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Article in *Archaeologia Austriaca* · January 2016

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Local Forms and Regional Distributions. Metallurgical Analysis of Late Bronze Age Objects from Bosnia

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Abstract

This paper discusses the first results of the archaeometallurgical investigation conducted in cooperation between the institutes OREA (Institute for Oriental and European Archaeology, Austrian Academy of Sciences) and VIAS (Vienna Institute for Archaeological Science, University Vienna) and the regional museums in Doboj and Travnik (Bosnia-Herzegovina). The 76 sampled artefacts are dated between the 13th and 9th centuries BC (Ha A1–Ha B3). The spectrum of finds includes forms of supra-regional, regional and local distribution, originating from different contexts (settlements, graves and hoards). After the first analysis of 91 samples (metals and ores) using a scanning electron microscope (SEM-EDS) at the VIAS, a group of 30 archaeologically and metallurgically significant samples was additionally examined by ED-XRF analysis to determine the trace element concentration of each single artefact. The focus of this research is to determine whether the increase of copper based metal artefacts during the Late Bronze Age was stimulated by the use of local copper ore resources – since they were accessible during this time period – or if a long-range, European distribution network was used to cover the need for raw material. Furthermore, it should be examined whether locally distributed bronzes can be distinguished from supra-regional types, by not only typological differences but also regarding their metallurgical composition.

Keywords

Bosnia, bronze artefacts, exchange networks, metal trade, archaeometallurgical analyses, Late Bronze Age, Hallstatt period.

Zusammenfassung – Lokale Formen und regionale Verteilung. Metallurgische Analysen spätbronzezeitlicher Objekte aus Bosnien

Im vorliegenden Beitrag werden die ersten Ergebnisse archäometallurgischer Untersuchungen vorgestellt, die im Rahmen einer Kooperation zwischen OREA (Institut für Orientalische und Europäische Archäologie), VIAS (Vienna Institute for Archaeological

Science, Universität Wien) und den Regionalmuseen in Doboj und Travnik (Bosnien-Herzegowina) entstanden sind. Die 76 beprobten Objekte datieren in die Zeitspanne zwischen dem 13. und dem 9. Jh. v. Chr. (Ha A1–Ha B3). Das Fundrepertoire umfasst Formen über-regionaler, regionaler und lokaler Verbreitung aus unterschiedlichen Kontexten (Siedlung, Grab und Depot). Nach den ersten Analysen von 91 Proben (Metalle und Erze) mittels Rasterelektronenmikroskopie (SEM-EDS) am VIAS, wurde eine Gruppe von 30 archäologisch und metallurgisch signifikanten Objekten mittels Röntgenfluoreszenzanalyse (ED-XRF) analysiert, um die Konzentration der Spurenelemente jedes einzelnen Artefaktes zu bestimmen. Der Schwerpunkt der Untersuchungen lag auf der Frage, ob der beobachtbare metallurgische Aufschwung während der Spätbronzezeit durch den Abbau der lokalen, damals zugänglichen Kupfererze stimuliert wurde oder ob der Rohmaterialbedarf durch andere – europäische – Versorgungsnetze gedeckt wurde.

Schlüsselbegriffe

Bosnien, Buntmetallgegenstände, Bronze, Austauschnetzwerke, Metallhandel, Archäometallurgie, Spätbronzezeit, Hallstattzeit.

1. Introduction (M. Gavranović, M. Mehofer)

The presented article introduces the preliminary outcome of a research project aimed at the archaeometallurgical and mining archaeological investigation in Bosnia-Herzegovina and the neighbouring regions in the western Balkans.¹

¹ The term western Balkans is used here to describe the western part of the Balkan Peninsula that includes most of Croatia, Bosnia-Herzegovina, Montenegro and Serbia. The frequent political use of the same term for the countries Albania, Macedonia, Montenegro, Serbia, Bosnia-Herzegovina and Croatia is a contemporary bureaucratic euphemism.

