

RESEARCH ARTICLE – VÝZKUMNÝ ČLÁNEK

Creating the so-called graphite-coated pottery of the Late Bronze and Early Iron Ages: An experimental approach to manufacturing prehistoric pottery

Takzvaná tuhovaná keramika mladší doby bronzové a starší doby železné: Experimentální přístup ve výrobě pravěké keramiky

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Over the centuries, various minerals were used in pottery production; for some societies, graphite played a unique role. Certain areas lack local sources of this mineral but simultaneously reveal a great occurrence of 'graphite-coated' pottery. Still, it is commonly believed that the surface of these vessels was coated with graphite. The aim of the article is to examine whether the surface visually characterised as 'graphited' (suggesting the use of graphite) could be achieved without the application of the mineral and what the technological process of manufacturing might have looked like. Macroscopical and archaeometry recognition features of 'graphite-coated' pottery and mineral graphite were indicated. A series of experiments were performed to achieve a lustrous, silver surface without applying mineral graphite. The firing process was conducted in two types of kilns reconstructed according to archaeological sources from the territory of Poland dated to the Late Bronze and Early Iron Ages. The reproduced pottery shows surfaces very similar to their prehistorical counterparts. The significant occurrence of this type of pottery indicates its production could also be conducted in areas lacking mineral graphite.

graphite-coated pottery – graphite – Late Bronze Age – Early Iron Age – Poland – experiment

V průběhu staletí se při výrobě keramiky používaly různé minerály. Pro některé společnosti hrál grafit jedinečnou roli. Určité oblasti postrádají místní zdroje tohoto minerálu, ale zároveň vykazují velký výskyt tuhované keramiky. Přesto se všeobecně předpokládá, že povrch těchto nádob byl potažen grafitem. Cílem článku je prozkoumat, zda povrchu vizuálně charakterizovaného jako „tuhovaný“ (což naznačuje použití grafitu) mohlo být dosaženo i bez aplikace tohoto minerálu a jak mohl vypadat technologický postup takové výroby. Indikovány byly makroskopické a archeometrické rozpoznávací znaky „tuhované“ keramiky a minerální tuhy. Byla provedena série experimentů, jejichž cílem bylo dosáhnout lesklého stříbrného povrchu bez aplikace minerálního grafitu. Proces výpalu byl proveden na dvou typech vypalovacích zařízení rekonstruovaných podle archeologických nálezů z území Polska datovaných do pozdní doby bronzové a starší doby železné. Reprodukovaná keramika vykazuje povrchy velmi podobné těm pravěkým. Významný výskyt tohoto typu keramiky naznačuje, že její výroba mohla probíhat i v oblastech bez výskytu minerálního grafitu.

tuhovaná keramika – grafit – mladší doba bronzová – starší doba železná – Polsko – experiment

Introduction

Over the centuries, various minerals were used in pottery production. Graphite played a unique role for some societies. Its use is a crucial factor in distinguishing two groups of graphitic pottery, namely graphite-coated and graphite-tempered pottery. In the case of the former, graphite was used to apply decorative motifs or to coat the surface of vessels, while the latter was employed as a non-plastic inclusion added to the clay during the creation of the ceramic paste.

