PETROGRAPHIC AND GEOCHEMICAL STUDY OF CERAMICS OF NEOLITHIC SETTLEMENTS ON THE NORTHERN BOUNDARY OF THE GREAT HUNGARIAN PLAIN – TISZASZŐLŐS-DOMAHÁZA (KÖRÖS CULTURE) AND FÜZESABONY-GUBAKÚT (ALP CULTURE, SZATMÁR GROUP)

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Kivonat

Az itt bemutatott vizsgálatok és eredmények egy DAAD-MÖB kutatóprogram keretében valósultak meg, amely kis mintaszámmal ugyan, de Tiszaszőlős-Domaháza és Füzesabony-Gubakút (ÉK-Magyarország) neolit lelőhelyek agyagárujának (kerámiák és padló, illetve patics) anyagvizsgálatára is kitért. Emellett a lelőhelyek közvetlen környezetében a felszín közelében található talajszelvények agyagos képződményeiből is gyűjtöttünk mintákat. A vizsgálatokat a fazekasáru gyártására leginkább megfelelő nyersanyagon végeztük. A kerámiákat és az üledékeket azonos (mikroszkópos petrográfiai és műszeres kémiai) módszerekkel vizsgáltunk, így az eredmények összehasonlíthatóvá váltak.

Kutatásunk egyrészről a két eltérő (Tiszaszőlős-Domaháza a Körös-, míg Füzesabony-Gubakút az Alföldi Vonaldíszes Kerámia) kultúrából származó lelőhely kerámia (és egyéb agyag anyagú) leletanyagának összehasonlítására irányult. Kiderült, hogy a kultúrabeli különbségek ellenére a kétféle fazekasáru nagy technológiai hasonlóságot mutat egymással, illetve a Körös kultúra agyagárujával. Vizsgálataink másik célja az alkalmazott nyersanyagok lehetséges azonosítása, illetve a technológiai paraméterek leírása volt. Kimutattuk, hogy a kora neolit fazekasok nagy valószínűséggel helyi folyóvízi üledékeket használtak az edények nyersanyagául különösebb előkészítés (tisztítás) nélkül, amelyeket a lelőhely környezetében a topográfiai mélyedésekből gyűjthettek. Az agyagos anyagba kisebb-nagyobb méretű növényi soványító anyagot kevertek. Az edényeket szabadon formázták, majd viszonylag alacsony hőfokon (700—750 ºC-on) égették ki nem szabályozott atmoszférában. A Tiszaszőlős-Domaházáról előkerült padlótöredék a többi lelethez képest karbonátosabb alapanyagból készült.

Eredményeink egyrészről alapját képezik a két lelőhely neolit agyagműves hagyományainak régészeti szempontú tovább értelmezésének, másrészről tovább bővítik a korszakból származó, egyelőre még szórványosnak mondható archeometriai kerámia alapadatokat.

Abstract

The investigations and results presented here were carried out in the framework of a DAAD-MÖB bilateral project. As a part of the complex aim of this project, a limited sample collection (containing ceramics, floor and daub) from two Neolithic archaeological sites, Tiszaszőlős-Domaháza and Füzesabony-Gubakút, was investigated. In addition to this archaeological sample group, geological samples (near surface clayey soils/sediments) were collected from the vicinity of the sites to find the most likely sources of raw materials for pottery making. Both ceramic and sediment samples were subjected to the same methodological research (microscopic petrographic and instrumental chemical investigations). In this way comparable data could be gained.

One aim of our research was to make a comparison between the ceramic (and other clay derivative) finds of the two Neolithic sites (Tiszaszőlős-Domaháza is connected to the Körös, while Füzesabony-Gubakút to the Alföld Linear Pottery Culture). It became clear that – despite the different cultures – the two pottery assemblages show significant technological similarities to each other and to ceramic material from the Körös Culture. The other aim of our research was to identify the most probable sources of raw materials for pottery making and to characterise the pottery manufacturing process. The results show that Early Neolithic potters probably made their pots directly (without any washing or cleaning) from the local alluvial clayey sediment which they could collect from topographic depressions of the landscape in the vicinity of the sites. They added variable sized plant remnants to this paste as a temper. Then the hand fashioned vessels were fired at a relatively low (700—750°C) temperature in an atmospherically non-controlled firing place. A floor remnant from Tiszaszőlős-Domaháza was made of a more carbonatic raw material than the pots.

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On the one hand, our results can help to define the pottery traditions of these two Neolithic sites from an archaeological point of view. On the other hand, they can extend the presently sporadic raw data on archaeometrical ceramic investigations of this archaeological era.

KULCSSZAVAK: NEOLIT, KERÁMIA (PADLÓ, PATICS), TALAJ/ÜLEDÉK, PETROGRÁFIA, TELJES KÉMIA

KEYWORDS: NEOLITHIC, POTTERY (FLOOR, DAUB), SOIL/SEDIMENT, PETROGRAPHY, BULK CHEMISTRY

Introduction

This research formed part of the DAAD-MÖB German-Hungarian bilateral project carried out in 2005-2006 with the title of „Archaeometrical analysis of Neolithic pottery and comparison to potential sources of raw materials in their immediate environment" (see details on the project's website: www.ace.hu/daad/daad2). The project was launched, partly, to start a systematic database for archaeometrical investigations of the Neolithic period in Hungary. Former natural scientific research have been confined to ceramic assemblages from individual sites, especially from the Early Neolithic Körös (Szakmány et al., 2005; Spataro, 2004, 2006; Szakmány and Starnini, 2007) and Starčevo Cultures (Gherdán et al., 2004; Biró et al., 2007) as well as Early-Middle Neolithic Szakálhát (Szakmány and Starnini, 2007) and Bükk Cultures (Szakmány, 2001).

The two archaeological sites studied here – Tiszaszőlős-Domaháza and Füzesabony-Gubakút – have a close temporal and spatial connection since both were settled in the beginning of the Neolithic Age and are situated on the Northern margin of the Great Hungarian Plain in the vicinity of the foothills of Mátra Mountains (**Fig. 1**). Although both settlements could play an important role in the neolitisation of the Northern territory of the Great Plain, Tiszaszőlős-Domaháza is an Early Neolithic Körös Culture site while Füzesabony-Gubakút is a Middle Neolithic ALP Culture (Szatmár Group) site (Domboróczki, 2005).

A comparative archaeometrical investigation of archaeological ceramics of these sites provides interesting data on the raw material usage and manufacturing techniques of pottery making. In addition to this, the results yielded new data for the complex investigation of the process of neolitisation in the territory of Hungary.

Samples and methods

As a part of the above mentioned MÖB-DAAD project, in addition to the ceramic collection, systematically collected soil/sediment samples were investigated.

For the Tiszaszőlős-Domaháza archaeological site, eight pieces of ceramics (six fragments from plant tempered, thick and porous walled vessels, one sample from thin walled, weakly painted fine ware and another one from a statue; DIV-01—02,04—09) and a remnant of a compact, non plant-tempered floor (DIV-03) of a house were selected for detailed examinations (**Fig. 2**).

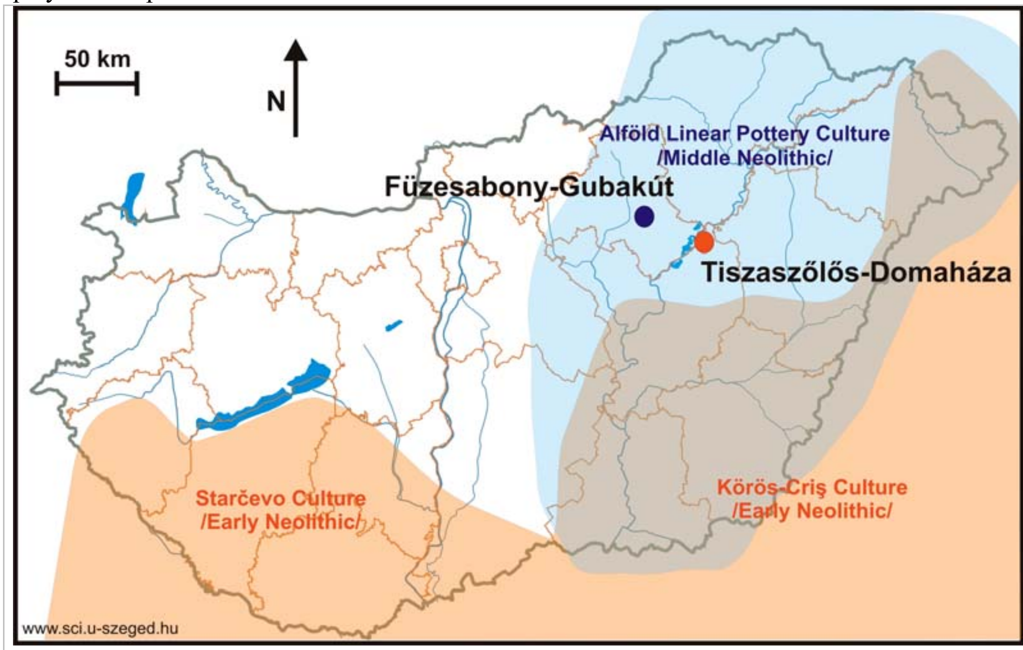

Figure 1

Location of the studied Neolithic sites (geographic extension of the concerned archaeological cultures are shown after Visy et al. eds. 2003 p. 98)

