PETROGRAPHIC INVESTIGATION OF THE FINDS OF BALATONŐSZÖD-TEMETŐI DŰLŐ BADEN SETTLEMENT

[1]Gherdán, K. – [2]Horváth, T.

[1] Department of Petrology and Geochemistry, Eötvös Loránd University, Hungary, gherdankata@hotmail.com
[2] Hungarian Academy of Sciences Institute of Archaeology, valdemar@archeo.mta.hu

Abstract: *A rescue excavation was carried out on the planned route of M7 motorway, near the village of Balatonőszöd. A Late Copper Age Baden Culture settlement was excavated, exceptionally rich in ceramic finds. The aim of the authors was to group the pottery samples according to their petrographic properties and compare the petrographic composition of the ceramics with that of technological remains and daub fragments also found at the site. Comparative petrographic analysis and archaeological investigations suggest that the examined ceramics were produced at the site most probably from locally available raw materials. Comparison with archaeological description showed that differences in composition and fabric of the investigated ceramics are not in connection with chronological and archaeo-typological differences.*
Keywords: *Baden Culture, pottery, technological remains, daub, petrography*

INTRODUCTION

A rescue excavation was carried out on the planned route of M7 motorway, near the village of Balatonőszöd, during 2001-2002. The site lies about 2.5 kilometres south of Lake Balaton and extends over 100000 m^2 (**Fig. 1**). It was a multi-period settlement of the Baden Culture, which was established along a small water course running down to the lake.

At the site the so far biggest settlement of the Baden Culture was excavated. This is the first case when there is a possibility to outline the original extent of a Late Copper Age settlement and to estimate its size not only in space, but also in time as well as observe its structure.

This article presents the results of the petrographic study of the pottery finds, technological remains and daub fragments excavated at the site.

ARCHAEOLOGICAL BACKGROUND

The settlement lies about 2–2.5 km south of the present shore of Lake Balaton, west of the canals Kis- and Nagymetszés. Its excavated part is situated along the valley of a former current running down to Lake Balaton, and its territory is confined by the gently sloping hill ridges lying in a NW-SE direction. The Baden Culture settlement, lying parallel to the shore of the lake, was continuously shifting towards the south, where it most probably extended further. However, at this territory excavations have not been carried out (Fig. 1).

Based on the finds, the approximately 1000 dug-in features (pits, post-holes, buildings, ditches) and 93 hearts/ovens can be classified as belonging to Baden Culture.

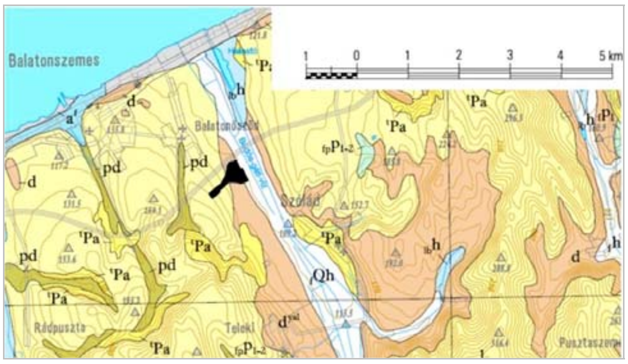

Fig. 1 Geological map of the area. The black area represents the archaeological site.

86911 potsherds, weighing 2878 kg were examined and documented. Based on this ceramic assemblage it can be concluded that the excavated part of the settlement – according to the typological system elaborated by Viera Němejcová-Pavúková – was established during the Boleraz IB-C phase, and lasted until the end of phase III, or the beginning of phase IV (taking into account its probable southward extension). Radiocarbon data show that the settlement existed between 4680–4110 BP (*Horváth et al. 2006*).

East of the marshy area along Kis- and Nagymetszés canals, opposite the excavated area, another Baden settlement was identified during field walking in 2001. The finds show that this area was also part of a settlement, which might have been in connection with the other settlement west of the canals. This way the territory of the whole Baden settlement could have reached 200000 m^2.

In the Late Copper Age this Baden settlement was most probably situated at the mouth of the stream flowing into Lake Balaton, so it was a settlement on a lake-shore, on a

Fig. 2a Side fragment of a vessel built up of slabs

Fig. 2b Bottom discs

Fig. 2c Handles with peg joints

Fig. 2d Side fragment of a vessel, signs of smoothing by hand are well visible

Fig. 2e Rough, coarsened surface of a vessel

riverside and on a marshland at the same time. Putting it more simply: it was established on damp land (cp. Ufer-, Seeufer-, Feuchtboden-, Moorsiedlung). Buildings standing on posts, characteristic of such habitat can also be found at the site (cp. Pfahlbau) (*Horváth et al. 2007*).

The settlement is not considered to be a continuously inhabited, permanent settlement. It might have been formed as a long-stretched chain of seasonal settlements, which existed only for a few months and were homes for small groups of people. That part of the settlement where remains of buildings were found, came into being only in the classical phase of the Baden Culture, when, because of its linear type of settling, it looked like a Hungarian 'szer' (hamlet) (*Horváth 2006*).

Archaeological investigation suggests that ceramics were fired at the site in bonfires and in pits. Semi-finished products and technological waste, as well as other technological bits and pieces, such as fired clay balls, slabs were also excavated. The great number of ovens and open-air pits suggests that intensive pottery firing took place at the settlement, most probably at places, which were not used by the inhabitants at that time, thus which were lying at the periphery of the settlement. One can draw this conclusion from the chronological position of the ovens, which is in most cases just the opposite of what could be inferred from their geographical position: in the northern parts, where Boleraz phase features dominated, finds came from the classical phase, whereas in the southern parts of the settlement, where older, classical phase features were detected, finds came from the Boleraz phase.

