Attila Kreiter

A Celtic pottery kiln and ceramic technological study from Zalakomár–Alsó Csalit (S-W Hungary)

The site

The settlement of Zalakomár–Alsó Csalit is situated on the eastern side of Zala county (Fig. 1). In 2006 a rescue excavation was carried out at the site prior to the M7 motorway construction. Within the area that was affected by motorway constructions, 29916 m² were excavated. The archaeological site is situated east from an approximately north-south oriented natural elevation and the Celtic settlement itself was situated on a low lying area of that natural elevation. The settlement was occupied during the Early Neolithic by the Transdanubian Linear Pottery culture. During the Late Bronze Age a cemetery was established there by the Urnfield culture and in the Iron Age the Celts settled there. In this paper only the bi-chambered Celtic pottery kiln is discussed and specifically the ceramics from the kiln in terms of production technology. The settlement features of the Celtic occupation are discussed by László Horváth (HORVÁTH 2008). The site is dated to the La Tène C1a period, around 250–230 BC (IBID.). Celtic settlements are usually situated close to water and the site at Zalakomár is no exception. Even today the area east from the cluster of Celtic houses is waterlogged and the site is situated at the edge of the former Little Balaton Lake. Since the excavated area is relatively large, it can be assumed that the Celtic village discontinued north, west and east. This indicates that the kiln situated at the edge of the settlement, was relatively close to the water.

Structure of the kiln

Understanding the design process of a kiln is a necessary first step toward interpreting the connected archaeological records. The main advantage of a kiln is that it efficiently allows control of the firing temperature, the rate of heating and atmosphere of firing, and they protect the vessels from coming in contact with fuel, wind and moisture (RICE 1987, 109).

The pottery kiln at Zalakomár is a bi-chambered updraught kiln (Figs. 2–3). Updraught kilns have enclosed firing chambers in which the heat moves upward from underneath the pots and is then vented outward (RICE 1987, 159). Fuel is fired in a firing chamber through a stokehole, through which air is also admitted. The flames and combustion products rise through flues in the top of a fire chamber, which is also the floor of the pottery firing chamber, and exit through flues or openings at the top of the kiln (RYE 1981, 100).

The kiln appeared under the subsoil as a round red patch. The filling of the kiln was grey and black sand. The kiln was dug into the clayey subsoil and it crosscut two Neolithic pits (features 379 and 352). Inside the flues tool marks, which had a straight end, were observed. The tool marks in the flues indicate that the kiln was dug into the subsoil. Because of the filling of the Neolithic pits differed from the filling of the stoke hole, the fillings could well be identified and their finds could be separated. The stoke hole has a rectangular shape with rounded edges. The bottom of the stokehole was *ca.* 35 cm deeper from the bottom of the firing chamber. The yellow subsoil at some places in the stoke hole, close to the opening of the flues, was burnt red.

The firing chamber of the kiln was rounded with a thick dividing rib in the middle. The width of the firing chambers measured 129 cm internally and 145 x 155 cm externally. The total length of the kiln including the flues was *ca.* 225 cm. The rib in the middle of the firing chamber is 17 cm thick on its top and tapered downward towards its bottom showing 27 cm in thickness. The rib divided the kiln into two equal parts and with no connections between the firing chambers. Thus the pottery kiln was bi-chambered and the two chambers had to be fired separately. The kiln had two flues with square openings and they run parallel to each other but were not connected. The rounded frame of the kiln was carefully constructed because it was regular in size and its surface was flat and smoothed. The axis of the kiln was south-west oriented with the stokehole being situated at the eastern end of the chamber. Thus the kiln was fired from the east. The bottom of the chamber had a solid red burnt clay floor which is basically the clayey subsoil and no plastered bottom was identified. The bottom of the chamber was not hard but had a slightly red burnt appearance and it was covered with grey-black ashy filling. It is surprising that the frame of the kiln was hard and very well fired and the bottom of the firing chamber was not. This probably indicates that the frame of the kiln was deliberately fired. This seems somewhat obvious since the kiln frame supports the raised floor and holds the whole upper structure of a kiln. Thus the success of the operation of a kiln greatly depends on the careful preparation of the frame. Moreover, it was observed in the cross section of the kiln frame that towards the top of the frame and middle rib it was more thoroughly fired in red, and towards the bottom of the firing chamber the thickness of red burning decreases (Fig. 4b). The frame of the kiln survived exceptionally well in a height of 40 cm above the clay floor of the firing chamber. The majority of the raised floor survived showing 6–11 cm in thickness and a large part of it could be excavated in situ. The floor did not have sherds built into it. Macroscopically the raw material of the raised floor differs from that of the kiln frame although no microscopic analysis was carried out. In order to examine the construction method of the kiln during the excavation the subsoil around it was removed. It was observed that during the construction of the kiln the producers cross cut several clayey layers, which show differences in terms of the amount of sand and calcareous inclusions. The kiln frame was formed within a clayey layer that contained smaller calcareous inclusions than the clayey layers above it. The raised floor, however, seems to be built from clay with larger calcareous inclusions than the kiln frame. Thus it seems that the raised floor was made from a clayey layer that the maker/s of kiln cross cut during the kiln construction, although this assumption is based on a macroscopic analysis and no chemical analysis was carried out. The raised floor was not solid but it was made of several layers of clay which can be observed in cross-section. It seems that the clay of the floor was kneaded and then applied in many layers that show a laminate structure. In the raised floor vent-holes were pierced, which were arranged within each chamber in three arched rows (Fig. 2). The rounded vents were quite regular in size showing 3.5–4 cm in diameter although a 6 cm large hole also appeared when two holes were pierced so close so that they cross-cut each other. Most of the vents were pierced in angles about 60–70° degrees in such a way that heat was directed towards the middle of the kiln. The raised floor was not overly burnt, this could be accounted for by its relative thickness or perhaps the kiln was not used for a very long period.

An interesting feature of the raised floor was that it did not sit on the kiln frame nor on a pedestal, as in the kiln construction method often observed in La Tène kilns (BÓNIS 1981, 11; ILON 1996–1997, 85; SOMOGYI 2004, 20). The raised floor sat within the chambers and where it was attached to the frame in the inside of the chamber it was thicker (11 cm) than towards the middle of the chamber (6–8 cm). Because the raised floor was excavated in situ it could be observed that it was attached to the upper part of the kiln frame within the firing chamber and it was not built on the top of the firing chamber (Fig. 4 a). The raised floor had a flat side where it was attached to the frame. The increased thickness of the floor where it was attached to the inside of the frame was probably due to increasing the cohesion between the firing chamber and raised floor. A further intriguing feature of the raised floor was that in the bottom of it imprints of 3–5 mm thick twigs were observed. The twigs were arranged in one row more or less parallel to each other but some twigs were also applied as a second row approximately in 45° degrees to the first row. Because twigs must have disintegrated at the first firing it is assumed that the twigs supported the raised floor during its construction. The twigs that composed the frame of the raised floor surely disintegrated at the first firing and the cohesion between the floor and the kiln frame probably could not have been strong enough to hold it in its position in particular because during firing every clay shrinks. Thus after the first firing the raised floor should have collapsed into the firing chamber, however this was not the case. Shrinkage depends on the type of clay but experiments show that it ranges between 6.5 and 14% (RICE 1987, 89, Tab. 4.3). Potters surely have been aware of clay shrinkage that they must put into consideration. In inspecting the characteristics of the excavated kiln it has been realised that the builders of the kiln chose a particularly interesting solution to overcome the clay shrinkage. They formed the frame and in particular the middle rib into a conical form. The rounded frame for example at its northern side measured *ca.* 10–14 cm on its top and tapered down towards its bottom showing *ca.* 17 cm. At the southern side the frame was *ca.* 13 cm wide on the top and 19 cm at its bottom. As it has already been mentioned the rib in the middle of the kiln was 17 cm thick on its top and tapered towards its bottom showing 27 cm in thickness. Thus the rib in the middle of the firing chamber shows more tapering towards its bottom than the round frame of the kiln. It is suggested that as a result of the conical shape of the kiln frame and rib, when the raised floor was fired first the twigs disintegrated and the floor shrank a little bit and moved downwards but because of the conical shape of the kiln frame and rib the raised floor stacked within the frame moving into its final position. This construction method is remarkable indicating an exceptional skill in kiln construction and an outstanding knowledge about the properties of raw materials.

The flues of the kiln leading from the stokehole had a slight elevation towards the firing chamber. It had a domed clay roof over its whole length, which was 75 cm and its width was 119 cm. The domed flue was an integral part of the walls of the kiln and the floor of the flue was a continuation of that of the furnace chamber (Fig. 3). The opening of the flues was 32–33 cm wide and 17–18 cm high. The two openings were divided by a 25 cm wide rib. The flues tapered in plan, at the entrance they were narrower and towards the firing chamber they became slightly wider. The roof of the dome was horizontal.

The firing chamber of the kiln from Zalakomár did not have a dome-shaped structure and no remains of a built-up structure could be identified. No fragments from or around the kiln indicate that the kiln had any kind of permanently built dome. It could be observed, however, that the top of the kiln frame was flat all around. It is assumed that if the kiln had a permanent dome structure the frame would not have been as flat and smoothed. For this reason it is highly probable that at each firing a temporary structure had to be built from either clay and/or some vegetal material. At the edge of the raised floor remains of brownish organic material was identified that may indicate the remains of a dome built from organic material.

Discussion

The pottery kiln at Zalakomár was situated at the edge of the settlement close to water. Situating kilns in this way is commonly observed at the La Tène settlements, for example, at Sajópetri–Hosszú-dűlő (LT B2–C1), where the kilns are not only situated at the edge of the settlement but the potters' corner was even separated from the settlement by a ditch (SZABÓ–KRIVECZKY–CZAJLIK 2004, 27). In other cases such as at Mezőkeresztes–Cethalom (LT) the kilns are situated within the settlement (WOLF–SIMONYI 1997) similarly as at Sopron–Krautacker (JEREM 1984b).