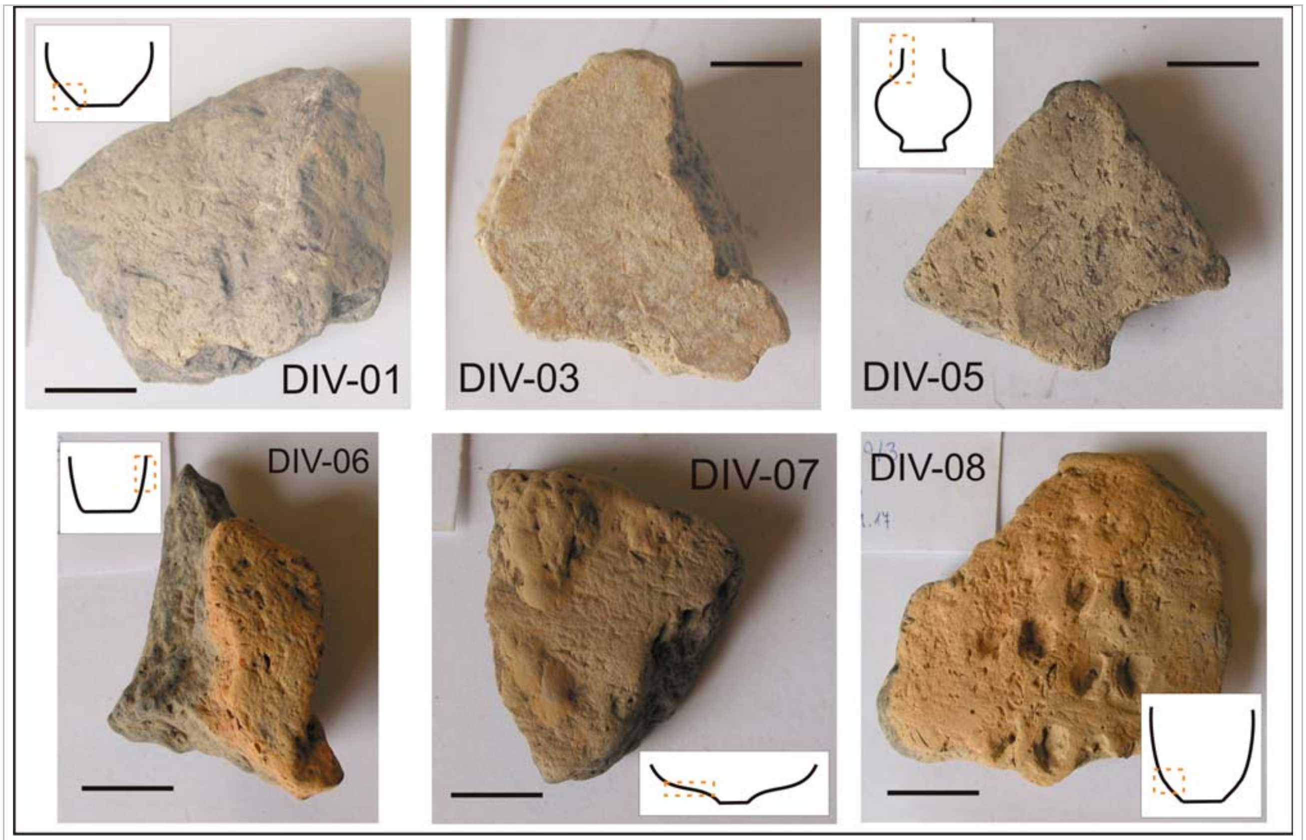

Figure 2 - Archaeological samples from Tiszaszőlős-Domaháza. (Scale is 1 cm).

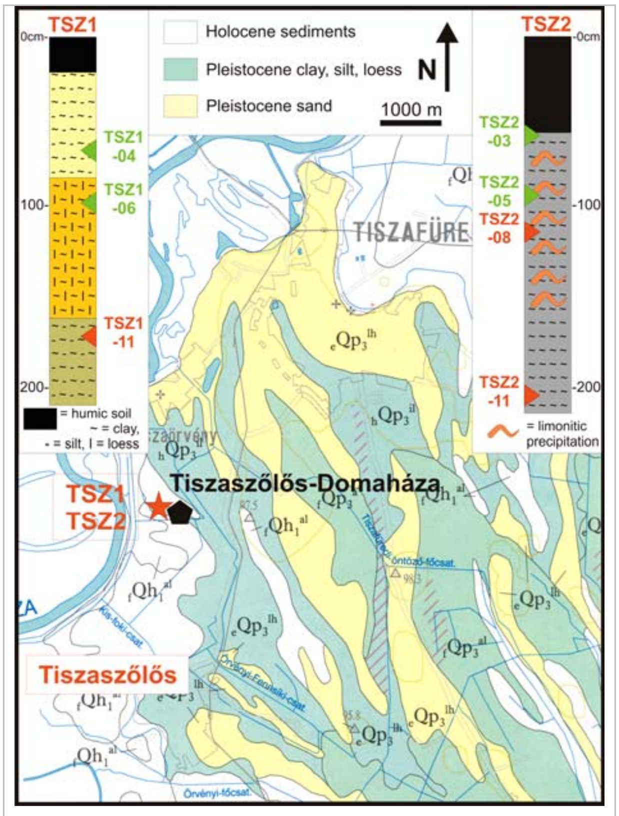

Figure 3 - Geological map of the surroundings of Tiszaszőlős-Domaháza site (red star marks the drilling sites, black pentagon the archaeological site) and the location of the comparative soil/sediment samples in each drillcore (samples marked with red arrows were investigated petrographically and chemically, samples marked with green arrows were investigated only chemically). The colours in the soil sections are roughly correct (After Gyalog ed. 2005).

Geological soil/sediment samples from Tiszaszőlős-Domaháza were collected by two hand drillings (No. TSZ1 and TSZ2) 2 m in depth and executed in the vicinity of the settlement site (**Fig. 3**). Drillcore No. TSZ1 came from an elevated area (similar to which the settlement was located) while drilling No. TSZ2 is from a depression. The two drill sites, approximately 200 m apart, were chosen to sample surface material from the Pleistocene clay, silt, loess (as shown on the geological map (Gyalog 2005)). We sampled (geologically young, Pleistocene) fine grained sediments which could be potential raw materials for pottery manufacturing and that were available on the surface/near-surface in the Neolithic time period. We selected samples from this collection for further studies, that is, we chose representative and prospective ones from the aspect of workability

Table 1.

Codes, descriptions (and depth) of sampling and applied analytical methods (PM: petrographic microscopy; XRF: X-ray fluorescence chemical measurement) of the investigated samples of this study.

Sample no.	Sample code	Sample type/ Sampl. depth	Description	PM	XRF
ARCHAEOLOGICAL SAMPLES					
1	DIV-01 (TSz)	Coarse ceramic	yellowish light grey, plant tempered	+	+
2	DIV-02 (TSz)	Statue	grey, fine grained	+	+
3	DIV-03 (TSz)	Floor	yellow, packed plane surface, compact	+	+
4	DIV-04 (TSz)	Fine ceramic	yellow and grey, plant tempered	+	+
5	DIV-05 (TSz)	Coarse ceramic	grey, plant tempered	+	+
6	DIV-06 (TSz)	Coarse ceramic	red and grey, plant tempered	+	+
7	DIV-07 (TSz)	Coarse ceramic	light grey, plant tempered	+	+
8	DIV-08 (TSz)	Coarse ceramic	yellow and grey, plant tempered	+	+
9	DIV-09 (TSz)	Coarse ceramic	light grey, plant tempered	+	+
10	DIV-10 (FG)	Fine ceramic	painted, brown, plant tempered	+	+
11	DIV-11 (FG)	Coarse ceramic	grey, plant tempered	+	+
12	DIV-12 (FG)	Coarse ceramic	dark grey, plant tempered	+	+
13	DIV-13 (FG)	Daub	dark yellow	+	+
GEOLOGICAL SAMPLES (SOILS/SEDIMENTS)					
14	TSZ1-04	65—80 cm	yellow clayey silt		+
15	TSZ1-06	95—110 cm	limonitic light yellow loessy clay		+
16	TSZ1-11	170—185 cm	yellowish green clayey silt	+	+
17	TSZ2-03	55—70 cm	dark grey clay		+
18	TSZ2-05	90—100 cm	grey clay with limonitic mottles		+
19	TSZ2-08	135—150 cm	grey clay with limonitic mottles	+	+
20	TSZ2-11	190—215 cm	yellowish grey clay	+	+
21	FG1-03	50—70 cm	black humic soil		+
22	FG1-07	110—120 cm	light yellow-grey calcareous clay		+
23	FG1-12	185—210 cm	yellow silty clay	+	+
24	FG2-04	70—90 cm	dark brown clayey soil		+
25	FG2-07	120—150 cm	grey plastic clay	+	+
26	FG2-09	165—180 cm	greyish yellow clay	+	+

