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FROM POTS TO POTTERS: RECONSTRUCTING GROUP AND INDIVIDUAL VARIABILITY IN POTTERY PRODUCTION. A CASE STUDY OF THE LBK SITE CZĄSTKÓW POLSKI XII, CZOSNÓW COMMUNE

ABSTRACT

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This article presents the results of the analysis of the manufacturing macrotraces on the LBK pottery from Cząstków Polski, Site XII, Czosnów commune. It is a small, highly fragmented, and eroded assemblage and the usefulness of such material for the study of pottery production was tested. Different lines of evidence could be combined and led to the recognition of various vessel forming methods and to the reconstruction of distinct *chaînes opératoires* and even individual traits within them, indicating the occupation of the site by one community of practice with multiple manufacturers. Pottery production at Cząstków Polski followed general LBK potting standards but also shows some peculiarities indicating some degree of idiosyncrasy within this community of practice.

Keywords: pottery production, pottery technology, vessel forming techniques, chaîne opératoire, LBK
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INTRODUCTION

Techniques of production, especially of pottery production, have been regarded in common archaeological practice as representing highly pragmatic, rational, and somehow passive decisions determined by the availability and properties of raw material. This approach is visible in the processual archaeology, which stressed the dichotomy of style and function, as well as in post-processual archaeologies which were mainly interested in reading the symbolic meaning of the material culture (see Gosselain 2002, 10, further references therein). Archaeology of the new millennium is influenced by the materiality turn stressing the affordance of things, their networks or entanglements with humans (*e.g.*, Harris and Cipolla 2017), but even these directions focus much more on finished items and their agency than on their production. However, this topic has been addressed by the early French archaeology, always strongly connected with the French school of anthropology of techniques. This school refers to M. Mauss's seminal achievements (Mauss 1935; 1947), where he noticed that even the most "natural" techniques depended on culture and could be expressions of identities (Lemonnier 1986). This led to the development of studies on operational sequences – *chaînes opératoires* (see Burdukiewicz 2012, further references therein). This concept, describing the series of operations involved in the transformation of matter from the raw material to the finished product (Creswell 1976), is broadly applied in research on flaked stone artefacts (Tixier 1967) but also, increasingly, in pottery studies (Roux 1994). This growing interest in pottery technology correlates with the third scientific revolution in archaeology of recent decades, which brought the development and spread of many new analytical methods, especially connected with the determination of raw materials. The term *chaîne opératoire* can be found in many pottery publications not only of the French school, although sometimes it is limited to the determination of fabric groups. However, apart from the collection and processing of raw materials, the following stages of pottery production, *i.e.*, fashioning, finishing, surface treatments, decoration, firing and post-firing treatments, are also determinant to grasp ancient pottery production structures and can be reconstructed by archaeologists though an array of analytical methods (Roux 2019). During each of these stages, a wide range of techniques have been recognised by ethnographic research (*e.g.*, Livingstone Smith 2001; Gosselain 2002; Gelbert 2003) and experimental research work, enabling the interpretation of the traces identified on the archaeological material in terms of technical gestures (*e.g.*, Martineau 2000; Roux 2019). Reconstructing the stages of pottery fashioning or forming is crucial for developing social interpretations in archaeological context (Roux 2020), as those stages involve techniques and methods acquired through long-term apprenticeship requiring close contact between a tutor and an apprentice. Non discursive knowledge in the form of embodied skills and routines connected to pottery fashioning is conservative and less prone to superficial trends and changes than, for example, the raw material choices (Gelbert 2003) or the decoration of pots (Dietler and Herbich 1994). It is precisely the process of

apprenticeship that ensures the continuity of technical traditions: forming techniques and methods are transmitted from one generation to another within a given community of practice (see Wenger 1999), whose social structure can correspond to, for example, an ethno-linguistic group, a caste, a gender *etc.* (Roux 2011), although the rules of these correlations are complex (Gosselain 2002). The determination of production techniques thus enables archaeo-logists to identify and distinguish groups of producers in archaeological context, to follow their spatial trajectories over time and can thus be regarded as a crucial step of the *chaîne opératoire*; sometimes, indeed, the analysis focuses mainly on this stage, as in the case of this paper.

Research on the production techniques of the pottery of the Linear Pottery culture (LBK) has so far been conducted only for a dozen sites (less than a tenth of a percentage of all LBK sites; Cámara Manzaneda *et al.* 2021, fig. 1). The literature on the LBK from Poland contains only general remarks that the vessels were produced by the coiling technique (Kulczycka-Leciejewiczowa 1979, 83; Czekaj-Zastawny 2017, 44); different types of coil joints were observed on some fresh breaks from Strzelce, Site 2 (Wiślański 1959) and a similar but singular case of a good, visible example of a coil junction was noted for the material from Strzelin, Site 16 (Wojciechowski and Cholewa 1995, 77), though both descriptions were solely qualitative, not quantitative, and no systematic analysis was ever conducted. Research on the production techniques does not belong to a standard procedure applied for this culture in any of the regions of its vast territory. Most of this research was conducted in francophone countries: France and Belgium. After the first general papers indicating the necessity of such an analysis (Constantin 1994) and preliminary small case studies (Bosquet *et al.* 2005), more complex methods of quantitative analysis of macrotraces were established (inspired by Livingstone Smith 2001, see: Gomart 2006; 2011; 2014; Gomart *et al.* 2017; Van Doosselaere *et al.* 2013; 2016), combined with radiography (Van Doosselaere *et al.* 2016) and computer microtomography (*e.g.*, Neumannová *et al.* 2017). Similar studies were also conducted for a few sites from Hungary (Gomart *et al.* 2020; Kreiter *et al.* 2017, ongoing project: Marton *et al.* 2020), and the Czech Republic (Neumannová *et al.* 2016; 2017; Thér *et al.* 2019), although in the latter case they had a preliminary character and have not yet yielded quantitative results (*e.g.*, Thér 2020).

