



The Early Chalcolithic and Late Chalcolithic at Sultana–Ghețarie site (southern Romania). A look from the pots

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ABSTRACT

This study examines two prehistoric pottery assemblages from the Sultana–Ghețarie site (southern Romania), excavated in 2021 from distinct contexts: an Early Chalcolithic pit (Boian–Vidra tradition, ca. 4950–4650 cal BC) and a Late Chalcolithic pit (Cernavodă III tradition, ca. 3650–3350 cal BC). Through macroscopic analysis and geochemical characterization (pXRF), the research investigates depositional, technological, and functional patterns, focusing on fragmentation, tempers, clay sources, forming methods, surface treatments, decoration, and firing techniques. The results reveal technological features shared by both assemblages that can be understood as common prehistoric practices and/or adaptations to local resources (e.g., the frequent use of grog temper in fine clays lacking sandy inclusions), alongside distinct vessel shapes, finishing practices, and decorative repertoires reflecting different cultural traditions. Functional patterns also diverge: the Early Chalcolithic repertoire was oriented toward vessels used for liquids, individual consumption, and food processing, while the Late Chalcolithic assemblage emphasized shared use, storage, and processing of solid materials. These findings highlight long-term adaptations to local resources, while also underscoring the technological and social transformations that accompanied shifting cultural horizons in the Lower Danube over a span of 1,500 years.

KEYWORDS

Boian–Vidra; Cernavoda III; ceramic technology; grog temper; pXRF analysis; Lower Danube prehistory

Introduction

Technological analysis of prehistoric pottery is essential for understanding craft traditions, resource use, and social practices of past humans, yet such approaches remain limited in southern Romania (Thissen 2017; Ignat et al. 2019; Koutouvaki et al. 2021; Stoicescu et al. 2023; Opriș 2025). Research has focused primarily on typology and relative chronology (Berciu 1961; Comșa 1967; 1974), leaving underexplored the technological choices that shaped ceramic production. This gap is particularly evident for two key moments in regional prehistory: the Early Chalcolithic (Boian–Vidra tradition, first part of the 5th millennium BC) (Comșa 1974; Opriș et al. 2017) and Late Chalcolithic (Cernavoda III tradition, mid–4th millennium BC) (Morintz, Roman 1968a; 1968b; Diamandi, Roman 2001; Oanță-Marghitu 2003), separated by almost 1,500 years and belonging to distinct cultural horizons.

This study follows the cultural–historical periodisation currently accepted in Romanian archaeol-

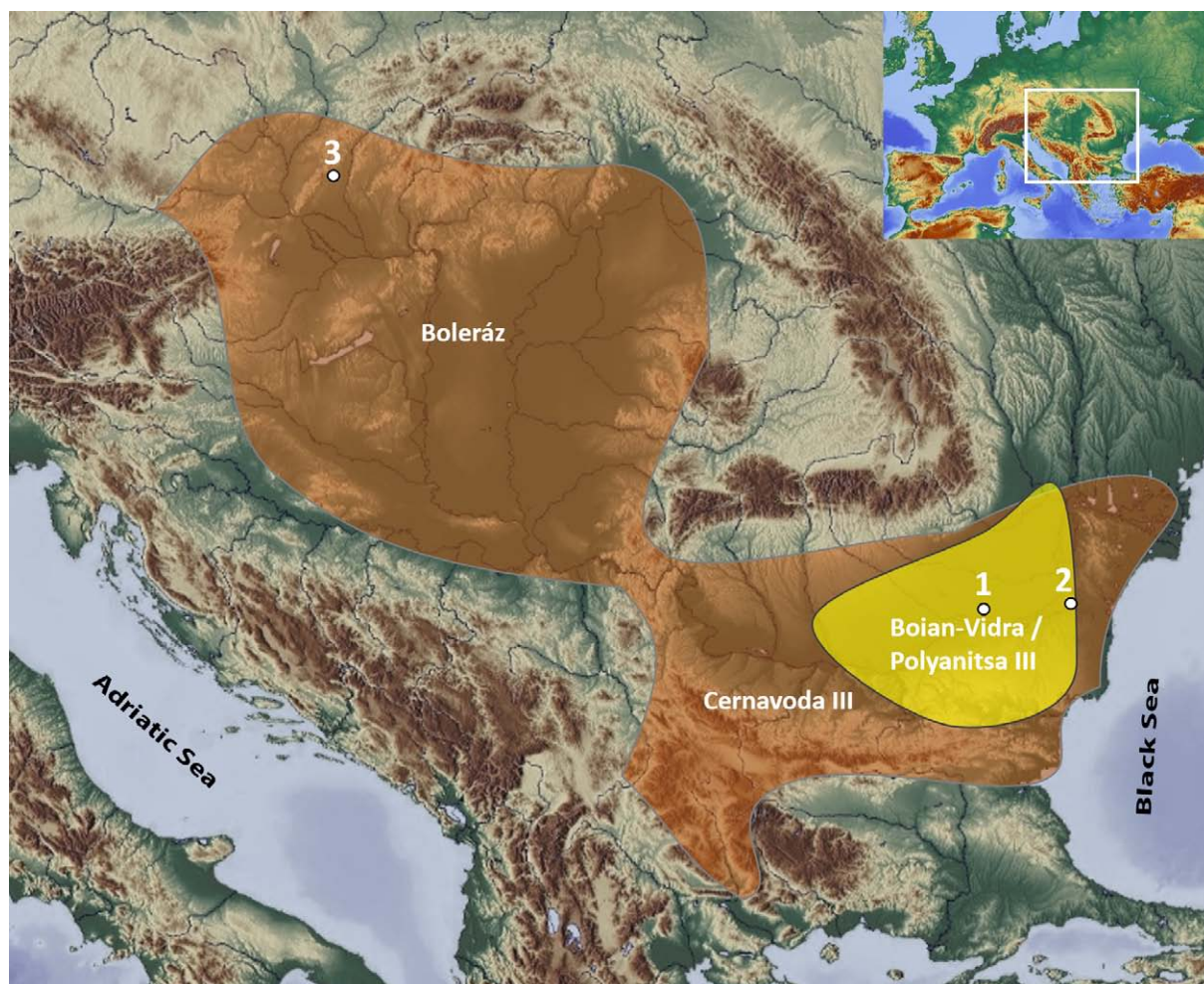


Fig. 1. Approximate spatial extent of Boian–Vidra/Polyanitsa III (yellow) and Cernavoda III–Boleráz (orange) cultural groups. The sites marked on the map: 1. Sultana–Ghețarie; 2. Cernavoda; 3. Boleráz (figure by V. Opreș using base map from <https://maps-for-free.com>)

ogy (Petrescu-Dîmbovița, Vulpe 2001), even though the same phases are classified differently in neighbouring regions. The Early Chalcolithic in southern Romania broadly corresponds to contemporaneous assemblages in northern Bulgaria but is designated as Late Neolithic in Serbia and Hungary. Likewise, the Cernavoda III culture, included in the so-called “Cernavoda III–Boleráz phenomenon”, is regarded in Romania as part of the Late Chalcolithic (Late Eneolithic/Aeneolithic, e.g., Late Copper Age) or, in older literature, the Transitional Period to the Bronze Age. In contrast, in Bulgaria, it is assigned to the Early Bronze Age, and in Serbia and Hungary, to the Middle or Late Chalcolithic (Oanță-Marghitu 2003, 110). In addition, this study adheres to the chronological and terminological conventions used in the most recent publication on the site (Hofmann et al. 2025), thereby maintaining internal consistency and facilitating the interpretation of intra-site contexts within their broader regional framework.

The ceramic assemblages – one of the key markers of these distinct cultural entities – show significant variation in both shapes and decoration. The Early Chalcolithic repertoire is characterised by fine black-burnished beakers, cylindrical pedestal vessels decorated with excised geometric motifs, and common holemouth pots (Comșa 1974; Opreș et al. 2017). These forms can be traced across a well-defined area of the Lower Danube region, encompassing southern and southeastern Romania and northern to northeastern Bulgaria (fig. 1). In southern Romania, they are attributed to the Boian culture, Vidra and Spanțov phases (Petrescu-Dîmbovița, Vulpe 2001), which display strong continuity with earlier local

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traditions. In northern Bulgaria, they are known as the Polyanitsa culture, phases III and IV (Naydenova 2010), likewise maintaining clear connections to preceding Polyanitsa phases and Karanovo III–IV culture.