Archaeological investigation revealed some characteristic pottery manufacturing methods. Vessels were built up of slabs or sheets of different thickness and width. The size of these slabs/sheets depended on the size of the vessel: big vessels were made of thicker and wider slabs. The edges of the bands were thinned or made as to form a slope in order to make their joining easier. This is well visible, as pots most often broke along these surfaces (**Fig. 2a**).

Bottom discs were usually made separately and joined to the body of the vessel later, by applying an extra layer on the outer and inner surfaces. As a consequence, the bottom often 'falls off' the vessel (in case of smaller vessels, such as small mugs, the bottom was formed together with the side and it forms a spherical section). In many cases there is a square shaped imprint on the bottom. This might indicate the use of a primitive wheel in order to support the vessel and make turning easier for the potter (**Fig. 2b**).

Handles were pegged to the body of the vessel. In the upper part the handle was pinched together with the side from inside and outside, while in the lower part, where it should be stronger, it was pegged (**Fig. 2c**). This technique was already known in the middle Copper Age, Balaton-Lasinja Culture.

Smoothing, burnishing and polishing were most probably done by plants, bone tools or sherds. Rougher surfaces were made by hand; in some cases fingerprints are well visible (**Fig. 2d**).

In many cases the outer surface of the vessel was 'coarsened' by applying another layer (**Fig. 2e**). In order to 'stick' this layer to the ceramic, potters slit the surface of the vessel.

There are big storage vessels such as amphorae the lower and upper parts of which were made differently. The lower parts were heavily coarsened on the surface, while the upper parts were burnished or polished and sometimes decorated (pit Nr 1464, amphora with a capacity of 125 l). Cultural anthropological observations show that in case of certain vessels sometimes two different kinds of raw materials are used for building different parts (*Deboer & Lathrap 1979, Kreiter 2007*).

After forming, the vessels were laid on vegetal material to dry. On the bottom discs imprints of vegetal material are well visible. On the coarsened surfaces of the sides, imprints of seeds, husks and stems can be identified. It might have been chaff or hay/straw that they put under the vessels during drying (*Horváth et al. 2007, in press*).

Technological waste and broken ceramics were used in different ways. Broken fragments were laid down as a basal layer of ovens. Broken pottery fragments were also used as grog for tempering. However, there is no archaeological evidence (such as ground-stones, hand-stones) for the breaking, grinding and sorting of this material.

Technological waste and other remains found at the site prove that ceramic manufacturing was in progress.

In spite of this only few quartzite pebbles used for the burnishing and polishing of the ceramics were found. Although the lake nearby could have provided these in sufficient amounts. Smaller quartzite pebbles were used for forming the base of ovens or as hand-stones.

It is supposed that bone tools, very frequent at the site, were used for this purpose. As an experiment we tried to use these tools when imitating the manufacture of Baden pottery, and we were successful. According to Erika Gál (personal communication) tools of *„large point"* and *„round diaphyzis point"* type were suitable for this kind of work. Most of these tools were made of the tibia of ruminants.

Larger pottery fragments could also have been used for burnishing or polishing. This is suggested by those sherds whose sides are heavily worn.

THE ISSUE

Pottery analysis started in 2003 in order to answer questions arising during archaeological investigation. Research is still in progress, the selection of further samples for analysis is based on what other questions emerge.

The following questions have been asked so far:

1. The settlement, according to the classical archaeological-typological and radiocarbon data existed from the beginning of the Baden Culture almost until its latest phase: that is for more than half a millennium. Based on the typological analysis the development of the settlement was continuous, the phases following each other in time were based functionally on each other. The first question to be answered was if typological changes of shape and decoration of the ceramics through time can be followed in pottery making technology as well? In other words are there any differences in pottery composition and manufacture (tempering, vessel building and firing technology) of the different phases defined by Němejcová-Pavúková.

2. Are there any differences in composition and fabric among typologically different vessels? For example do large and small vessels differ concerning the composition and grain size of the non-plastic inclusions? Do large storage vessels have uniform composition: are their lower, strongly coarsened parts of the same composition as their upper, well smoothed parts?

3. Do semi-finished products, technological waste and fired clay balls have the same composition as finished pottery? When trying to answer this question tracing the reprocess of clay artefacts (use of technological waste, broken, unusable pottery as grog) was also kept in mind.

4. Based on archaeological evidence ceramics are supposed to be made locally. If so, is it possible to identify the raw material source (clay mine, sand temper)?

5. How is pottery production, if at all, related to wall building, that is, are ceramics and daub fragments similar or different in composition and manufacture?

GEOLOGICAL BACKGROUND

The territory surrounding the archaeological site (represented by the black area on the geological map (**Fig. 1**) (after *Gyalog 2005*) is covered mainly in young sediments, among which more were suitable and could be used as a raw material for pottery manufacture. The most important sediments are Upper Pleistocene – Holocene lacustrine, fluvial and deluvial sediments, lithic aleurit and the Miocene (Pannonian) sediments of the Tihany Formation, dominantly consisting of clay.

According to the archaeological model of the acquisition of pottery raw materials, clay and other constituents could be obtained at or near the site by Late Copper Age people.

From the clay resources suitable for pottery manufacture mentioned by *Kalecsinszky (1905)* Balatonboglár and Lengyeltóti are the closest to the site. Refractory clays are mentioned only to the north of Lake Balaton around Sümeg, or further south in Mecsek mountains (Mányok, Szent Katalin, Vásárosdomba).