Apart from these studies, selected LBK pottery from two sites from Moldova and Ukraine were analysed according to the quite similar Russian tradition of technological studies (*e.g.*, Bobrinsky 1978). Coiling with the paddle and anvil technique was identified as a dominating technique characteristic for the LBK pottery irrespective of the raw material and vessel type (Kozhin and Palaguta 2016; Palaguta and Starkova 2021). This conclusion corresponds to some extent to the above mentioned results obtained for other LBK regions, where beating is registered but is not the only prevailing technique of shaping among the assemblages. In the eastern part of the LBK oecumene, the slab technique, also registered in the preceding Starčevo culture (Burke 2022), could be identified as well (Thér *et al.* 2019; Gomart *et al.* 2020).

There has not been, and probably never will be, established one universal methodology of pottery analysis according to the *chaîne opératoire* approach and the description of traces of forming techniques.

Studies of pottery forming techniques are mainly conducted as comparative analyses, as technological and spatial variability can reveal different social networks of prehistoric communities (Roux 2020). The research presented in this paper focuses on a single pottery assemblage from one, small site. Its goal is to test the variability of the pottery assemblage in order to apprehend the social structure of the Cząstków Polski XII community: was this settlement inhabited by one single group of people sharing one technical tradition or by different groups with distinct technical repertoires? The pottery is badly preserved and highly fragmented, no single complete vessel profile could be identified, and well preserved vessels are regarded as best suited for preliminary definition of *chaînes opératoires* (Gomart 2006; 2011). The additional goal is thus to test how much information can be obtained from such fragmentary data. It is the first such analysis of forming techniques of the LBK pottery from Poland.

MATERIALS AND METHODS

LBK pottery from Cząstków Polski, site XII

The pottery assemblage under study comes from Cząstków Polski, Site XII. Czosnów commune. The site is located in a peripheral and not well-known region of the Polish Lowlands LBK oecumene: the Vistula Basin in Mazovia where a small cluster of a dozen LBK sites was detected (Fig. 1: 1). They are located on the Weichselian terrace of the Vistula River where small elevations of sandy formations existed close to wet depressions, presumably oxbow lakes in the Atlantic period, as well as large fertile silty areas which attracted the first farmers (Budziszewski and Pyzel 2022). The site Cząstków Polski XII was excavated in 2008 to a small extent (850 sqm; Fig. 1: 2) by M. Czarnecki due to the construction of a storage facility. He recorded altogether five pits with a depth of 0.6-0.9 m. Features 3, 4 and 5 formed a small cluster; Features 1 and 2, excavated only partially, were located 10 and 20 m to the east. Four pits (Features 1, 2, 3 and 4) contained artefacts dated only to the LBK: 547 pottery fragments (very few also from the cleaning of the trench, without a precise assignment to a feature), 77 flint and seven stone artefacts, small fragments of daub and animal bones. The pottery assemblage is quite homogeneous, leading to the hypothesis that is tested in this paper that all features are more or less contemporary and represent an occupation of a single group of people. The temper and decoration date the site to the early Music Note Phase (LBK IIA; Budziszewski and Pyzel 2022).

The material is highly fragmented: the average weight of a sherd was 15 g. Many sherds were so eroded that they resembled pebbles; it was difficult to analyse ornament which

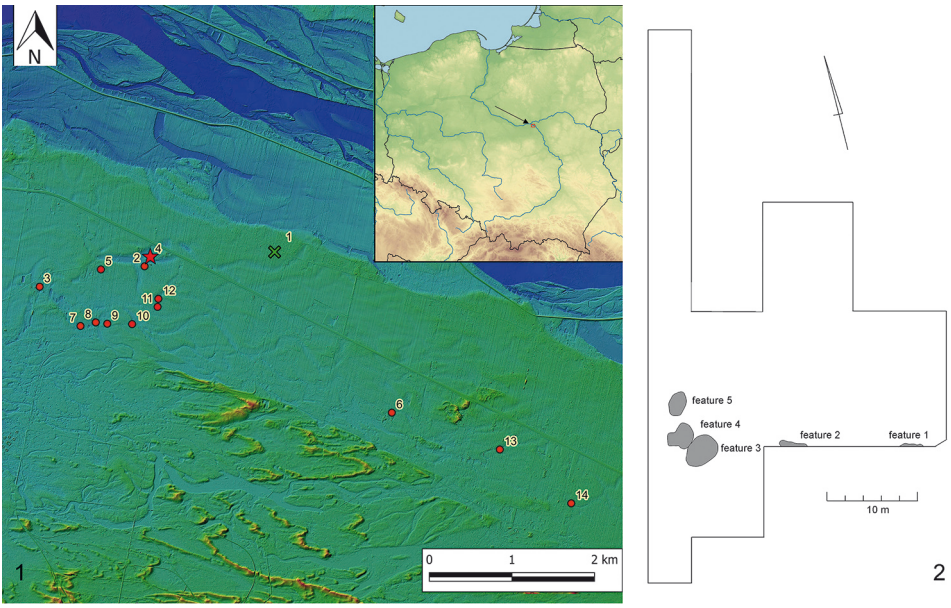

Fig. 1. 1 – Location of Cząstków Polski Site XII (marked with asterisk) within the LBK Vistula Basin microregion (other LBK sites are marked with red dots). After Budziszewski and Pyzel 2022; 2 – Plan of the excavated area

