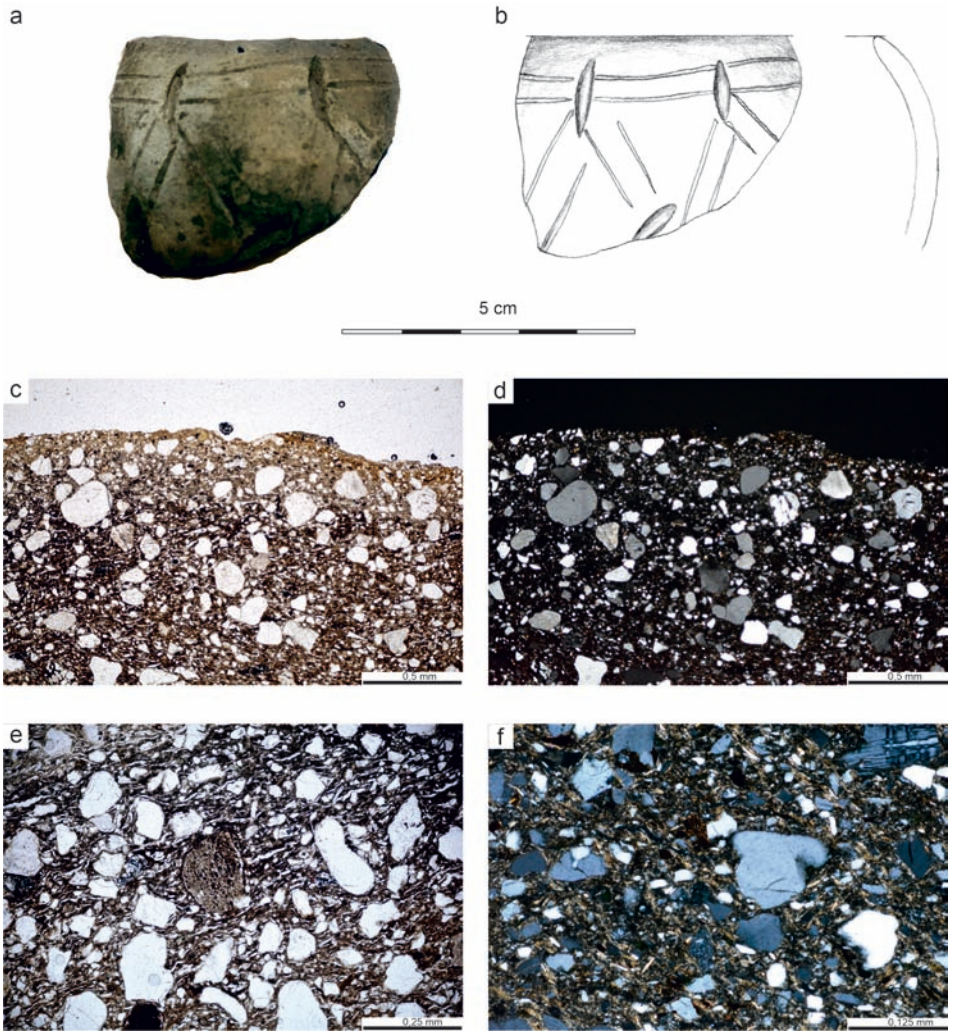
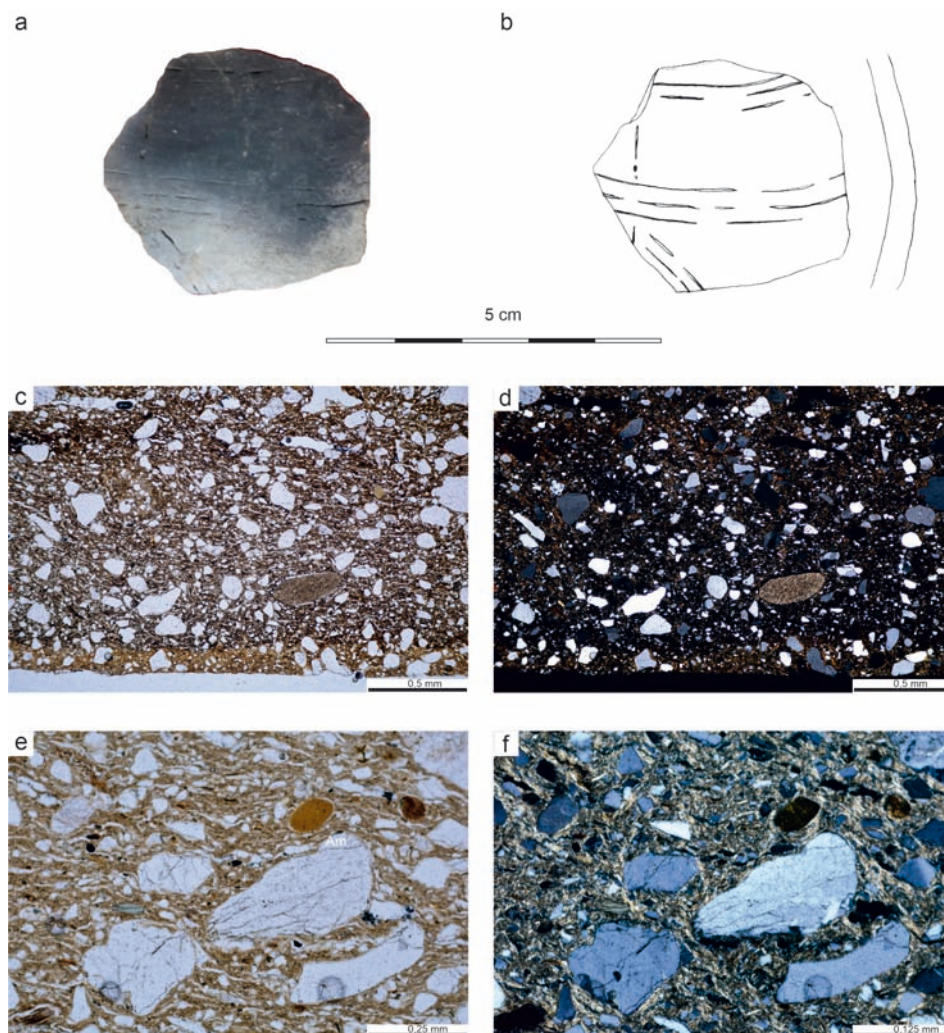


