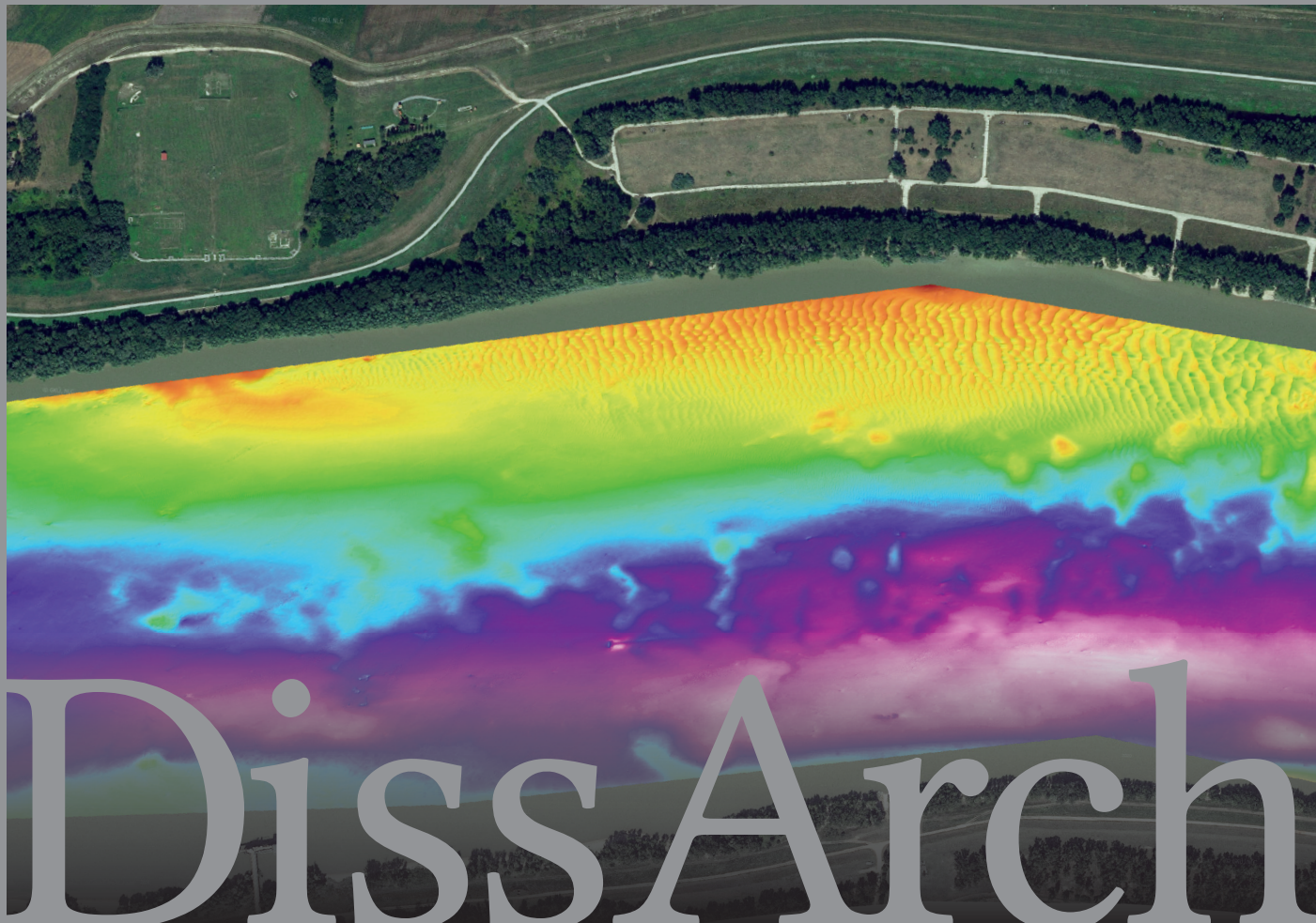


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Pottery technological analysis of the Copper Age Transdanubia (Western Hungary)

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Abstract: This article focuses on the technological analysis of the Early and Middle Copper Age (4500–3650 cal BCE) pottery vessels from Transdanubia (Western Hungary), which can reveal the previously unknown social connections based on strong personal interactions in this region. The pottery material of four settlements was studied: Zalavár-Basasziget, Magyar-egres-Varga-Bonyi-árok-tól keletre, Tikos-Nyárfás-dűlő, and Győr-Szabadrétdomb. As a result, several forming methods, coiling processes, and surface treatment techniques were identified. Their techno-stylistic and spatial analysis revealed a principal technical tradition in the region, which was observed on every site, regardless of the period or location. This tradition constitutes a relatively restricted technological repertoire; most of the vessel forms were created with the same forming method. Thus, most potters belonged to the same community of practice. However, other forms of technical knowledge also appear in the region besides the common technical tradition, albeit in low numbers and only at a few sites. Thus, a few potters were probably part of other communities of practice. The certain settlement communities

probably responded differently to the appearance of these new technical knowledges. The potters in some settlements strictly followed the same technical tradition; they did not adopt any other methods or techniques. In contrast, the potters in other settlements were presumably more open to other technical knowledges.

Keywords: Early and Middle Copper Age, Carpathian Basin, pottery forming, surface treatment, technical tradition

Introduction

Transdanubia is located in modern-day Western Hungary, in the western part of the Carpathian Basin. It is predominantly defined by low mountain ranges and minor uplands intersected by numerous watercourses, mainly the Danube and its tributaries. One of the largest lakes in Central Europe, Lake Balaton, is situated at the centre of the region. In the Early and Middle Copper Age (4500–3650 cal BCE), small settlements with a few houses dominated the region.¹ The burials were sparse, with no formal cemeteries known; instead, a few burials and mass graves were uncovered.² Copper tools and gold ornaments mainly appeared in the Early Copper Age, with the first traces of local metallurgy, which connects the region with the Central European metallurgical circle.³ Traditionally, four archaeological cultures were differentiated in Transdanubia during the studied period. The Early Copper Age was characterised by a short period of the end of the Lengyel complex, followed by the Balaton–Lasinja culture with a dense network of small settlements.⁴ The following Middle Copper Age started with the *Furchenstich* (i.e. stab-and-drag) culture around 3900 cal BCE and continued with the Protoboleráz period.⁵

Our aim was to study the social connections based on strong personal interactions in this period with a technological approach of pottery analysis. The theoretical framework of this methodology is rooted in the French anthropological approach of techniques.⁶ The method is based on the strong relationship between the potter and several steps of the pottery fabrication process (i.e. *chaîne opératoire* of the pottery vessels). Forming is a crucial step of pottery-making because it can only be acquired during a long learning process, which requires strong personal contact between the tutor and the learner. After the learning, the required motoric and cognitive skills become automatic, which are difficult to modify once the learning is completed.⁷ Therefore, the continuous transmission of the same technical knowledge over a long period creates a technical tradition.⁸ Since the learning process requires personal contact between the tutor and the learner, potters always form communities of practice, i.e. social groups connected by shared technical knowledge.⁹ Thus, technical traditions are transmitted through social networks that were established by personal relationships.

1 KALICZ 1991; KALICZ 1995; M. VIRÁG 2003; M. VIRÁG 2004; M. VIRÁG 2005a; M. VIRÁG – FIGLER 2007.

2 REGENYE 2006; SZÉCSÉNYI-NAGY *et al.* 2019; REGENYE *et al.* 2022.

3 KALICZ 1982; M. VIRÁG 1986; KALICZ 1992; SIKLÓSI *et al.* 2022; M. VIRÁG *et al.* 2025.

4 KALICZ 1982; M. VIRÁG 2005b; P. BARNA – KREITER 2006; REGENYE 2006; REGENYE *et al.* 2022; M. VIRÁG *et al.* 2025.

5 KALICZ 1991; HORVÁTH 2001; KALICZ 2001; HORVÁTH – SIMON 2003; FÁBIÁN – SERLEGI 2009; LÁSZLÓ-MATEOVICS *et al.* 2021.

6 LEROI-GOURHAN 1943; LEROI-GOURHAN 1945; MAUSS 1947; LEROI-GOURHAN 1964; LEROI-GOURHAN 1965; CRESSWELL 1976; BALFET 1991; LEMONNIER 1991; LATOUR – LEMONNIER 1994.

7 BRIL 2002; GOSSELAIN 2002, 26; GELBERT 2003, 53–59; ROUX 2010, 6.

8 GELBERT 2003, 53–59; ROUX 2010, 6; GOMART 2014a, 43.

9 LAVE – WENGER 1991; WENGER 1999.



Fig. 1. Location of the analysed sites.

However, the transmission of surface treatment techniques, i.e. the transformation and/or regularisation of the surface of the finished vessel,¹⁰ is a more nuanced issue. On the one hand, they may reflect long-term technical traditions;¹¹ on the other hand, aesthetic preferences or functional considerations may also influence the choice of surface treatment.¹² Since the results of these treatments remain visible on the finished vessel, it can be assumed that, in certain cases, they could be copied simply by visual observation, without direct personal interaction.

The pottery technological analyses from the Neolithic and Copper Age Transdanubia are scarce. So far, two Early and Middle Neolithic sites have been studied with the same approach,¹³ and only a few publications have mentioned Early or Middle Copper Age forming techniques.¹⁴ Therefore, we aimed to carry out the first, larger-scale, systematic technological analysis on Early and Middle Copper Age pottery assemblages. On the one hand, this reveals the technical knowledge of the

pottery makers: the techniques they used, the extent of their technological repertoire, and whether different vessel forms were shaped using distinct techniques. On the other hand, the reconstruction of technical tradition(s) can reveal the social networks of the pottery makers, based on personal interactions, whether they belonged to the same community of practice.

