Tracing Pottery-Making Recipes in the Prehistoric Balkans 6th–4th Millennia BC

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Petrological Analysis of Late Neolithic Ceramics from the Tell Settlement of Gorzsa (South-East Hungary)

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Abstract: Hódmezővásárhely-Gorzsa is a Late Neolithic (4846-4495 cal BC) Tisza culture tell settlement. This multi-layered settlement is situated in the southeastern part of the Great Hungarian Plain in Hungary at the confluence of the Tisza and Maros Rivers. The area is covered with Holocene clayey silt and Pleistocene loessic sand. The tell lies 3-4 m above the floodplain, formerly surrounded by backswamps, oxbow-lakes and minor watercourses. The aim of this study is to provide archaeometric data on the ceramics from Gorzsa and assess the composition and technological characteristics of ceramics. Vessels were examined in thin-section by polarising microscopy and SEM-EDX analysis. The 51 examined vessels were made from non-calcareous local silty clays or clayish silt and were divided into four fabric groups: 1) Lean clay, ARF/grog tempered; 2) Mica-rich fat clay with 20-25% non-plastic inclusion (a) or with maximum 10% non-plastic inclusion (b); 3) Fat clay, tempered with organic material (plants); 4) Slightly lean clay without tempering and very well sorted inclusions. Organic tempering, which was identified in the form of charred plant material and phytoliths, was used only in the earliest phase of the settlement.

Introduction, archaeological background

The Late Neolithic (5000-4500/4000 BC) Tisza culture was mainly distributed in the southeastern part of the Great Hungarian Plain in the Carpathian Basin. Hódmezővásárhely-Gorzsa was one of the largest tell settlements situated in the southeastern part of the Great Hungarian Plain in Hungary near the confluence of the Tisza and Maros Rivers, on the banks of the former Kéró creek (Figure 1). The area is covered with dominantly fluviatile Holocene clayey silt and eolic-hydroeolic Pleistocene loessic sand and redeposited loessic sand (Kalmár *et al.* 1997; Gyalog and Síkhegyi 2005). The tell lies 3-4 m above the floodplain formerly surrounded by backswamps, oxbow-lakes and minor watercourses, and although the entire settlement occupies about 5 ha, the area of the actual tell complex is estimated to be around 3-3.5 ha (Figure 2). During several seasons of excavations (1978-1996), 1000 m^2 of the tell settlement were excavated (Horváth 2005). Even though the excavation was finished a long time ago, only preliminary archaeological and archaeometric studies have been published, mainly on chipped, polished and ground stones (Biró 1998; Starnini *et al.* 2007; 2015; Szakmány *et al.* 2008; 2009; 2011). Apart from a preliminary report (Vanicsek *et al.* 2013), no detailed archaeometric research was carried out on the ceramics of Gorzsa until now. A large project started a few years ago to assess the stratigraphy and chronology of the Gorzsa tell, process the archaeological finds and carry out archaeometric research (on stones, bones, ceramics, etc.), and the new results will be published in the following years.

The remains, ranging from the Late Neolithic to the Sarmatian period, make up the 2.6-3 m thick archaeological sequence of the site. The thickest layer was 180-200 cm, which represents the Late Neolithic,

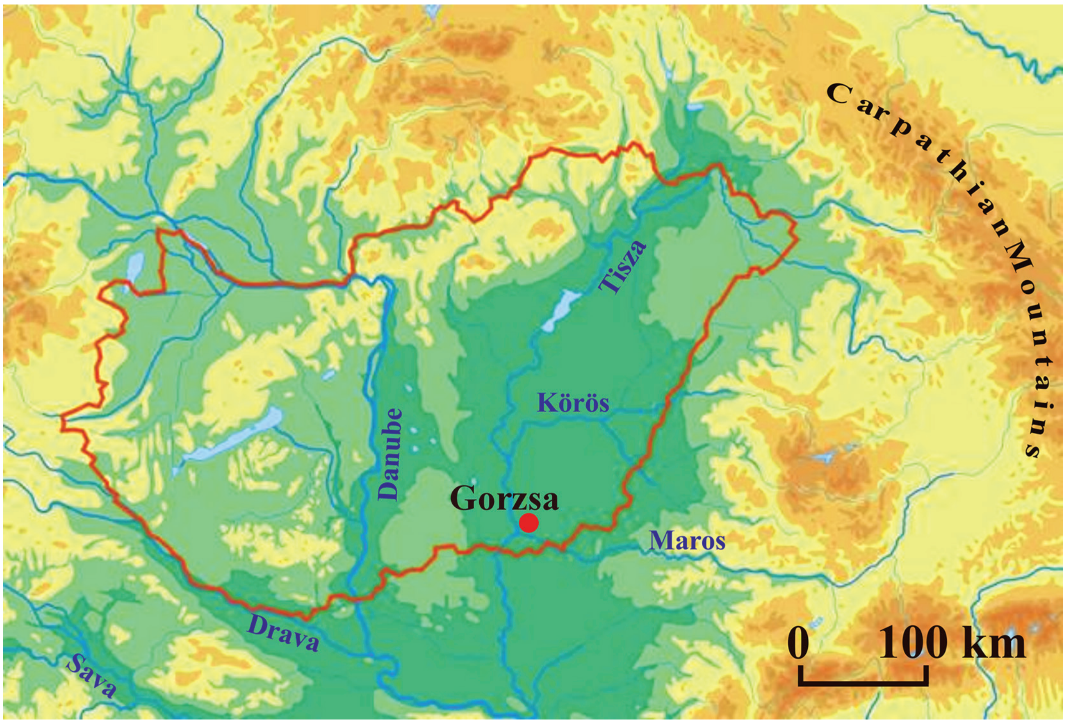

Figure 1: The examined site in the Carpathian basin.

Figure 2: The tell and its surrounding area. The tell raises some 3-4 m above the floodplain.

dating to the Tisza II-V periods. According to the stratigraphy and the typology of the features, the Late Neolithic occupation of the tell can be divided into four different phases, with no hiatus between them: D, C, B, A – phase D being the oldest (Horváth 1987; 2003; 2005). Phase B of the tell is limited to graves within the excavated area. This phase seems to show a close stratigraphical relationship with Phase A, therefore the ceramics of these phases are analysed together (marked as AB). According to calibrated radiocarbon dates, the Late Neolithic occupation of the Gorzsa tell occurred between 4846-4495 cal BC (Yerkes *et al.* 2009; Horváth 2014), but the evaluation of new AMS dates is still in progress. Gorzsa belongs to the Tisza-Herpály-Csőszhalom cultural complex and was roughly contemporary with the Proto-Lengyel, Lengyel I-IIIa culture in Transdanubia; the Iclod group and Petreşti A/Foeni culture in Transylvania and Banat and with Vinča C1/first half of D2 phases in the northern Balkans (Horváth 2005; 2014; Starnini *et al.* 2015). The most characteristic Tisza culture ceramics at Gorzsa are collared vessels and the so-called Gorzsa type burnished vessels with small applied knobs. Moreover, vessels with typical geometric ornaments are also very characteristic (Horváth 2005). Vessels are decorated with incised meander patterns. The complexity and dominance of this decoration increased at the end of phase D of the settlement and decreased during the latest phases (AB, Horváth 1987; 2005). The excavation of Gorzsa resulted in the collection of approximately one million sherds. These dominantly represent characteristic Tisza ceramics but also include imported or import-like ceramics. The analyses of ceramics assumed to be imports will be published later in a different paper. In order to unequivocally distinguish imports from copies, we must characterize the most typical ceramics of Gorzsa. Therefore, it is important to provide baseline archaeometric data on the most characteristic ceramics of the Tisza culture from Gorzsa and assess their composition and technology.

Materials and methods

51 representative Tisza culture sherds were chosen for analyses from phases AB, C and D (Table 1), together with 5 daub and 11 sediment samples. The analysed ceramic types include pots, large storage vessels, mugs, cups, bottles, hollow pedestalled bowls, and collared vessels with incised decorations and flowerpot forms featuring incisions (Figures 3, 4). The sediment samples were collected on the tell and its vicinity from shallow boreholes. The daubs and sediments were studied to obtain more precise information on potential raw materials of the ceramics. All vessels, daub fragments and test bricks made from the sediment samples were examined in thin-section using polarising microscopy, and representative samples were chosen for SEM-EDX. Sediment samples were collected from four shallow boreholes drilled to a depth of 150 cm in the deepest area around the tell. In this area sediments had the highest clay content. Moreover, a 3 m deep borehole was also drilled on the tell in which Early Holocene clayish silt sediments occurred (Figure 5).

Altogether 11 test bricks were made from clayish sediments taken at different depths and were fired at 750ºC in an oxidizing atmosphere for 2 hours in a Nabertherm L15/12/320-type electric kiln in the

Table 1: Summary of the analysed ceramics.