By contrast, the origins, characteristics, and diffusion of Cernavodă III–Boleráz pottery style remain a subject of debate, as this ceramic tradition is documented across a wide area of the Middle and Lower Danube basin (Oanţă-Marghitu 2003; Bulatović, Kapuran 2016) (fig. 1). Features commonly regarded as diagnostic for Cernavodă III vessels include tunnel handles, fine black or greyish-black carinated plates and bowls, interior decoration with shallow vertical fluting, and exterior ornamentation with rows of pricks (Zmeykova 2001).

The 2021 excavations at Sultana–Gheţărie (SGH) (Hofmann et al. 2025) provide a rare opportunity to compare pottery from both periods, recovered from two successive pits (C40 – Boian–Vidra; C37 – Cernavoda III). A first overview of this material was presented in general terms by Hofmann et al. (2025). The present study goes further by examining and comparing raw materials, tempers, forming techniques, surface treatments, and firing practices in detail.

At first glance, juxtaposing ceramic assemblages separated by nearly 1,500 years may seem of limited interpretive value. There is no indication that the Early Chalcolithic community at SGH maintained direct cultural or genealogical continuity with the later Cernavodă III inhabitants. However, we argue that such a comparison is productive, as it highlights long-term adaptations to local resources, the persistence and transformation of prehistoric technological practices, and shifts in social and functional priorities embedded in pottery production. Beyond refining our understanding of ceramic traditions at Sultana, this approach situates southern Romania within broader trajectories of cultural change across the Lower Danube during the 5th and 4th millennia BC.

The site, contexts and chronology

The site at SGH is located in Southern Romania, on the right bank of Mostiştea Lake, at a distance of ca. 7 km from the Danube (fig. 1). From a topographical perspective, the site is located on a promontory of the high terrace of Lake Mostiştea, on its western side, at ca. 300 m to the west of the necropolis at Sultana–Malu Roşu (Lazăr et al. 2012). The geographical coordinates of the SGH are 44°15'37.83072" N and 26°51'47.93720" E, while the absolute elevation of the area occupied by the prehistoric settlement ranges between 44.891 m and 46.399 m, data reported in the STEREO 70 coordinate projection system and the Black Sea 1975 elevation system (Opriş, Lazăr 2014).

This prehistoric settlement has been known in the specialised literature for some time (Şerbănescu, Trohani 1978), though it had not previously been investigated archaeologically. Due to the accelerated erosion of the Mostiştea lake terrace caused by natural phenomena, a process amplified by the use of the site area for clay extraction by locals, several test trenches were carried out starting in 2008. In 2012 a systematic archaeological research was initiated, which continues to this day (Lazăr et al 2012; Opriş, Lazăr 2014; Hofmann et al. 2025) (fig. 2).

During the 2021 fieldwork at the SGH site, the majority of prehistoric pottery was recovered from two superimposed pits (Hofmann et al. 2025).

The first, investigated only partially, was designated as C37 (fig. 2). It was filled with dark-brown sediment (Stratigraphic Unit – SU 1077) containing pottery characteristic of the Cernavoda III tradition, alongside other materials such as animal bones, stones, and flint tools. Calibrated radiocarbon dates obtained from four animal bone samples collected from the backfill of pit C37 place its use between 3650 and 3350 cal BC (Table 1). Bayesian modelling of these dates refined the chronological resolution, suggesting multiple short episodes of use, with a brief interval around 3600 cal BC proposed as the most probable scenario (Hofmann et al. 2025, 55).

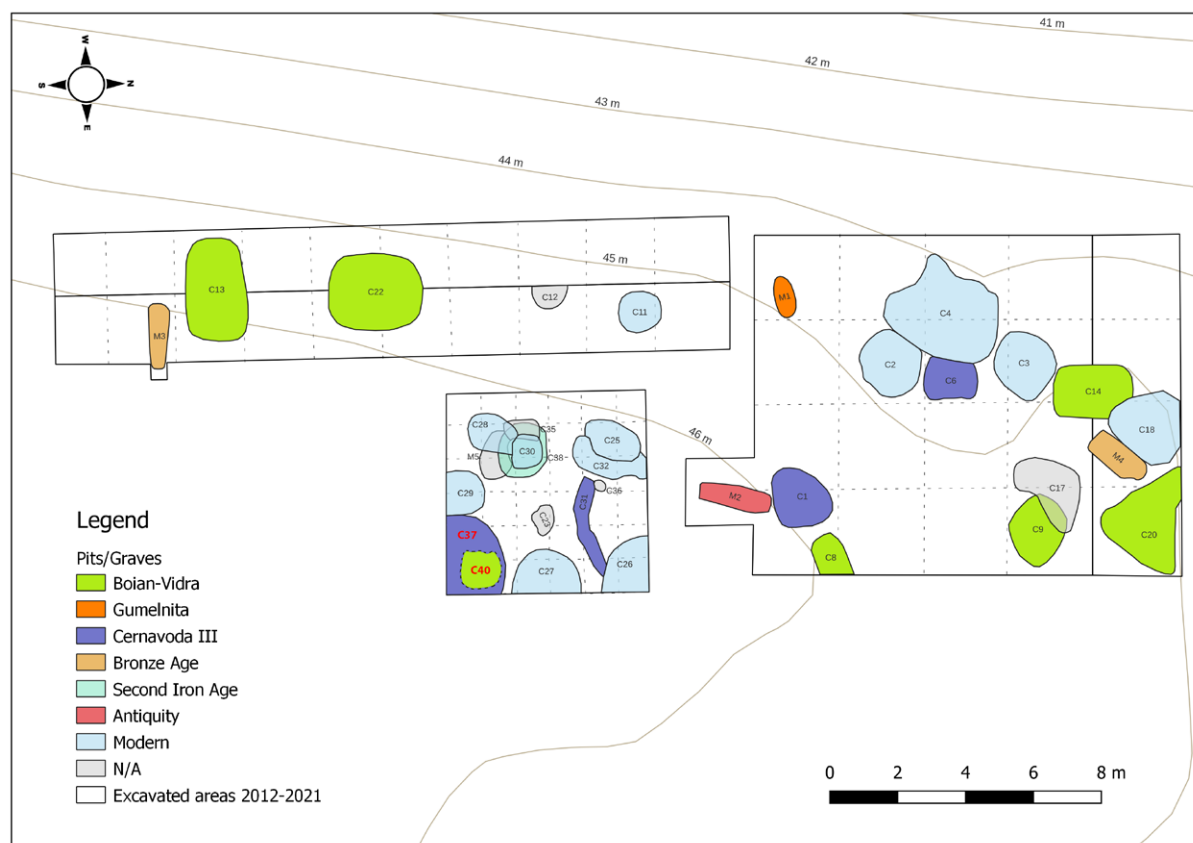


Fig. 2. Sultana–Gheșărie. General plan of the excavations with the relative dating of the archaeological features (plan by C. Covătaru, modified by V. Opreș)

Beneath C37, a smaller pit was identified and designated as C40. Its backfill (SU 1093) contained abundant fragmentary pottery of the Boian–Vidra tradition, along with a mixture of earth and ash in the lower section. Unfortunately, no suitable sample material (e.g., bones) was available for radiocarbon dating from pit C40 itself (Hofmann et al. 2025, 54). However, radiocarbon dates from two other refuse pits at SGH containing similar pottery place the Early Chalcolithic occupation of the site between 4950 and 4650 cal BC (Table 1).

Later materials from C37, including pottery sherds, were found in secondary deposition in animal burrows that disturbed the fill of C40. Also, Boian–Vidra sherds were identified in the fill of C37, most probably accidentally gathered from the Early Chalcolithic layers that cover the site surface. Given these issues of provenance, the sherds from disturbed contexts were excluded from the present analysis.

Materials and methods

The total number of pottery sherds from the pits C37 and C40 counted 332 fragments that after the restoration process formed 255 distinctive pieces, with a total weight of 7259 g (Table 2).

