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# MICROSCOPIC ANALYSIS OF POTTERY FRAGMENTS FROM THE CORDED WARE CULTURE AT SITES 11, 15 AND 20 IN ŚWIĘTE, JAROSŁAW DISTRICT

## ABSTRACT

For microscopic examination, 22 pottery fragments from sites 11, 15 and 20 in Święte, Jarosław District were selected. The pottery types included beakers (N=19) and amphorae (N=3). The goal of the petrographic analysis was to identify mineralogical composition of ceramic fabric, sources of raw materials, and intentional additives to the clay. The analysis yielded data that helped determine ceramic fabrics types and preparation methods, as well as pottery firing conditions and approximate firing temperature.

In all samples analysed, ceramic fabrics were prepared in a similar way, using heavy clay poor in muscovite, with grog deliberately added. Crystalline material present in some of the samples is most likely a natural component of raw materials used in the production process. No sand is added to the clay. No other method for preparing pastes was identified for the amphorae type. Previous observations on amphorae firing are confirmed: amphorae are fired in oxidizing conditions. The ceramic fabrics of two vessels have a deliberate admixture of bones in addition to grog and argillaceous rock intraclasts. Vessels decorated with cord impressions and vessels with herringbone or

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other incised patterns are more often made from paste type A (inclusion and grog) and paste type B (grog), respectively.

**Key words:** Corded Ware culture, south-eastern Poland, petrographic analysis, ceramic fabric.

## INTRODUCTION

Twenty-two pottery fragments from grave features at sites 11, 15 and 20 at Święte, Radymno Commune, Jarosław District, were selected for microscopic examination [Olszewski, Włodarczak 2018; Janczewski *et al.* 2018; Dobrakowska, Włodarczak 2018]. The overhelming majority of the fragments were from beaker-like vessels, with just three fragments belonging to amphorae (Table 1; Fig. 1). The primary goal of the petrographic analysis was to identify mineralogical composition of ceramic fabrics, sources of raw materials, and intentional additives to the clay. The analysis yielded data that helped determine ceramic fabric types and preparation methods, as well as pottery firing conditions and approximate firing temperature.

## 1. METHODOLOGY

Thin sections of potsherds were prepared for the study under the polarizing microscope. The quantitative microscopic analysis involving point counting established the percentage content of components such as clay minerals, quartz, potassium feldspars, plagioclases, muscovite, biotite, carbonates, sedimentary, igneous and metamorphic rock fragments, reused potsherds (grog), as well as organic material. Thin sections were provided with petrographic descriptions. The descriptions included the percentage content of particular components, level of fabric kneading, as well as firing atmosphere and temperature. Collected data were then used for comparative analysis and allowed classification of the samples according to clay preparation and finished-product firing technologies. Approximate firing temperature was determined based on thermal transformation of clay minerals, as well as observations of biotite, hornblende and glauconite [Quinn 2013: 190-203]. Grain sizes were measured under the polarizing microscope, using a micrometer scale. Percentage volumetric content of particular fractions was estimated using

Table 1

List of examined samples

| Symbol of sample | Site | Feature no. | Vessel type | Inventory no. |
|---|---|---|---|---|
| 14 | site 20 | 40A | beaker, body fragment | M/2/Św20 |
| 15 | site 20 | 43 | amphora, body fragment | W/14/Św20 |
| 16 | site 20 | 43 | beaker, body fragment | M/20/Św20 |
| 17 | site 20 | 43 | beaker, body fragment | W/12/Św20 |
| 18 | site 15 | 405 | beaker, body fragment | M/87/Ś |
| 19 | site 15 | 405 | beaker, body fragment | M11/69/Ś |
| 20 | site 15 | 427 | beaker, neck fragment | M/82/5 |
| 21 | site 15 | 431 | beaker, body fragment | 11/83/Ś |
| 22 | site 11 | 751 | beaker, body fragment | W/37/Św11 |
| 23 | site 11 | 756A | beaker, body fragment | W/36B/Św11 |
| 24 | site 11 | 814 | beaker, body fragment | W/23B/Św11 |
| 25 | site 11 | 863 | beaker, body fragment | W/22B/Św11 |
| 26 | site 11 | 863 | small amphora, body fragment | W/22A/Św11 |
| 27 | site 11 | 876 | beaker, body fragment | W/33B/Św11 |
| 28 | site 11 | 1134 | beaker, body fragment | W/51D/Św11 |
| 29 | site 11 | 1149 | beaker, body fragment | W/45E/Św11 |
| 30 | site 11 | 1284 | beaker, neck fragment | W/66/Św11 |
| 31 | site 11 | 1290D | beaker, body fragment | W/46H/Św11 |
| 32 | site 11 | 1290D | amphora, body fragment | W/469/Św11 |
| 33 | site 11 | 1434 | beaker, body fragment | W/640/Św11 |
| 34 | site 11 | 1434 | small wide-mouthed beaker, body fragment | W/64A/Św11 |
| 35 | site 11 | 1434 | beaker, body fragment | W/64/Św11 |

quantitative microscopic analysis involving point counting. This study adopts the classification into grain fractions developed by the Soil Science Society of Poland [Polskie Towarzystwo Gleboznawcze 2009].

