

IRON AGE CRAFTS AND CRAFTSMEN IN THE CARPATHIAN BASIN

PROCEEDINGS OF THE INTERNATIONAL COLLOQUIUM
FROM TÂRGU MUREŞ

10–13 October 2013

Edited by
Sándor BERECKI

Editura MEGA
Târgu Mureş
2014

CONTENTS

J. Vincent S. MEGAW

Preface. Proceedings of the Sixth International Colloquium held at Târgu Mureş.....7

Nathalie GINOUX–Dominique ROBCIS–Manuel LEROUX–Florence DUSSERE

Metal Craft and Warrior Elites in the Third Century BC: New Sights from the Carpathian Basin to Gaul.....9

Tiberius BADER

Nachbau des Wagens aus dem Fürstengrab von Hochdorf, Deutschland.....19

Marcin RUDNICKI

Nowa Cerekwia. A Celtic Centre for Craft and Commerce of Interregional Importance North of the Carpathians.....33

Peter C. RAMSL

La Tène Period Craftsmanship in Eastern Austria.....71

Ivan DRNIĆ–Ana FRANJIĆ

pXRF Analysis of South Pannonian Late Iron Age Silver Artefacts.....83

Marko DIZDAR

Bronze Fibulae with Enamel Inlay from Scordiscan Sites.....97

Csilla GÁTI

On the Crossroads of Cultures. Cultural and Trade Connections of the Site of Szajk in South Transdanubia in the Sixth–Fourth Centuries BC.....115

Zoltán CZAJLIK

Traces of Prehistoric Smelting Workshops in the Carpathian Basin.....139

Károly TANKÓ

Traces of Iron Smelting in La Tène Iron Age Settlement at Ménfőcsanak.....147

Attila, HORVÁTH M.

A Decorated La Tène Sword from the Budapest–Csepel Island.....161

Katalin ALMÁSSY–Horea POP

Remains of a Pottery Workshop (?) from the Upper Tisza Region.....171

Martin FURMAN

A Central European Form of La Tène Ornament: Rings with Three and Four Large Hollow Knobs from Slovakia.....183

Gertrúda BŘEZINOVÁ

La Tène Bone and Antler Artefacts from Nitra.....191

János NÉMETI Pottery Production during the Late Iron Age in North-Western Romania.....	199
Horea POP The Metal Smiths' Settlement at Șimleu Silvaniei–Uliul cel Mic.....	209
Corneliu BELDIMAN–Dan Lucian VAIDA–Diana-Maria SZTANCS–Carmen PAVEL–Florin CONSTANTIN Composite Artefact Discovered in the Celtic Cemetery of Fântânele–La Gâța (Bistrița-Năsăud County). Data on Use-Wear Analysis and X-Ray Computed Tomography.....	217
Mariana EGRI Desirable Goods in the Late Iron Age – The Craftsman's Perspective.....	233
Aurel RUSTOIU–Sándor BERECKI Celtic Elites and Craftsmen: Mobility and Technological Transfer during the Late Iron Age in the Eastern and South-Eastern Carpathian Basin.....	249
Iosif Vasile FERENCZ–Dan Lucian VAIDA Craftsmanship and Crafts in the Transylvanian Celtic Horizon.....	279
Marija LJUŠTINA–Miloš SPASIĆ Scordiscan Potters in Action: A Late Iron Age Pottery Kiln from Karaburma.....	287
Vojislav FILIPOVIĆ–Milica TAPAVIČKI-ILIĆ Craftsmen in the Celtic Cemetery of Karaburma, Belgrade.....	297
Andreea DRĂGAN Production and Circulation of La Tène Painted Pottery North of the Lower Danube.....	301
Jan BOUZEK Hook, Lock, Furnace Rake or a Damaged Sickle for Harvesting Olives?.....	319
ABBREVIATIONS	325

TRACES OF IRON SMELTING IN LA TÈNE IRON AGE SETTLEMENT AT MÉNFŐCSANAK

Károly TANKÓ

MTA–ELTE Interdisciplinary Archaeological Research Group
Budapest, Hungary
csisztar@gmail.com

Keywords: Late Iron Age, La Tène culture, NW Hungary; Celtic settlement; iron blommery, iron ore, iron slag, smelting, slag-pit furnace, tuyere

In the vicinity of Ménfőcsanak, near the city of Győr, on top of a levee on the southern side of the Marcal River lies a complex of La Tène sites including a large cemetery and cluster of settlements (Pl. 1). The first burials were found in 1967. The ten burials recovered during this short period of rescue excavation made Ménfőcsanak a key La Tène site in the Carpathian Basin (Uzsóki 1969a; 1969b; 1987). Excavations started on a larger scale in 1993 in and around the area of the previously known cemetery. Two and a half hectares were investigated and 277 burials unearthed, making this the largest excavated Celtic burial ground in the Carpathian Basin (EGRY 2007, 32–33). According to preliminary reports the cemetery dates to the LT B1–C period (VADAY 2006, 609; EGRY 2007, 33).

While Ménfőcsanak became an important archaeological site in terms of burials in the history of the Celtic ‘migrations’ in the fourth century BC, the Late Iron Age settlement to the east of the cemetery has not yet received the attention it merits. The completion of the processing of material from excavation prior to the construction of *National Highway 83* (which took place in 1993) and the *Bevásárlóközpont* excavation (in 1995, 2006) has provided an opportunity briefly to summarize the settlement features and archaeological assemblages (TANKÓ–EGRY 2009; TANKÓ 2012a).

Another large-scale excavation was the Celtic settlement investigated between 2009 and 2011. During this from an area of 277.165 m² nearly eleven thousand structures has been documented (Pl. 1/1–2). More than 90% of the archaeological finds were dated to the Late Iron Age and Roman Imperial Period. The remains of these two periods were observed the most intensely (ILON 2012a, 104–105; ILON 2012b, 237–238; MERKL–ILON 2012, 53).

The Late Iron Age settlement site is located on the gentle slope of the *Szeles-dűlő* hill rising above a bend in the Marcal River to the north of Ménfőcsanak, and is surrounded by the marshy meadows of the Pándzsa stream. According to current data it is apparent that the Celtic settlement of Ménfőcsanak was established in the LT B1 phase, in the second half of the 4th century BC. It was abandoned during the LT B2/C1 transition period or LT C1 period at the latest, in the second half of the 3rd century BC (TANKÓ 2012a, 256–257).

Based on the uncovered structures and artifacts, Ménfőcsanak was primarily an agrarian settlement (TANKÓ 2012a, fig. 3). However, can be observed in the case of recently published Celtic villages in north-east Hungary (SZABÓ–CZAJLIK 2004; SZABÓ *ET AL.* 2008), much information suggests that industrial activity – mainly metalwork – was conducted on primarily agricultural land at Ménfőcsanak too. The most obvious signs of this are the iron ore (Pl. 2/6) and/or furnace slag (Pl. 2/8, 10),¹ even though no

1 We would like to thank to A. Vaday for allowing us to analyse the findings.

in situ bloomery furnace was found. Analyzing the fragments of slags on the site it can be determined that the iron processing was carried out in the southern part of the settlement, near the structure 93/31, 93/492, and 95/49. The finds which can be connected primarily to ironwork were found in sunken buildings or in their vicinity in this part of the settlement. The largest volume of iron ore (two pieces) and bloomery slags (52 pieces) were in the filling of the building no. 93/31 (TANKÓ 2004). Some of these fragments of slags and ores were analyzed by X-ray diffraction (Fig. 1).²

ID	S%	Fe%	MnO%	P ₂ O ₅ %	TiO ₂ %	Cr ₂ O ₃ %	SiO ₂ %	Al ₂ O ₃ %	CaO%	MgO%	Na ₂ O%	K ₂ O%	V ₂ O ₅ %	Cr ₂ O ₃ %
31/1. obj., 95.1.2014, material	0.04	2.52	0.05	0.16	0.20	0.02	44.31	7.38	42.11	2.51	1.19	1.2	-	-
31/1. obj., 95.1.2014, crust	-	0.44	-	-	-	-	17.11	1.11	CaCO ₃ 81.69	1.72	-	-	-	-
31/3. obj., 95.1.636 slag	0.08	2.60	0.19	1.22	0.37	0.01	68.20	10.00	14.75	1.88	2.29	4.19	-	-
31/1. obj., 95.1.626 iron ore	-	39.81	3.49	0.66	0.08	-	7.87	1.85	5.8	1.31	-	-	0.032	0.01
31/4. obj., 95.1.644 iron ore (partly melted)		50.13	4.83	0.4	0.15	-	17.52	2.67	2.97	1.62	-	-	0.035	0.02

Fig. 1. Analysis of iron ore and slags from structure no. 93/31

The two iron ores were particularly interesting (Fig. 1/95.1.626 and 95.1.644; Pl. 2/6). Both of them had high (40–50%) iron content (Fe). The good quality iron ore had a high content of manganese oxide (MnO), with a significantly lower content of titanium oxide (TiO₂), vanadium oxide (V₂O₅) and chrome oxide (Cr₂O₃). During the blooming process these components of ore had improved the quality of the iron and would probably have increased the impact strength and wear resistance however, this may have been at the expense of its tensile strength. The high volume of silicium oxide probably had no effect on iron quality (more than 1 m% in iron can cause difficulties in machining), because most of it was removed from iron ore as slag during the smelting process. The iron ore contained in small amounts calcium oxide (CaO), magnesium oxide (MgO) and alum earth (Al₂O₃).