EXPERIMENTAL

In order to answer the above mentioned questions pottery sherds forming a so called „base series" were chosen for petrographic analysis. The intention was to sample all typological forms present at the site in great quantities (jugs, small mugs, cheers-cups, pitchers, bowls, amphorae, cooking-pots, storage vessels) and also to analyse sherds from each phase from the earliest Boleraz, until the latest Classic phase. Another standpoint was the macroscopic characteristics (fracture, non-plastic inclusions etc.) of the sherds.

Altogether 37 pottery samples, 5 technological remains (a fired clay ball, fired clay slabs, pottery slags) and 4 daub fragments were chosen for petrographic analysis. All fragments were studied macroscopically and then were subjected to thin section analysis.

The main aim of the authors was to group the samples according to their petrographic properties, compare these groups with the so called technological remains, and – where possible – make comments on ceramic-making technology.

Thirty-seven pottery samples were chosen for petrographic analysis by macroscopic examination of fabric and form. These ceramics were thin-sectioned and examined under a polarising microscope. In order to be able to answer the question whether large storage vessels have uniform composition, one big storage jar was sampled in four parts. That is: one thin section was made from its lower, heavily coarsened part, one from its upper, well smoothed part, and two thin sections from the coarsening surface material.

Thin section analysis was based on the method elaborated by *Szakmány (1996, 1998)*.

Textural analysis included the examination of fabric (hiatal, serial), grain-size distribution, the measurement of average grain-size, as well as the description of the roundness and sphericity of the grains (*Pettijohn et al. 1987*).

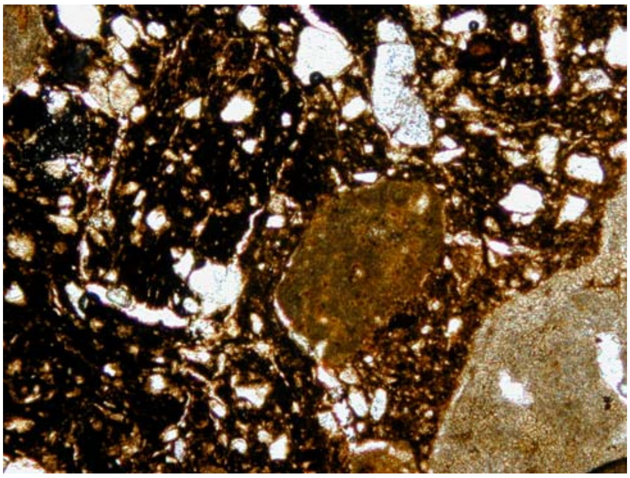

Fig. 3a Carbonate rock fragments and grog fragments in a pottery, Group1, 1N

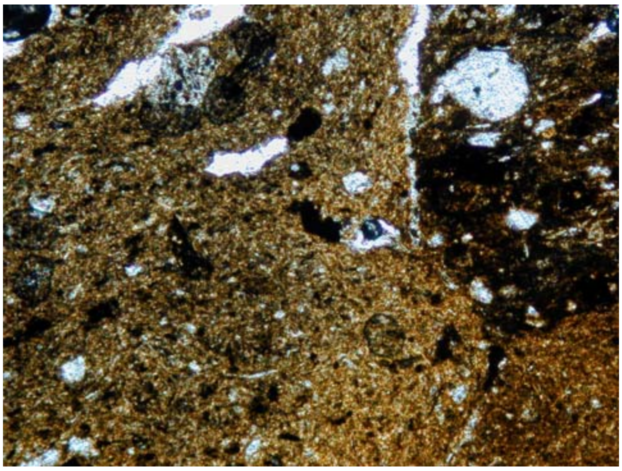

Fig. 3b Grog fragment in a pottery, Group2, 1N

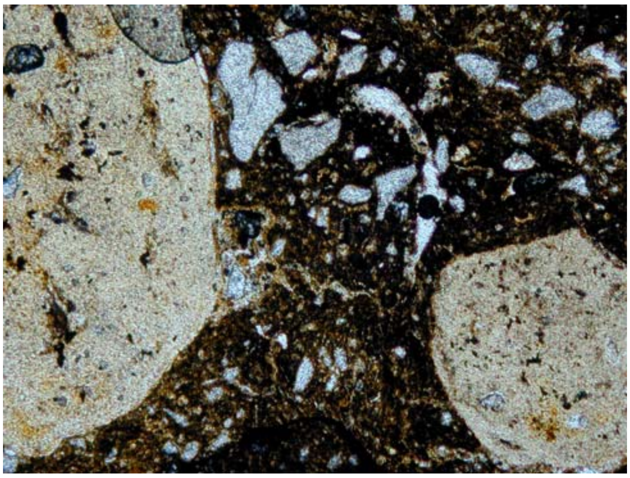

Fig. 3c Argillated volcanic glass fragments in a pottery, Group3, 1N

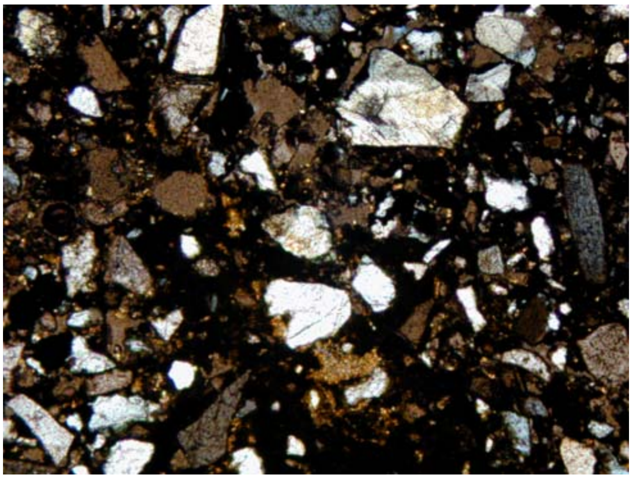

Fig. 3d Pottery slag fragment, +N

The orientation of the grains, the colour and optical activity of the groundmass were also recorded (*Whitbread, 1986*). Textural analysis was accompanied by estimating the amount of the non-plastic inclusions.

