

## FIELD SURVEY AND MATERIALS

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### THE FIRST FIND OF LBK GRAPHITE-COATED POTTERY IN LESSER POLAND: WIĘCKOWICE, SITE 4, KRAKÓW DISTRICT

#### ABSTRACT

Brzeska-Zastawna A., Borowski M. P. and Zastawny A. 2021. The first find of LBK graphite-coated pottery in Lesser Poland: Więckowice, site 4, Kraków district. *Sprawozdania Archeologiczne* 73/1, 221-249.

In the years 2006-2011, at the site Więckowice 4, rescue excavations were carried out in the eastern part of an extensive (over 15 ha) multicultural zone. The most numerous are the remains of the LBK settlement from the “music note” phase. The south-eastern part of the settlement was explored, discovering lines of building pits and post holes belonging to 3-4 longhouses. A particularly unique discovery was a fragment of a LBK vessel with powdered graphite preserved on the outer surface. In addition to the LBK ornament of engraved lines, it is decorated in a manner referring to the ornamentation of the Eastern Linear circle (Tiszadob-Kapušany group). The presence of graphite on the vessel wall has been confirmed by the results of SEM-EDS analyses. This is the first such find in Lesser Poland. To comprehensively address the cultural significance of this find we provide an up-to-date overview of graphite usage in a wide range of LBK contexts.

Keywords: Linear Pottery culture, Lesser Poland, graphite-coated pottery, Eastern Linear circle ornamentation  
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## INTRODUCTION

In the years 2006-2011 at the site Więckowice 4, Kraków district (Fig. 1), archaeological excavations were carried out related to the intensively developing residential buildings in the eastern part of the site (Fig. 2). These were not wide-ranging, but spot tests, organized in places where new single-family houses, internal access roads to the property and technical infrastructure were built. Within a few years, research work was carried out at the construction sites of 10 buildings, two internal roads with a total length of 251 meters and a 60-meter-long water line. A total area of 31 ares was examined. The type and scope of the research was varied and depended on the implementation of several stages of investment works. The research excavations had different dimensions: *e.g.* 134.0 × 5.5 m; 117.0 × 4.0 m; 18.0 × 20.0 m; 25.0 × 12.0 m; 12.0 × 13.0 m; 60.0 × 0.6 m (Fig. 3). They were located at a distance of several dozen meters from each other in an area of approx. 1 ha. In this context, the nature of the research and the degree of exploration of the area should be considered probative. In the years 2006-2011, the excavations were conducted by A. Zastawny (trenches I-XIV). In 2011, additional works were managed by I. Mianowska (trench XV). The result of the research was the identification of a portion of a settlement with longhouses of the Linear Pottery culture (LBK) and a settlement of the Lusatian culture from the Bronze Age, as well as traces of a settlement of the Funnel Beaker culture and the Lengyel culture (several features).

Site no. 4 in Więckowice is located on the southern edge of the Kraków-Częstochowa Upland, 14 km north-west of the center of Kraków (Fig. 1). It has an area of over 15 ha and occupies a well-exposed, wide terrain elevation, separating the valley of the Jurassic stream called Kobylanka from the wide floodplain valley of the Rudawa river (Fig. 2). Particularly favorable for prehistoric settlement, the topographic location of the described place and its soil (loess formations) and water conditions, as well as the close proximity of Jurassic flint outcrops should be emphasized. Prior to the excavation, the site was known only from a surface survey carried out in 1987 (AZP 101-55/13).

During the excavation work in 2009 (Zastawny 2009), a complex of LBK construction pits, adjacent to dwelling structures was discovered (features no. 45, 46, 47, trench III.9). A fragment of the vessel with a graphite-coated surface come from one of them (feature no. 45). The use of this mineral in the preparation of the surfaces of the ceramics from Więckowice has been additionally confirmed by the results of archaeometric analyses discussed in this article. This is the first time that LBK ceramic materials in Lesser Poland have been diagnosed with graphite powder on the vessel wall. This was the impetus for this article and its discussion of the aforementioned vessel and the pottery and lithic inventory of accompanying feature no. 45. The materials from the research on site 4 in Więckowice have not been published so far.

In 2012, a fragment of the vessel with graphite was made available for petrographic research, conducted as part of a project led by A. Czekaj-Zastawny (see Rauba-Bukowska

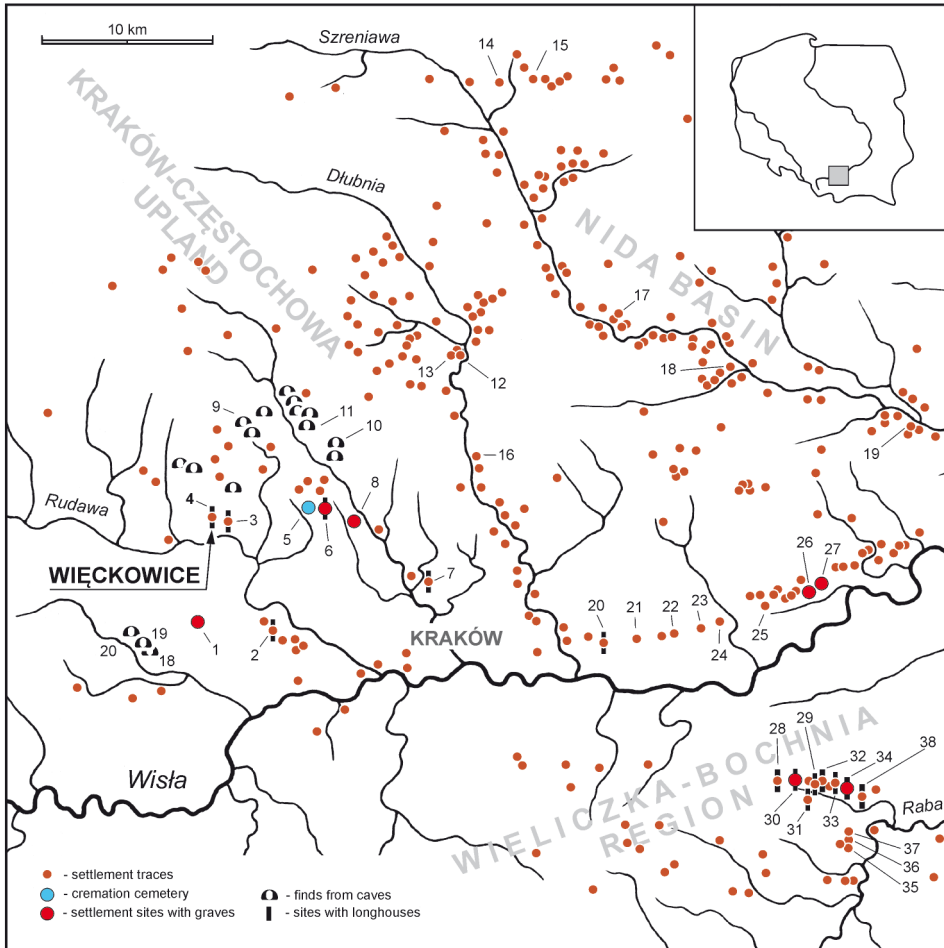


Fig. 1. Location of site 4 at Więckowice in the LBK settlement area near Kraków (acc. to Zastawny and Grabowska 2014).

Main sites: 1 – Aleksandrowice site 2; 2 – Kraków Olszanica, site 4; 3 – Bolechowice, site 9; 4 – **Więckowice, site 4**; 5 – Modlniczka, site 2; 6 – Modlnica, site 5; 7 – Kraków Górka Narodowa, site 9; 8 – Giebułtów, site 1; 9 – Wierzychowie, site 2 (Wierzychowska Górna cave); 10 – Maszyce, site 1 (Maszycka cave); 11 – Ojców, site 3 (W Okopach Wielka Górna cave); 12 – Iwanowice Dworskie, site 1 (Babia Góra I, II); 13 – Iwanowice Włościańskie, site 1 (Góra Klin); 14 – Pstroszyce; 15 – Miechów, site 65; 16 – Michałowice, site 27; 17 – Brończycy, site 1; 18 – Przesławice, site 8; 19 – Kowala, site 1; 20 – Kraków Mogiła, site 62; 21 – Kraków Pleszów, site 17-20; 22 – Kraków Branice, site 76; 23 – Kraków Wyciąże, site 5; 24 – Kraków Cło, site 7; 25 – Zofińskie, site 1; 26 – Igołomia, site 1; 27 – Złotniki, site 1; 28 – Zagórze, site 2; 29 – Szarów, site 9; 30 – Brzeziny, site 17; 31 – Brzeziny, site 40; 32 – Targowisko, site 16; 33 – Targowisko, site 14,15; 34 – Targowisko, site 12,13; 35 – Łęzkowice, site 1; 36 – Targowisko, site 1; 37 – Targowisko, site 2; 38 – Targowisko, site 10,11

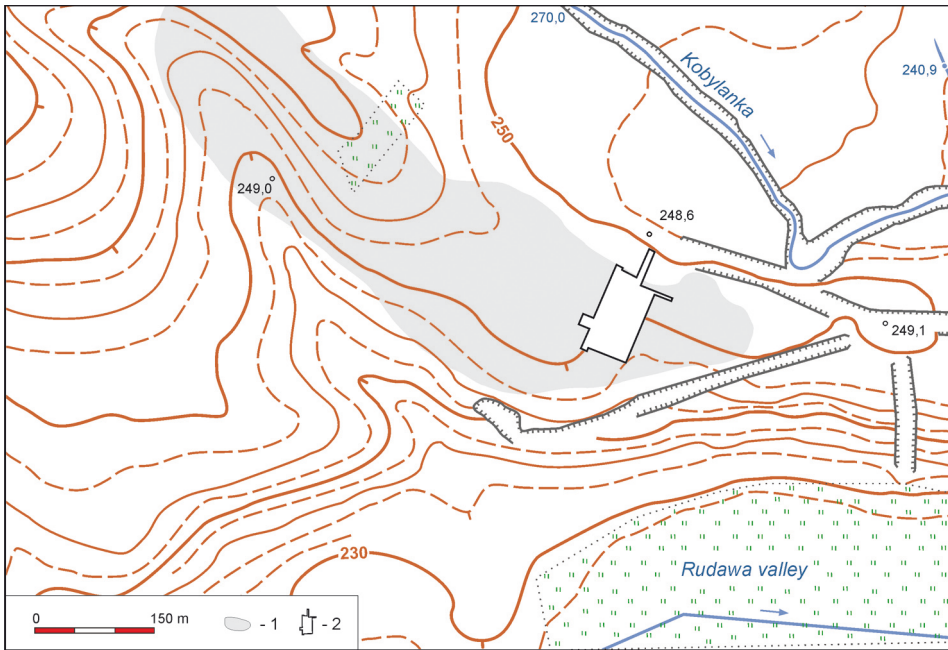


Fig. 2. Więckowice, site 4, Kraków district. Range of the site (1) with research area in 2006-2011 (2). Illustration by A. Zastawny

and Czekał-Zastawny 2020, tab. 1). The results of the analyzes performed at that time were not made available to the authors of this article.

## LBK SETTLEMENT AT WIĘCKOWICE

Most numerous at site no. 4 in Więckowice are the remains of an LBK settlement from the “music note” phase of this culture, with traces of residential buildings and flint workshops. The south-eastern part of the settlement was explored, in which lines of building pits were discovered, along with post holes belonging to 3-4 above-ground pole-structure buildings (Fig. 3). Apart from ceramic and flint products, obsidian and amphibolite artifacts were obtained. A total of 35 features were discovered and examined, including post holes, construction pits, adjacent to dwelling structures and utility pits with ceramic materials – uniform in terms of style and chronology.