Material

130 vessels were analysed from four Transdanubian settlements (Fig. 1):¹⁵ 61 pieces from Zalavár-Basasziget, 38 pieces from Magyaregres-Varga-Bonyi-ároktól keletre, 20 pieces from Tikos-Nyárfás-dűlő, and 11 pieces from Győr-Szabadrétdomb. This contains a total of 120 Early Copper Age and 10 Middle Copper Age vessels (see the supplementary material), including all technologically diagnostic vessels (Fig. 2); no preselection was made, similarly to our previous studies.¹⁶ Among the examined vessels, some had been restored using adhesive and plaster fills.

Zalavár-Basasziget was found in the southeastern part of Transdanubia. Before the reconstruction of the Kis-Balaton, Zsuzsanna M. Virág excavated a part of an Early Copper Age Balaton-Lásinja settlement in 1983–1984 and 1987 (Fig. 3). This typical, small-scale settlement consists of pits and six

10 RYE 1981, 24; BALFET *et al.* 1989, 73; BINDER *et al.* 1994; LEPÈRE 2014; ROUX 2017; ROUX 2019, 96.

11 DERENNE *et al.* 2022.

12 GUCSI 2001, 196; SOLNAY *et al.* 2023.

13 GOMART 2014b; KREITER *et al.* 2017; GOMART *et al.* 2020.

14 GUCSI 2006; HORVÁTH 2010.

15 All photos and illustrations were made by the authors.

16 SOLNAY 2022; SOLNAY – SZILÁGYI 2024; SOLNAY *et al.* 2025.

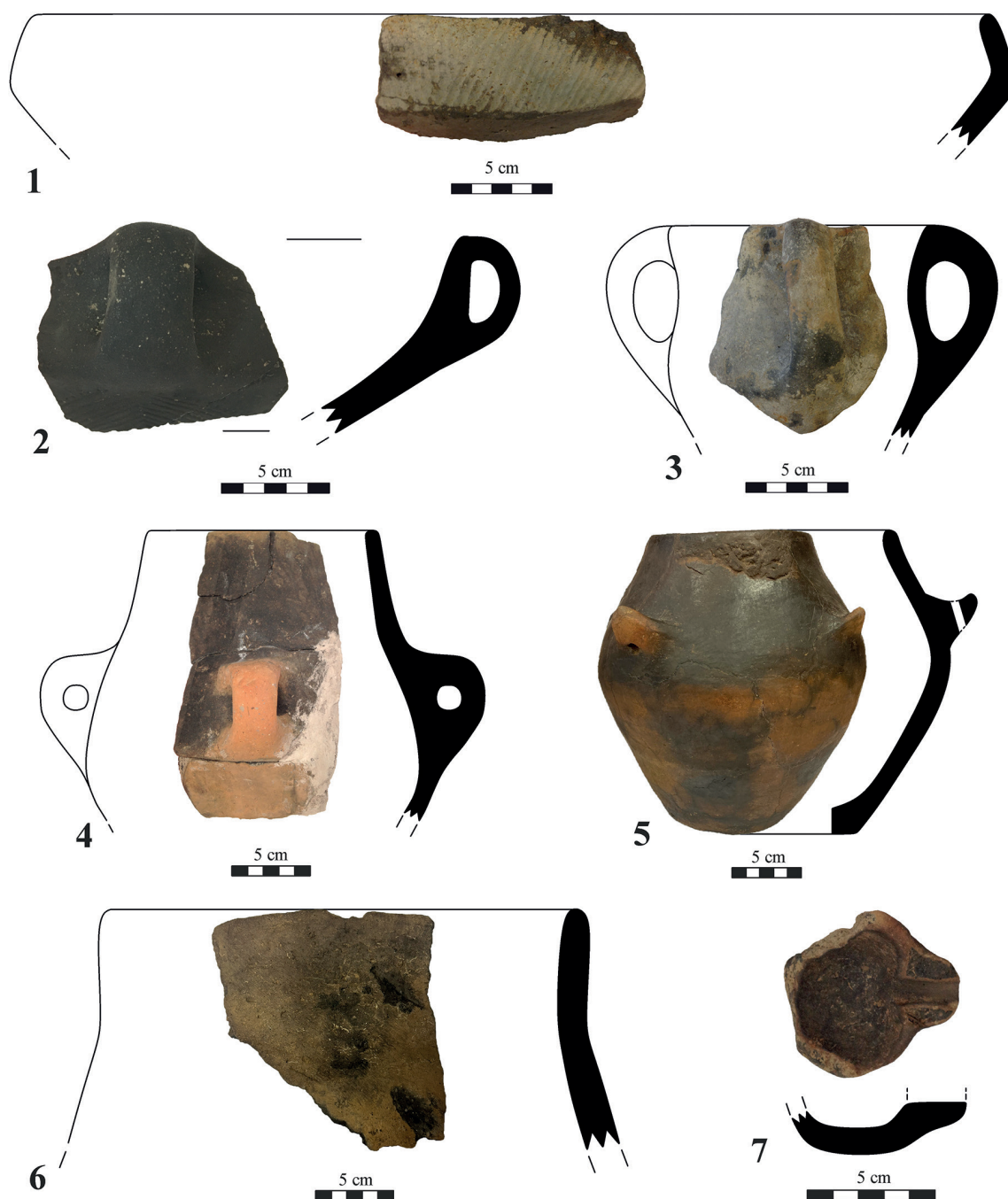


Fig. 2. Selection of the analysed vessel categories. 1 – bowl from Zalavár-Basasziget, 2 – bowl from Magyar-egres-Varga-Bonyi ároktól keletre, 3 – cup from Zalavár-Basasziget, 4–5 – pot from Magyar-egres-Varga-Bonyi ároktól keletre, 6 – storage vessel from Tikos-Nyárfás-dűlő, 7 – ladle from Magyar-egres-Varga-Bonyi ároktól keletre.

rectangular, timber-framed buildings.¹⁷ The settlement was probably used continuously for three distinct phases, without a temporal abandonment, during which one to three houses were occupied at the same time.¹⁸ A few copper artefacts were found in the settlement features.¹⁹ In total, 61 vessels were suitable for technological analysis from 33 settlement features (Tab. 1). These were bowls, cups,

17 M. VIRÁG 2003; M. VIRÁG 2005a.

18 M. VIRÁG 2005b, 37.

19 M. VIRÁG 1986; M. VIRÁG *et al.* 2019; M. VIRÁG *et al.* 2025, 5.

pots, ladles, strainers, as well as fine wares, coarse wares, and bases whose exact form is unknown. Plastic applications (knobs, lugs) dominated the studied assemblage, but incised decorations also occurred. The condition of this material was extremely poor, as the site may have been underwater for a long time in this marshy area. Consequently, the structural integrity of the vessels had significantly deteriorated, rendering them extremely fragile.

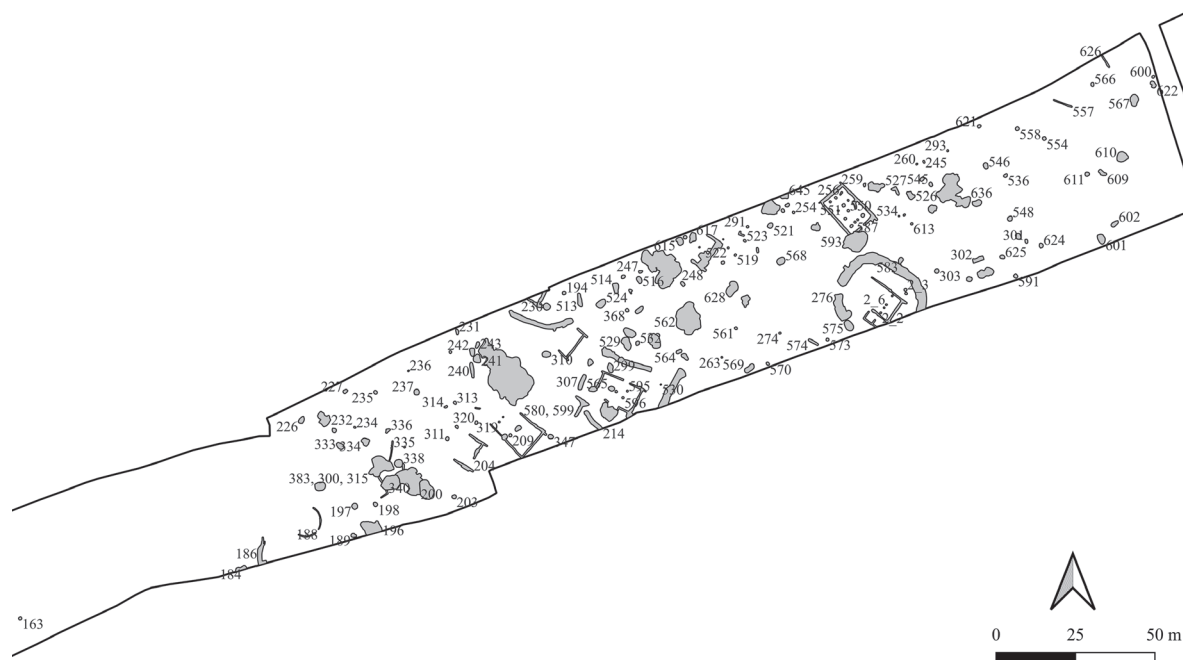


Fig. 4. Map of Magyaregres-Varga-Bonyi-áróktól keletre.