Graphite was used in pottery production with varying intensity from the Neolithic until the Middle Ages (*Hlava 2008; Kreiter et al. 2014*). In the Bronze Age and in the Early Iron Age (the Hallstatt period), it was typically applied on the surface and used to make decorative elements, especially in areas with abundant geological deposits of graphite rocks, i.e. in Bulgaria, Moravia and southern Bavaria (*Kreiter et al. 2014, 129*). At the end of the Hallstatt period, it came to be employed as temper in the ceramic paste and as the base material for paints, while graphite lumps were used for coating surfaces of vessels as well as for applying decorative patterns. This use of graphite intensified in the La Tène period (*Trebsche 2011, 449–453*). Painting employing graphite (graphite painting) most commonly accompanies painting in red, which is characteristic of the western Hallstatt cultural zone. It was common in the Alb-Hegau group (*van den Boom 2001, 337*) and at sites such as Heuneburg (*Dämmer 1977, 43, Table 4: 2–3, 5: 6; 1978, 27, 31, Table 1–5, 77: 845, 846, 134: 4, 140: 2*) and Sopron (*Eibner-Persy 1980, 53–54*). In southwestern Poland, combining ‘graphite-coated’¹ surfaces with painted ones is an extremely rare phenomenon (*Gedl 1962, 58*). This combination has only been recorded several times in Upper Silesia (Chorula, district of Krapkowice: *Glaser 1937, 148, Table 14, group I: 1; Kietrz, district of Głubczyce: Gedl 1973, 51; Opole-Nowa Wieś Królewska: Gedl 1962, 58, 303, Table XXX: 9*) and Lower Silesia (Świniary, district of Wrocław: *Glaser 1937, 87, Table 15: 8; Proszkowa, district of Wołów: a fragment of a bowl with rims turned inward and displaying a ‘graphite-coated’ strip, the fragment was identified during a preliminary survey of museum collections, Łaciak 2017, 183, Table 19: 4 and one of the two zoomorphic vessels originally ‘graphite-coated’ and painted red, Domańska 1997, 196–197, Fig. 4: 1*) and Greater Poland (Gorszewice, district of Szamotuły: *Narożna-Szamałek – Szamałek 2007, 149, Fig. 21: 1, Photo 5; 164, Fig. 30: 11, Photo 7; Sobiejuchy, site 2, district of Żnin, grave 97/74: Ostoja-Zagórski – Strzałko 1982, 137; Bruszczewo, site 12, district of Kościan: Kaczmarek 2003, Photo 1*).

In Poland, ‘graphite-coated’ pottery is considered typical of the Late Bronze Age and especially the Early Iron Age. It features black or dark grey outer and inner surfaces with a characteristic metallic lustre thought to be achieved with graphite (*Malinowski 1963, 181, footnote 3 – ibid. further literature*) despite areas lacking graphite outcrops (e.g. Lower Silesia: *Lis – Sylwestrzak 1986, 236–241*). However, the visual effect might also be the result of polishing and smouldering a vessel’s surface during firing (*Malinowski 1963, 181, footnote 4; Gedl 1973, 32*). In the case of the latter, it is generally agreed that the contribution of graphite was absent (*Malinowski 1963, 181, footnote 5*), which is corroborated by ethnographic analogies (*Malinowski 1963, 181, footnote 6*).

Yet another technique producing surfaces with a metallic lustre was put forward by *Mierzwiński (2003, 243, footnote 14)*. He proposed the idea of “*acquiring mica from rock (erratic boulders), which was subsequently pulverised; the produced dust was rubbed into the still wet surface of a vessel’s wall. This method enabled the precise application of mica zones or linear patterns*”. Also, *Hohubowicz (1948, 14–16; 1950, 228)* disagreed that Lusatian culture vessels were coated with graphite and claimed that smouldering applied during

¹ Hereinafter, this term refers to a specific black metallic coating irrespective of whether graphite was actually used.

firing was responsible for the characteristic colour. He successfully completed a few experimental firings, which confirmed his conjectures but no details on conducted surface treatment and firings were published (*Hołubowicz 1948*, 15–16).

Without an archaeometrical approach, recognition of ‘graphite-coated’ surfaces depends only on subjective perception and could lead to the wrong identification. Most scholars identify ‘graphite-coated’ vessels only by recognising surface treatment as polished with silver, black and grey-black colour. Some others also used the term painted black, because of the deep, uniform colour of black (*Mierzwiński 1994*, 57–58; *Stepnik 2010*, 44, 49, 57, 62, 74–75). The literature does not provide any macroscopic method to distinguish unambiguously between blackening, smouldering, graphite-coating and painting, which stems from the absence of clear-cut definitions and confusing technological/decorative activity (graphite-coating, painting) with the actions applied during firing (blackening, smouldering). Consequently, this adversely affects the recognition of ‘graphite-coated’ products and their correct classification.