Despite the fact that the excavation covers a fairly large area (approx. 1 ha), the relatively large distances between the archaeological trenches prevents us from recreating a complete picture of the settlement layout. In one trench with an area of 12.0 × 13.0 m



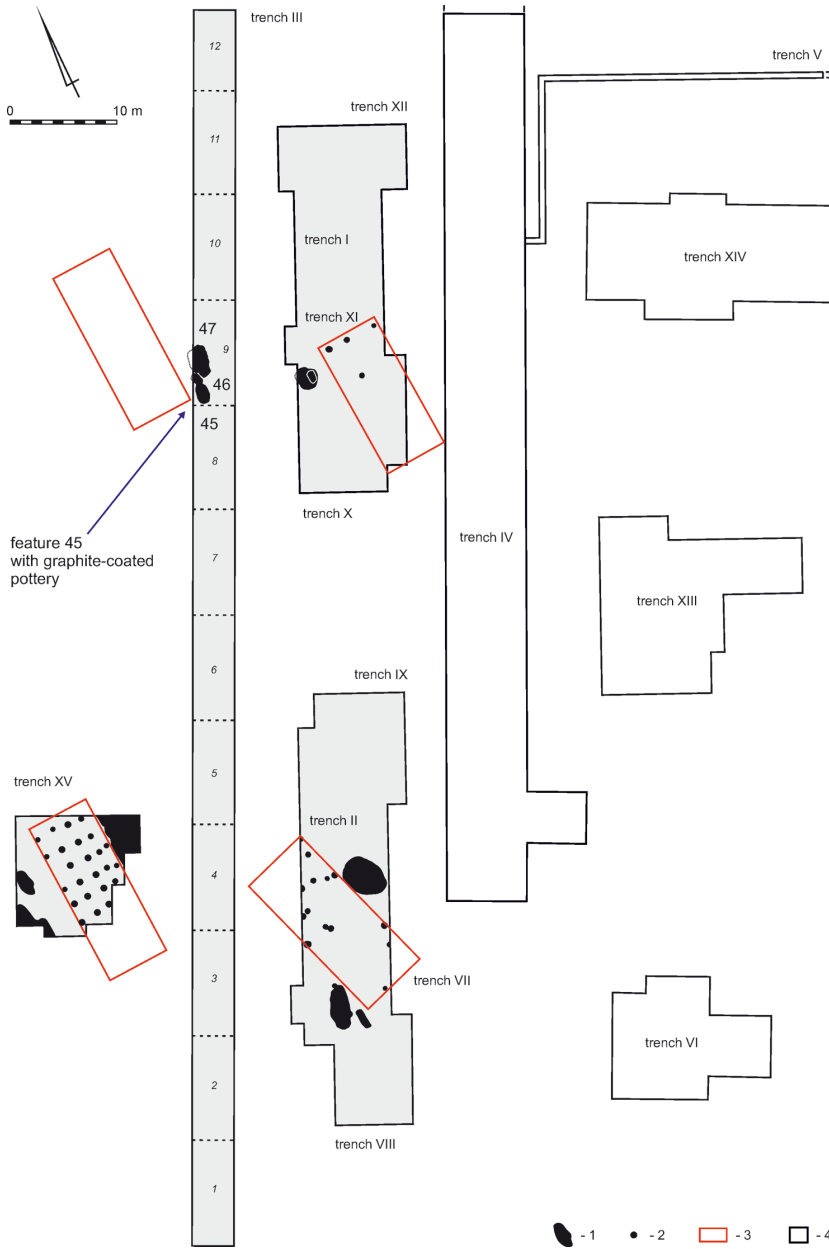


Fig. 3. Więckowice, site 4, Kraków district.

Trenches with LBK features: 1 – pits, 2 – postholes, 3 – reconstructed outlines of longhouses, 4 – trenches without LBK features. Illustration by A. Zastawny

(trench XV), a nearly complete structure of a longhouse was captured, consisting of 5 rows of postholes and lines of construction pits at both long sides of the building (Fig. 3). In other parts of the study area, construction pits with a partially preserved arrangement of posthole pits, as well as those without rows of postholes (trench III; features 45, 46, 47; Fig. 3). Thus, at the site in question, traces of four LBK longhouses were discovered: one documented almost in its entirety (trench XV), two fragmentarily preserved (trench II, XI) and one possible longhouse (trench III).

An important distinguishing feature of the settlement character is the abundance of flint artifacts, which confirms the existence of flint workshops in which the preliminary stages of processing took place, including initial trimming of nodules. Materials of this kind come from the pits surrounding longhouses, including pit no. 45, in which a vessel with an admixture of graphite was discovered.

LBK pottery from the settlement in Więckowice represents a uniform ornamental style, characteristic of the “music note” phase of this culture in Lesser Poland. Older and younger materials, typical of the *Želiezovce* phase, have not been discovered in any of the features. We associate the entire settlement with the “music note” phase and thus verify the incorrectly defined relationship with the *Želiezovce* phase, which, on the basis of an incomplete assessment of materials, was previously attributed to the settlement in Więckowice (see Zastawny and Grabowska 2014, fig. 43; Rauba-Bukowska and Czekaj-Zastawny 2020, tab. 1).

Więckowice belongs to the group of the most western LBK sites in the region near Kraków, associated with the Rudawa River basin and the area of flint outcrops in the southern part of the Kraków-Częstochowa Upland (Fig. 1). Sites with stray finds and cave materials prevail here. There are also settlements with graves (Aleksandrowice site 2, Giebułtów site 1; Czekaj-Zastawny 2009) and a unique cremation cemetery, the only one in Lesser Poland (Modlniczka, site 2; Czekaj-Zastawny and Przybyła 2012). Settlements with longhouses are characteristic of the area in question. Such settlements include Bolechowice, site 9 (Breitenfellner and Rook 1991), Kraków-Olszanica, site 4 (Milisauskas 1986), Kraków-Górka Narodowa, site 9, and Modlnica, site 5 (Czerniak 2010). On the map of the entire region near Kraków, they can be described as the western cluster (Fig. 1), which is less numerous compared to the eastern grouping, including the settlements in the Tusznicza valley in the Wieliczka-Bochnia loess. Against this background, and according to the current state of research, the settlement from Więckowice presents itself as the farthest west LBK settlement with longhouses in Lesser Poland (Fig. 1). The aforementioned site of Bolechowice 9 is the one closest to our settlement, just 1.1 km to the east and located just like Więckowice on the right bank of Kobyłanka stream; it also has traces of longhouses from the same (“music note”) chronological phase (Breitenfellner and Rook 1991).

### FEATURE NO. 45. MATERIALS AND ANALYSIS

Feature no. 45 belongs to the complex of 3 construction pits (features 45, 46, 47), discovered in trench III.9 (Fig. 4). The outlines of these features partly extend beyond the boundary of the excavation on the west side, where the part with postholes of the long-

Features 45, 46, 47

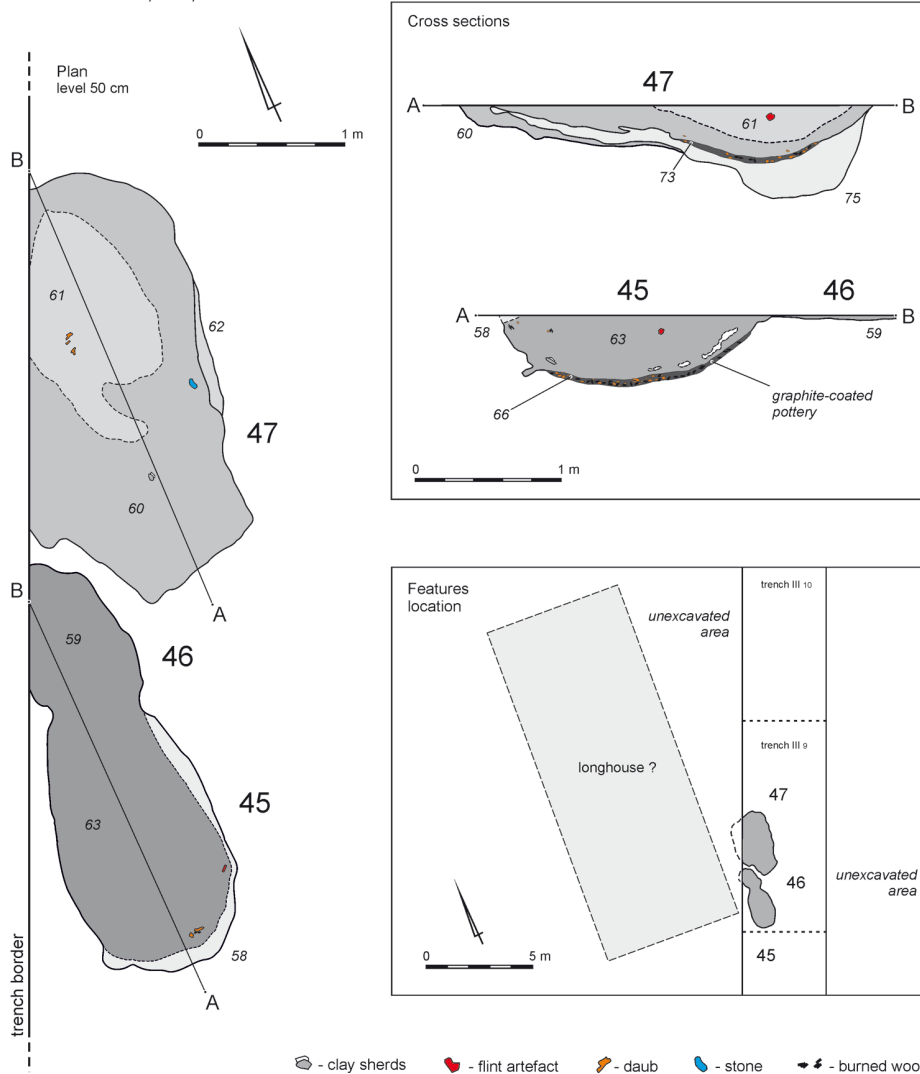


Fig. 4. Więckowice, site 4, Kraków district. Plan with the arrangement of LBK features Nos. 45, 46, 47. Illustration by A. Zastawny

house structure is probably located (the zone outside the research area). Features 45 and 46 have a partially common outline, while pit 47 is located several dozen cm north of them. The longitudinal axes of all features are oriented on a N-S axis. They have a layout typical for construction pits, and with high probability they mark the south-eastern “corner” of the LBK longhouse.

Pit no. 45 was preserved as an oval silhouette with an elongated outline and dimensions of 188 × 108 cm (Fig. 4). From the north, it connects to a small pit (no. 46), which is actually a shallower part of the described feature. At the level of discovery (approx. 50 cm below the present ground level), the pit was filled with brown-black earth, mixed only on its circumference with yellow loess. In its vertical section, the fill had a regular, trough-shaped outline, with a thin layer of intensely black earth with daub lumps and charcoals clearly distinguished at the bottom. From feature 45, a large amount of lithic material was obtained (257 items), along with a less abundant collection of potsherds (46 fragments), coming from at least 7 vessels of the LBK. A small, flat amphibolite adze was also discovered. The fragments of the vessel with the graphite-coated surface were in the intensely black layer of soil filling the bottom of the feature, at a depth of 40 cm below the level of discovery of the pit (Fig. 4).