Magyaregres-Varga-Bonyi-áróktól keletre is located in southern Transdanubia on the western slopes of a hill between the Varga-Bonyi Valley and the Deseda Stream. Péter Kiss and Péter Hornok excavated an Early Copper Age Balaton–Lásinja settlement before the construction of the motorway 69 in 2016–2017 (Fig. 4). Pits and eight rectangular, timber-framed buildings were unearthed, one of which was surrounded by a rectangular ditch and two others by circular ditches. It can be assumed that only a part of the site was recovered. Besides, a copper hoard was found in the western part of the settlement.²⁰ The radiocarbon dating suggests that the establishment of the settlement can be estimated to 4425 (68.3%) 4235 *cal* BCE, and it was abandoned around 3940 (68.3%) 3775 *cal* BCE after 295 (68.3%) 445 years of use.²¹ The forming and surface treatment of 38 vessels can be studied from 13 settlement features. They were mainly bowls, cups, pots, ladles, as well as fine wares, coarse wares, and bases of unknown forms. Several plastic applications (knobs, lugs) were identified on the analysed vessels, but other techniques, such as incised decoration, were also observed.

Tikos-Nyárfás-dűlő is situated in the southeastern part of Transdanubia on the slope of a hill. Péter Gergely Németh and Zsuzsanna Siklósi recovered a multiperiod site, including an Early and Middle Copper Age settlement in 2003–2004 before the construction of the M7 motorway (Fig. 5).²² The Early Copper Age Balaton–Lásinja settlement consists of a presumably partially unearthed ditch and some pits. A few Middle Copper Age, *Furchenstich* and Protoboleráz pits were also uncovered in the same area of the excavation trench. 20 vessels were considered diagnostic for technological

20 HORNOK – KISS 2017; SIKLÓSI *et al.* 2022.

21 SIKLÓSI *et al.* 2022, 13.

22 HONTI *et al.* 2004, 45–47.



Fig. 5. Map of Tikos-Nyárfás-dűlő.

analysis: 12 Early Copper Age Balaton–Lásinja vessels from four features and eight Middle Copper Age Protoboleráz vessels from two features. The Middle Copper Age *Furchenstich* material was not suitable for our method of technological analysis. The exact form of the Early Copper Age vessels are mostly unknown (fine wares and bases), only the form of a bowl can be defined. No decoration was observed on these vessels. The examined Middle Copper Age vessels were bowls, pots, and storage vessels, as well as some fine wares and bases whose form is unknown. Only a few of them are decorated with knobs.

Győr-Szabadrétdomb is located at the northern edge of Transdanubia, in the Little Hungarian Plain, near the Rába River. András Figler revealed a multiperiod, Early and Middle Copper Age settlement in 1990–1991 during a preventive excavation before the construction of the M1 motorway (Fig. 6). The Early Copper Age settlement consists of two phases. Three rectangular, timber-framed buildings and pits were identified that can be dated to the Lengyel III phase, while a later Early Copper Age occupation includes seven smaller, timber-framed buildings that were dated to the Balaton–Lásinja/Ludanice culture.²³ The Middle Copper Age settlement pits were also dated to two cultures: the *Furcheinstich* and the following Protoboleráz phase. Technological analysis was carried out only on 11 vessels: nine Early Copper Age (eight Lengyel III and one Balaton–Lásinja/Ludanice) and two Middle Copper Age *Furcheinstich* vessels from two features. The Middle Copper Age Protoboleráz material cannot be technologically studied with our methodology. The Lengyel III vessels were bowls, pots, ladles, as well as a few base and coarse ware whose forms are unknown. Most of the analysed vessels were decorated with knobs, and impressed decoration was also observed. The single analysed Balaton–Lásinja vessel was a bowl with knobs. The two examined *Furcheinstich* vessels were an undecorated miniature bowl and an undecorated ladle.

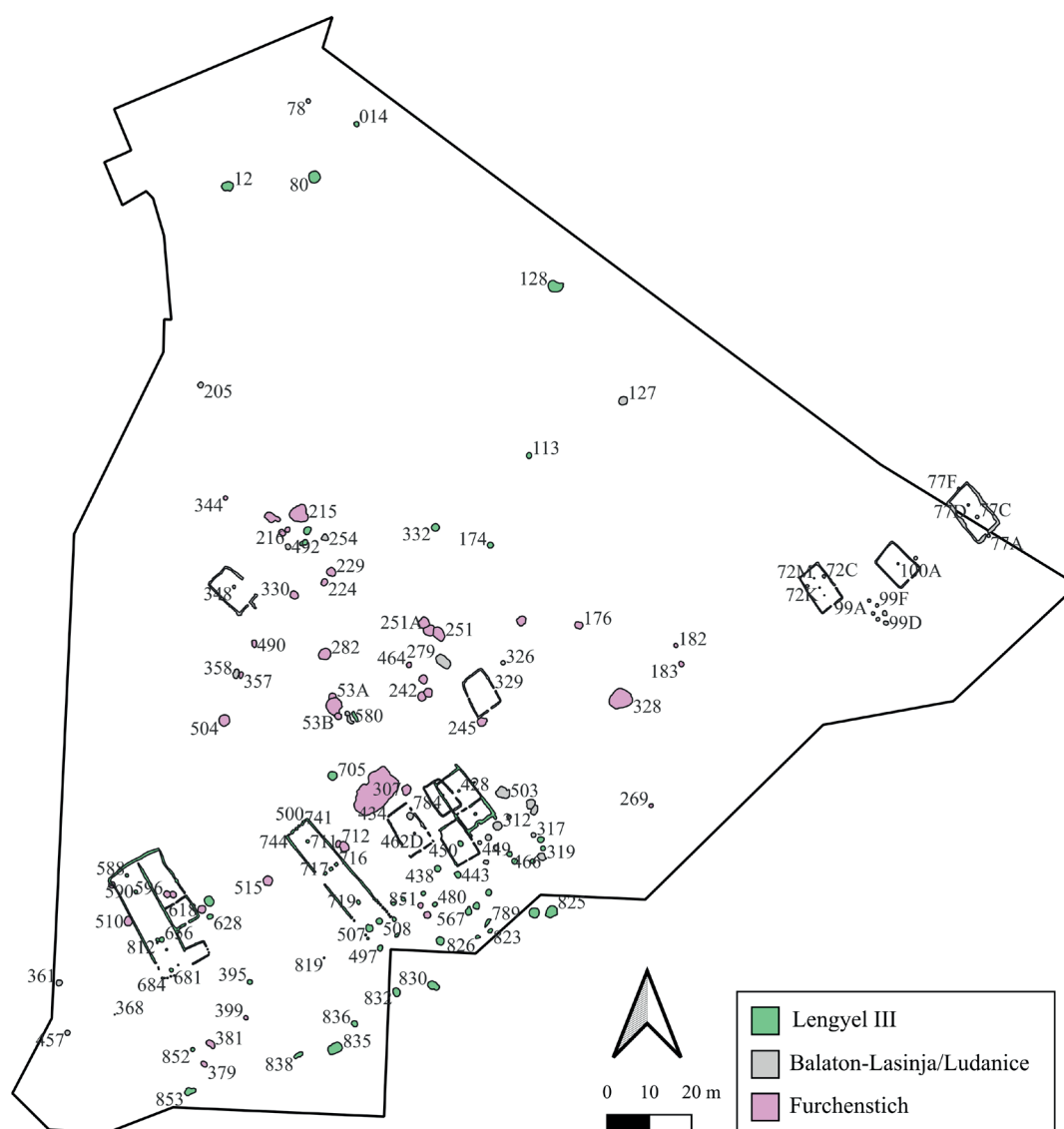


Fig. 6. Map of Győr-Szabadrétdomb.

23 M. VIRÁG – FIGLER 2007; M. VIRÁG *et al.* 2025.

Method

The study focuses on the examination of pottery forming and surface treatment. The pottery forming can be separated into two phases: roughing-out (i.e. basic shape is formed) and preforming (i.e. final form is obtained).²⁴ One or the ordered sequences of several different forming techniques can be used to build a vessel. This can be called the forming method of the vessels.²⁵

The analytical method of the pottery technological study focuses on identifying macroscopic features, i.e. the traces of forming and surface treatment that are visible to the naked eye. This includes the observation of the surface topography, variation in wall thickness, lines of fractures, and internal structure.²⁶ The identified techniques and methods can be interpreted with different ethnographic and experimental reference works, where not only the traces but also the manufacturing process have been observed.²⁷ However, occasionally, the preliminary technological hypothesis cannot be reinforced due to the lack of references. In these cases, it is important to carry out our own experiments that specifically investigate the problem that has arisen. Thus, the preliminary assumptions can be confirmed or rejected.

Tab. 2. Forming methods and their variants on the analysed sites.

Method	Variant	Győr-Szabadrétdomb	Magyaregres-Varga-Bonyi-ároktól keletre	Tikos-Nyárfás-dűlő	Zalavár-Basasziget
1	–	3	3	0	0
2	2.1	4	7	5	55
	2.2	0	3	6	0
	unknown neck or rim	0	7	9	0
3	–	0	8	0	0
4	–	4	10	0	6

Similar to previous studies,²⁸ the definition of forming methods was based on the roughing-out techniques of five distinct vessel parts: pedestal, base, body, neck, and rim.²⁹ However, the highly fragmented state of preservation of pottery vessels does not always allow the reconstruction of the whole forming method. Furthermore, we were able to identify two variants of one of the methods. Traces of preforming can only be observed on one analysed vessel. Therefore, it will only be mentioned under the relevant forming method, but cannot be considered a separate method or variant.

Surface treatment techniques can be applied before or after firing. However, the post-firing treatments were difficult to distinguish from the use-wear of the vessels,³⁰ and they can frequently disappear due to abrasion during usage, post-depositional, or post-excavation processes.³¹ Therefore,

24 RYE 1981; ROUX 1994; PIERRET 1995; MARTINEAU 2000; GOSSELAIN 2002; LIVINGSTONE SMITH 2007; GAL-LAY 2012; ROUX 2019; SOLNAY 2021.