The methodology used for pottery analysis was the one applied in our previous macroscopical studies on fragmentary prehistoric pottery from sites at Sultana (Opreș et al. 2012; 2017), and Gumelnița (Lazăr et al. 2017; 2020; 2021). The quantified data on fragmentation, representation of body parts, size, weight, paste categories, tempers, forming techniques, shapes, decoration methods, firing, and use-wear traces was gathered for each ceramic sherd in a Microsoft Access database. To enable comparison of pottery attributes across the analysed assemblages, all numerical values were standardised as percent-

Lab. No.	Archaeological context	Period	Culture-Phase	Age_14C	SD (+/-)	BC 2σ (95.4%)	Sample type	Species	References
Poz-78730	Refuse pit C20	EC	Boian–Vidra	5970	40	4956–4729	bone	Bos taurus	Opriş et al. 2017, Tab. 1
Poz-78731	Refuse pit C13	EC	Boian–Vidra	5870	40	4839–4654	bone	Bos taurus	Opriş et al. 2017, Tab. 1
Poz-147008	Ditch C31	LC	Cernavoda III	4790	40	3646–3384	bone	Bos taurus	Hofmann et al. 2025, Tab. 10
Poz-147004	Refuse pit C37	LC	Cernavoda III	4730	40	3632–3376	bone	Bos taurus	Hofmann et al. 2025, Tab. 10
Poz-147006	Refuse pit C37	LC	Cernavoda III	4710	40	3629–3372	bone	Bos taurus	Hofmann et al. 2025, Tab. 10
Poz-147017	Refuse pit C37	LC	Cernavoda III	4720	40	3631–3373	bone	Bos taurus	Hofmann et al. 2025, Tab. 10
Poz-147097	Refuse pit C37	LC	Cernavoda III	4780	35	3641–3385	bone	Bos taurus	Hofmann et al. 2025, Tab. 10

Table 1. Available radiocarbon dates from Early Chalcolithic (EC) and Late Chalcolithic (LC) features from Sultana–Gheţărie Site

ages calculated against the total number of individual vessels within each batch.

Geochemical characterisation of the ceramic samples was carried out using a portable XRF spectrometer (Bruker Tracer S1 Titan). The instrument is equipped with a rhodium (Rh) anode (operable up to 50 keV) and an SDD detector with an energy resolution of 120 eV (FWHM at 5.9 keV). Measurements were taken with an 8 mm beam, penetrating ca. 100 µm in depth. The device was calibrated in “Ceramics” mode, and data acquisition was performed at 40 kV with a counting time of 90 s. Elemental concentrations were recorded for elements from Mg to Th.

In total, 26 prehistoric pottery samples (7 Boian–Vidra and 19 Cernavoda III) and eight experimental ceramics produced with clays collected from two local argillaceous sources beneath the loess mantle were analysed. Two measurements were performed on exterior surfaces of each sample, and the results were averaged, given the low intra-sample variability.

To explore and compare the chemical characteristics of these assemblages with the experimental wares, Principal Component Analysis (PCA) (Papageorgiou 2020) was applied using Minitab 17 software. The input variables consisted of log10-transformed concentrations (ppm) of the detected elements.

Results

Pottery assemblages and deposition

Based on the counting of rim parts and complete profiles, the maximum number of vessels represented in each pit can be estimated at 21, although the minimum number differs substantially when calculated from base counts (19 in C40 versus 5 in C37, see fig. 3).

Considering the similarities in sherd size (Table 2), average weight (fig. 4), and the distribution of vessel parts, together with the low number of joins and the absence of fully restorable vessels, the assemblages can be interpreted as secondary refuse (Schiffer 1996, 58). Nevertheless, some exceptions suggest deposition shortly after breakage: for example, half of a common pot from C40 could be restored, while 12 fragments from C37 formed approximately 60% of a fine dish showing traces of secondary firing. These observations indicate that although most pottery was discarded as refuse, some

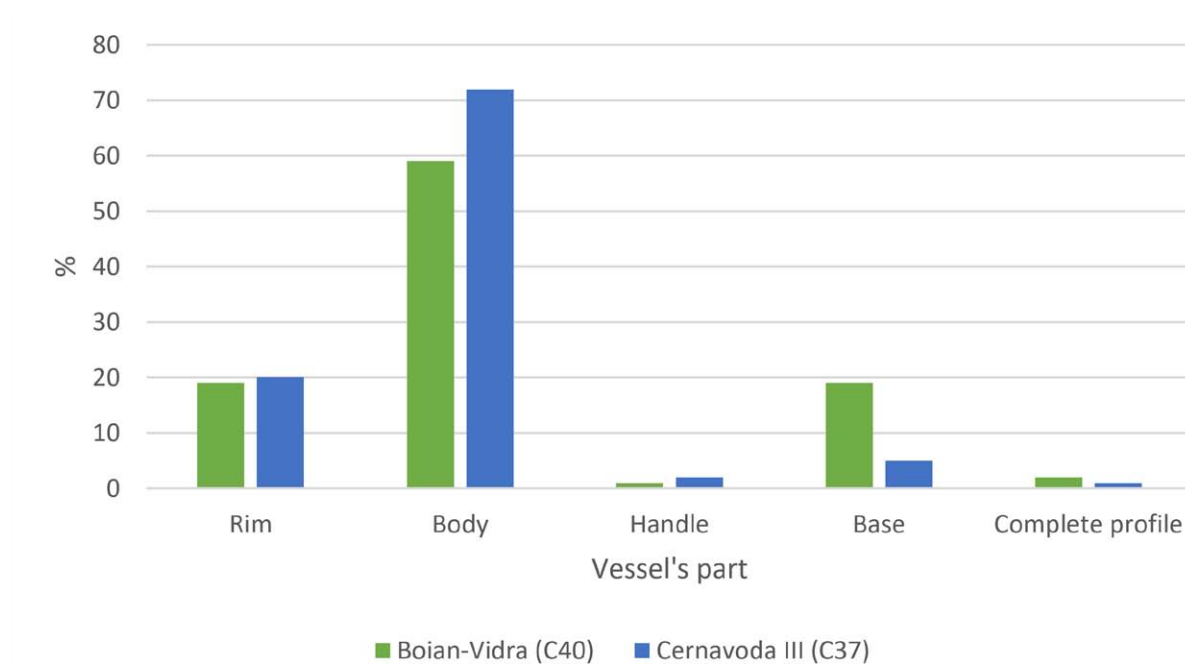


Fig. 3. Contextual distribution of the vessels' parts (n=255) (figure by V. Opreș)

Area	Complex (C) / House (L)	SU	Tradition	<2.5 cm	<5 cm	<7.5 cm	<10 cm	>10 cm	Total	
									No.	Grams
Son 1/2018	C37 (pit)	1077	Cernavoda III	11	68	31	15	2	127	3197
	C40 (pit)	1093	Boian-Vidra	10	61	31	17	9	128	4062
Total				21	129	62	32	11	255	7259

Table 2. Contextual distribution of the pottery from SGH 2021 by sherd size and total weight

vessels may have been broken, reused, or intentionally fragmented shortly before deposition, reflecting complex practices of discard and site maintenance rather than simple accumulation of domestic waste.

Paste analysis

Boian-Vidra pottery paste (C40 – SU1093) (Table 3)

The paste categorization was made according to Ignat et al. (2012, 106). The fine category is the best represented due to the high amount of sherds from cups, beakers and bowls, while the semi-fine and the coarse categories were specific to fragments from pans¹, pots and storage vessels.

Most of the Boian-Vidra pottery from C40 was grog-tempered. Grog occurs across all paste categories and cannot be tied to specific vessel shapes. Organic temper was only rarely identified, generally in combination with grog. A significant portion of the assemblage consists of fine vessels (cups and beakers) manufactured without intentional temper; these contain small amounts of sparse vegetal matter interpreted as natural inclusions. The presence of limestone (carbonate concretions) in over one-fifth of the assemblage was likewise considered natural/accidental and may reflect the use of local clay sources

¹ Plate-like vessel characterized by specific morphological and technological traits, often accompanied by use-wear traces indicating exposure to fire, suggesting a function comparable to that of a modern frying pan.