All this prompts the verification of techniques that will produce ‘graphite-coated’ surfaces without the use of graphite. The aim of the article is to examine whether the surface visually characterised as ‘graphited’ (which suggests the use of graphite) could be achieved without the application of mineral graphite. A series of experiments will follow the research question on how the technological process of manufacturing could look.

Issues in the identification of graphite on pottery surface

‘Graphite-coated’ ceramics are recognised macroscopically based on a metallicly shiny surface, black or dark grey in colour. Subjective assessment of these features led to the creation of a very large number of ceramic assemblages called ‘graphite-coated’, which suggests the use of graphite in the process of manufacturing lustrous surfaces. The identification of such surfaces may be solved by archaeometry analysis aimed at recognising the presence of graphite.

Graphite is a crystalline, polymorphic form of elementary carbon, but in nature it appears in less perfect form and in a variety of disordered types. Their transitional forms are dispersed in sedimentary or metamorphic rocks and differ by varying degrees of graphitisation of carbon contained in carbonaceous substances or organic matter (semi-graphite, meta-anthracite, anthracite). Usually, the division into pure graphite by the degree of their crystalline perfection and transitional forms is based on X-ray analysis, measurements of %R_{max}, and the H/C atomic ratio. Additional information can be obtained from scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), differential thermal analysis (DTA), Raman microspectroscopy, and also from chemical and physical analysis (*Kwiecińska – Petersen 2004*, 100–101).

In relation to vessels dated to the Late Bronze Age and Hallstatt period from the area of Europe, various analytical methods were undertaken; these achieved different results. Graphite was admixed in the black paint applied to the surface of pottery from Heuneburg, which was confirmed by specialist investigation (*Noll 1977*, 15). It was also used during the production of Hallstatt and La Tène pottery from Württemberg, which was corroborated by electromicroscopic and X-ray examination (*Schwing 1966*, 179). The application of graphite in the production of pottery was also tested by multiple experiments that provided

results similar to prehistoric originals (*Chocholoušek – Nudera 1968*, 453; *Mogielnicka-Urban 1975*, 462; *Abramowicz – Karwowski 2009*, 383; *Kreiter et al. 2014*).

Various analytical techniques involved in pottery identified by archaeologists as ‘graphite-coated’ derived from southern Poland and dated to the Late Bronze Age and Early Iron Age have shown the problems of proper identification of graphite on ceramic surfaces. The most reliable method – the XRD examination – reveals similarly high values for graphite and quartz, which causes an overlap between peaks and difficulties in the reliable identification of graphite (*Łaciak 2007*, 152; *Łaciak – Stoksik 2010*, 122, fig. 12; *Łaciak 2017*, 323, fig. 56). A combination of thin section analysis in reflected and transmitted light, X-ray, and chemical and thermal analyses identified that the glossy, black surface of one vessel was achieved by soot (*Malinowski 1963*; *Święcki 1963*). Raman spectroscopy confirmed carbonaceous material, carbon-based pigment, which was also detected in the black painted ornament on Oder-zone pottery (*Łydźba-Kopczyńska et al. 2008*, 169–170). The presence of numerous graphite grains was identified on other samples of metallic-silver lustre surfaces (*Łaciak et al. 2017*, 197, fig. 16, 17; *Łaciak – Łydźba-Kopczyńska 2017*, 62, fig. 5, 7). SEM-EDS and TEM examination identified graphite in lustrous, dark surfaces of vessels from the Late Bronze Age and the Early Iron Age from Upper Silesia (*Abramowicz – Karwowski 2009*, 380) and Greater Poland (*Borowski 2017*, 308–310).

It should be borne in mind that archaeological pottery discovered today involves objects with a complex life cycle that begins with production and ends with deposition. Besides the diverse processes of changes happening during the life of pottery, it belongs to and is influenced by a variety of contexts (systemic, archaeological and heritage management according to *Santacreu 2014*). Archaeological pottery is the subject of continuous changes that cause different alterations. They have an impact on the different physicochemical, mineralogical, and textural attributes of the pottery (*Santacreu 2014*, 45–58). When attempting to solve the problem using archaeometric examinations, these changes should be taken into account and analytical methods should be selected accordingly.