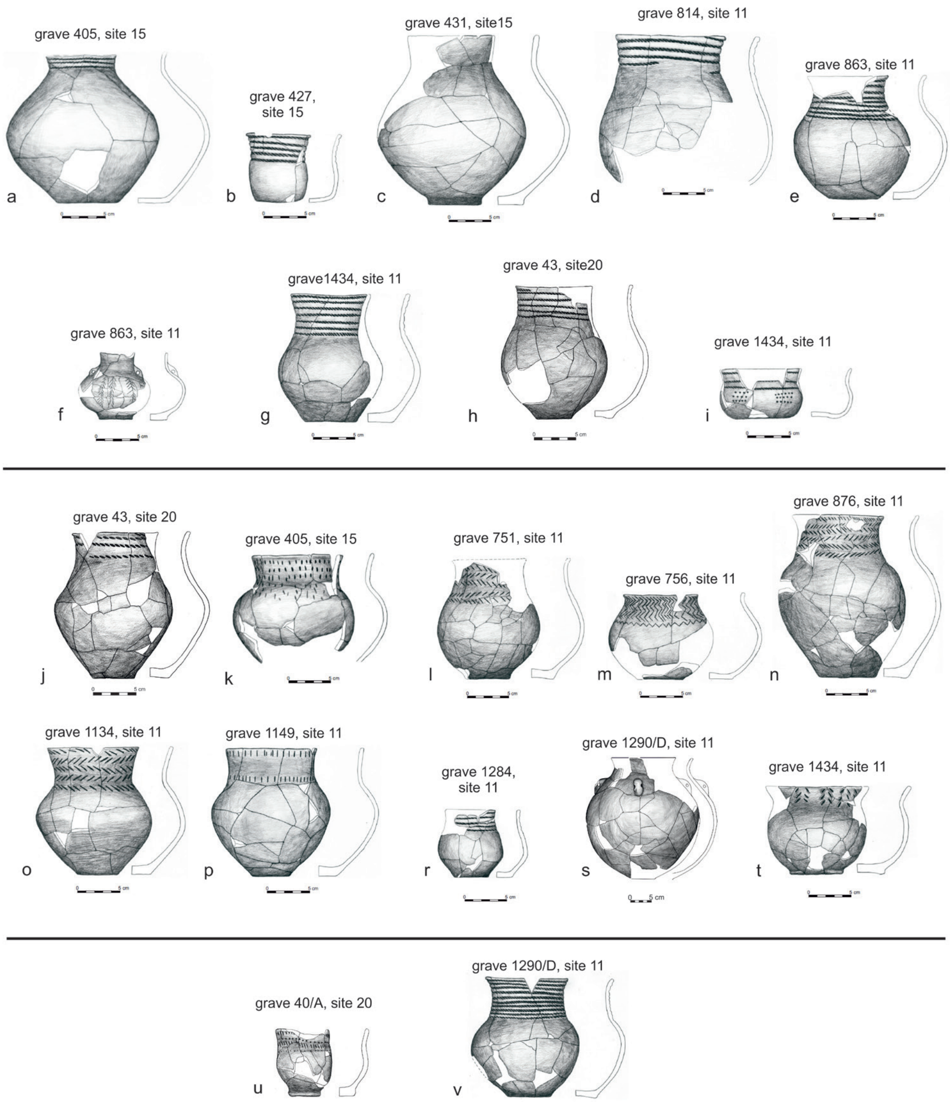



Fig. 1. Drawings of vessels; ceramic fabric type A: a – sample no. 18; b – sample no. 20; c – sample no. 21; d – sample no 24; e – sample no. 25; f – sample no. 26; g – sample no. 33; h – sample no. 16; i – sample no. 34; ceramic fabric type B: j – sample no. 17; k – sample no 19; l – sample no. 22, m – sample no. 23; n – sample no. 27; o – sample no. 28; p – sample no. 29; r – sample no. 30; s – sample no. 32, t – sample no. 35; ceramic paste fabric C: u – sample no. 14; ceramic paste fabric D: v – sample no. 31. Drawn by: M. Podsiadło