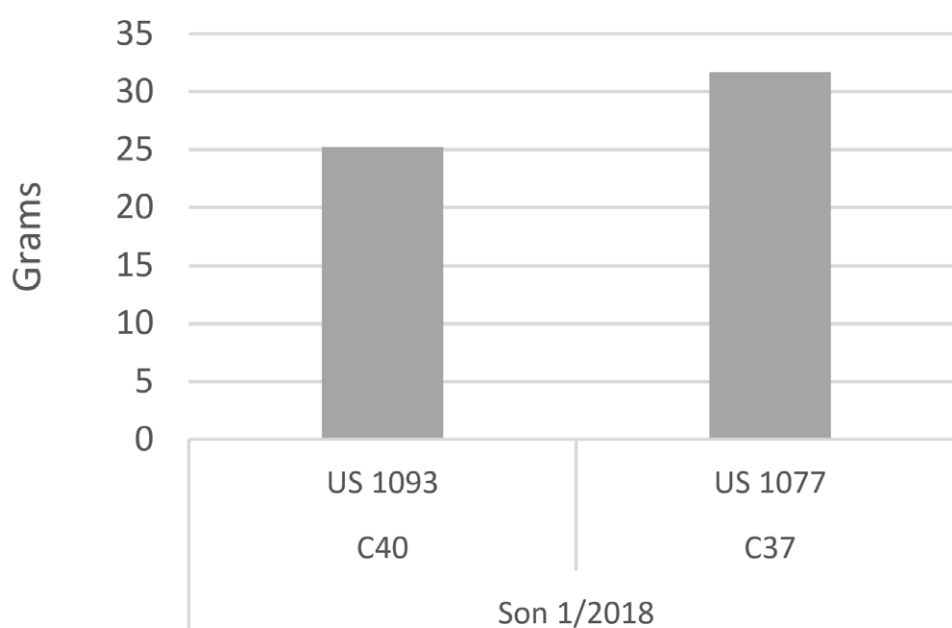


Fig. 4. Contextual distribution of the mean values of sherds weight (n=255) (figure by V. Opriș)

Inclusions C40 – SU1093		Paste categories			Total	
Identified as	Type	Fine	Semi-fine	Coarse	No.	%
Temper	Grog	34	50	21	105	82
	Organic	0	1	0	1	0.8
	Grog and organic	0	1	1	2	1.5
	None	20	0	0	20	15.7
Natural or accidental	Limestone	2	9	3	14	10.9
	Limestone and organic	4	8	3	15	11.8
	Organic and pebbles	1	0	0	1	0.8
	Organic	35	28	10	73	57
	Shell	1	0	0	1	0.8
	None	11	7	6	24	18.7
Total		54	52	22	128	100

Table 3. Boian–Vidra pottery (C40 – SU1093). The distribution of identified inclusions within the main categories of paste (n=128)

(see below). Overall, the assemblage illustrates a consistent technological approach characteristic of Boian–Vidra pottery (Opriș et al. 2017; Lazăr et al. 2020, 56–63), combining intentional grog-tempering with the exploitation of available clay resources.

Cernavoda III pottery paste (C37 – SU1077) (Table 4)

In this assemblage, fine wares make up the smallest proportion, represented mainly by fragments of small dishes and cups. Semi-fine and coarse pastes, on the other hand, occur in a broad range of shapes, from medium-sized dishes to large storage vessels. The rough texture of the paste is generally the result of grog tempering, which was used with particularly high frequency. In a few cases, fine-grained grog (≤ 1 mm) was applied even in the production of fine wares. Overall, grog was identified in almost the entire assemblage (c. 97%), occasionally mixed with crushed shells. Other tempers such

Inclusions C37 – SU1077		Paste categories			Total	
Identified as	Type	Fine	Semi-fine	Coarse	No.	%
Temper	Grog	23	50	44	117	92.1
	Shells	0	1	0	1	0.8
	Sand	0	1	0	1	0.8
	Grog and shells	2	3	1	6	4.7
	None	2	0	0	2	1.6
Natural or accidental	Limestone	6	12	10	28	22
	Limestone and organic	0	6	2	8	6.4
	Fine sand	1	0	0	1	0.8
	Pebbles and limestone	0	1	0	1	0.8
	Pebbles and organic	0	1	0	1	0.8
	Organic	12	19	11	42	33
	Limestone and shell	0	0	1	1	0.8
	None	8	16	21	45	35.4
Total		27	55	45	127	100

Table 4. Cernavoda III pottery (C37 – SU1077). The distribution of identified inclusions within the main categories of paste (n=127)

as organic matter, sand, and shells occur only sporadically. Small, sparse organic debris and carbonate concretions were the most common inclusions identified as natural/accidental.

The Cernavodă III pottery from C37 reveals an overwhelming preference for grog temper, used in nearly all vessels regardless of category or size. This is noteworthy, as crushed shell temper is generally considered a diagnostic feature of Cernavodă III ceramic technology. In this batch, however, shells were identified in only a handful of cases, either as a primary temper or in combination with grog (Table 4). Their low incidence suggests that, at least at SGH, shell tempering was not a dominant practice.

Clay sources

The bi-plot of the first and second principal components (fig. 5) indicates the exploitation of common clay sources for a substantial proportion of both the Boian–Vidra and Cernavodă III assemblages. Regardless of ceramic tradition, overall distribution patterns were strongly conditioned by fabric groups (paste category and temper type).

Within the Boian–Vidra assemblage, a clear separation is visible between fine wares (e.g. BV1233, BV1234) and semi-fine or coarse vessels tempered with grog (e.g. BV1341, BV1302, BV1298). This pattern suggests differential clay selection, with fine pottery likely produced from carefully prepared or distinct raw materials, while coarser vessels incorporated locally available clays combined with temper.

Several Cernavodă III fine wares (CVD1237, CVD1401, CVD1364) cluster closely with the Boian–Vidra fine pottery and with part of the experimental ceramics produced from local clays, pointing to shared or similar clay sources for these categories. Notably, three sherds tempered with a grog-and-shell mixture (CVD1456, CVD1477, CVD1483) plot in the same area, strongly suggesting local manufacture. Outliers include one shell-tempered sample (CVD1473) and one sand-tempered sample (CVD1478). In these cases, it is uncertain whether the marginal distribution reflects distinct clay sources or instead the geochemical impact of abundant tempers. Other Cernavodă III coarse samples are scattered across the grog-tempered group on the left side of the plot, where experimental ceramics with added grog (SECb-

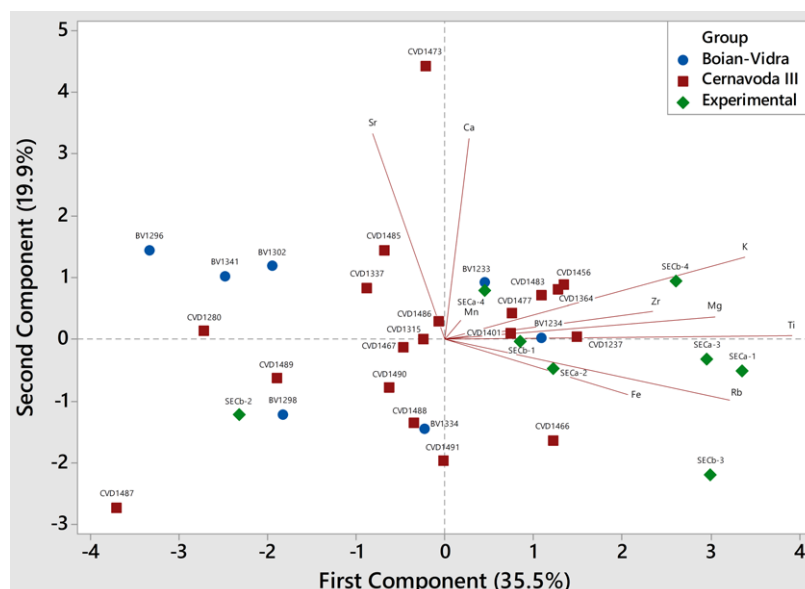


Fig. 5. Bi-plot of the first and second principal components resulting from PCA on the log10 transformed XRF (Mg, K, Ca, Ti, Mn, Fe, Rb, Sr, Zr). Grouping by pottery traditions (SBVnumber – Boian–Vidra tradition; CVDnumber – Cernavoda III tradition; SEC – Sultana Experimental Ceramics) (figure by V. Opriș using Minitab 17)

2) also cluster, indicating technological convergence when coarse tempers were employed.