RESULTS

Pottery

On basis of petrographic examinations the 37 pottery samples could be divided into four groups, two of which is divided into subgroups. Main types are presented in **Fig. 3**, on micrographs taken with a polarising microscope.

Group 1 This group is divided into two subgroups, group 1a and group 1b. Fabric and non-plastic material of the sherds belonging to the subgroups 1a and 1b are very similar. Characteristic non-plastic inclusions are mineral grains, carbonate rock fragments and grog fragments. Difference is in the proportion of the different kinds of non-plastics (**Fig. 3a**).

Group 1a 18 samples (5, 8, 9, 10, 11, 12, 13, 17, 19, 20, 21, 23, 27, 28, 29, 33, 34, and 38) belong to this subgroup. Colour of the groundmass varies from light brown to dark brown in plain polarized light, and from yellowish brown to black in crossed polarized light. Optical activity varies from active to inactive. Fabric is hiatal, non-plastic inclusions are poorly or fairly sorted. Grain size distribution has got two maxima. The size of fine and medium sand sized grains is below 300 µm, while coarse sand size grains are between 500 and 2000 µm.

Fig. 4a Layers of a daub fragment (on the scale the distance between two signs is 1 mm)

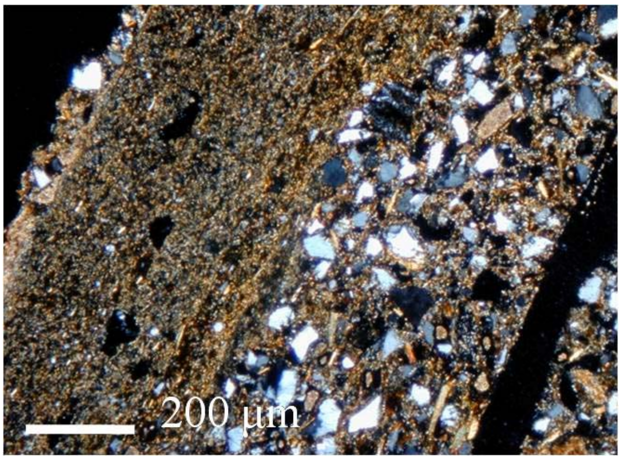

Fig. 4b Fine grained calcareous surface layer, and quartz, feldspar, mica and carbonate rock fragments in the basal layer of a daub fragment, +N

Fine sand size grains are dominantly quartz grains, accompanied by lesser amounts of feldspars and accessory minerals. They have a low sphericity and the grains are angular. Quartz grains have sharp or undulatory extinction. Mineral grains account for 5–10 volume percent of the potteries. Medium sand size grains are mainly composed of carbonate rock fragments and grog fragments, and in lesser amounts of mineral grains. Carbonate grains show low sphericity, the grains are subrounded or rounded micrites. Grog fragments are usually isometric or prolate in shape and have sharp boundaries. They are optically inactive and contain 5–15 percent non-plastic inclusions. Coarse sand size inclusions are dominantly grog fragments – they make up 5–15 volume percent of the sherds –; and micritic carbonate fragments – their amount in the potteries is between 5–10 volume percent.

Group 1b Five sherds (6, 22, 30, 31, and 32) belong to this subgroup. Fabric and non-plastic material of these samples are very similar to that of the sherds belonging to subgroup 1a, however the amount of carbonate rock fragments is slightly different. These potteries contain only 1–2 volume percent carbonate rock fragments.

Group 2 This group is divided into two subgroups: 2a and 2b. All sherds belonging to this group are carbonate-free (**Fig. 3b**). Characteristic non-plastic inclusions are mineral grains and grog fragments. The differentiation of the two subgroups is based on the amount of the non-plastic inclusions, as subgroup 1 sherds contain less fine and very fine sand sized mineral grains.

Group 2a Four sherds (2, 15, 18, and 25) belong to subgroup 2a. Fabric: Colour of the groundmass is brown in plain polarised light, and yellowish brown – optically active – in crossed polarised light. The fabrics are hiatal; the grain-size distribution is bimodal. The size of fine and very fine sand is below 200 µm, while that of the coarse sand size grains are between 500 and 5000 µm. Non-plastic inclusions are poorly sorted. Non-plastics below 200 µm are mainly monocrystalline quartz and other mineral fragments, such as feldspars, micas, opaque minerals and accessories, while coarse sand size grains (500–5000 µm) are dominantly grog fragments, accompanied by polycrystalline quartz grains. Fine and very fine sand size mineral grains are of low sphericity and angular. Grains have either undulatory or sharp extinction. Their amount is 1–2 volume percent. Grog fragments have either prolate or isometric shape, sharp boundaries. They contain mineral fragments, dominantly quartz grains; however, there are also grog fragments containing other argillaceous fragments as inclusions. Grog fragments make up 10–20 volume percent of the ceramics. On basis of fabric and the amount of non-plastic inclusions grog fragments can be divided into two groups. One group is very similar to the groundmass. That is their matrix is brown in plain polarized light and yellowish brown, optically active in crossed polarized light and contains fine and very fine sand sized mineral grains in 1–2 volume percents, occasionally coarse sand size argillaceous fragments. The other group of grog fragments is different from the groundmass. Their matrix is dark brown in plain polarized light and black, optically inactive in crossed polarized light. These fragments contain 5–10 volume percent non-plastics. In sample 18, 5 volume percent of clay pellets can also be found. These grains usually have distorted shape and either sharp or merging boundaries (sometimes within one grain). Their colour is yellowish brown in plain polarized light and dark yellowish brown, optically active in crossed polarized light. In sample 15 iron-rich nodules were identified.