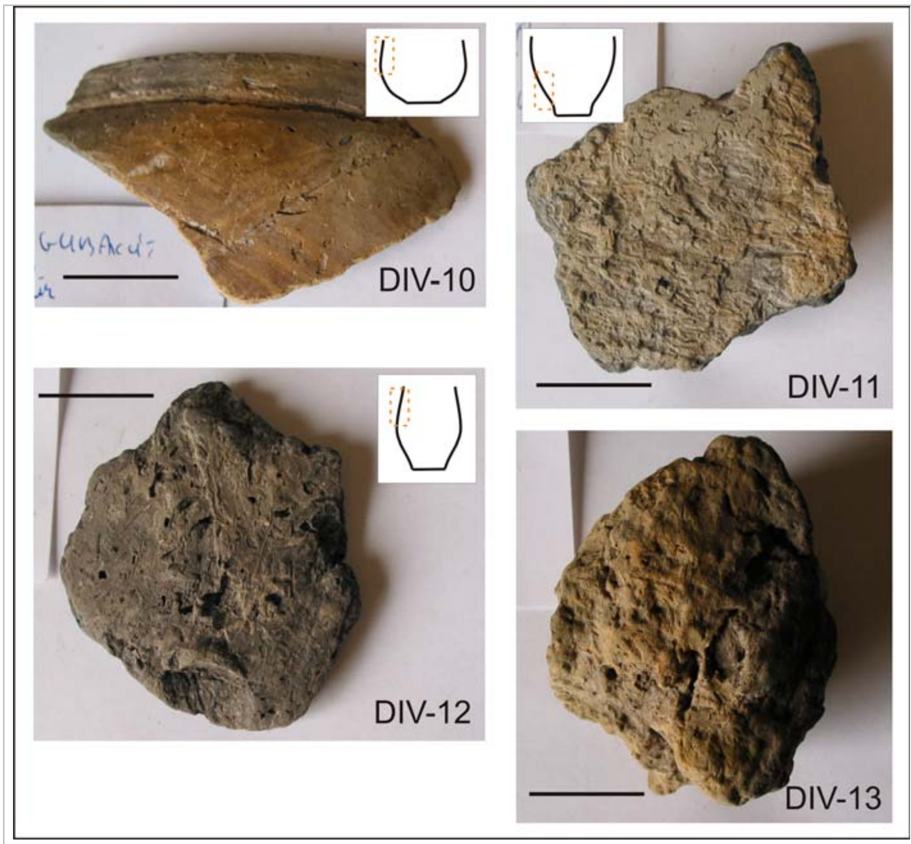

Figure 4

Archaeological samples investigated from Füzesabony-Gubakút. (Scale: 1 cm)

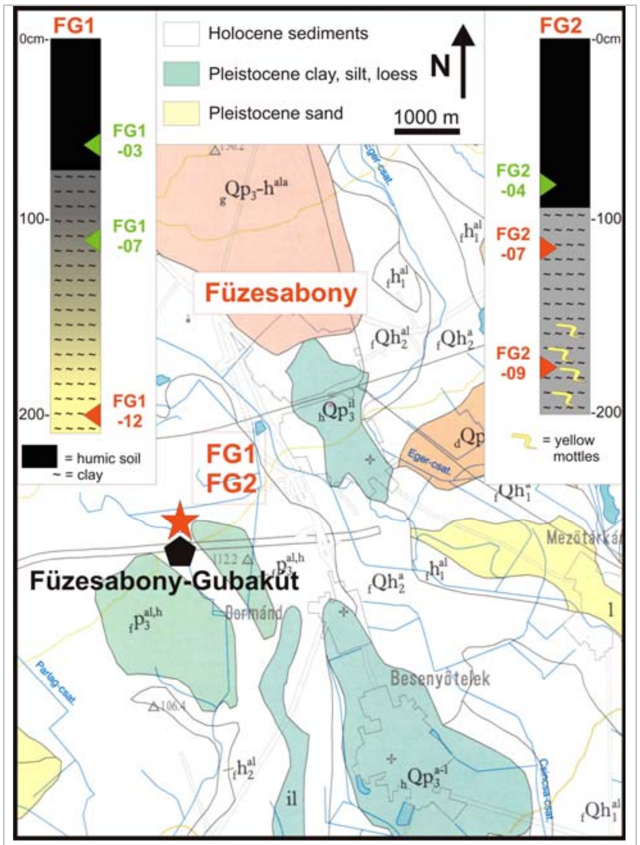

Figure 5 - Geological map of the surroundings of Füzesabony-Gubakút site (red star marks the drilling sites, black pentagon the archaeological site) and the location of the comparative soil/sediment samples in each drillcore (samples marked with red arrows were investigated petrographically and chemically, samples marked with green arrows were investigated only chemically). The colours in the soil sections are roughly correct. (After Gyalog ed. 2005)

(clay and carbonate content). Seven samples from the two drillings were selected for further analyses: all of them for instrumental chemical measurements and three for microscopic investigations (**Table 1**).

For the archaeological site of Füzesabony-Gubakút, two fragments of plant tempered, thick and porous walled ceramics (DIV-11—12), a piece of plant tempered, thin walled painted ceramic (DIV-10) and another of a daub with compact fabric and without plant tempering (DIV-13) formed the basic archaeological sample group (**Fig. 4**). In addition, soil/sediment samples were collected by the same method as in Tiszaszőlős-Domaháza. The two hand drillings were carried out at an elevated (No. FG1) area (similar to which the settlement was located) and a depression (No. FG2), and were aimed to sample potential fine grained raw materials for pottery production (**Fig. 5**).

Table 2 - Detailed microscopic petrographic description of archaeological and geological samples from Tiszaszőlős-Domaháza. Legend: Av=average grain size, Max=maximum grain size; 1N=plain polarised light, +N=cross polarised light; MQtz(s/u)=monocrystalline quartz (straight/undulatory extinction), PQtz=polycrystalline quartz, Kfs=potassium feldspar, µQtz=microcrystalline quartz, Pl=plagioclase, Ms=muscovite, CalMP=calcite (micritic/sparitic), Tur=tourmaline, Lm=limonite, Rt=rutile, Px=pyroxene, Am=amphibole, Zrn=zircon, Bt=biotite, Grt=garnet; Mmf=metamorphic rock fragment, Gran=granitoid rock fragment, Volc=volcanic rock fragment, Pyrocl=pyroclastic rock fragment, ARF=argillaceous rock fragment, Silts=siltstone.

Sample code	Fabric	Matrix	Non-plastics	Pores
ARCHAEOLOGICAL SAMPLES				
DIV-01	Serial, well sorted, moderately oriented, medium rounded Av: 50 µm, Max: 250 µm	1N: brown, +N: anisotropic (orange) Micaceous clay Heterogeneous Dark pigmentation around plant remnant	MQtz(s/u)+PQtz(u)+ (Kfs+Pl+Ms+Cal/P+ Tur+Rt+Px) ARF(lm)	Medium-high porosity Elongated thin pores (1250*20 µm) and phytolites, no fill → plant origin
DIV-02	Serial, medium sorted, moderately oriented, medium rounded Av: 30 µm, Max: 70 µm	1N: brown, +N: anisotropic (brown) Micaceous clay Homogeneous	MQtz(s/u)+PQtz(u)+ (Kfs+Zrn) ARF	Medium-high porosity Elongated thin pores (250 µm long) and phytolites, charcoal fill → plant origin
DIV-03	Serial, well sorted, not oriented, medium rounded Av: 30 µm, Max: 180 µm	1N: brown, +N: anisotropic (orange) Very micaceous clay Heterogeneous Dark pigmentation around plant remnant	MQtz(u)+PQtz(u)+ Mu+(Cal/M+Kfs+Pl+ Lm+Zrn) Mmf	Low porosity, compact fabric Small (50 µm) pores (from spilling) Secondary carbonate fill
DIV-04	Hiatal, medium sorted, not oriented/kneaded, silt - medium rounded, sand - well rounded Av: 50 µm, Max: 625 µm	1N: brown (striped), +N: anisotropic (yellow)-isotropic-anisotropic (brown) Micaceous clay Heterogeneous	MQtz(s/u)+PQtz(u)+ Pl+(Kfs+µQtz+Ms+ +Tur) Mmf+Gran+Volc	Medium porosity Elongated pores (280 µm long) and phytolites, secondary carbonate fill → plant origin
DIV-05	Serial, med-well sorted, not/weakly oriented, medium rounded Av: 50 µm, Max: 300 µm	1N: brown, +N: anisotropic (orange) Micaceous clay Heterogeneous Dark pigmentation around plant remnant	MQtz(u)+PQtz(u)+ (Pl+Kfs+Ms+Cal/P+ µQtz+Lm) ARF(lm)	Medium porosity Elongated thin pores (1500 µm long) and phytolites, no fill → plant origin
DIV-06	Serial/weakly hiatal, poorly-medium sorted, moderately oriented, sub-medium rounded Av: 30 µm, Max: 625 µm	1N: brown (striped), +N: anisotropic-weakly anisotropic (brown) Micaceous clay Heterogeneous Dark pigmentation around plant remnant	MQtz(s/u)+PQtz(u)+ (Kfs+Pl+Ms+ Tur+Lm) Gran+Mmf+ARF	Medium-high porosity Elongated thin pores (2000*120 µm) and phytolites, charcoal fill → plant origin Other pores (coil shaped, anisotropic)