This raises the question what was the source of this iron ore? There are several ore deposits at the western, south-eastern and eastern edge of the Small Hungarian Plain. Ferrous minerals are known in the Burgenland and Transdanubian mountains (GÖMÖRI–KISHÁZI 1985, fig. 1), According to the present state of research only in Burgenland and the western part of Hungary – from Oberpullendorf to Vasvár – has it been possible to prove iron ore mining taken place in the Iron Age (SCHMID 1977, 11–23; MEYER 1977, 25–48; BIELEININ 1977, 49–62; KAUS 1977, 63–70; CZAJLIK 2012, 55–56). R. Pleiner in many works dealing with the theme of early iron smelting and smithing in Carpathian Basin, localized a mining and primary processing center in the Burgenland based on east Austrian iron ore deposits (PLEINER–PRINC 1984, Tab. 5–7; PLEINER 1994, fig. 1). After analyzing iron ores and slag samples, which was found in western Hungarian La Tène Iron Age settlements, it seems that the processing of ferrous minerals was not limited to only the Burgenland, but the using of bloomery technology is also detectable further afield – for example Sopron–*Krautacker* (GÖMÖRI–KISHÁZI 1985, 337, fig. 7) or Velemzentvid (CZAJLIK 2000, 70–71).

Ménfőcsanak is located roughly 100 km east from the processing center mentioned by Pleiner. However, it is not surprising. According to Pleiner, the small-scale production of early ironmakers was in any case not dependent upon the rich and large ore bodies which become important late; only in stead, very small deposits of bog ore or weathered limonite and haematite outcrops in the vicinity of

² The analysis was conducted by Kohászati Múzeum and Metalcontrol Kft in Miskolc.

the settlement could have been used (PLEINER 2000, 90); it cannot be excluded to have been the case at Ménfőcsanak.

Beside iron ore, the large amount of slags is also important evidence for the use of a bloomery smelter in Ménfőcsanak. According to the slag typology of SPERL (1980), residual furnace slag with embedded charcoal and unreduced ore pieces, Sperl type B1 (Pl. 2/8, 10), slagged wall, Sperl type B2 (Pl. 2/12) and last slag flow from the outlet channel, Sperl type C1 were found at the site. Analyzing slags confirmed that slag deposit on sandstone (Fig. 1/95.1.2014, Pl. 2/11) and the residual furnace slag (Fig. 1/95.1.636, Pl. 2/8) have detectable iron content (Fe). The analysis of ferrous slag composition has been made at La Tène period settlements at Ordacsehi and Sajópetri a few years ago (CZAJLIK–MOLNÁR 2007; TÖRÖK *ET AL.* 2013).

It is not a long distance in space or in time between Ordacsehi and Ménfőcsanak Celtic villages. It is necessary to compare the data because of Ordacsehi's relative proximity to Ménfőcsanak besides their similarities in settlement structures. There are ten samples of slags at Ordacsehi, but only two at Ménfőcsanak. In this situation and the relatively small sample size the resultant indicative values it is necessary in the future to have a larger sample to get a better picture about different types of furnace. The slags from Ménfőcsanak contain manganese oxide (MnO), but it is relatively low as is the case at Ordacsehi. However, significant differences can be detected in connection with the proportion of phosphorus (P₂O₅). This component has a significantly higher proportion than the sample in Ordacsehi (TÖRÖK *ET AL.* 2013, 25, 1. táblázat). As J. Piaskowski has mentioned, the phosphorus could come from slag-forming gangue during the reductive smelting process. 0.4–0.7% rates of phosphorus are not rare in this situation (PIASKOWSKI 1965, 84). The high rate (7–10%) of alumina (Al₂O₃) is also noticeable in the Ménfőcsanak slags. The alumina content rarely exceeds 6%, but higher values have also been described, for example from Mšec in the Czech Republic (PLEINER–PRINC 1984, 159). Alumina comes principally from the ore gangue or furnace lining, while it also comes from fuel ash (PLEINER 2000, 252). The samples examined from both sites are acid slags in which there is more silica and silicates (SiO₂) than lime (CaO) and magnesia (MgO).

There could be several reasons for the high rate of silicates and lime. The iron ore might be contained it, but these components could be enriched from the additional slag-forming gangue (limestone, sandstone, clay, etc.) during the smelting process. Recently conducted research has shown that, on the surface of metallurgical slags contact with the soil particles may produce a thin silicate oxide layer. This may have different results in examination (MCDONNELL 1991, 25).

Low levels of sulfur (S), sodium (Na₂O) and potassium (K₂O) can be found only in slags. These components are missing from iron ore, thus it can derive from the fuel ash. Components (mainly MnO, TiO₂ és MgO) of examined slags in Ménfőcsanak are related with the early medieval slags from Hidegség (GÖMÖRI 1995 194, Abb. 8). The similarity between Late Iron Age and early medieval slags requires further investigation.

In structure no. 93/31 there were two fragments of stone, which have slag flow deposit on their surface (Pl. 2/11). Analyses were made both for the slag (Fig. 1/95.1.2014 material) and the limestone (Fig. 1/95.1.2014 crust). The fragments of limestone contain quartz (SiO₂) in smaller part (17%) and calcium carbonate (CaCO₃) in greater part (82%). The carbonate rocks (e.g. limestone) are used in iron metallurgy today as slag-forming gangue, but this method of slag-making was known already known in the La Tène settlement of Sajópetri (SZABÓ–CZAJLIK 2004, 131; CZAJLIK–MOLNÁR 2007, 265). In the case of Ménfőcsanak – according to the polished side of sandstone – this was not a slag-forming gangue but more likely was used for the construction of furnace.

Based on this information, it was certain that good quality ore with a high percentage of iron (Fe) was available at Ménfőcsanak. This contained some of components (Mn, Ti, Cr, V) which improve the quality of steel. Most of the harmful substances (P, Si, Ca) left as slag from the ore during the smelting process, while some other elements (S, Na, K) was left as slag-forming gangue or fuel ash.

There is not any direct data to reconstruct the blooming furnace, since it was not possible to investigate the furnace *in situ* in Ménfőcsanak. However – like as was previously mentioned – Sperl B1 type residual furnace slag with embedded charcoal and unreduced ore pieces (Pl. 2/8, 10), Sperl B2 type slagged wall (Pl. 2/11) and Sperl C1 type last slag flow from the outlet channel were found in the structures of Celtic settlement; this, according to Sperl's theory (SPERL 1980, 14–18, 64–65), refers

to use of a smelting furnace. The curved rim-crafted, highly burned fragment of a pottery structure with indications of the flow deposit of slag might be a part of a furnace. Some stone fragments also refer to the use of furnace. The highly burned sandstone with slag deposition may be associated with iron smelting. Many examples are known that inside the furnace may be lined with sandstone in order to maintain the heat inside effectively (KRASA 1933, fig. 5; GARNER 2011, fig. 16–17). Bloomery furnaces lined with clay – sometimes having stone lining at their basis – are known in the eastern Celtic world.

Domed furnaces were widely used in the Late Iron Age from Bavaria to the Burgenland (PLEINER–PRINC 1984, 133–135, Abb. 1). This ‘Burgenland type’ furnace (BIELENIN 1994) has not yet been discovered east from the eponymous region, but based on available data we cannot exclude that the domed furnace was used in Ménfőcsanak. Another type of furnace – widely used from the Czech Republic to south Poland and eastern Austria (PLEINER 2000, 149–162) – is the slag-pit furnace (Pl. 2). It has great variability of form and constructions but usually it is easy to identify by its slag pit. Although its existence cannot be denied there is a yet no information about it having been in use in Ménfőcsanak.