Petrographic group	Phase	Vessel type	Sample No
1a	AB	indeterminable	001
1a	AB	large storage vessel	002
1a	AB	large storage vessel	003
1a	AB	pot	004
1a	AB	indeterminable	005
1a	AB	indeterminable	101
1a	AB	indeterminable	102
1a	AB	indeterminable	103
1a	AB	large storage vessel	104
1a	AB	indeterminable	156
1a	AB	indeterminable	158
1a	C1	large storage vessel	010
1a	C3	large storage vessel	007
1a	D	collared vessel (incised)	112
1a	D1	flowerpot form (incised)	119
1a	D1	indeterminable	165
1a	D1-D3	hollow pedestalled bowl	129
1a	D2	bowl	132
1a	C2	indeterminable	161
1a	D2	pot	170
1a	D2	indeterminable	171
1a	D2	indeterminable	172
1b	AB	large storage vessel	150
1b	AB	indeterminable	151
1b	C2	large storage vessel	160
2a	AB	pot	006
2a	AB	indeterminable	153
2a	AB	large storage vessel	155
2a	C1?	collared vessel (incised)	111
2a	D3	pot	009
2a	C3-D1	flowerpot form (incised)	123
2b	D1	flowerpot form (incised)	125
2b	D1	large storage vessel	164
2b	D2	pot	169
3a	D1	flowerpot form (incised)	118
3a	D1	flowerpot form (incised)	124
3a	D1	indeterminable	166
3a	D1-D2	flowerpot form (incised)	127
3a	D1-D2	cup	131
3a	D2	indeterminable	126
3a	D2	indeterminable	128
3a	D2?	flowerpot form (incised)	120
3b	D1	cup	130
3b	D2	indeterminable	168
4	AB	indeterminable	152
4	AB	indeterminable	154
4	AB	hollow pedestalled bowl(?)	157
4	AB	indeterminable	159
4	C2-C3	indeterminable	113
4	C3	collared vessel (incised)	117
4	D1	indeterminable	167

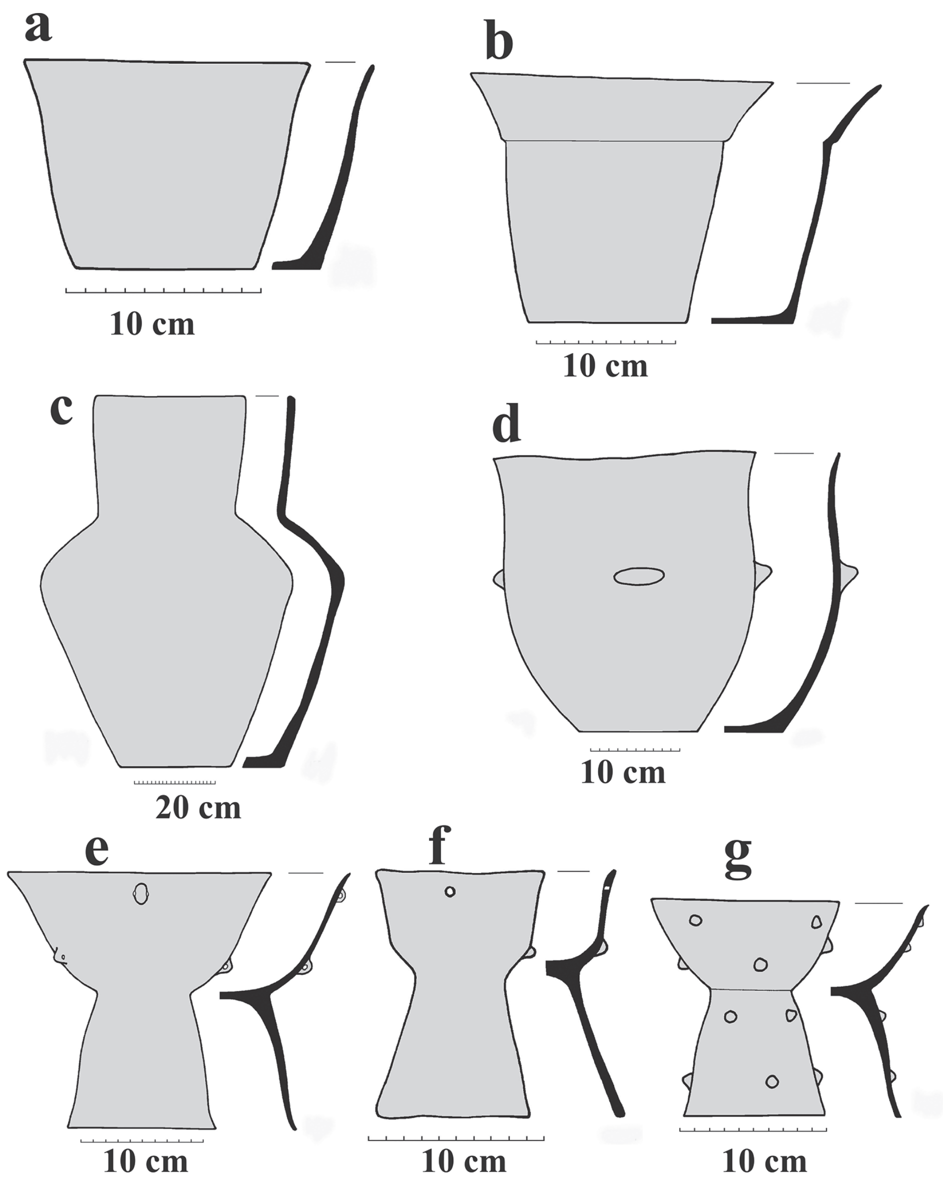

Figure 3: Characteristic vessels types from Gorzsa: a) flowerpot form; b) collared vessel; c) large storage vessel; d) pot; e, g) hollow pedestal bowls; f) hollow pedestal chalice.

Laboratory of Applied Research, Hungarian National Museum. The SEM-EDX analyses on six ceramics and four sediment samples were carried out by an AMRAY 1830-type scanning electron microscope equipped with an EDAX PV9800 energy dispersive spectrometer in the Department of Petrology and Geochemistry, Eötvös Loránd University. The measurements were made at an accelerating voltage of 20 kV and a sample current of 1 nA. The measurement time was 100 seconds live time. Analyses of ceramics, clayey inclusions and raw material matrices were carried out on three small areas (25 μm^2 each); however, analyses of minerals within the ceramics were carried out by focused electron beam (diameter 50 nm). During the SEM-EDX analyses international standards were applied for the determination of mineral compositions using Moran Scientific software. Carbon coating of the samples was made by a JEOL JEE-4B-type vacuum evaporator. We measured the samples' fabric in 5x5 μm^2 areas and analysed the composition of argillaceous rock fragments (ARF)/grogs in the ceramics.

The analyses of plant tempering of the selected vessels were carried out in accordance with the methodological guidelines of phytolith analysis of thin-sections (described in Pető and Vrydaghs 2016; Kreiter *et al.* 2013). Reference plant material for comparison was collected from the herbarium of the University of Debrecen and the Laboratory of Applied Research, Hungarian National Museum.

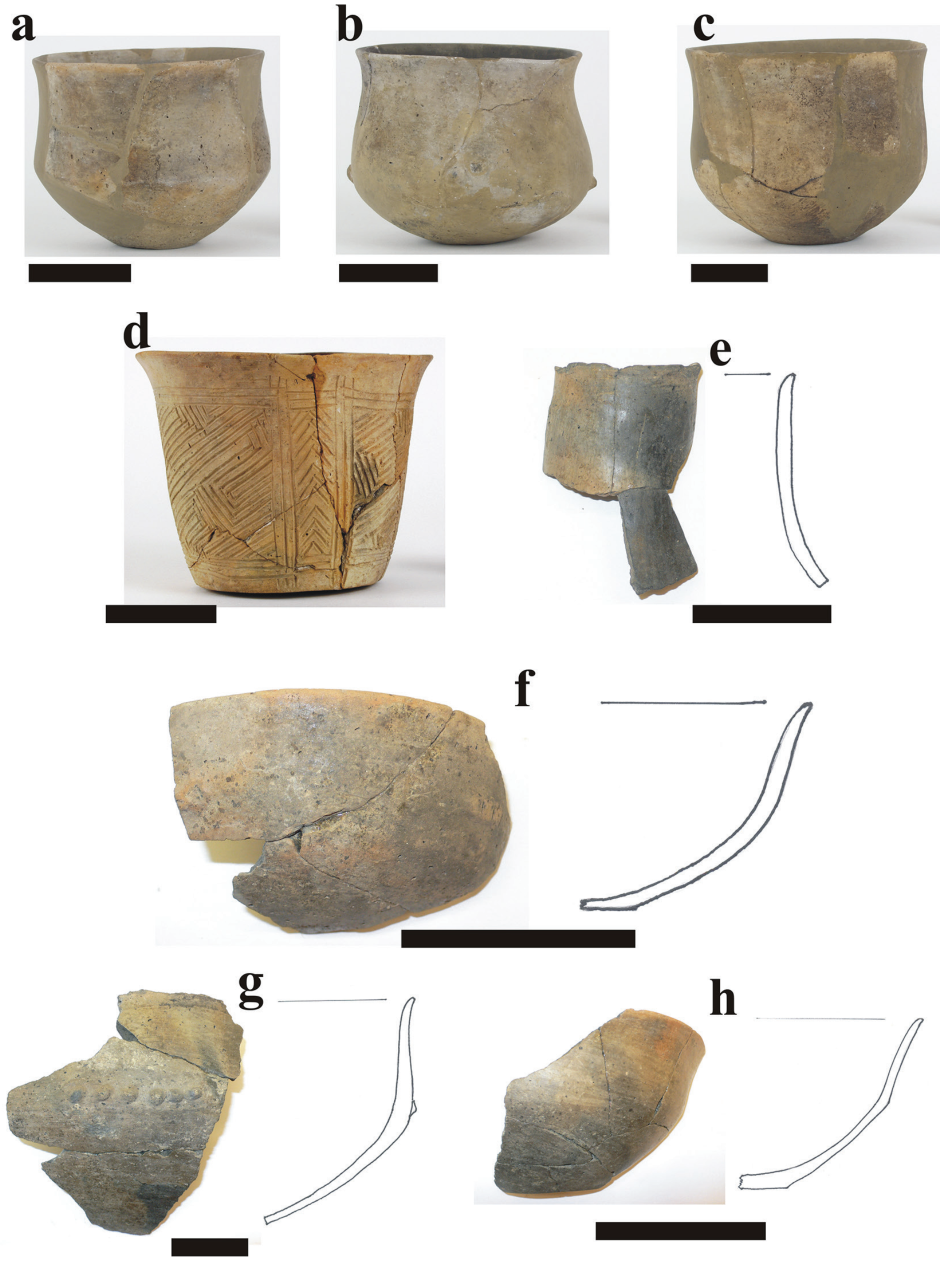

Figure 4: Characteristic vessel types from Gorzsa tempered with plants: a, b, c) mugs; d) flowerpot form (incised); f) fragment of bottle (neck); e) and g) bowls; h) fragment of cup. Black scales are 5 cm.