DIV-07	Serial, well sorted, moderately oriented, well rounded Av: 25 µm, Max: 250 µm	1N: grey (striped), +N: anisotropic- weakly anisotropic (brown) Micaceous clay Heterogeneous	MQtz(s/u)+PQtz(u)+ (Pl+Ms+Bt)	Medium-high porosity Elongated thin pores (2500*30 µm) and phytolites, charcoal fill → plant origin
DIV-08	Serial/weakly hiatal, medium sorted, not or weakly oriented/ kneaded, medium rounded Av: 50 µm, Max: 250 µm	1N: brown (mottled), +N: anisotropic (orange)- isotropic Micaceous clay Heterogeneous	MQtz(u)+PQtz(u)+ (µQtz+Kfs+Pl+Ms+ Tur+Am+Grt+Lm) Mmf+ARF	Medium-high porosity Elongated thin pores (300 µm long) and phytolites, charcoal fill → plant origin Unique size and shape
DIV-09	Hiatal, poorly sorted, weakly oriented/ kneaded, sub-medium rounded Av: 40 µm, Max: 300 µm	1N: brown, +N: anisotropic (orange) Micaceous clay Heterogeneous Dark pigmentation around plant remnant	MQtz(u)+PQtz(u)+ (µQtz+Kfs+Pl+Ms+ Zrn) Mmf+ARF(lm)	Medium porosity Elongated thin pores (500 µm long) and phytolites, charcoal fill → plant origin
GEOLOGICAL SAMPLES (SOILS/SEDIMENTS)				
TSZ1-11	Serial (fine grained with coarse grained mottles), well sorted, not oriented, subrounded Av: 40—55 µm, Max: 75 µm	1N: brown, +N: anisotropic (yellow) Micaceous silty clay Heterogeneous	MQtz(s/u)+PQtz(u)+ Ms+(Pl+Kfs+Cal/MP +Lm) µQtz+ARF(lm)	-
TSZ2-08	Serial (fine grained with coarse grained mottles), medium/well sorted, not oriented, sub-medium rounded Av: 40—50 µm, Max: 125 µm	1N: brown, +N: anisotropic (yellow) Micaceous silty clay Heterogeneous	MQtz(u)+PQtz(u)+ Ms+(Pl+Kfs+ Lm+Tur) ARF(lm)+Volc	-
TSZ2-11	Serial (fine grained with coarse grained mottles), medium sorted, not oriented, medium rounded Av: 50—75 µm, Max: 125 µm	1N: brown, +N: anisotropic (yellow) Micaceous silty clay Heterogeneous	MQtz(u)+PQtz(u)+ Ms+(Pl+Kfs+ Lm+Tur) Mmf+Gran+ARF	-

To determine the best materials for ceramic manufacturing from the drillings, six samples of the two drillings were selected for further analyses: all of them for instrumental chemical measurements, three for microscopic investigations (**Table 1**).

For the microscopic petrographic observations the selected soil/sediment samples were experimentally fired in an oxidising atmosphere, at 700°C maximum temperature for 4 hours in an electric kiln (Eberhard Karls University, Tübingen).

The complete set of investigated samples is summarised in **Table 1**.

In order to describe and compare the archaeological and geological samples, microscopic petrographic investigation (Eötvös Loránd University of Budapest, Dept. of Petrology and Geochemistry)(see detailed description in **Tables 2 and 3**) and X-ray fluorescence geochemical analysis (Eberhard Karls University of Tübingen, Dept. of Geochemistry)(see data in **Table 4**) were used.

Table 3 - Detailed microscopic petrographic description of archaeological and geological samples from Füzesabony-Gubakút. For legend see Table 2.

Sample code	Fabric	Matrix	Non-plastics	Pores
ARCHAEOLOGICAL SAMPLES				
DIV-10	Serial/weakly hiatal, compact, medium sorted, not oriented/kneaded, sub-medium rounded Av: 60—70 µm, Max: 750 µm	1N: brown (mottled), +N: weakly anisotropic (yellow) Micaceous clay Heterogeneous Dark pigmentation around plant remnant	MQtz(s/u)+PQtz(u)+ (Kfs+Pl+Ms+ Tur+Px) Mmf+Silts+Volc/ Pyrocl	Low porosity Elongated small pores (100 µm long) and phytolites, charcoal fill → plant origin
DIV-11	Serial, well sorted (bimodal), not oriented/ kneaded, subrounded Av: 25—30 and 80—100 µm, Max: 750 µm	1N: (striped) black - red, +N: isotropic - anisotropic (brown) Micaceous clay Homogeneous	MQtz(s/u)+PQtz(u)+ (µQtz+Kfs+Pl+Ms+ Tur+Am) Volc/Pyrocl+ARF (lm)	Medium-high porosity Elongated thin pores (1250 µm long) and phytolites, charcoal fill → plant origin
DIV-12	Hiatal, medium sorted, not oriented/kneaded, silt - medium rounded, sand - well rounded Av: 30 µm, Max: 850 µm	1N: brown (mottled), +N: anisotropic (brown) Micaceous clay Heterogeneous	MQtz(s/u)+PQtz(u)+ (Pl+Ms+Lm) Mmf+Volc+ARF (lm)=iron nodules	Medium-high porosity Elongated thin pores (1250 µm long) and phytolites, charcoal fill → plant origin
DIV-13	Serial/weakly hiatal, compact, medium sorted, not oriented, subrounded Av: 30 µm, Max: 370 µm	1N: grey, +N: almost isotropic Micaceous clay Homogeneous	MQtz(s/u)+PQtz(u)+ (Kfs+Pl+Ms+Cal/M +Lm) ARF(?)	Low porosity Small pores (100 µm), no fill
GEOLOGICAL SAMPLES (SOILS/SEDIMENTS)				
FG1-12	Serial (fine grained), well sorted, not oriented, subrounded Av: 50 µm, Max: 750 µm	1N: brown, +N: anisotropic (orange) Micaceous silt Heterogeneous	MQtz(s/u)+PQtz(u)+ (Kfs+Pl+Ms+Cal/M +fossils?+Lm+Tur+ Am+Grt) Pyrocl+Mmf+ARF+ secondary Cal	-
FG2-07	Hiatal (fine grained), poorly sorted, not oriented, medium rounded Av: 30 µm, Max: 1500 µm	1N: brown, +N: anisotropic (yellow) Micaceous silty clay with calcareous nodules Heterogeneous	MQtz(s/u)+PQtz(u)+ (Pl+Kfs+Ms+Lm+ Opaque+Zrn) Calcareous nodules+ Volc+Radiolarite +ARF	-
FG2-09	Hiatal (fine grained), medium sorted, not oriented, sub-medium rounded Av: 30 µm, Max: 1000 µm	1N: brown, +N: anisotropic (yellow) Micaceous silty clay with calcareous nodules Heterogeneous	MQtz(s/u)+PQtz(u)+ (Pl+Kfs+Ms+Tur+ Lm+Opaque +Zrn+ Grt+Ortite+Epidote) Calcareous nodules+ Volc+ARF	-