Group 2b Three ceramics (24, 26, and 43) belong to this subgroup. Also three other samples (44, 45, 46) belonging to the same big storage vessel (43) comprise this subgroup. The colour of the groundmass is dark brown or brown in plain polarized light, and black – optically inactive – or dark yellowish brown – optically fairly active – in crossed polarized light. The fabric is hiatal with bimodal grain-size distribution. The size of fine and very fine sand non-plastics is below 200 μm, while that of the medium sand size grains are 250–500 μm and coarse sand size grains are between 800 and 6000 μm. Non-plastic inclusions are fairly or poorly sorted. Fine and very fine sand size non-plastics are mainly monocrystalline quartz and other mineral fragments (feldspars, micas, opaque minerals and accessories), while medium sand size grains are mineral fragments accompanied by smaller grog fragments. Coarse sand size grains are dominantly grog fragments. Fine and very fine sand size mineral grains are of low sphericity and are angular. Grains have either undulatory or sharp extinction. They make up 10–15 volume percent of the ceramic. Grog fragments – of both medium and coarse sand size – have either isometric or prolate shape and sharp boundaries. Their non-plastic material is between 5 and 10 volume percent. They make up 5–15 volume percent of the sherd.

Group 3 Three sherds (7, 14, and 16) belong to this group. The most important characteristic of these sherds is that they contain argillated volcanic glass fragments (**Fig. 3c**). The groundmass is light brown, brown in plain polarized light and yellowish brown and optically moderately active in crossed polarized light. The fabric is hiatal, the non-plastic inclusions are poorly sorted. The grain-size distribution has two maxima. Fine and medium sand size grains are less than 300 μm, while coarse sand size grains are between 800 and 3000 μm. Fine and medium sand size grains are dominantly monocrystalline quartz, feldspars, opaque minerals, mica and accessories (zircon and tourmaline are characteristic). Mineral grains show low sphericity and they are angular. The medium and coarse sand size grains show high or low sphericity, amongst them well rounded argillated volcanic glass fragments are characteristic. The dominant coarse sand size grains are grog fragments. Their groundmass is dark brown in plain polarized light and black, optically inactive in crossed polarized light. Grog fragments are usually isometric, have sharp boundaries and contain about 10–15 volume percent non-plastic inclusions.

Group 4 One sherd (39) belongs to this group. The most important characteristics of this sherd are that it does not contain any grog fragments and also that the amount of non-plastic inclusions is exceptionally great, reaching 50%. The groundmass is light brown in plain polarized light and yellowish brown in crossed polarized light, with moderate–weak optical activity. The fabric is serial; the amount of non-plastic inclusions is about 50%. The sorting of grains is poor. The most abundant non-plastics are carbonate rock fragments, which show low sphericity, they are subrounded, well rounded, or have high sphericity, and they are well rounded. Their size is between 200–1800 μm. Monocrystalline quartz grains (50–600 μm) and polycrystalline quarts grains (250–1100 μm) are accompanied by feldspars, mica and accessory minerals.

The classification of three sherds (1, 3, and 4) is uncertain. The three sherds have similar fabrics with light brown groundmass in plain polarized light and reddish brown, optically inactive groundmass in crossed polarized light. The composition and grain-size distribution of the non-plastic inclusions seem to be slightly different. Sample 1 – having serial fabric – does not contain any argillaceous fragments, while in samples 3 and 4 argillaceous grains are well visible. Although their identification as grog fragments is not certain: they might be either argillaceous rock fragments or grog fragments. The size of fine and medium sand size grains in all samples is below 300 μm, while coarse argillaceous fragments in samples 3 and 4 are between 1000 and 3000 μm.

Technological remains

One fired clay ball, two fired clay coils/slabs and two pottery slag samples were also analyzed in order to gain information on potential raw materials.

Fired clay ball (40) Its groundmass is brown in plain polarized light and yellowish brown in crossed polarized light with moderate optical activity. Its fabric is serial, the groundmass contains about 7–8% well sorted non-plastic inclusions. The majority of them are monocrystalline quartz, feldspars, in traces polycrystalline quartz grains and accessory minerals are also present. Few grog fragments and very few carbonate rock fragments are also present. The latter have low sphericity, well rounded grains, and their size is between 200–800 μm. The sample's fabric and composition is similar to that of sherds belonging to *Group 1b*.

Fired clay coil/slab (41) The groundmass is brown in plain polarized light and yellowish brown in cross polarized light. Isotropy is weak. The fabric is hiatal; the amount of non-plastic inclusions is about 10–15%. The sorting of grains is poor. The most abundant non-plastic inclusions are monocrystalline quartz grains and grog fragments. In small amounts argillated volcanic glass grains are also present. Their size is between 800–1300 μm. Based on its fabric and composition this sample would belong to *Group 3*.