was badly preserved. Based on refitting and characteristic traits such as temper, colour, wall thickness, decoration and surface treatment, some sherds could be assigned to vessels and the total number could be reduced to 251 sherd families (Orton *et al.* 1993) representing both distinctive pots, but also small undiagnostic pieces. Most of them are body sherds, only 32 rims and 18 bases could be identified. For 32 vessels the basic form could be estimated: the majority (23 vessels) are globular pots typical for the LBK; others could be classified as bowls, collared jars and miniature vessels. The complete profile could not be reconstructed in any case.

The pottery can be divided into fine (63% of sherd families) and coarse ware (37%). Most of the fine ware was produced using a pure clay, but in some cases fine organic and sand temper was visible. For the coarse ware, organic temper was the most common, but sand could be identified macroscopically as well.

44% of the fine and 25% of the coarse ware was decorated; the identification of ornament was sometimes difficult due to the bad state of preservation of the material.

Traces of production on archaeological pottery

Traces indicating various production methods applied at different stages of pottery production are difficult to identify (*e.g.*, Gucsi 2022), as they are often erased by subse-

quent gestures and only a combination of various scales of observation and different analytical tools can yield valuable information on forming (*e.g.*, Roux 2017). This approach was also applied in our study, combining mainly macroscopic observations (with the naked eye and a magnifying lamp with 5 dioptres magnification) of various traces: breakage pattern and fractures, traces on the inner and outer surface as well as vessel sections: old and fresh breaks, polished sections as well as thin sections. On a total of 70 sherds or sherd families – 25 rims, 20 bases and 25 body fragments – various macrotraces could be observed.

Breakage pattern and fractures

The breakage pattern of a vessel can indicate its forming technique, as a clay pot breaks most easily on joints of various parts which were formed in different steps, such as the base, body and collar or even separate coils or slabs. In the case of the assemblage from Cząstków Polski, an average sherd family consisted of only 2.2 sherds, which means that in most cases it was too fragmented to recognise any clear breakage pattern. Fractures were also heavily eroded in most cases but for ten sherd families it was possible to identify clear horizontal breakages (rounded fractures); in one case the break on the collar-body joint was oblique to the exterior and a similar bevelled fracture joint was noted for one lower base fragment.

Surface traces

Traces of continuous and discontinuous pressure indicate gestures connected with the forming of a vessel. The bad state of preservation limited their detection but, in some cases, it was possible to observe both types of pressure. Traces of continuous movements were detected only twice, on the interior part of vessels, one on the lower part of the body and one on the bottom. Discontinuous traces were registered on the outer surface of a miniature vessel and in 13 cases on the inner surface of vessels: once on the lower part and nine times under the rim. In five cases such imprints were associated with traces of beating on the external surface.

Traces of beating were visible on external surfaces as overlapping flat circular areas (Fig. 2: 4); in these places wall thickness was also lower than in their surroundings (*e.g.*, Fig. 3: 2 – difference between the wall thickness of the rim and the part underneath). Such traces were registered 11 times: five in the upper part of a vessel, five in the lower part and one in an undefined body part.

Wall thickness

Apart from the differences in wall thickness caused by beating, in one case roughness of walls in the form of horizontal depressions and bulges could be observed on the inner side (Fig. 2: 3).

Sections

Radial sections of pottery, combined with surface features, are one of the best sources of information on the shaping techniques (*e.g.*, Thér 2020), as the alignment and orientation of inclusions and voids depend on forces applied while performing certain gestures