Fig. 10. Prandocin site 1, sample Pran01; technological type III; photography (a) and drawing (b) of the fragment; microphotography of thin section (c-f); numerous sand grains (c-f); plane polarized light (c, e); crossed polarized light (d, f). Photo A. Rauba-Bukowska, drawing VV. Rumian

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 Prano8 (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

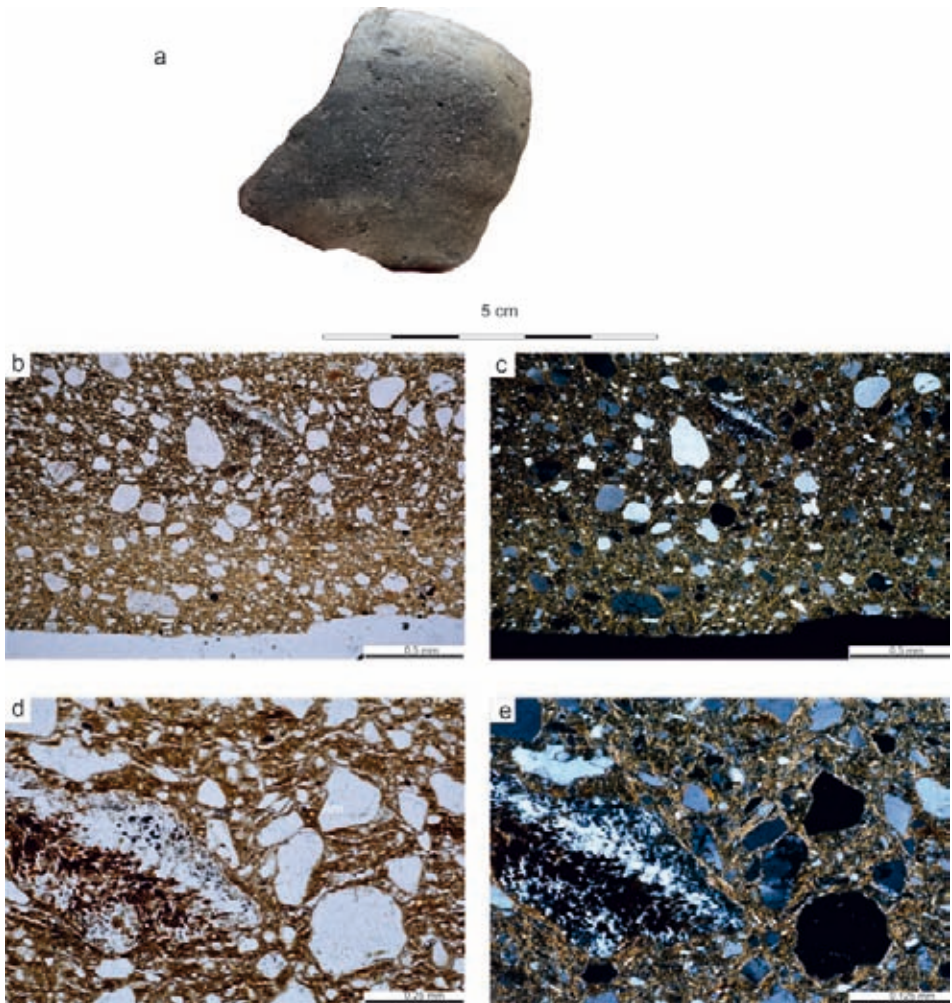


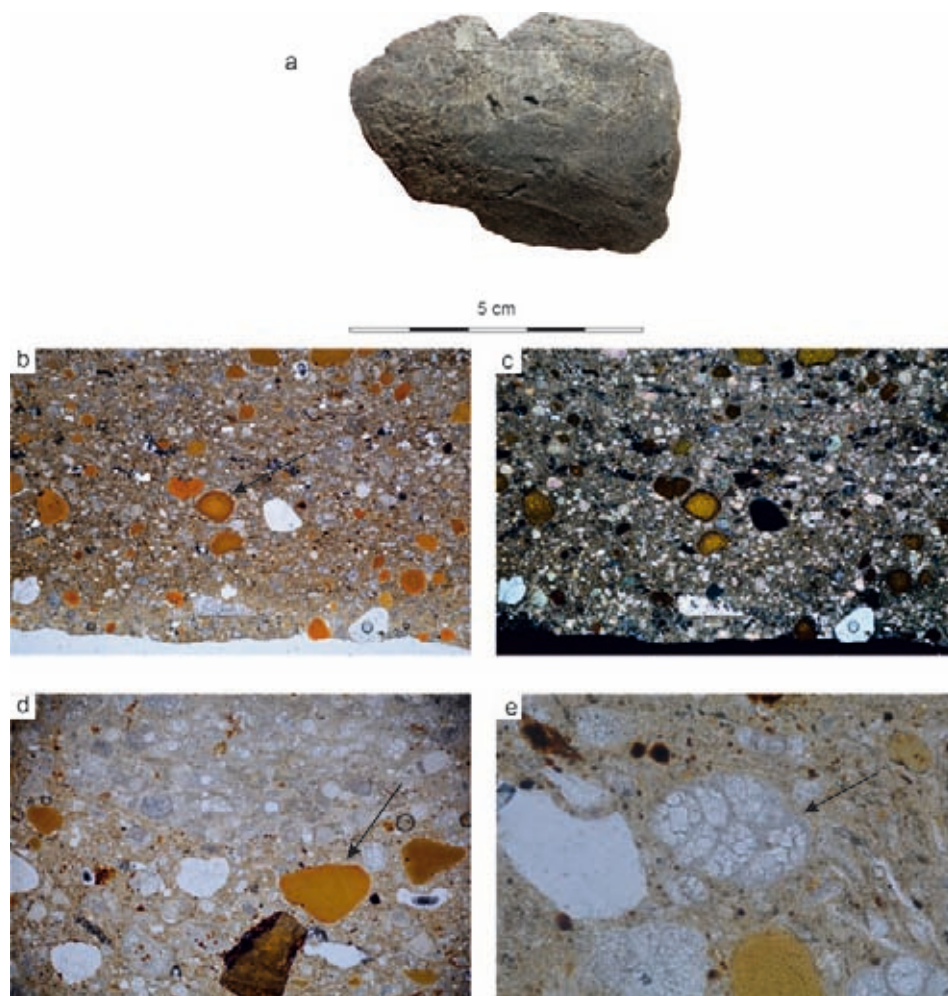
Fig. 12. Prandocin Site sample Pran06; technological type III; photography (a) of the fragment; microphotography of thin section (b-e); numerous grains of silt and sand fraction (b, c); grain of chalcedony (d, e); plane polarized light (b, d); crossed polarized light (c, e).