## Pottery

1. Clay vessel preserved in twelve fragments (reconstructed belly diameter: 19.2 cm; vessel height: 17.5 cm). Spherical belly merging into a clearly distinguished conical neck with a slightly everted lip (Fig. 5: 2). On the belly, at the point of its maximum protrusion, there is a small, vertically pierced handle (Fig. 5: 4). The vessel is richly ornamented with engraved lines in various arrangements. There are 4-5 circular lines on the belly, enclosing the space with smaller bands composed of 3 parallel lines in an arched arrangement (Fig. 5: 1). It cannot be determined whether these strands are separate, closed patterns of decorations or whether they connect with each other in parts of the belly that are not preserved. The ornament was made carelessly. The lines are discontinuous, uneven and repeatedly corrected (Fig. 5: 4). There are traces of accidental indentation in many places (Fig. 5: 1). In the ornamental zone, traces of graphite powder with a granulation of up to 2 mm, “scattered” on a surface of 3.8 × 4.0 cm, were visible to the naked eye (Fig. 5: 1; 6: A, B). There is an additional decorative field above the handle, connecting the belly with the conical neck (Fig. 7). It is composed of vertical rows of zigzags, enclosed with diagonal lines engraved on both sides, and a horizontal line from above (Fig. 5: 2; 6: C). Above this line, the neck becomes a short spout with a slightly bent outward edge. The field with the zigzag ornament placed above the handle is also fragmentarily preserved in another part of the vessel, where graphite is also present, proving that the described vessel had at least 2 handles with zigzag ornaments placed above them. The described bowl is a thin-walled vessel made of dusty, loess-like clay. Very fine grains of sand are present in the ceramic mass. A crumbled

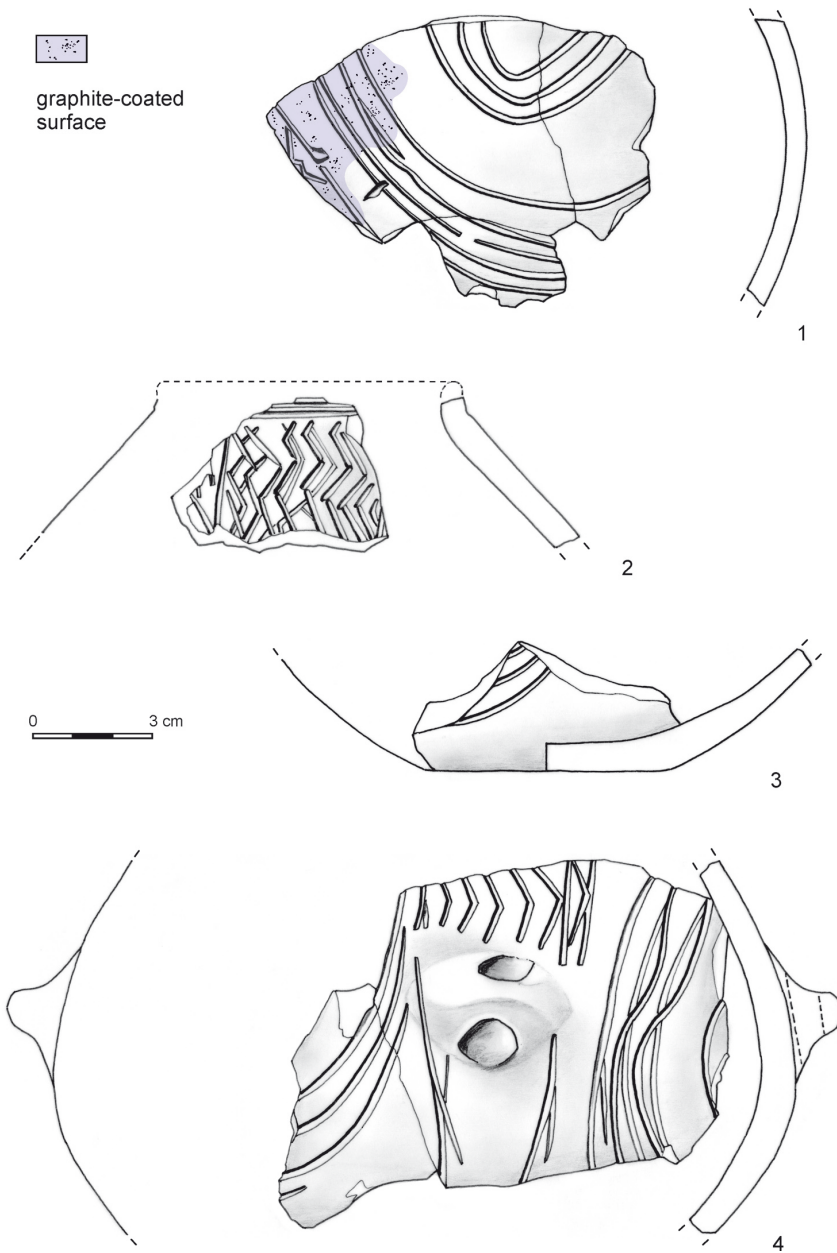


Fig. 5. Więckowice, site 4, Kraków district.  
 LBK vessel with graphite-coating from feature No. 45.  
 Illustration by A. Zastawny

fragment of pottery is visible on the outer surface. The cross-section shows the colour zoning: light beige core, dark gray to beige-brown outer surface, brown-orange inner surface.

2. The upper part of a thin-walled hemispherical bowl, preserved in seven fragments, with a mouth diameter of 17.5 cm (Fig. 8: 1). The vessel is decorated with an ornament of engraved lines, with “note” points placed on and between the lines. Below the edge of the rim, there is an horizontal line with an engraving around the vessel, under which fragmentary, single, arched lines have been preserved, arranged in three U-shaped motifs, closed



**Fig. 6.** Więckowice, site 4, Kraków district. LBK vessel with graphite-coated surface from feature No. 45: graphite powder on the outer wall (A, B); the upper part of the vessel, decorated with an engraving in the style of the Tiszadob-Kapušany group (C). Photo by A. Susuł and A. Zastawny



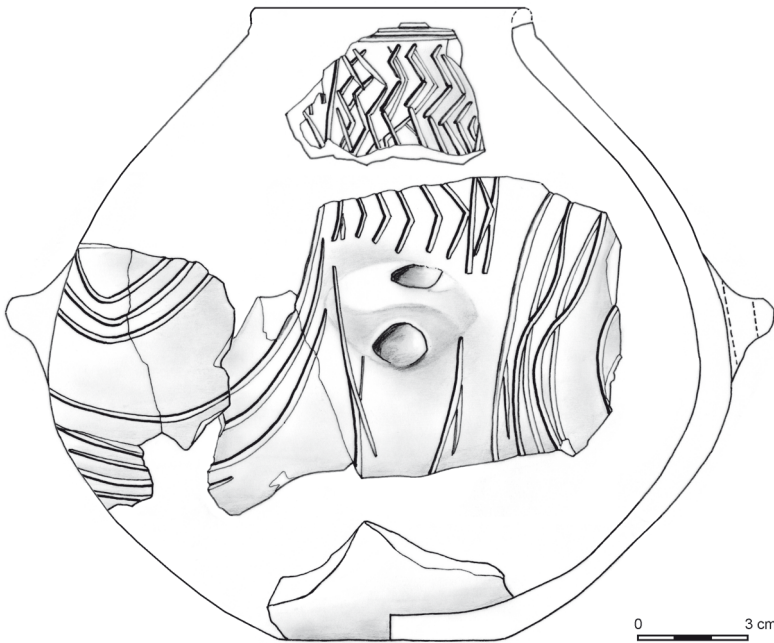


Fig. 7. Więckowice, site 4, Kraków district.

Reconstruction of the LBK vessel with graphite-coated surface. Illustration by A. Zastawny

at the top. The walls of the vessel are badly damaged and the outer surfaces are completely worn (no admixture).

3. Upper and middle parts (3 pieces) of a thick-walled hemispherical bowl with a mouth diameter of 14 cm (Fig. 8: 2). The outer surface is uneven and rough with visible traces of various admixtures in the pottery mass: ceramic and stone rubble, sand, plant ingredients. There are three short, parallel lines on the belly.

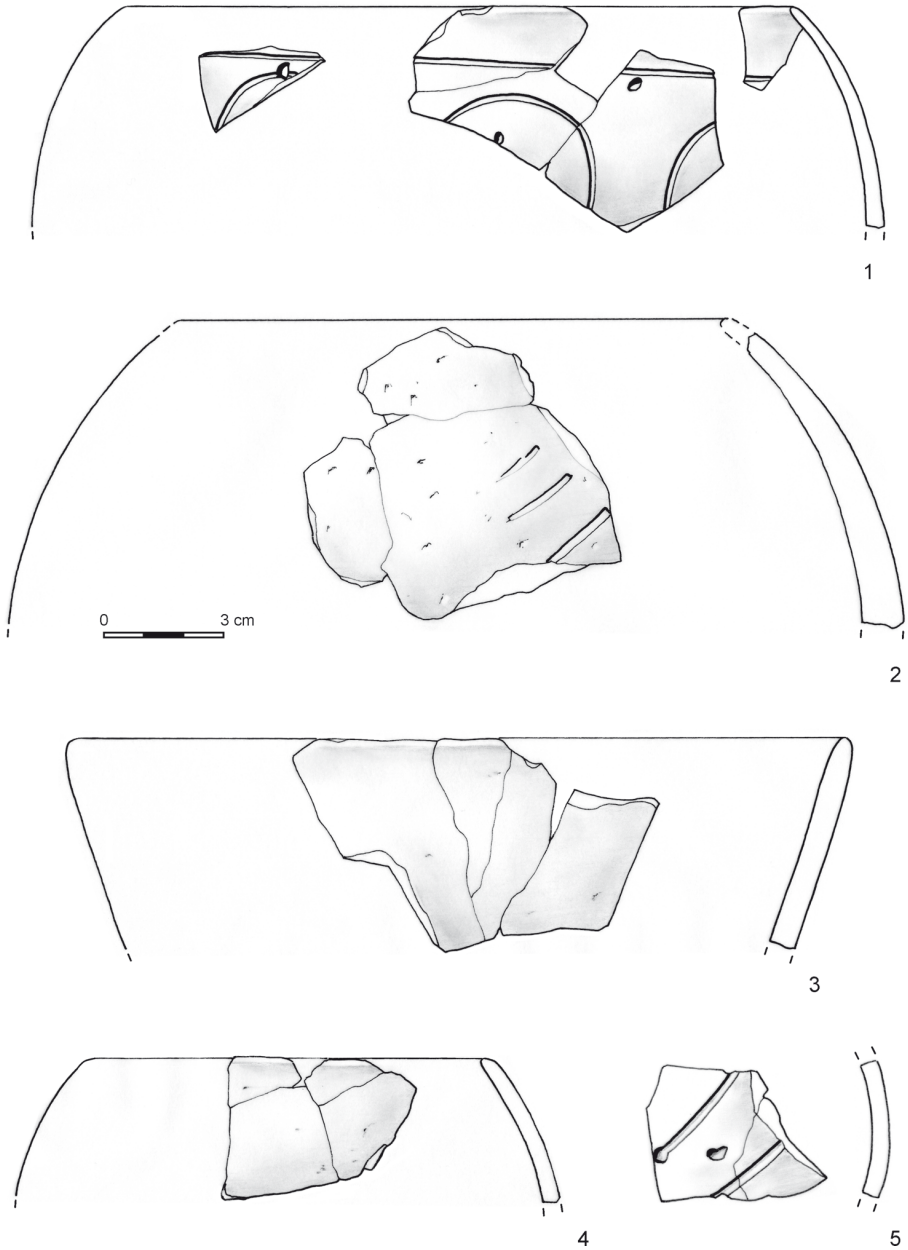
4. The upper part of a thin-walled hemispherical bowl without ornament (4 pieces), with a mouth diameter of 10.5 cm (Fig. 8: 4). Numerous traces of organic admixture are visible on the partially preserved outer surface.