Results of analyses

Macroscopically, the majority of the Gorzsa ceramics have a sandwich structure with grey-black cores and thin reddish edges. The average thickness of the ceramics is about 1 cm (ranging from 0.3 to 2.5 cm). Several coarse-grained grog and ARF are visible in the fabrics, mainly in the fractured surfaces of the ceramics. No other clasts can be recognised by the naked eye. The ceramics are only slightly porous (Figure 6).

On the basis of microscopic petrographic investigation, the 51 examined vessels were divided into four groups, based on their tempering materials and fabrics. Generally, the basic raw materials of Gorzsa ceramics are very fine or fine-grained non-calcareous silty clays with a wide range of non-plastic inclusions, the amounts of which vary between moderate and abundant (10-40%). The main composition of ceramics is monocrystalline quartz and muscovite-sericite. Small or modest amounts of polycrystalline quartz, plagioclase and K-feldspar also occur. Accessories are generally rarely visible under the polarizing microscope, the most common are garnet, epidote, ilmenite, amphibole, apatite and zircon. In addition to the use of a polarizing light microscope, accessories

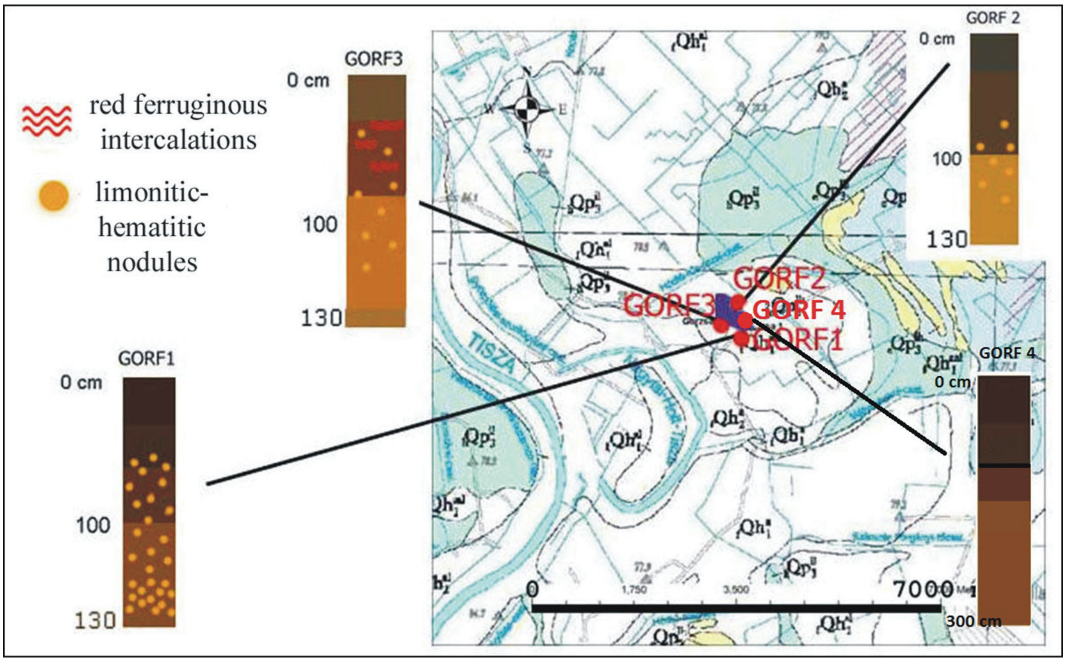

Figure 5: Geological map of the site and simplified well-log of the collected shallow drillings (after Gyalog 2005).

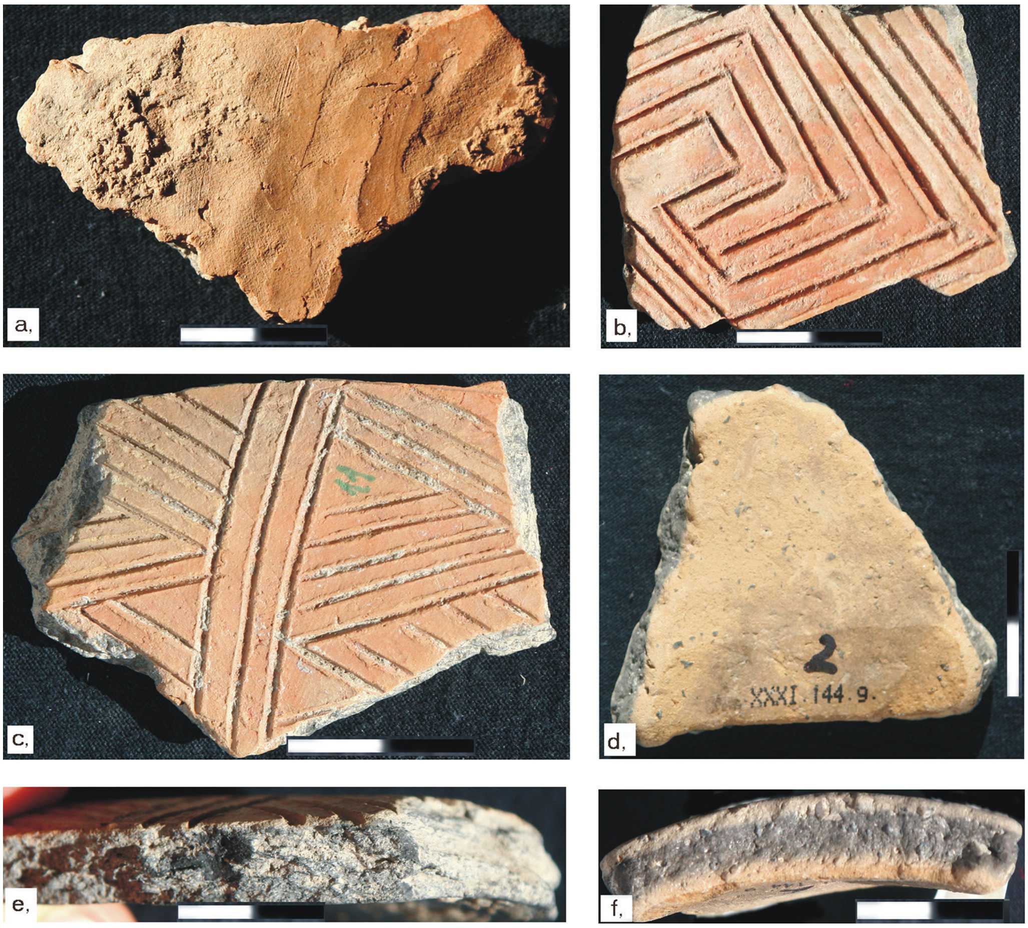

Figure 6: Examples of Tisza culture ceramics from the Gorzsa tell: a) type 2a (sample Gorker-155); b) type 3a (sample Gorker-118); c and e) type 2a (sample Gorker-111); d and f) type 1a (sample Gorker-102). Scales are 2 cm.

were identified by electron-microscopy. Matrices are generally optically active with crossed polars, but some heterogeneities also occur. On the basis of the quantity, size and distribution of natural non-plastics and the different tempering materials, four fabrics and some sub-fabrics could be distinguished: 1) lean clay, ARF/grog tempered; 2) mica-rich fat clay without (A) or with (B) ARF/grog tempering; 3) fat clay tempered with organic material (plants) with (A) and without (B) ARF/grog; 4) ceramics made from slightly lean clay without tempering material with very well sorted inclusions. Table 2 summarises the most important features of the analysed ceramic samples.

1) The lean clay with ARF/grog tempering is the most common type. The ceramics have hiatal fabrics, they contain high but variable amounts of ARF/grog temper (5-30%), showing high variability in their colour, density, porosity and non-plastic inclusions under polarising microscope (Figure 7a–b). According to the dominant size of ARF/grog we can distinguish two subgroups: the grain size of ARF/grog is between 200 and 500 μm (subgroup A) or dominantly >500μm (subgroup B). Non-plastic clasts are very fine or fine, generally well sorted, the dominant grain size is between 25 and 75 μm. The amount of non-plastic inclusions is 15-25%. Monocrystalline quartz, muscovite-sericite, K-feldspar, plagioclase, rare amounts of polycrystalline quartz, hematite and accessories also occur, which are mainly garnet, amphibole and zircon. Limonitic nodules may also occur. Distinguishing between ARF and grog is not easy. We could define grog fragments when they showed visible signs of earlier firing: some of the grog fragments showed fire clouding, or their colours were different from that of the incorporating matrix (e.g. oxidised grog appeared in a reduced ceramic or the other way around). It could also be recognised by its optically inactive fabric or stronger vitrification that was visible through electron-microscopy (Whitbread 1986; Cuomo di Caprio and Vaughan 1993). In light of this, apart from grog temper, harder clay pieces were also identified in the ceramics.