25 ROUX 2019, 41; SOLNAY – SZILÁGYI 2024, 5.

26 PIERRET 1995; LIVINGSTONE SMITH 2010; GOMART 2014a; ROUX 2019.

27 SMITH – CRÉPEAU 1983; GELBERT 2003; GILIGNY 2010; GOMART 2014a; ROUX 2019; DÍAZ BONILLA *et al.* 2020; SOLNAY 2021.

28 SOLNAY – SZILÁGYI 2024; SOLNAY *et al.* 2025.

29 The alignment of plastic applications (i.e., knobs and lugs) is not diagnostic in the material.

30 DRIEU 2017.

31 SKIBO – SCHIFFER 1987; MARITAN 2020.

only the pre-firing surface treatment techniques with characteristic macrotraces were analysed, although it is always important to keep the taphonomic loss in mind.

Results

Forming methods

In total, four different forming methods (with some variants) were detected: 1) bottom-up coiling without a support, 2) coiling in/on a support, 3) moulding and coiling, and 4) modelling (Tab. 2). In the case of coiling, the potters could have applied 1) stretched, 2) superposed, or 3) superposed pre-flattened (i.e. band-like³²) coils (Tab. 3). One preforming technique, shaving was also observed, along with two surface treatment techniques: 1) burnishing and 2) coarse slip (Tab. 4). See the supplementary material for the technological data of each analysed vessel.

Tab. 3. Coiling processes and configurations on the analysed sites.

Coiling process	Configuration of coils	Győr-Szabadrét-domb	Magyaregres-Varga-Bonyi-ároktól keletre	Tikos-Nyárfás-dűlő	Zalavár-Basasziget
Stretched coils (originally circular cross-section)	Inward oblique	2	3	2	0
	S–Z-shaped	0	5	2	0
Superposed coils (originally circular cross-section)	O-shaped	4	3	0	3
Pre-flattened, superposed coils	Mainly horizontal	0	5	3	30

Forming method 1

Forming method 1 (6 vessels) consists of bottom-up coiled bodies, necks, and rims³³ from Magyaregres-Varga-Bonyi-ároktól keletre and Győr-Szabadrét-domb (Fig. 7.1). This is supported by the characteristic undulations or the horizontal lines of fractures on the inner and outer surfaces of the vessels. The internal structure of the body was inward oblique, indicating stretched coils that were attached from an inward oblique direction. The forming technique of the base is unknown, but bottom-up coiled necks can be identified, depending on the morphology of the vessel. The internal structure of the neck can also be inward oblique or O-shaped, suggesting the stretched or superposed attachments of the originally rounded cross-sectioned coils. Furthermore, on one occasion, the O-shaped internal structure of the rim implied that superposed, non-deformed coils were attached to the body (from stretched coils) to form the rim.

The single preformed vessel in the analysed assemblages (from Győr-Szabadrét-domb) was also made with this forming method (Fig. 8). Longitudinal flat stripes were found on the inner surface of this vessel. These suggest that the surface was shaved after the roughing-out.³⁴

32 GUCSI 2021.

33 RYE 1981, 68; MARTINEAU 2000, 157–160; GOSSELAIN 2002, 106–115; BOSQUET *et al.* 2005; LIVINGSTONE SMITH 2007, 102–103; GOMART 2014a, 61; ROUX 2019, 54–58; SOLNAY 2021, 203–204; SOLNAY – SZILÁGYI 2024, 6,9; SOLNAY *et al.* 2025, 6.

34 RYE 1981, 86–87; GOSSELAIN 2002, 202; BERG 2008, 1185; MAYOR 2010, 653; VAN DOOSSELAERE 2010, 289; ROUX 2019, 64; SOLNAY *et al.* 2025, 9.

Tab. 4. Surface treatment techniques on the analysed sites.

Surface treatment technique	Győr-Szabadrétdomb	Magyaregres-Varga-Bonyi-árokától keletre	Tikos-Nyárfás-dűlő	Zalavár-Basasziget
1	1	7	2	20
2	0	0	1	0

Forming method 2

Forming method 2 (96 vessels) consists of vessels with a separately formed base that was pressed in/on a support and a coiled body that was also built in/on a support (Figs 9–10).³⁵ The base is often broken off from the body, and its internal structure is homogeneous or laminar, which suggests that it was probably made of one or multiple superposed clay discs. Both surfaces of the bodies are generally homogeneous, i.e. lacking macroscopic traces, which may, however, be the result of severe abrasion observed on the majority of vessels. The outer surface of the less abraded vessels is more uneven than the inner surface. The most commonly observed traces on the body are the repetitive horizontal lines of fractures. Two types of internal structure can be separated. First, an O-shaped internal structure can be found, suggesting that superposed, non-deformed coils were applied. Second, the mainly horizontal, occasionally slightly U-shaped, or very slightly oblique configurations were observed. In this case, the internal structure is often difficult to describe if the mainly horizontal fissures are not visible. Moreover, the fissures are generally sparse on the internal structure of these vessels, repeating every 2–5 cm. This indicates that the coils were flattened before forming, in contrast to Forming method 1, and it can be supposed that they were attached together in/on the support, without significant overlap. Therefore, this can be called pre-flattened coiling.³⁶

However, the absence of ethnoarchaeological references for this hypothesis requires the experimental verification of this specific technique. Therefore, we made an experimental vessel from four pre-flattened coils with rounded edges (width: 3–3.5 cm, thickness: 1.2 cm) from a commercially available, natural earthenware body (Fig. 11). The clay used in the experiment was mined in Kishajmás (Baranya County, Southern Transdanubia). Its total shrinkage after drying and firing is approximately 8–9%. The shape of the vessel was a wide, hemispherical bowl, which often appears in the studied material. We placed four pre-flattened coils on top of each other in a reversed position, without overlapping, on a support (another vessel). We formed the base from a rounded disc that was placed on top of the form after the last coil. We worked together the coils by fingers using diagonally upward movements from the rim towards the base, applying only the minimal pressure necessary to conceal the joints and achieve a relatively even surface (Fig. 11.1–5). After, we left the vessel to dry for one and a half hours, which was sufficient for the mould to be removed and the pot to maintain stability, while the inside surface remained workable. The inner surface was regularised with diagonally downward movements of the fingers from the rim towards the base. The dried vessel was fired at 750 °C in a Rohde TE 50 QS electric kiln. Afterwards, the vessel was documented and then broken so that we could observe its internal structure. The breakage was carried out by dropping the vessel from a height of about one meter onto a flat concrete surface, with the base facing downwards.

Similarly to the Copper Age vessels, the outer surface of the fired experimental vessel appeared more uneven than the inner one, though slight undulation was observed on both surfaces. However, it is possible that the undulation could not be observed on the Transdanubian vessels due to

35 SOLNAY *et al.* 2025, 6, 9.

36 GUCSI 2021.



Fig. 7. Macrotraces of 1 – coiling technique without support (Forming method 1) from Magyaregres-Varga-Bonyi ároktól keletre, 2 – modelling the entire vessel (Forming method 4) from Magyaregres-Varga-Bonyi ároktól keletre, 3 – modelling the entire vessel (Forming method 4) from Győr-Szabadrétdomb.

the severe abrasion of the pottery surfaces. A horizontal line of fissure was already visible after drying between the base and the first pre-flattened coil, along which the vessel subsequently fractured completely in two. However, the other lines of fractures did not form along the coils, unlike several archaeological vessels. This suggests that it was indeed possible to produce strong, durable vessels using this seemingly weak coiling process. It is possible that the difference in fragmentation between Transdanubian and experimental vessels may be caused by the severe abrasion of the materials from Transdanubia, especially from Zalavár-Basasziget, which significantly weakened the structural integrity of the otherwise well-formed vessel. The internal structure was mainly horizontal or slightly U-shaped, similarly to the archaeological vessels. This pattern was more visible on the experimental, than the Copper Age material, but this can probably be explained by minor differences in the composition or the moisture content of the raw material.

Therefore, the experiment supported our preliminary hypothesis that it is possible to build a vessel from pre-flattened coils that were attached without significant overlap. Furthermore, our hypothesis of the application of support is reinforced by the difference between the inner and outer surfaces (more even and uneven). It is also likely that such wider vessels with a significantly flaring profile would be difficult to create without support. While it cannot be entirely excluded that a highly experienced potter could produce these vessels without support, it should be noted that vessels larger than our experimental samples have also frequently occurred, which would necessitate the use of even more rows of pre-flattened coils.

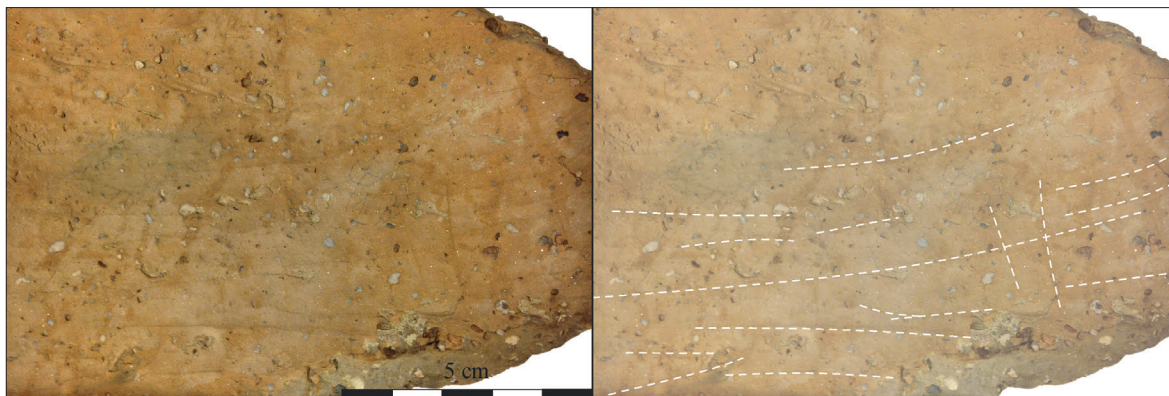


Fig. 8. Macrotraces of shaving from Győr-Szabadrétdomb.