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Sample Code	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Rb	Sr	Ba	Zr	Nb	Y	La	Ce	Nd	Sm	Eu	Yb	V	Cr	Co	Ni	Zn	Sum
Div-01	59.69	0.73	15.66	5.72	0.05	2.02	1.32	0.96	3.39	0.47	9.30	126	147	584	171	14	26	26	63	28	6	0.8	2.4	118	103	14	65	96	99.46
Div-02	65.05	0.79	14.36	4.08	0.02	1.46	1.27	1.19	3.12	0.24	7.64	122	163	603	222	0	21	24	55	26	5	0.7	2.6	96	94	7	0	67	99.36
Div-03	55.71	0.77	13.93	5.32	0.11	2.45	5.83	1.12	6.21	0.92	6.92	103	280	660	205	19	40	31	74	23	6	1.1	2.6	99	101	13	78	77	99.48
Div-04	65.66	0.71	14.79	2.91	0.02	1.36	1.67	1.00	3.06	0.64	7.64	110	260	771	182	13	26	30	65	29	7	1.0	2.4	97	117	4	53	47	99.63
Div-05	64.01	0.76	15.88	6.00	0.06	1.91	0.84	1.11	3.70	0.47	4.42	126	134	489	186	16	28	24	61	26	5	0.7	2.5	121	141	15	84	107	99.32
Div-06	60.72	0.82	16.75	5.65	0.09	2.53	1.08	0.97	2.98	0.61	7.19	125	146	963	189	17	28	25	84	32	6	0.8	2.5	131	121	22	89	102	99.60
Div-07	63.62	0.78	14.57	4.32	0.02	1.49	1.44	1.18	2.88	1.02	7.67	119	195	1049	231	17	33	23	69	28	4	0.7	2.9	97	110	7	52	92	99.21
Div-08	64.94	0.81	15.94	4.98	0.03	1.52	1.61	0.98	2.69	1.32	4.47	145	199	959	206	15	34	28	78	33	7	0.9	3.1	116	149	11	78	99	99.48
Div-09	60.58	0.78	15.94	5.82	0.04	2.04	0.99	0.95	3.13	0.41	8.20	118	164	578	174	14	22	28	60	27	3	0.6	2.3	127	118	13	41	92	99.03
Div-10	72.26	0.76	12.14	3.81	0.06	1.30	1.41	1.34	2.20	0.27	3.47	92	141	589	305	18	33	26	66	34	6	0.8	2.8	84	92	9	65	43	99.17
Div-11	67.95	0.83	14.02	5.09	0.04	1.62	1.73	1.14	2.48	0.45	3.61	117	136	697	296	20	39	32	81	27	5	0.7	3.3	99	96	9	60	68	99.14
Div-12	65.26	0.77	12.56	4.67	0.11	1.64	1.35	1.12	2.05	0.21	9.20	105	125	703	282	18	32	23	74	26	5	0.7	2.8	90	86	13	58	76	99.10
Div-13	65.40	0.78	12.13	4.25	0.06	1.64	2.25	1.17	2.02	0.24	9.46	97	174	783	296	18	34	23	74	27	3	0.7	2.9	89	80	8	60	50	99.59
TSZ1-04	50.06	0.61	11.50	4.34	0.08	2.51	11.99	1.07	2.54	0.25	14.63	102	269	408	169	0	26	24	57	25	5	1.0	2.1	88	71	10	50	67	99.71
TSZ1-06	50.92	0.61	11.65	4.33	0.09	4.21	10.15	1.16	2.57	0.16	14.20	96	341	415	168	0	25	35	59	19	4	1.1	2.1	90	70	11	54	61	100.20
TSZ1-11	45.96	0.62	11.59	4.50	0.09	2.74	14.23	1.03	2.66	0.11	15.87	100	176	395	162	0	28	19	58	24	4	0.7	2.3	94	72	10	54	65	99.53
TSZ2-03	60.27	0.81	15.72	5.82	0.05	1.76	1.15	1.08	2.45	0.11	10.31	138	100	482	203	16	35	32	75	36	4	0.6	3.2	123	104	14	66	96	99.66
TSZ2-05	63.76	0.83	15.16	5.53	0.14	1.73	1.01	1.28	2.42	0.13	8.11	128	101	512	242	17	37	30	70	30	9	0.9	3.2	119	101	16	85	89	100.20
TSZ2-08	66.53	0.81	14.14	4.61	0.03	1.55	0.93	1.41	2.29	0.12	6.98	117	99	434	262	19	35	25	69	30	6	0.7	3.1	101	97	10	66	74	99.55
TSZ2-11	65.53	0.81	14.21	5.31	0.15	1.59	0.86	1.40	2.38	0.17	6.88	117	97	475	243	17	35	26	70	28	7	0.8	3.1	109	95	19	76	79	99.44
EW-01	51.74	0.93	17.25	6.98	0.08	2.91	4.69	1.34	3.02	0.14	10.16	138	173	415	213	19	41	32	82	36	4	0.7	3.6	140	138	19	111	99	99.40
FG1-03	63.70	0.77	12.73	4.67	0.08	1.86	1.61	1.11	2.20	0.13	10.73	112	109	428	280	19	38	26	73	31	7	0.8	3.3	92	80	10	63	60	99.73
FG1-07	48.05	0.52	8.85	2.84	0.03	2.72	15.50	0.96	1.52	0.15	18.56	70	218	326	183	0	25	18	49	18	5	0.8	2.0	60	48	2	21	36	99.81
FG1-12	61.00	0.63	10.08	2.98	0.05	2.55	7.04	1.29	1.87	0.12	11.37	87	139	338	219	14	29	21	53	27	4	0.7	2.6	64	55	5	27	35	99.09
FG2-04	64.63	0.78	13.16	4.81	0.04	1.83	0.99	1.09	1.94	0.08	9.34	111	100	385	281	20	35	27	71	34	6	0.7	3.1	93	91	10	48	60	98.82
FG2-07	64.52	0.78	12.86	4.66	0.04	1.87	2.19	1.13	1.90	0.08	9.42	107	109	420	285	19	37	28	77	35	5	0.6	3.2	89	88	9	62	57	99.59
FG2-09	59.18	0.72	12.26	4.61	0.05	1.91	5.58	1.04	1.78	0.10	12.10	101	119	475	250	18	32	29	68	32	5	0.7	2.7	84	75	10	49	59	99.47
Det. limit (ppm)	240	12	244	180	5	88	48	75	24	14		2.9	3.0	11.1	8.5	3.8	1.8	5.1	10.2	3.2	2.1	0.0	0.2	2.6	3.5	1.6	3.3	3.0	

Table 4 - Chemical composition of archaeological and geological samples (major elements in oxides and in wt%, trace elements in ppm, LOI and detection limits are also given).

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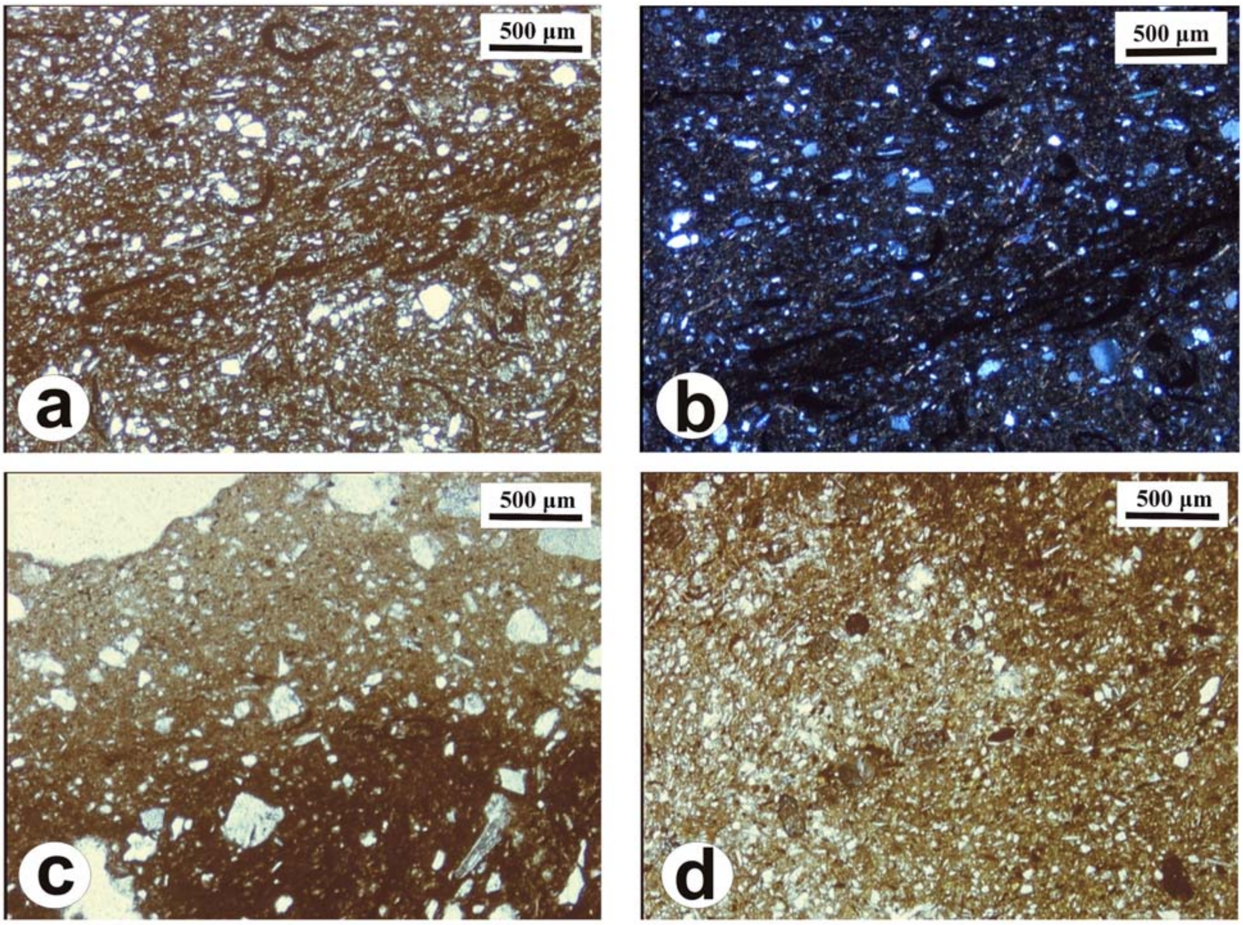

Figure 6 - Microphotographs of the Tiszaszőlős-Domaháza archaeological sample collection: (a) dominant petrographic type of ceramics (DIV-02)(parallel polars=PPL), (b) the same in crossed polars (=+PL), (c) exceptional ceramic (DIV-04)(PPL), (d) floor fragment (DIV-03)(PPL).