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 Prano2, Prano3, Prano4, and Prano8 are fine-grained and well-sorted, while the fabrics of vessels Prano1, Prano5, and Prano6 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 Prano2, Prano3, Prano4 (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 Prano1, Prano5, and Prano6 correspond to Type III with a high sand content. The fabric of vessel Prano8 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).

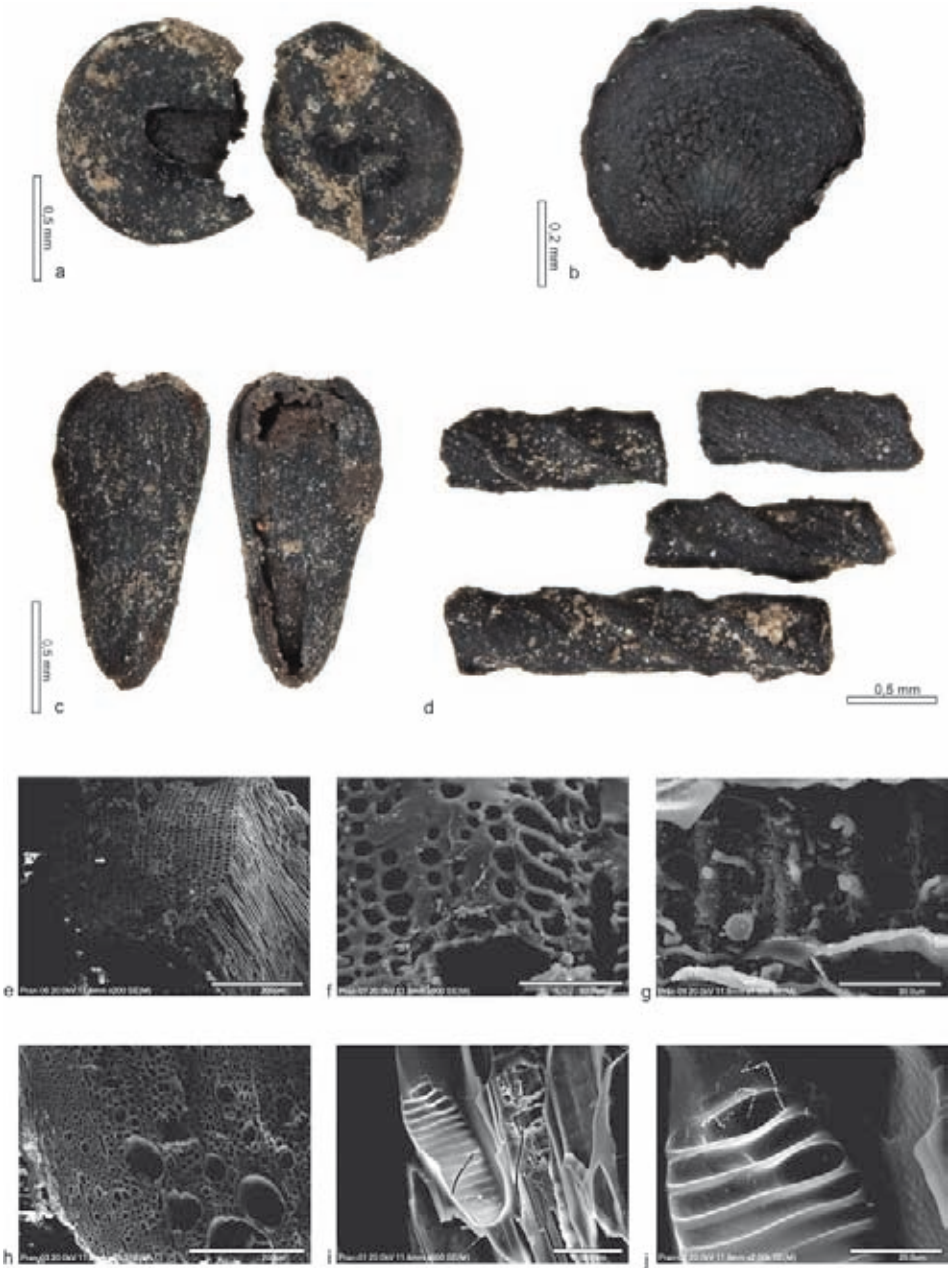
A unique feature of the examined vessels is the absence of additives typical for LBK pottery, such as organic material and grog additives.