Two variants of this method can be separated based on the forming of the neck or rim. Variant 2.1 was the most common (71 vessels), where no further elements were added to the vessels (Fig. 9.1, Fig. 9.3). This can be identified in every analysed settlement. In contrast, Variant 2.2 contains those vessels where an additional, bottom-up coiled neck or rim was attached to the body (9 vessels) (Fig. 10.2). This was indicated by the undulation, longitudinal depressions, and bulges on the inner and outer surfaces, and the inward oblique or S–Z-shaped internal structure (stretched coils). Variant 2.2 only known from Magyaregres-Varga-Bonyi-árokától keletre and Tikos-Nyárfás-dűlő. Furthermore, in a few cases (16 vessels) from these sites, the variant cannot be determined in the absence of the neck or rim.

Forming method 3

In Forming method 3 (8 vessels), that can only be detected at Magyaregres-Varga-Bonyi-árokától keletre, the body of the vessels were moulded, while the rim was coiled (Fig. 12).³⁷ This can be assumed by the homogeneous inner, outer, and internal surfaces of the body, as well as the inward oblique, horizontal, S–Z- or O-shaped internal structure of the rim. The latter suggests that the rim can be formed with three different coiling processes: 1) stretched coils, superposed, 2) pre-flattened coils, or 3) superposed coils with originally circular cross-section.

Forming method 4

Forming method 4 (20 vessels) includes modelled vessels (i.e. pinching or drawing)³⁸ from every site except Tikos-Nyárfás-dűlő (Fig. 7.2–3). This was indicated by the several characteristic oval and circular depressions on the inner and outer surface, as well as the homogeneous internal structure.

37 RYE 1981, 81; HUYSECOM 1994, 39, 43; GOSSELAIN 2002, 88–90; LIVINGSTONE SMITH 2007, 106; MANEM 2008, 45; ROUX 2019, 61; SOLNAY 2021, 207, 209; FÜZESI 2023, 170–173; SOLNAY *et al.* 2023, 15; SOLNAY – SZILÁGYI 2024, 9–10; SOLNAY *et al.* 2025, 9.

38 RYE 1981, 81; GOSSELAIN 2002, 86, 88; LIVINGSTONE SMITH 2007, 101–105; ROUX 2019, 60–61; SOLNAY 2021, 207; SOLNAY *et al.* 2023, 15.



Fig. 9. Macrotraces of coiling in/on a support (Forming method 2). 1 – vessel without additional bottom-up coiled elements (Variant 2.1) from Zalavár-Basasziget, 2 – vessel from Zalavár-Basasziget (neck/rim is unknown), 3 – vessel without additional bottom-up coiled elements (Variant 2.1) from Magyaregres-Varga-Bonyi ároktól keletre, 4 – vessel from Magyaregres-Varga-Bonyi ároktól keletre (neck/rim is unknown).

Coiling processes and configurations

In total, four configurations of the coils were identified on the vessels made with Forming methods 1, 2, and 3. From these, three coiling processes were reconstructed, of which at least two were used at the same settlement. However, these processes are never combined on the same vessel.

S-Z-shaped and inward oblique configurations suggest originally circular cross-sectioned coils that were stretched during forming. These were found on every site except Zalavár-Basasziget, while László Gucsi also observed this coiling process at the Early Copper Age Zamárdi-Kútvölgyi dűlő site.³⁹

39 GUCSI 2006, 9.

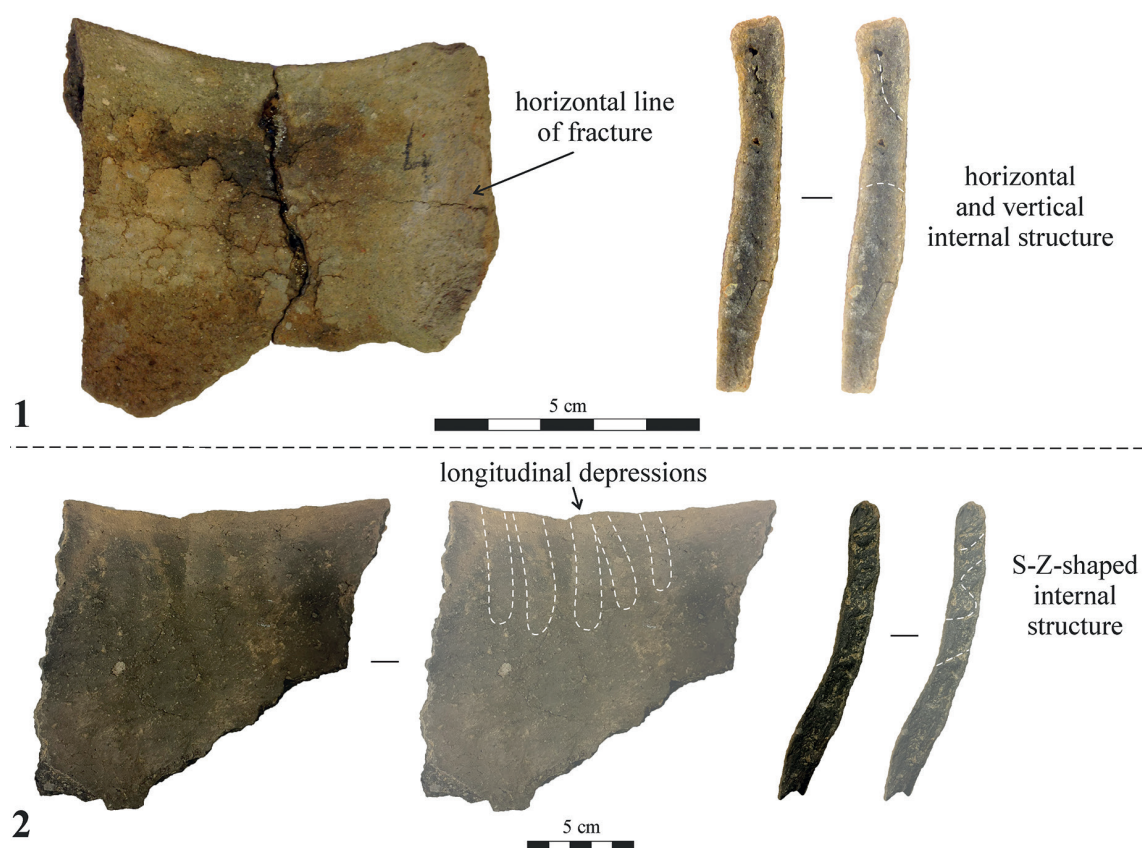


Fig. 10. Macrotraces of coiling in/on a support (Forming method 2). 1 – vessel without additional bottom-up coiled elements (Variant 2.1) from Zalavár-Basasziget, 2 – neck from additional bottom-up coils (Variant 2.2) from Tikos-Nyárfás-dűlő.

O-shaped internal structure also implies originally circular cross-sectioned coils, which were placed on top of each other in a superposed position, without strong deformation of the coils. This coiling process was also found on every site except Tikos-Nyárfás-dűlő. László Gucsi also identified this coiling process at the previously mentioned Zamárdi-Kútvölgyi dűlő site.⁴⁰

Widely spaced horizontal configurations refer to pre-flattened coils that were placed on top of each other in a superposed position. This process was also identified at every site except Győr-Szabad-rét-domb. Tünde Horváth also detected this coiling process at the Middle Copper Age Balatonőszöd-Temetői dűlő site.⁴¹

Due to the relatively low number of diagnostic vessels, it is generally not possible to determine unequivocally whether a main coiling process existed at each settlement. Zalavár-Basasziget was the only site where pre-flattened coils were more dominant than superposed coils.

Surface treatment techniques

Surface treatment technique 1 (30 vessels) characterised by entirely or partially shining inner or outer surfaces, mainly with thin, shallow striations, which suggest burnishing⁴² (Fig. 13.1).⁴³ This

⁴⁰ GUCSI 2006, 14, 2. kép 9.

⁴¹ HORVÁTH 2010, 61, Fig. 5.3–4, 62.

⁴² The use of the term burnishing, alongside or instead of polishing, was explained in another publication (SOLNAY *et al.* 2025, 13).

⁴³ RYE 1981, 90; BALFET *et al.* 1983, 87; BINDER *et al.* 1994, 259; ROUX 2019, 96; IONESCU *et al.* 2015; IONESCU *et al.* 2019; IONESCU – HOECK 2020; DUBREUIL *et al.* 2023.

technique was found on every settlement. Generally, the inner surface had fewer traces of burnishing (19 vessels) than the outer surface (26 vessels). However, this phenomenon can be explained by, for example, aesthetic reasons or the abrasion of the surface during usage or after deposition.

Surface treatment technique 2 (1 vessel) was observed on the outer surface of a Middle Copper Age vessel from Tikos-Nyárfás-dűlő that was covered by an additional layer of coarse clay (i.e. *Schlickwurf*) (Fig. 13.2).