The most efficient analytical methods enabling the differentiation of graphite-based and non-mineral black coatings were combined SEM-EDS, optical microscopy and Raman spectroscopy (*Łaciak et al. 2019*). They were applied both to archaeological ‘graphite-coated’ pottery and to experimental pottery covered by graphite and those without minerals (smouldering applied during firing). Some reference samples manufactured during experiments (*Łaciak et al. 2019*, Fig. 3) were included in this article.

Materials and methods

Pottery of the Late Bronze and Early Iron Ages represents the most common archaeological material, with ‘graphite-coated’ surface treatment being very popular in these periods of time. The author of the article has macroscopically investigated pottery material and elaborated the archaeological sources of some locations (for results see: *Łaciak 2005*; *2008*; *2010*; *2012*; *2017*; *Józefowska – Łaciak 2012*; *Łaciak – Markiewicz 2013*; *Łaciak – Orlicka-Jasnoch 2013*; *Łaciak – Nowak 2016*). The pottery, especially that found in graves, is well preserved, which enabled the reconstruction of vessels and ornament; for this same reason, the surfaces (including ‘graphite-coated’), were mostly preserved in a practically unchanged condition.



Fig. 1. Examples of 'graphite-coated' pottery: a – the whole surface (inner and outer) of the vessel (Łazy, site 1, Wołów district, grave 8/97, vessel 22); b – only one (inner) surface of the vessel; c – outer surface of the vessel is blackened (no visible metallic lustre) (Rogowo, site 1, Gostyń district, grave 9, vessel 6) (photo by D. Łaciak).

'Graphite-coated' surfaces display a silvery, lustrous colour, which may uniformly coat the whole vessel (*Fig. 1a*) or one side of the object (*Fig. 1b*), whereas the outer surface was black with no metallic lustre (*Fig. 1c*). Unevenly coated surfaces where stains occur (*Fig. 2a*) have also been identified as 'graphite-coated'. Among pottery sources, a consistent pattern may be seen on bowls with inverted rims, i.e. on the outside they display a 'graphite-coated' strip whose lack of lustre contrasts with the rest of the vessel's surface (*Fig. 2b*).

The author of the article conducted a series of experiments involving the forming of vessels, the treatment of their surfaces and firing. The whole procedure of conducting experiments is based on the guidelines existing in the archaeological literature and rooted in the knowledge of archaeological sources. The vessels were formed from clay containing iron oxide (yellow and red colours) with an admixture of mineral grains of varying sizes. However, the granulation never exceeded 2 mm because the grains of a larger size prevent or considerably hinder the evening out and smoothing of the surfaces of the objects (*Kozyra – Wyrwicki 1970, 8–21*). The ceramic paste that was used enabled the evening out of the vessels' walls and their smoothing, burnishing and polishing with various tools at various stages of the process. In all cases, the same set of tools was used.



Fig. 2. Examples of 'graphite-coated' pottery: a – unevenly coated surface with stains of a natural layer of the vessel (Domasław, site 10/11/12, Wrocław district, grave 5970, vessel 4); b – the strip visible near the inverted rim (follow the arrows) of the bowl (Domasław, site 10/11/12, Wrocław district, grave 3797, vessel 30) (photo D. Łaciak).

After the vessels were formed in the coiled technique, their outer walls were evened out by hand and then were beaten by a wooden paddle (*Fig. 3a*), which gave them a uniform thickness and smooth surface. Then the external leather-hard surfaces were burnished with wooden spatulas (*Fig. 3b*). The burnishing was repeated after the vessels partially dried until distinct polished areas appeared. The next step was polishing with a stone pebble to achieve a lustrous surface (*Fig. 3c*). The inner walls of vessels weren't processed to create a polished surface, so they were treated only by hand to smooth the coils.