5. Top part of a thin-walled bowl with a conical neck (Fig. 8: 3). Reconstructed diameter of the mouth – 20 cm. The outer surface is completely destroyed, the ornament is missing, and the clearly visible composition of the pottery is grog and plant material. The vessel is preserved in five fragments.

6. Two fragments of the belly of a thin-walled bowl with an ornament of engraved lines in an arched pattern and “note” points on and between the lines (Fig. 8: 5). External surfaces worn down.

7. The belly of a thin-walled vessel (8 fragments) with a very poorly preserved “note” ornament. External surfaces worn down.





**Fig. 8.** Więckowice, site 4, Kraków district.  
Fragments of the LBK pottery from feature No. 45.  
Illustration by A. Zastawny

#### 8. Five small fragments of thin-walled vessels without ornament.

The pottery from feature no. 45, numbering 46 fragments from at least 7 vessels, is a standard for the “music note” phase of the LBK in western Lesser Poland. It is represented by both the predominantly smooth, thin-walled pottery (Fig. 8: 1, 3-5) and thick-walled ceramics (Fig. 8: 2). Reconstructable fragments came from hemispherical bowls of various sizes and proportions. In one case, the upper part of a conical bowl was distinguished (Fig. 8: 5). The decoration has been preserved on several fragments, mainly in the upper parts of the vessels. The engraved lines and the “note” points create simple compositions, consisting of U-shaped motifs in the middle of the belly and horizontal lines below the edge of the rim. The “note” points appear on and between the engraved lines (Fig. 8: 1). On the belly of the thick-walled cup, three short, parallel lines are placed (Fig. 8: 2).

With the exception of the last fragment, where the original surface has been preserved (rough, with traces of ceramic, stone, sand and plant admixture), the thin-walled ceramics survived in a very poor condition (without external surfaces). The thin-walled pottery contained fine-grained sand and organic material. Analogies to the pottery fragments discussed above can be found at many LBK sites near Kraków. The most important are Bolechowice, site 9 (Breitenfellner and Rook 1991), and Brzezcie, site 17 (Czekaj-Zastawny and Zastawny 2011; Czekaj-Zastawny 2014). The latter is a settlement with longhouses from the “music note” phase, at which the graphite pendant and imported pottery (from the Eastern Linear circle) come. Compared to the materials from Bolechowice, arched motifs predominate in the systems of engraved lines from Więckowice (Fig. 8: 1, 5), while in Bolechowice, angular motifs are the most common (Breitenfellner and Rook 1991, fig. 6: r-t). The same decoration, on the other hand, occurs on thick-walled ceramics (Fig. 8: 2) (Breitenfellner and Rook 1991, fig. 6: u). In the construction pit of longhouse no. III (feature no. 90) at Brzezcie 17, where a graphite pendant was discovered, the engraved ornamentation with “note” points occurs in both arched and angular arrangements (Czekaj-Zastawny 2014, pl. 27: d-i). The inventory of this pit includes a fragment of a conical bowl (Czekaj-Zastawny 2014, pl. 27: c), similar to the one from feature 45 from Więckowice (Fig. 8: 3).

In the materials from feature 45, the fragments of the vessel with graphite powder stand out in all respects (Fig. 5; 6). Compared to the ceramics discussed so far, their technical condition is better, the preserved fragments are larger, and the ornamentation is more varied and covers the entire surface of the vessel. Its shape is also a bit different. The spherical belly, as in the case of typical bowls, turns into a conical neck with a slightly everted lip (Fig. 5). Crushed pottery sherds of various sizes are present in the admixture in the clay mass. (Fig. 6: A). The most important element (apart from the presence of crushed graphite) is the decoration. The typical ornament of multiple engraved lines with U-shaped motifs (Fig. 6: A) is accompanied by fields covered with vertical rows of zigzags, closed with diagonally engraved lines on both sides and a horizontal line from above, located above the handle (Fig. 5; 6: C). It is an ornament referring directly to the style of the Eastern Linear group of Tiszadob-Kapušany (here we thank Dr. R. Hreha from the Slovak Academy

of Sciences in Košice for his consultation). Vessels with such an ornament are known from the Eastern Slovak sites of Šarišské Michaľany and Zemplínske Kopčany (Hreha and Šiška 2015, pl. 129: 7, 131: 4, 134: 1). The decoration in the form of arched engraved lines and vertical zigzag lines, appearing (as in Więckowice) as a composition on one vessel, appeared on a pear-shaped vase in Zemplínske Kopčany (Hreha and Šiška 2015, pl. 134: 1). We also know of arrangements of vertical zigzags on ceramics of foreign origin from Lesser Poland. From the above-mentioned site in Brzezcie 17 comes a bowl with an everted lip, imported from the environment of the Tiszadob-Kapušany group (Czekaj-Zastawny 2014, fig. 45: A; pl. 186: e). This is another element connecting the settlement of Więckowice and Brzezcie (“music note” phase, longhouses, ornamentation of the Eastern Linear circle, graphite). The technological difference of the discussed bowl with the graphite surface from Więckowice, and its ornamentation, which refers to the Eastern Linear style, seem to indicate its status as an import. However, the carelessness of the ornamentation (imitation?) and the presence of graphite raw material (probably put on the spot on the surface of the vessel) suggest that it may rather be a local product.

The use of graphite powder, identified on the outer surface of the vessel discussed here, represents the most common use of graphite in the LBK in Europe. Examples are known from sites in Moravia, southern Bavaria, the Bohemia and Silesia (see the rest of the article). An analogy from the Bavarian site of Mangolding (Pechtl and Eibl 2011, Abb. 86) deserves attention here. There, a graphite bowl was discovered with grains of crushed graphite on the surface that most closely (except the mouth diameter) resembles the vessel from Więckowice (Fig. 13: 6).

### Lithic artefacts

The few ceramic fragments were accompanied by numerous (257 specimens) lithic artefacts, including a small amphibolite adze (*Flachhacke*) with dimensions of 51 × 27 × 9 mm (Fig. 10: 1) and 256 flint products made of the local brown Jurassic-Kraków flint. The vast majority (58%) are flakes (149 specimens). Apart from that, there were 3 pre-core irregular forms and 4 single-platform flake cores, including a carinated initial core (Fig. 9: 4) with dimensions of 61-77 mm in length, 36-69 mm in width and 38-90 mm in thickness (the others represent similar types of boat-shaped cores, most often with crests, and with trimmed sides and platforms), along with 1 splintered piece, 5 scaled flakes, 25 technical flakes and blades, 8 tools, 12 blades, 37 chips and 12 chunks.

The so-called “technical” forms are represented predominantly by forms related to core trimming – mainly by crested flakes (Fig. 9: 2; 13 specimens). Their average dimensions are 51 × 49 × 16 mm. Crested blades are less numerous (Fig. 9: 3; 7 specimens), and have average dimensions of 77 × 28 × 16 mm. Most were removed by hard-hammer percussion. The exception is a very regular, partially crested *débordant* blade (Fig. 10: 4) with a dihedral butt and a straight longitudinal section. The next group consists of secondary

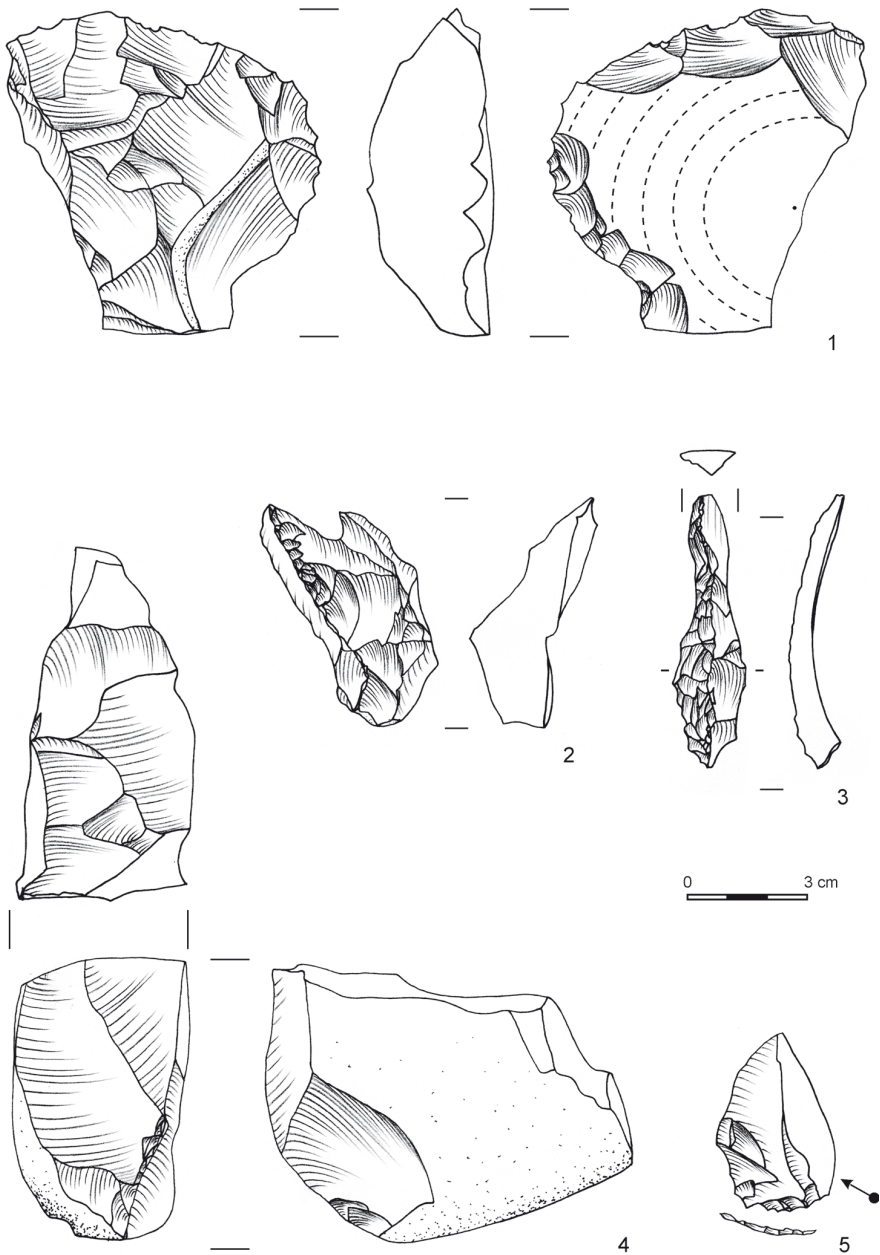


Fig. 9. Więckowice, site 4, Kraków district.  
 Selected LBK flint artefacts from feature No. 45.  
 Illustration by A. Brzeska-Zastawna