A new find probably having been in use in connection with metallurgical activity was uncovered in 2011 in the north-eastern area of the La Tène settlement.³ The archaeological structure has two different numbers in the documentation, because the limits of the excavation could not be identified in the soil, thus these two structures are considered one context based on the location of the finds. The structure 8539/8654 was a shallow pit from which pottery and animal bones were unearthed (Pl. 3). Two pots standing on their mouths were found at one end of the pit. Between them three other pots, were broken and were lying on the bottom of the pit together with some other sherds, animal bones and a clay funnel-shaped vessel. The animal remains were identified as bones of hares, sheep and goats. Beside the hand-made, graphite tempered, bi-conical shape pots and conical shape bowl, there was a wheel-thrown, black colored, reductive fired cooking pot found (Pl. 4/2). There is no doubt that this last was the product of the La Tène culture and it is known many parallels from early and middle La Tène period in Transdanubia (UZSOKI 1987, pl. XIX, 1; HORVÁTH 1987, pl. XVIII, 9; TANKÓ 2012b, 103, fig. 3). The dating of the hand-made pot with fingernail-impressed motifs under rim (Pl. 4/1) is more complicated. This type of pot is dated to the early La Tène period by KAPPEL (1969, 58–65) from end of Ha D to beginning of LT B is proved by many sites from east Austria and western Hungary too, like Sopron–*Krautacker* (JEREM 1986, Taf. 3) or Inzersdorf (RAMSL 1998, 21).

The most interesting find of this unusual context is the ‘clay funnel’ (Pl. 5). It is made of strongly tempered graphite clay; the surface is covered with graphite powder. It has a diameter of 190 mm, and 130 mm length. In the middle of the funnel-shape object there is a slightly oval hole with 35–40 mm diameter. It has cracks on it and slightly chipped on its rim. There was no opportunity to get a direct conclusion for the function of this object from this context. Because of its heavy weight and robust design the using as passage or avenue for a fluid or flowing substance in a pot cannot be imagined.

This find is unique and it is so far without analogies in La Tène material culture. However – considering its size and shape – it is very reminiscent of modern industrial tuyeres as used in present-day metallurgy. The tuyere is a nozzle into which the outlet tube of a blowing device is inserted, to permit a blast of air to be delivered to the interior of a smelting furnace. Its roles were to protect the bellows tube from the effect of the hot furnace charge and to dampen down the vibrations from the bellows to the furnace wall. Tuyeres were mostly made of specially prepared clays. Clay tuyeres usually used dry, so during smelting, the inner tips became fired and because of this these tips survive more frequently, than the rest of tuyere (PLEINER 2000, 197). The origin of clay tuyeres dates back to the Bronze Age, before the introduction of iron technology. Various types of tuyere were used for non-ferrous metallurgical operations (TYLECOTE 1987, 115–123). In iron production, tuyeres were used both in smelting furnace and in forging hearts (PLEINER 2000, 197–198). The shapes of tuyeres vary greatly. The earliest Iron Age finds are connected to the Late La Tène and Roman period. In this time the clay tuyeres were typical (PLEINER 2000, 208–212; GARNER 2011, 64). Conical tuyeres (Pl. 6) have only been found at two Roman Age site, both in Vaud, Switzerland (PELET 1973, 31–32, fig. 2–3; PLEINER 2000, fig. 56/1). They are similar to the find from Ménfőcsanak in form and size. They are 105 mm long (Ménfőcsanak: 130 mm) with a 30–40 mm bore

3 I would like to thank to G. Ilon for allowing the publishing of the findings from structure 8539/8645.

(Ménfőcsanak: 35–40 mm). At Mšec in western Bohemia, in a Middle La Tène context a fragment of a thick, trumpet-shaped tuyere was found in a layer of slag and debris (PLEINER–PRINC 1984, 145, fig. 8C, 10, 8). A similar conical-shaped tuyere was found in Siegen-Niederschelden which could be dated to LT B-C (GARNER 2011, 40, fig. 46).

The fragments in Mšec and Siegen are clear evidence of the use of the conical-shaped tuyeres in the La Tène Iron Age. Based on this fact, it is highly probable that the ‘clay funnel’ – which was found in structure of 8539/8645 – in Ménfőcsanak is a tuyere for metallurgy. However, it was probably not used, although patches either major or secondary combustion heat traces can be observed on surface.

The tuyere of Ménfőcsanak is particularly interesting in its circumstances. Whole pots – two of which were standing in an unusual way – upside down – were beside sherds, animal bones and the mentioned industrial artefact. It is very difficult to understand the purpose of deposition and context of this find, but a similar pit was recently uncovered at Sajópetri. A whetstone and iron tools (shears, axe, iron knife and staple) were placed on a grind stone, which was found in a pit in the central part of the site no. 46A (SZABÓ ET AL. 2004, 26, fig. 3, 5). These depots are sometimes interpreted as a victim of construction, however often there is no available data for the interpretation. Finally, it is also questionable whether the carefully hidden artifacts are possibly indicative of an emergency situation or not (GUICHARD–PAQUELOT 2003, 16–21). However, the votive character of Sajópetri finds could scarcely be doubted. On the one hand there are no signs of disaster in the settlement. On the other hand, the composition of the dépôt for agricultural production (a whetstone and grinding stone), livestock (shears), the tree and the building work (axe, staple) refers to both. The aim of ritual deposition could be the fertility and perhaps the flourishing settlement or to ensure security (SZABÓ 2005, 102; SZABÓ 2007, 225–227). Based on Szabó’s interpretation of Sajópetri we cannot deny the possibility of a ritual purpose in Ménfőcsanak.

In summary, it can be stated even though a furnace was not uncovered many traces were found pointing to the on-site processing of iron smelting. The iron ore, the different types of slags, perhaps the fragments of furnace wall with flow slag and the conical tuyere confirm Celtic metallurgy in the early La Tène period at Ménfőcsanak.

References

- BIELENIN 1977 Bielenin, K., Einige Bemerkungen über das altertümliche Eisenhüttenwesen im Burgenland, *WAB*, 59 49–62.
- BIELENIN 1994 Bielenin, K., Der Rennofen vom Typ Burgenland in der frühgeschichtlichen Eisenverhüttung in Mitteleuropa – Les fours du type Burgenland dans les centres sidérurgiques protohistoriques d’Europe central, IN: Mangin, M. (éd.), *La sidérurgie ancienne de l’Est de la France dans son contexte européen. Archéologie et archéométrie. Actes du Colloque de Besançon, 10–13 novembre 1993*, Besançon–Paris, 255–267.
- CLEERE 1968 Cleere, H. F., Bardown Roman bloomery, Sussex. *Bulletin of the Historical Metallurgy Group*, 2, 1, 55.
- CZAJLIK 2000 Czajlik, Z., Activités métallurgiques à Velem-Szentvid et à Sajópetri, IN: Guillaumet, J.-P. (dir.), *Dix ans coopération franco-hongroise en archéologie 1988–1998*, Budapest, 67–76.
- CZAJLIK 2012 Czajlik, Z., *A Kárpát-medence fémnyersanyag-forgalma a későbronzkorban és a vaskorban*, Budapest.
- CZAJLIK–MOLNÁR 2007 Czajlik, Z.–Molnár, F., Sidérurgie, IN: Szabó, M. (dir.), *L’habitat de l’époque de La Tène à Sajópetri–Hosszú-dűlő*, Budapest, 263–270.
- EGRY 2007 Egrý, I., Preliminary report on the investmentled excavation at Ménfőcsanak, Eperföldek (2005–2006), *AIH 2006*, 27–53.
- GARNER 2011 Garner, J., *Der latènezeitliche Verhüttungsplatz in Siegen-Niederschelden „Wartestraße“*, Metalla, 17, Bochum.