FORMING PROCESS



MACROTRACES

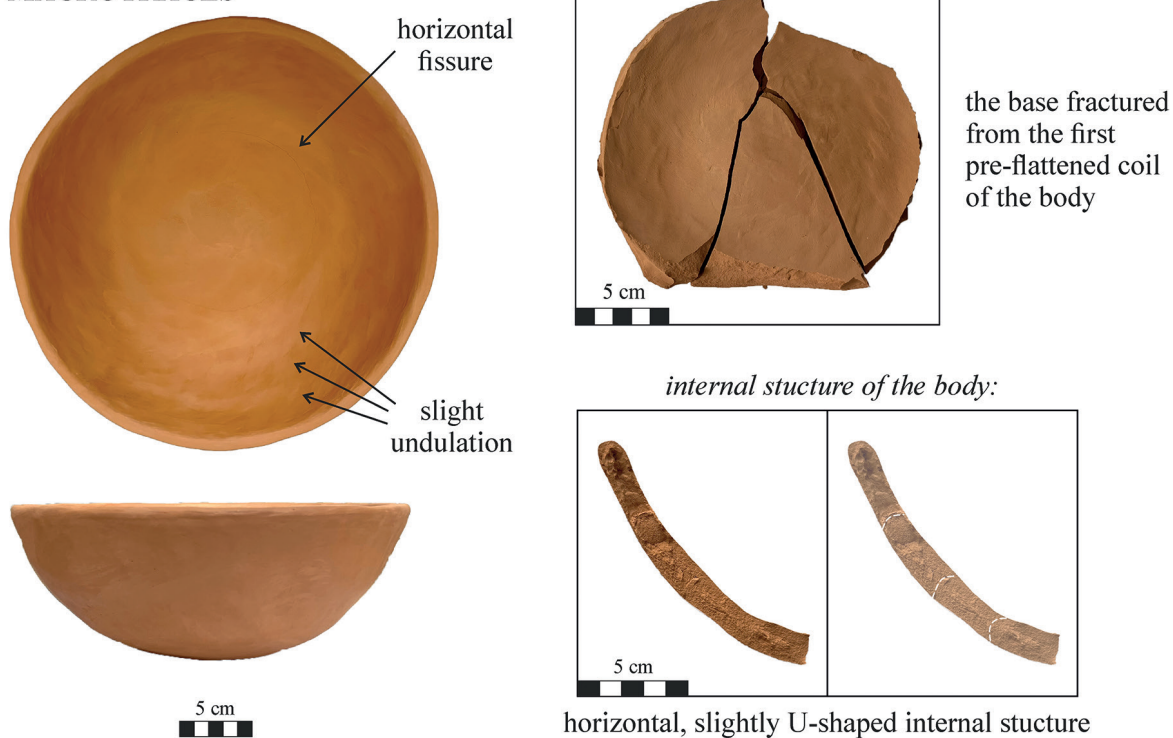


Fig. 11. Forming process and macrotraces of the experimental vessel from pre-flattened coils in superposition, without overlap. The figures present the vessel before and after the intentional break.

Technology and vessel forms

Previous studies testified that technological choices are often influenced by the form of the vessels.⁴⁴ Therefore, technological results had to be complemented by the comparison of the technology and typology. To avoid the frequently arising issues of typological nomenclature, the analysis was conducted at the level of vessel categories (i.e. bowl), without addressing detailed types (i.e. biconical bowl).

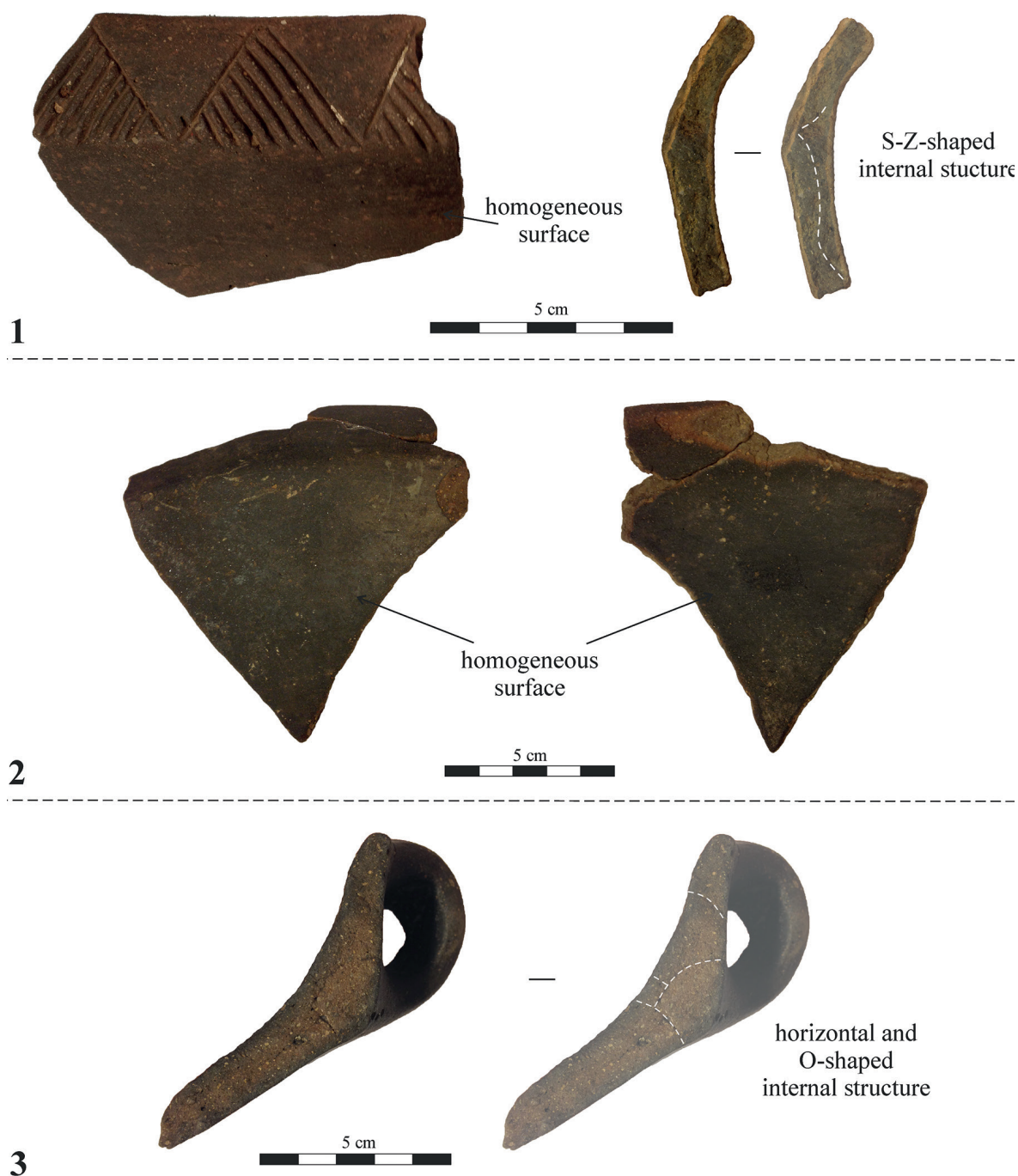


Fig. 12. Macrotraces of moulding (Forming method 3) of three different vessels from Magyaregres-Varga-Bonyi ároktól keletre.

⁴⁴ ARNOLD 1989, 34; SOLNAY – SZILÁGYI 2024, 10–12; SOLNAY et al. 2025, 13.

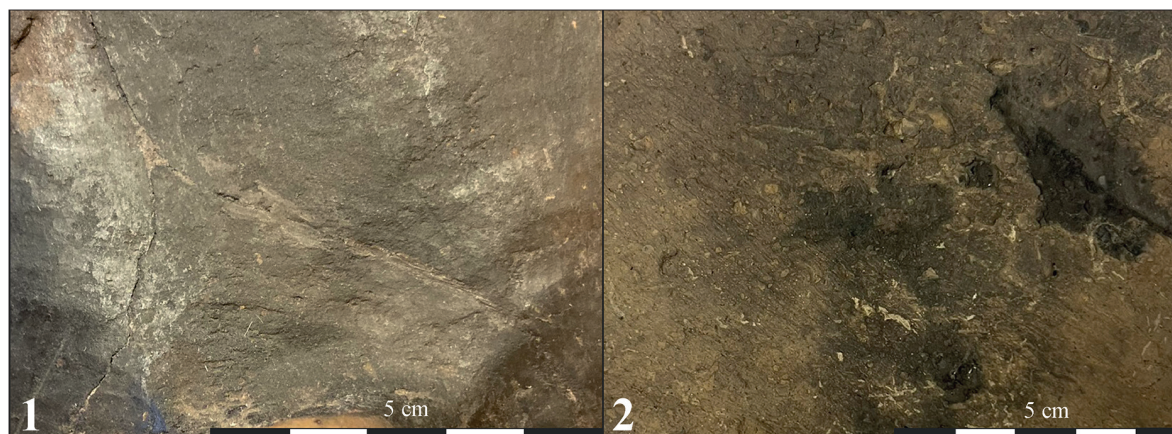


Fig. 13. Macrotraces of the surface treatment techniques. 1 – Burnishing (Surface treatment technique 1) from Magyaregres-Varga-Bonyi ároktól keletre, 2 – coarse slip (Surface treatment technique 2) from Tikos-Nyárfás-dűlő.

The most common forming method, the coiling in/on a support (Forming method 2), was used to create a large variety of vessels: bowls, pots, storage vessels, two cups, and a strainer, as well as coarse wares, fine wares, and bases whose exact form could not be reconstructed (Fig. 14). Both variants were presumably used to form all these vessel categories, although the variant with an additional, bottom-up coiled neck or rim (Variant 2.2) cannot be identified on cups, strainers, coarse wares, and bowls. However, this can probably be explained by the low number of vessels. Bottom-up coiling without support (Forming method 1) was also observed on a few of these vessel categories: a bowl, a cup, pots, and coarse wares of unknown form.