2) The mica-rich 'fat' clay is quite common among the studied ceramics. The matrix contains increased amounts of fine-grained mica but only rare amounts of other very fine clasts. The raw material is a plastic, 'fat' clay showing much less inclusions than the other fabrics. These ceramics have hiatal fabrics. We have divided this group into two subgroups based on the amount of tempering material: there is more, 15-20% fine sand or silt tempering in subgroup A, while subgroup B contains a maximum of just 10%. In subgroup A the amount of non-plastic inclusions is between 20 and 25%. The amount of non-plastic clasts in the matrix is moderate and they are fine-grained (dominantly 40-50μm). The inclusions are monocrystalline quartz, polycrystalline quartz, muscovite-sericite, feldspars and accessories (mainly garnet, amphibole, epidote). In subgroup B, the size and type of non-plastic inclusions are similar to

Table 2: The summarized textural characteristics of the ceramic types and subtypes, daubs and sediments.

	Ceramics							Daubs	Drillings			
type	**Fabric 1a**	**Fabric 1b**	**Fabric 2a**	**Fabric 2b**	**Fabric 3a**	**Fabric 3b**	**Fabric 4**	**Daubs**	**GORF1**	**GORF2**	**GORF3**	**GORF4**
Number of studied samples	22	3	6	3	8	2	7	5	3	3	3	3
Hiatal/serial	serial	serial	hiatal	hiatal	hiatal	serial	serial					
Dominant grain sizes of clasts in matrix (μm)	25-75	25-75	40-50	25-30	25-50, 150-200	50-75	25-75	75	30-75	75-100	25-50	25-50, 200-250
Max grain size of clast (μm)	125-225	125-225	250	250	125-250	150	110-130	200	100	150	75	250
Amount of clasts (%)	15-25	15-25	20-25	10	5-15	15-20	15-25	10-15	20	15	25-30	20-30
Sorting of clasts	very well	very well	well	well	well	well	very well	well	well	well	very well	well
ARF/grog amount (%)	5-30	5-30	5-25	10	3-10	no	no					
ARF/grog size (μm)	250-500	>500	250-500	250-500	500	-	-					
Plant temper (%)	no	no	no	no	5-25	5-10	no	5				
Rock fragments	no	no	no	no	no	no	no	no	no	no	no	no
Carbonate contents (%)	no	no	no	no	no	no	no	1-2	no	no	no	2-3

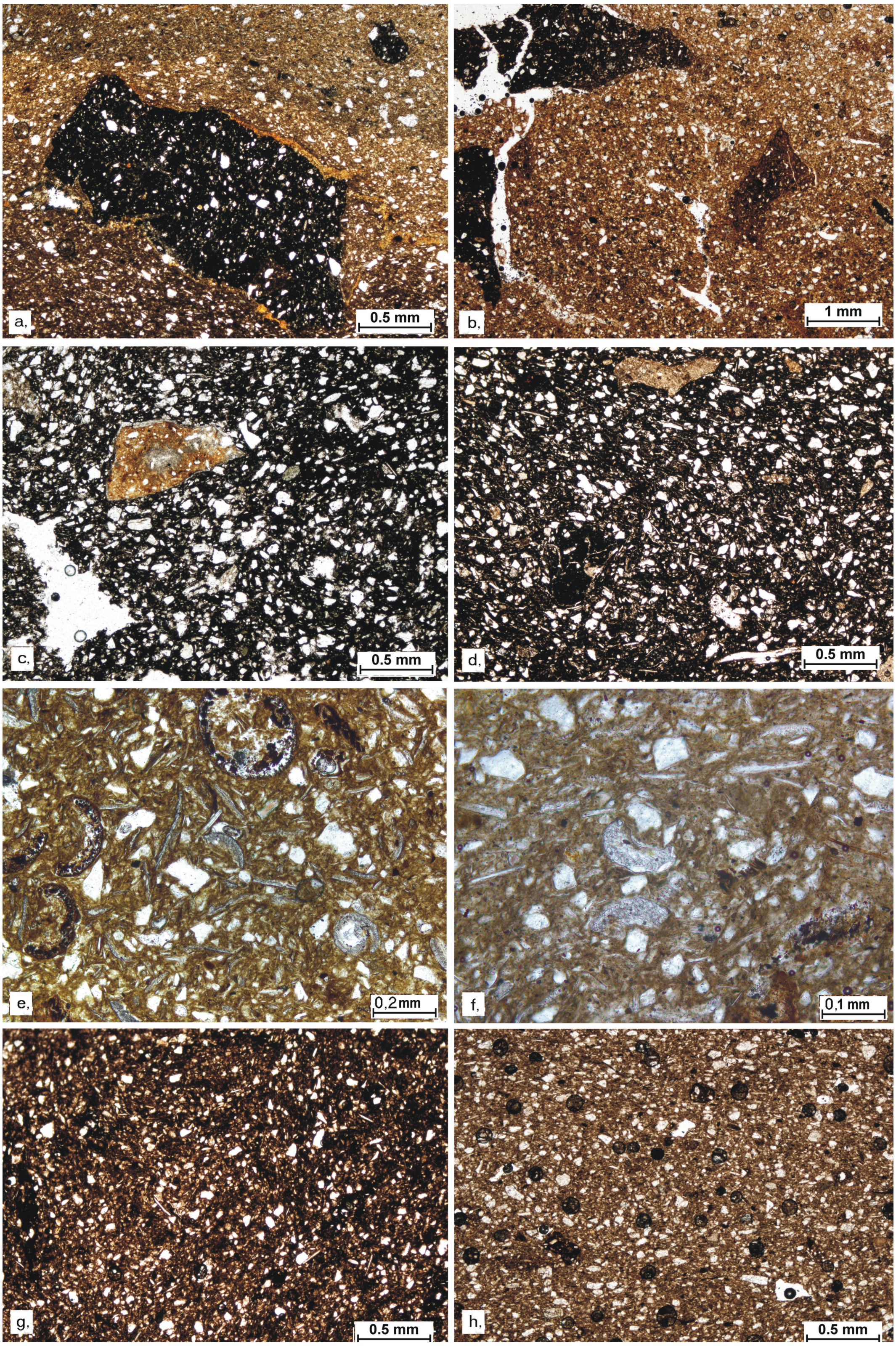

Figure 7: Photomicrographs of Tisza culture ceramics from Gorzsa tell: a) fabric 1a (sample Gorker-001); b) fabric 1b (sample Gorker-150); c) fabric 2a (sample Gorker-006); d) fabric 2b (sample Gorker-123); e) fabric 3a (sample Gorker-120); f) fabric 3a (sample Gorker-124); g) fabric 4 (sample Gorker-152); h) fabric 4 (sample Gorker-154). All images were taken in plane polarised light.

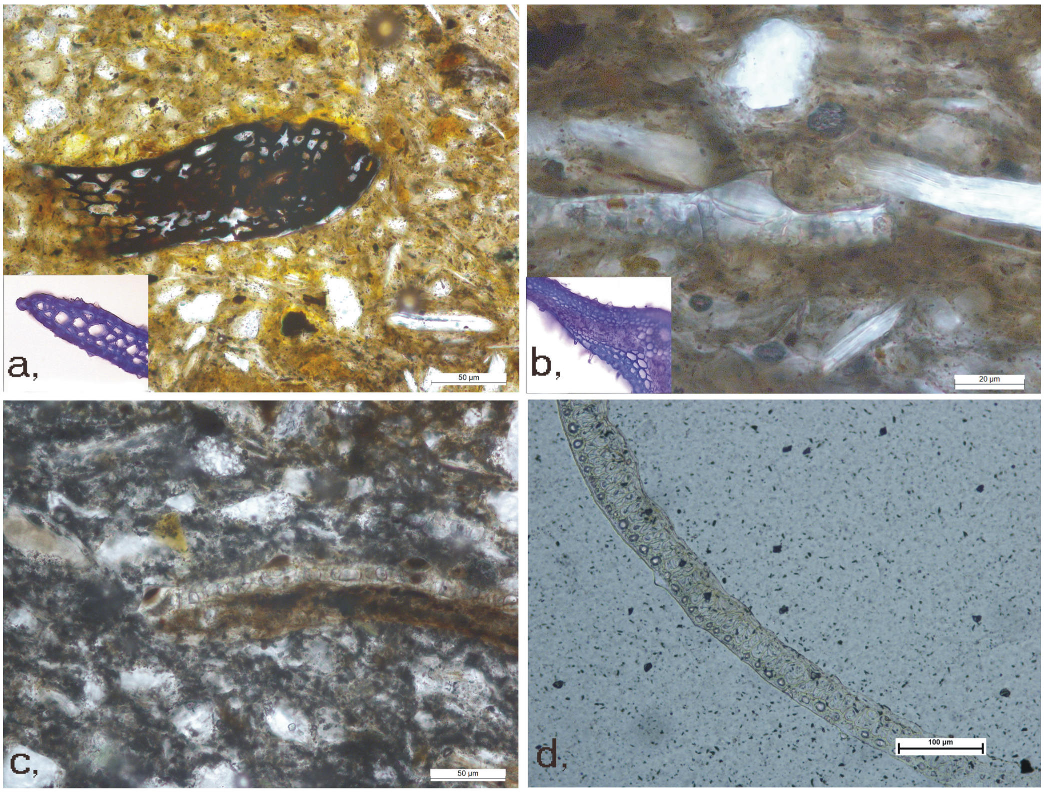

Figure 8: Plant matter in fabric 3: a) fabric 3a (sample Gorker-118), bottom left recent *Triticum* sp. is shown; b) fabric 3a (sample Gorker-125), bottom left recent *Triticum* is shown; c) fabric 3b (sample Gorker-130); d) recent *Triticum turgidum* L. subsp. dicoccum. All images were taken in plane polarised light.

subgroup A (dominantly 25-30 µm), but these ceramics contain lower amounts of tempering material (Figure 7: c-d).