- GÖMÖRI 1995 Gömöri, J., Archäologische Überreste alter Schmiedewerkstätten in Ungarn, IN: *Paléometallurgie du Fer & Cultures. Actes du Symposium du Comité pour la sidérurgie ancienne de l'Union Internationale des Sciences Préhistoriques et Protohistoriques. Belfort-Sévenans. 1–2–3 novembre 1990*, Paris, 187–201.
- GÖMÖRI–KISHÁZI 1985 Gömöri, J.–Kisházi, P., Iron ore utilization in the Carpathian Basin up to the Middle Ages with special regard to bloomeries in Western Transdanubia, IN: Hála, J. (ed.), *Neogene mineral resources in the Carpathian Basin: historical studies on their utilization*, Budapest, 323–352.
- GUICHARD–PAQUELOT 2003 Guichard, V.–Paquetot, F. (dir.), *Forgerons et Ferrailleurs: fer et savoir-faire à l'époque celtique*, Livret accompagnant l'exposition, Gluy-enGlenne, Bibracte.
- HORVÁTH 1987 Horváth, L., The surrounding of Keszthely, IN: Kovács, T.–Petres, É.–Szabó, M. (eds.), *Corpus of Celtic Finds in Hungary I. Transdanubia 1*, Budapest, 63–178.
- ILON 2012a Ilon, G., Győr-Ménfőcsanak – Széles-földek, IN: Kvassay, J. (ed.), *Évkönyv és Jelentés a Kulturális Örökségvédelmi Szakszolgálat 2009. évi feltárásairól / Field Service for Cultural Heritage 2009 Yearbook and Review of Archaeological Investigations*, Budapest, 104–105.
- ILON 2012b Ilon, G., Győr-Ménfőcsanak – Széles-földek. *AIH 2010*, 237–238.
- JEREM 1986 Jerem, E., Bemerkungen zur Siedlungsgeschichte der Späthallstatt- und Frühlatènezeit im Ostalpenraum, IN: Jerem, E. (red.), *Hallstatt Kolloquium Veszprém 1984*, MittAIUAW, 3, Budapest, 107–118.
- KAPPEL 1969 Kappel, I., *Die Graphittonkeramik von Manching*, Die Ausgrabungen in Manching, 2, Wiesbaden.
- KAUS 1977 Kaus, K., Zur Zeitstellung von ur- und frühgeschichtlichen Eisenverhüttungsanlagen Burgenlands auf Grund der Kleinfunde, *WAB*, 59, 63–70.
- KRASA 1933 Krasa, O., Auf den Spuren vorchristlicher Eisenhüttenleute im Siegerlande, *MittRLW*, 1, 124–129.
- MCDONNELL 1991 McDonnell, G., A model for the formation of smithing slags, *MatArch*, 26, 23–26.
- MERKL–ILON 2012 Merkl, O.–Ilon, G., Rovarmaradvány egy római kori kútból Ménfőcsanak–Széles-földekről / Insect remains found in a Roman Age well located in the lands of Ménfőcsanak–Széles-földek, *Archeometriai Műhely*, 1, 53–56.
- MEYER 1977 Meyer, W., Bestandaufnahme von Pinginfeldern im Bezirk Oberpullendorf, Bgld., *WAB*, 59, 25–48.
- PELET 1973 Pelet, P.-L., *Une industrie méconnue: Fer, Charbon, Acier dans le Pays Vaud*, Lausanne.
- PIASKOWSKI 1965 Piaskowski, J., Correlation between the phosphorus content in the iron ore or slag and that in bloomery iron, *ArchPol*, 8, 83–103.
- PLEINER 2000 Pleiner, P., *Iron in archaeology. The European bloomery smelters*, Praha.
- PLEINER–PRINC 1984 Pleiner, R.–Princ, M., Die latènezeitliche Eisenverhüttung und die Untersuchung einer Rennschmelze in Mšec, Böhmen. *PamArch*, 75, 133–180.
- RAMSL 1998 Ramsel, P. C., *Inzersdorf-Walpersdorf. Studien zur späthallstatt- / latènezeitlichen Besiedlung im Traisental, Niederösterreich*, FÖ, A6, Wien.
- SCHMID 1977 Schmid, H., Die montangeologischen Voraussetzungen des Ur- und frühgeschichtlichen Eisenhüttenwesens im Gebiet des mittleren Burgenlands (Becken v. O. Pullendorf), *WAB*, 59, 11–23.
- SPEL 1980 Sperl, G., *Über die Typologie urzeitlicher frühgeschichtlicher und mittelalterlicher Eisenhütenschlacken*, Studien zur Industrie-Archäologie, VII, Wien.
- SZABÓ 2005 Szabó, M., *A keleti kelták. A késő vaskor a Kárpát-medencében*, Budapest.
- SZABÓ 2007 Szabó, M., L'archéologie de culte, IN: Szabó, M. (dir.), *L'habitat de l'époque de La Tène à Sajópetri – Hosszú-dűlő*, Budapest, 225–227.
- SZABÓ–CZAJLIK 2004 Szabó, M.–Czajlik, Z., Vasművesség Északkelet-Magyarországon a Kr. e. 3. században: Sajópetri – Hosszú-dűlő, *HOMÉ*, 43, 127–138.
- SZABÓ ET AL. 2004 Szabó, M.–Kriveczky, B.–Czajlik, Z., Late Iron Age settlement at the outskirts of Sajópetri (Sajópetri, Hosszú-dűlő) (Borsod-Abaúj-Zemplén county), *AIH 2002*, 25–34.

- SZABÓ ET AL. 2008 Szabó, M.–Czajlik, Z.–Tankó, K.–Timár, L., Polgár 1: l'habitat du second Age du Fer (III^e siècle av. J.-Chr.), *ActaArchHung*, 59, 183–223.
- TANKÓ 2004 Tankó, K., Rekonstruktion eines latènezeitlichen Grubenhauses aus Ménfőcsanak-Szeles (B 83), *ComArchHung*, 105–112.
- TANKÓ 2012a Tankó, K., Late Iron Age settlement in the vicinity of Ménfőcsanak (Road no. 83 and Bevásárlóközpont), IN: Borhy, L. (dir.), *Studia celtica classica et romana Nicolae Szabó septuagesimo dedicate*, Budapest, 249–260.
- TANKÓ 2012b Tankó, K., Paks-Gyapa–Vörösmalom-dűlő (Tolna megye), IN: Kvassay, J. (ed.), *Évkönyv és jelentés a Kulturális Örökségvédelmi Szakszolgálat 2009. évi feltárásairól / Field Service for Cultural Heritage 2009 Yearbook and Review of Archaeological Investigations* Budapest, 102–104.
- TANKÓ –EGRY 2009 Tankó, K.–Egry, I., Kelta település Győr–Ménfőcsanak-Bevásárlóközpont területén. Az 1995. és 2006. évi ásatás, IN: Ilon, G. (ed.), *MOMOS, Őskoros Kutatók VI. összejövetele, Kőszeg 2009. március 19–21. Nyersanyagok és Kereskedelem*, Szombathely, 401–416.
- TÖRÖK ET AL. 2013 Török, B.–Kovács, Á.–Barkóczy P.–Kristály F., Ordacsehi-Csereföld kelta településéről származó vassalak és vastárgyak anyagvizsgálata és készítés-technológiai vonatkozásai, *Archeometriai Műhely*, 10, 23–32.
- TYLECOTE 1986 Tylecote, R. F., *The prehistory of metallurgy in British Isles*, London.
- TYLECOTE 1987 Tylecote, R. F., *The early history of metallurgy in Europe*, New York.
- UZSOKI 1969a Uzsoki, A., Die Siedlungsgeschichte der La Tène B-C Periode des Komitats Győr-Sopron, *MFME*, 2, 69–82.
- UZSOKI 1969b Uzsoki, A., Előzetes jelentés a ménfőcsanaki kelta temető ásatásáról, *Arrabona*, 12, 17–57.
- UZSOKI 1987 Uzsoki, A., Ménfőcsanak, IN: Kovács, T.–Petres, É.–Szabó, M. (eds.), *Corpus of Celtic Finds in Hungary I. Transdanubia I*, Budapest, 13–63.
- VADAY 2006 Vaday, A., The chronological model of the celtic cemetery of Ménfőcsanak (Rescue excavation, Road 83), IN: Sírbu, V.–Vaida, D. L. (eds.), *Thracians and Celts. Proceedings of the International Colloquium from Bistrita 18–20 May 2006*, Cluj-Napoca, 279–294.

List of figures

Fig. 1. Analysis of iron ore and slags form structure no. 93/31

List of plates

- Pl. 1. Győr-Ménfőcsanak. 1. Site plan with the location of the La Tène cemetery and settlement; 2. Distribution of iron ore and slags in the territory of southern part of the La Tène settlement.
- Pl. 2. Reconstruction of the slag-pit furnace with the metallurgical finds in Ménfőcsanak. A. Before smelting: 1. shaft; 2. virgin soil; 3. tuyere; 4. bellow; 5. charcoal; 6. iron ore, staw or brush wood. B. After smelting: 8. furnace slag with ore residues and charcoal; 9. iron sponge; 10. slag bloc in the pit; 11. charcoal and ash (after PLEINER 1980; 2000).
- Pl. 3. Ménfőcsanak, structure no. 8539/8645.
- Pl. 4. Ménfőcsanak, pottery from structure no. 8539/8645.
- Pl. 5. Ménfőcsanak, tuyere from the structure no. 8539/8645.
- Pl. 6. Conical and disc-shape tuyeres (after PLEINER 2000). 1. Bellaires (PELET 1973), 2. Ballyvourney (TYLECOTE 1986, without scale), 3. Bradown (CLEERE 1963).