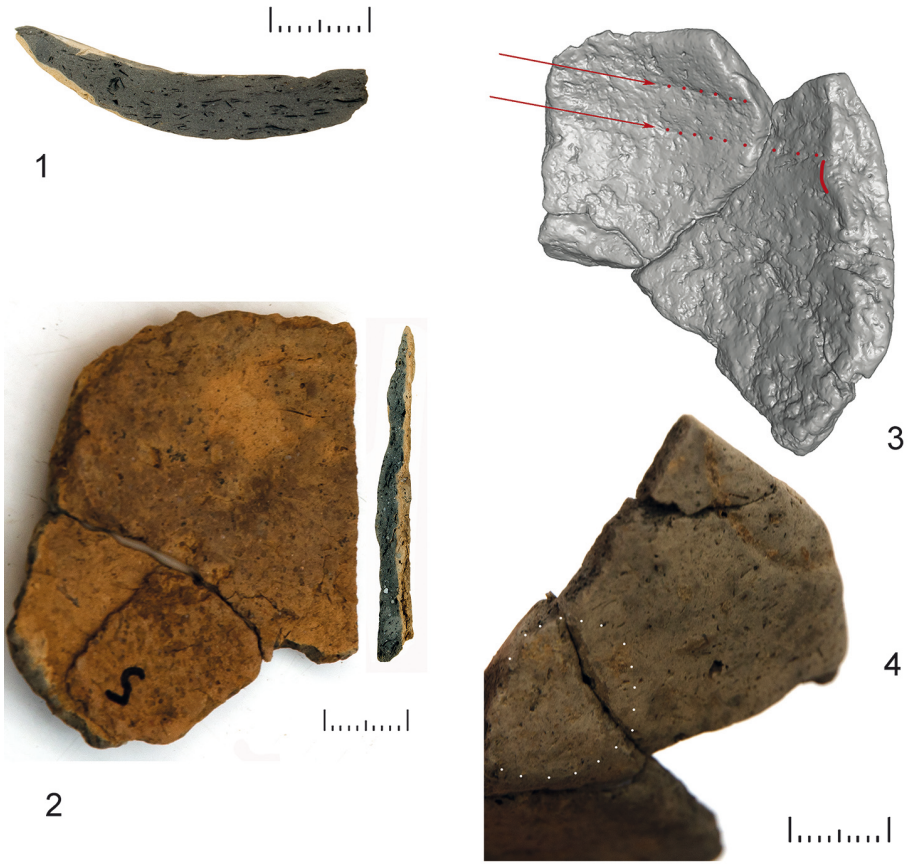

Fig. 2. Selected macrotraces on the LBK pottery from Cząstków Polski Site XII. 1 – polished radial section of a miniature vessel, *chaîne opératoire* CzP4, 2 – vessel with undulations on the inner surface and the radial section, *chaîne opératoire* CzP1, 3 – Lower part of a vessel with a beating trace on the outer surface, *chaîne opératoire* CzP3, 4 – Radial section and outer surface of a vessel with some traces of a hypothetical slab technique. Photos Joanna Pyzel

(Livingstone Smith 2001, Pl. V-26). In our study we used different types of radial sections: old (Fig. 2: 3) and new breaks (Fig. 3: 1, 2, 4, 5, 6), freshly polished sections (Fig. 2: 1; 3: 7), freshly polished sections of pottery hardened by adding a resin (Fig. 3: 3) and thin sections of such hardened pottery. Old breaks were observed first on the whole body of material; however, they were not always informative due to the high state of erosion. In 26 cases some observations were possible, and no other treatment was applied there mainly in order not to damage small and diagnostic pieces. In other cases, the pottery was broken, and such fresh breaks were the main source of information in 24 cases. Some sherds were also selected for sections to verify observations made on breaks or to cut pieces which were too thick to be broken with pincers. Thirteen sherds (nine with fresh, two with old breaks and