3) Organic-tempered ceramics contain variable amounts of burnt plants. Their raw material was fat clay. Non-plastics are very fine or fine, dominantly between 25 and 50 µm (in some ceramics 75 µm), the maximum grain size is 250 µm. The amount of non-plastic inclusions which are monocrystalline quartz and muscovite-sericite is around 10-15 %; there are rare amounts of feldspar and polycrystalline quartz; accessories include amphibole, hematite, epidote and apatite. We have divided this group into two subgroups: in group A there are some ARF grains, while in the other (B) no ARF was identified (Figure 7: e-f).

The ceramics contain different amounts (5-25 %) of charred plant remains with phytoliths (Figure 8). According to the observations of the analysed thin-sections, straw material, leaf and stem fragments were not utilised as vegetal temper, only the by-products of the latter cereal cleaning phases were used. Based on the anatomical observations of the cell wall patterns of articulated phytoliths, and on the comparison of the charred tissue remains to modern reference collection (plant anatomical thin-sections) the vegetal tempering of the ceramics can be associated with wheat (*Triticum* sp.). It must be noted, however, that the exact taxonomical species identification of the plant used for tempering cannot be carried out on the basis of the botanical evidence encapsulated in the ceramic fabrics (Figure 8). This statement is in relation with two different issues: 1) based on individual phytoliths, or on small sample sizes of measurable disarticulated phytolith assemblages, it is not possible to distinguish between closely related taxa (for details see Ball *et al.* 2017); 2) morphometric measurements that would facilitate plant identification in these cases are hindered by thin-sectioning and the so-called '2D analytical space'; namely phytoliths and silica skeletons (disarticulated phytoliths) cannot be rotated for the sake of precise morphometric measurements under the microscope within the thin-sections, since they are fixed (for a description of the methodological issues of this field, see Kreiter *et al.* 2013; 2014; Pető and Vrydaghs 2016).

The taxonomical identification of plant species and genera based on archaeological or fossilised phytolith assemblages is a highly debated issue and requires exceptional sample conservation. Based on the so-called cell wall patterns produced by the disarticulated elongate dendritic cells of cereal species,

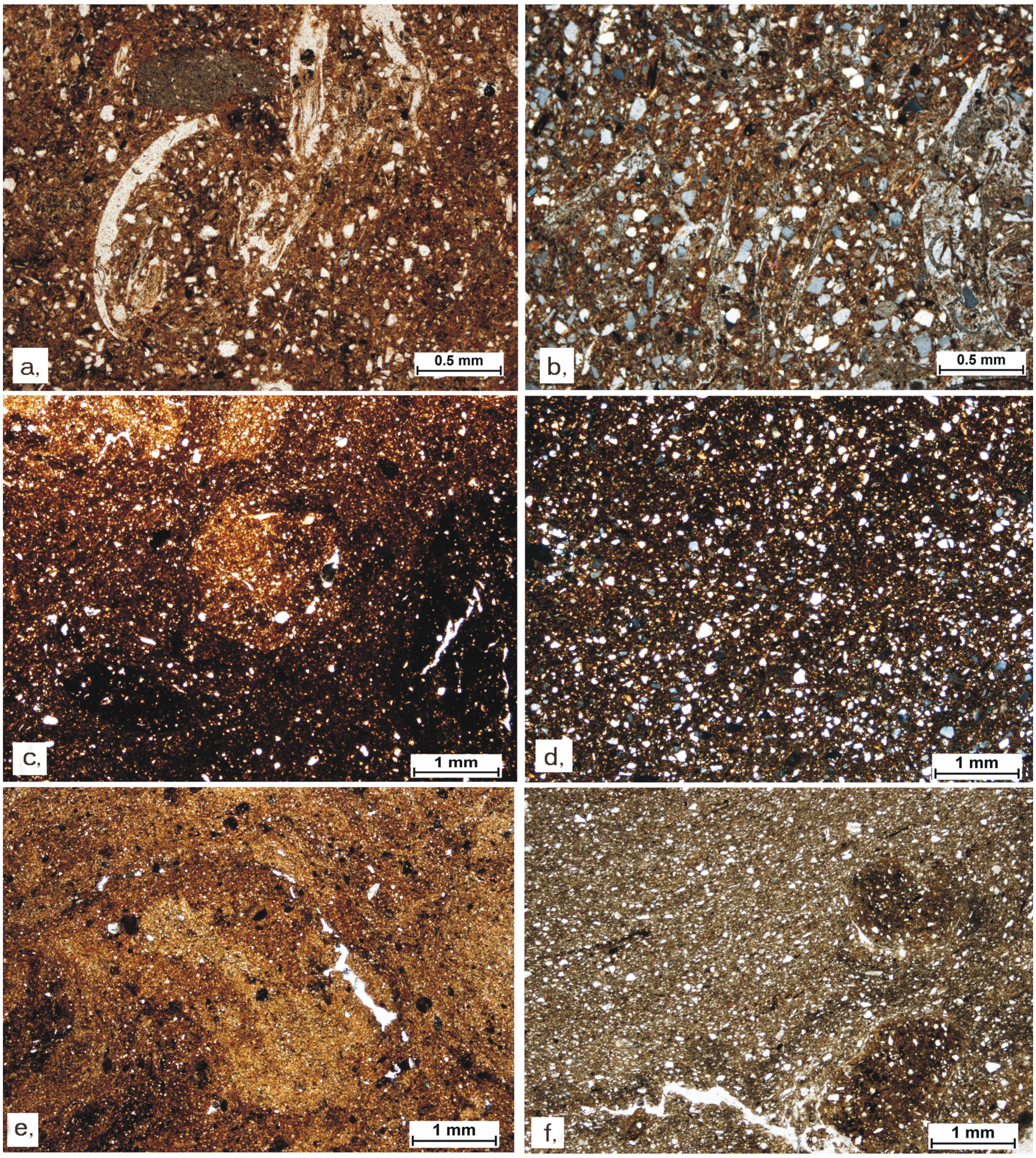

Figure 9: Photomicrographs of very fine-grained daub fragments from Gorzsa tempered with vegetal materials, and photomicrographs of sediments from shallow drillings: a) sample Gorker-011; b) sample Gorker-012; c) drill Gorf-1; d) drill Gorf-2; e) drill Gorf-3; f) drill Gorf-4. All images, except b) were taken in plane polarised light.

a visual comparison can be the basis of the genera identification, however without a statistically sound number of measurements on these remains a species identification cannot be carried out with high certainty (Ball *et al.* 2017).

4) The ceramics that belong to this group are made from slightly lean clay without tempering. The fabric is serial, not oriented. The non-plastic inclusions are fine: 25-75 μm, the maximum size is 130 μm, the inclusions are very well sorted. The amount of non-plastic inclusions is around 15-25 %. There are increased amounts of monocrystalline quartz and muscovite-sericite, less plagioclase and rare biotite and accessories (dominantly apatite, zircon and rutile). Limonitic-hematitic nodules also occur (Fig, 7: g–h).

The examined five daub fragments came from clayey floor or wall fragments and are assumed to have a composition very similar to contemporary sediments, since their raw materials may not have been modified as much as that of the ceramics. Daub fragments are mainly 3-5 cm thick, burned clayey materials. The samples are very porous and contain organic materials which are well visible with the naked eye. The composition and distribution of non-plastic inclusions in the examined daub samples is very similar to those of ceramics (mainly monocrystalline quartz, feldspar and

Table 3: Chemical compositions of ceramics and sediment matrices (wt%).