Several decades² have passed since the last studies have been carried out in this field, therefore it seems advisable to review and enhance the current state of research regarding the metal exchange networks of the Late Bronze Age in this part of the continent. This attempt will be made with the help of various chemical-analytical and archaeological methods,³ particularly with regard to the possible use of local copper ore deposits; these are mainly found in the Central Bosnian Mountains;⁴ an area where several locations of prehistoric mining activities have been recorded.

The current state of research on this topic is insufficient and, since systematic studies are lacking, conclusions are based more on assumptions rather than on exact scientific results. This deficiency is particularly conspicuous for the advanced stage of the Late Bronze Age (11th–9th century BC) since archaeological evidence points to a significant increase of bronze industry in Bosnia. This manufacture growth included several production centres that apparently operated not only locally, but also regionally.

In total, 76 drill samples of bronze artefacts (13th to 9th centuries BC) and 15 ore samples available at the geological collection of the Travnik museum were taken and processed for further analysis at the VIAS archaeometallurgical laboratory.⁵ Additionally, 20 samples from artefacts, slags and ores found in Bosnia-Herzegovina and Serbia were also taken and analysed at VIAS.

2. Late Bronze Age Metallurgy in Bosnia (M. Gavranović, M. Mehofer)

2.1 A Short Overview of the Previous Archaeometallurgical Research

The last comprehensive overview regarding Bronze Age metallurgy in Bosnia-Herzegovina was made more than 40 years ago at a 1973 symposium dedicated to the history of mining and metallurgy in southeast Europe.⁶ Despite the clear statement by B. Čović about the necessity of advanced geological and chemical analysis in order to gain at least basic information regarding possible ore sources and

ancient casting technology,⁷ almost nothing has been done in this field since then. It is somewhat paradoxical that more work regarding the local Bronze Age metallurgy was accomplished before, rather than after, the stated paper. Two objects from the pile-dwelling site Ripač on the Una River (10th–7th century BC) had already been chemically analysed in 1895.⁸ The bowl shaped ingot contained 44 % Pb, 18 % Cu and 8 % Sn, while ‘metallic grains’ were obviously bronze drops (Cu 81 %, Sn 15 %, Pb 0.2 %). Important to this early research stage is also the discovery of two presumably prehistoric mining shafts in the area of the Central Bosnian Mountains in the upper valley of the Vrbas River (Mračaj and Maškara); items found include grooved stone axes, bone tools, handmade pottery and charcoal.⁹ However, according to F. Katzer, it could not be determined which ore was actually exploited or during which time period, since the geological structure offers several possibilities (siderite, tetrahedrite).¹⁰ Some of the artefacts from these two shafts were eventually published in 1908 by V. Čurčić and dated to the Late Bronze Age.¹¹ This short article was the first attempt to correlate archaeological finds, Bronze Age metallurgy and local ore resources. At the time of publication, emphasis was already being placed on numerous casting mould finds from various Late Bronze Age settlements sites in central and northern Bosnia,¹² as well as on the question of copper ore supply for the flourishing domestic workshops. According to Čurčić, the two described shafts in central Bosnia were likely used for the mining of the copper-antimony ores, which were either cast in the nearby workshops or distributed further before processing.¹³ Since these early studies, the area of the Central Bosnian Mountains (geologically defined as Mid-Bosnian schist mountains) has been frequently cited in numerous archaeological papers as a potential ore source for Bronze Age metallurgy.¹⁴ These presuppositions were supported by geological investigations pointing to certain concentrations of copper ores, gold, silver and tin stone in this area¹⁵ as well as by historical sources that refer to mining during the Roman period and the Middle Ages.¹⁶

7 ČOVIĆ 1999, 57.

8 RADIMSKÝ 1897, 329.

9 KATZER 1905.

10 KATZER 1905, 375.

11 ČURČIĆ 1908, 77.

12 GAVRANOVIĆ 2013, Fig. 2.

13 ČURČIĆ 1908, 90.