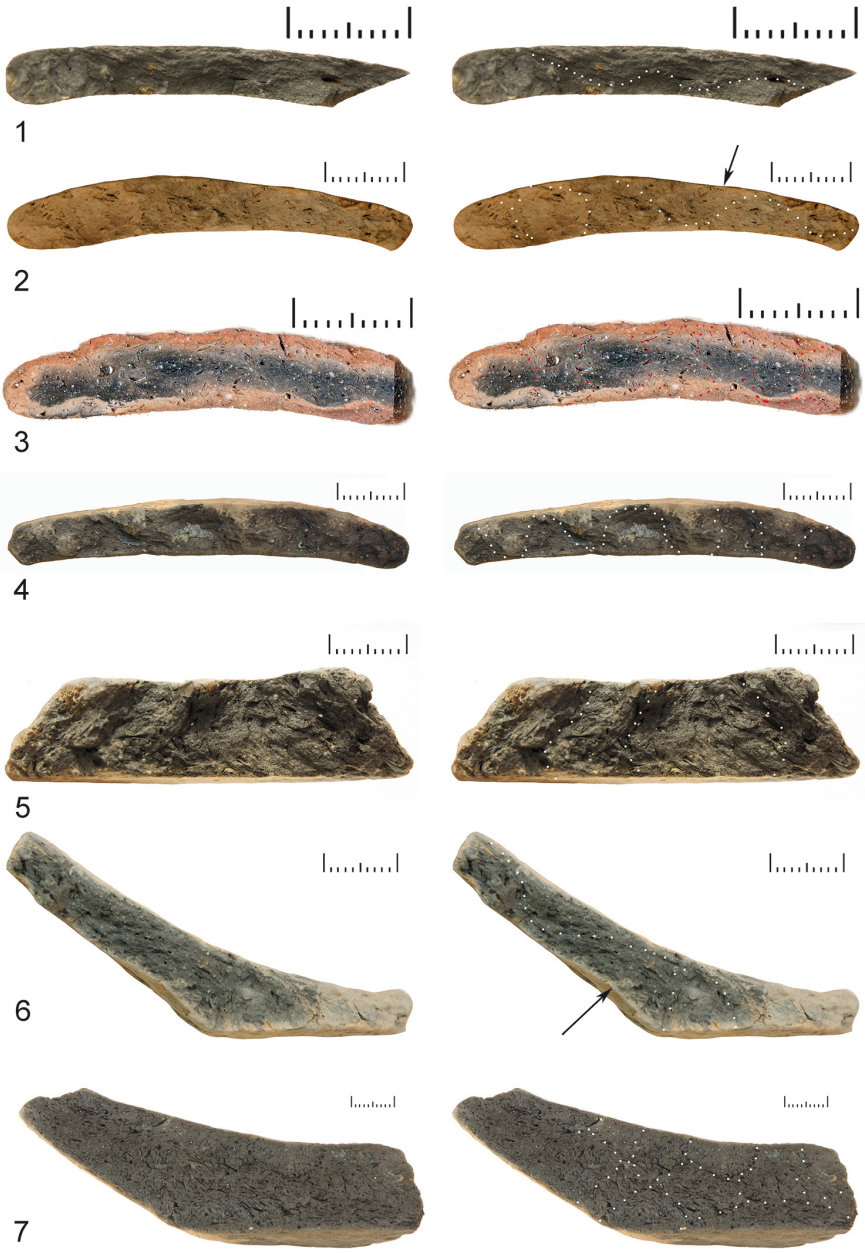

Fig. 3. Radial sections of selected vessels from Cząstków Polski Site XII. 1, 2, 4, 5, 6 – fresh breaks, 3 – polished section of a resin-hardened sample, 7 – polished section without resin; 3, 4 – *chaîne opeìratoire* CzP1, 1 – *chaîne opératoire* CzP2, 2, 6 – *chaîne opeìratoire* CzP3, 5 – fragment of a base with coils in a C/O configuration, 7 – fragment of a base made of double coil spirals. Photos 1-2, 4-7 Joanna Pyzel, photo 3 Anna Rauba-Bukowska

two too thick to break them) were selected for polished sections. Ten pieces were hardened with a resin; on eight of them simple polished sections and on two thin sections were performed. As the results of thin sections, microphotographs made in plane-polarised light and crossed-polarised light could be analysed enabling an analysis of the microfabrics (Courty and Roux 1995). In the case of one vessel, four methods could be used and compared: an old and fresh break as well as a polished section with and without resin.

In general, fresh breaks turned out to be most informative as not only the alignment and orientation of inclusions and voids, but also the roughness of the wall relief could be observed, which indicated different building units (Fig. 3: 4, 5). All kind of sections which made the wall surface flat could only sometimes confirm the results obtained in this way but were seldom precise enough to yield any new substantial information. Cutting of very soft and silty material closed the voids in many cases, which made the observation difficult.

For fresh breaks, the dimensions (length and width) of well visible building units (coils) were measured. This was possible for 29 bodies, nine rims and four bases.

Tangential sections were in most cases highly abraded and were not broken or cut in order not to fragment the sherd family additionally to radial sections. Thus, no observation was possible for them.

RESULTS

A combination of various macrotraces could be detected in certain configurations.

C/O configuration

Not so strongly deformed coils were the best visible and thus the most common feature in the assemblage from Cząstków Polski. They were registered on a total of 26 sherd families in the form of various macrotraces. They could be traced in joints as flat sectioned fractures and even as roughness on the inner side of one vessel where the remains of coils did not become totally smoothed while finishing (Fig. 2: 3). They could be quite well observed in the old breaks in the form of small circular bulbs and depressions (Fig. 2: 3). These relief undulations became even more clear in fresh breaks (Fig. 3: 4) – in these cases the radial arrangement of voids and temper was clearly visible. This was also the case for polished sections with and without a resin (Fig. 3: 3). Some coils are more circular, and they have a zig-zag or C arrangement (Fig. 3: 4), while others are slightly more rounded or elongated in the form of a chain of Os (Fig. 3: 3). This C/O configuration (Bosquet *et al.* 2005) was registered more often on the coarse (19 vessels) than on the fine pottery (seven vessels). These are mainly upper fragments with rims as well as indistinctive body parts and lower pieces with bases. In all cases the coil arrangement does not change between vessel parts, and it is uniform for bodies and rims as well as bodies and bases. All identified vessels of this group belong to the globular vessel type.

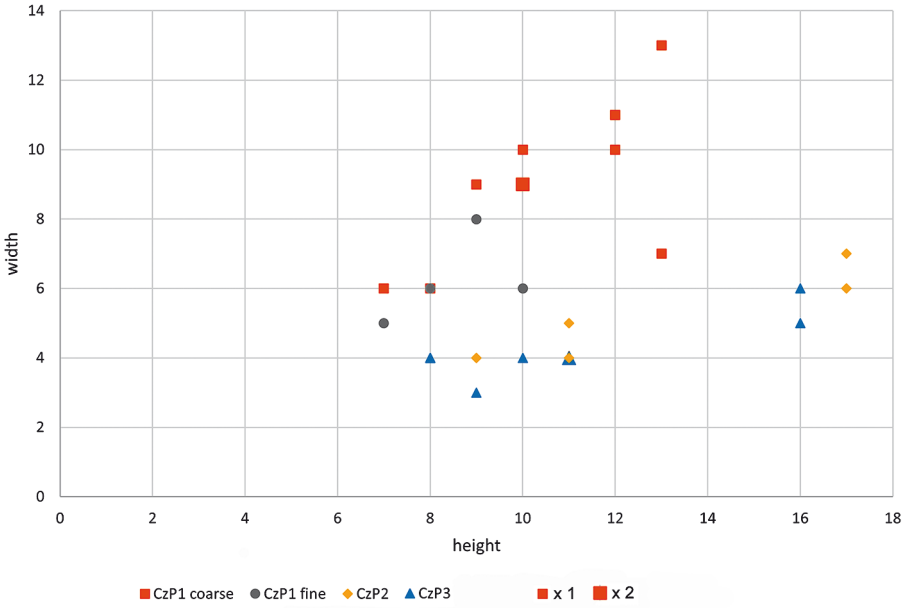

Fig. 4. Height-width relationship of coils forming vessel bodies from Cząstków Polski Site XII

Most of the C/O shaped coils forming vessel bodies have a similar size: the height lies between 7 and 13 mm for the coarse and 7 and 10 mm for the fine pottery and the width between 6 and 13 mm for the coarse and 5 and 8 mm for the fine pottery with an average size of 10 × 9 mm for the coarse and 8 × 6 mm for the fine pottery (Fig. 4). The size of coils forming rims and bases is similar.