### 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		
<i>Anthemis arvensis</i>	fruit	7
<i>Chenopodium album</i> type	seed	2
<i>Galium</i> sp.	fruit	1
<i>Stipa</i> sp.	awn	4
Caryophyllaceae	seed	1
Chenopodiaceae	seed	1
Cerealia indet.	caryopsis	2
Undetermined		7
Anthracological material		
<i>Pinus sylvestris</i>	charcoal	2
<i>Alnus</i> sp.	charcoal	2
<i>Quercus</i> 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; Czekań-Zastawny and Rauba-Bukowska 2014; Kozłowski *et al.* 2014; Rauba-Bukowska 2014a; Czekań-Zastawny 2017; Czekań-Zastawny *et al.* 2017; Kadrow and Rauba-Bukowska 2017a; Rauba-Bukowska and Czekań-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; Czekań-

**Table 4.** Prandocin Site 1. Technological features of the LBK pottery – Źeliezovce phase Poland (Rauba-Bukowska 2021) in comparison to Źeliezovce 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	++		+	-	+
Źeliezovce phase LBK	+	+	++	very rare	+
Ceramics from Prandocin site	-	-	++	+	-
Źeliezovce 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 Źeliezovce 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 ŹIIb. To date, there is no evidence of interaction with the youngest stylistic phase of the Źeliezovce group from Slovakia, namely ŹIII (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 Źeliezovce 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 Źeliezovce group in Slovakia, where no organic additives or grog were noted (Pavúk 1994; Furrholt *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-Zajęc *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. dicocum* and einkorn *Triticum monococum*) or barley (*Hordeum vulgare*), crops typically found in LBK sites in southern Poland (Lityńska-Zajęc *et al.* 2017). Among wild herbaceous plants, taxa indicating segetal and ruderal communities appeared (Lityńska-Zajęc 2005), while a presence of feather grass indicates steppe-like vegetation or open canopy forests (Ceynowa-Gieldon 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 *Żeliezowce* phase (Moskal del-Hoyo *et al.* 2017b). However, these changes in the technology of LBK vessel production between pots with Music-Note and *Żeliezowce* ornamentation styles are less radical than those observed in Prandocin. The materials from Prandocin exhibit a unique blend of characteristics from the *Żeliezowce* group ceramics from Slovakia and the ceramics of the *Żeliezowce* 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.

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