14 DURMAN 1983. – ČOVIĆ 1995. – KARAVANIĆ 2006. – GAVRANOVIĆ 2011. – BLEČIĆ-KAVUR, JAŠAREVIĆ 2013.

15 JURKOVIĆ 1958. – HRVATOVIĆ 1999. – RAMOVIĆ 1999. – PALINKAŠ, ŠOŠTARIĆ, PALINKAŠ 2008. – JURKOVIĆ, HRVATOVIĆ 2014.

16 PAŠALIĆ 1954. – BASLER 1999. – BOJANOVSKI 1999.

2 RADIMSKÝ 1897. – KATZER 1905. – ČURČIĆ 1908. – JUNGHANS, SANGMEISTER, SCHRÖDER 1960. – JUNGHANS, SANGMEISTER, SCHRÖDER 1968a, b, c. – JUNGHANS, SANGMEISTER, SCHRÖDER 1974. – ČOVIĆ 1975. – ČOVIĆ 1995.

3 PERNICKA 2014.

4 ČOVIĆ 1995. – RAMOVIĆ 1999.

5 As a starting point for this project, a first journey was made in the fall of 2014 to the Bosnian region, during which the local museums of Doboj and Travnik were visited.

6 ČOVIĆ 1999.

Unfortunately, this promising initial stage of research during the time of the Austrian rule in Bosnia (1878–1914) was not followed by further studies in the later periods, especially with regard to Late Bronze Age finds (Ha A–Ha B). Within the pan-European Project SAM (*Studien zu den Anfängen der Metallurgie*), only three objects of this period from Bosnia were sampled,¹⁷ one axe of the so called ‘Albanian-Dalmatian type’ from the hoard Debelo Brdo I near Sarajevo¹⁸ and two heavy axes from Debelo Brdo (chance find)¹⁹ and the depot Mačkovac in northern Bosnia.²⁰ Results of the trace element analysis revealed that pieces from Debelo Brdo contained respectively 3.5 % and 6.5 % tin, while the find from Mačkovac was made of pure copper (Sn 0.18 %, Pb 0.22 %); this suggests that the artefact should be described as an axe-shaped ingot rather than as a tool or weapon.²¹ Trace element analyses were also performed for the two objects from the Osredak hoard (northwestern Bosnia), which are dated to the end of the Late Bronze Age (Ha B3);²² unfortunately precise specification of the particular finds was not available. Both samples contained 89 % Cu, 1 % Sn and – quite unexpectedly – 10 % Fe. Analysis of the ore samples from the two previously mentioned shafts in central Bosnia, are also worthy of note and are presented almost 100 years after their discovery.²³ The samples were, as previously assumed, identified as a copper-antimony fahlore (tetrahedrite).

Valuable contributions were made for the periods prior to the Late Bronze Age, such as trace element analysis of the Copper and Early Bronze Age objects from Bosnia-Herzegovina and Croatia²⁴ as well as lead isotope analysis of the same samples.²⁵ Considering the possible exploitation of the local copper antimony ores, it is important to underline that all samples from this study with higher antimony concentration also contained silver in notably higher amounts (100 times greater) than the so far known ore samples from Bosnia.²⁶ Even if the chemical composition of the initial ore can be changed significantly in the course of smelting and casting, it is nearly impossible that the silver amount increased to such a high percentage during processing. Finally, lead

isotope analysis revealed that the signature of the analysed Early Bronze Age objects from Bosnia-Herzegovina and Croatia does not match any obtainable data from the identified deposits in Serbia, Bulgaria, Greece or Anatolia.²⁷