Group/ drill	sample	SiO_2	TiO_2	Al_2O_3	FeO^{tot}	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SUM
Ceramics												
1a	Gorker 001_mx1	65.94	0.35	19.23	6.18	nd	2.58	1.33	nd	4.4	nd	100.01
	Gorker 001_mx2	63.48	1,16	18.87	5.79	nd	2.94	2.10	nd	4.53	1.11	99.98
	Gorker 001_mx3	70.53	0.35	15.57	5.24	nd	2.18	1.05	nd	3.75	1.34	100.01
1a	Gorker 003_mx1	70.71	0.23	17.07	4.65	nd	3.06	0.71	nd	3.57	nd	100.01
	Gorker 003_mx2	53.52	0.20	24.31	10.56	0.39	3.72	0.90	0.58	5.83	nd	100.00
	Gorker 003_mx3	58.93	0.81	22.61	7.32	nd	4.26	1.19	nd	4.88	nd	100.00
1a	Gorker 119_mx1	53.49	0.24	23.41	12.14	nd	4.30	0.70	1.95	3.78	nd	100.01
	Gorker 119_mx2	54.25	0.67	24.66	7.99	nd	4.17	1.70	2.15	4.42	nd	100.01
	Gorker 119_mx3	63.54	0.90	19.50	6.87	nd	3.31	1.04	1.10	3.72	nd	99.98
1b	Gorker 150_mx1	55.74	0.59	24.70	7.07	nd	3.49	2.73	nd	5.18	0.50	100.00
	Gorker 150_mx2	62.79	0.54	19.59	5.75	nd	2.86	1.86	1.34	5.27	nd	100.00
2a	Gorker 009_mx1	61.25	0.41	23.01	6.99	nd	3.67	0.51	nd	4.16	nd	100.00
	Gorker 009_mx2	57.99	0.62	24.39	8.28	nd	4.12	0.72	nd	3.87	nd	99.99
3a	Gorker 120_mx1	53.50	0.62	20.56	13.81	nd	3.34	1.71	nd	5.16	1.28	99.98
	Gorker 120_mx2	60.61	0.50	20.27	5.10	nd	3.47	0.94	1.23	7.17	0.70	99.99
Drills												
Gorf-1	Gorf 1_mx1	60.20	0.45	24.00	6.83	nd	3.80	1.56	nd	3.15	nd	99.99
	Gorf 1_mx2	67.44	0.57	19.88	4.14	nd	2.39	2.49	nd	3.08	nd	99.99
	Gorf 1_mx3	59.47	0.61	24.71	6.44	nd	3.63	1.70	nd	3.43	nd	99.99
Gorf-2	Gorf 2_mx1	57.29	0.47	21.90	8.04	nd	3.74	2.57	nd	4.91	1.07	99.99
	Gorf 2_mx2	54.25	0.37	24.98	6.02	nd	4.64	3.63	nd	5.10	1.02	100.01
	Gorf 2_mx3	56.54	0.62	20.87	7.64	nd	4.17	4.79	nd	4.21	1.17	100.01
Gorf-3	Gorf 3_mx1	71.98	1.15	15.66	5.24	nd	2.88	0.76	nd	2.16	0.17	100.00
	Gorf 3_mx2	60.69	0.58	22.72	7.05	nd	3.88	1.41	nd	2.79	0.88	100.00
	Gorf 3_mx3	61.67	0.62	23.06	6.55	nd	3.29	1.29	nd	3.14	0.28	100.00
Gorf-4	Gorf 4_mx1	53.07	0.37	26.73	6.97	nd	3.87	1.85	1.55	5.59	nd	100.00
	Gorf 4_mx2	52.47	0.27	23.17	10.43	nd	4.28	2.74	1.96	4.68	nd	100.00
	Gorf 4_mx3	53.88	0.23	24.62	6.02	nd	4.40	3.19	2.04	5.64	nd	99.99

nd - not determined

mica). Like ceramic Fabric 3, the daub was tempered with organic materials and therefore it contains phytoliths and pores but no grog or ARFs. The amount of non-plastic inclusions is 10-15%, the dominant grain size is 75 μm and the maximum size is 200 μm. Most of them contain rare amounts of primary carbonate (~1–2%) (Figure 9: a-b).

The colour and inclusion size of the sediment samples from the four drillings show high variability. Neither of them contains carbonate, apart from those which were collected on the tell. These samples yield scarce (2-3%) amounts of carbonate. In the samples from the three drillings of the vicinity of the site, the amount of non-plastic inclusions varies between moderate and common (10-30%); the inclusions are very fine (25 μm and 125 μm) and mainly comprised of monocrystalline quartz, mica and accessories such as garnet, epidote, ilmenite, amphibole and apatite. Similar to the ceramics, they contain limonite-hematite nodules. The amount of non-plastic inclusions in the samples from the tell is common (25-30%), and the dominant size of inclusions is 25-75 μm, the largest are 200-250 μm (Figure 9: c-f).

In addition to the results of microscopic petrography, SEM-EDX analyses were also carried out. First the chemical composition of matrices was determined both in ARF/grog inclusions and the matrix incorporating them to assess similarities or differences between them

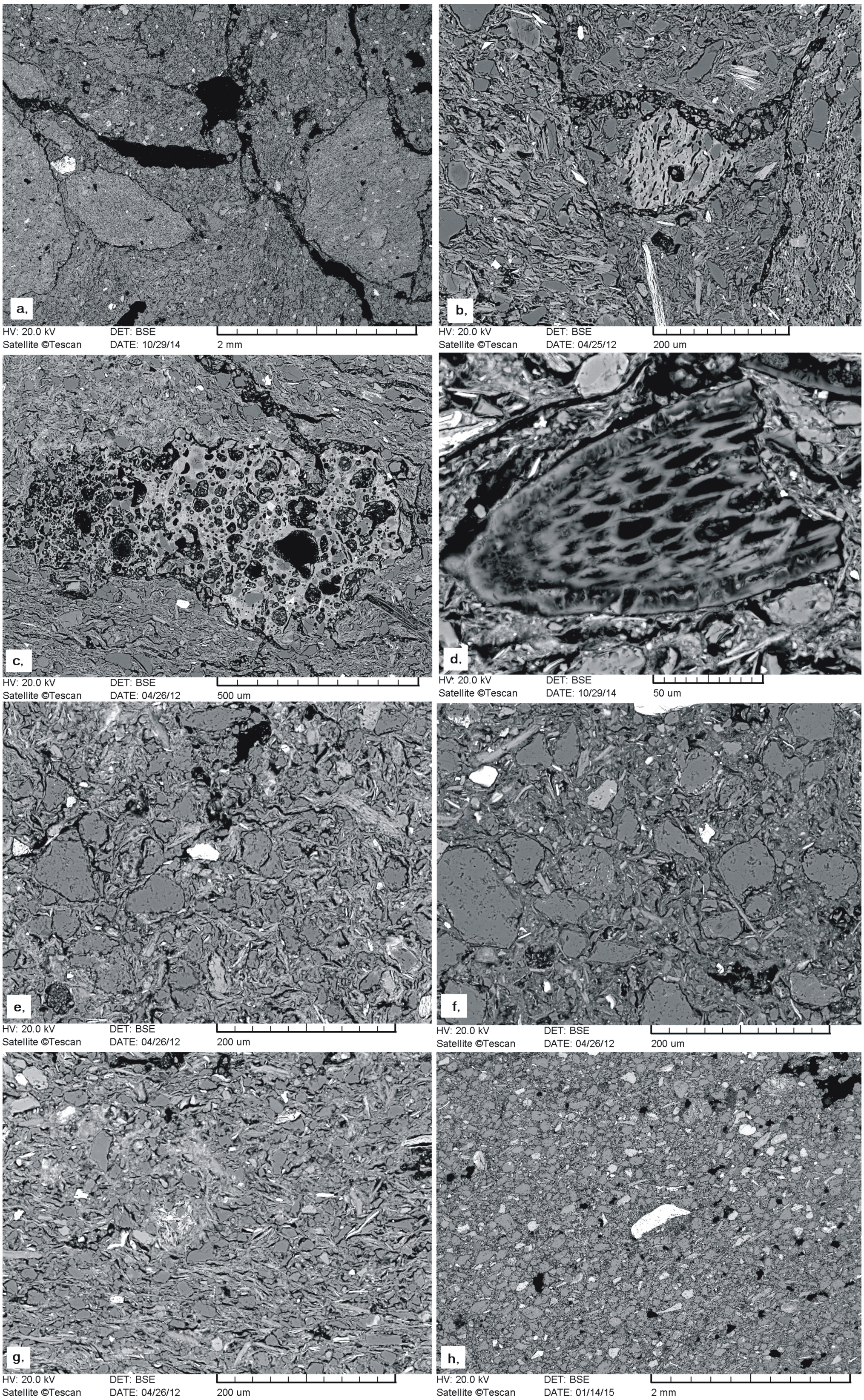

Figure 10: Backscattered electron images of ceramics and the argillaceous sediment samples from the site: a) fabric 1b (sample Gorker-150); b) fabric 2a (sample Gorker-009); c) fabric 2a (sample Gorker-009); d) fabric 3a (sample Gorker-120); e) drill Gorf-1; f) drill Gorf-2; g) drill Gorf-3; h) drill Gorf-4.

and to determine whether they represent similar raw materials. The compositional analyses of matrices of the collected sediments helped us determine whether local clayish raw materials were used to make ceramics and if different types of clays were mixed. The latter practice seemed probable according to the results of petrographic analysis. The results indicate that the composition of ceramic matrices and local clayish sediments is similar, therefore the analysed ceramics were made from local raw materials (Table 3). Only minor differences exist between them in terms of grain size, distribution of grains and amount of non-plastic inclusions. In this respect, the composition of the sediments slightly differs from that of the ceramics. These differences, together with inhomogeneities in the ceramic matrices, suggest that diverse types of local clays (fat and lean) were mixed during the preparation of ceramic raw materials.

As mentioned earlier, most of the accessories are very fine (20-40 μm). In this respect SEM-EDX helped a great deal to identify these inclusions (Figure 10: a-b). According to SEM-EDX analyses, the ceramic matrices show no vitrification or only initial vitrification, suggesting that the firing temperature of the examined ceramics was relatively low. Increased vitrification was only identified in some strongly fired grog inclusions (Figure 10: c).