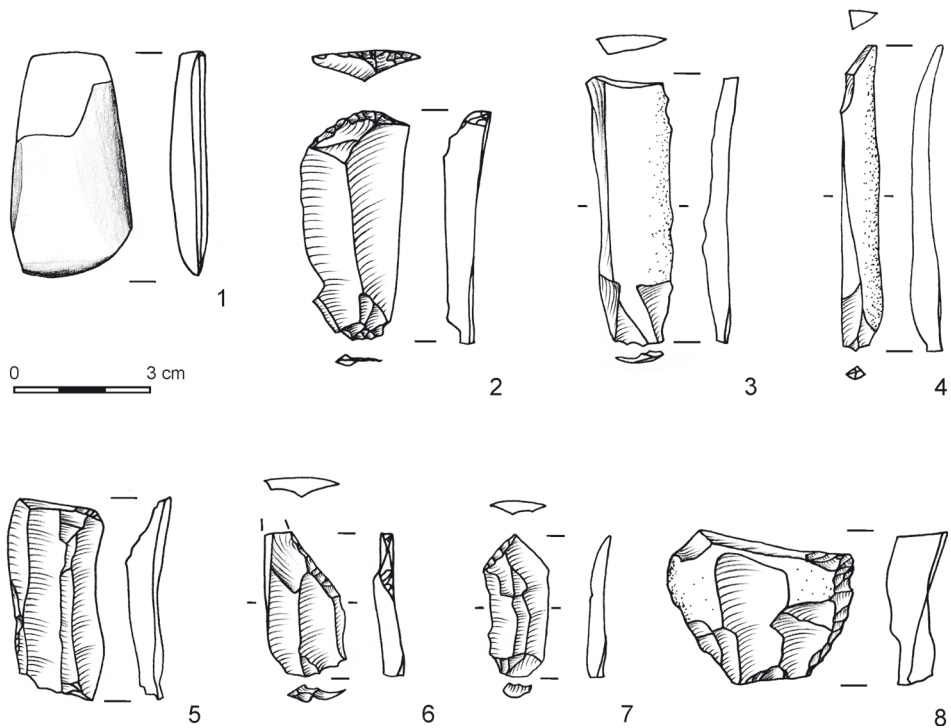


Fig. 10. Więckowice, site 4, Kraków district.

Selected LBK flint and amphibolite artefacts from feature No. 45. Illustration by A. Brzeska-Zastawna

crested blades and flakes (2 specimens each). Moreover, a repair flake appeared in the form of a core tablet (Fig. 9: 5).

Tools are represented by a modest group of 8 artefacts, including: 1 endscraper on a secondary crested blade (Fig. 10: 2) with dimensions of  $52 \times 23 \times 8$  mm, 2 truncated blades (Fig. 10: 6, 7) with dimensions of  $33 \times 18 \times 5$  and  $32 \times 15 \times 4$  mm, 1 retouched blade (Fig. 10: 5) 21 mm wide and 6 mm thick, 2 retouched flakes, 1 flake perforator (Fig. 10: 8) with dimensions of  $34 \times 42 \times 11$  mm, and a massive bifacial denticulate-notched tool of the mining type on a chunk (Fig. 9: 1) with dimensions of  $68 \times 89 \times 29$  mm.

Among the flakes (149 specimens), there is a distinct group of specimens from the decortication and initial core-trimming stages. Flakes with cortex constitute 72.5% of all flakes. Fifteen are completely cortical, and 41 are specimens with more than 50% cortex (37.6% of flakes in total). Fifty-two specimens are covered with cortex up to 50% (34.9% of flakes in total). In addition, they have negatives of a trimming character. They have strongly convex bulbs, sometimes double or dispersed bulbs with obtuse angles, depending on the angle of

impact. They are often accompanied by Hertzian cones as well as bruises and crumbles. These features prove that all trimming treatments are carried out by direct hitting with a hard hammer.

Most of the blades are associated with the early stage of exploitation. All blades on which tools were not made are covered to a varying extent with cortex, most often to a degree exceeding 50% (Fig. 10: 3). Almost all of them are defragmented. Their average dimensions are 19 mm wide × 5 mm thick. Butts are usually multi-negative, and less often single-negative. Most of them were obtained by indirect percussion with an antler punch (striking angle approx. 90 degrees, erailure scars, convex bulbs, protruding lateral edge in the butt part, flat butts, lip). Two of them could have been obtained by the pressure technique (an angle of about 95 degrees, diffuse bulb, uniform thickness, a straight longitudinal section with a slight bend in the distal part).

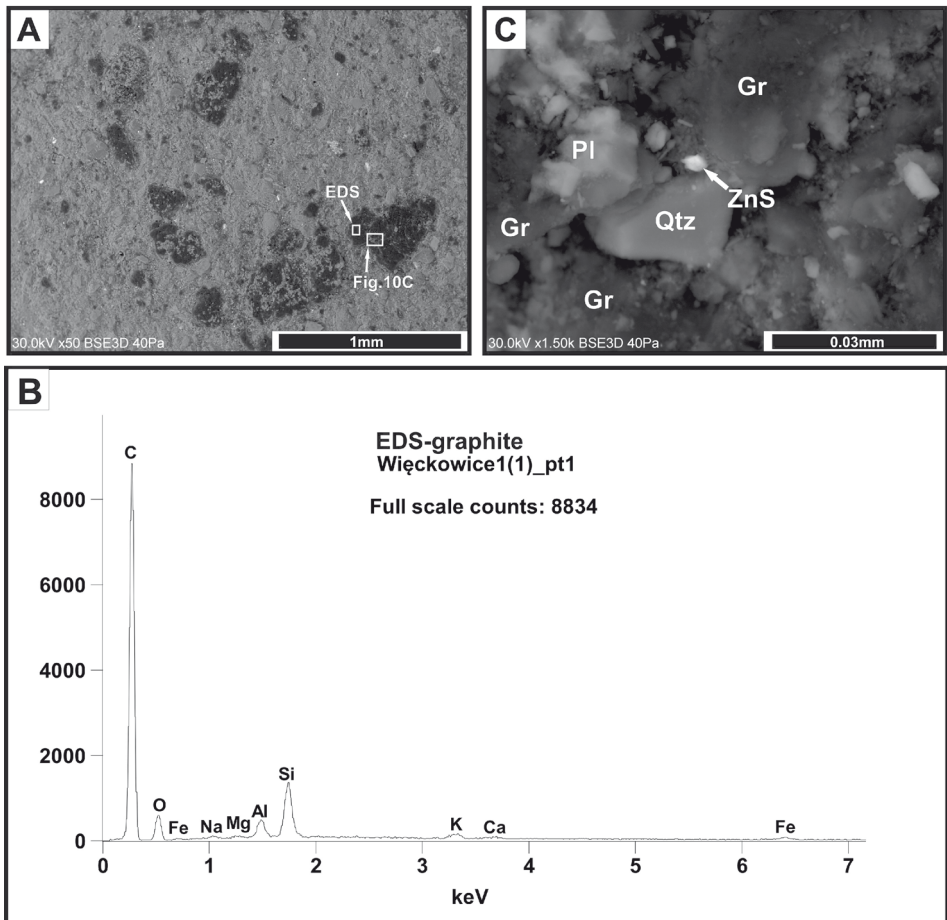
The only forms from the later stages of exploitation in this pit are represented by a modest set of tools in the form of two truncated blades made on regular blades, 15 and 18 mm wide. The blades on which the tools were made were obtained by antler punch. They have a multi-negative and a single-negative butt, respectively, one prominent and one diffuse bulbs, lips, and a right angle of striking. One has an erailure scar. The secondary crested blade on which the endscraper was made was detached by direct percussion. There are no regular blades from advanced exploitation in the pit, but there are a few broken fragments of such blades, along with unsuccessful blades or flakes on which fragments of the striking surface were removed with traces of regular blade exploitation. This proves that the group of regular blade blanks were taken out of the pit.

The inventory of the pit is dominated by the remains of flint-making activities related to the decortication of raw material nodules, initial trimming and early exploitation. Moreover, the inventory shows a typical form of a massive, mining-type tool. All the described elements indicate the typical production character of the inventory of pit 45, which is well-known from the Lesser Poland LBK flint-production settlements located near outcrops of flint (Lech 1981; Caspar *et al.* 1989), such as Kraków-Olszanica 4, Modlnica 5 (Wąs 2010) Spytkowice 26 or the closest sister site to Więckowice in Bolechowice 9 (Milisauskas 1986; Breitenfellner and Rook 1991; Brzeska-Pasek *et al.* 2018). Site 4 in Więckowice is therefore another settlement point of the LBK in the area near Kraków related to the production of flint products. The presence of graphite at the site in Więckowice is particularly important for research on the potential model of contacts and distribution of flint products from Jurassic-Kraków flint from the areas near Kraków to the Silesian-Moravian environments. A collection from one characterized feature does not entitle us to further conclusions in this regard. A completely study of archaeological materials from Więckowice 4 will probably provide an answer to the question of the general structure of the inventories, as well as whether the settlement produced blades for export and whether this settlement could have played a role in the flint-product distribution network.



## ARCHAEOMETRIC ANALYSIS OF GRAPHITE-COATED POTTERY

The scanning electron microscope examination was performed – without the application of any conductive layers – on a small ceramic flake (several millimetres in diameter) broken off from the exterior of the vessel. The observations were carried out by means of a Hitachi S-3400 N device with tungsten cathode (low vacuum mode, air pressure 30 Pa) in the Laboratory of Electron Microscopy, Faculty of Chemistry, University of Wrocław.



**Fig. 11.** Results of SEM-EDS examination of graphite-coated pottery from Wiąckowice, site 4: A – low magnification BSE image showing general view of the investigated ceramic surface. The two small rectangular features indicate the area shown in detailed view (Fig. 11: C) and the area used for EDS analysis (Fig. 11: B); B – Representative EDS spectrum of graphite; C – detailed view of graphite-rich rock fragment. Identification of particular minerals is based on interpretation of EDS spectra: Gr – graphite, Pl – plagioclase, Qtz – quartz, ZnS – zinc sulfide (sphalerite or wurtzite)



EDS spectra of particular mineral phases observed on the studied surface were acquired using a Thermo Scientific Ultra Dry detector (resolution 129 eV), and were analysed by Noran System 7.

In the low magnification BSE images, the analysed sample reveals a characteristic spotty pattern composed of dark-grey angular particles (up to *ca.* 0.5 mm across) scattered on the moderate-grey background of clay groundmass (Fig. 11: A). The spotty appearance is considered typical of ceramic surfaces covered with intentionally applied graphite coatings (*cf.* Kreiter *et al.* 2014; Borowski 2017; Łaciak *et al.* 2019). At higher magnifications, the dark grey objects embedded in the groundmass can be recognised as strongly flattened rock fragments with lepidoblastic or lepidogranoblastic structures and well-developed foliation. EDS spectra indicate the extremely high carbon content of these particles (Fig. 11: B). The rock fragments tend to be monomineralic or nearly monomineralic. Besides the predominant carbon-rich phase, showing a distinctive platy appearance, subordinate intergrowths of other rock-forming minerals can be observed. These are mostly represented by quartz, feldspars and micas. Sporadically, individual isometric sulfide grains (typically up to *ca.* 5  $\mu\text{m}$  across) also occur (Fig. 11: C). On the basis of the results obtained, it may be assumed that the vessel's exterior was deliberately covered with pulverized graphite-rich metamorphic rock, such as graphite schist or graphite-muscovite schist. The coating may be classified as poorly preserved (in places moderately well preserved). This is indicated by its rather irregular distribution and the low amount of graphite-rich particles (up to *ca.* 15% of the surface area).