2.2 Late Bronze Age Settlements with Metallurgical Activities

Finds of casting moulds, cores, crucibles, ingots and semi-finished objects are usually strong indicators of metallurgical activities within a settlement area. However, such objects do not necessarily signify the existence of permanent workshops, since some of the production locations could also have been of a temporary character. Moreover, most of the casting moulds from Bosnia were discovered in older excavations (before 1945) and therefore are not clearly assigned to the particular structure (house, pit) or layer. Nevertheless, it is striking that, judging by the typo-chronological classification of the manufactured artefacts, the majority of casting locations were not in use until the advanced phase of the Late Bronze Age, i.e. before the stage Ha B1 (11th century BC). Thus, evidence of earlier metallurgical activities (Bz D–Ha A1) is surprisingly rare.²⁸ Similar tendencies of an upsurge of bronze metallurgy in the advanced stages of the Late Bronze Age are also noticed in the neighbouring region of continental Croatia.²⁹

Among the sporadic objects pointing to metallurgical activities during the time of Bz D–Ha A1, the first one to be addressed is a half mould for socketed axes without a loop and with three V-shaped ribs from the Crkvina hilltop near Dobož.³⁰ Fragmented bronze objects and ingots from this period were also discovered in the settlements of Topolovaca Bregovi³¹ and Sječkovno,³² both locations are situated in the plains along the Sava River in the northern part of the country. A symbolic representation of metal processing or craftsmanship from the same time span (13th–12th century BC) is indicated through several apparently non-used tools (small anvils, bronze cores) from the depot Boljanić, – some 15 km east of Dobož – and one further bronze core from the depot Vidovice on the Sava bank.³³ Some of the depots from Bosnia-Herzegovina dated to Ha A1 also contained plane convex ingots,³⁴ which are a frequent component of

17 JUNGHANS, SANGMEISTER, SCHRÖDER 1968a, Nos. 2584, 2587, 2588.

18 ŽERAVICA 1993, Pl. 11/107. – KÖNIG 2004, Pl. 58/1.

19 ŽERAVICA 1993, Pl. 12/124.

20 ŽERAVICA 1993, Pl. 13/127. – KÖNIG 2004, Pl. 49/B/2.

21 ČOVIĆ 1999, 78. – KÖNIG 2004, 98.

22 KNEZ 1958, 258. – KÖNIG 2004, Pls. 59–61.

23 ČOVIĆ 1995, Tab. 4.