Fired clay coil/slab (42) The groundmass is brown in plain polarized light and dark yellowish brown in crossed polarized light, isotropy is moderate. The fabric is hiatal, the groundmass contains about 15–20%

non-plastic inclusions. The sorting of grains is moderate. Dominant non-plastics are monocrystalline quartz grains and grog fragments. This sample's fabric and composition resembles to that of samples belonging to *Group 2b*.

Pottery slag (35) The groundmass is dark brown in plain polarized light and black in crossed polarized light, isotropy is strong. The fabric is hiatal, there are about 15–20% non-plastic inclusions. The sorting of grains is moderate. Dominant non-plastics are monocrystalline quartz grains and grog fragments. Fabric and composition resembles to that of ceramics in *Group 2b*.

Slag (36) Practically no groundmass is visible. The fabric is serial with about 50–60% non-plastic inclusions the sorting of which is good. Non-plastic inclusions are dominantly monocrystalline quartz grains (50–300 μm) accompanied by small amounts of feldspars, polycrystalline quartz grains, accessories and carbonate rock fragments. Carbonate rock fragments have high sphericity, and subrounded grains with the size of 250–500 μm (**Fig. 3d**). Its fabric and composition make this sample resemble to carbonate-bearing daub fragments (see below), however the proportion of the constituents is slightly different.

Daub

Four daub samples (G1, G2, G3, and G4) were subjected to macroscopic description (**Fig. 4a**) and thin section analysis. For detailed petrographic description of the samples please consult the supplement. The examined daub fragments are of two types.

Samples G1 and G2 has serial fabrics and contains 40–50% non-plastic inclusions. These are dominantly: monocrystalline quartz, feldspars, mica, opaque minerals and accessories. In small amounts metamorphic rock fragments are present. As a consequence of burial some of the pores are filled with secondary carbonate. The bulk of both daub fragments is covered with a thin layer of a fine grained carbonate material. The contact line is sharp, but sometimes has a wavy pattern. In sample G1 this layer – based on its optical characteristics – can be divided further into sub layers. Muscovite grains present in this fine grained material are oriented parallel to the surface.

Samples G3 and G4 also have serial fabric with 40–50% non-plastic inclusions (**Fig. 4b**). Non-plastic material dominantly consists of monocrystalline quartz, feldspars, opaque minerals, mica and accessories. Calcite and iron-rich nodules are also present in small amounts, as well as metamorphic rock fragments. Some of the pores are filled with secondary carbonate. Characteristic constituents are carbonate rock fragments, which are dominantly high sphericity, well rounded grains. The bulk of these two samples are also covered with a thin layer of a fine grained carbonate material. It can be divided further into sub layers.

DISCUSSION

Petrographic examination of the pottery assemblage shows that almost all of the samples are deliberately tempered with grog, although potters did not always use the same amount. Grog-tempering in three cases is probable, but uncertain. Only one sample was found without grog temper.

The majority of the samples that way are very closely related to each other both on the basis of the composition of non-plastic inclusions and granulometry. The only difference is in the proportion of the components.

The 23 sherds belonging to *Group 1a* and *Group 1b* are all tempered with grog. The grain size distribution has two maxima: fine sand size inclusions are dominantly mineral fragments, while medium sand size and coarse non-plastics are mostly grog fragments accompanied by carbonate rock fragments. These latter components – medium sand size and coarse sand size grains as well – are low sphericity (sometimes high sphericity) subrounded–rounded grains.

The 7 pottery samples forming *Group 2a* and *Group 2b* are also tempered with grog, however, these samples do not contain carbonate rock fragments. Interesting feature is that in sherds belonging to *Group 2a* the amount of non-plastics, except for grog fragments, is only 1–2%. Grog fragments are of two types: one type contains non-plastics in about the same amount as the groundmass, while in the other type non-plastic inclusions are present in much greater amounts, in about 10%. Iron-rich nodules present in these samples might be the sign of sediment from a marshland or riverbank (*Szakmány 2004*). *Group 2b* samples are much the same as the sherds in the previous group; however they contain 10–15% non-plastic inclusions (except for grog fragments).

Group 3 samples are also grog tempered, but they have a special characteristic: they contain high or low sphericity, well rounded argillated volcanic glass fragments.

Group 4 consists only of one sample. This sherd is exceptional because it contains extraordinarily great amounts, about 50%, of non-plastic inclusions, dominantly high or low sphericity, well rounded carbonate rock fragments.

In the case of the three sherds whose classification is uncertain we can deduce that considering that as all ceramics, except for one sample, were tempered with grog, the argillaceous fragments found in these samples are most probably grog fragments and not argillaceous rock fragments. Assuming this, these samples would belong to *Group 2b.*

Considering these results three possible *raw materials* can be identified: (1) carbonate rock free; (2) carbonate rock bearing and (3) argillated volcanic glass bearing.

The different amount of carbonate rock fragments in pottery samples belonging to *Group 1a* and *Group 1b* compared to that of the extraordinary sample of *Group 4* might suggest that there was a raw material containing carbonate rock fragments in small or moderate amounts, but in some cases (39) the raw material (carbonate free or carbonate rock bearing), for special, presently unknown reasons, was tempered with a carbonate sand.

Comparing the ceramics with the composition of the *technological remains* we can see that we have remains belonging to *Groups 1, 2* and *3*.

This fact supports the idea that the examined ceramics were produced at the sites from locally available raw materials. Variation in pottery composition probably reflects natural variation of the sediments. Sampling and further investigations of potential raw materials might yield additional information.