The identification of natural inclusions provides further evidence for the exploitation of at least two distinct local clay sources. Carbonate concretions, characteristic of argillaceous deposits beneath the loess mantle – comparable to the sources used in the experimental ceramics analysed here – were frequently recorded. In addition, small organic debris, typical of alluvial deposits from the Mostiștea Valley (though not directly identified in the field), was also observed in the ceramic pastes from both C40 and C37. Taken together, these observations indicate that prehistoric potters intentionally drew on multiple clay environments in the vicinity of the site, selecting or modifying raw materials according to vessel function and paste recipes.

Forming techniques and constructed shapes

More than half of the fragments in both assemblages lacked diagnostic traces that would allow the identification of primary forming techniques. Where observable, all methods belong to the repertoire of hand-forming practices, either employed individually or in combination. These include coiling, slabbing, moulding, and hand modelling (fig. 6).

The coiling technique was most frequently identified in wall fragments, recognisable by horizontal breaks and smooth joining areas. The combination of coiling and slabbing, as well as the use of horizontal slabs for base construction, was attested only in pots from the Boian–Vidra assemblage. In contrast, two dishes from the Cernavodă III tradition appear to have been formed in a mould, a technique otherwise absent. Hand modelling occurs in both assemblages in comparable proportions and is associated primarily with small vessels, such as beakers and cups.

The most striking difference between the two groups of pottery lies in the repertoire of shapes. The Boian–Vidra pottery from C40 includes cylindrical-necked beakers (fig. 7.1–2), cups (fig. 7.5), lids, pans (fig. 7.4), and carinated pots (fig. 7.3), all typical for this tradition. By contrast, the Cernavoda III assemblage from C37 is characterised by open dishes (fig. 8.1), storage vessels (fig. 8.8), and collar-

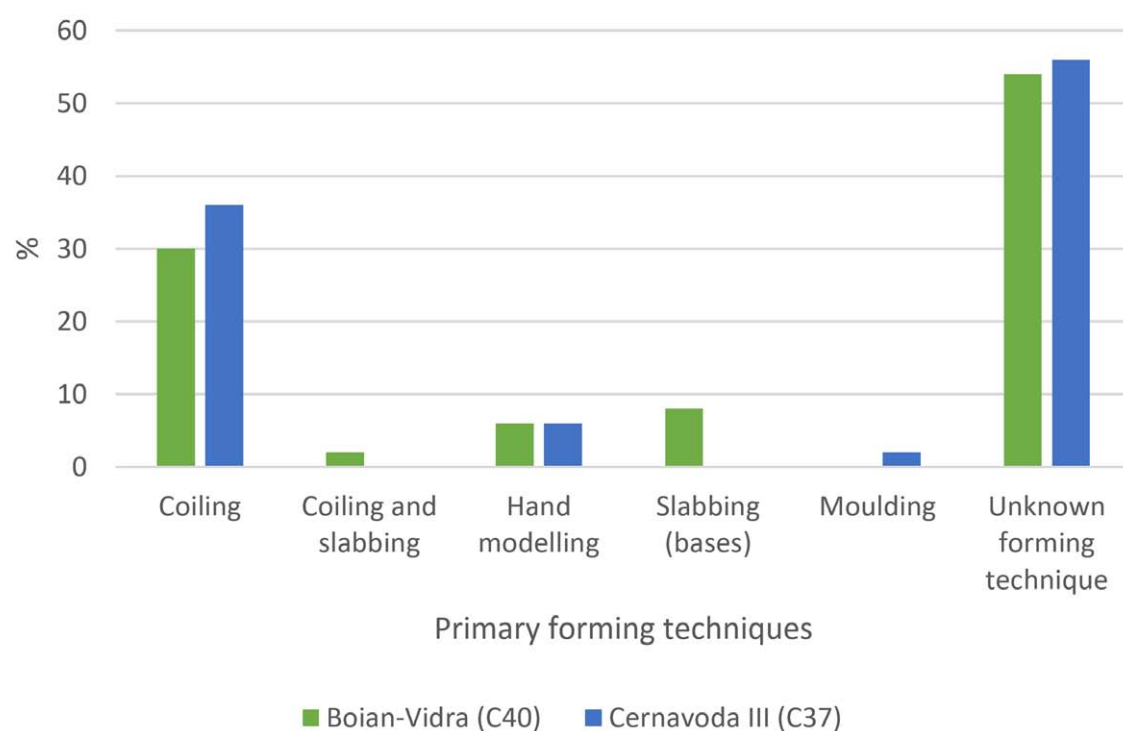


Fig. 6. The percentage distribution of primary forming methods (n=255) (figure by V. Opreș)

Constructed shape	Boian-Vidra (C40)			Cernavoda III (C37)		
	No.	%	Average rim diameter (cm)	No.	%	Average rim diameter (cm)
Beaker/Cup	25	19.4	10.5	5	3.8	8.5
Dish	0	0	-	17	13.5	22.7
Bowl	12	9.4	14.3	1	0.8	17.5
Pot	23	18	17.2	8	6.3	11
Platter/Pan	2	1.6	19	0	0	-
Storage vessel	0	0	-	2	1.6	n/a
Simply truncated	1	0.8	n/a	0	0	-
Lid	2	1.6	n/a	0	0	-
Pedestaled vessel	2	1.6	n/a	1	0.8	n/a
Undetermined shape	61	47.6	n/a	93	73.2	15.2
Total	128	100	15.2	127	100	15

Table 5. Distribution of the constructed shapes and the averages rim diameters (n=255)

necked pots (fig. 8.2–3). Average rim diameters (Table 5) indicate that both assemblages were dominated by small and medium-sized vessels.

A decorated pedestalled base from C37 (fig. 7.7) represents an unusual find for the Cernavodă III ceramic repertoire in southern Romania. Comparable shapes and decorations are known from later contexts in the western part of the Romanian Plain, for example in the upper level at Siliștioara (Comșa 1967, 206, fig. 6.21) and at Orlea (Roman 1976, fig. 1.1). Nevertheless, the geochemical signature and fabric characteristics of the fragment (CVD 1491 on fig. 5) are consistent with local SGH production, suggesting it was not an import but an atypical product of local potters.