24 GOVEDARICA, PERNICKA, RITTERSHOFER 1995.

25 BEGEMANN, SCHMITT-STECKER 2005.

26 BEGEMANN, SCHMITT-STECKER 2005, 59.

27 BEGEMANN, SCHMITT-STECKER 2005, 60.

28 GAVRANOVIĆ 2013, Figs. 1–2.

29 KARAVANIĆ 2009, Figs. 41–44.

30 RADIMSKÝ 1893, 262. – ŽERAVICA 1993, Pl. 32/436.

31 BELIĆ 2010, Pl. 7/1–3.

32 LUDAJIĆ 2010, 136.

33 KÖNIG 2004, 49.

34 KÖNIG 2004, 90.

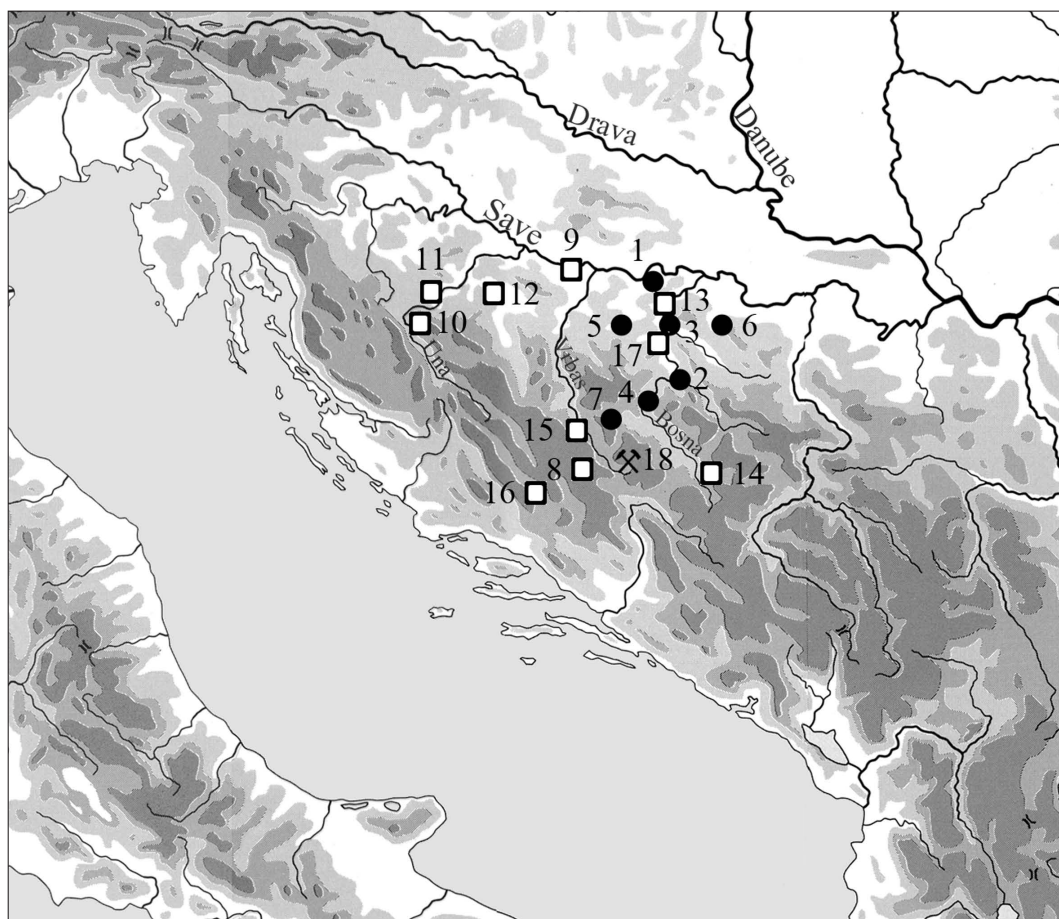


Fig. 1. Map of the Bosnian region (sampled objects derive from sites 1–7 [black dots]). – 1. Kućišta. – 2. Majdan/Ridžali. – 3. Grapska. – 4. Brezovo Polje. – 5. Derventa. – 6. Modriča. – 7. Travnik and settlements with casting mould finds metallurgic activities (squares). – 8. Varvara. – 9. Donja Dolina. – 10. Ripač. – 11. Čungar. – 12. Kekića Glavica. – 13. Pivnica. – 14. Debelo Brdo. – 15. Pod. – 16. Korita. – 17. Crkvina. – 18. Mračaj and Mačkara, two presumably prehistoric mining shafts (Graphics: M. Gavranović).

the hoards from this period in all adjacent territories of southeast Europe.³⁵

The following periods Ha B1 and Ha B2/3 show a fundamentally different situation in which there are far more finds; this indicates a significant increase of metallurgical activities. The hilltop settlement of Varvara in the border zone between Bosnia and Herzegovina (Fig. 1) is one of the most evident sites with emerging bronze production – there are over 30 different casting moulds as well as several cone-shaped cores and crucibles.³⁶ All of these objects were found in 1899 in a layer that was ascribed to the Ha B1 period, af-

ter subsequent excavations.³⁷ The same time span (11th–10th century BC) is also indicated by a typology of the casted objects. However, what is remarkable is the distribution of specific forms cast in Varvara, such as specific sword pommels with bronze analogies among weapons of northern Europe³⁸ or bronze scabbards whose closest parallels are in northern Dalmatia.³⁹ The range of products from Varvara also includes several variants of vase-shaped pins, spearheads with a faceted middle part, chisels, wheel pendants and rings.⁴⁰

35 VINSKI-GASPARINI 1973, 28. – PETRESCU-DÎMBOVIȚA 1977, 80. – VASIĆ 1982, 274. – MOZSOLICS 1985, 37.

36 ČURČIĆ 1902, 99. – ŽERAVICA 1993, Pl. 47/683–692, 707. – KARAVANIĆ 2009, Fig. 46. – GAVRANOVIĆ 2011, Fig. 266.