Discussion

The results of polarising microscopy and SEM-EDX analyses of ceramics, daubs and local clayish sediments proved that at Gorzsa local clayish silts or silty clays were used for ceramic production. Based on their composition, the analysed ceramics were divided into four major fabric groups, but subgroups were also established in Fabrics 1, 2 and 3 (see Tables 1 and 2). ARF/grog tempering was the most common practice in all Late Neolithic periods of the tell, except for ceramics of Fabric 4, in which there are no traces of any tempering. Ceramics in Fabric 4 show very well-sorted fine-grained non-plastic inclusions. At this stage of research, it cannot be assessed whether the raw materials of the ceramics were levigated or if a naturally very well-sorted fine-grained raw material was used to make these vessels. However, it must be noted that Gorzsa is surrounded by floodplains and such very well-sorted raw materials can occur naturally in this environment. Organic tempering appeared only in the earliest (D) phase of the tell. Although there are similarities between the composition of the ceramics and the local sediments, they show slight differences in their grain size distribution. Moreover, we recognised weak inhomogeneities in ceramic matrices, with variable amounts of non-plastic inclusions being unevenly distributed. These differences, together with the large amount of ARF, may suggest that at least two types of raw materials were mixed (fat and lean clay) during ceramic production and the homogenisation of raw materials was inappropriate. Based on optically active matrices in crossed polars and no extensive vitrification in the matrices examined using electron microscope, the firing temperature of vessels was relatively low, probably less than 700-750°C.

The compositions and fabrics of the ceramics and daubs are very similar, apart from the carbonate content, which occur only in daubs. Therefore, the raw materials of daub fragments probably originate from the tell itself rather than from its larger surrounding environments.

ARF/grog tempering was common in the Late Neolithic of Hungary, therefore Gorzsa fits well into observations made earlier at other Late Neolithic sites. Distinguishing between ARF and grog tempering is important, because grog may have been used in a particular manner for cultural reasons rather than functional (Kreiter 2007), while ARF could occur naturally in the raw material as a result of inappropriate raw material preparation (harder clay pieces were not homogenised properly). In Whitbread's (1986) and Cuomo di Caprio and Vaughan's (1993) studies there are some guidelines to help distinguish between ARF and grog, such as optical features, shape and border of the inclusions, orientation of pores and inclusions. It must be noted that in some cases we could not make clear distinctions between grog and ARF fragments.

Unfortunately, there are only a few petrographic and/or SEM-EDX analyses of grog tempered ceramics in the southern part of the Great Hungarian Plain and its larger area. For example, Spataro (2013) mentions ARF from Vinča B and C phases at Parţa in the Romanian Banat. Ceramic analyses of other Late Neolithic sites in Hungary, such as Aszód (Lengyel-Tisza culture) (Kreiter *et al.* 2017), Pusztataskony (Tisza culture) (Sebők *et al.* 2012), Szemely-Hegyes, Zengővárkony and Belvárdgyula (Lengyel culture) (Kreiter and Szakmány 2008a; 2008b), also show that grog tempering was the most common practice during this period. It must also be noted that grog tempered Late Neolithic ceramics almost always contain ARF fragments, thus ARF seems to appear consistently with grog tempering. Therefore, their appearance in ceramics may have been intentional and may not have been a result of inappropriate raw material preparation. ARF fragments and grog have similar physical and thermal characteristics (Rice 1987: 229), therefore it can easily be ascertained that potters also used dry clay for tempering. Similar assumptions were also made for the Copper Age, when grog tempering is the most common tempering practice and ARF fragments also appear with grog (Kreiter 2009).

Regarding organic tempering in the Carpathian basin and in the Balkans, this practice is widespread in Early

Neolithic cultures (Körös/Cris/Starčevo, e.g. Szakmány and Starnini 2007; Kreiter 2010; Spataro 2013). Besides other tempering practices, organic tempering was still extensively used in the Middle Neolithic (Kreiter *et al.* 2011; Zsók *et al.* 2012; Spataro 2013) but almost disappeared in the Late Neolithic. In fact, amongst the Late Neolithic sites in Hungary so far examined (see above), Gorzsa and Tápé-Lebő are the only known sites where the practice of organic tempering still appears in the Late Neolithic (Tápé-Lebő is unpublished). It must be noted, however, that this is the least common practice at these sites. Decrease in vegetal tempering towards the Late Neolithic is also noted in Poland (Rauba-Bukowska 2009: 247).

Conclusions

This is the first comprehensive archaeometric (petrographic and SEM-EDX) study on the ceramic material of Gorzsa. The examined ceramics were made from fine-grained, local non-calcareous silty clays and clayish silts. The most common tempering was ARF/grog, which was used in substantial amounts. This practice fits well in terms of the observations made at other Late Neolithic sites in Hungary. As opposed to other previously analysed Late Neolithic sites in Hungary, organic tempering also appears in Gorzsa but only in the oldest, D phase of the tell. The reason why this practice remained in use for so long in Gorzsa is yet to be understood. Untempered ceramics rarely occur; this technological practice also comprises the minority of the assemblage. The dominantly very fine-grained accessories could only be determined by SEM-EDX, which contributed greatly in assessing the local origin of the ceramics and to understand how potters used their environment and how they manipulated their raw materials.

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Bibliography

Ball, T., Vrydaghs, L., Mercer, T., Pearce, M., Snyder, S., Lisztes-Szabó, Zs. and Pető, Á. 2017. A morphometric study of variance in articulated dendritic phytolith wave lobes within selected species of Triticeae and Aveneae. *Vegetation History and Archaeobotany* 26: 85-97.

Biró, T. K. 1998. *Lithic Implements and the Circulation of Raw Materials in the Great Hungarian Plain during the Late Neolithic period*. Budapest, Magyar Nemzeti Múzeum.

Cuomo di Caprio, N. and Vaughan, S. J. 1993. An experimental study in distinguishing grog (chamotte) from argillaceous inclusions in ceramic thin sections. *Archaeomaterials* 7: 21-40.

Gyalog, L. and Síkhegyi, F. (eds), 2005. *Magyarország földtani térképe, M=1:100 000*. Printed and digital version. Budapest/Magyar Állami Földtani Intézet.

Horváth, F. 1987. Hódmezővásárhely-Gorzsa. A settlement of the Tisza culture. In: P. Raczky and L. Tálas (eds), *The Late Neolithic of the Tisza Region. A Survey of Recent Excavations and their Finding*: 31-46. Budapest-Szolnok, Country Museum of Jász-Nagykun-Szolnok.

Horváth, F. 2003. Hódmezővásárhely-Gorzsa: A Late Neolithic settlement in the Tisza Region. In: Zs. Visy (ed.), *Hungarian Archaeology at the Turn of the Millennium*: 106-107. Budapest, Ministry of National Cultural Heritage/Teleki László Foundation.

Horváth, F. 2005. *Gorzsa. Preliminary results of the excavations of the Neolithic tell between 1978–1996*: 51-83. Hódmezővásárhely, Hétköznapok Vénuszai, Tornyai János Múzeum. [In Hungarian: Horváth, F. 2005. *Gorzsa. Előzetes eredmények az újkőkori tell 1987 és 1996 közötti feltárásából.*: 51-83. Hódmezővásárhely, Hétköznapok Vénuszai - Tornyai János Múzeum].

Horváth, F. 2014. Questions relating to the Proto-Tiszapolár Period in South-Eastern Hungary. Main issues and present stage of research. In: W. Schier and F. Draşovean (eds), *The Neolithic and Eneolithic in Southeast Europe*: 297-318. Prähistorische Archäologie in Südosteuropa, Band 28. Rahden/Westf., Leidorf.

Kalmár, J., Kuti, L., Kovács-Pálffy, P. and Szendreiné Koren, E. 1997. Mineralogical and sedimentological investigations on the surface and subsurface formation of the area around Szarvas. *Földtani Közlöny* 127(3-4): 385-403. [In Hungarian: Kalmár, J., Kuti, L., Kovács-Pálffy, P. and Szendreiné Koren, E. 1997. Ásványtani és szedimentológiai vizsgálatok a Szarvasi-mintaterület felszín-felszínközeli képződményein. *Földtani Közlöny* 127(3-4): 385-403].

Kreiter, A. 2007. Ceramic technological tradition and the concept of time in the Bronze Age. *Ősrégészeti Levelek* 8-9: 146-166. [In Hungarian: Kreiter, A. 2007. Kerámia technológiai tradíció és az idő koncepciója a bronzkorban. *Ősrégészeti Levelek* 8-9: 146-166].

Kreiter, A. 2009. Macroscopic and petrographic analysis of the pottery of the Baden culture. In: J. Kvassay (ed.), *Settlement and Cemetery Excavations at the Borders of Dunaszentgyörgy. Results of the Archaeological Salvage Excavations (2007) between the 121+650 – 124+800 km sections of Highway No. 6*: 41-59. Budapest, Kulturális Örökségvédelmi Szakszolgálat. [In Hungarian: Kreiter, A. 2009. A Baden kultúra kerámiáinak makroszkópos és petrográfiai vizsgálata. In: J. Kvassay (ed.), Település - *és millivoltmeter Dunaszentgyörgy határában. A 6 sz. főút 121+650 – 124+800 km szakasza között, a rehabilitációs munkálatokat megelőző régészeti feltárások (2007) eredményei. – Settlement and cemetery excavations at the borders of Dunaszentgyörgy.*: 41-59. Budapest, Kulturális Örökségvédelmi Szakszolgálat].

Kreiter, A. 2010. Crafting difference: Early Neolithic (Körös culture) ceramic traditions in north-east Hungary. In: J. K. Kozłowski and P. Raczky (eds), *Neolithization of the Carpathian Basin: Northernmost Distribution of the Starčevo/Körös Culture*: 177-193. Kraków/Budapest, Polish Academy of Arts and Sciences/Institute of Archaeological Sciences of the Eötvös Loránd University.