A small polished thin section (*ca.* 1  $\times$  1 cm) was prepared from the graphite-coated sherd. The limited size of the preparation was dictated by concern for the preservation of this unique artefact. The thin section was analysed in both transmitted and reflected light by means of a Nikon LV100POL microscope equipped with an LV-UEPI attachment. For the purpose of petrographic characterisation, the descriptive system proposed by Quinn (2013) was followed. The Udden-Wentworth classification was used for grain size description.

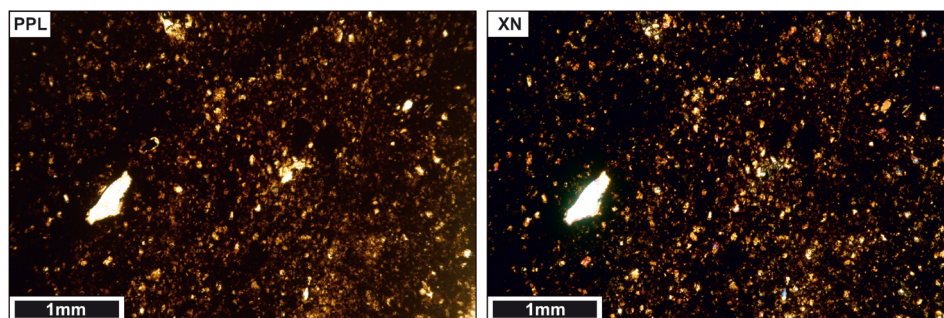


Fig. 12. Photomicrographs showing general view of ceramic thin section produced from the graphite coated pottery fragment from Więckowice, site 4 (PPL – plane polarised light; XN – crossed polarisers)

The fabric (Fig. 12) is characterised by a very weakly bimodal grain-size distribution. The predominant fine fraction (ca. 20-25 vol. % of ceramic body) is very well-sorted and largely represented by medium silt to very fine sand grains (mode: 0.05 mm). The inclusions of fine fraction are very angular to subrounded (mostly angular to subrounded) and composed of predominant quartz; abundant feldspars; uncommon mica (mostly muscovite); rare opaque phases; and rare to very rare accessory minerals (including zircon and tourmaline). The poorly-represented coarse fraction consists of a few angular quartz grains of medium-to-coarse sand (up to ca. 0.6 mm; mode: 0.45 mm). The colour of groundmass is brown to dark brown in both PPL and XN. In XN, the matrix is characterised by high optical activity and stipple-speckled b-fabric. The voids are mainly represented by scarce meso- to macro-vughs. Some of them show characteristics typical of organic-related porosity, such as slightly blackened margins and enclosed charred plant remnants (see Quinn 2013, 97). No graphite flakes can be observed in the marginal part of the sherd in the reflected light observation. This, however, should most likely be attributed to delamination of the coating, which tends to split off easily during thin section preparation, especially when dealing with poorly preserved surfaces (Łaciak *et al.* 2019).

The predominant grain-size range of mineral inclusions in the analysed pottery fragment can be considered indicative of ceramics produced from ubiquitous loess-derived silty clays, which are widely available throughout southern Poland. These ubiquitous raw materials were eagerly used by LBK potters in Central Europe (*e.g.* Rauba-Bukowska 2019, 13; Borowski *et al.* 2021). The individual sand-sized mineral inclusions could have been present as either intrinsic components of the clay raw material or deliberately added during ceramic paste preparation. The former possibility appears more likely, since the presence of larger grains belonging to a psammitic fraction has been previously reported from loess-like clays in Lesser Poland (Rauba-Bukowska 2019, 10). The scarce organic-related voids should most likely be attributed to naturally or artificially incorporated impurities of the paste rather than intentionally added vegetal temper. The presence of grog, tentatively indicated by macroscopic observations of the sherd, has not been confirmed by petrographic results. It cannot be ruled out, however, that this discrepancy is due to the relatively small size of the studied thin-section and the inhomogeneous distribution of grog fragments within the ceramic body.

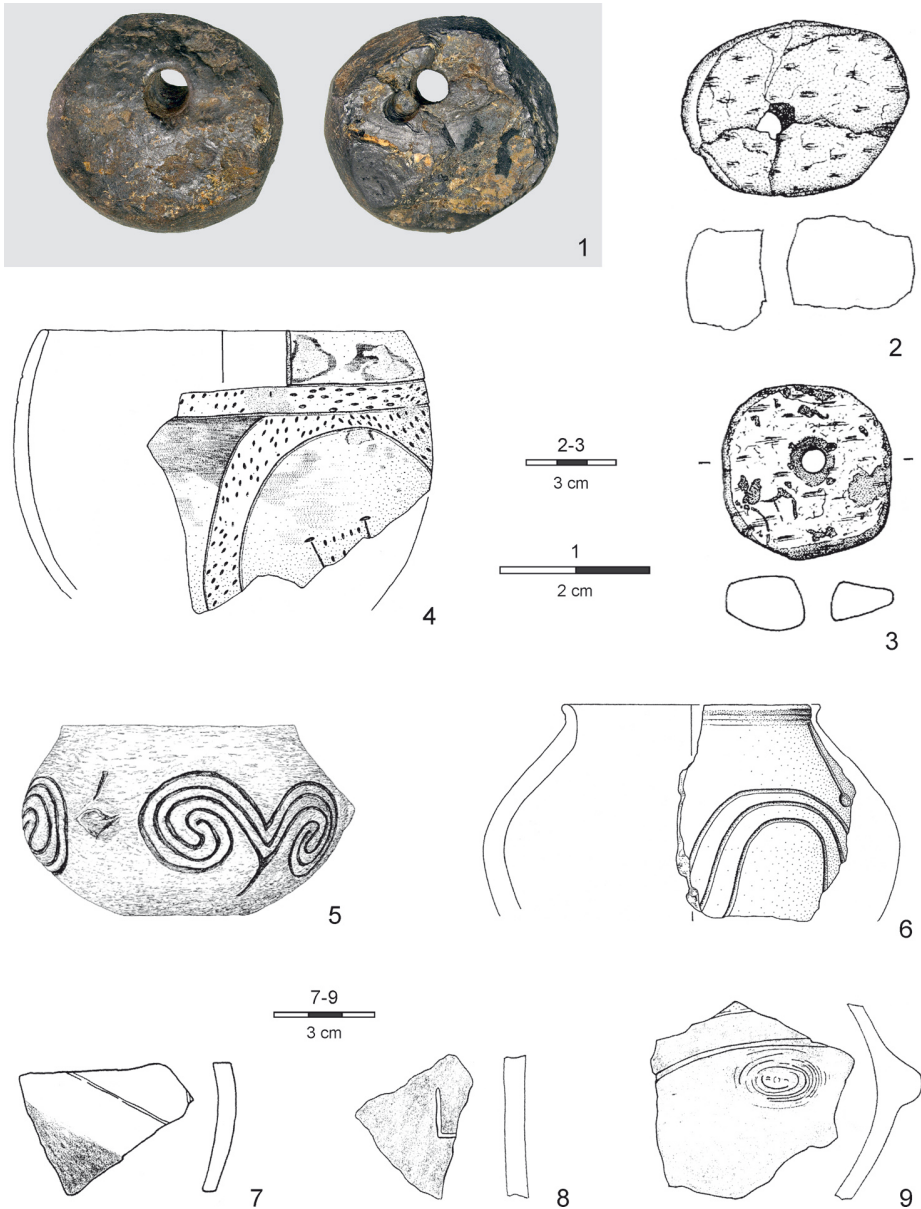
## GRAPHITE-COATED POTTERY FROM WIĘCKOWICE IN TERRITORIAL AND CHRONOLOGICAL CONTEXT

Graphite was used in several ways in the LBK in Europe (Tichý 1961; Pavúk 1972; Podborský 1993; Nieszery 1995; Hložek and Kazdová 2007; Pechtl and Eibl 2011; Lička 2011). It was most commonly used in a powdered form, as a component of clays covering the outer and inner surfaces of vessels (pottery with a graphite-coated surface) and as an ad-

mixture of pottery masses from which whole vessels were produced (graphite pottery). In pottery, graphite powder is most often present on smooth pottery, and less often on thick-walled ceramics. Ornaments in the form of circular, perforated pendants are examples of prestigious manifestations of graphite processing, and are discovered almost exclusively in funerary contexts. The role of graphite as a valuable and rare raw material is emphasized by finds of lumps and blocks of raw graphite (often with traces of attrition), placed in graves and discovered in settlements.

The discovery of a vessel covered with graphite powder at the site in Więckowice is the first documented example of the use of graphite in the production of LBK clay vessels in Lesser Poland. It is also only the second recognized case of graphite use in any of the materials of this culture at sites in Lesser Poland. For the first time, an artefact made of this raw material was discovered at a settlement from the “music note” phase of the LBK in Brzezcie, site 17, Wieliczka district. It is a circular graphite pendant with a hole for hanging (Fig. 13: 1), found in a construction pit (feature no. 90) of one of the longhouses (Rodak and Zastawny 2011, 20; Czekań-Zastawny 2014, 86-87; Trąbska and Weseluchy-Birczyńska 2014). It is the only decoration of this type known from any part of Poland. An admixture of graphite powder was also found in a sherd of Neolithic pottery from feature no. 44 in Stanisławice, site 10, Bochnia district (Nowak 2015, 64-68; Borowski 2015, 330-333). It was pottery with the addition of crumbled fragments of graphite pottery (individual graphite grains lying loose in the ceramic mass). The cultural affiliation of this feature has not been clearly established, although its relationship with the LBK has not been ruled out (Nowak 2015, 66).

In south-western Poland, the occurrences of graphite-coated pottery are largely confined to LBK sites located in the northern foreland of the Moravian Gate (the Głubczyce Plateau and its immediate surroundings). In Lower Silesia, an individual graphite-coated sherd has been recognised only at the Skoroszowice site, in the Niemcza Strzelin-Hills (see Łaciak *et al.* 2019, fig. 1). It can be stated that graphite used in Neolithic ceramic production in Upper Silesia was not of a local origin, since the area is dominated by sedimentary rocks and, therefore, lacks natural deposits of graphite (as is also the case in Lesser Poland). The nearest sources of this particular raw material are attributed to metamorphic rocks of the eastern part of the Bohemian Massif, with outcrops in the area of western Moravia. It remains an open question, however, whether these were lumps of raw graphite or rather graphite-coated vessels themselves that were transported. The results of an extensive archaeometric study on the late LBK ceramic assemblage from the Dzielnica site indicate that at least one of the graphite-coated vessels was probably produced elsewhere, as evidenced by its assignment to the non-local fabric group (Borowski *et al.* 2021). The Dzielnica site has also provided several graphite-tempered pottery fragments. The presence of these coarse-ware sherds, hitherto unrecognised at any other LBK site in Poland, is assumed to have resulted from the occasional trans-Sudetic importation of vessels from northern Moravia (Borowski 2018; Borowski *et al.* 2021).