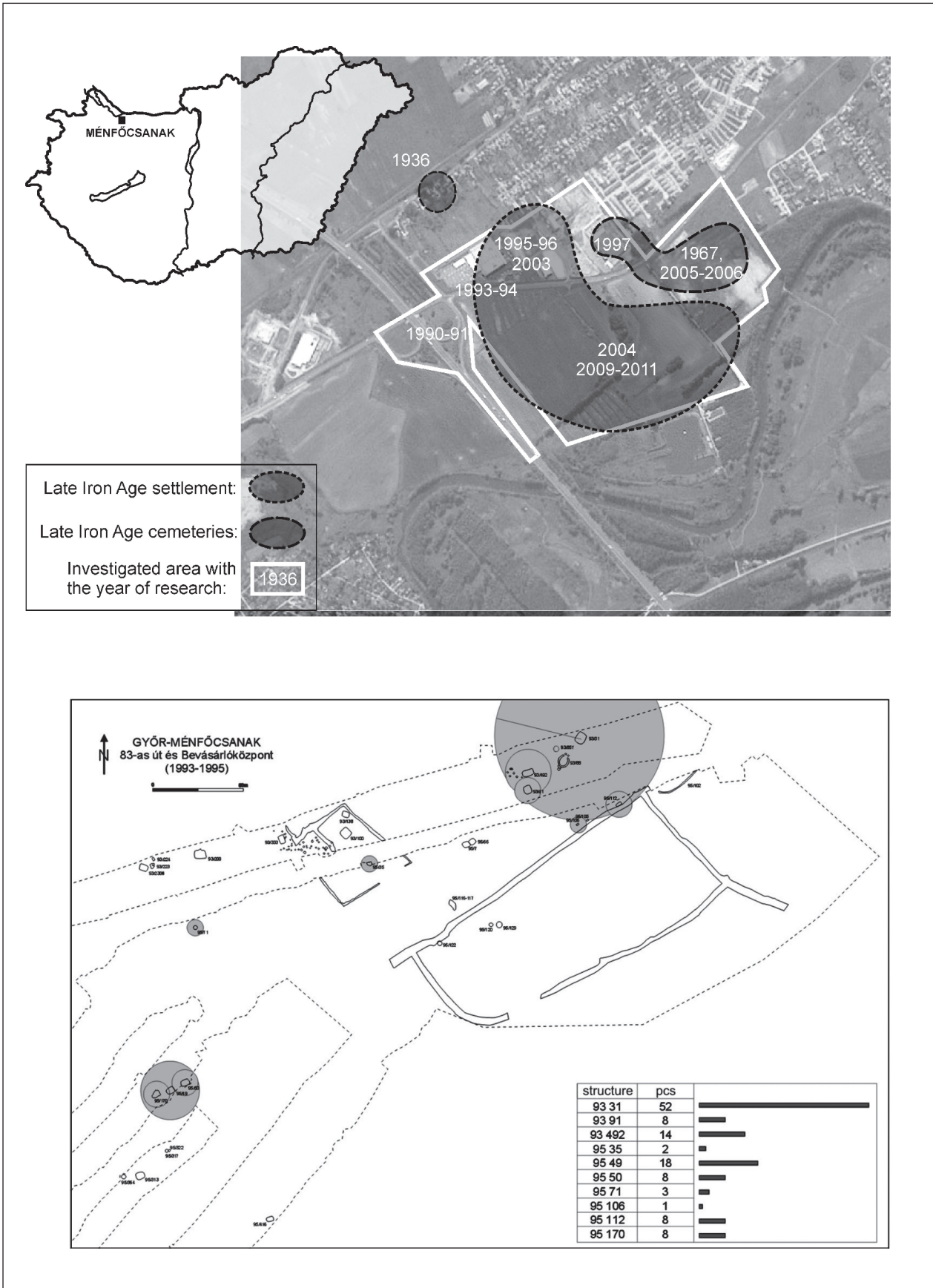


Plate 1. Győr-Ménfőcsanak. 1. Site plan with the location of the La Tène cemetery and settlement;
 2. Distribution of iron ore and slags in the territory of southern part of the La Tène settlement.

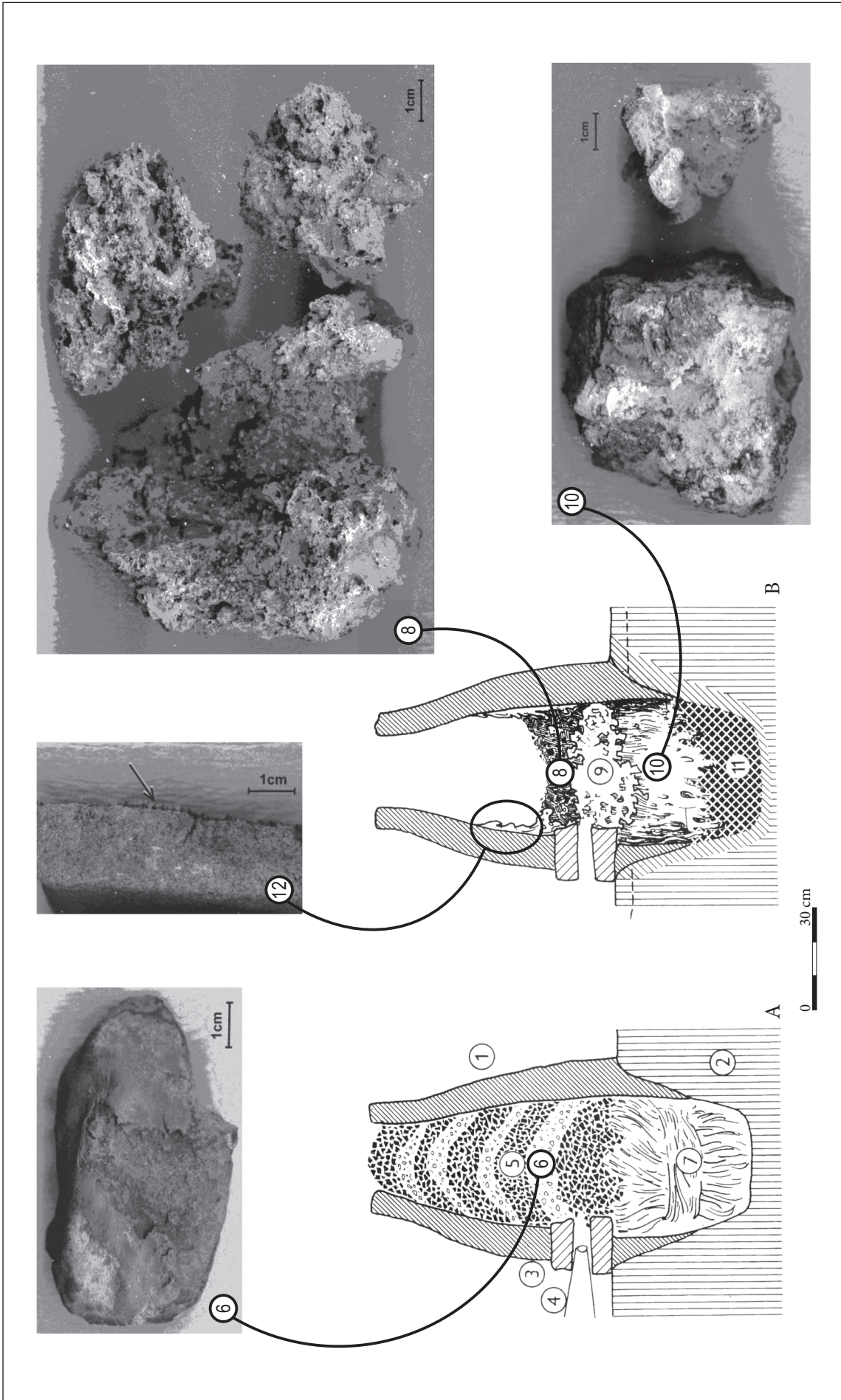


Plate 2. Reconstruction of the slag-pit furnace with the metallurgical finds in Ménfőcsanak.

A. Before smelting: 1. shaft; 2. virgin soil; 3. tuyere; 4. bellow; 5. charcoal; 6. iron ore, staw or brush wood.

B. After smelting: 8. furnace slag with ore residues and charcoal; 9. iron sponge; 10. slag bloc in the pit; 11. charcoal and ash (after PLEINER 1980; 2000).