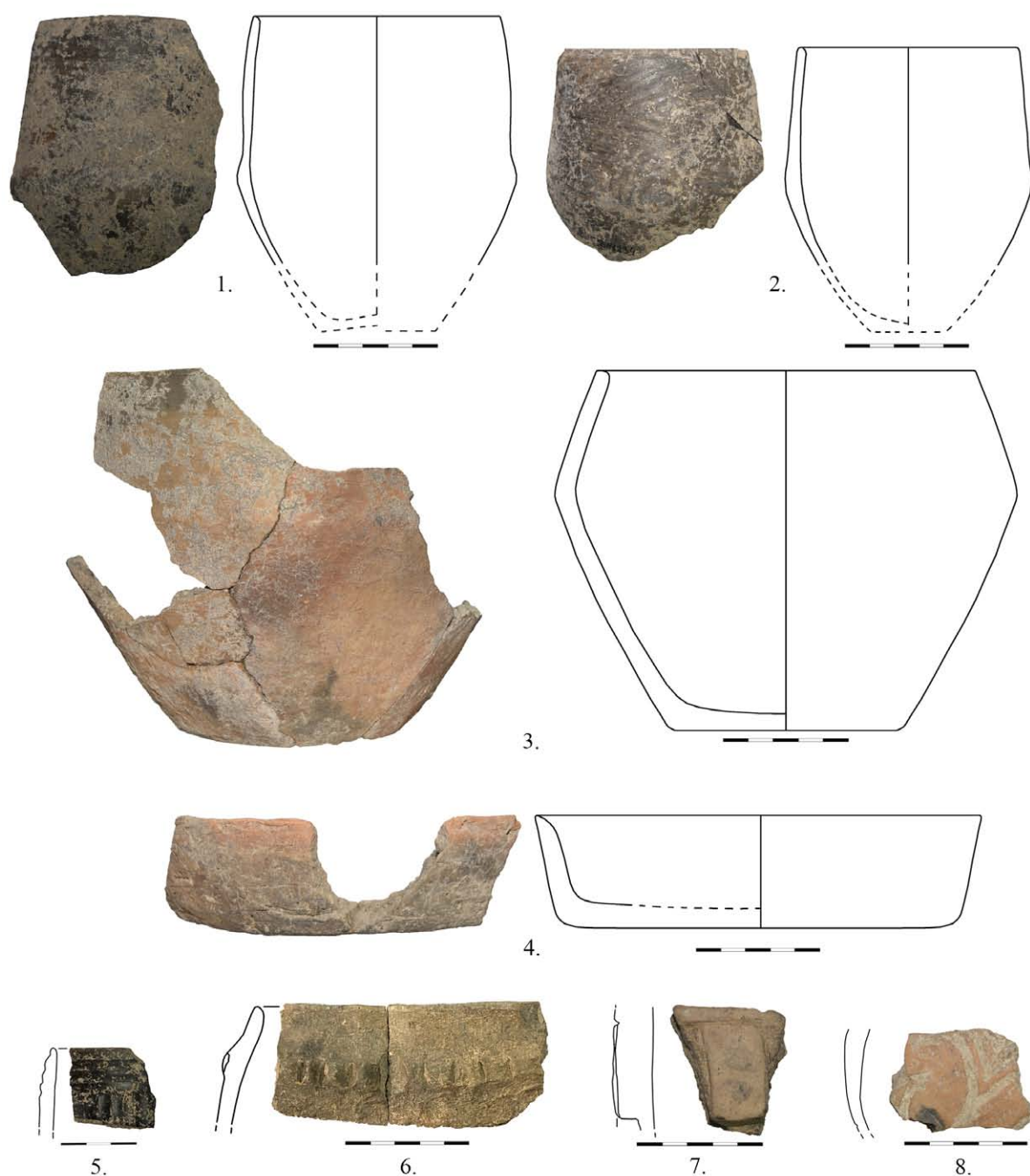


Fig. 7. Examples of shapes and decorations from C40 (SU 1093) (photos and drawings by V. Opriş, S. Beyer and A. Heitmann)

Surface treatments

The finishing techniques identified in the two pottery assemblages include scraping, smoothing, polishing, burnishing, and the application of barbotine. In some cases, the treatment could not be determined (marked as N/A) due to surface degradation, the presence of isolated handles, or post-depositional limestone encrustations.

For external surfaces (fig. 9), Boian–Vidra vessels were predominantly finished by burnishing, with smaller proportions smoothed, polished, barbotined, and more rarely, scraped. In contrast, while

Cernavodă III pottery also displays a consistent share of burnished and polished exteriors, the majority of fragments show smoothed or barbotined surfaces.

Differences are also evident in the treatment of internal surfaces (fig. 10). In the Boian–Vidra group, burnishing and polishing dominate, reflecting a preference for carefully finished interiors in small fine vessels such as cups and beakers. The Cernavodă III assemblage, however, shows a prevalence of smoothing and polishing, with burnishing appearing less frequently.

Overall, these contrasts suggest distinct technological traditions: Boian–Vidra potters favoured highly burnished surfaces – particularly on vessel interiors – emphasising visual and tactile qualities linked to serving and display vessels, while Cernavodă III potters adopted more utilitarian finishing practices, favouring smoothing and barbotine for larger domestic containers.

Decoration methods (Table 6)

The decorative repertoire of the Boian–Vidra assemblage from C40 corresponds closely to that observed in other assemblages from Sultana (Opriș et al. 2017, 102), though it shows slight differences from the Gumelnița site (Lazăr et al. 2020, 62). The most common decorative technique is plissé – consisting of small, polished, parallel channels – typically applied on beakers and cups (fig. 7.1–2, 5). The other techniques, such as barbotine, incised (fig. 7.7), excised (fig. 7.8), impressed, and embossed (fig. 7.6) occur in much lower proportions.

In the Cernavodă III assemblage from C37, decorated sherds are rare. Identified motifs include impressed lines on the rims of collar-necked pots, impressed triangles filled with white paste on a small cup, plissé on the inner or outer surfaces of fine dishes (fig. 8.1), incised patterns on a pedestalled base (fig. 8.7), organized barbotine, and oblique impressed belts on storage vessels (fig. 8.8).

As shown in Table 6, undecorated fragments dominate both assemblages, accounting for 69.5% of Boian–Vidra and 92.9% of Cernavodă III pottery. Plissé decoration is the most frequent in the Boian–Vidra batch (13.3%), while no single decorative technique achieves a comparable share in the Cernavodă III assemblage. Painting is absent in both groups, a trait consistent with the broader ceramic traditions of these horizons.

The contrast in decorative practices highlights divergent approaches to vessel aesthetics: Boian–Vidra potters invested more effort in decorative elaboration, particularly on small, fine vessels used for serving and display, while Cernavodă III production emphasised undecorated surfaces, with decoration confined to isolated vessels or functional zones such as rims and bases.

Firing observations

Firing conditions were assessed (fig. 11) considering surface and core colours, acknowledging that firing traces on prehistoric pottery often vary across different vessel areas. Approximately half of the Boian–Vidra pottery from C40 was fired in a reduced atmosphere, indicated by light black, dark grey, or dark brown surface colours. However, the lighter or reddish cores of these vessels suggest an initial oxidising firing phase, followed by a final reduction stage in which black smoke impregnated the surfaces under conditions of restricted air supply.

The black pottery from C37 exhibits similar features, pointing to comparable firing techniques. These vessels were likely fired in enclosed structures such as pits, which were charged with smoke-generating materials and subsequently sealed, creating the required reducing environment. By contrast, incompletely oxidised and irregularly fired pottery from both assemblages appears to have been produced in open-air conditions, such as bonfires or domestic hearths, where atmospheric control was minimal. Secondary firing was identified in low proportions, affecting sherds that display clear evidence of thermal alteration after vessel breakage. These fragments may represent wasters from primary firing events, debris originating from burned dwellings, or material subsequently reused in activities associ-

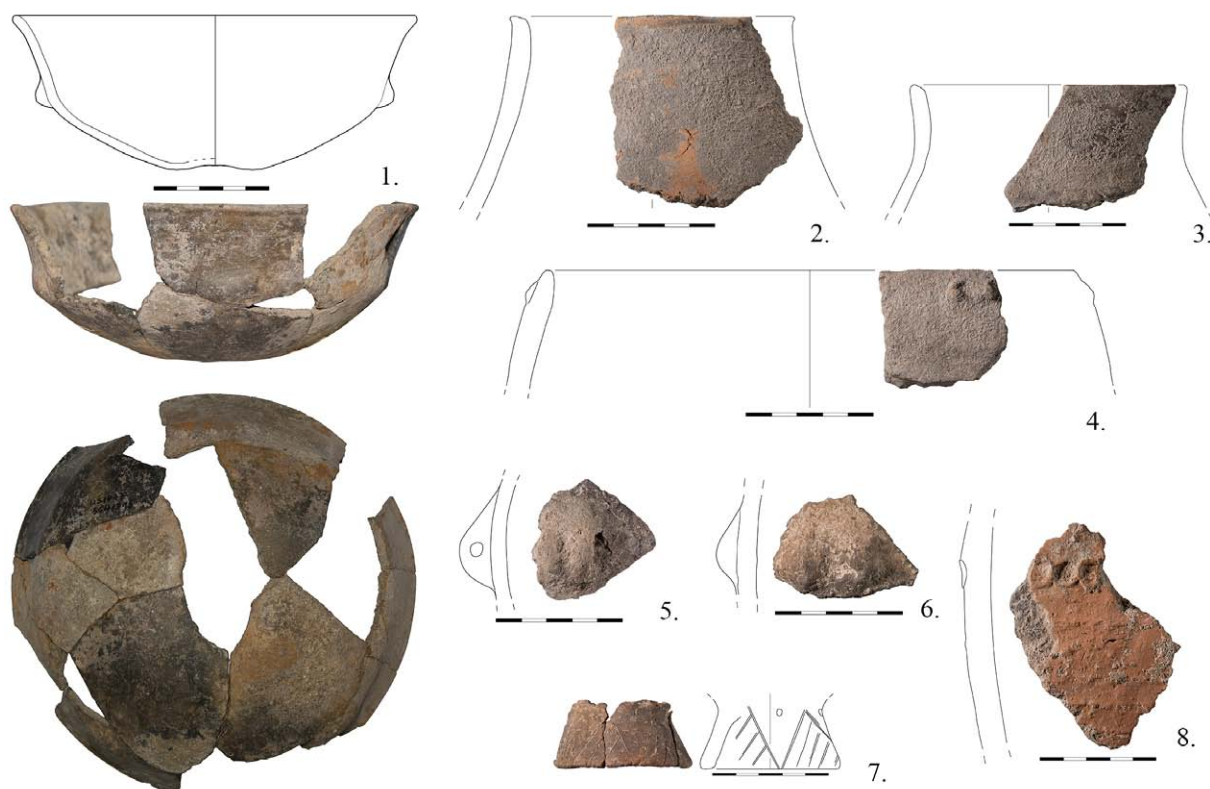


Fig. 8. Examples of shapes and decorations from C37 (SU 1077) (photos and drawings by V. Opriș, S. Beyer and A. Heitmann)