The shape of La Tène updraught kilns shows high variability. The majority of them are rounded (KOREK 1958, 79; HORVÁTH 1987, 63; ILON 1996–1997, 85) but horseshoe- (KULCSÁR 2004, 26), pear- (NAGY 1942, 163; PETŐ 1981, 34; BÓNIS 1981, 11) or rectangular-shaped (BÓNIS 1981, 11) kilns also came to light.

The dimensions of the kilns also seem to vary. For example the diameter of a rounded kiln at Gór–Kápolnahalom is 90 cm (ILON 1996–1997, 85), at Garabonc–Ófalu is 130 cm (HORVÁTH 1987, 63) and at Sopron–Krautacker is 108 x 104 and 100 x 110 cm (JEREM 1984a, 59–60). Larger kilns were also observed for example at Békásmegyer where the kiln measured up to 3 metres in length and 190 cm in width (NAGY 1942, 163).

The variations in the internal structures of the kilns are difficult to explain adequately and it seems that variations cannot be linked with kiln size. The choice between a pedestal in the axis of the firing chamber, a central pedestal or clay cylinders seems to be arbitrary. There is also variation among the pedestals. Some are built of clay (Sajópetri–Hosszú-dűlő, SZABÓ–KRIVECZKY–CZAJLIK 2004; Ózd, KOREK 1958, 79), others of stone (Sopron–Krautacker, JEREM 1984a, 60; Ordacsehi–Kis-töltés, KULCSÁR 2002) and there is also a report of a pedestal made from a raised floor of an old kiln (Ordacsehi–Csereföld, SOMOGYI 2004, 20).

The raised floors of La Téne kilns usually sat on a pedestal situated in the axis of the firing chamber (TANKÓ–CZAJLIK 2007) or on a single pedestal (BÓNIS 1981, 11). It has also been reported that at Ordacsehi–Csereföld (kiln 545) the raised floor was placed onto three vertically arranged hollow clay cylinders (SOMOGYI 2004, 20), while at Strachotín four cylindrical pedestals hold the raised floor (ČIŽMÁŘ 1987, 207, 211 Obr.3.5). At Gór–Kápolnahalom the raised clay floor sat on a clay pedestal situated in the middle of the kiln. It was 5 cm in thickness in general and the diameter of vent holes varied between 8–10 cm (ILON 1996–1997, 85). At Ózd the raised floor sat on a 20 cm thick pedestal that was situated across the middle of the kiln. The thickness of the raised floor was uncommonly thick showing 55–60 cm and the vent holes were distributed irregularly showing 4–5 cm in diameter (KOREK 1958, 79). At Garabonc–Ófalu the floor sat on a 40 cm wide pedestal running in the middle of the kiln. The floor was 8 cm in thickness. The vent holes were arranged in concentric circles in three rows and their diameter varied between 5–6 cm (HORVÁTH 1987, 63). At Sopron–Krautacker (kilns 151, 199) the floor of the kilns sat on a pedestal built of a worked stone placed in the axis of the firing chamber. The floor of the firing chamber of kiln 199 was 10–14 cm in thickness and circular went holes were arranged more or less in concentric circles (JEREM 1984a, 59).

The pedestal, of course, is an excellent support for the raised floor of a very large kiln and it is sometimes found in this context (Békásmegyer, 3 m, NAGY 1942: 163), but pedestals were also used in quite small kilns (Sopron–Krautacker kiln 151: 100 x 110 cm, kiln 199: 104 x 108 cm, JEREM 1984a, 59–60).

The flues of the La Tène pottery kilns also show variability. At Gór–Kápolnahalom the width of the flue is 50 cm and its length is 37–40 cm but the flue was not divided into two parts (ILON 1996–1997, 85). The kiln at Garabonc–Ófalu had two flues each measuring 42 cm in width. The dividing wall between them was 40 cm thick (HORVÁTH 1987, 63). A kiln (No. 199) at Sopron–Krautacker had one flue measuring 30 cm in length and 26 cm in height (JEREM 1984a, 59). A late La Tène kiln at Békásmegyer had two flues but the length of the flue is not specified (NAGY 1942, 163).

The kilns usually have stoke holes but their size and shape show high variability. For example at Garabonc–Ófalu (LT–C2) the stokehole was rectangular-shaped with rounded edges and measured 210 x 170 cm (HORVÁTH 1987, 63). At Ózd (LT–C) the size of the rectangular shaped stoke hole was 250 x 185 cm and the interesting feature of it is that its depth was 152 cm from the opening of the kiln and it could be loaded with fuel in a standing position (KOREK 1958, 80).

The orientation of the kilns is also variable. For example at Sopron–Krautacker kiln 199 was west-east oriented being fired from the west (JEREM 1984a, 59), kiln 151 was oriented north-south and it was fired from the north (IBID., 60), kiln 332 was oriented north-west–south-east and it was fired from the north-west (IBID., 62). At Gór–Kápolnahalom the kiln was west-east oriented and it was fired from the west (ILON 1996–1997, 85). At Garabonc–Ófalu the kiln was fired from the east (HORVÁTH 1987, 63).

It has been noted that Celtic kilns are faced towards the main wind direction and, since the dominant wind direction in the Carpathian Basin is west, north-west in this way potters used wind to achieve the appropriate oxygen flow and firing temperature (JEREM 1984, 95; ILON 1996–1997, 85). In this respect it seems that the pottery kiln at Zalakomár was faced opposite the wind direction. Does this practice indicate that these potters were un-knowledgeable? Potters exploiting wind direction is an interesting argument, however, there is evidence to suggest that this may not have been a good practice. Facing kilns towards wind direction may have made it difficult for the potter to effectively manipulate how much air gets into the kiln and this practice may have resulted in the breakage of vessels. Ethnographic examples indicate that during firing the temperature can suddenly increase by even 300 °C and often results in an increased waste (LEACH 1977, 195; REINA–HILL 1978, 24; GOSSELAIN 1992, 254, Figure 6). Wind can easily fan the fire resulting in uneven firing or overfiring (warping, vitrified spots, and/or colour changes). Leach (1977, 180, 184, 195) notes that the evolution of kilns must have been governed by the necessity to conserve heat and exclude draughts because the kiln has to be protected from the wind. In the light of this the kiln at Zalakomár may have been purposefully directed opposite to the main wind direction. Variations in wind direction cannot be predicted and differences in facing the kilns represent a specific logic in which particular behaviour meet particular needs, however, the nature of these relationships needs further analysis.

The firing chamber of Celtic kilns is often covered with a dome-shaped structure (KOREK 1958, 79; JEREM 1984a, 59, 1984b, 88; HORVÁTH 1987, 63; ILON 1996–1997, 85). Jerem (1984b, 88) notes that the kiln dome at Sopron–Krautacker was probably a temporary structure, which more or less had to be rebuilt at each firing.

As it has already been mentioned the kiln from Zalakomár did not show any permanent structure on the top of the firing chamber. The dome of a kiln has important roles during firing such as retain heat and protect vessels from sudden changes in the firing atmosphere. Even though remains of a dome structure of Celtic kilns are often found, it has been pointed out that for non-vitrified wares the kiln does not necessarily need to have a permanent enclosure for retaining heat (KINGERY 1997, 13). This is important to note since Celtic ceramic samples examined by X-ray diffraction analysis from Sopron–Krautacker were non-vitrified wares, and were typically fired between 600–700 °C (JEREM 1984a, 67). For non-vitrified wares the crystalline clay structure breaks up to form an amorphous phase which agglomerates and sinters by surface diffusion (KINGERY 1997, 12). This process is rapid and does not require a long firing time. There is no doubt that some kilns were equipped with a clay dome, however, it would be very laborious to rebuild it after each firing, and experimental work has shown that a temporary cover of turf is an adequate way of conserving heat and fuel (PEACOCK 1982, 73) and it is easy to imagine a permanent cylindrical kiln structure with a temporary covering (dome). Experiments also show that for non-vitrified wares open firing system work just as well when the source of heat is rapidly burning organic material or any other combustible material distributed within, below and surrounding the wares (KINGERY 1997, 12), although in the case of the examined kiln from Zalakomár the type of fuel is not known. Nevertheless, the firing chambers of the kiln at Zalakomár are relatively small suggesting that bulky fuels were not employed. The raised floor with vent holes pierced in an angle allow combustion air to surround the vessels effectively from all directions increasing the rate of convection and providing relatively even heat distribution from each direction. In the case of the kiln at Zalakomár it is not known whether the kiln was fired in the flues or in the firing chamber only (JEREM 1984b, 99) or fuel was also put amongst the wares. It must also be noted that if fuel was placed among and top of the vessels, the burning fuel above the wares acted as a blanket (just as a dome) enclosing heat and providing a residual layer of highly effective insulating ash (KINGERY 1997, 13). Ethnographic studies indicate that the temperature achieved in different types of firing structures (bonfires and kilns) are not so different in terms of the length of firing and temperature uniformity (GOSSELAIN 1992, 246). The main difference between them is that permanent-walled kiln structure contains heat more effectively and achieves a slightly higher temperature (IBID.). The kiln structure takes up much of the heat produced and require a slower increase in temperature. Further advantage of updraft kilns is that the firing chamber and the setting area where the vessels are put are separated. In the kilns the atmosphere may be controlled by the selection of fuel and regulating air circulation within the kiln. The atmosphere of firing affects several properties of the finished product in particular colour and hardness, but also porosity and shrinkage (RICE 1987, 81). The sherds examined in this paper show that the firing atmosphere was a mixture of different firing conditions. Some sherds seem to be neither completely oxidised nor completely reduced and fire clouded sherds are also present, although some of the completely reduced sherds suggest a well-controlled firing. It must be noted, however, that it cannot be proven whether the examined sherds from the kiln were actually fired in that kiln. Notwithstanding, the kiln from Zalakomár shows, in many respects, distinct characteristics from other La Tène kilns. The size of the kiln and the flues, and the general structure of the kiln seem to be similar to other kilns. The interesting feature of this kiln, is the unique way of constructing the raised floor and arranging vent holes in an angle allowing heat to be directed towards the middle of the kiln. These practices indicate that the makers of this structure were inventive craftspeople.