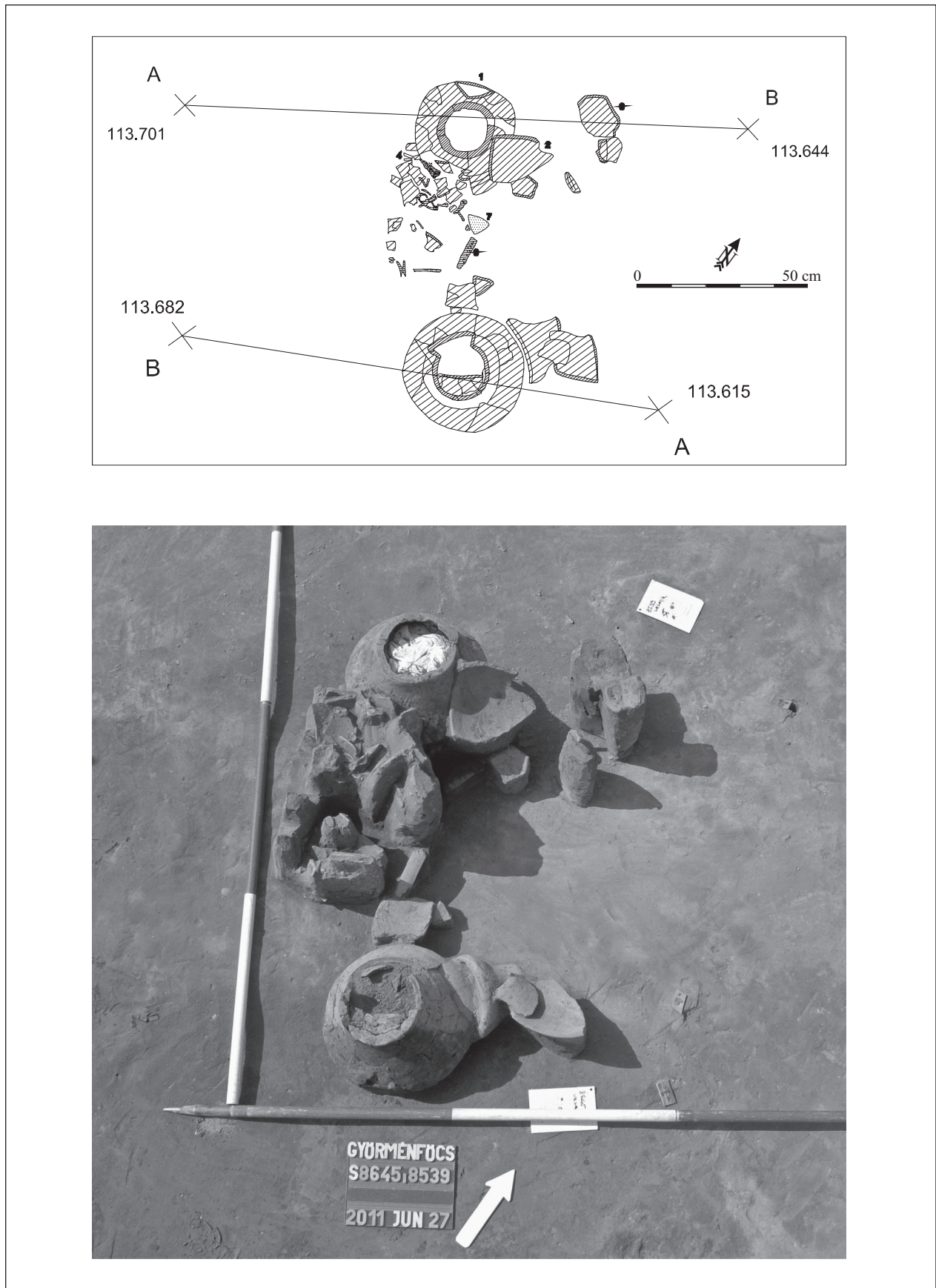


Plate 3. Ménfőcsanak, structure no. 8539/8645.



Plate 4. Ménfőcsanak, pottery from structure no. 8539/8645.

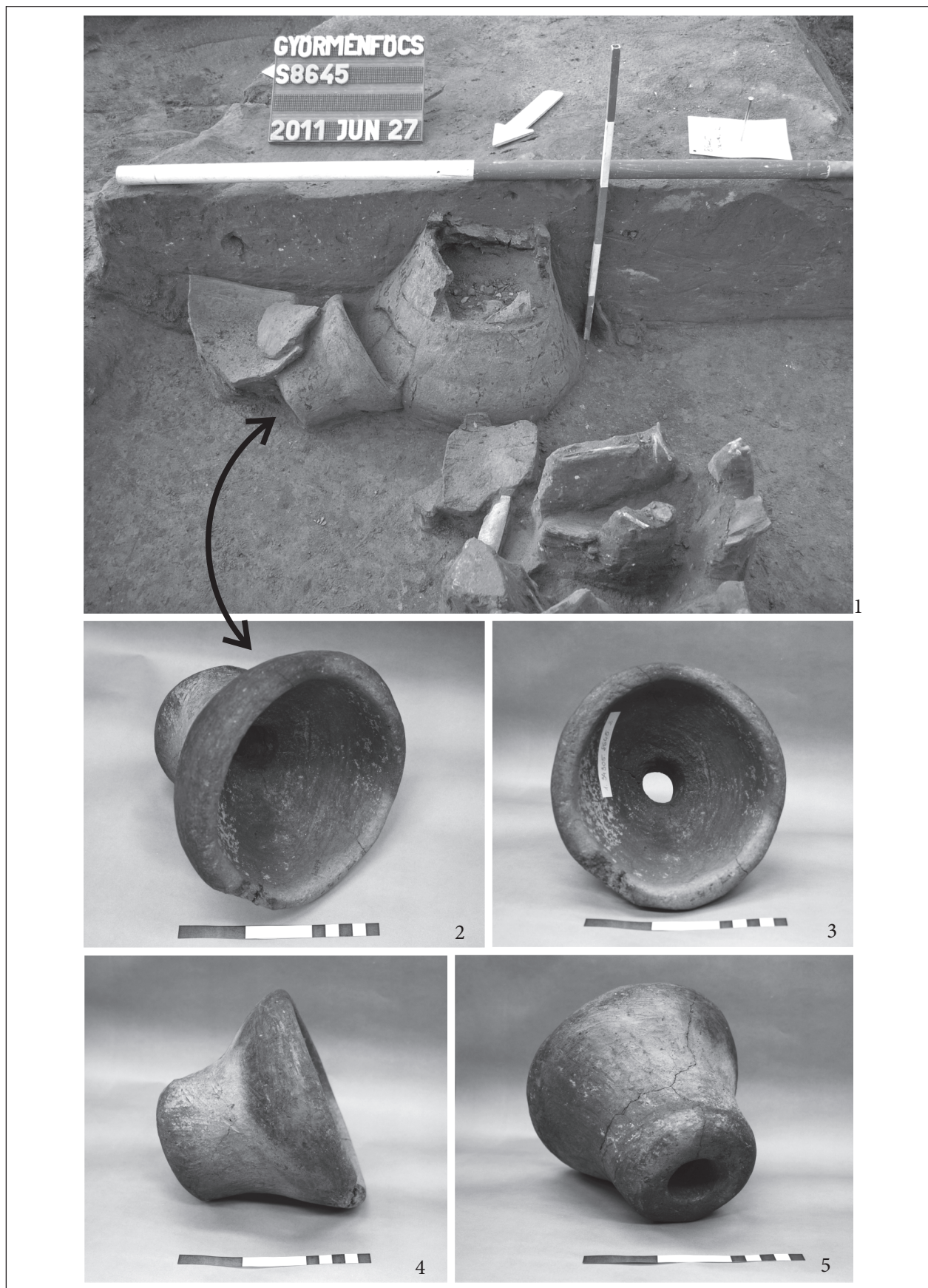


Plate 5. Ménfőcsanak, tuyere from the structure no. 8539/8645.