Local production of the ceramics is also supported by the results of daub petrography. Investigations showed that daub fragments just like sherds, are basically of two kinds: carbonate rock free and carbonate rock bearing. The size, roundness and sphericity of the grains are very similar, however the amount is different.

All daub samples consist of two parts: on a sandy basal layer a fine grained calcareous material can be found. The latter one can further be divided into sub layers of different thickness (50–1000 µm). This covering layer has a smoothened, flat surface, just like the interfaces between the sub layers. In one sample a sandy basal layer also exists between the sub layers. This fine grained, highly calcareous layer must have been applied to the walls as a kind of plaster or decoration. The appearance of the basal layer material between the fine grained layers shows that this plastering was renewed several times.

Macroscopic (dark reddish brown colour, hardness) and microscopic (strong isotropy of the groundmass) properties suggest that the examined samples were subjected to fire.

CONCLUSIONS

No differences concerning fabric and petrographic composition were found in pottery vessel forms of the phases defined by Němejcová-Pavúková. It seems that similar raw material recipes concerning raw material choice were in use during the whole period. However fine, thin walled pottery fragments naturally do not contain large non-plastic inclusions, their amount is not necessarily smaller.

As a contrast, macroscopic examination of the samples revealed that there are significant differences: Boleraz phase ceramics are of poorer quality in a sense that they come apart or break easily, from this aspect very similar to the finds of Balaton Lasinja culture (a continuous relationship is supposed in the case of these two cultures). This phenomenon is probably not caused by secondary effects like burial, as all finds were found in a very similar environment. It can not be caused either by different surface treatment, as Boleraz ceramics, which are more prone to fall into pieces, have even more elaborated (more carefully polished, decorated, etc.) surface than classic phase pottery. The cause might be the different firing technique (maximum temperature, soaking time) of the potters. This idea is supported by the optical properties of pottery groundmass: Boleraz ceramics have in most cases weak or moderate isotropy.

It was found that compositional differences do not reflect typological differences.

Lower and upper parts of the examined big storage vessel do not differ considerably (sample 43: lower part, 44: upper part, 45, 46: coarsening material), although in the lower part grog fragments can be found in greater amounts: about 10% more grog fragments were identified in the lower part and in the coarsening material.

Among ceremonial objects (idols, altar models, house models, a mask) – these have not been subjected to petrographic analysis yet – grog is not typical. These objects are dominantly tempered with vegetal material.

Technological remains have similar composition to finished ceramics fragments, but some fragments are over fired. Slag fragments contain greater amounts of non-plastics, similar to daub fragments.

The use of grog as temper does not only have functional, but also cultural reasons. In our samples grog was not used in the same amount; however we could not reveal direct correspondence to neither archaeological period nor function. Previous studies have argued (*Barley 1984, ibid. 1994*) that if the amount of temper does not reach 10%, its use is probably not functional becasue the little amount of grog would not enhance the physical or thermal properties of the vessel. On grog tempering see also *Kreiter 2007, in press*. The use of grog as tempering material is very practical as its working properties are very similar to that of the ceramic's groundmass. On the other hand grog can represent tradition through the circulation of the ceramic material, transferring between past and present. According to several anthropological examples it represents the ancestors, and its use forms part of the group's ceremonies (*Kreiter 2007)*.

Among our samples there are some which are worth mentioning because they contain two types of grog fragments. In these ceramics the groundmass contains very little amount of non-plastic inclusions (1–2%), while grog fragments present in these ceramics are of two types. one type resembles the groundmass with very few inclusions, while the other is similar to all other ceramics. The presence of these two types in one pot supports the idea that slight compositional variations of the ceramics might be due to the natural variation of the locally available sediments.

A great deal of the examined pottery samples contains carbonate rock fragments. In most of the cases (see above) it is supposed that these fragments were present as natural inclusions in the raw material. However, in one pottery sample (39) and in two daub fragments it seems that based on a special recipe carbonate sand was added to the clay.

As technological remains of unfinished products belong to different pottery petrography groups it can be concluded that ceramics were produced at the site from locally available raw materials.

The raw materials used for pottery and daub manufacture are very similar; however they are used in different ways. Comparison with daub fragments (assumed to be local products based on the research of *Kovács (2005)* also supports the conclusion drawn above. As a result it can also be stated that petrographic analysis of daub fragments can assist to the interpretation of the results of pottery analysis.

FINAL REMARKS

The archaeological assumption that ceramics were manufactured at the site from local raw materials has been proved by both archaeological and comparative petrographic methods. The role of potters is, however, unknown yet. It is not clear if pottery manufacture was already specialized. The great quantity of ceramics found at Baden sites, their diverse typology and function suggest that the answer to this question is yes. Variable forms, similar storing practices suggest the existence of some formal and technical rules and also some kind of communication between potters of different settlements of the Baden Culture, even if lying far away from each other.

In spite of the similarities in form and decoration within the Baden Culture, different sites – even those that lie close to each other – also have differences in their ceramic assemblages. This fact might be explained by the use of different pottery making recipes, raw materials, procedures or simply by different potters.

At Balatonőszöd in some cases primitive marks – identifying either the potter or the owner of the piece – can be seen. Such as a triple imprint under the handle of a pitcher, or a symbol consisting of 10 imprints under the handle of another small pitcher. These signatures can only be seen on pitchers. On such kind of pots this type of decoration is unusual and probably was made for a different purpose.