The above section outlined the high variability in pottery kilns and even though they look similar they vary in terms of shape and internal structure and their variability seems to be arbitrary. For this reason it is hard to discern logical reason for the different choices. If one had advantages over the other these remain elusive, and it is difficult to escape the conclusion that the matter was determined at least partially by the tradition and training of the potters. By studying the construction of pottery kilns and ceramic technology we cannot overlook the underlying logic in these practices because they constitute the entire context and rationale for investigating the relation between pottery and society.

Discussion of ceramics

In the filling of the kiln 11 rim, 64 body, 1 handle and 5 base sherds were found. None of the sherds were used in the construction of the kiln. The sherds were either wasters, although no overfired or warped vessels were identified, or the kiln may have been used as a rubbish pit after its abandonment. The sherds came to light from above the raised floor, and also from the firing chamber and stokehole suggesting that after the use of the kiln was discontinued it was used as a rubbish pit. In this paper only the most characteristics sherds in terms of typological categories are presented with great emphasis on their building techniques.

Description of characteristic ceramics from the kiln

1. Inv.No. 722.378.1.1 (Fig. 5/1): It is an orangey and light brownish out-curved rim sherd of an amphora. Just below the rim it is decorated with a rib. Inside just below the rib it is decorated with a shallow impression. The sherd is fully oxidised on its exterior, interior and core although its core shows occasional dark patches indicating that the firing atmosphere were slightly uneven. The vessel was slab-built then it was finished on a slow wheel or turn table. The height of the slab was *ca.* 5 cm. The fabric of the sherd shows increased amounts of sand. The quartz grains are mainly opaque and white showing up to 1–1.5 mm in size although sparse amounts coarse quartz grains are also present. Maximum height: 5–5.2 cm, max. width: 10.6 cm, thickness: 0.6 cm.

2. Inv.No. 722.378.1.2 (Fig. 5/2): It is a light brown out-curved rim sherd of a bowl with an S profile. In the exterior just below the rim it is decorated with a shallow impression and two shallow impressions are running on its shoulder. The sherd is fire clouded and both its exterior and interior show reduced patches. Its core is orange and dark grey that indicates irregular firing conditions. The vessel was slab-built. The upper part of the vessel was made out of one slab which was 5 cm in height. To this a much smaller *ca.* 1.5 cm high slab was attached probably to accommodate the increased curvature at the widest part of the vessel. Then the vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amounts of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size although sparse amounts of coarse quartz grains are also present. Rare amounts of medium calcareous inclusions are also present just as rare amounts of iron oxide. Maximum height: 6.8 cm, max. width: 6.9 cm, thickness range: 0.5–0.6 cm.

3. Inv.No. 722.378.1.3 (Fig. 5/3): It is a light brown out-curved rim sherd of an amphora. Just below the rim it is decorated with a rib. The sherd is oxidised in its exterior, interior and core. Its core is orangey. The vessel was slab-built. The upper, out curved, slab that formed the rim shows 2.5 cm in height, which was applied onto a slab which is *ca.* 5.5 cm in height. These slabs overlapped each other. The vessel was finished on a slow wheel or turn table. The fabric of the sherd show increased amounts of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size although sparse amounts of coarse quartz grains are also present although the amount of 2–3 mm large quartz grains is more than in the previous samples and rare amounts of iron oxide was observed. Maximum height: 7.3 cm, max. width: 6.1 cm, thickness range: 0.7–0.8 cm.

4. Inv.No. 722.378.1.4 (Fig. 5/4): It is a dark grey out-curved rim sherd of an amphora. Just below the rim it is decorated with a rib. The sherd is evenly reduced in both its exterior and interior. Its core is irregularly fired. On this sherd no slab building was identified but striations made by a wheel was observed on its interior. Unfortunately it cannot be decided whether the wheel marks were made by a slow or fast wheel or a turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size. Rare amounts of coarse and very coarse quartz grains are also present and rare amounts of iron oxide was also observed. Maximum height: 7 cm, max. width: 10 cm, thickness range: 0.6–0.7 cm.

5. Inv.No. 722.378.1.5 (Fig. 5/5): It is a light brown out-curved rim sherd of an amphora. In the exterior just below the rim it is decorated with a shallow impression. The sherd is oxidised in both its exterior and interior. Its core is also oxidised. The vessel was slab-built, in the cross section of the fragment overlapping slabs could be identified. The height of the slab is *ca.* 4.2 cm. The vessel was finished on a slow wheel or turn table. The fabric shows increased amount of sand. The majority of quartz grains are opaque and white showing up to about 1 mm in size. Sparse amounts of coarse quartz grains are also present. Maximum height: 4.2 cm, max. width: 5.8 cm, thickness range: 0.6–0.7 cm.

6. Inv.No. 722.378.1.6 (Fig. 5/6): It is a dark grey out-curved rim sherd of an amphora. Just below the rim it is decorated with a rib. The sherd is evenly reduced on both its exterior and interior. Its core is oxidised. Since the reduced layer on the exterior and interior is relatively thin (1 mm) and the core is evenly oxidised it is assumed that the vessel was fired under oxidised conditions then towards the end of the firing process the flow of oxygen was decreased that resulted in reduced exterior and interior. On this sherd no slab building was identified but striations made by a wheel are seen on its interior and exterior. Unfortunately it cannot be decided whether the wheel marks were made by a slow or fast wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size. Maximum height: 6.9 cm, max. width: 4.8 cm, thickness range: 0.6–0.7 cm.

7. Inv.No. 722.378.1.7 (Fig. 5/7): It is an orange-red rim sherd of a bowl. The sherd is oxidised on its exterior, interior and core. In this sherd overlapping slabs were identified but the vessel was finished on a slow wheel or turn table. The wheel marks on this sherd are much less in number than in the previous samples indicating that the finishing off this vessel was considerable shorter. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size. Rare amounts of coarse quartz were also identified. Maximum height: 5.5 cm, max. width: 5.6 cm, thickness range: 0.6–0.7 cm.

8. Inv.No. 722.378.1.8 (Fig. 5/8): It is a light brown out-curved rim sherd of an amphora. Just below the rim on its interior it is decorated with a rib. The sherd is evenly oxidised on its exterior, interior and core although there are small patches of fire clouding. The sherd was built using the slab technique. The upper, out-curved, part was a 3.2 cm high slab, which was attached to a *ca.* 5 cm high slab. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size. Sparse amounts of coarse quartz were also identified. Maximum height: 6.2 cm, max. width: 8.2 cm, thickness range: 0.6–0.7 cm.

9. Inv.No. 722.378.1.9 (Fig. 5/9): It is a grey, out-curved rim sherd of a bowl. The bowl shows an S profile with a carinated neck. The sherd is evenly reduced on both its exterior and interior although its core shows irregular firing conditions. The vessel was slab-built. The upper part of the sherd from the shoulder is a clearly identifiable slab with *ca.* 2.5 cm height. This slab was overlapped by another slab but the fragmented nature of the sherd does not allow the assessment of the height of that slab. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size. Sparse amounts of coarse quartz were also identified. Maximum height: 4.2 cm, max. width: 5.2 cm, thickness range: 0.7–0.8 cm.

10. Inv.No. 722.378.1.10 (Fig. 5/10): It is a light grey, out-curved rim sherd of a bowl. The bowl shows an S profile with a carinated neck. The exterior of the sherd is heavily worn. The sherd was reduced on its exterior and interior which was worn off. The core shows irregular firing conditions. Overlapping slabs were identified in the cross section of the sherds. Then the vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size. Sparse amounts of coarse and very coarse quartz were also identified. Rare amounts of iron oxide are also present. Maximum height: 4.3 cm, max. width: 4.6 cm, thickness range: 0.6–0.7 cm.

11. Inv.No. 722.378.4.1 (Fig. 5/11): It is a light brown body sherd of an amphora with smoothed wide channel decoration. The sherd is fire clouded on both its exterior and interior showing irregular firing conditions. The core also shows irregular firing conditions. The vessel was slab-built and the fragment itself is one slab showing *ca.* 6 cm in height. The interesting feature of this slab is that on the top of it another slab was joined to it in a way that they did not overlap each other but only were pressed together. On the bottom of the fragment the next slab was joined to it by a slight overlap. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size. Sparse amounts of coarse quartz were also identified. Rare amounts of iron oxide are also present. Maximum height: 6 cm, max. width: 7.8 cm, thickness range: 1–1.5 cm.

12. Inv.No. 722.378.4.2 (Fig. 5/12): It is a dark grey body sherd of an amphora with smoothed wide channel decorations running parallel to each other. The sherd is reduced on both its exterior and interior. Some parts of the core are also reduced. The vessel was built using the slab technique. The fragment itself is one slab showing 6.1 cm in height. Similarly to the previous sample on the top of the slab another slab was joined by only pressing them together and the slabs did not overlap each other. On the bottom of the slab the next slab was joined to it in a way that they overlapped each other. The vessel was finished on a slow wheel or turn table. It seems that the slabs were not joined together properly and during firing the vessel fell apart where the slabs were joined together and the edges of the slabs similarly became reduced to the exterior and interior of the sherd. Since all sides of the slab are evenly reduced this indicates that the vessel was actually made by the Morsel technique and not out of a ring. Thus this fragment is one actual slab. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size. Maximum height: 6.1 cm, max. width: 8.5 cm, thickness range: 1–1.5 cm.

13. Inv.No. 722.378.4.3 (Fig. 6/1): It is a light brown body sherd of an amphora with smoothed wide channel decorations running parallel to each other. The sherd is oxidised on its exterior, interior and core although there is some fire clouding on its exterior. The vessel was built using the slab technique. The fragment itself is one slab showing *ca.* 6 cm in height and 12.4 cm in width. On the top of the slab another slab was joined in a way that the two slabs overlapped each other. On its bottom the next slab was also joined in a way that the two slabs overlapped each other. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size. Maximum height: 6 cm, max. width: 12.4 cm, thickness range: *ca.* 1–1.5 cm.