Table 2

Mineral composition (% v/v), firing atmosphere, and approximate firing temperatures ($^{o}$C), redox- reducing atmosphere with a small inflow of air; red – reducing atmosphere; ox – oxidizing atmosphere

| Symbol of sample | Site | Type | Clay minerals | Silt fraction | Quartz | Flint | K-feldspars | Plagioclases | Fragments of sedimentary rocks | Fragments of igneous rocks | Fragments of metamorphic rocks | Muscovite | Biotite | Opaque minerals | Iron oxides and hydroxides | Grog | Clay clasts | Organic fragments | Fragments of bones | Heavy minerals | Other | Voids | Firing atmosphere | Approximate firing temperature |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | site 20 | beaker, body fragment | 53.4 | 20 | 9.1 | | 2.8 | | | | | 3.5 | 0.4 | 0.8 | 1.6 | 0 | 4.7 | | | 0.1 | 0.8 | 2.8 | redox | 750 |
| 15 | site 20 | amphora, body fragment | 53.1 | 6.2 | 20.2 | | 2.3 | 0.1 | | | | 2 | 0.7 | 1.6 | 2.6 | 4.9 | | | | 0.1 | 0.1 | 6.1 | ox | 750-800 |
| 16 | site 20 | beaker, body fragment | 55.6 | 4.7 | 5.9 | | 1.9 | | 3.1 | | | | | 2.5 | 1.5 | 15.8 | 0.6 | | 2.8 | | 0.6 | 5 | redox | 700-750 |
| 17 | site 20 | beaker, body fragment | 63.8 | 14.6 | 4.7 | 0.2 | 0.5 | | 0.8 | | | 1.6 | | 0.3 | 1 | 7.3 | 1 | | | | 0.3 | 3.9 | redox | 700-750 |
| 18 | site 15 | beaker, body fragment | 56.1 | 8.3 | 8.9 | | 3.9 | | 2.4 | | | 1.2 | | | | 13.6 | 0.6 | | | | 0.3 | 4.7 | redox | 750 |
| 19 | site 15 | beaker, body fragment | 66.1 | 2 | 0.9 | | 0 | | 1.4 | | | | | 1.4 | 2.3 | 13.4 | 6.5 | | | | | 6 | ox | 750-800 |
| 20 | site 15 | beaker, neck fragment | 65.1 | 7.6 | 12 | 0.1 | 1.6 | | 3.7 | 0.4 | 0.1 | 0.4 | | 0.8 | 0.4 | 2.4 | 1.2 | | | 0.2 | | 4 | redox | 750 |
| 21 | site 15 | beaker, body fragment | 53.7 | 12.3 | 9.7 | 1.7 | 1.7 | | 0.3 | 0.3 | 0.1 | 1.4 | 0.3 | 2 | 0.3 | 10.6 | | | | 0.1 | 0.6 | 4.9 | ox | 750-800 |
| 22 | site 11 | beaker, body fragment | 71 | 3.1 | 5 | | 1.4 | | | | | | | 0.4 | 1.4 | 9.2 | 3.2 | | | | | 5.3 | redox | 700-750 |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | site 11 | beaker, body fragment | 78.4 | 1.2 | 2 | | 0.4 | | | | | | | 0.8 | 0.4 | 12.7 | 0.4 | | | | | 3.7 | redox | 750 |
| 24 | site 11 | beaker, body fragment | 49 | 4.5 | 18 | 0.6 | 3.7 | | 9.9 | 2.5 | 1.7 | 0.6 | 1.1 | 0.6 | 0.3 | 0 | 0 | | | 0.2 | | 7.3 | redox | 750-800 |
| 25 | site 11 | beaker, body fragment | 35 | 14.2 | 11.3 | 0.1 | 2.2 | | 1.3 | | 1.6 | 0.9 | | 0.3 | 0.6 | 20.1 | 0.6 | | | 0.5 | 0.6 | 10.7 | red | 750-800 |
| 26 | site 11 | small amphora, body fragment | 61 | 14.5 | 8.9 | 0.3 | 0.6 | | | 0.6 | | 0.3 | | 0.9 | 0.6 | 6.5 | 2.4 | | | 0.1 | | 3.3 | ox | 800-850 |
| 27 | site 11 | beaker, body fragment | 70 | 4.3 | 2.1 | | 0.7 | 0.2 | | | | | | | 0.4 | 15 | 0 | | | | | 7.3 | redox | 700-750 |
| 28 | site 11 | beaker, body fragment | 58.8 | 4.5 | 2.5 | | 0.6 | | 3.4 | | | 0.3 | | | 1.4 | 19.2 | 1.7 | | | | | 7.6 | redox | 700-750 |
| 29 | site 11 | beaker, body fragment | 74.4 | 2.7 | 5.7 | | 1.5 | 0.1 | | | | | | 0.3 | 1.5 | 8.7 | 1.5 | | | | | 3.6 | redox | 700-750 |
| 30 | site 11 | beaker, neck fragment | 75 | 0.9 | 1.9 | | 0.5 | | | | | | | | 9.9 | 9 | | | | | | 2.8 | redox | 700-750 |
| 31 | site 11 | beaker, body fragment | 65.7 | 2 | 14.4 | 0.1 | 1 | | | | 0.5 | | | | | 12.8 | 1 | | | | | 2.5 | redox | 800-850 |
| 32 | site 11 | amphora, body fragment | 71.8 | 0.3 | 7.6 | | 1.3 | | | | | | | 0.6 | 1.3 | 6.7 | 2.5 | 0.6 | | | | 7.3 | ox | 800-850 |
| 33 | site 11 | beaker, body fragment | 58.1 | 1.4 | 6.1 | | 1.7 | | 1.7 | | | | | 1.7 | 0.6 | 20.3 | 1.7 | | | | | 6.7 | redox | 800 |
| 34 | site 11 | small wide-mouthed beaker, body fragment | 73.3 | 7.3 | 4.2 | | 1 | | | | | 0.3 | | | 0.3 | 4.9 | 0 | | 2.8 | | 0.3 | 5.6 | redox | 800 |
| 35 | site 11 | beaker, body fragment | 63.7 | 6.2 | 4.2 | | 0.3 | | 0.7 | | | 0.3 | | | 1.6 | 11.5 | 2 | | | | | 9.5 | redox | 700-750 |