Traces of discontinuous pressure inside were registered in seven cases: five upper parts under the rim and two body fragments.

S configuration

On other sherd families, a different type of configuration was visible in sections. For old breaks it looks like an elongated semi-circular bulb. In the case of fresh breaks, the orientation of voids and temper follows that pattern as well, forming a wavy, S-shaped line in a radial section (Fig. 3: 1). This S configuration (Bosquet *et al.* 2005) was registered only on bodies of fine pottery vessels. In the case of four vessels, it co-occurs with bases where traces of not so strongly transformed coils (C/O configuration) could be identified.

In ten cases, beating traces could be observed on the upper and lower parts of vessels (Fig. 2: 4; 3: 2, 6) in the form of circular flat areas of *c.* 1.5 cm diameter, repeating at different density. For one lower body part such traces occur every 3 cm. For this and four upper body fragments, traces of discontinuous pressure were registered on the inner surface op-

posite to the beating traces. Beating traces were also visible as a flattening of the vessel wall: the thickness is slightly lower than that of the other parts (Fig. 3: 2, 6). In general, the wall thickness of sherds showing an S configuration in the radial plan without beating traces on the surface is between 3 and 7 mm with a mean of 5 mm, while for sherds with beating traces it is slightly lower: between 2 and 6 mm with a mean of 4 mm. In the case of one body sherd, which had clear beating traces on the outer surface and a thickness of only 2 mm, no traces of coil junctions could be observed, while voids are elongated and oriented parallel to the radial profile. In other cases when beating was registered, the vessels body was characterized by S-shaped coils, while the vessel rim/neck showed a combination of 2-3 small non deformed coils (Fig. 3: 2). This type of configuration was observed for globular vessels and collared jars where O-shaped coils formed the neck and S-shaped coils the body. In the case of five sherd families, a combination of a lower body part with visible S configuration with beating traces and bases with C/O configuration could be identified.

S-shaped coils have a similar size irrespective of the presence or absence of beating traces. Coils without beating are 9-17 mm high and 4-7 mm wide with an average of 13 × 5 mm; for sherds with beating traces these values are 8-16 mm and 3-6 mm with an average of 11 × 4 mm. Slightly higher values for coils without beating traces may be influenced by fragments of lower body parts, where coils are extremely elongated: sherds with and without beating form a clear cluster on the right side of the diagram (Fig. 4). O-shaped coils forming the rim are smaller: 4-7 mm high and 4-7 mm wide, with a mean of 4 × 5 mm.

S-shaped coils without beating traces could be registered for 18 sherd families and with beating for 11 sherd families altogether.

Other configurations

Apart from these coiling procedures registered for all vessel parts, there were also some small fragments where the classification is equivocal. There were three small rim fragments representing the fine ware only with O-shaped coils visible in the radial sections. It is not clear if they represent the C/O group of vessels or just fragments of S-shaped profiles with beating where the lower part was not preserved. The same applies to six bases where a single row of singular coils in C/O configuration is visible (Fig. 3: 5), especially for five of them representing the fine ware. There were also two very thick and heavily eroded coarse ware bases that had to be cut because it was not possible to break them. Unfortunately, the polished section perturbed the voids so the observation was difficult, but traces of two layers of coils can be suggested here due to some circulating arrangements of organic temper whose sizes are regular and correspond to typical coil size at the site (Fig. 3: 7). The body part, however, is too disturbed to conclude the form of coils in the walls. The shape of fracture, which can indicate a coil joint, is in one case oblique and in the other flat.

One miniature fine vessel (a 2.8 cm high deep bowl) was also cut, and the polished section revealed elongated voids oriented along the radial section and running uninterrupted

through the whole profile (Fig. 2: 1), which is unique for the analysed assemblage. A trace of discontinuous pressure could be registered on its outer surface.

Another unique case is represented by a rim fragment of a strongly eroded coarse globular vessel. Its outer surface is very irregular but so damaged that it is not possible to interpret the irregularities. On the inner surface, lines of tensions are visible as well as foliation of the surface (Fig. 2: 2). This is also visible in the polished section – the sherd was also cut because this method seemed gentler than breaking such a sensitive piece. In the section some oblique oriented voids are visible as well (Fig. 2: 2), which is unique for the assemblage.

DISCUSSION

Reconstruction of forming techniques

Most of the vessels from Cząstków Polski were made with the coiling technique.

Different forming methods can be reconstructed from the identified macrotraces. The C/O configuration visible in sections in the form of rhythmic undulations, radial arrangement of voids and temper, bumpy walls with differences in thickness as well as flat or rounded fractions indicate vessel building by placing coils on top of each other without strong transformation. In this procedure, coils were joined through pinching (Livingstone Smith 2001, 122; Roux 2019, 161) and traces of discontinuous pressure are indeed quite common on sherd families of the C/O group despite their bad preservation.