14. Inv.No. 722.378.4.4 (Fig. 6/2): It is a dark grey body sherd of an amphora? with a shallow thin smoothed line on its exterior. The sherd is reduced on its exterior, interior and core. The vessel was built using the slab technique. The fragment itself is one slab showing *ca.* 4.2 cm in height and *ca.* 10 cm in width. It seems that the slabs did not overlap each other but they were only pressed together. The vessel was finished on a slow wheel. The examined sherd is probably one slab itself because its sides (cross sections) all around seem to be reduced. This indicates that the vessel probably broke during firing. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size although rare amounts of coarse and very coarse quartz could also be identified. Maximum height: *ca.* 4.2 cm, max. width: *ca.* 10 cm, thickness range: *ca.* 0.6–0.7 cm.

15. Inv.No. 722.378.5.1 (Fig. 6/3): It is a dark grey body sherd of an amphora with a shallow thin smoothed line on its exterior. Below the smoothed line it is decorated with a rib. The sherd is reduced on its exterior and interior while its core is oxidised. The vessel was built using the slab technique. This fragment itself is one slab. It is clear from the fragment that the following slabs, which were joined together, overlapped each other. On the top of the sherd the slabs overlap each other in a length of 2.2 cm, while on the bottom of the sherd the length of overlapping is *ca.* 2 cm. The vessel was finished on a slow wheel. The examined sherd is probably a slab itself because it seems to be reduced all around in its cross sections. Thus the edges of the slab were reduced during firing as a result of breakage of the vessel. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size although sparse amounts of coarse quartz up to *ca.* 2 mm could also be identified. Maximum height: *ca.* 7.2 cm, max. width: *ca.* 6 cm, thickness range: *ca.* 0.8–1.1 cm.

16. Inv.No. 722.378.5.2 (Fig. 6/4): It is a light brown body sherd of an amphora with a rib decoration. The sherd is oxidised on its exterior and interior although fire clouding is also present on both its exterior and interior. The vessel was built using the slab technique. In this sherd the joining of two slabs were identified. In the interior of the sherd there is a clearly visible straight line where the slabs were joined. In the cross section of the sherd it could also be observed that the slabs did not overlapped each other, they were simply attached together. The sherd itself is *ca.* 4.3 cm high slab to which another *ca.* 2 cm high slab was attached. Shorter slabs are usually attached to larger slabs where there is a sudden change in vessel curvature. In this way a shorter slab accommodates abrupt change in vessel curvature because this is the part of a vessel where stress accumulates during drying and firing. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size. Maximum height: 7.4 cm, max. width: 7 cm, thickness range: *ca.* 0.7–0.8 cm.

17. Inv.No. 722.378.5.3 (Fig. 6/5): It is a dark grey body sherd of an amphora with two parallel rib decorations on its exterior. Straight below the ribs there are shallow smoothed channels. The sherd is reduced on its exterior and interior. The core is irregularly fired. The vessel was built using the slab technique and the slabs overlapped each other. The vessel was finished on a slow wheel or turn table. The overlapping area of the slabs on the top of the sherd is *ca.* 2.6 cm, on its bottom is *ca.* 2.4 cm. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size. Maximum height: *ca.* 7.2 cm, max. width: *ca.* 6.5 cm, thickness range: *ca.* 0.8–1 cm.

18. Inv.No. 722.378.9.1 (Fig. 6/6): It is a light brown body sherd of an amphora. The sherd is oxidised on its exterior, interior and core although red and black patches of fire clouding are present on its exterior and interior. The vessel was built using the slab technique. The joining of two slabs was identified; they were simply pressed together without overlapping each other. The upper part of the sherd shows a *ca.* 6 cm high slab. Because of the fragmented nature of the sherd the size of the other slab could not be assessed. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size although sparse amounts of coarse quartz could also be identified. The majority of the coarse quartz are up to *ca.* 2 mm in size. Maximum height: 11.5 cm, max. width: 11.7 cm, thickness range: *ca.* 0.6–0.9 cm.

19. Inv.No. 722.378.9.2 (Fig. 6/7): It is a light brown and dark grey body sherd of an amphora. The sherd is irregularly fired on its exterior, interior and core. The vessel was built using the slab technique and the slabs overlapped each other. This is indicated by the two layers present in the cross section of the sherd. The sides of the sherd are fairly straight that may indicate that the examined sherd was itself one slab. The vessel was finished on a slow wheel or turn table. The fabric shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size. Rare amounts of red iron oxide are also present. Maximum height: 7.1 cm, max. width: 7.1 cm, thickness range: *ca.* 0.6–0.7 cm.

20. Inv.No. 722.378.9.3 (Fig. 6/8): It is a light brown and grey body sherd of an amphora with a shallow smoothed channel decoration. The sherd is irregularly fired on its exterior, interior and core. The vessel was built using the slab technique and the sherd is itself one slab. In the upper part of the sherd a further slab was joined to it by the overlapping technique and the squeezing movements of the fingers are clearly identifiable where the two slabs were attached together. The pressing movements of the fingers as the two slabs were squeezed together created micro cracks on the interior of the vessel, which are clearly visible. At the bottom of the examined sherd another slab was joined but they did not overlap, they were simply attached together. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size although sparse amounts of quartz with up to 3 mm are also characteristic. Maximum height: 6.2 cm, max. width: 10.4 cm, thickness range: *ca.* 1.2–1.5 cm.

21. Inv.No. 722.378.9.4 (Fig. 6/9): It is a dark grey body sherd of an amphora with a shallow smoothed channel decoration. The sherd is reduced on its exterior and irregularly fired on its interior and core. The vessel was built using the slab technique and the sherd is probably a slab itself, which is indicated by the firing marks on its cross section. The next slabs above and below of this slab were simply attached to this slab and no overlapping of slabs could be identified. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1–1.5 mm in size. Maximum height: 5.7 cm, max. width: 12 cm, thickness range: *ca.* 1.2–1.5 cm.

22. Inv.No. 722.378.9.5 (Fig. 6/10): It is a light brown body sherd of an amphora. The sherd is oxidised on its exterior, interior and core. The vessel was built using the slab technique. The joining of two slabs is identified in the cross section. The slabs were simply attached together without overlapping. The size of one of the slabs was *ca.* 4.8 cm. The next slab broke irregularly and for this reason its size could not be measured. The vessel was finished on a slow wheel or turn table. The fabric of the sherd shows increased amount of sand. The majority of quartz grains are opaque and white showing up to 1 mm in size. Maximum height: *ca.* 8 cm, max. width: *ca.* 10.7 cm, thickness range: *ca.* 1–1.2 cm.

Discussion of ceramic building techniques

Celtic pottery building techniques are usually considered in terms of wheel made and handmade pottery but the technological aspects of Celtic pottery construction are not discussed in detail. In this paper particular attention is given to vessel building techniques since in different vessel types slab building was identified as the primary method of construction, which was combined with the slow wheel technique or turn table.

On the sherds from the kiln wheel-marks are also present, suggesting that the vessels were worked on a wheel or turn table during some part of their construction. A closer look at the sherds, however, also shows characteristics of a slab building technique. The fragmented nature of the ceramics does not make it possible in all cases to ascertain whether the vessels were built of rings that are as large as the circumference of the vessel or they were built by a variation of slab building the so-called Morsel building. In the latter case flattened, rectangular clay slabs were joined together in a row to build the vessel wall around and then vertically (FEWKES 1940: 172). Morsel building method seems to be more probable for the vessels examined because in many cases it seems that the slabs were not joined together properly and during the firing process the vessels broke along almost straight horizontal and vertical lines where the slabs were joined together (e.g. Figs. 4/11, 4/12, 5/1, 5/2, 5/6, 5/7, 5/8, 5/9). This is particularly apparent in the case of vessels that have been reduced on their exterior and interior because when the vessels broke along the slabs during firing all the sides (cross section) of the slabs became reduced. During the analysis it was often observed that even though all sides of the slabs were reduced a fresh break of the sherds show that the cross section of the sherd was actually oxidised. The uniformly rectangular sherds give a strong impression that these fragments were the actual building units of vessels. The attachment of the slabs could also be observed. In some cases the top and bottom of the slabs were made flat onto which the next slab was simply attached or a shallow channel was made by a finger to accommodate the next slab, then the edges of the two slabs were slightly smoothed together. The signs of slab building are often recognisable on the sherds even if they did not break along their building units. For examples horizontal cracks are often present on vessel interior and/or cross-section (Figs. 5/3, 6/10b). In other cases slabs overlapped each other, this practice made the vessels stronger since it allowed a better cohesion between the building units.

It was observed that different sizes of slabs were used to construct different vessels or vessel parts. The height of the slabs varies between *ca.* 2 and 7 cm, although the majority of the slabs are *ca.* 5–6 cm high in particular in the case of amphorae. Regularities in building units for a particular vessel type (amphorae) implies a fairly good weight and volume management by the potters, although it is clear that more research is needed to assess possible correlations between building techniques/weight and volume management and vessel types. Nevertheless, ethnographic data shows that regularities in technological practices do indicate good weight and volume management (WALLAERT-PÊTRE 2001). Short slabs (*ca.* 2–3 cm) were applied where there is a sudden change in vessel curvature (Fig. 5/3). This practice is a practical way of overcoming breakage since shorter building units accommodate sudden changes in vessel curvature by decreasing stress in the clay. Sudden changes in vessel curvature are the regions where the most stress accumulates during drying and firing and it was an advantage to apply a shorter building unit rather than bend a larger slab.

The base of the vessels was made of a flat disk to which the first vertical slab was attached. The slabs were simply placed on the disk vertically and the edges of the slab and the disk were slightly squeezed together. The slabs, in many cases, were not attached to the disk properly, which is indicated by the slabs breaking off the disk.