37 ČOVIĆ 1983, 294.

38 WANZEK 1997, 529.

39 HARDING 1995, 75.

40 GAVRANOVIĆ 2013, Fig. 13.

The same variety of bronze objects has also been produced in the riverbank settlement of Donja Dolina on the Sava River (Fig. 1).⁴¹ Although the exact context is not documented, some of the casted forms are fairly typo-chronologically determinable. One example is the mould for the lunate razor of the type Určice (Ha B3); its main distribution is in the eastern part of central Europe between the Austrian part of Styria, and Moravia and Bohemia.⁴² Another specific object produced in Donja Dolina from the same period (Ha B3) and with similar distribution is the pin with a small, vase-shaped head.⁴³ Cast at the same site are also some bronze forms typical for the area of the western Balkans, like the small undecorated socketed axes with a thickened or fluted mouth.⁴⁴

Intensive casting activity took place at the previously mentioned pile dwelling site Ripač on the Una River in western Bosnia (Fig. 1). Beside ingots and bronze drops, early excavations yielded 17 casting moulds and numerous cores, among these there were three moulds for small undecorated socketed axes with a thick rounded mouth and a low-placed loop.⁴⁵ Axes of this shape are a characteristic regional type for the end of the Late Bronze Age (Ha B3). Corresponding bronze finds have been documented mostly at surrounding sites of western and northwestern Bosnia and Croatia.⁴⁶ Some of the moulds from Ripač were also used for the casting of multiple bars (10 cm long), probably with an ingot function and for small (8 cm) spearheads and triangular and disc-shaped pendants.⁴⁷ Further finds of casting moulds (small undecorated axes, spear heads) and clay cores were identified in the nearby hilltop settlement of Čungar near Cazin.⁴⁸

Another remarkable find is that of two moulds for the two different types of faceted spearheads, found at Pivnica near Odžak in northern Bosnia (Fig. 1).⁴⁹ The moulds were found together with decorated pottery (incised horizontal, undulated and zigzag lines), which is typical for the settlements of the period between Ha B1 and Ha B3 in this area.⁵⁰ The backside of one of the two moulds was also used for the

casting of small, socketed hammers.⁵¹ Bronze finds which correspond with the faceted spearheads are appearing in depots of the 10th and 9th centuries BC in Bosnia-Herzegovina and Croatia. Of particular note are weapons from Ometala in Herzegovina,⁵² Matijevići on the Croatian bank of the Una River,⁵³ as well as from Lučica in central Bosnia.⁵⁴

Multiple casting moulds, bronze ingots and slags were also collected amongst dislocated material from the hilltop settlement of Debelo Brdo near Sarajevo (spearheads, dagger and bars) and Radmanići near Banja Luka (pin with bowl-shaped head).⁵⁵ Repeatedly quoted, but not published or specified, are casting moulds from the settlements of Kekića Glavica in northwestern Bosnia, Korita in southwestern Bosnia, and Pod in central Bosnia; all sites have been dated between the 11th and 9th centuries BC (Fig. 1).⁵⁶

Despite the fact that most of the named settlements were investigated with outdated archaeological methods, it is more than obvious that bronze casting activity in Bosnia gained new momentum from the time of Ha B1, with a number of sites producing both for local requirements as well as for the supra-regional exchange network. Combined with the intensity of production, there is also the appearance of specific, local forms of jewellery and weaponry with limited distribution within one or two neighbouring regions.⁵⁷ However, due to the lack of archaeometallurgical analysis, the technological background of the bronze industry upsurge in the western Balkans remains unknown. Hence, the following presented trace element analysis is the first contribution towards a metallurgical understanding of the bronze objects from Bosnia-Herzegovina, dated to the Late Bronze Age.