## 2. RESULTS

*Mineral composition*

The examined samples consist of an matrix composed of: clay minerals (35-78.4%), small quantities of silt-fraction grains (0.3-20%), mica flakes (0.3-3.9%), iron oxides and iron hydroxides, opaque minerals and heavy minerals (zircon, rutile, hornblende). Some samples show the presence of grains of glauconite, flint and chalcedony, and relics of microfauna (forams and diatoms). Coarser (>0.1 mm) inclusion includes grains of quartz (0.9-20.2%), potassium feldspar (0-3.9%), and less frequent plagioclases. Lithoclasts primarily include fragments of sedimentary rocks (clay, mud, less frequently sandstones). They can be found in most of the examined samples. Small fragments of igneous and metamorphic rocks are sporadically present. Numerous bits of grog (0-20.3%) are identified in nearly all of the examined fragments except sample 14, i.e. beaker fragment from grave 40A at site 20 (Table 2).

*Raw materials*

Raw materials for vessel production include chiefly low silt-fraction clays and insubstantial amounts of fine mica flakes, except for two vessels from site 20 (samples 14 and 17) whose fabrics are high in silt fraction. Several petrographic types of raw material can be distinguished based on the content of mineral and petrographic components. Type I contains glauconite grains and relics of microfauna. The relics are sometimes highly transformed. Type I is higher in inclusion such quartz, feldspars, flints, chalcedony, and in fine fragments of crystalline rocks. The following samples belong to type I: 15, 18, 20, 21, 24, 25, 28, 33 (Fig. 2: a). Type II is composed of heavy clay with small quantities of silt fraction grains with quartz and feldspar grains as major crystalline components. Numerous iron compounds (concentrations, orange streaks of discoloration) can also be seen (samples: 19, 22, 23, 27, 29, 30, 32, 35; Fig 2: b, c). Type III describes fine silty clay free of any coarse fraction (samples: 14, 17; Fig. 2: d). Type IV refers to heavy clay with a well-sorted (ca. 0.05-0.25 mm) admixture of subangular grains of quartz and feldspar, sporadically present flints, and rock fragments (sample 31; Fig. 2: e). Type V describes silty clay containing few shards of volcanic glass and the admixture of rounded crystalline inclusions, mainly including quartz and feldspar (sample 26; Fig. 2: f). Type VI refers to heavy clay containing crystalline grains (quartz, feldspars). This type is glauconite, flint and chalcedony free (samples 16 and 34).

*Admixtures*

The common deliberate additive identified in ceramic pastes is chammotte (grog). Vessels are fired at moderately high temperatures and bits of grog are sometimes hardly distinguishable from argillaceous intraclasts (Fig. 2: c) as the latter are also commonly present in ceramic pastes. Dimensions of grog fragments