It was observed that in all cases, after the vessel was built using the slab technique, they were finished on a wheel or turn table. Wheel marks were commonly identified on the interior of the examined sherds. The utilisation of a slow wheel or a turn table is suggested rather than the use of a fast wheel to finish off the vessels since it would be very difficult to work with an already built vessel on a fast moving wheel. First of all when a vessel is made on a fast wheel a lump of clay is thrown on the wheel, and it should be attached to the wheel firmly. The strength of throwing determines whether the lump will stay on the wheel and can be formed into a vessel or comes off. The next step is to centre the clay on the wheel. The aim of centring is to make the clay revolve centrally on the wheelhead so that when subsequently it is opened and pulled up the walls have a constant thickness (in horizontal section) and even height. The closer the lamp of clay is placed to the centre, the quicker and easier will be the centring process (COLBECK 1991: 24). This is also essential to make a symmetric vessel. This is a simplified outline of vessel throwing but it is aimed at highlighting that when a vessel is already made by the slab technique it would be very difficult to attach it onto a fast moving wheel firmly so it would not come off when the wheel spins. Moreover, it would also be very difficult to place a ready vessel exactly on the middle of the wheel otherwise it would not revolve centrally.

Technological practices are governed by the traditions of the potters and from the many available technological possibilities they tend to choose the ones that are dictated by their tradition (VAN DER LEEUW 1993). It seems that at Zalakomár Celtic potters had a potting tradition of slab building combined with the slow wheel technique. There are minor variations between the slab techniques in terms of the sizes of the slabs although in general the ceramic technology at Zalakomár is very similar between the different vessel types. It must be noted that the fabrics of the examined sherds are also very similar showing a sandy raw material with occasional appearance of small pebbles. Assessment of the scale of production would shed more light on the meaning of technological similarities, however, at this stage of the research the scale of pottery production could not be assessed.

At Zalakomár slab building was identified as the main method of vessel construction (Fig. 7) and even though slab building of Celtic vessels was not reported previously it is probably not an isolated case. Preliminary studies of Celtic ceramic technology from Bátaszék–Kálvária 56-os út and Dunaszentgyörgy 6-os út also show that the majority of vessels were made by the slab technique and were finished by the slow wheel/turn table technique (KREITER 2008a, b). Moreover, Celtic pottery representations in the literature often show vessels which broke along more or less straight lines (JEREM 1984b, 92–93, Figs. 5.4, 5.5, 5.10, 6.3). Perhaps these vessels were also made by the slab technique although a comprehensive study of Celtic potting technology has yet to be carried out. Nevertheless, this paper shows the potential of ceramic technological studies in understanding the organization of pottery production and in assessing the nature of intra-site ceramic traditions, which in turn makes it possible to compare the organisation of ceramic production between different settlements. The paper also provides a unique way of a pottery kiln construction indicating an exceptional skill of the producers and their outstanding knowledge about the properties of raw materials.

References cited:

BÓNIS 1981

Bónis, B. É.: *A pannóniai római kori fazekaskemencék.* In: Gömöri, J.: Iparrégészeti kutatások Magyarországon. Égetőkemencék régészeti és interdiszciplináris kutatása. Sopron, 1980. július 28–30. Veszprém: Magyar Tudományos Akadémia veszprémi akadémiai bizottságának történelmi szakbizottsága. 11–17.

COLBECK 1991

Colbeck, J.: *Pottery: the technique of throwing.* London: B.T. Batsford Limited.

ČIŽMÁŘ 1987

Čižmář, M.: *Latenénké sídliště ze Strachotína okr. Břeclav – Eine latènezeitliche Siedlung aus Strachotín, Bez.* Břeclav. PA LXXVIII (1). 205–230.

FEWKES. 1940

Fewkes, V. J.: *Methods of Pottery Manufacture.* American Antiquity 6 (2). 172–173.

GOSSELAIN. 1992

Gosselain, O. P.: *Bonfire of the inquiries – pottery firing temperatures in archaeology – what for?* Journal of Archaeological Science 19 (3). 243–259.

HORVÁTH 1987
Horváth, L.: *Késővaskori ház- és településtípusok Dél-Zalában.* Zalai Múzeum 1. 59–80.
HORVÁTH 2008
Horváth, L.: *Kelta pszeudo-kantharos Zalakomárból (Zala m.).* Zalai Múzeum 17. 109–130.
ILON 1996–1997
Ilon, G.: *Korai kelta fazekas kemence Gór – Kápolnadombról.* Savaria 23 (3). 83–96.
JEREM 1984a
Jerem, E.: *An early Celtic pottery workshop in north western Hungary: some archaeological and technological evidence.* Oxford Journal of Archaeology 3 (1). 57–80.
JEREM 1984b
Jerem, E.: *Kelta fazekaskemencék Sopronban.* In: Gömöri, J.: Iparrégészeti és archaeometriai kutatások Magyarországon: Veszprém, 1982. aug. 9–11. Veszprém: Magyar Tudományos Akadémia veszprémi akadémiai bizottságának történelmi szakbizottsága. 83–105.
KINGERY 1997
Kingery, D. W.: *Operational principles of ceramic kilns.* In: Rice, P. M. (Ed.): The prehistory and history of ceramic kilns. Ceramics and Civilization. The American Ceramic Society. Volume 7. 11–19.
KOREK 1958
Korek, J.: *Kelta edényégető kemence Ózdon.* HOMÉ 2. 79–81.
KREITER 2008a
Kreiter, A.: *Jelentés a Bátaszék–Kálvária-56-os út lelőhelyről származó kerámiák (rézkori, későbronzkori, kelta és szkíta) makroszkópos és petrográfiai vizsgálatáról.* Előzetes közlemény – K.Ö.SZ. irattár.
KREITER 2008b
Kreiter, A.: *Jelentés Dunaszentgyörgy 6. sz. főút lelőhelyről származó kelta kerámiák makroszkópos és petrográfiai vizsgálatáról.* Előzetes közlemény – K.Ö.SZ. irattár.
KULCSÁR 2002
Kulcsár, G.: *Ordacsehi–Kis-töltés.* Somogy Megyei Közlemények 15, 23–28.
KULCSÁR 2004
Kulcsár, G.: *Ordacsehi–Kis-töltés.* In: Belényesy, K. – Gallina, Zs. – Kiss, V. – Kulcsár, G. – Marton, T. – Nagy, Á. – Németh, P. G. – Oross, K. – Sebők, K. – Somogyi, K.: A tervezett M7-es autópálya Somogy megyei szakaszának 2000–2001-ben végzett megelőző régészeti feltárások. Előzetes jelentés II. Somogy Megyei Múzeumok Igazgatósága, MTA Régészeti Intézete. 23–28.
LEACH 1977
Leach, B.: *A Potter's book.* London: Faber and Faber.
NAGY 1942
Nagy, L.: *Békásmegyeri késő La-Tène fazekaskemence.* ArchÉrt. 162–172.
PEACOCK 1982
Peacock, D. P. S.: *Pottery in the Roman world: an ethnoarachaeological approach.* London: Longman.
PETŐ 1981
Pető, M.: *La-Tène D – koracsászárkori fazekastelep a Gellérthegytől délre elterülő síkságon.* In: Gömöri, J.: Iparrégészeti kutatások Magyarországon. Égetőkemencék régészeti és interdiszciplináris kutatása. Sopron, 1980. július 28–30. Veszprém: Magyar Tudományos Akadémia veszprémi akadémiai bizottságának történelmi szakbizottsága. 33–36.
REINA–HILL 1978
Reina, R. E. – Hill, R. M.: *The traditional pottery of Guatemala.* Austin: University of Texas Press.
RICE 1987
Rice, P. M.: *Pottery analysis: a sourcebook.* Chicago: University of Chicago Press.
RYE 1981
Rye, O. S.: *Pottery technology: principles and reconstruction.* Manuals on Archaeology 4. Washington: Taraxacum.
SOMOGYI 2004
Somogyi, K.: *Ordacsehi–Cserefföld.* In: Belényesy, K. – Gallina, Zs. – Kiss, V. – Kulcsár, G. – Marton, T. – Nagy, Á. – Németh, P. G. – Oross, K. – Sebők, K. – Somogyi, K.: A tervezett M7-es autópálya Somogy megyei szakaszának 2000–2001-ben végzett megelőző régészeti feltárások. Előzetes jelentés II. Somogy Megyei Múzeumok Igazgatósága, MTA Régészeti Intézete. 20–23.
SZABÓ–KRIVECZKY–CZAJLIK 2004
Szabó, M. – Kriveczky, B. – Czajlik, Z.: *Késő vaskori település Sajópetri határában (Sajópetri, Hosszú-dűlő) (Borsod-Abaúj-Zemplén megye).* In: Archaeological Investigations in Hungary 2002. Budapest. 25–34.
TANKÓ–CZAJLIK 2007
Tankó, K. – Czajlik, Z.: *Fours.* In. Szabó, M. (Ed.) L'habitat de l'époque de La Tène à Sajópetri Hosszú-dűlő. M. Szabó, Budapest: L'Harmattan – Institut archéologique de l'université Eötvös Loránd. 220–225.
VAN DER LEEUW 1993
Van Der Leeuw, S.: *Giving the potter a choice. Conceptual aspects of pottery techniques.* In: Lemonnier, P. (Ed.): Technological choices: transformation in material cultures since the Neolithic. London: Routledge. 238–288.
WALLAERT-PÊTRE 2001.
Wallert-Pêtre, H.: *Learning how to make the right pots: apprenticeship strategies and material culture, a case study in handmade pottery from Cameroon.* Journal of Anthropological Research 57. 471–492.
WOLF–SIMONYI 1997
Wolf, M. – Simonyi, E.: *Mezőkeresztes – Cethalom.* In: Utak a múltba – Az M3-as autópálya régészeti leletmentései. Budapest. 128–131.

Kelta edényégető kemence és kerámia technológiai megfigyelések Zalakomár–Alsó Csalit lelőhelyről

Zalakomár–Alsó Csalit lelőhelyen 2006-ban folyt leletmentő feltárást az M7-es autópálya nyomvonalán. A feltárás 29916 m^2-re terjedt ki. A lelőhelyen előkerült a Dunántúli Vonaldíszes Kerámia kultúrájának településrészlete, a későbronzkori urnamezős kultúra temetője, és egy kelta település részlete.