The microscopic petrographic investigations were carried out on a Nikon ALPHAPHOT-2 polarising microscope. The chemical measurements provided concentrations for eight major (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5) and many trace elements (Rb, Sr, Ba, Zr, Nb, Y, La, Ce, Nd, Sm, Eu, Yb, V, Cr, Co, Ni, Zn). The chemical analyses were done with a wavelength dispersive X-ray fluorescence analyser (Bruker AXS S4 Pioneer X-ray spectrometer, Rh tube, 4 kW) on homogenised samples. During the sample preparation 1.5000 g of the unheated and powdered sample and 7.5000 g Spectromelt melting material (Merck A12, di-lithiumtetraborate : lithiummetaborate = 66:34) were mixed and melted at 1200°C using a CBR Analyse Service OxiFlux device to make homogeneous glassy tablets. The loss on ignition (LOI) was measured on each sample heated to 1000°C for 1 hour.

Petrographic investigations

All of the archaeological and some of the geological samples were subjected to microscopic petrographic observations. The characteristics studied were the fabric, the ratios of plastic and non-plastic components and pores, the optical behaviour of the plastic matrix, the roundness and the mineralogical composition of grains, and the average and maximum grain size. These results are summarised in **Tables 2 and 3**.

Based on the results of the microscopic petrographic investigations, three types of materials-fabrics could be distinguished in the Tiszaszőlős-Domaháza archaeological sample group. The dominant petrographic group (DIV-01—03, DIV-05—09) of the Tiszaszőlős-Domaháza ceramics (**Fig. 6a-b**) can be characterised by a fine grained, serial fabric which makes probable the use of natural unprepared sediments. The high content and large size of the plant remnants suggests the utilisation of artificially added, crushed plant tempering material. The orange-light brown anisotropy of the matrix suggests a low (~700°C) firing temperature and a dominantly oxidative atmosphere (some samples show a sandwich structure).

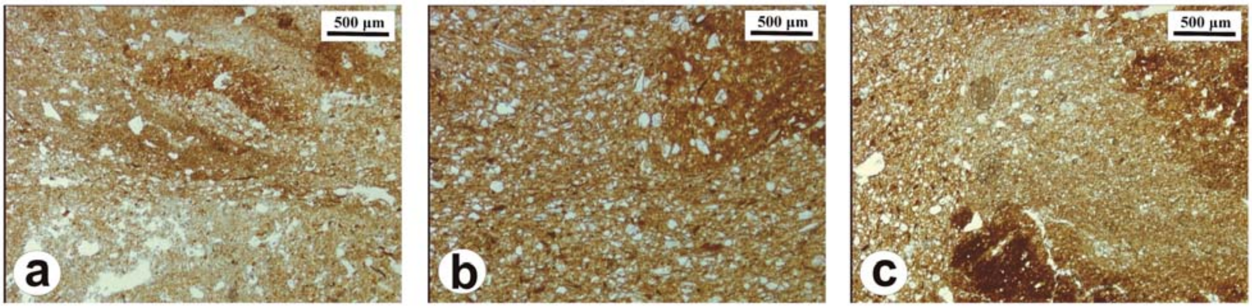

Figure 7 - Microphotographs (PPL) of the Tiszaszőlős-Domaháza geological sample collection: (a) TSZ1-11, (b) TSZ2-08, (c) TSZ2-11.

Non-plastic inclusions of ceramics mainly consist of mineral fragments (quartz + mica (muscovite) + feldspar (plagioclase) + rare accessories) and could derive from a far off, low grade metamorphic, geological setting. There is one sample (DIV-09) in this dominant petrographic group which is a bit different from the others: it has a less ferrous, more pure clay matrix but the non-plastics were similar to the dominant group.

The only exceptional sample (DIV-04) among Tiszaszőlős ceramics (**Fig. 6c**) has coarse grained, hiatal fabric which contains non-plastic mineral and rock inclusions deriving from a volcanic and granitoid geological setting. The yellow-brown striped anisotropy of the matrix suggests low (~700°C) firing temperature and varying atmosphere. The appearance of numerous crushed plant remnants supports the usage of artificially added, plant tempering material. It is probable that the raw material of this sample differs from that of the other ceramics from Tiszaszőlős.

The floor fragment (DIV-03) has a quite different appearance from the ceramics (**Fig. 6d**). Its fabric is compact, shows calcareous clay raw material and does not contain plant remnants.

On the basis of microscopic examination of Tiszaszőlős-Domaháza soils/sediments we can state that fine grained materials in the vicinity of the archaeological site are (moderately) micaceous clays-silts (**Figs.7a-b-c**). The average grain size is approximately 50 µm and the sediments have serial fabric. The main non-plastic component is undulatory extincting quartz and rare accessories. To sum up, the Tiszaszőlős-Domaháza soils/sediments are similar to the majority of the ceramics and could have supplied the raw materials for the pottery manufacturing. The most likely sample is No. TSZ2-08 (collected from a depression) which can be characterised by almost the same grain size, grain composition and fabric as found in the archaeological ceramics. Contrary to it, sample No. TSZ1-11 contains dispersed calcareous mottles which could not be separated by potters (a bit similar to the investigated floor fragment), while sample No. TSZ2-11 is a bit coarser in grain size than the ceramics. These results suggest that potters at the Neolithic Tiszaszőlős-Domaháza site preferred clayey sediments from depressed areas for pottery manufacturing while people probably used calcareous sediments from elevated areas for house building.

Following the same analytical process on the sample collection from Füzesabony-Gubakút it can be stated that ceramics (DIV-10—12) have serial-weakly hiatal fabric (**Fig. 8a-b**). This feature suggests the use of natural, unprepared sediments. The fact that crushed plant remnants are common and abundant components of the non-plastics supports the plant tempering technology (the quantity is higher and the size is smaller than in the Tiszaszőlős-Domaháza pottery). The heterogeneous optical behaviour (orange anisotropy and isotropy vary in strips) of the matrix indicates a low (~700°C) firing temperature and weakly controlled atmosphere. Non-plastic inclusions consist mainly of pyroclastic/volcanic rock and mineral fragments (**Fig. 8c**).

The daub fragment (DIV-13) of the archaeological collection from Füzesabony-Gubakút has a compact fabric, contains no plant remnants or volcanic material but its fabric is similar to the ceramics' fabric (**Fig. 8d**).

Soil/sediment samples from Füzesabony-Gubakút can be described as moderately micaceous calcareous clays-silts with different forms of carbonate (nodules or dispersed mottles)(**Figs.9a-b-c**). Soil samples of drillcore No. FG2 contain calcareous nodules and volcanic rock/mineral fragments. These samples – after removal of nodules visible with the naked eye – are similar to the fabric of the ceramics, but they have coarser grain size than the ceramics. Sample No. FG1-12 contains dispersed calcareous mottles (unremovable with handicraft techniques) and no volcanic components. There is a clay inclusion in this sample whose fabric is similar to the samples of the drilling FG2. To sum up, soil/sediment samples from drillcore No. FG2 are similar to the ceramics, so they could have provided the raw materials for the ceramic production.