As at neither Balatonőszöd nor at other Baden settlements there is no proof of the existence of kilns, archaeological evidence and cultural anthropological observations support the idea that in the Late Copper Age, pottery manufacture was carried out at home for families, or as a home-industry by potters who specialized in this job and worked part-time. Similar argument for the scale of ceramic production was also put forward for the Bronze Age in Hungary (*Kreiter 2006*). Pottery manufacture most probably took place at the periphery of the settlement together with other manufactures.

Concerning the pottery assemblage we have further questions to answer. According to archaeological and petrographic interpretation pottery was made locally. Petrographic analysis showed the type of raw materials used, however it is still in question if their source can be identified more precisely. Some of the ceramics are decorated with a white incrustation. The composition of this material is unknown yet. On ritual objects, pots and inside a small mug red 'paint' was found. It is in question if this paint could have been made of the ochre fragments lying beside human skeletons and in waste pits. Archaeological investigation suggests different firing techniques (see above), so further investigations are planned to understand the firing procedure (maximum firing temperature, heating rate, soaking time) more precisely.

ACKNOWLEDGEMENTS

This work was supported by OTKA F-67577.

REFERENCES

BARLEY, N. (1984): 'Placing the West African potter'. In: Picton, J. (ed.): Earthenware in Asia and Africa. London, Percival David Foundation.

BARLEY, N. (1994): Smashing pots: Feats of clay from Africa. London, British Museum Press.

DEBOER, N. & LATHRAP, D. (1979): The making an breaking of Shipibo-Conibo ceramics. In: Kramer, C. (ed.): Ethnoarchaeology: implications of ethnography for archaeology. New York: Academic press, 102-138.

GYALOG, L. (ed) (2005): Magyarázó Magyarország fedett földtani térképéhez, 1:100000. MÁFI.

HORVÁTH, T. (2006): Állattemetkezések Balatonőszöd-Temetői dűlő badeni lelőhelyen. – Animal burials in the Late Coppe Age Baden Site: Balatonőszöd-Temetői dűlő. SMK 17, 107-152.

HORVÁTH, T. (2006): A badeni kultúráról – rendhagyó módon. – About Baden Clture – An irregular Approach. JAMÉ XLVIII, 89-133.

HORVÁTH, T. (in press): A szárazföldi szállítás kezdetei és hatása a badeni kultúra életében. ΜΩΜΟΣ V.

HORVÁTH, T., SVINGOR, É. S. & MOLNÁR, M. (2006): Újabb adatok a baden-péceli kultúra keltezéséhez. Archeometriai Műhely 2006/1, 1-12, Melléklet: 1-6.

HORVÁTH, T., GHERDÁN, K., HERBICH, K. & VASÁROS, Zs. (2007): Häuser der Badner Kultur am Fundort Balatonőszöd-Temetői dűlő. ActaArchHung LVIII, 43-105.

HORVÁTH, T., GHERDÁN, K., HERBICH, K, HAJNALOVA, M., HŁOZEK, M. & PROKEŠ, M. (in press): Techno-tipológiai megfigyelések a badeni kultúra fazekasáruin Balatonőszöd-Temetői dűlő badeni településen. ΜΩΜΟΣ IV.

KALECSINSZKY, S. (1905): A Magyar Korona országainak megvizsgált agyagai I. Budapest, a Magyar Királyi Földtani Intézet kiadványa, 1:900000 átnézeti térképpel.

KOVÁCS, T. (2005): Paticsok - a kerámia és az üledék között Archeometriai Műhely 2005/2, 24–30. http://www.ace.hu/am/index.html

KREITER, A. (2006): Kerámia technológiai vizsgálatok a Halomsíros kultúra Esztergályhorváti-alsóbárándpusztai településéről: hagyomány és identitás. – Technological examination of Tumulus culture pottery from Esztergályhorváti-Alsóbárándpuszta: tradition and identity. Zalai Múzeum 15, 149-170.

KREITER, A. (2007):Kerámia technológiai tradíció és az idő koncepciója a bronzkorban – Ceramic technological tradition and the concept of time in the Bronze Age. In Ősrégészeti Levelek 8-9. 146-166.

KREITER, A. (in press): Bronzkori kerámia technológiai vizsgálata Százhalombatta-Földvárról. In: ΜΩΜΟΣ IV, in press.

PETTIJOHN, F. J., POTTER, P. E. & SIEVER, R. (1987): Sand and sandstone. New York, Springer Verlag, 1-618.

SZAKMÁNY, GY. (1996): Petrographical Investigation in Thin Section of Some Potsherds. In Makkay, J., Starnini, E. and Tulok, M.: Excavations at Bicske-Galagonyás (part III). The Notenkopf and Sopot-Bicske Cultural Phases. - Societa per la Preistoria della Regione Friuli-Venezia Giulia, Quaderno 6, Trieste, 143-150.

SZAKMÁNY, GY. (1998): Insight into the Manufacturing Technology and the Workshops: Evidence from Petrographic Study of Ancient Ceramics. In: Költő, L.– Bartosiewitz, L. (eds.): Archaeometrical Research in Hungary. Budapest–Kaposvár–Veszprém, 77–83.

SZAKMÁNY, GY., GHERDÁN, K. & STARNINI, E. (2004): Kora neolitikus kerámia készítés Magyarországon: a Körös és a Starčevo kultúra kerámiáinak összehasonlító archeometriai vizsgálata Archeometriai Műhely 2004/1, 28-31. http://www.ace.hu/am/index.html

WHITBREAD, I. K. (1986): The Characterisation of Argillaceous Inclusions in Ceramic Thin Sections. Archaeometry 28/1, 79–88.