In contrast, moulding and coiling (Forming method 3) was only used to create bowls. Similarly, modelling (Forming method 4) was solely identified on ladles and a miniature bowl.

Burnishing (Surface treatment technique 1) was found on almost every studied vessel category: bowls, pots, ladles, coarse wares, fine wares, and bases (the form of the latter three is unknown), as well as a cup and a ladle. Therefore, it was used on both coarse and fine vessels.

By contrast, coarse slip (Surface treatment technique 2) was only detected on a storage vessel. However, further conclusions cannot be drawn from this sole diagnostic vessel.

Discussion

Four forming methods (i.e. bottom-up coiling technique without a support, coiling with a support, moulding, and modelling), two variants of a forming method (i.e. coiling in/on a support with or without additional coils to form the neck or rim) (Fig. 15), three coiling processes (i.e. stretched coils with originally circular cross-section, superposed coils with originally circular cross-section, and pre-flattened coils) (Fig. 16), and two surface treatment techniques (i.e. burnishing and coarse slip) (Fig. 17) were identified in the analysed Transdanubian settlements. The intra-site spatial distribution of the forming methods, coiling processes and configurations, as well as the surface treatment techniques does not show any characteristic pattern, possibly because of the low number of diagnostic vessels. Therefore, we focused on the regional analyses.

Based on our observations, we can assume that most Early and Middle Copper Age potters on the studied Transdanubian settlements used two different forming methods to produce their primary vessel repertoire. Both the coarse and fine wares, e.g. bowls, cups, pots, storage vessels, and strainers, were made with coiling in/on a support (Forming method 2), while the ladles and the few miniature bowls were formed with modelling (Forming method 4). These methods can be found on every site (except

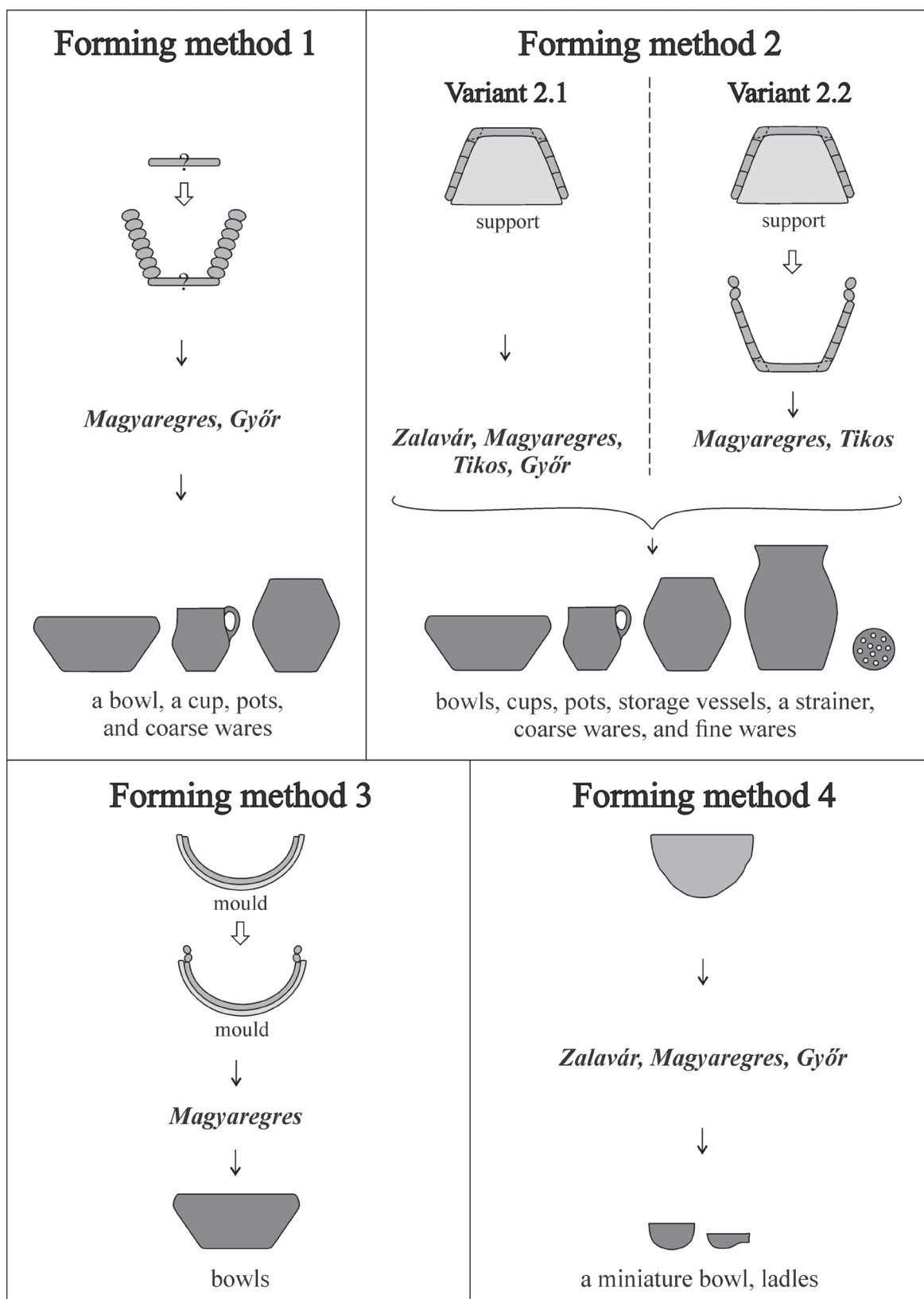


Fig. 14. *Chaîne opératoire* of each forming method and variant, the settlements where they occurred, and the resulting vessel categories.

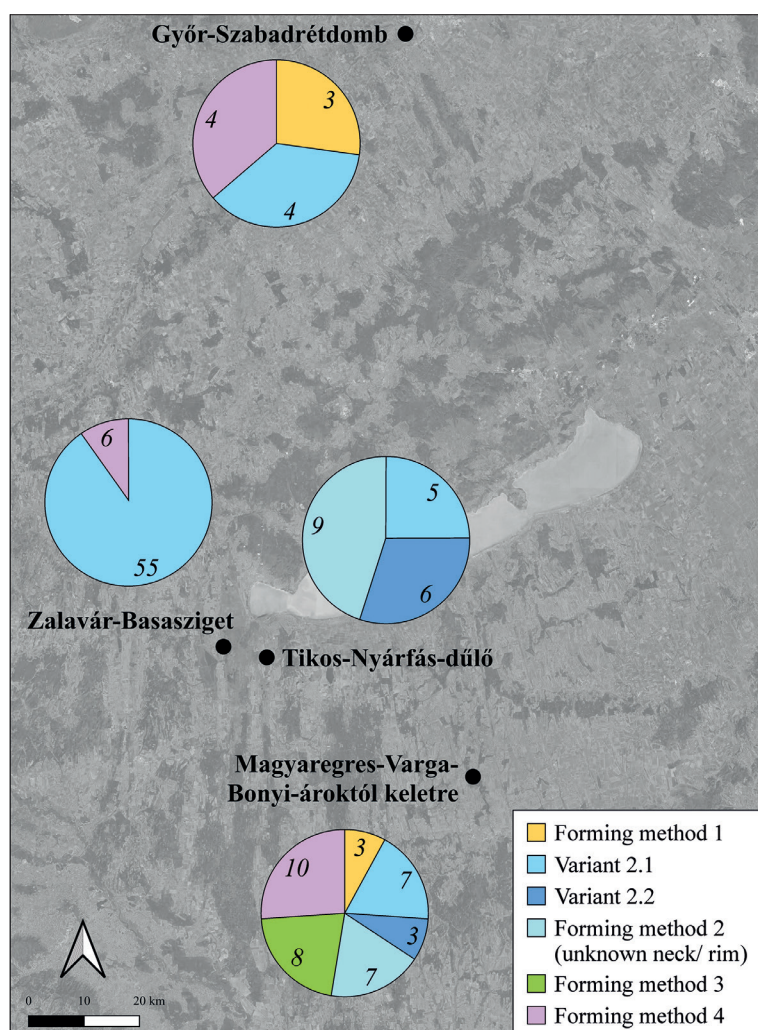


Fig. 15. Identified forming methods and variants per site.

tion in the region.⁴⁶ However, the present study revealed that pre-flattened coils have already appeared in other sites in the region (i.e. Zalavár-Basasziget, Magyaregres-Varga-Bonyi ároktól keletre, and Tikos-Nyárfás-dűlő). Only the examination of additional sites will reveal whether these differences (i.e. quantitative distribution, absence from Győr-Szabadrétdomb) reflect true differences in technological traditions, or only the result of the limited sample size or other distorting factors.