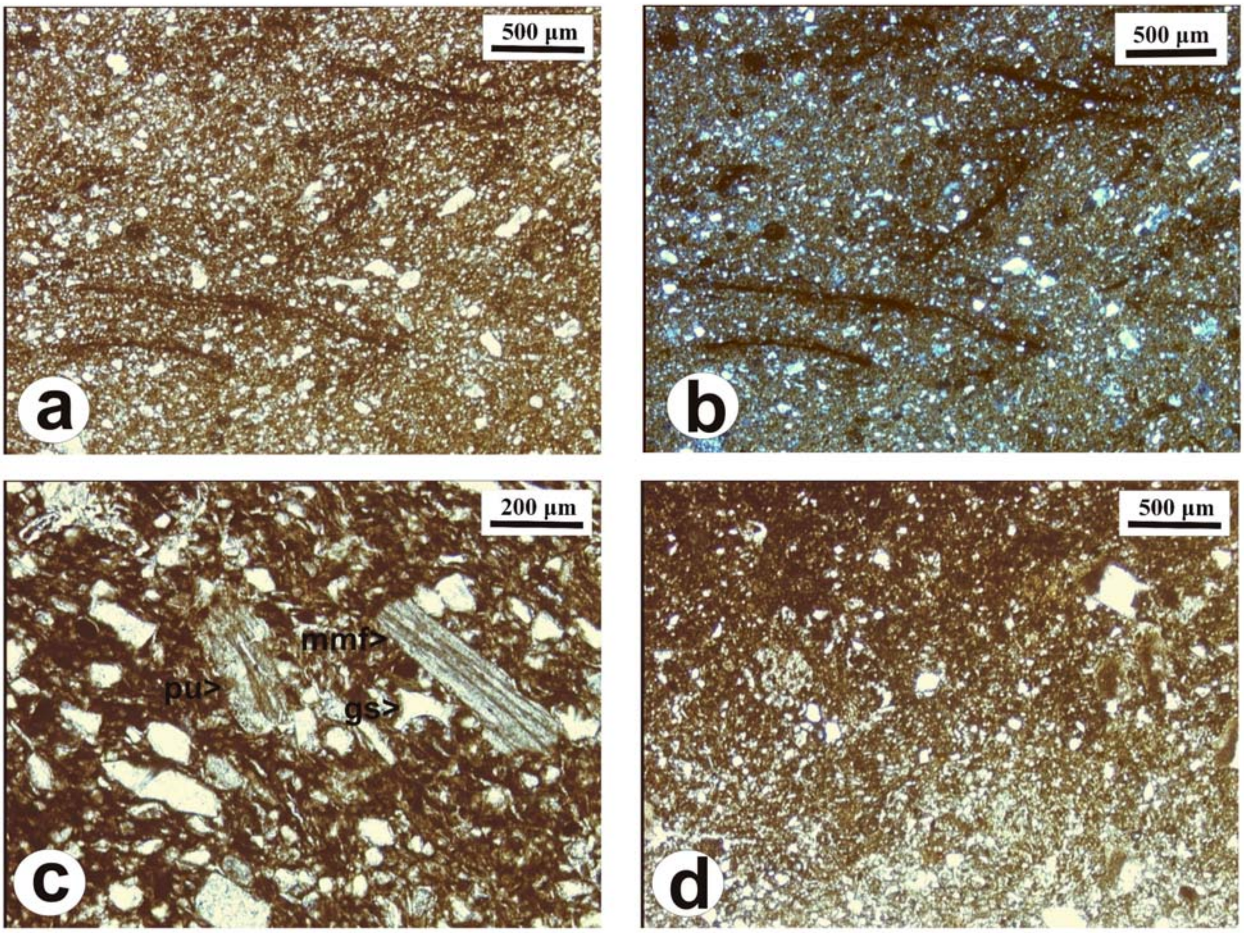

Figure 8 - Microphotographs of the Füzesabony-Gubakút archaeological sample collection: ceramics (a) DIV-12 (PPL), (b) the same in +PL, (c) DIV-10 (PPL) and (d) daub fragment (DIV-13)(PPL).

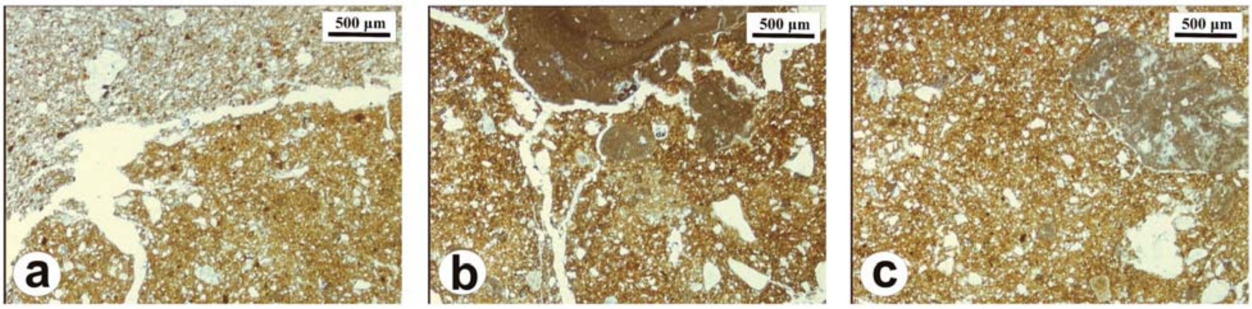

Figure 9 - Microphotographs (PPL) of the Füzesabony-Gubakút geological sample collection: (a) FG1-12, (b) FG2-07, (c) FG2-09.

These results make it probable that potters at the Neolithic Füzesabony-Gubakút site chose clayey sediments from the depressions for ceramic manufacturing and maybe for house building too.

Geochemical characterisation

Geochemical characterisation of both archaeological and geological samples (**Table 4**) was done by X-ray fluorescence analysis of whole samples (major and trace elements).

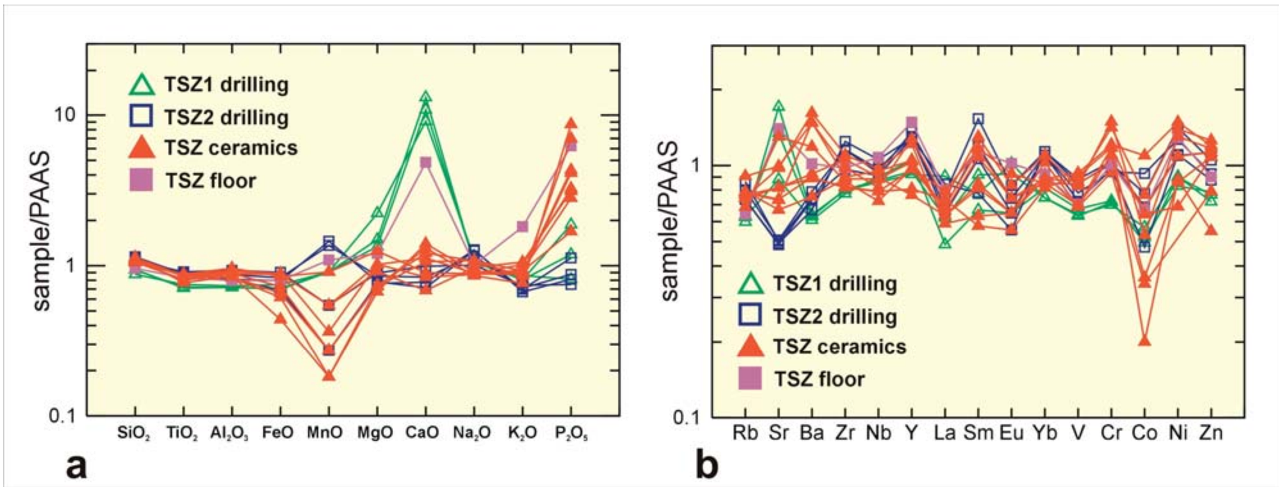

Figure 10 - Multi-elemental abundance (so-called spider) diagrams (normalised to PAAS) of the Tiszaszőlős-Domaháza archaeological finds and soil/sediments according to their (a) major and (b) trace element distribution.

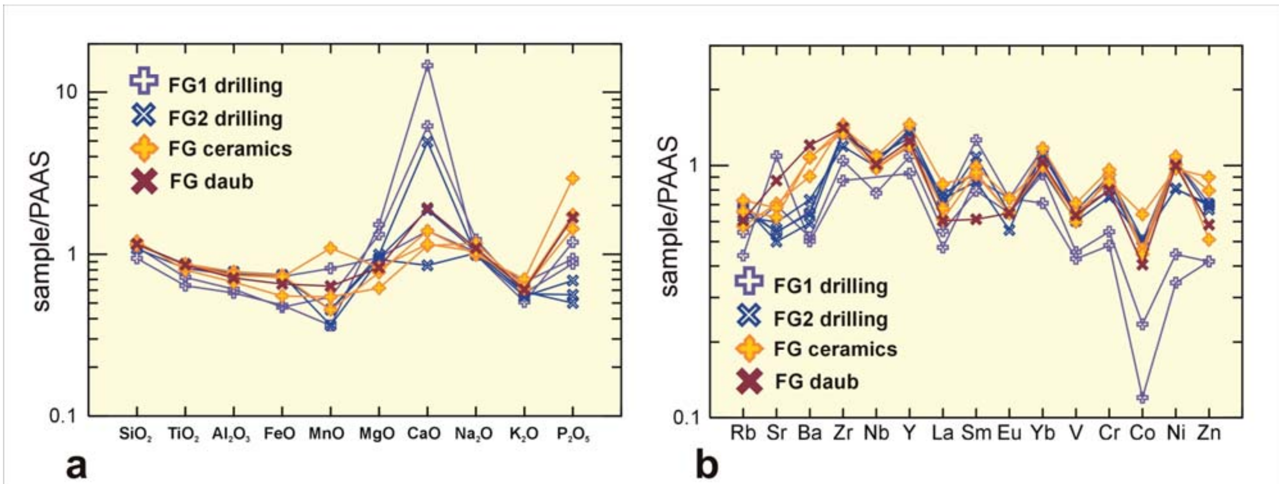

Figure 11 - Multi-elemental abundance (so-called spider) diagrams (normalised to PAAS) of the Füzesabony-Gubakút archaeological finds and soil/sediments according to their (a) major and (b) trace element distribution.