**Fig. 13.** Examples of graphite pendants (1-3) and the use of graphite in the production of pottery as an ingredient of pottery mass (5) and as powder on vessel surfaces (4, 6-9) in various chronological LBK stages: 1 – Brzezcie 17, Lesser Poland, “music-note”, settlement pit; 2, 3 – Aiterhofen-Odmuhle, Bavaria, LBK, graves; 4 – Haimbuch, Bavaria, ältere LBK, pit near grave; 5 – Niederhummel, Bavaria, ältesten LBK, settlement pit; 6 – Mangolding, Bavaria, ältesten LBK; 7 – Kosoř, Bohemia, Lnk II, pit; 8, 9 – Kosoř, Bohemia, Lnk I, pits (1 – collection of Archaeological Museum in Kraków, photo A. Susuť; 2-6 /without scale/after Pechtl and Eibl 2011; 7-9 after Lička 2011)

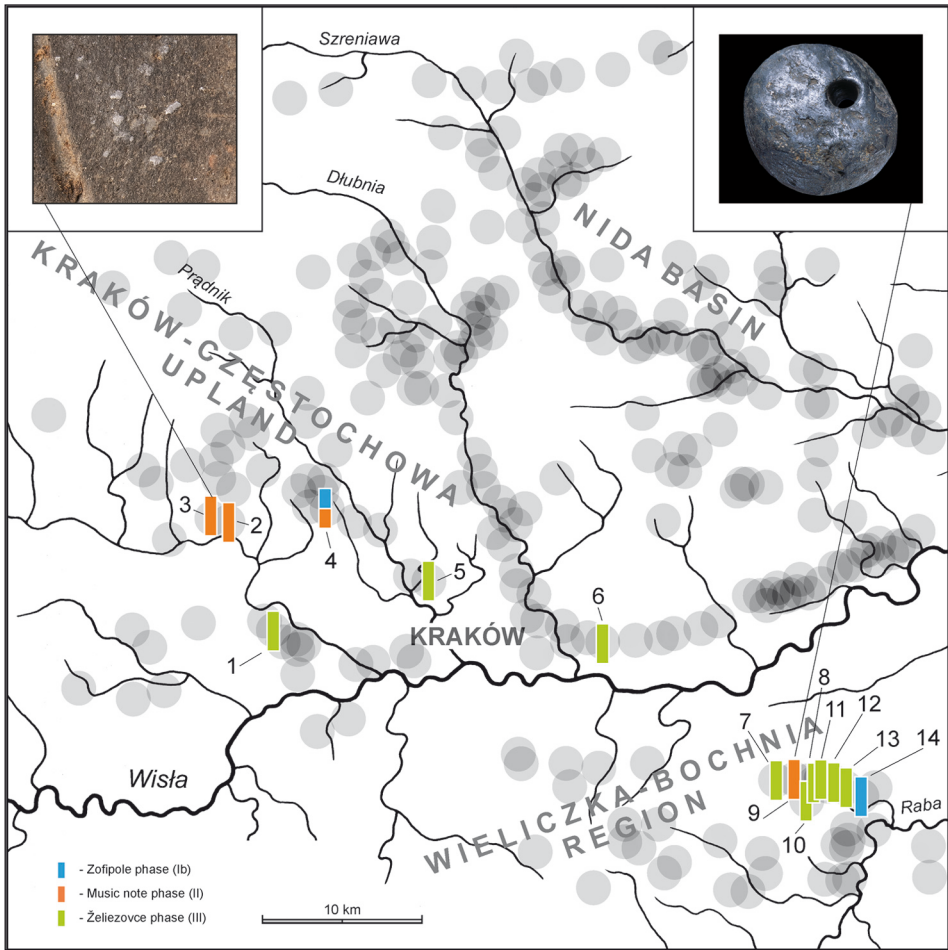
Graphite finds associated with the LBK are much more numerous in the areas of graphite deposits, mainly in Moravia and southern Bavaria (Tichý 1961; Pechtl and Eibl 2011; Hložek 2012). In Moravia, already by the 1960s, there were 60 known sites with graphite and graphite ceramics (Tichý 1961). The use of graphite in the production of pottery in Moravia is most fully discussed in relation to the finds from the Těšetice-Kyjovice settlement, where pottery with traces of graphite powder occurred in 5 settlement pits (mostly related to longhouses) as well as in one of the grave pits (Hložek and Kazdová 2007, 24; Vostrovská 2018, 115, 119). Lumps of raw graphite and fragments of vessels with graphite on the surfaces of the walls were discovered in the Moravian settlements of Vedrovice (Ondruš 1975-76; Hložek 2012) and Svinov (Hložek and Kazdová 2007).

Southern Bavaria clearly stands out on the map of LBK sites with graphite in Europe as the only area where all uses of graphite by the LBK communities have been recorded (Nieszery 1995; Pechtl and Eibl 2011). It is also the only area that has been thoroughly discussed and cataloged in the materials of the LBK /33 sites/ (Pechtl and Eibl 2011). Graphite appears here as a raw material used in the production of pottery (graphite powder), both as an admixture in pottery masses (graphite pottery) and as a raw material for covering the surface of dishes (pottery with graphite-coated surfaces). Examples of the use of graphite in pottery are the most abundant (Fig. 13: 4-6). Finds of raw pieces of graphite, often with signs of surface attrition, are numerous. Pottery with graphite, as well as raw graphite lumps, are finds that have been discovered in Bavaria in both settlement and burial contexts (Pechtl and Eibl 2011, 373-379). The most effective form of graphite use is seen in ornaments in the form of circular and oval pendants with a hole (Fig. 13: 2, 3). These prestigious items are known from Bavarian sites as stray finds and, above all, as pieces of grave equipment. The most numerous series comes from the well-known cemetery in Aiterhofen-Ödmühle (Nieszery 1995; Pechtl and Eibl 2011). An individual find of a similar graphite pendant was also reported from northern Moravia (Davidová 2007, fig. 17, 30: 9).

The areas with graphite finds also include the Bohemia and Slovakia, although there are definitely fewer such discoveries there. Pottery with traces of graphite is known from the settlement in Kosoř, Prague-West district (Lička 2011, 71). Eight pottery sherds were found there, with graphite used both as a component of ceramic mass and in the form of graphite powder applied to the outer and inner walls (Fig. 13: 7-9). Interesting finds come from Nitra in Slovakia, where at the LBK cemetery, similarly to Bavaria, pieces of raw graphite were found in a male grave and in a child's grave (Pavúk 1972, 63, tab. 1). Interestingly, the presence of graphite in LBK ceramic pastes was also recently reported from the Kamyane-Zavallia site (southern Ukraine), situated in close proximity to a large graphite deposit (Kiosak 2014, 124; Gaskevych 2017; Kiosak 2017, 258).

Graphite products and traces of graphite use in pottery production are known from all developmental stages of the LBK in Central Europe. It is most clearly observed in areas where examples of the use of graphite are the most numerous. In Bavaria, raw graphite –





**Fig. 14.** Distribution and chronology of sites with longhouses on the background of the LBK settlement zones in the Kraków region (acc. to Zastawny and Grabowska 2014, modified) with marked sites at Więckowice, site 4 (vessel with graphite-coated surface, photo by A. Susuł) and Brzezie, site 17 (graphite pendant, after Rodak and Zastawny 2011). Main sites: 1 – Kraków Olszanica, site 4; 2 – Bolechowice, site 9; 3 – Więckowice, site 4; 4 – Modlnica, site 5; 5 – Kraków Górka Narodowa, site 9; 6 – Kraków Mogiła, site 62; 7 – Zagórze, site 2; 8 – Szarów, site 9; 9 – Brzezie, site 17; 10 – Brzezie, site 40; 11 – Targowisko, site 16; 12 – Targowisko, site 14, 15; 13 – Targowisko, site 12, 13; 14 – Targowisko, site 10, 11

in the form of untreated pieces and lumps with traces of attrition – is found in all LBK phases (Pechtl and Eibl 2011, Abb. 2). Graphite on vessel surfaces (the most common) and graphite in ceramic mass dominate in the older phases (*ÄLBK*, *ältere LBK*), while pendants with a hole come from the middle and younger phases (*mittlere*, *jüngere LBK*). The chronological range is also characteristic for the finds in Moravia, where pottery with

graphite was found in the context of all LBK phases, except phase Ia (Podborský 1993, 91). On a multiphase settlement in Kosoř in the Bohemia, graphite pottery and pottery with graphite-coated surfaces were discovered in features dated to phase Ic and, above all, to the II Lnk phase (Lička 2011, 71). In Nitra, Slovakia, the pottery of one of the graves in which a graphite lump was deposited shows transitional features between the youngest LBK phase and the oldest stage of the Želiezovce group (Pavúk 1972, 76-87). Both settlements from Lesser Poland (Brzezie 17 and Więckowice 4), from which the graphite pendant and the graphite vessel originate, represent the middle, “music note,” phase of the LBK (Fig. 14).

It is estimated that the use of graphite in the production of pottery had both practical and aesthetic reasons (Podborský 1993, 91; Hložek and Kazdová 2007, 29; Lička 2011, 71). Graphite added to the pottery mass (eng. *graphite-tempered pottery*; pol. *ceramika grafitowa*; cz. *tuhová keramika*; ger. *Graphittonkeramik*) increased the technical quality of the vessel (thermal properties), while at the same time serving as an attractive ornament (yielding black and shiny surfaces on the vessel walls). Graphite powder on the surface of a vessel (eng. *graphite-coated pottery*; pol. *ceramika grafitowana*; cz. *tuhovaná keramika*; ger. *Oberflächengrafitierung*), the most common use of graphite in pottery, probably already had an aesthetic function, and could be perceived as a rare and original ingredient for finishing vessels. Moreover, it seems likely that this kind of surface treatment could have served some symbolic or emblematic functions. For the above reasons, graphite was a valuable raw material for exchange and could end up in areas remote from graphite deposits, including Lesser Poland, along with other raw materials or finished products, e.g. amphibolite tools.

## FINAL REMARKS

The presented article discusses the materials from an LBK settlement pit (feature no. 45) at site 4 in Więckowice, which was dated to the “music-note” phase. The site is situated on the southern edge of the Kraków-Częstochowa Upland (Fig. 1). This location makes the settlement discovered here stand out from the LBK settlement cluster near Kraków. According to the current state of research, it is the westernmost LBK settlement with long-houses (Fig. 14). An additional distinguishing feature is its location in the immediate vicinity of sources of Jurassic flint, which is reflected in the nature and number of flint inventories.

Fragments of an ornamented vessel with powdered graphite preserved on the outer surface of its wall were discovered in feature no. 45 and constituted a very unique find. This is the first such discovery confirmed in Lesser Poland. The presented results of an SEM-EDS examination prove that the investigated ceramic surface was coated with pulverised graphite originating from remote metamorphic deposits. Unfortunately, in this case, ceramic petrography does not provide any clear indications of the vessel’s prove-



nance, since the ubiquitous loess-like clays tend to be very uniform throughout Central Europe, in both textural and mineralogical terms. It seems likely, however, that this vessel was produced locally and coated with imported graphite. This interpretation is consistent with the results of ethnoarchaeological studies of Arnold (1985, tab. 2.3), indicating that raw materials used for surface finishing, such as slips or paints, are often obtained from relatively distant resources.

Not only is the presence of graphite noteworthy, but also, the use of this material on a vessel decorated in a style reminiscent of the ornamentation of the Eastern Linear group of Tiszadob-Kapušany. As stated above, this vessel was probably made on the spot, using imported graphite and foreign ornamental motifs. For this reason, the discussed artefacts constitute an interesting source in the research on interregional contacts of the LBK settlement cluster on the Vistula: Moravian graphite and Sudeten amphibolite (miniature adze from feature no. 45) and references to the ornamentation of the Eastern Linear circle.