The vessels were fired in kilns reconstructed on the basis of archaeological finds from Poland or reconstructed on the basis of objects interpreted as pottery kilns dated to the Late Bronze Age and the Early Iron Age (Łaciak 2017, 59–51, fig. 6). Two types of 'single-chamber' kilns were used: a) a pit kiln constructed as a shallow depression in the ground in which the vessels and firewood were placed (type 1a after Cnotliwy 1960, 54), and b) a pit kiln with the hearth dug into the ground and a dome built over it (type 1b after Cnotliwy).

When fired in a simple pit kiln without a dome (type 1a), vessels were arranged into the hollow (*Fig. 4a*) and covered with dry firewood. During firing, wood was continuously added so that a pile tightly filling the hollow and vessels was formed above it (*Fig. 4b*).



Fig. 3. Surface treatment of vessels walls: a – evening with a wooden paddle; b – burnishing by wooden spatula; c – polishing with stone pebble (photo by M. Łaciak).

This made it possible to achieve the reducing atmosphere. The firing lasted five hours and the vessels were left overnight in the hearth, where the fire was slowly dying down. The next morning, the vessels were removed from the still smouldering ashes (*Fig. 4c*). No precise measurement of firing temperature was made, but in this type of kiln the temperature should be higher than in open bonfires (generally ranging between 600 °C and 850 °C, *Rice 2015, 175*).

Firing in a pit kiln with a dome (type 1b), vessels were placed in a pit dug in the ground, which was covered with a dome made from wattle construction pasted with clay (*Fig. 5a*). The firewood was placed in the pit above the pottery and inside the dome (*Fig. 5b*). The firing lasted six hours. After its main part was over, the hole in the dome's upper part and the junction between the dome and the pit were tightly sealed with clay and pottery shards (*Fig. 6a*). This cuts off the supply of air and creates the reducing atmosphere necessary to achieve the black colour of surfaces. The next morning, the vessels were retrieved through a hole in the dome (*Fig. 6b*). In this kiln, the temperature was monitored during the firing with a pyrometer in order not to exceed 600 °C, since this threshold had been determined for 'graphite-coated' and painted pottery by archaeometric examination (*Łaciak – Stoksik 2010, Table 9, 10; Łaciak 2017, Table 12*). The temperature was measured repeatedly in various parts of the kiln. The highest temperature (643 °C) was reached at the beginning of the firing and directly at the flames (*Fig. 7a*). At the end of the firing, when the wood was almost combusted (*Fig. 7b*), the temperature was the lowest (495 °C).



Fig. 4. Firing process in the pit kiln: a – vessels placed in the hollow; b – wood pile covering the vessels during firing; c – vessels after firing (photo D. Łaciak).

Results

The series of experiments proved that vessels with surfaces similar to or approximating the originals determined as 'graphite-coated' by macroscopic observations can be produced without mineral graphite.

Fig. 5. Firing process in the pit kiln with dome: a – arrangement of vessels in the pit covered by a wattle-clay construction of the dome; b – firewood placed inside the dome (photo D. Łaciak).



All twelve vessels fired in the pit kiln with a shallow depression have blotchy surfaces, i.e. two-coloured (dark and bright). Among them, only five were also covered by ‘graphite-coatings’ (Figs. 8a; 9). The firing in the hearth placed in the depression in the ground was not protected against unpredictable gusts of wind, which caused rapid increases in temperature and, consequently, changes in the firing atmosphere and broken walls on a few vessels.

The firing carried out in the pit kiln with the dome produced surfaces uniformly coated in black or shades of black with a metallic lustre (‘graphite-coating’), which proves that the atmosphere in the firing chamber was evenly distributed (Fig. 10a, b). Thanks to the dome, it is easier to control the temperature and atmosphere in a kiln, and consequently, to acquire a coating with a uniform coverage.



Fig. 6. Final stage of firing process in the pit kiln with a dome: a – sealing the dome with clay and potsherds; b – kiln at the end of firing (photo D. Łaciak).

Regardless of the type of kiln, the vessel surfaces display a silvery, dark-grey lustre in the areas where the treatment process ended with polishing with a stone pebble. The places where only fingers were used and thus the surface was not polished are matt and devoid of a lustre (*Fig. 8b*).