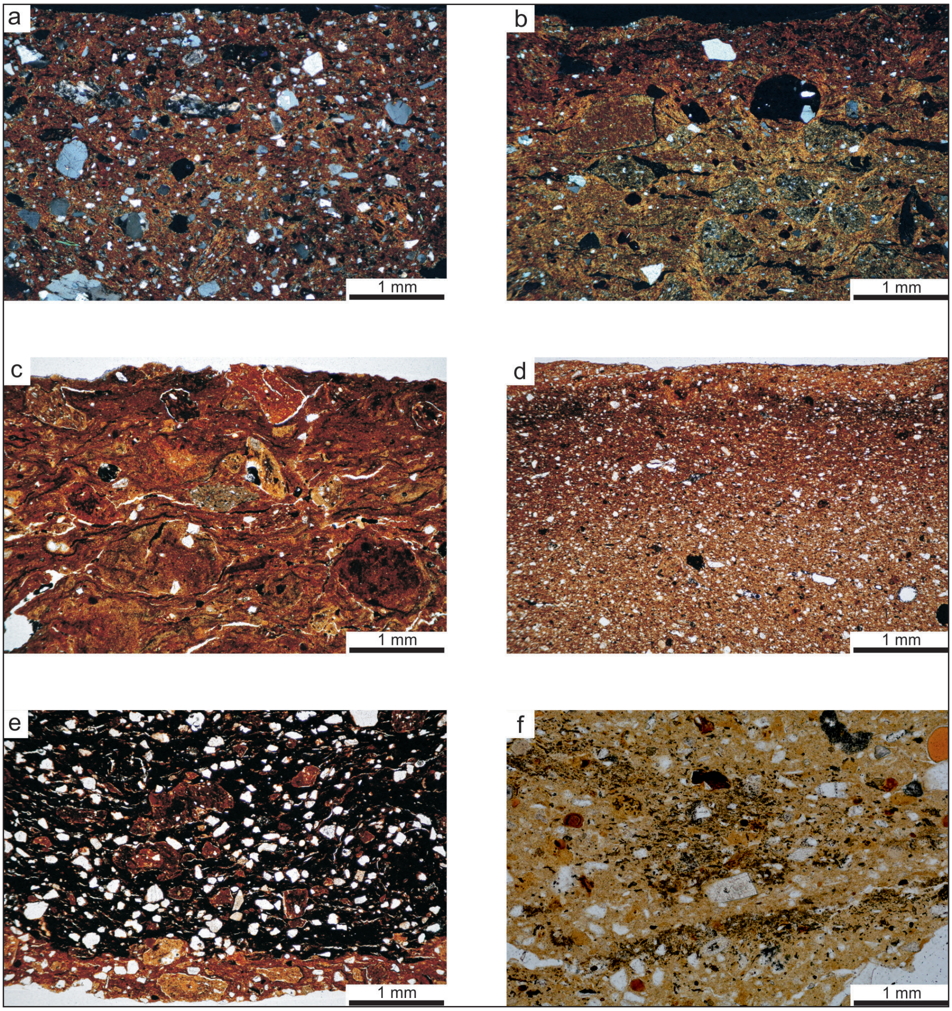
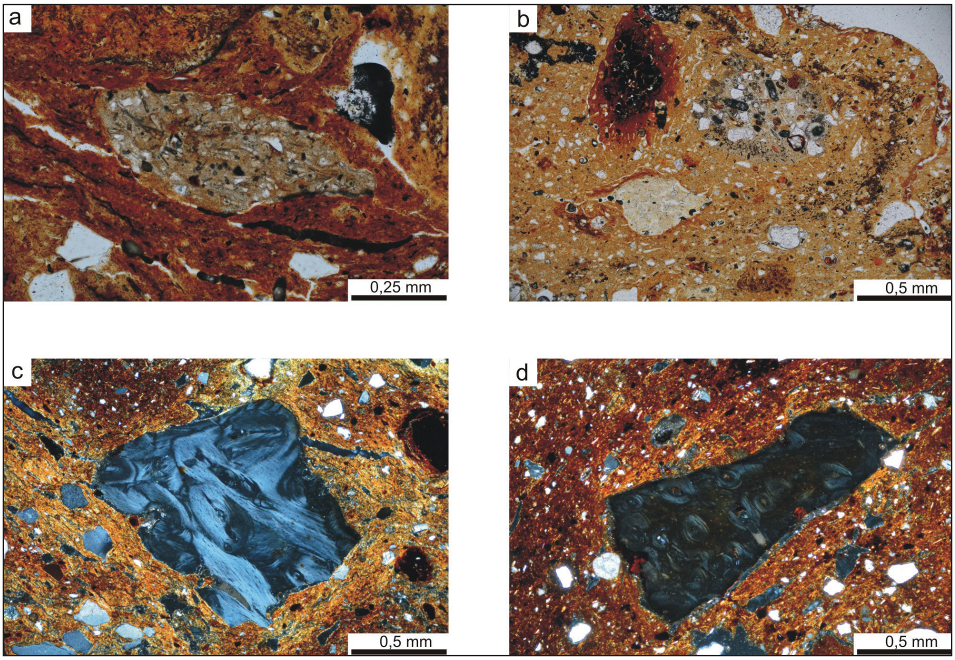



Fig. 2. Microscope photos of thin sections of pottery – raw material types; a – sample no. 15, numerous crystalline grains, elongated fragments of chalcedony visible at the top, XPL; b – sample no. 35, heavy clay with numerous fragments of grog, XPL; c – sample no. 19, clay with very small quantities of crystalline material, larger clay intraclasts, and grog, PPL; d – sample no. 14, fine-grained, homogenous (loess-like) raw material, PPL; e – sample no. 31, "pure" argillaceous matrix free of silt fractions or micas; in this one, sorted and moderately rounded crystalline grains of very fine sand can be seen, PPL; f – sample no. 26, silty clay with few bits of volcanic glass (light object at the bottom center), PPL

vary from vessel to vessel. Fabrics classified to type A have fine grog fragments (ca. 0.1-0.5 mm), while grog fragments in fabrics of type B are coarser.