Kreiter, A. and Szakmány, Gy. 2008a. Preliminary study on the petrographical investigation of Late Neolithic pottery from Belvárdgyula-Szarkahegy. *Archeometriai Műhely* 3: 65-74. [In Hungarian: Kreiter, A. and Szakmány, Gy. 2008a. Előzetes tanulmány Belvárdgyula-Szarkahegy (M60-as gyorsforgalmi út 98. sz. lelőhely) késő neolitikus (Lengyel kultúra) településről származó kerámiák petrográfiai vizsgálatáról. *Archeometriai Műhely* 3: 65-74].

Kreiter, A. and Szakmány, Gy. 2008b. Preliminary report on the petrographic analysis of Late Neolithic ceramics from Szemely-Hegyes and Zengővárkony. *Archeometriai Műhely* 2: 55-68. [In Hungarian: Kreiter, A. and Szakmány, Gy. 2008b. Előzetes tanulmány Szemely-Hegyes és Zengővárkony késő neolitikus (Lengyel kultúra) településről származó kerámiák petrográfiai vizsgálatáról. *Archeometriai Műhely* 2: 55-68].

Kreiter, A., Azbej Havancsák, I., Sipos, P., Tóth, M. and Viktorik, O. 2011. The petrographic, XRF and XRD analyses of the Neolithic pottery from Maroslele-Pana. In: T. Paluch (ed.), *Maroslele-Pana. A Middle Neolithic Site at the Frontier between Cultures*: 303-325. Szeged, Móra Ferenc Múzeum. [In Hungarian: Kreiter, A., Azbej Havancsák, I., Sipos, P., Tóth, M. and Viktorik, O. 2011. Maroslele–Panáról származó neolitikus kerámia töredékek petrográfiai, XRF és XRD vizsgálata. In: T. Paluch (ed.), *Maroslele-Pana. Egy középső neolitikus lelőhely a kultúrák határvidékén*: 303-325. Szeged, Móra Ferenc Múzeum].

Kreiter, A., Kalicz, N., Kovács, K., Siklósi, Zs. and Viktorik, O. 2017. Entangled traditions: Lengyel and Tisza ceramic technology in a Late Neolithic settlement in northern Hungary. *Journal of Archaeological Science: Reports* 16: 589-603.

Kreiter, A., Pető, Á. and Pánczél, P. 2013. Materializing tradition: Ceramic production in Early and Middle Neolithic Hungary. In: E. Bánffy (ed.), *The Early Neolithic of the Duna-Tisza Interfluve*: 127-140. Oxford, Archaeopress.

Kreiter, A., Riebe, D.J., Parkinson, W.A. Pető Á., Tóth, M., Pánczél, P. and Bánffy, E. 2014. Unique in its chaîne operatoire, unique in its symbolism: undressing a figurine from the 6th Millennium BC Körös culture, Hungary. *Journal of Archaeological Science* 44: 136-147.

Pető, Á. and Vrydaghs, L. 2016. Phytolith analysis of ceramic thin sections. First taphonomical insights gained through experiments with vegetal tempering. In: E. Sibbesson, B. Jervis and S. Coxon (eds), *Insight from Innovation: New Light on Archaeological Ceramics*: 57-73. St. Andrews, The Highfield Press.

Rauba-Bukowska, A. 2009. Bone temper in Early Neolithic vessels from southern Poland. Examinations using scanning microscopy. In: D. Hofmann and P. Bickle (eds), *Creating Communities. New Advances in Central European Neolithic Research*: 235-248. Oxford, Oxbow Books.

Rice, P. M. 1987. *Pottery Analysis: A Sourcebook*. Chicago, IL, University of Chicago Press.

Sebők, K., Kreiter, A. and Viktorik, O. 2012. Influences of Lengyel origin in the Late Neolithic of the Great Hungarian Plain. First results from the excavations at Pusztataskony-Ledence 1. Appendix*:* Petrographic analysis of ceramics from a grave and the settlement of the Tisza culture at Pusztataskony-Ledence 1. *Archaeológiai Értesítő* 137(1): 97-123. [In Hungarian: Sebők, K., Kreiter, A. and Viktorik, O. 2012. Lengyeli eredetű hatások az Alföld kései neolitikumában. Pusztataskony-Ledence 1. feltárásának első eredményei. Appendix: Kerámiák petrográfiai vizsgálata Pusztataskony-Ledence 1. lelőhely, a tiszai kultúra települése és sírja anyagából. *Archaeológiai Értesítő* 137(1): 97-123].

Spataro, M. 2013. Continuity and change in pottery manufacture between the early and middle Neolithic of Romania. *Archaeological and Anthropological Science* 6: 175-197.

Starnini, E, Voytek, B. and Horváth, F. 2007. Preliminary results of the multidisciplinary study of the chipped stone assemblage from the Tisza Culture site of Tell Gorzsa (Hungary). In: J. K. Kozlowski and P. Raczky (eds), *The Lengyel, Polgár and Related Cultures in the Middle/Late Neolithic in Central Europe*: 257-268. Krakow, The Polish Academy of Arts and Sciences and Eötvös Loránd University Institute of Archaeological Sciences.

Starnini, E., Szakmány, Gy., Józsa, S., Kasztovszky, Zs., Szilágyi, V., Maróti, B., Voytek, B. and Horváth, F. 2015. Lithics from the tell site Hódmezővásárhely-Gorzsa (Southeast Hungary): Typology, technology, use and raw material strategies during the Late Neolithic (Tisza Culture). *Archäologie in Eurasien* 31: 115-138.

Szakmány, Gy. and Starnini, E. 2007. Archaeometric research on the first pottery production in the Carpathian Basin: Manufacturing traditions of the Early Neolithic, Körös Culture ceramics. *Archeometriai Műhely* 4(2): 5-19.

Szakmány, Gy., Starnini, E., Horváth, F. and Bradák, B. 2008. Investigating trade and exchange patterns in Prehistory: Preliminary results of the archaeometric analyses of the stone artefacts from tell Gorzsa (SE Hungary). *Archeometriai Műhely* 5(3): 13-25. [In Hungarian: Szakmány, Gy., Starnini, E., Horváth, F. and Bradák, B. 2008. Gorzsa késő neolit tell településről előkerült kőeszközök archeometriai vizsgálatának előzetes eredményei (Tisza kultúra, DK Magyarország). *Archeometriai Műhely* 5(3): 13-25].

Szakmány, Gy., Starnini, E., Horváth, F., Szilágyi, V. and Kasztovszky, Zs. 2009. Investigating trade and exchange patterns during the Late Neolithic: First results of the archaeometric analyses of the raw materials for the polished and ground stone tools from Tell Gorzsa (SE Hungary). In: G. Ilon (ed.), *Nyersanyagok és Kereskedelem. Őskoros Kutatók VI. Összejövetelének Konferenciakötete*: 363-377. Szombathely, Field Science for Cultural Heritage and Vas County Museums' Directorate.

Szakmány, Gy., Starnini, E., Horváth and F. Bradák, B. 2011. Investigating trade and exchange patterns in prehistory: Preliminary results of the archaeometric analyses of stone artefacts from Tell Gorzsa (South-East Hungary). In: I. Turbanti-Memmi (ed.), *Proceedings of the 37th International Symposium on Archaeometry, 12th–16th May 2008, Siena, Italy*: 311-319. Berlin, Springer-Verlag.

Vanicsek, K., Szakmány, Gy., Horváth, F., Kreiter, A. and Bendő, Zs. 2013. Preliminary results of Late Neolithic ceramic analysis from Hódmezővásárhely-Gorzsa (Tisza Culture, SE Hungary). *Archeometriai Műhely* 10(1): 5-12. [In Hungarian: Vanicsek, K., Szakmány, Gy., Horváth, F., Kreiter, A. and Bendő, Zs. 2013. Előzetes eredmények Hódmezővásárhely-gorzsai tell késő neolit kerámiáinak (Tisza-kultúra Gorzsa-csoport) vizsgálatáról. *Archeometriai Műhely* 10(1): 5-12].

Whitbread, I. K. 1986. The characterisation of argillaceous inclusions in ceramic thin sections. *Archaeometry* 28: 79-88.

Yerkes, R. W., Gyucha, A. and Parkinson, W. 2009. A multiscalar approach to modeling the end of the Neolithic on the Great Hungarian Plain using calibrated radiocarbon dates. *Radiocarbon* 5(3): 1071-1109.

Zsók, I., Szakmány, Gy., Kreiter, A. and Marton, T. 2012. Archaeometric investigation of Neolithic ceramics from a site at Balatonszárszó. In: A. Kreiter, A. Pető and B. Tugya (eds), *Environment-Human-Culture: Dialogue between Applied Sciences and Archaeology*: 411-422. Budapest, Magyar Nemzeti Múzeum Nemzeti Örökségvédelmi Központ. [In Hungarian: Zsók, I., Szakmány, Gy., Kreiter, A., Marton, T. 2012. A balatonszárszói neolit korú kerámia leletegyüttes archeometriai vizsgálata. In A. Kreiter, A. Pető, B. Tugya (eds), *Környezet–Ember–Kultúra: az alkalmazott természettudományok és a régészet párbeszéde*: 411-422. Budapest, Magyar Nemzeti Múzeum Nemzeti Örökségvédelmi Központ].