Ebben a dolgozatban csak a kelta kemencét és a belőle előkerült kerámiát elemzem, mindkettőt készítéstechnikai szempontból. A kemence, és a kelta település objektumainak lehetséges kapcsolatát Horváth László vizsgálja ugyan ebben a kötetben. A leletanyag alapján a település, így az edényégető kemence is a LT C1a időszakra, vagyis i.e. 250–230-re keltezhető. A kemence egy dupla tüzelőteres edényégető kemence, amely az altaljban vörös foltként jelentkezett. A bontás során megfigyelhető volt, hogy a kemencét az altaljban alakították ki, a tüzelőcsatornákban egyértelműen látszottak egy egyenes végű lapos szerszám nyomai, amellyel kivájták a kemencét. A tüzelőtér formája kerekded, melyet középen egy vastag borda oszt két részre. A tüzelőtérbe két párhuzamosan futó tüzelőcsatorna torkollik, amelyek azonban nem voltak összeköttetésben, hanem egy borda választotta őket ketté. Így a két tűzteret külön kellett fűteni keleti irányból. A kemencének nem volt megfigyelhető boltozata.

A kemencének lekerekített sarkú téglalap alakú hamusgödre volt, melynek alja kb. 35 cm-el volt lejjebb a kemence tüzelőterének egyenes aljánál. A kemence alapja teljesen megmaradt, magassága 40 cm, a kör alakú tüzelőtér vastagsága a tetején 10–14 cm, az alján 17–19 cm, a középső borda vastagsága a tetején 17 cm, az alján 27 cm. A kör alakú tüzelőtér belső átmérője 129 cm, külső átmérője 145–155 cm. A kemence teljes hossza a tüzelőtérrel és tüzelőcsatornával kb. 225 cm. A rostély vastagsága átlag 6–8 cm, ahol pedig a kerethez volt erősítve 11 cm. A rostélyon a lyukak három, nagyjából szabályos koncentrikus körben helyezkednek el, a lyukak átlagos átmérője 3,5–4 cm. A tüzelőcsatornák nyílása kissé íves tetejű, szélességük 32–33 cm, magasságuk 17–18 cm. A két tüzelőcsatorna hossza 75 cm, együttes szélességük 119 cm. A két csatornát egy 25 cm széles borda választotta el egymástól.

A kemence érdekességét az adja, hogy a rostély nem a keretre, vagy a középső bordára támaszkodott, hanem a két rostély a két tüzelőtér belső felületéhez volt tapasztva. Mivel a kemence in situ lett feltárva, meg lehetett figyelni, hogy a rostély azon a részen, ahol a kemence keretéhez csatlakozik vastagabb volt. Továbbá a rostély alján áglenyomatok voltak, amelyek a készítés során tartották a rostélyt, de az első égetéskor természetesen elégtek. További érdekessége a kemencének, hogy a készítők alapos anyagismeretéről tanúskodik. A kemence bontása során felmerült, hogy a rostély, mivel nem a keretre, illetve a középső bordára támaszkodik, miért nem esett bele a tüzelőtér belsejébe, hogy bírta ki a saját súlyát, illetve a kerámiáét, amit kiégettek benne? Ez a gondolatmenet abból indul ki, hogy minden agyag zsugorodik a kiégetésekor (6,5–14%), amelyet a készítőknek figyelembe kellett venni a kemence építésekor. A bontási megfigyelések során világossá vált, hogy a készítők hogyan küszöbölték ki ezt a problémát. Azt megakadályozandó, hogy a rostély a kemence belsejébe essen a kiégetés során, a tüzelőtér gyűrűjét és a középső bordát is enyhén kúposra alakították ki (4. kép). Így, amikor a rostélyt kiégették, ha a zsugorodás miatt kicsit el is mozdult a helyéről, a keret enyhén kúpos kiképzése miatt nem tudott a kemence belsejébe csúszni. A kemence készítése tehát úgy rekonstruálható, hogy a gondosan elkészített (egyenletes méretű, simított felszínű) és vörösre égetett keret belsejében tartóágak segítségével elkészítették a rostélyt, amelyet azokon a részeken, ahol a kerethez tapadt megvastagítottak. További érdekessége a kemencének, hogy rostély nyílásainak egy része 60–70°-os szögben dőlt a kemence közepe felé, így a nyílások közvetlenül a kemence belseje felé irányították a hőt.

A kemencében talált kerámiák technológiai vizsgálata azt mutatja, hogy a kerámiák laptechnikával készültek. A kerámiákon a laptechnikának azon változata figyelhető meg, amikor a készítők nem körbefutó gyűrűket alkalmaztak, hanem kisebb lapokat, amelyeket egymás mellé rakva hoztak létre egy sort, majd a következő sort erre építették rá. Mivel azonban a lapok összeillesztése nem volt alapos, az edények nagy része az építési egységek – többnyire vízszintes és függőleges vonalak – mentén törtek el. Miután az edények elkészültek azokat lassú korongon, vagy valamilyen lassan forgó alkalmatosságon fejezték be, hiszen a vizsgált mintákon a korongolás nyomai is felismerhetők.

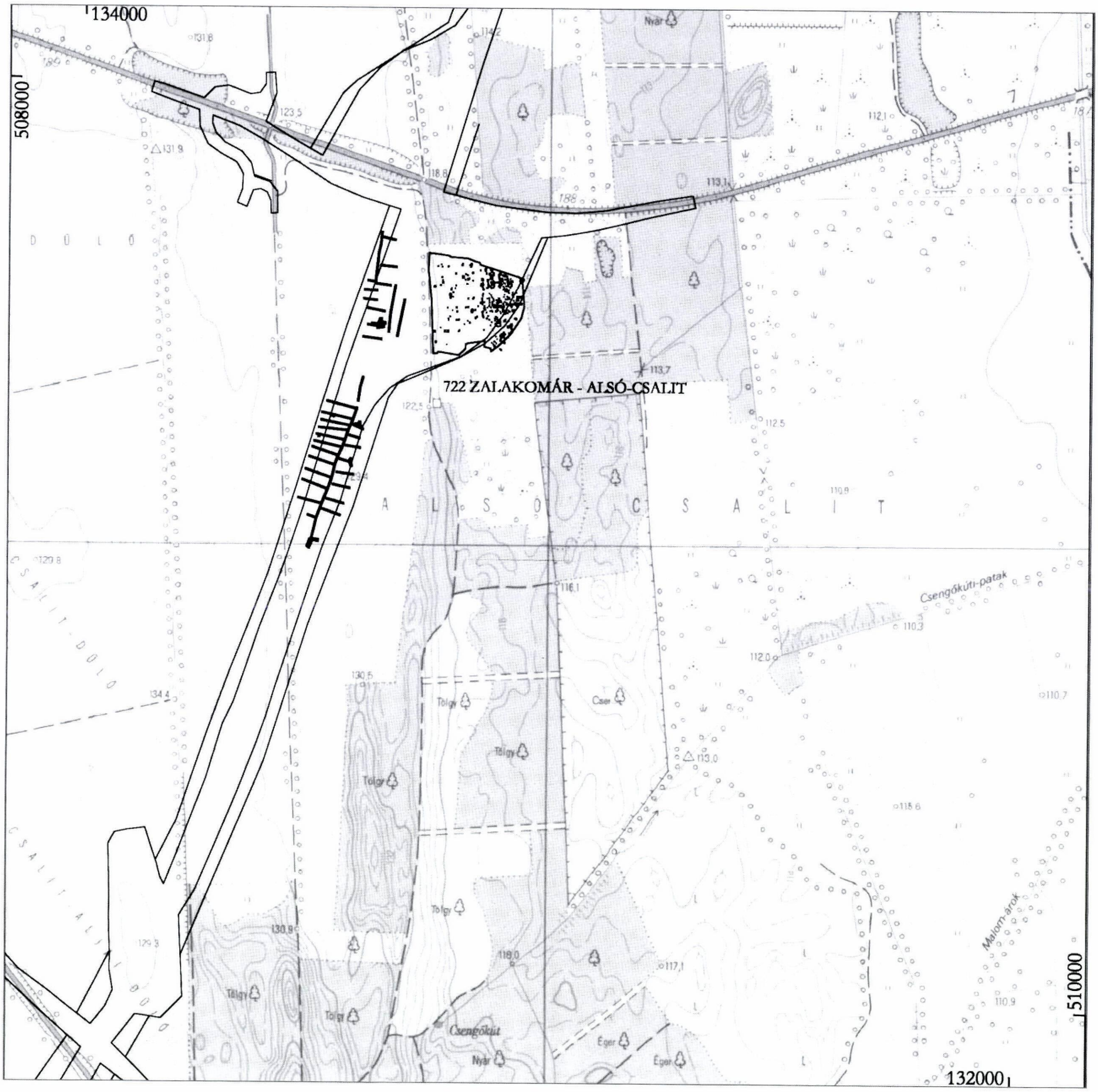

Fig. 1: Topographic map with the site. Scale: 1:10 000
1. kép: Topográfiai térkép a lelőhely ábrázolásával. 1:10 000