Present in pastes, clay intraclasts differ sometimes in composition from a clay matrix of a vessel. For example, samples nos. 19 and 26 (Fig. 3: a, b) show frag-




F i g. 3. Microscope photos of thin sections of pottery – admixtures; a – sample no. 19, clay clast containing microfauna relics (at the center), PPL; b – sample no. 26, clay clast containing microfauna relics (top right), PPL; c – sample no 16, bone fragment with visible microstructure – oval osteon, XPL; d – sample no 34, bone fragment with visible microstructure – circular osteons, XPL

ments of isotropic clay clasts with microfossils. They may be an indication that there are clay deposits with microfaunal remains commonly occurring in the vicinity of the sites at Święte.

There are two samples (nos. 16 and 34) in which bone fragments are present. Larger bits (ca. 0.5-1 mm) exhibit characteristic structural components of the bone tissue, such as Haversian canals and osteons. One larger bone fragment present in sample no. 16 shows oval osteons (larger diameter ca. 0.38 mm – Fig. 3: c), while the bone fragment from sample no. 34 shows smaller, circular and more densely packed osteons (Fig. 3: d). This may indicate that, for example, the bone fragments are different species.

*Types of ceramic fabric*

The methods for preparing ceramic fabrics are connected with the selection of raw materials and intentional additives. For the analysed samples, two primary fabrics may be distinguished based on the mineral and quantitative composition as well as on the fabric structure. The first type (A) is characterised by the predominance of crystalline grains over the grog admixture. Fabrics of type A are dark brown and poorly sorted (ca. 0.05-0.3 mm), with poorly to moderately rounded

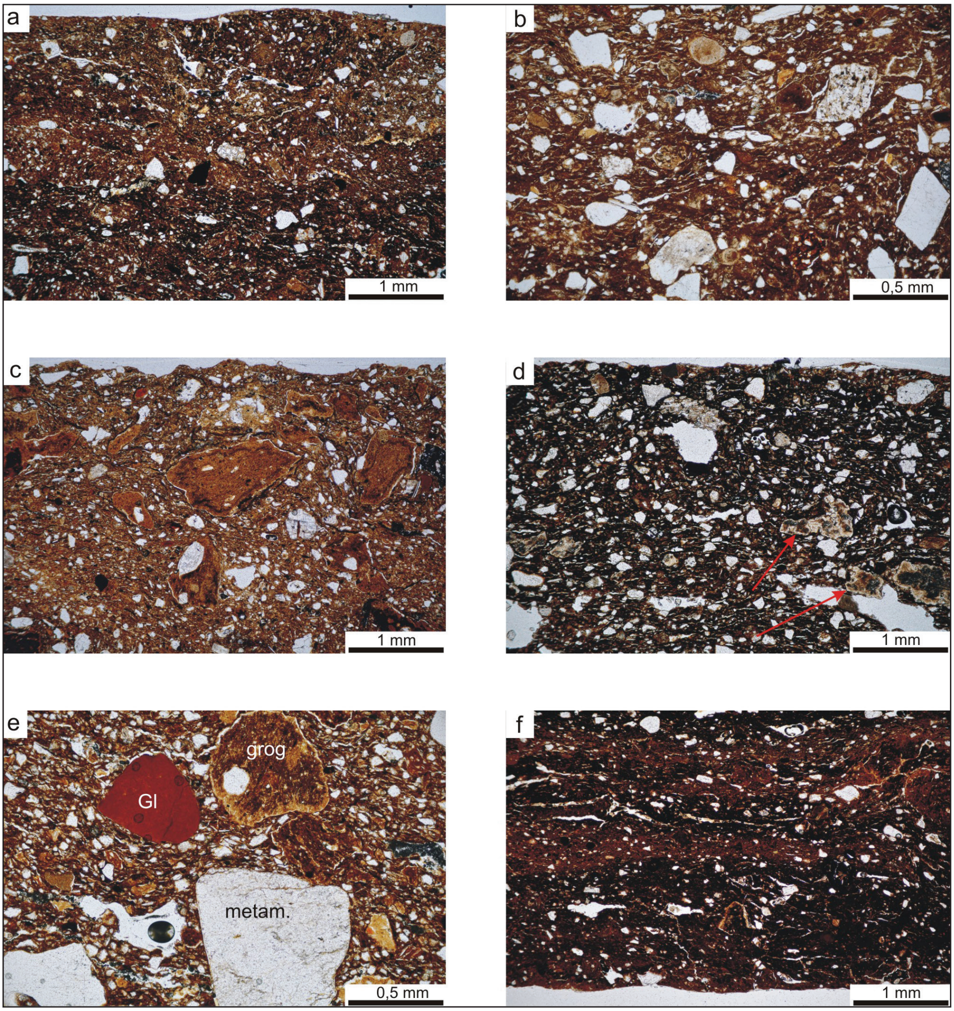



Fig. 4. Microscope photos of thin sections of pottery – ceramic fabric type A (inclusion + grog); a – sample no 18, dark brown clay matrix, abundant clastic material, well-crushed grog, PPL; b – sample no 20, dark brown clay matrix, abundant clastic material, well-crushed grog, PPL; c – sample no 21, brown clay matrix, abundant clastic material and grog, PPL; d – sample 24, dark brown clay matrix, abundant crystalline material, chalcedony fragments at the center (indicated by arrows), PPL; e – sample 25, red (thermally altered) glauconite grain, bit of grog, metamorphic rock fragment, PPL; f – sample no 33, dark brown clay matrix, visible streaks of discoloration, abundant, well-sorted clastic material, PPL. Gl – glauconite, metam. – fragment of metamorphic rock

crystalline grains and well-crushed grog (ca. 0.1-0.5 mm). Type A is identified in samples nos. 15 (amphora), 16, 18, 20, 21, 24, 25, 26 (small amphora), 33 and 34 (Fig. 4: a-f). The second type (B) is characterised by a light orange colour of