Decoration type	Boian-Vidra (C40)		Cernavoda III (C37)	
	No.	%	No.	%
Organized barbotine	4	3.1	2	1.6
Plissé	17	13.3	2	1.6
Plissé&Impresso	9	7	0	0
Impresso	0	0	3	2.3
Embossed&impressed belt	4	3.1	1	0.8
Excised	3	2.3	0	0
Incised	2	1.6	1	0.8
Undecorated surfaces	89	69.5	118	92.9

Table 6. Distribution of decorative types (n=255)

ated with combustion structures, such as the construction of hearths and ovens or other pyrotechnological processes.

At present, no prehistoric combustion structures associated with pottery firing have been documented at Sultana, leaving open the question of whether specialised facilities existed or whether firing took place in ephemeral installations that have left no archaeological trace.

Discussion and conclusions on pottery analysis

The prehistoric pottery excavated in 2021 at Sultana–Ghețarie was deposited as secondary refuse in two pits of uncertain function, dating respectively to the Early Chalcolithic (Boian–Vidra tradition) and the Late Chalcolithic (Cernavodă III tradition). Although separated by roughly 1,500 years, the as-

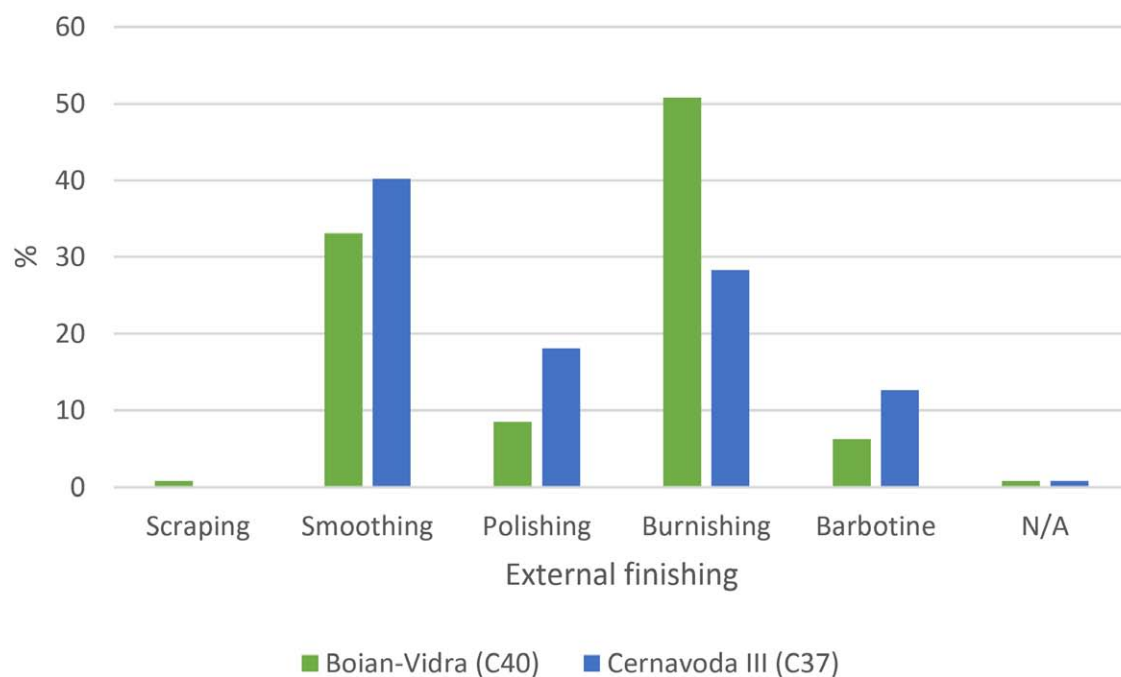


Fig. 9. Comparison of external finishing methods between Boian-Vidra and Cernavoda III pottery at SGH (n=255) (figure by V. Opreș)

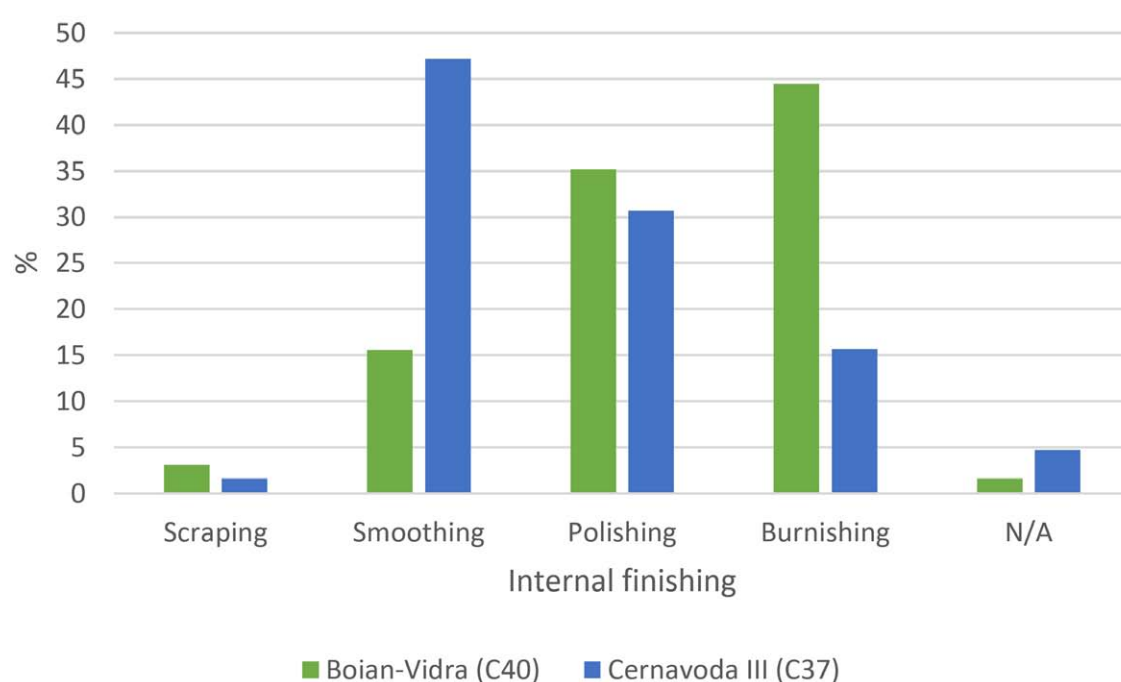


Fig. 10. Comparison of internal finishing methods between Boian-Vidra and Cernavoda III pottery at SGH (n=255) (figure by V. Opreș)

semblages share several technological traits, which can be interpreted as long-term adaptations to local environmental resources.