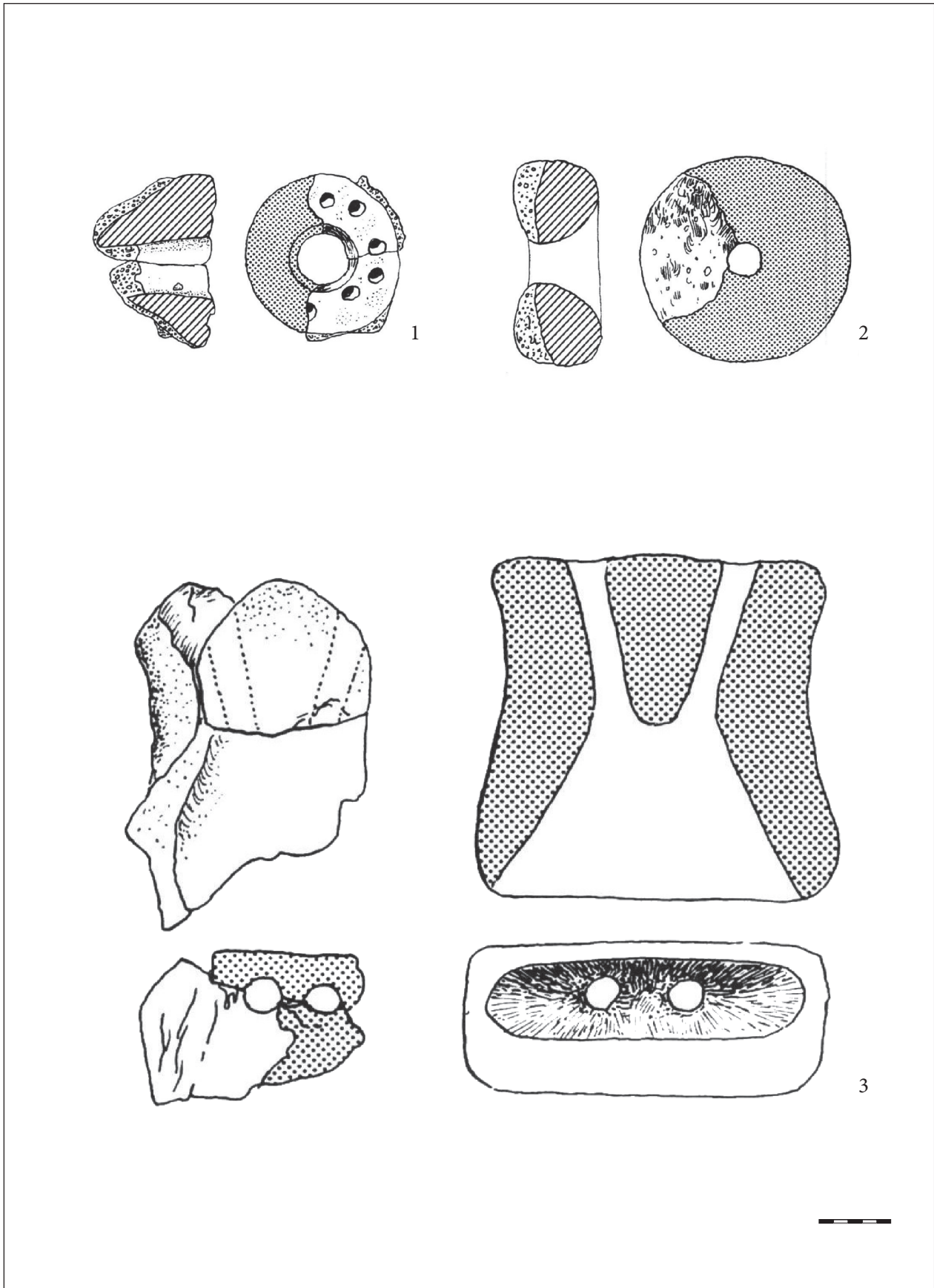


Plate 6. Conical and disc-shape tuyeres (after PLEINER 2000).

1. Bellaires (PELET 1973), 2. Ballyvourney (TYLECOTE 1986, without scale), 3. Bradown (CLEERE 1963).

ABBREVIATIONS

<i>ActaArchHung</i>	Acta Archaeologica Academiae Scientiarum Hungaricae, Budapest
<i>ActaArch</i>	Acta Archeologica, København
<i>ActaB</i>	Acta Bernensia, Bern
<i>ActaIA</i>	Acta Interdisciplinaria Archeologica, Nitra
<i>ActaMB</i>	Acta Musei Brukenthal, Sibiu
<i>ActaMC</i>	Acta Musei Cibalensis, Vinkovci
<i>ActaMM</i>	Acta Musei Moraviae
<i>ActaMN</i>	Acta Musei Napocensis, Cluj-Napoca
<i>ActaMP</i>	Acta Musei Porolissensis, Zalău
<i>AFN</i>	Archäologische Forschungen in Niederösterreich
<i>AFSB</i>	Arbeits- und Forschungsberichte zur Sächsischen Bodendenkmalpflege
<i>AIH</i>	Régészeti Kutatások Magyarországon / Archaeological Investigation in Hungary, Budapest
<i>Alba Regia</i>	Alba Regia, Annales Musei Stephani Regis, Székesfehérvár
<i>AnnalesUV, SAH</i>	Annales d'Université "Valahia" Târgoviște. Section d'Archéologie et d'Histoire
<i>AO</i>	Arhivele Olteniei, Craiova
<i>Apulum</i>	Apulum, Acta Musei Apulensis, Alba Iulia
<i>ArchAd</i>	Archaeologia Adriatica
<i>ArchAustr</i>	Archaeologia Austriaca, Wien
<i>ArchBulg</i>	Archaeologia Bulgarica, Sofia
<i>ArchÉrt</i>	Archaeologiai Értesítő, Budapest
<i>ArchHung</i>	Archaeologia Hungarica, Budapest
<i>ArchKorr</i>	Archäologisches Korrespondenzblatt, Römisch-Germanischen Zentralmuseum in Mainz
<i>ArchPol</i>	Archeologia Polona
<i>ArchRoz</i>	Archeologické Rozhledy, Prague
<i>ArchS</i>	Archäologie in Salzburg
<i>ArchSl</i>	Archeologia Śląska
<i>ArchSlov</i>	Archaeologia Slovaca Monographiae Studia, Nitra
<i>ArhPregl</i>	Arheološki Pregled, Arheološko društvo Jugoslavije
<i>ArhVest</i>	Arheološki vestnik (Acta Archaeologica), Inštitut za arheologijo, Ljubljana
<i>Arrabona</i>	Arrabona, a Győri Múzeum Évkönyve
<i>ASM</i>	Archaeologia Slovaca Monographiae
<i>AVSC</i>	Archeologický výskum v severných Čechách
<i>Banatica</i>	Banatica, Muzeul de istorie al județului Caraș-Severin, Reșița
<i>BAR</i>	British Archaeological Reports, International Series / British Series, Oxford
<i>BayerVorgbl</i>	Bayerische Vorgeschichtsblätter, München
<i>BB</i>	Bibliotheca Brukenthal, Sibiu
<i>BerRGK</i>	Bericht der Römisch-Germanischen Kommission
<i>BFA</i>	Bochumer Forschungen zur ur- und frühgeschichtlichen Archäologie
<i>BIA</i>	Bulletin of the Institute of Archaeology
<i>BJ</i>	Bonner Jahrbücher