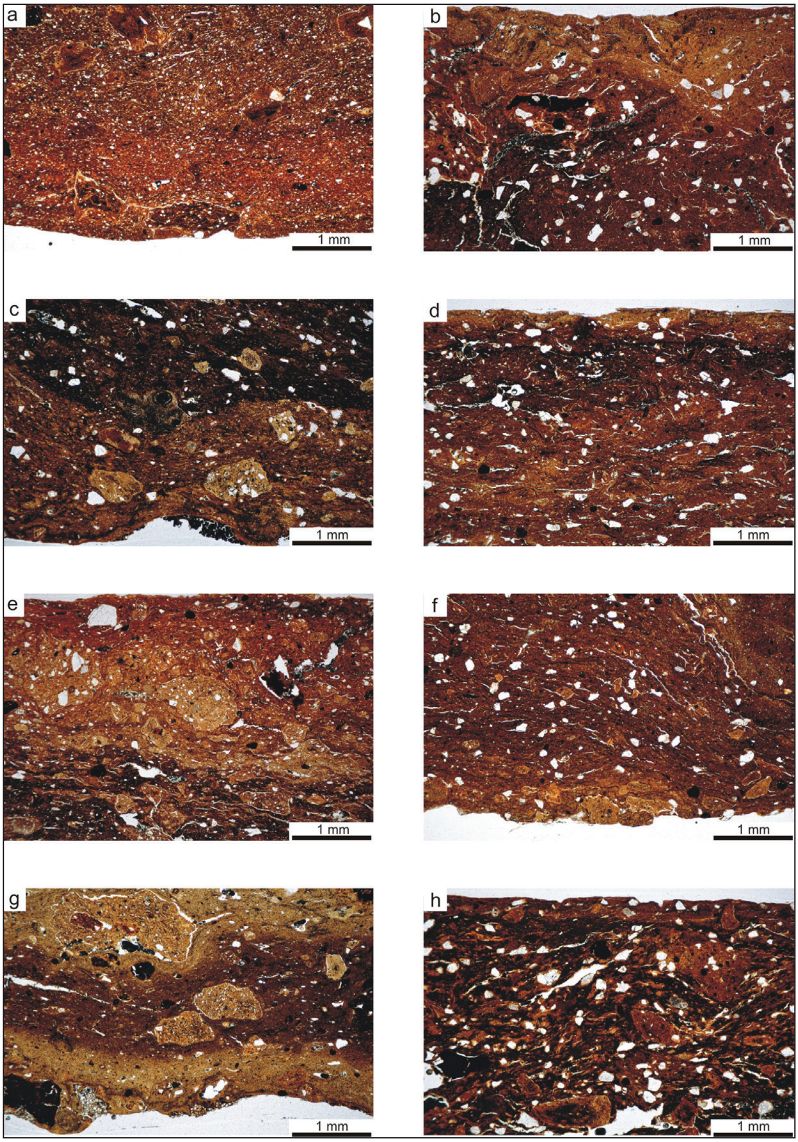



Fig. 5. Microscope photos of thin sections of pottery – ceramic fabric type B (grog); a – sample no. 17, orange clay matrix, no larger crystalline grains, bits of grog, and argillaceous intraclasts, PPL; b – sample no. 22, orange clay matrix, few quartz and feldspar grains, abundant argillaceous intraclasts, PPL; c – sample no. 23, orange to dark brown clay matrix, scarce clastic material and numerous bits of grog, PPL; d – sample no. 27, orange clay matrix, scarce clastic material, dark brown discolorations close to the outer surface, PPL; e – sample no. 28, orange clay matrix, numerous bits of light brown grog fragments, PPL; f – sample no. 29, orange clay matrix, few sorted crystalline grains, bits of light brown grog, PPL; g – sample no. 30, non-uniformly coloured argillaceous paste, light orange or dark orange streaks of discoloration, larger bits of grog, PPL; h – sample no. 32, orange and dark brown clay matrix, stained, crystalline grains, and larger bits of grog, PPL

clay matrix and predominance of the grog admixture, with crystallites present in small quantities or not at all. Fabrics of type B are heterogeneous, have a non-uniform colour and are poorly kneaded. Samples nos. 17, 19, 22, 23, 27, 28, 29, 30, 32 and 35 are included in this type (Fig. 5: a-h). There are only two vessels that cannot be classified into any of the two types above. Compared to ceramic fabrics of other examined vessels, the paste of vessel no. 14 is exceptional (type C) as it is fine-grained, sorted, homogenous, free of any larger crystallites or any admixture of grog or clay intraclasts (Fig. 2: d). By contrast, vessel no. 31 is made of clay containing well-sorted sand (ca. 0.1-0.25 mm) with intentional admixture of grog (type D). Longitudinal narrow parallel planar voids can be seen (Fig. 2: e).