The petrographic analysis suggests that the Transdanubian vessels were possibly made locally in every settlement.⁴⁷ Therefore, it is likely that potters familiar with this common technical tradition were present at every studied site. This implies that these potters were socially connected by being part of the same community of practice. Despite the considerable similarities in material culture, this is the first direct evidence of social connections based on strong personal interactions among certain individuals living in different settlements. This does not necessarily imply direct contact between contemporaneous potters living in different settlements, but rather that their shared practices connected them within a network sustained by personal relationships. However, the nature and strength of these relationships may have been highly variable,⁴⁸ which cannot be answered by purely pottery techno-

modelling at Tikos-Nyárfás-dűlő due to the absence of related pottery categories), suggesting a common technical knowledge, i.e. technical tradition, in Transdanubia. In this framework, the two variants of coiling in/on a support may be interpreted as local variabilities that evolved within the common technical tradition during the ca. 850 years examined. Burnishing (Surface treatment technique 1) could also be a part of this technical tradition, although it is also strongly connected with the visual and functional properties of the vessels.⁴⁵ By contrast, it remains uncertain whether some of the coiling processes were part of this technical tradition. The most frequent are the pre-flattened coils, but 4/5 of them were found at Zalavár-Basasziget, while they are missing from Győr-Szabadrétdomb. László Gucsi could also observe pre-flattened coils in Late Copper Age occupation at Zamárdi-Kútvölgyi dűlő, revealing the continuity of this tradi-

45 SOLNAY et al. 2023.

46 GUCSI 2006.

47 BALÁZS et al. 2024.

48 GOSSELAIN 2002, 23–27; ROUX 2010, 4,6.



Fig. 16. Identified coiling processes per site.

These results suggest that there were settlements where the potter(s) strictly followed the same technical tradition and did not adopt other methods or techniques. This phenomenon was described by several ethnoarchaeological studies.⁵³ The most striking example of this in Transdanubia is Zalavár-Basasziget, where almost no trace of variation can be observed, even though the settlement was

logical examinations. Although this community of practice can be found in both of the studied periods, it is important to note that a significantly lower number of Middle Copper Age vessels could be analysed than Early Copper Age vessels.

Moreover, certain technological features also appeared that were likely not part of this technical tradition. A few bowls, cups, and pots were formed with the bottom-up coiling technique without a support (Forming method 1) at Magyaregres-Varga-Bonyi ároktól keletre and Győr-Szabadrétdomb and further bowls with moulding (Forming method 4) at Magyaregres-Varga-Bonyi ároktól keletre. Furthermore, coarse slip (Surface treatment technique 2) also appeared at Tikos-Nyárfás-dűlő. These forming methods and the surface treatment technique were characteristic pottery-making practices in other regions, i.e. the Great Hungarian Plain⁴⁹ and the Budapest Region,⁵⁰ which connects the Transdanubia with the other parts of the Carpathian Basin. Thus, it can be assumed that these were part of another, probably non-local technical tradition,⁵¹ which appears only sporadically at the analysed Transdanubian settlements. Therefore, it is possible that some potters on a few Transdanubian sites were part of other communities of practice. Moreover, the reason behind the appearance of the stretched and superposed coils (both from originally rounded cross-sectioned coils) remained obscure. These not only occurred in most Transdanubian sites, but they were common in other parts of the Carpathian Basin as well.⁵²

These results suggest that there were settlements where the potter(s) strictly followed the same technical tradition and did not adopt other methods or techniques. This phenomenon was described by several ethnoarchaeological studies.⁵³ The most striking example of this in Transdanubia is Zalavár-Basasziget, where almost no trace of variation can be observed, even though the settlement was

49 BOGNÁR-KUTZIÁN 1979, 55, Abb. 11; PATAY 1979, 45, Abb. 18.2,4; PATAY 2005; SOLNAY 2022, 202; SOLNAY *et al.* 2023, 15; SOLNAY – SZILÁGYI 2024; SOLNAY 2025.

50 SOLNAY *et al.* 2025.

51 SOLNAY 2025; SOLNAY *et al.* 2025.

52 SOLNAY 2022; SOLNAY – SZILÁGYI 2024; SOLNAY *et al.* 2025.

53 E.g. GALLAY 1994; GELBERT 2003; ROUX 2013; CAULIEZ *et al.* 2017; ROUX *et al.* 2017; GARCÍA-SOTO *et al.* 2024.

possibly used continuously through multiple phases, with numerous houses.⁵⁴ Therefore, it is highly unlikely that only one potter created all these vessels, even if the high degree of homogeneity might suggest otherwise.

In contrast, another contemporaneous settlement, Magyaregres-Varga-Bonyi ároktól keletre, displayed a significantly greater degree of technological variability, as numerous other technological elements appeared alongside the common technical tradition (i.e. bottom-up coiling without a support, moulding, both variants of the coiling in/on a support, as well as numerous coiling processes and configurations). This suggests that multiple potters created the vessels, some of which were in the possession of non-local technical knowledge. This phenomenon was observed in numerous other studies.⁵⁵ This conclusion corresponds well with the radiocarbon dating and at least two building phases of the settlement,⁵⁶ although a characteristic intra-site spatial distribution of technological traits cannot be observed.

The technological dynamics of Tikos-Nyárfás-dűlő and Győr-Szabadrétdomb are more difficult to determine due to the low number of diagnostic vessels compared to the long, multiperiod occupation of the settlements (i.e. Early and Middle Copper Age). Although both sites showed technological diversity, besides or in the framework of the common technical tradition, they cannot be associated with any specific period. Therefore, most probably more than one potter worked on these settlements, some of which (but probably not all of them) certainly belonged to the same community of practice. At Győr-Szabadrétdomb, the presence of the bottom-up coiling technique without support probably implies potter(s) with wider technical knowledge.

Conclusion

We carried out the first systematic, regional analysis of the Early and Middle Copper Age pottery forming and surface treatment techniques in Transdanubia. The examination of the four sites revealed the application of four forming methods,

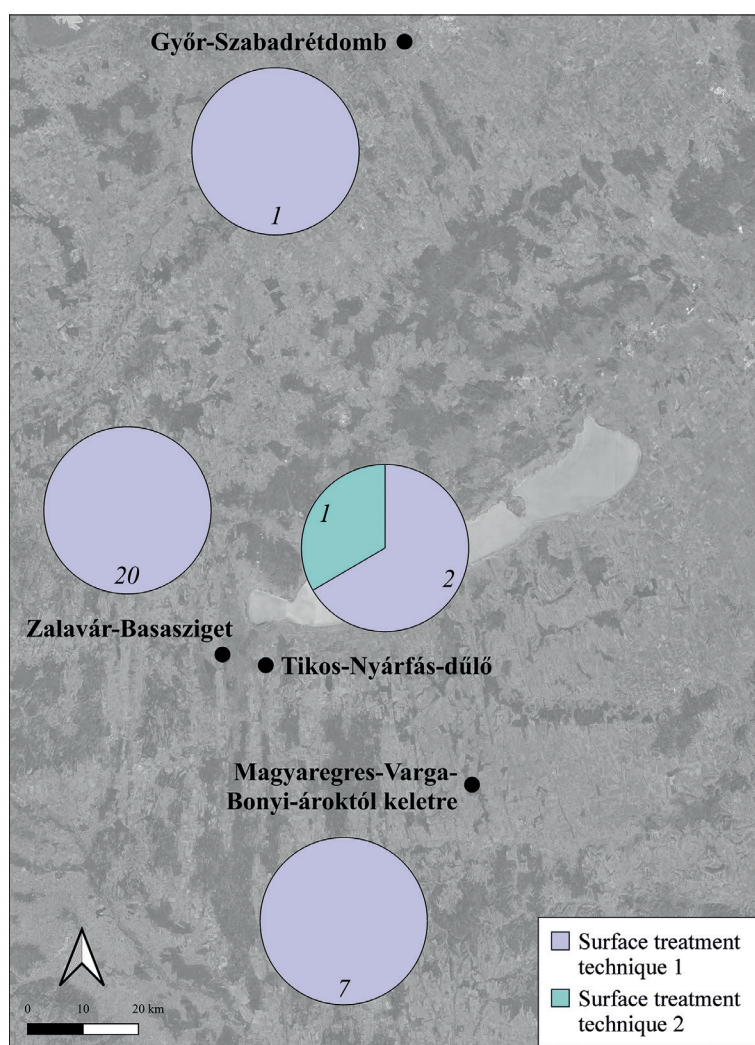


Fig. 17. Identified surface treatment techniques per site.

⁵⁴ E.g. M. VIRÁG 2005b, 37.

⁵⁵ GELBERT 2003; GOMART 2014a; KREITER *et al.* 2017; FRANK 2021.

⁵⁶ HORNOK – KISS 2017; SIKLÓSI *et al.* 2022, 13.

three coiling processes, and two surface treatment techniques. The principal technical tradition in the region constitutes a relatively restricted technological repertoire; most of the vessel categories were created with coiling in/on a support (Forming method 2), and the few other categories were made with modelling (Forming method 4). This can be identified on every site, regardless of the period or location. It is possible that other technological characteristics were also part of this technical tradition, i.e. the pre-flattened coils and burnishing (Surface treatment technique 1), which further studies can clarify. These results suggest that most potters belonged to the same community of practice, which is the first direct evidence that individuals in different settlements were part of the same social network based on strong personal relationships.

In contrast, the appearance of other forming methods on a few sites, e.g. bottom-up coiling technique without a support (Forming method 1) or moulding (Forming method 4), suggests that other technical knowledges existed besides the common technical tradition. It can be supposed that few potters were part of other communities of practice, which were dominant in other regions of the Carpathian Basin.⁵⁷

The different communities probably responded differently to the appearance of new technical knowledges. The potters in Zalavár-Basasziget strictly followed the same technical tradition; they did not adopt any other methods or techniques for many possible reasons (e.g. they did not know or intentionally rejected). However, in other sites like Magyaregres-Varga-Bonyi ároktól keletre, the appearance of other technological elements alongside the common technical tradition suggests more open communities where some potters possibly had a wide social network. Therefore, this study not only presents the first broader pottery technological analysis of the Early and Middle Copper Age Transdanubia, but also the first to underline the social networks of strong personal contacts in this period.

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Supplementary material

The technological data of the examined pottery vessels are available and can be referenced on the Zenodo platform: <https://doi.org/10.5281/zenodo.18412073>.

57 SOLNAY 2025; SOLNAY *et al.* 2025.

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