Discussion

The conducted experiments confirm the hypothesis put forward by W. Hołubowicz that graphite was not a factor determining the appearance of lustrous, silvery surfaces of pottery vessels. Surface polishing and a reducing atmosphere during firing were sufficient to produce the visual effect generally known as ‘graphite-coating’. To obtain a lustrous silver

Fig. 7. Measurement of temperature in pit kiln with dome: a – at the beginning of firing and directly in the flame; b – at the end of firing (photo D. Łaciak).



effect, the process of surface treatment appears to be crucial. Joining the coils properly and reaching the even surface is an initial step in the process. Only after forming even vessel walls with fingers and a wooden paddle can the next processing steps be made. To perform a proper polishing of the surface that ensures the ‘graphite-coating’ effect, multiple treatments are required in different stages of vessel drying. The surface should be smoothed by hand, burnished with a flat wooden tool and then polished with a stone pebble.

The second factor that produces the dark grey or black surface of pottery is firing in a reduction atmosphere, which relies on cutting off the supply of air. Achieving a completely reduced atmosphere during firing is very difficult and possible only in fully enclosed kilns (Longacre *et al.* 2000, 277; Rice 2015, 176, 180). Moreover, it is easy to control the heating and maximum temperature in enclosed kilns to achieve even firing with less or no cracking, breaking, warping, and also a uniform colour.



a

0 3 cm



b

Fig. 8. Dipper fired in a pit kiln – surface covered by stains including a ‘graphite-coated’ one: a – polished, lustrous, b – smoothed, matt (photo D. Łaciak).

In the smudging process, the ceramics are covered with organic material (e.g. sawdust, manure), which closes off the supply of oxygen to the ware so that carbon is deposited on the surface and in the pores, which causes the appearance of dark – blackened – pottery products. In this case, no unique kiln construction is needed, just firing in bonfire or pit kiln.

The vessels from experimental firings owe their black colour to the reducing atmosphere, which was achieved by sealing off the air supply by covering them with wood during firing. The burning wood deposited carbon on the pottery walls. The kiln’s dome provided protection from the wind, which causes rapid temperature jumps, and thus the non-uniform colour of the vessel’s surfaces. Therefore, vessels from the kiln with a dome obtained surfaces of a uniform dark grey or black colour, while those from the pit kiln have a surface with black-grey-cream stains. In both cases, smudging was used as a method to achieve reducing firing.