*Firing*

Most of the examined vessels (samples nos.: 14, 16, 17, 18, 20, 22, 23, 24, 27, 28, 29, 30, 31, 33, 34 and 35) were fired in atmosphere with limited air access (Table 2), with firing temperatures usually ranging between 700 and 750°C, except for three vessels (samples nos. 31, 33, 34) that were fired at higher temperatures of ca. 800-850°C. Five vessels (samples nos.: 15, 19, 21, 26, 32), including all of the amphorae, were fired in oxidizing conditions and exposed to higher temperatures of ca. 750-850°C. And one vessel (no. 25) was fired under reducing conditions at ca. 750-800°C.

## 3. INTERPRETATION OF RESULTS

The mineral composition is indicative of the use of heavy clay rather than silty clay (samples nos. 14 and 17, 26), from several locations. Commonly present in the analysed samples, the clay with the admixture of poorly to moderately sorted inclusion having poorly or moderately rounded grains may be the evidence of short-distance transportation. This material includes chalcedony and flints, while the clay matrix contains glauconite and microfauna. These genetic components suggest that sediments predating the Holocene were washed out in places such as river valleys, and then accumulated in alluvial sediments. Such components have been already identified in materials from the sites at Jankowice, Mirocin and Szczytna [Rauba-Bukowska 2015: 186-188; Trąbska *et al.* 2017: 161-190; Rauba-Bukowska 2019]. The sites are located up to 25 km north-west of Święte cemeteries. Close location of the sites corresponds with the similarity of raw materials used for pottery vessel production. Clays, whether free of, or containing small quantities of crystalline grains, constitute yet another raw material used, which is, however, somewhat different. These clays do not contain components such as glauconite, microfauna relics, flints or chalcedony. At the current research stage, the sources of this raw material type are yet hard to be determined. This clays are most likely sediments accumulated in wide river valleys. Two vessels are made from fine-grained silty loess-like clays that are locally available.

The method for preparing ceramic pastes was similar for all of the examined samples and was based on the use of low silt-fraction clays poor in muscovite, with a deliberate admixture of grog. Similar way of clay preparing was noted in the case of samples from CWC graves at sites 24 and 27 in Mirocin (Rauba-Bukowska 2019.

The inclusions present in some of the examined samples are likely to be a natural component of the raw materials used. However, for this hypothesis to be verified, one should collect reference samples in the vicinity of the site, examine the samples and compare the results so obtained with what has been determined for the pottery fragments. While grain sizes in the ceramic fabrics do not exceed 0.5 mm, most of the grains are ca. 0.1 – 0.3 mm. It may suggest things such as the removal of the coarsest fraction from the raw material for proper granularity. No sand was added to the clays. No other ceramic paste preparation technique is identified for the amphorae (N=3). Two amphorae (nos. 15 and 25) are made from the fabric type A (with crystalline grains and grog content). The amphora no. 32 is made from the fabric with grog temper. Previous observations that oxygen was allowed free access in amphorae firing are confirmed (Rauba-Bukowska 2019). The ceramic pastes of two vessels (beaker from feature 43 at site 20; beaker from feature 1434 at site 11) have a deliberate admixture of bones in addition to grog and clay intraclasts.

Similar raw materials, which are low in silt-fraction grains, have been identified in ceramic pastes of the Corded Ware culture from the site of Modlnica, Małopolska Province (Cracow-Sandomierz group of the Corded Ware culture) [Rauba-Bukowska 2011: 573-578, 592-594, 626-629]. However the most common ceramic fabrics found in the material from Modlnica (N=7) are with the predominance of mineral admixture over grog. They have been identified in all of the beakers and in one amphora. The pastes of the other two amphorae contain smaller quantities of the crystalline material and are less kneaded. Two beakers from Modlnica have been made of fabric without grog (samples nos. Msz1 and Msz7) and similar fabrics are also noted on the site at Święte (samples nos. 14 and 24). Only one amphorae from Modlnica were fired in oxidizing atmosphere while at the sites Święte and Mirocin (Rauba-Bukowska 2019) all amphorae were fired in oxidizing conditions.

In most cases, the diversified nature of the fabrics recorded at Święte reflects the use of different raw materials. However, vessels decorated with cord impressions are found to be more often made of fabric type A (inclusion+ grog), while vessels decorated with herringbone or other incised patters are usually made of fabric type B (grog).

*Translated by Piotr T. Żebrowski*

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