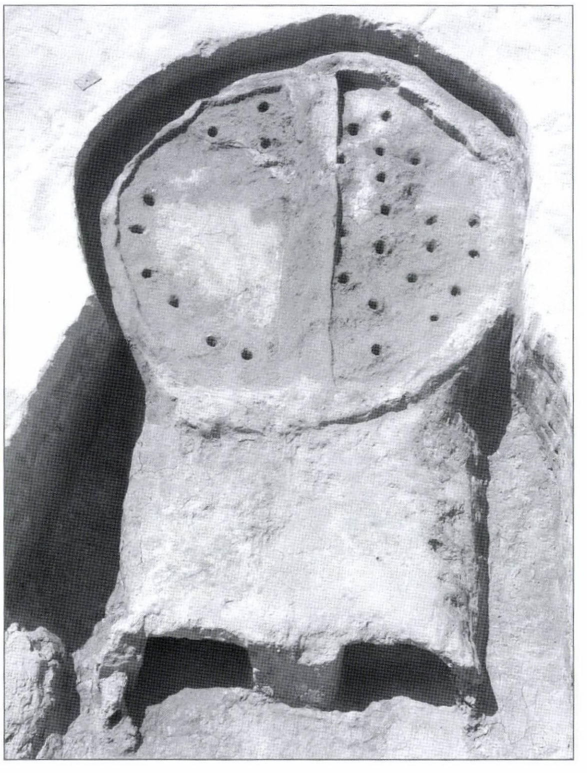

Fig. 2: Photograph of the in situ excavated pottery kiln
2. kép: Az in situ feltárt fazekaskemence fotója

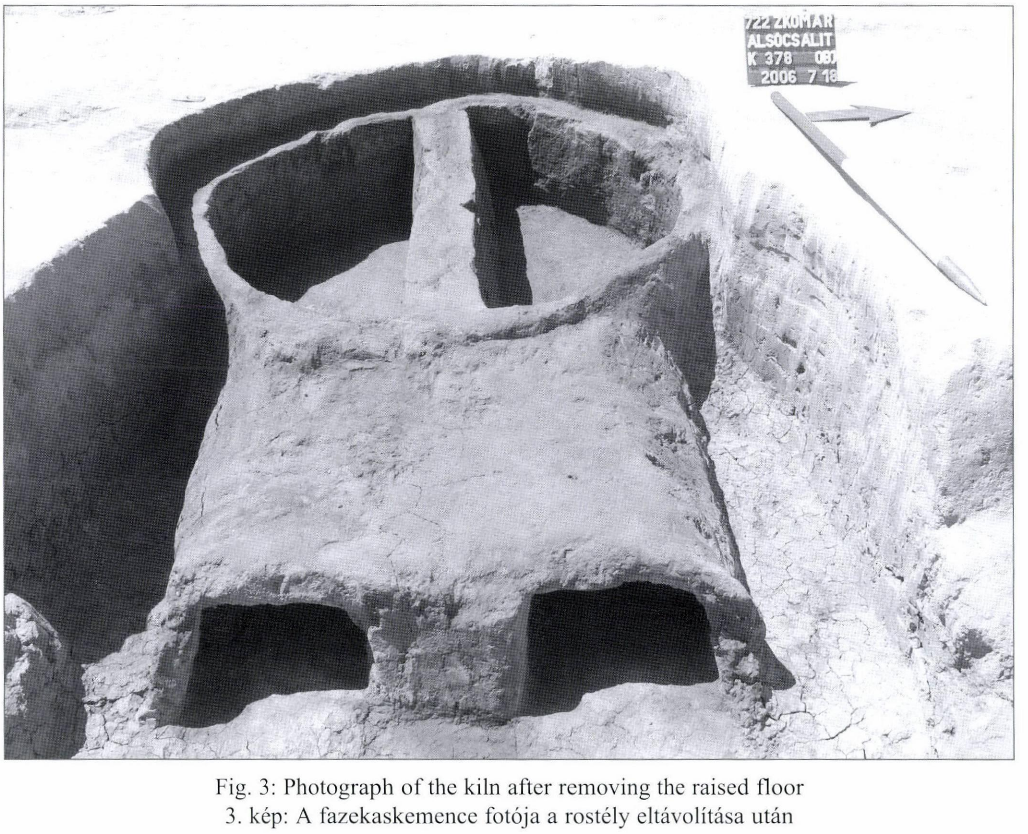

Fig. 3: Photograph of the kiln after removing the raised floor
3. kép: A fazekaskemence fotója a rostély eltávolítása után

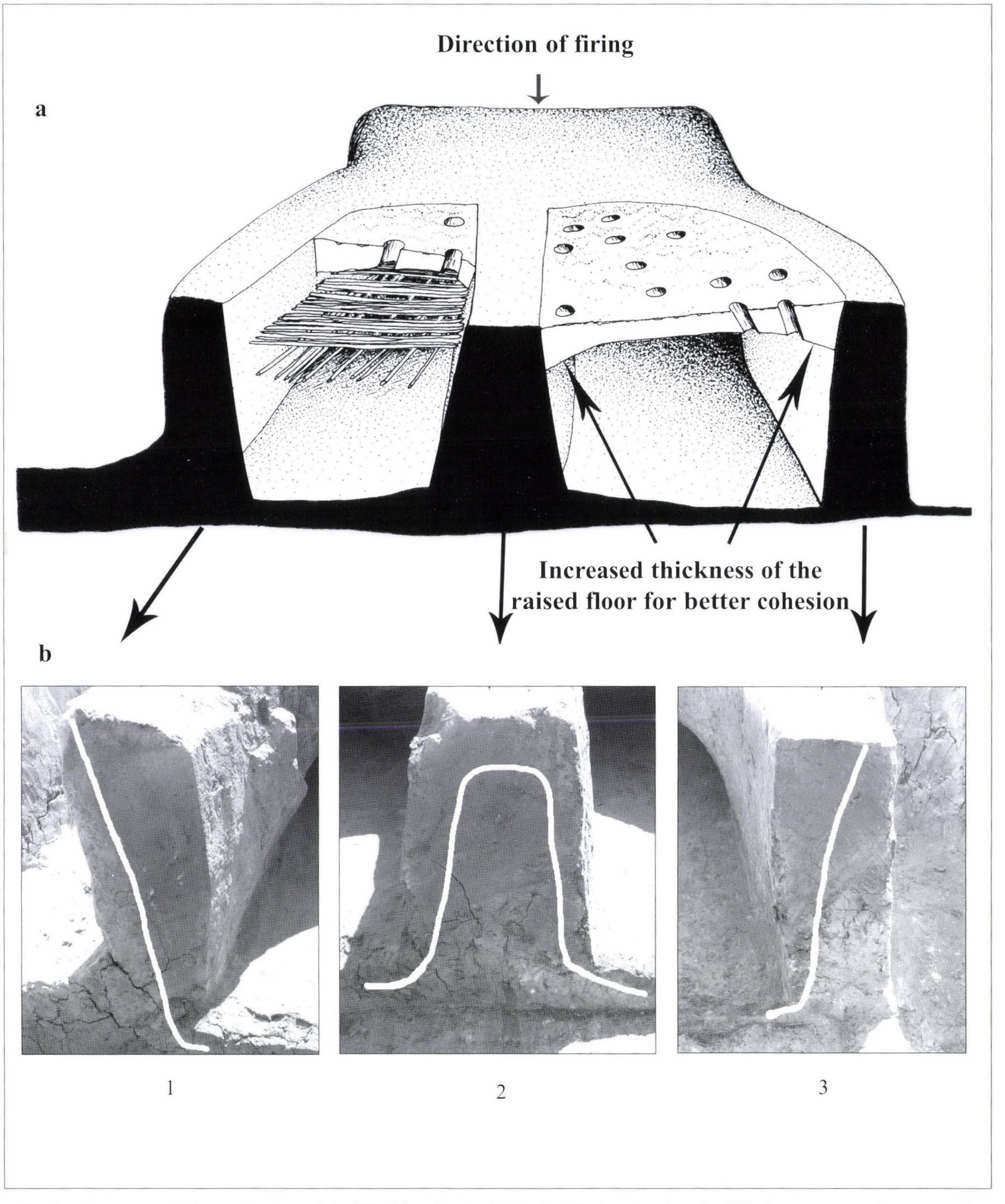

Fig. 4 a: Reconstructed cross section of the kiln (drawing by Márta Lakó) showing that the kiln frame tappers down towards its bottom and that the raised floor has increased thickness when it was attached to the kiln frame;
b: Photograph of the cross section of the kiln frame showing that the frame was burnt thoroughly in its upper part indicating that the fire during its use was mostly situated in the upper part of the firing chamber
4. kép: a: A kemence rekonstruált metszete (Lakó Márta rajza), amely mutatja a kemence keret, illetve a középső borda kúpos kiképzését, valamint a rostély megvastagodását azon a részen, ahol a kerethez és a bordához volt erősítve;
b: A kemence metszetének fotója. A jelölések azt mutatják, hogy a rostélyhoz közelebb a kemence kerete és a középső borda jobban át van égve. Ezért feltételezhető, hogy a kemence használatakor a tűz a kemence tüzelőterének felső részében összpontosult