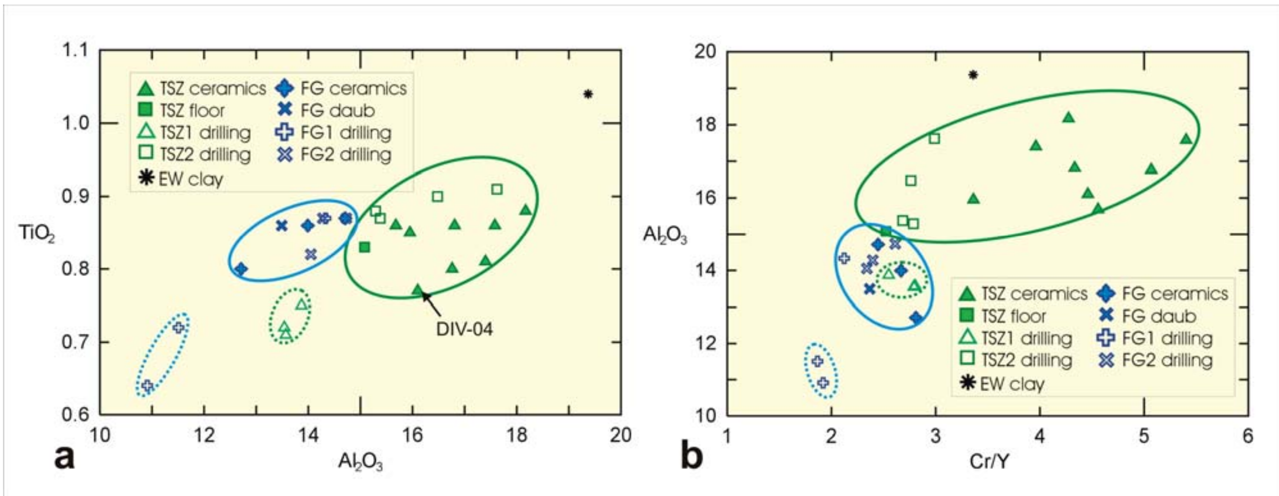

Figure 12 - Bivariate correlation diagrams of Tiszaszőlős-Domaháza and Füzesabony-Gubakút samples, (a) Al_2O_3 vs. TiO_2 and (b) Cr/Y vs. Al_2O_3 diagrams.

For a better comparison, the geochemical data were plotted in multi-elemental abundance (so-called spider) and bivariate correlation diagrams. Normalisation was made to an average value for Post Archaean Australian Shale (PAAS) which is a preferred standard material in sedimentary rock investigations for fine grained siliciclastic sediments (Nance & Taylor, 1976; Taylor & McLennan, 1985; McLennan, 1989, 2001).

In the case of the comparison between Tiszaszőlős-Domaháza ceramics and soil/sediments it can be stated that while the distribution of the major and trace elements is similar (**Figs.10a-b**), some more significant scattering can be detected at Mn and Fe (major elements which are mobile in soil system) and for mobile and immobile trace elements. Moreover, some differences can be observed between the archaeological and geological sample groups in the Ca content, especially in the (carbonate bonded) high Ca (and Mg) and Sr content of TSZ1 soil/sediments. This feature can be identified in the floor sample (DIV-03) too, but coupled with a higher K content. However, its trace element distribution is similar to the pottery. Another interesting point is the systematically higher K and lower Na concentrations in ceramics compared to soil/sediments (this can be the effect of the weathering conditions). There are some differences between soil/sediments of drillcores No. TSZ1 and TSZ2. TSZ1 samples show depletion in immobile trace elements (e.g. Zr, Y, REE) relative to the TSZ2 samples. This feature – as it is not correlated with the average grain size in this case – can be the effect of different clay mineral or accessories content. From the point of view of this geochemical characteristic, the ceramics usually show a distribution between the two soil/sediment groups. As in many other cases, P concentrations of the ceramics and floor are higher than the same values of soils. The significantly low Co values border on the detection limit so these data are uncertain.

Analysing the geochemical data from the Füzesabony-Gubakút sample collection, it is clear that the distribution of the major and trace elements is similar in the archaeological samples and soils (**Figs.11a-b**). Some weak scatterings can be detected at Mn-Fe and mobile and immobile trace elements. As in the Tiszaszőlős group, some soil/sediments (samples of drillcore No. FG1 and sample No. FG2-09) have high Ca and Mg content. From this point of view ceramics have characteristics more similar to the FG2 soil/sediments. There is one significant difference among the archaeological samples: daub has higher Ca content than pottery, although their trace element distributions are similar. Soil/sediments of drillcore No. FG1 show depletion in immobile trace elements relative to the FG2 samples. This feature can be interpreted similarly as in the case of Tiszaszőlős materials. Ceramics and daub show enrichment in P content relative to soils.

The bivariate correlation diagrams (**Figs. 12a-b**) show further evidence for differences between the different soil/sediment samples at each site and for closer similarities between the ceramic groups and their potential raw materials. For comparison to a near likely raw material, the clayey sediment of the nearest contemporarily operating clay mine, Eger-Wind (EW: Eger—Wind-brickyard) was used. It is clear that for neither site could the Eger-Wind clay be the raw material for this pottery manufacturing. For Tiszaszőlős-Domaháza samples, it is true that the archaeological samples are similar to TSZ2 soil/sediments (though they have lower Ti content and higher Cr/Y ratio) but they even more differ from the TSZ1 samples. The same statement applies to Füzesabony-Gubakút samples: the archaeological material could derive from a FG2-like source, but not likely from a FG1-like one. In the case of the Tiszaszőlős-Domaháza sample collection the petrographically exceptional ceramic sample (DIV-04) is at the margin of the main cluster of ceramics and TSZ2 soil/sediments. Tiszaszőlős-Domaháza's floor (DIV-03) is the nearest data point in the archaeological collection to the TSZ1 geological samples, while Füzesabony-Gubakút's daub (DIV-13) does not show any special similarity to the FG1 sediment samples.

As a result of the geochemical characterisation, the hypotheses that the potters of both Neolithic sites preferred clayey sediments collected from depressed areas for pottery making – while in the case of Tiszaszőlős-Domaháza, calcareous sediments from elevated areas were used for building processes – gained further confirmation.

Discussion

Based on the petrographic investigations, the pottery manufacture of both Neolithic sites can be described as a handicraft which followed a long-time tradition concerning the usage of raw materials. The direct use of alluvial sediments and the tempering with different sized plant fragments are characteristic features of both workshops' techniques. Creating in this way a prepared raw material, the potters used a free hand fashioning method and the vessels were fired at a relatively low temperature (according to our evaluation at 700—750 ºC) and in a uncontrolled (dominantly reducing) atmosphere. As a result of this process, the pots are porous and usually thick-walled, they are greyish coloured and the remnants (or pores) of the burned out plant fragments can be observed on their surface. Any dissimilar samples could be identified only in the Tiszaszőlős-Domaháza assemblage, with only one specimen which could be characterised with specific fabric and non-plastic composition. The presence of this pot in the collection could be interpreted as an imported vessel or made by a potter following another manufacturing tradition.

Based on the comparative chemical analyses of the archaeological specimens (ceramics, floor, daub) and soil/sediment samples, it can be stated that they show a significant similarity, so they can derive from a local raw material. The floor sample from Tiszaszőlős-Domaháza contains more (carbonate related) Ca than the others.

Based on the general geochemical experience, it is common that the near-surface clayey sediments deriving from the river plain area, but in the vicinity of the mountains, show relatively high diversity in their element composition. This fact can be the cause of the finding that the similarity between the ceramics and the potential raw materials is varying. However, it is clear for both archaeological sites that the chemical composition of the archaeological samples – with the exception of one specimen – is similar to the composition of the local raw materials. It is highly probable that the local clayey soils/sediments were directly used for the manufacturing of the clay artefacts. We have to mention that – because of the small sample numbers – an intentional selection of different raw materials for the pottery manufacturing and for house building can only be tentatively outlined, e.g. non-calcareous clayey soils/sediments from depressed areas for ceramics, calcareous clayey-silty sediments from elevated areas for building.

Conclusion

To sum up, from our archaeometric study of a reduced ceramic assemblage of two Neolithic archaeological sites (Tiszaszőlős-Domaháza and Füzesabony-Gubakút) we could characterise the local pottery making technology as the following: probable direct utilisation of the local alluvial sediment (in the case of Tiszaszőlős it means the alluvium of the flood plain of river Tisza, at Füzesabony it is the alluvium of small rivers-streams – presently the Laskó stream – coming from the Bükk Mountains) and vegetal tempering of ceramics while a clayey material with higher Ca content was used for building floors of houses. Based on the two sites, it seems to be a systematic practice that people used the soils/sediments of the depressed areas for pottery making, while soils/sediments of the elevated areas for building. However, it is important to emphasise that in this research the small number of samples did not make it possible to unambiguously conclude such comprehensive statements. In agreement with the archaeometrical results of former researchers, these features are basic and very common characteristics of the known Early Neolithic Körös Culture sites. According to our results – although they derive from different archaeological cultures – the two studied sites show basically similar ceramic technological features. To decide whether this fact can prove a relationship – at least on the level of handicraft – between the two cultures, it is necessary to greatly expand the archaeological evaluation and interpretation to more samples in these sites and to many other sites.

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