One such similarity lies in clay procurement. Principal Component Analysis of XRF data indicates that both traditions exploited comparable local clay sources, though fabric and tempering choices strongly influenced compositional variation. Another common feature is the widespread use of grog as temper (Tables 3 and 4). This practice is also well attested in other Early Chalcolithic assemblages from

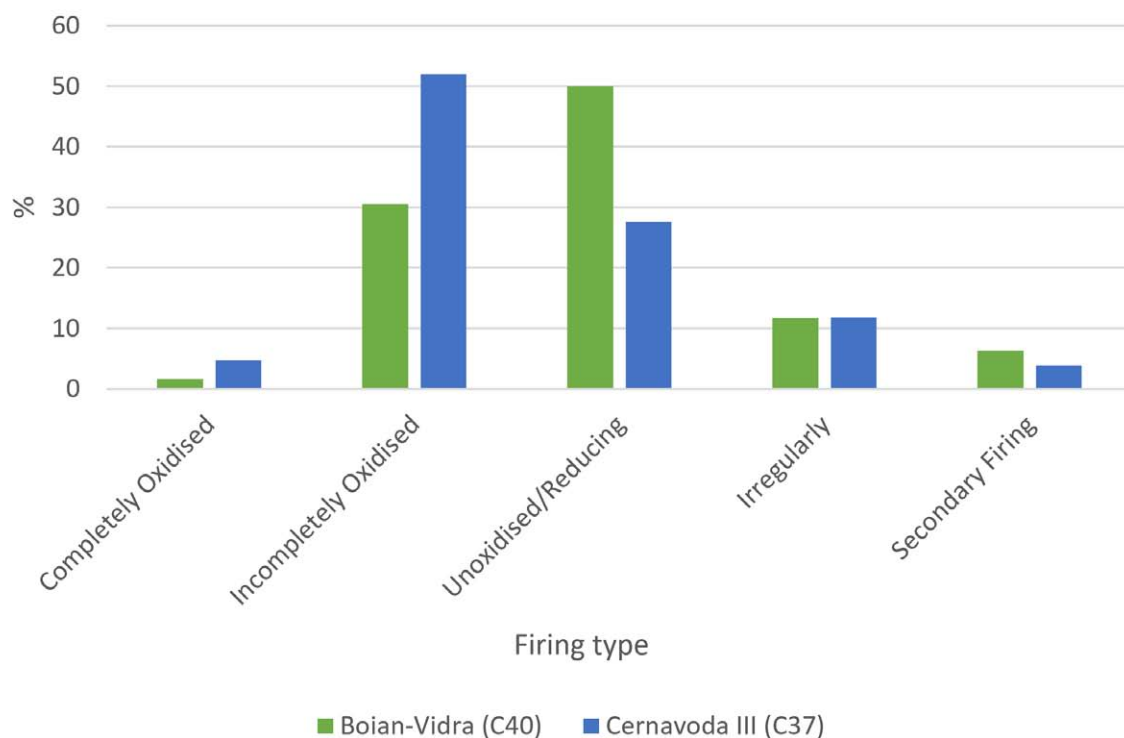


Fig. 11. Comparison of firing types (%) (figure by V. Opreş)

Sultana (Opreş et al. 2017) and persisted until the end of Chalcolithic habitation in the region, ca. 3950 cal BC (Ignat et al. 2019). While grog is technologically advantageous – improving thermal-shock resistance, workability, and vessel durability – it also appears to have acquired a traditional and possibly symbolic role in southern Romanian ceramic technology during the 5th millennium BC (Opreş 2025).

The Boian occupation at Sultana–Gheţărie represents an early core of farming colonisation in the Mostiştea micro-region by communities preserving genetic traits of the earlier waves of Anatolian migration (Hervella et al. 2015; Mattila et al. 2023), contemporaneous with the earliest tells (Vlădiceasca I/II) and closely linked to nearby necropolises; the ¹⁴C series for the Sultana–Gheţărie (4956–4839 cal BC) and for the Şcoala Veche burials (4934–4718 cal BC) indicate a nearly overlapping chronology and an integrated inhabited landscape, the points being only ~290 m apart (Lazăr 2023).

After the peak of the tell network (ca. 4500–4400 cal BC), a rapid decline beginning around 4350 cal BC led to the near-complete disappearance of tells in the valley; Sultana–Malu Roşu appears to have displayed greater resilience, probably until ~3973–3804 cal BC (Popescu et al. 2023; Lazăr 2023; Müller et al. 2025). In this post-tell context, the funerary landscape remained active beyond the end of Gumelniţa habitation, as evidenced by Cernavodă II graves (M75) and pits in the necropolis area (Andreescu et al. 2015) – signals of occasional spatial reuse and socio-economic reconfigurations at the end of the Chalcolithic (Lazăr 2023; Hofmann et al. 2025; Müller et al. 2025).

The Cernavodă III assemblage from the investigated pit (C37) is notable for its high proportion of grog-tempered wares, despite the fact that shell tempering has long been considered a cultural marker of this ceramic tradition (Morintz, Roman 1968b, 559; Zmeykova 2001). At Sultana–Gheţărie, only seven sherds (5.5%) were shell-tempered, and six of this also contained grog. Although published data on paste composition in Cernavodă III pottery are scarce, evidence from Măgura–Buduiasca (Romania) suggests a similar pattern, with only 12 shell-tempered sherds out of 150 (ca. 8%) (Torcică 2013). Together, these examples indicate that shell-tempered pottery was produced on a limited scale, representing a culturally significant but not dominant technological choice in northern Balkans during the mid–4th

millennium BC. At Sultana, the geochemical signatures suggest that some of the shell-tempered sherds were locally produced, while others are likely imports.

Forming and firing methods reveal both continuities and divergences between the two assemblages. The use of simple hand-forming techniques (coiling, modelling, moulding) and small-scale firing installations reflects shared practical knowledge rooted in non-specialised, household-level production. At the same time, each assemblage maintains a distinct technological identity. Boian–Vidra vessels are characterised by fine burnished beakers, lids, and pans, whereas the Cernavoda III pottery repertoire emphasises dishes, collar-necked pots, and large storage containers.

Decoration is generally scarce in both groups, with undecorated surfaces predominating. However, this trend is much more pronounced in the Cernavoda III assemblage, where decoration is almost entirely absent, and the pottery appears highly standardised. This reduction in ornamentation suggests a reconfiguration of pottery's role in community life: from a medium of social display and identity signalling in the Early Chalcolithic to an object with predominantly functional value in the Cernavoda III period. The same trend has been observed in assemblages from northeastern Bulgaria and southwestern Romania (Zmeykova 2001; Torcică 2013). At Sultana–Gheţărie, therefore, Cernavodă III ceramics no longer seem to have served as primary vehicles of social signalling, but rather reflect a proximity-based, household-oriented economy, in which functional utility took precedence. This transformation can plausibly be linked to broader changes in settlement patterns, population density, mobility, and the diminishing role of pottery as a marker of status or identity.

Taken together, these technological and morphological traits point to differences in consumption and use practices. The Boian–Vidra assemblage is dominated by small- and medium-sized vessels, suited to individual consumption, liquid transfer, and food preparation. By contrast, the Cernavodă III assemblage includes a higher proportion of large serving and storage vessels, suggesting practices oriented towards communal food processing and the storage of solid goods. This interpretation is consistent with zooarchaeological and palaeobotanical data from Hofmann et al. (2025), which point to semi-nomadic subsistence strategies.

Nevertheless, the relatively small sample sizes from both pits caution against overgeneralisation at site, regional, or cultural scales. Future work based on larger assemblages, ideally with systematically quantified temper data and expanded geochemical analyses, will be crucial for refining our understanding of technological traditions, resource use, and social practices across the long chronological span separating the Early Chalcolithic and the Late Chalcolithic in southern Romania.

In a broader perspective, the contrasts observed between the Boian–Vidra and Cernavodă III assemblages at Sultana–Gheţărie encapsulate key transformations across the Lower Danube during the 5th–4th millennia BC. Early Chalcolithic communities invested in finely made, decorated vessels that operated not only as functional containers but also as media of social communication and identity construction, part of a wider pattern documented at Balkans sites (in southern Romania and northeastern Bulgaria). By the mid–4th millennium, pottery traditions had shifted towards more standardised, undecorated, and functionally oriented forms, reflecting new socio-economic realities marked by greater mobility, flexible household economies, and changing relationships between communities and their landscapes. In this sense, the material evidence from Sultana–Gheţărie mirrors a broader regional trajectory, in which ceramic technology and style provide a window onto the reorganisation of social life at the threshold of the Bronze Age.

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