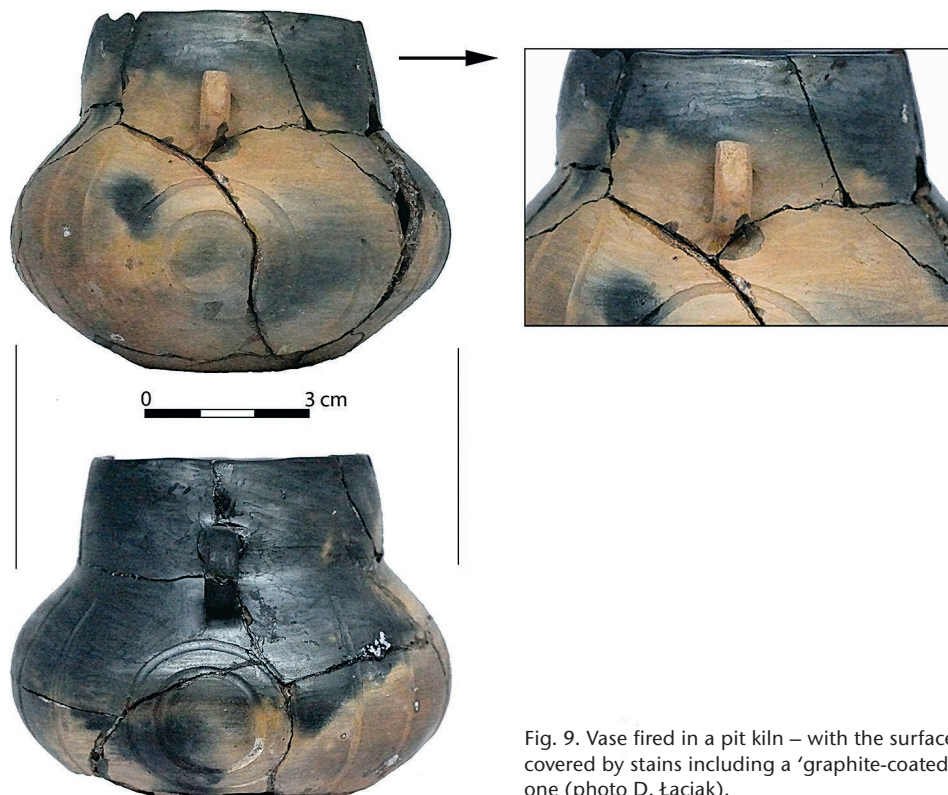


Fig. 9. Vase fired in a pit kiln – with the surface covered by stains including a ‘graphite-coated’ one (photo D. Łaciak).

It seems that production of ‘graphite-coated’ surfaces did not require any special or innovative techniques. The applied procedures were generally known and commonly used in Late Bronze Age and Early Iron Age pottery production. On the other hand, it is the application of mineral graphite that would require considerable effort. It involves knowledge of raw material outcrops, material extracting and processing. In regions with no natural deposits, graphite would need to be imported and traded. This makes the ‘graphite-coating’ achieved by surface treatment and firing a more affordable option for local pottery producers.

The common occurrence of grey or black pottery with a metallic lustre raises the question of the purpose of its production. At the end of the Bronze Age and in the Early Iron Age, nearly every burial in Central Europe was furnished with a vessel or vessels displaying uniformly ‘graphite-coated’ surfaces. It is thus possible that we are dealing with mass production specialised in pottery with uniformly dark silvery surfaces. One of the hypotheses assumes that lustrous pottery was meant to imitate precious and usually imported high-status metal vessels, which were used especially in funerary contexts (Kreiter *et al.* 2014, 130; Martino 2017, 3). Such pottery could be easily manufactured in regions with the presence of mineral graphite. Elsewhere, alternative solutions could be found to produce ceramic vessels that imitated metal ones. The process of manufacturing ‘graphite-coated’ pottery concerning surface treatment and firing seems to be available to a wider circle of



Fig. 10. Vessels fired in a pit kiln with a dome – uniformly ‘graphite-coated’ surfaces: a – vase; b – amphora (photo D. Łaciak).

potters. The increased interest in ‘graphite-coated’ ceramics was undoubtedly related to customer demand, but the reason for it remains an open question. Colour or burnishing as an improvement in appearance was highly coveted by people because such surface treatment would attract attention. For instance, the potters from San Juan Bautista (Philippines) testified that the smudging of their cooking pots is deliberate, because a shiny black product with a distinctive surface colour can be readily identified by consumers. Smudged pottery is perceived as more durable and resistant to failure (*Longacre et al. 2000, 274; Rice 2015, 177*).

Conclusion

The conducted experiments demonstrated that the visual effect of the dark grey or black lustrous surface could be obtained without the application of mineral graphite. To achieve such an effect, a combination of smoothing, burnishing and polishing is required in combination with firing in a reducing atmosphere.

Ceramics dated to the Late Bronze Age and Early Iron Age show many examples of spotted surfaces, where lustrous dark areas mingle with matt ones. According to the results of the presented experiments, they might be fired in a bonfire or in a kiln with control of firing conditions and atmosphere. On the other hand, ceramics with uneven, shiny, grey or black colour surfaces could have been fired in more advanced constructed kilns where stable conditions were easier to achieve.

The widespread occurrence of such ceramics, which could be produced without graphite and instead using commonly known methods and firing, meant that it also occurred in areas devoid of minerals. In this case, there was no need to import graphite or graphite-coated ceramics. They could be produced in any region to meet the demand for valuable items for Late Bronze Age and Early Iron Age societies. The situation changed later in the La Tène period, when graphite became an admixture in pottery clay, so the mineral or graphite-tempered pottery must have been imported into the areas without graphite outcrops. But such pottery represents a distinct type of pottery workshop stemming from a different society.

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