<i>BMAK</i>	Biblioteka Muzeum Archeologicznego w Krakowie
<i>BMB</i>	<i>Biblioteca Muzeului Bistrița</i>
<i>BMM</i>	Bibliotheca Mvsei Marisiensis, Seria Archaeologica, Târgu Mureș / Cluj Napoca
<i>BMN</i>	Bibliotheca Mvsei Napocensis, Cluj-Napoca
<i>BMP</i>	Bibliotheca Mvsei Porolissensis, Zalău
<i>BpRég</i>	Budapest Régiségei, Budapest
<i>BT</i>	Bibliotheca Thracologica, București
<i>BTMM</i>	Budapest Történeti Múzeum, Műhely
<i>CAB</i>	Cercetări Arheologice în București
<i>CAJ</i>	Cambridge Archaeological Journal
<i>Carpica</i>	Carpica, Muzeul Județean de Istorie și Artă „Iulian Antonescu”, Bacău
<i>CCA</i>	Cronica Cercetărilor Arheologice din România
<i>ComArchHung</i>	Communicationes Archaeologicae Hungariae, Budapest
<i>Crisia</i>	Crisia, Muzeul Țării Crișurilor, Oradea
<i>CurrA</i>	Current Anthropology
<i>Dacia (N.S.)</i>	Dacia, Recherches et découvertes archéologiques en Roumanie, I–XII (1924–1948), București; Nouvelle série (N. S.), Dacia. Revue d'archéologie et d'histoire ancienne, București
<i>DissPann</i>	Dissertationes Pannonicae, ex Instituto Numismatico et Archaeologico Universitatis de Petro Pázmány nominatae Budapestinensis provenientes, Budapest
<i>DMB</i>	Dissertationes et Monographiae Beograd
<i>ÉC</i>	Études Celtiques, Paris
<i>EJA</i>	European Journal of Archaeology
<i>EphemNap</i>	Ephemeris Napocensis, Cluj–Napoca
<i>FAB</i>	Folia Archaeologica Balkanica, Skopje
<i>FAM</i>	Fontes Archaeologiae Moravicae, Brno
<i>FAS</i>	Fontes Archaeologiae Slovakiae, Bratislava
<i>FBBW</i>	Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg
<i>FolArch</i>	Folia Archeologica, a Magyar Nemzeti Múzeum Évkönyve, Budapest
<i>FÖ</i>	Fundberichte aus Österreich, Wien
<i>Godišnjak</i>	Godišnjak Centra za Balkanološka Ispitivanja Akademije Nauka i Umjetnosti, Bosne i Hercegovine, Sarajevo
<i>Germania</i>	Germania, Frankfurt am Main
<i>Glasnik ZM</i>	<i>Glasnik Zemaljskog Muzeja</i> Bosne i Hercegovine u Sarajevu
<i>HOMÉ</i>	A Herman Ottó Múzeum Évkönyve, Miskolc
<i>IA</i>	Internationale Archäologie, Buch am Erlbach, Espelkamp, Rahden/Westf.
<i>Instrumentum</i>	Instrumentum, Bulletin du Groupe de travail européen sur l'artisanat et les productions manufacturées dans l'Antiquité
<i>IPH</i>	Inventaria Praehistorica Hungariae, Budapest
<i>Istros</i>	Istros, Buletinul Muzeului Brăilei, Brăila
<i>JAA</i>	Journal of Anthropological Archaeology, Amsterdam
<i>Jahrbuch KF</i>	Jahrbuch für Kleinasiatische Forschung
<i>Jahrbuch RGZM</i>	Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz
<i>JahrMV</i>	Jahresschrift für Mitteldeutsche Vorgeschichte, Deutscher Verlag der Wissenschaften for the Landesmuseum für Vorgeschichte (Halle), Berlin
<i>JahrOM</i>	Jahrbuch des Oberösterreichischen Musealvereines, Linz
<i>JAMT</i>	Journal of Archaeological Method and Theory
<i>JAS</i>	Journal of Archaeological Science, London
<i>JNES</i>	Journal of Near Eastern Studies
<i>KEMK</i>	Komárom-Esztergom Megyei Múzeumok Közleményei

<i>KTÈMA</i>	KTÈMA, Civilisations de l'Orient, de la Grèce et de Rome Antiques, Université de Strasbourg
<i>Marisia</i>	Marisia (V-), Studii și Materiale, Târgu Mureș
<i>MatANH</i>	Materiały Archeologiczne Nowej Huty
<i>MatArch</i>	Materiały Archeologiczne, Kraków
<i>MatBV</i>	Materialien zur Bayerischen Vorgeschichte
<i>MatStar</i>	Materiały Starożytne (i Wczesnośredniowieczne)
<i>MFMÉ</i>	A Móra Ferenc Múzeum Évkönyve, Szeged
<i>MHB</i>	Monumenta Historica Budapestiensia, Budapest
<i>MIA</i>	Monographiae Instituti Archaeologici, Zagreb
<i>MittAGW</i>	Mitteilungen der Anthropologischen Gesellschaft Wien
<i>MittAIUAW</i>	Mitteilungen des Archäologischen Instituts der Ungarischen Akademie der Wissenschaften, Budapest
<i>MittÖAUF</i>	Mitteilungen der Österreichischen Arbeitsgemeinschaft für Ur- und Frühgeschichte
<i>MittÖNG</i>	Mitteilungen der Österreichischen Numismatischen Gesellschaft
<i>MittPK</i>	Mitteilungen der Prähistorischen Kommission, Vienna
<i>MittRLW</i>	Mitteilungsblatt aus der Vorzeit in Rheinland, Lippe und Westfalen
<i>ΜΩΜΟΣ</i>	ΜΩΜΟΣ, Óskoros Kutatók Összejövetelének konferenciakötete
<i>MSVF</i>	Marburger Studien zur Vor- und Frühgeschichte, Marburg
<i>MVFBW</i>	Materialhefte zur Vor- und Frühgeschichte in Baden-Württemberg, Stuttgart
<i>NAFN</i>	Neue Ausgrabungen und Forschungen in Niedersachsen
<i>OJA</i>	Oxford Journal of Archaeology
<i>OpArch</i>	Opuscula Archaeologica, Arheološki zavod, Filozofski fakultet u Zagrebu
<i>OZ</i>	Osječki Zbornik, Osijek
<i>Ősrégészeti levelek</i>	Ősrégészeti levelek / Prehistoric newsletter, Budapest
<i>PamArch</i>	Památky Archeologické, Praha
<i>PAS</i>	Prähistorische Archäologie in Südosteuropa, Berlin, Kiel, München
<i>Peuce</i>	Peuce, Studii și cercetări de istorie și arheologie, Institutul de Cercetări Eco-Muzeale Tulcea, Institutul de Istorie și Arheologie, Tulcea
<i>PPS</i>	Proceedings of the Prehistoric Society, London
<i>Prilozi IAZ</i>	Prilozi Instituta za arheologiju iz Zagreba
<i>PrzArch</i>	Przegląd Archeologiczny, Instytut Archeologii i Etnologii Polskiej Akademii Nauk
<i>RACF</i>	<i>Revue archéologique du Centre de la France</i> , Tours
<i>RadMV</i>	Rad Muzeja Vojvodine
<i>RégFüz</i>	Régészeti Füzetek, Budapest
<i>RGZM</i>	Römisch-Germanisches Zentralmuseum, Monographien, Bonn / Mainz
<i>RVM</i>	Rad vojvođanskih muzeja
<i>Sargetia</i>	Sargetia, Buletinul Muzeului județului Hunedoara, Acta Musei Devensis, Deva
<i>Savaria</i>	Savaria, a Vas Megyei Múzeumok Értésítője, Szombathely
<i>SCIV(A)</i>	Studii și Cercetări de Istorie Veche (și Arheologie 1974-), București
<i>SHN</i>	Studia Historica Nitriensia
<i>SlovArch</i>	Slovenská Archeológia, Nitra
<i>SMK</i>	Somogyi Múzeumok Közleményei, Kaposvár
<i>SNMP</i>	Sborník Národního muzea v Praze, řada A – Historie / Acta Musei Nationalis Pragae, Series A – Historia, Praha
<i>SprArch</i>	Sprawozdania Archeologiczne, Kraków
<i>SSA</i>	Śląskie Sprawozdania Archeologiczne, Instytut Archeologii Uniwersytetu Wrocławskiego
<i>SSUUB</i>	Schriften des Seminars für Urgeschichte der Universität Bern
<i>Starinar</i>	Starinar, Arheološki institut, Beograd
<i>StCom Satu Mare</i>	Studii și Comunicări Satu Mare

<i>StudiaAA</i>	Studia Antiqua et Archaeologica, Iași
<i>StudiaArch</i>	Studia Archeologiczne
<i>Studia Hercynia</i>	Studia Hercynia, Praha
<i>Studia UBB</i>	Studia Universitatis Babeș-Bolyai, series Historia, Cluj-Napoca
<i>Študijne zvesti</i>	Študijne zvesti, Archeologického Ústavu Slovenskej Akadémie Vied, Nitra
<i>TAT</i>	Tübinger Archäologische Taschenbücher
<i>Thraco-Dacica</i>	Thraco-Dacica, Institutul de Tracologie, București
<i>TübSchr</i>	Tübinger Schriften zur Ur- und Frühgeschichtlichen Archäologie, Münster
<i>UPA</i>	Universitätsforschungen zur prähistorischen Archäologie, Bonn
<i>VAMZ</i>	Vjesnik Arheološkog muzeja u Zagrebu
<i>VHAD</i>	Vjesnik Hrvatskog arheološkog društva, Zagreb
<i>WA</i>	<i>Wiadomości Archeologiczne</i> , Państwowe Muzeum Archeologiczne, Warsaw
<i>WAB</i>	Wissenschaftliche Arbeiten aus Burgenland
<i>WArch</i>	World Archaeology, Oxford, Oxbow
<i>WissSchrN</i>	Wissenschaftliche Schriftenreihe Niederösterreich
<i>WMBH</i>	Wissenschaftliche Mitteilungen aus Bosnien und der Herzegowina, Wien
<i>WN</i>	<i>Wiadomości Numizmatyczne</i>
<i>WPZ</i>	Wiener Prähistorische Zeitschrift, Wien
<i>Zbornik Beograd</i>	Zbornik Muzeja primenjene umetnosti Beograd
<i>Zbornik NB</i>	Zbornik narodnog muzeja, Beograd
<i>Zborník SNM</i>	Zborník Slovenského Národného Múzea, Bratislava
<i>ZM</i>	Zalai Múzeum, Közlemények Zala megye múzeumaiból