The discovery of graphite ceramics in Więckowice has become an opportunity to recall the issues of graphite use in the LBK in Central Europe and to present the position of finds from Lesser Poland in this context. It can be assumed that there are many more finds of graphite-coated or graphite-tempered pottery in the LBK of Lesser Poland (e.g. at the settlement in Brzezcie 17, from which the graphite pendant comes). The problem seems to be the identification of graphite admixture on poorly preserved surfaces. The reach of graphite over the upper Vistula may be confirmed by the relationship with the Silesian-Moravian borderlands (lithic raw materials). An unquestionable distinguishing feature of the LBK settlement near Kraków is the coexistence of traces of interregional contacts with both the western (Silesia, Moravia) and eastern areas, from the Eastern Linear circle (eastern Slovakia, north-eastern Hungary). In this regard, the graphite-coated vessel itself may be considered unique in its stylistic syncretism, as expressed by the application of non-local ornamentation patterns and the use of exotic raw material in surface finishing.

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### References

- Arnold D. E. 1985. *Ceramic theory and cultural process*. Cambridge: Cambridge University Press.
- Borowski M. 2015. Wyniki badań surowcowo-technologicznych ceramiki neolitycznej i z wczesnej epoki brązu na stanowiskach 9 i 10 w Stanisławicach. In M. Nowak and T. Rodak (eds), *Osady z epoki kamienia oraz wczesnej epoki brązu na stanowiskach 9 i 10 w Stanisławicach, pow.*

bocheński (= *Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce*). Kraków: Krakowski Zespół do Badań Autostrad, 323-335.

- Borowski M. 2017. Methods of surface treatment on ceramic vessels from the Nadziejewo cemetery in light of mineralogical analyses. In M. Kaczmarek (ed.), *Nadziejewo. The Late Bronze Age and Early Iron Age Cremation Cemetery in Central Wielkopolska (= Hyperborea. Poznańskie studia nad epoką brązu i wczesną epoką żelaza 2)*. Poznań: Instytut Archeologii UAM, 305-319.
- Borowski M. 2018. Domieszki pozamiejscowych skał metamorficznych w ceramice kultur wstęgowych ze stanowiska w Dzielnicy (woj. opolskie). In V. Janák, M. Furmanek, A. Přichystal and S. Stuchlík (eds), *Petroarcheologický výzkum neolitu a eneolitu ve Slezsku (= Acta Archaeologica Opaviensia 5)*. Opava: Filozoficko-přírodovědecká fakulta Slezské univerzity v Opavě, 223-231.
- Borowski M. P., Goličko M., Furmanek M., Nowak M. and Szczepara N. 2021. Addressing the issue of the Early Neolithic pottery exchange through a combined petrographic and geochemical approach: a case study on LBK ware from Dzielnica (Upper Silesia, southern Poland). *Archaeological and Anthropological Sciences* 13/5. DOI: 10.1007/s12520-020-01244-6.
- Breitenfellner A. and Rook E. 1991. Sprawozdanie z badań osady kultury ceramiki wstęgowej rytej w Bolechowicach-Zielonej, gm. Zabierzów, woj. Kraków, stanowisko 9. *Sprawozdania Archeologiczne* 43, 9-20.
- Brzeska-Pasek A., Kenig R., Oberc T. and Nowak M. 2018. Wczesnoneolityczne osady w Spytkowicach i ich rola w dystrybucji krzemienia jurajskiego. In V. Janák, M. Furmanek, A. Přichystal and S. Stuchlík (eds), *Petroarcheologický výzkum neolitu a eneolitu ve Slezsku (= Acta Archaeologica Opaviensia 5)*. Opava: Filozoficko-přírodovědecká fakulta Slezské univerzity v Opavě, 139-164.
- Caspar J. P., Kaczanowska M. and Kozłowski J. K. 1989. Chipped stone industries of the Linear Band Pottery (LBP): Techniques, morphology and function of the implements in Belgian and Polish assemblages. *Helinium* 29/2, 157-205.
- 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. and Przybyła M. 2012. *Modlniczka 2, powiat krakowski – cmentarzysko kultury ceramiki wstęgowej rytej i osady neolityczne (= Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce)*. Kraków: Krakowski Zespół do Badań Autostrad.
- Czekaj-Zastawny A. and Zastawny A. 2011. Sprawozdanie z badań ratowniczych na stanowisku 17 w Brzeziu, gm. Kłaj, woj. małopolskie, z lat 2005-2006. In S. Kadrow (ed.), *Raport 2005-2007*. Warszawa: Narodowy Instytut Dziedzictwa, 349-358.
- Czerniak L. (ed.) 2010. Osady kultury ceramiki wstęgowej rytej w Modlnicy, gm. Wielka Wieś, woj. małopolskie, stanowisko 5 /AUT 5/ (unpublished elaboration for Krakowski Zespół do Badań Autostrad, Kraków).
- Davidová T. 2007. Šarecký stupeň na horním toku Moravy. Filozofická fakulta Univerzity Karlovy Ustav (unpublished MSc Thesis). Praha.

- Gaskevych D. 2017. Pottery with admixture of graphite and exchange networks in Neolithic of Ukraine: problem statement. In Y. Morozova and P. Shydlovskiy (eds), *Wetland Archaeology and prehistoric networks in Europe*. Kyiv: Vita Antiqua Library, 41-42.
- Hložek M. 2012. Multidisciplinárni technologická analýza neolitické keramiky (unpublished PhD dissertation, Masaryk University Brno). Brno.
- Hložek M. and Kazdová E. 2007. Nález grafitu v kultúre s lineárnou keramikou v Těšeticích-Kyjovicích a řešení otázky jejich provenience. *Sborník prací filozofické fakulty brněnské university* M7, 23-31.
- Hreha R. and Šiška S. 2015. *Bukovohorská kultúra na Slovensku vo svetle výskumov v Šarišských Michaľanoch a Zemplýnskych Kopčanoch* (= *Archaeologica Slovaca Monographiae* 20). Nitra: Archeologický ústav Slovenskej akadémie vied.
- Kiosak D. 2014. Settlements and indigenous populations at the easternmost fringe of the Linear Pottery culture. *Eurasia Antiqua* 20, 117-141.
- Kiosak D. 2017. Kamyane-Zavallia, the Easternmost Linear Pottery culture Settlement Ever Excavated. *Sprawozdania Archeologiczne* 69, 253-269.
- Kozłowski J. K. 1970. Z badań nad wytwórczością krzemieniarską w kulturze ceramiki wstęgowej rytej. In J. K. Kozłowski (ed.), *Z badań nad kulturą ceramiki wstęgowej rytej*. Kraków: Polskie Towarzystwo Archeologiczne, 73-94.
- Kreiter A., Czifra Sz., Bendő Z., Egri Imre J., Pánczél P. and Váczí G. 2014. Shine like metal: an experimental approach to understand prehistoric graphite coated pottery technology. *Journal of Archaeological Science* 52, 129-142. DOI: 10.1016/j.jas.2014.07.020.
- Lech J. 1981. *Górnictwo krzemienia społeczności wczesnorolniczych na Wyżynie Krakowskiej. Konec VI tysiąclecia – 1 połowa IV tysiąclecia p.n.e.* Wrocław, Warszawa, Kraków, Gdańsk, Łódź: Zakład Narodowy im. Ossolińskich.
- Lička M. 2011. Osídlení kultury s lineární keramikou v Kosoři, okr. Praha-západ. *Fontes Archaeologici Pragenses* 37. Praha: Národní Muzeum.
- Łaciak D., Borowski M.P., Łydźba-Kopczyńska B., Baron J. and Furmanek M. 2019. Archaeometric characterisation and origin of black coatings on prehistoric pottery. *Geochemistry* 79, 453-466. DOI: 10.1016/j.chemer.2019.07.004.
- Milisauskas S. 1986. *Archaeological investigations on the Linear culture village of Olszanica*. Wrocław, Warszawa, Kraków: Polska Akademia Nauk.
- Nieszery N. 1995. *Linearbandkeramische Gräberfelder in Bayern* (= *Internationale Archäologie* 16). Espelkamp: Verlag Marie Leidorf.
- Nowak M. 2015. Materiały kultury ceramiki wstęgowej rytej i kultury pucharów lejkowatych na stanowisku 10 w Stanisławicach. In M. Nowak and T. Rodak (eds), *Osady z epoki kamienia oraz wczesnej epoki brązu na stanowiskach 9 i 10 w Stanisławicach, pow. bocheński* (= *Via Archaeologica. Źródła z badań wykopaliskowych na trasie autostrady A4 w Małopolsce*). Kraków: Krakowski Zespół do Badań Autostrad, 61-72.
- Pavúk J. 1972. Neolithisches Gräberfeld in Nitra. *Slovenská Archeológia* 20/1, 5-105.
- Pechtl J. and Eibl F. 2011. Die neolithische Graphitnutzung in Südbayern. In K. Schmotz (ed.), *Vorträge des 29. Niederbayerischen Archäologentages*. Rahden/Westf.: Verlag Marie Leidorf, 349-432.

- Podborský V. 1993. Nástup zemědělské civilizace. In V. Podborský (ed.), *Pravěké dějiny Moravy* (= *Vlastivěda Moravská* 3). Brno: Muzejní a vlastivědná společnost, 71-154.
- Quinn P.S. 2013. *Ceramic petrography: the interpretation of archaeological pottery and related artefacts in thin section*. Oxford: Archaeopress.
- Rauba-Bukowska A. 2019. The diversity of ceramic raw materials used in the production of Neolithic vessels in the upper Vistula basin near Kraków. *Analecta Archaeologica Ressoviensia* 14, 7-16.
- 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 Transformations* 8. Leiden: Sidestone Press, 73-83.
- Rodak J. and Zastawny A. 2011. *Archeologiczna autostrada. Wykopiska przy wielkich inwestycjach drogowych pod Krakowem (Archaeological Motorway. Excavations carried out during great road investments near Kraków)*. Kraków: Muzeum Archeologiczne w Krakowie, Krakowski Zespół do Badań Autostrad.
- Tichý R. 1961. O používání tuhy v mladší době kamenné. *Památky archeologické* 52/1, 76-84.
- Trąbska J. and Weseluchy-Birczyńska A. 2014. Badania fazowe i strukturalne grafitowej zawieszki ze stanowiska Brzezie 17, gm. Klaj. 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, 491-498.
- Vostrovská I. 2018. Těšetice-Kyjovice – komunitní areál prvních zemědělců (unpublished PhD dissertation, Masaryk University Brno). Brno.
- Wąs M. 2010. Materiały krzemienne. In L. Czerniak (ed.), *Osady kultury ceramiki wstęgowej rytej w Modlnicy, gm. Wielka Wieś, woj. małopolskie, stanowisko 5 /AUT 5/* (unpublished elaboration for Krakowski Zespół do Badań Autostrad) Kraków.
- Zastawny A. 2009. Sprawozdanie z przeprowadzenia badań archeologicznych na stanowisku Więckowice, st. 4, gm. Zabierzów, woj. małopolskie (unpublished report for Provincial Heritage Protection Office in Kraków). Kraków.
- Zastawny A. and Grabowska B. 2014. Materiały kultury ceramiki wstęgowej rytej ze st. 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, 63-253.