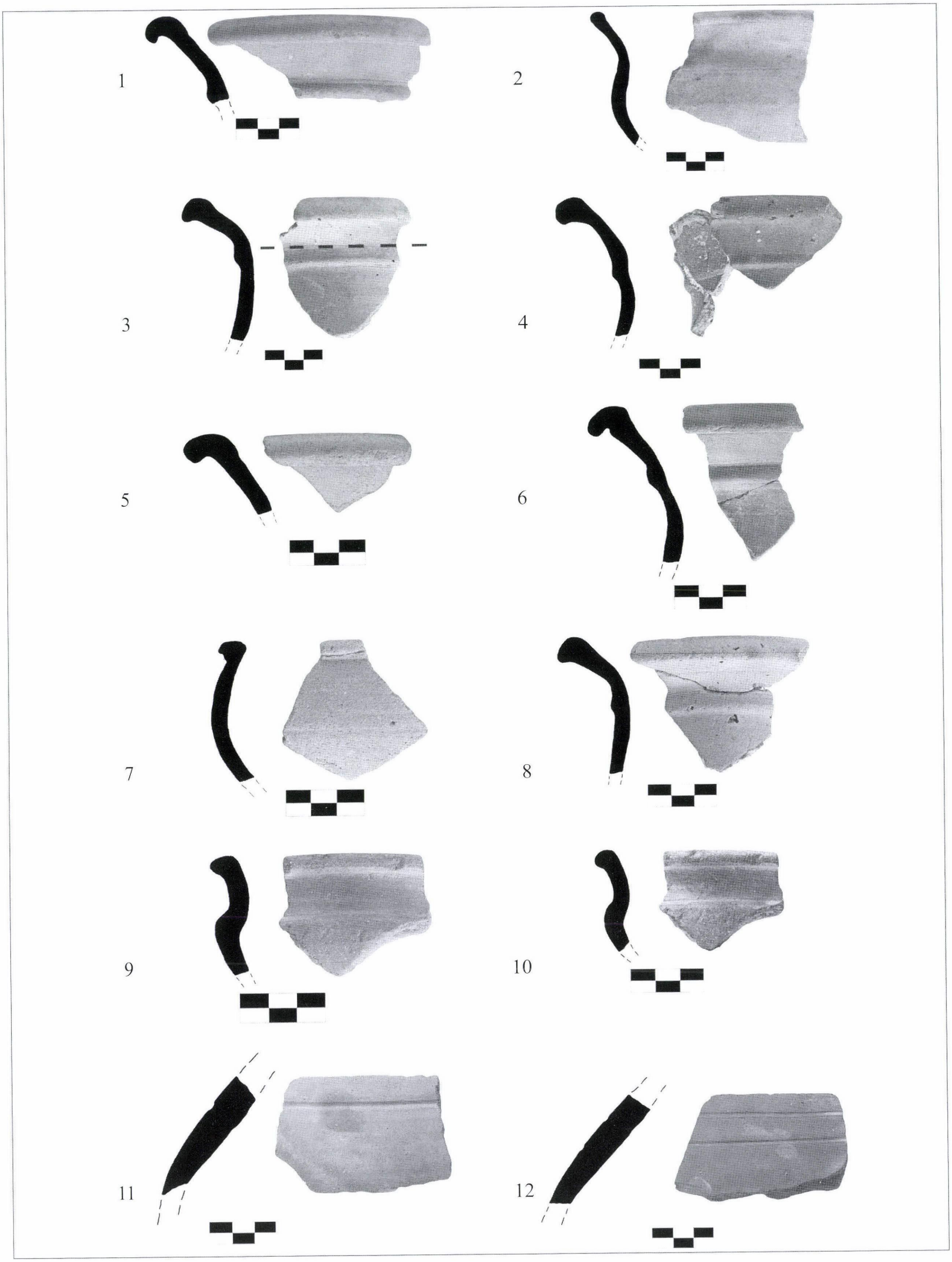

Fig. 5: Example of ceramics from the kiln
5. kép: Kerámiák a kemencéből

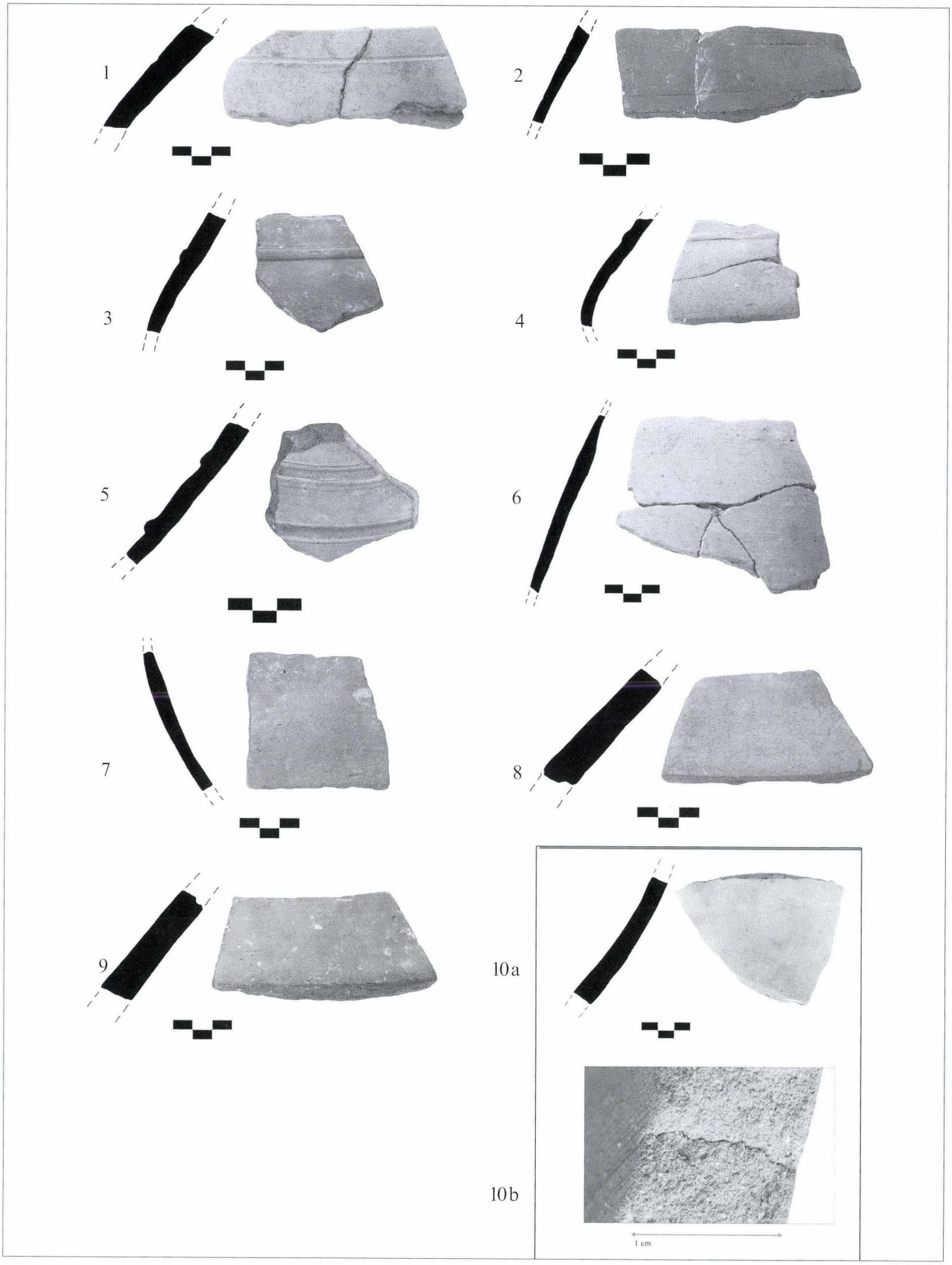

Fig. 6: Example of ceramics from the kiln
6. kép: Kerámiák a kemencéből

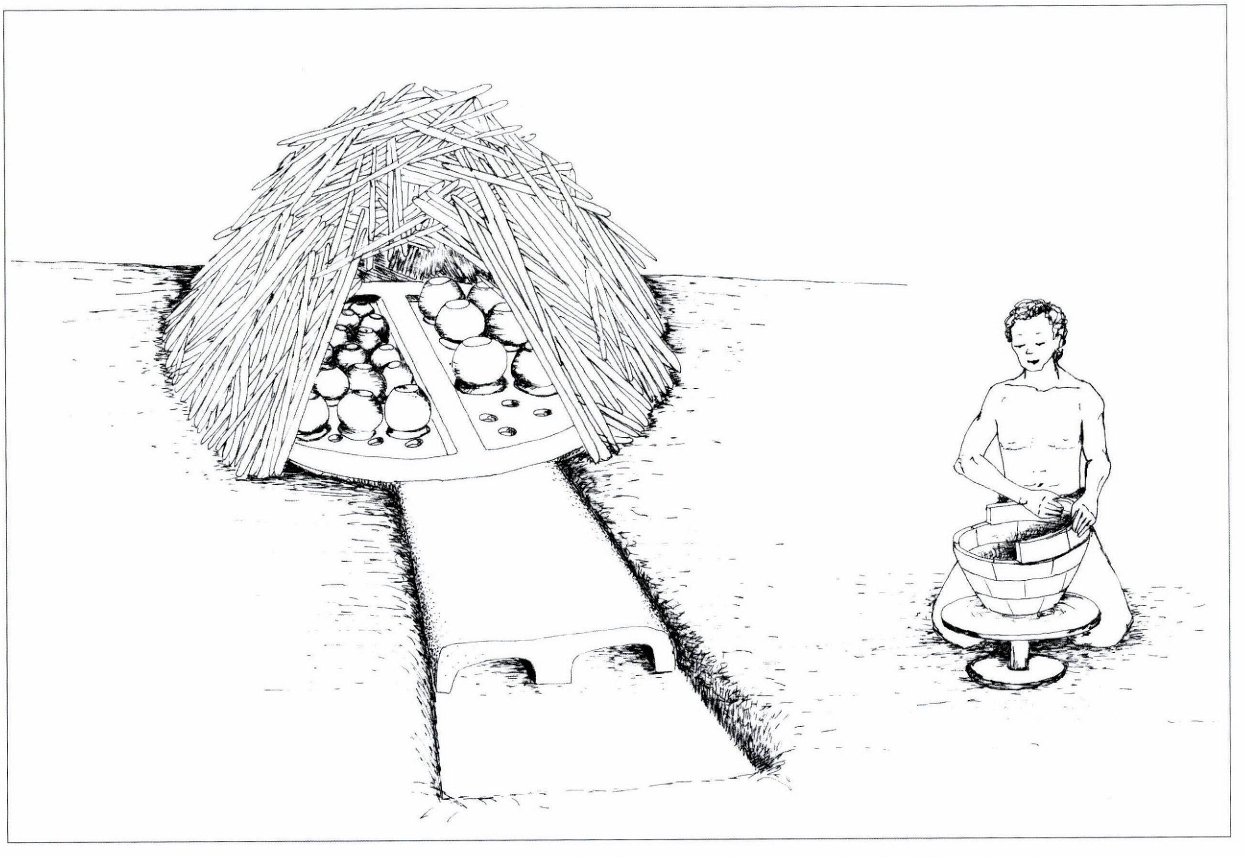

Fig. 7: Reconstruction of the use of kiln and potting. Drawing by Márta Lakó
7. kép: A kemence használatának, és az edények készítésének a rekonstrukciója (Lakó Márta rajza)