The S configuration echoes a variant of the same method (Livingstone Smith 2001, 121). Subcircular, elongated orientation of voids and temper and similar rhythmic undulations in radial sections represent coils placed along an alternating external/internal bevel and subsequently thinned and stretched (Roux 2019, 163).

The miniature vessel was formed from one piece of clay (Fig. 2: 1). The alignment and orientation of voids and temper running parallel to the vessel's walls (without any discontinuities that could indicate coil joints) refer to the vertical compression of a single clay mass caused by drawing and pinching (Roux 2019, 170). Traces of discontinuous pressure are an additional argument for pinching.

Another unique piece (Fig. 2: 2) is difficult to interpret due to its bad state of preservation, which erased many traces. That is why conclusions must be treated with caution. The section is unclear: diagonal orientation of some voids can indicate coil joints, but as they are quite irregular, they can also represent slab joints (*e.g.*, Vandiver 1987, Pl. V: 4). A clear foliation of the inner surface is visible in the section, which can indicate an overlapping of clay pieces (*e.g.*, Vandiver 1987, Pl. I: 1). The laminar fissuring is also visible on the inner side of the sherd. The interpretation of these traces is equivocal, but they can indeed indicate the sequential slab technique (Vandiver 1987; Roux 2019, 167).

Apart from these fashioning techniques, finishing in the form of beating/paddling could be identified on some sherd families. Traces in the form of alternating flattened and curved external surfaces are a strong indication of beating (Roux 2019, 177). The elongated and, in some cases even vertical configuration in radial sections, is an additional characteristic trait caused by a compression of clay (Livingstone Smith 2001, 121). On the inner surface, traces of discontinuous pressure suggest the use of a counter-paddle during beating (Roux 2019, 178).

Definition of *chaînes opératoires*

On the basis of the results of the technological analysis of the assemblage from Cząstków Polski we are able to distinguish the following *chaînes opératoires*:

CzP1. simple coiling with pinching

The vessel bases were formed using a singular spiralled coil. The coils forming the body were then added on top of each other until the vessel's rim. Coils of similar diameter were used for all vessel parts. They were not strongly transformed during forming nor finishing. This *chaîne opératoire* includes both fine (seven sherd families) and coarse pottery (nineteen sherd families; Table 1).

CzP2. coiling with pinching and subsequent thinning and stretching

The vessel bases were formed using a single spiralled coil. The coils forming the body were placed on top of each other with an alternate overlapping: every other coil is stretched once on the inner surface of the previous coil, and again on the outer surface of the previous coil. The coils became thinned and stretched during forming and finishing of the vessel. It is not clear how the vessel's neck was built here. This *chaîne opératoire* was applied only for the fine pottery (eighteen sherd families; Table 1).

CzP3. coiling with beating (paddle and anvil technique)

Vessels were formed following the same gestures as for the CzP2. The rims were formed from two or three smaller coils of clay placed on top of each other and slightly elongated through pinching but not as thinned and stretched as those of the body. The body was then shaped using the beating technique, especially in the upper and lower part. This *chaîne opératoire* was applied only for the fine pottery (eleven sherd families; Table 1).

CzP4. drawing from one piece of clay

Miniature vessels were formed from one piece of clay which was pulled and stretched out by drawing and pinching. Only one fine vessel representing this procedure could be identified in the assemblage.

Other chaînes opératoires

Additionally, a *chaîne opératoire* connected with the sequential slab technique can be assumed on one vessel, as described in Kreiter *et al.* (2017). The presence of vessel bases made of double coil spirals indicate also that other *chaînes opératoires* were used as well; however, they cannot be fully reconstructed due to the high fragmentation of the assemblage.

Table 1. Distribution of most common *chaînes opératoires* identified for the LBK pottery assemblage from Cząstków Polski Site XII. F – fine pottery, C – coarse pottery

	Feature 1			**Feature 3**			**Feature 4**			**Layer**			**Total**		
	CzP1	CzP2	CzP3	CzP1	CzP2	CzP3	CzP1	CzP2	CzP3	CzP1	CzP2	CzP3	CzP1	CzP2	CzP3
rim&body	1F, 1C	0F, 0C	2F, 0C	3F, 7C	0F, 0C	3F, 0C	1F, 1C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	5F, 9C	0F, 0C	5F, 0C
body&base	0F,1C	2F, 0C	3F, 0C	1F, 0C	2F, 0C	1F, 0C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	1F, 0C	1F, 1C	4F, 0C	5F, 0C
body	0F, 4C	3F, 0C	1F, 0C	1F, 5C	11F, 0C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	1F, 9C	14F, 0C	1F, 0C
total	1F, 6C	5F, 0C	6F, 0C	5F, 12C	13F, 0C	4F, 0C	1F, 1C	0F, 0C	0F, 0C	0F, 0C	0F, 0C	1F, 0C	7F, 19C	18F, 0C	11F, 0C

The traces observed in sections indicate that they could have been combined with bodies shaped using both the simple coiling technique with pinching (as the CzP1) and the coiling with thinning and stretching (as the CzP2).

Variability within *chaînes opératoires*: tracking "potters' hands"

Chaînes opératoires CzP1-3 are the most common in the analysed assemblage (Table 1). They could be identified in the two features that are the richest in pottery: Pits 1 and 3, located c. 10 m from each other. In both features some very characteristic vessels were found. Lower fragments of four small fine pots made using CzP3 have strong traces of beating above the base which caused a slight deformation of the profile (Figs 2: 3; 3: 6). The base-body junction was always built in the same way and, in all cases, coils of similar size were used: for two of these vessels, the lowest ones were measured, and these are extremely elongated (16 × 5 mm and 16 × 6 mm; Fig. 4); for two other vessels, the upper coils are smaller, but also similar (10 × 4 mm and 8 × 4 mm; Fig. 4). Almost identical coil sizes could also be observed for the vessels made using CzP1, which also share very similar traits: a slightly alternating alignment of sub-circular coils (C configuration: 10 × 9 mm and 10 × 10 mm as well as 12/10 mm and two 12/11 mm; Fig. 4) or overlapping alignment of circular coils (O configuration: 9 × 9 mm and 10 × 9 mm; Fig. 4). Although these are different vessels, such similarities in technical gestures and coil sizes are so striking that these vessel groups seem to have been built by one person for each group respectively. Such motor habits connected with rolling coils seem indeed very individual (Manem 2008; Gomart 2011; 2014). Pottery manufactured by these hypothetical manufacturers was spread in both Features 1 and 3, which is a strong additional indication for their contemporaneity. The small number of *chaînes opératoires* at Cząstków Polski Site XII, as well the low variability within them, is an argument that the site represents a LBK settlement inhabited by one group of people sharing the same technical tradition (*e.g.*, Roux 2019, 6), and including different manufacturers. This is not at all obvious as interpretations of the Vistula Basin microregion as only temporary stops on the "motorway" connecting the loess uplands with the Polish lowlands have been discussed for many years (*e.g.*, Kulczycka-Leciejewiczowa 1968; Budziszewski and Pyzel 2022, further references therein). On larger LBK settlements, such as Cuiry-lès-Chaudardes in Picardy (France), a higher number of co-existing technical traditions could be identified (Gomart 2014).

Comparison with other sites

Forming and fashioning techniques and methods reconstructed at Cząstków Polski are all known for the European Neolithic and the LBK. However, their combination in certain *chaînes opératoires* has some degree of idiosyncrasy.

Coiling with pinching without strong coil deformation was registered in the Hungarian (Kreiter *et al.* 2017), Bohemian (Neumannová *et al.* 2017; here as an S configuration), as well as French and Belgian LBK (Gomart 2014). However, nowhere can a direct analogy to the CzP1 be found. In Hungary, bases were made of superimposed coiled spirals (Method 2: Kreiter *et al.* 2017; which may correspond to one of the hypothetical *chaînes opératoires* of Cząstków Polski). In the western LBK, bases are rounded, and rims were made of smaller coils (*e.g.*, CCF2: Gomart 2014, 79). CzP2 has similarities in France (*e.g.*, CCF8: Gomart 2014, 79), but the bases are again different. CzP3 resembles the Method 1 from Hungary (Kreiter *at al.* 2017), but no traces of shaping the bases against a support could be detected at Cząstków Polski. The rims were also made in a different way, which looks like the practices known from France and Belgium (*e.g.*, CCF10 and FHC10: Gomart 2014, 79, 174). However, this method was not restricted to fine pottery there as is the case at Cząstków Polski. Also, in Ukraine and Moldova, the paddle and anvil technique was used on all types of vessels. This technique prevailed there, even if examples of not so strongly transformed coils (similar to CzP1) were also registered (Palaguta and Starkova 2021).

The sequential slab technique was suggested for Hungary (Method 3: Kreiter *et al.* 2017), which makes our hypothesis on its occurrence at Cząstków Polski more probable. The definition of slabs is not unequivocal among pottery specialists (*e.g.*, Vandiver 1987; Commenge 2009; Thér *et al.* 2019; Gucsi 2022): early Neolithic slabs in the Balkans and the Carpathian basin seem to correspond to flattened short coils (Kreiter *et al.* 2017), different from the small patches of clay described by P. Vandiver in the Levant (1987), or from the possibly larger slabs of clay documented by C. Commenge in Macedonia (2009).

The identified *chaînes opératoires*, with notably different coiling procedures, beating and sequential slab building, characterizes LBK pottery assemblages in different quantities from the emergence of the culture in Transdanubia to its final expansion in central Western Europe (Gomart *et al.* 2020). In that sense, the assemblage from Cząstków Polski fully integrates the LBK common ceramic tradition. At the individual scale, the limited size of the pottery assemblage allowed for the identification of specific "hands" within this common LBK tradition and to differentiate several individuals in charge of the production.

CONCLUSIONS

A variety of forming techniques could be identified for the pottery assemblage from Cząstków Polski and four *chaînes opératoires* could be reconstructed. This technical repertoire echoes the intrinsic variability of LBK pottery assemblages as described in other LBK contexts (Gomart *et al.* 2020). Our results demonstrate that even quite poor, highly fragmented, and badly preserved material can be used to study pottery production. We could not reconstruct the exact number and proportions of *chaînes opératoires,* but we could recognise some unique traits that distinguish the social group (community of practice) from Cząstków Polski and even certain producers within it. Thus, even if the LBK

manufacturers followed quite consistent general potting rules, some variability can be observed between (and even within) sites and regions. Our results demonstrate the very high potential of research on pottery production techniques: when so much information can be gained from such a site, we could obtain tremendous knowledge on various social groups and their interactions when analysing systematically better preserved settlements, microregions and whole regions. This offers valuable avenues for future research, and we hope that analysis of production techniques will become a standard in pottery studies.

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