3. Cultural and Chronological Background of the Sampled Objects (M. Gavranović, M. Mehofer, A. Jašarević, A. Sejfuli)

The sampled objects (see Fig. 1 for the distribution) are divided in four chronological groups, corresponding to the following stages: Ha A1, Ha A2–Ha B1, Ha B1, and Ha B3 (Tabs. 1–2).⁵⁸ The definition of the intermediate group Ha A2–Ha B1 was necessary because of the hoard from Brezovo Polje that contained a mixture of the typologically older finds such as sickle and long socketed axes with

41 TRUHELKA 1904. – MARIĆ 1964. – ŽERAVICA 1993, Pl. 22/289–292. – GAVRANOVIĆ 2013, Fig. 5.

42 JOCKENHÖVEL 1971, 213. – WEBER 1996, 247.

43 ŘÍHOVSKÝ 1983, 44. – GAVRANOVIĆ 2013, Fig. 6.

44 WANZEK 1989, 166. – ŽERAVICA 1993, Pl. 22/289–292.

45 RADIMSKÝ 1897, Pl. 21/63–69; Pl. 22/76. – ČURČIĆ 1908, Pls. 3/22; 4/13–14. – ŽERAVICA 1993, Pl. 22/284–287.

46 WANZEK 1989, 77. – ŽERAVICA 1993, Pls. 21–23. – KÖNIG 2004, 132. – GAVRANOVIĆ, JAŠAREVIĆ 2016, Map 5.

47 RADIMSKÝ 1897, Pl. 21/68. – ČURČIĆ 1908, Pl. 3/20.

48 ČOVIĆ 1983, 4. – ŽERAVICA 1993, Pl. 46/675–679.

49 BENAC 1967, 155.

50 GAVRANOVIĆ 2011, Fig. 254.

51 ŽERAVICA 1993, Pl. 41/597.

52 KÖNIG 2004, Pl. 67.

53 VINSKI-GASPARINI 1973, Pl. 129.

54 KÖNIG 2004, Pl. 59/A.

55 GAVRANOVIĆ 2013.

56 ČOVIĆ 1983, 75.

57 WANZEK 1989, 72. – GAVRANOVIĆ in press, Figs. 3–7.



Fig. 2. Sampled socketed axe from Kućišta (Inv. no. 1793, Museum Doboj, MA – 152351) (Photo: M. Gavranović, M. Mehofer).

multiple V-ribs with younger objects such as small axes with a winged-like ornament or socketed axes with Y-ribs.⁵⁹ Except for jewellery pieces from the destroyed graves in Travnik (Tab. 2), all other finds were discovered from a singular or collective deposition.

3.1 Ha A1-Group

The first chronological group contains forms typical of the older stage of the Urnfield Culture, with the main occurrence in numerous depots in the adjacent territories of the southern Carpathian Basin. In Bosnia-Herzegovina, depots of this time are found mainly along the Bosna River as a key north–south communication route between the plains of

the Carpathian Basin and the mountain region of the western Balkans.⁶⁰

A typical example of a hoard from this time is that of Kućišta with four sampled objects in the analysed series (Tab. 2). The first one is a socketed axe with a funnel-like mouth and no loop, decorated with two V-ribs hanging on one horizontal rib (Fig. 2).⁶¹ Axes of this type are one of the more significant bronze objects from the Ha A1 period,⁶² analogies have been found in contemporary depots from northern Croatia⁶³ and Serbia,⁶⁴ Hungary,⁶⁵ Transylvania,⁶⁶ and Slovakia.⁶⁷ A similar distribution area can also be identified for the socketed axes with a profiled mouth, which is the second sampled piece from Kućišta.⁶⁸ Comparable finds are known from the nearby Boljanić hoard close to Doboj,⁶⁹ but also from the following depots: Nova Bingula,⁷⁰ Jakovo,⁷¹ Brestovik I, Brestovik V⁷² and Rudnik⁷³ in northern Serbia, Kupinovo⁷⁴ and Poljanci I⁷⁵ in Croatia, Debeli Vrh⁷⁶ in Slovenia, and Palotabozsok and Rinyaszentkirály in southern Hungary.⁷⁷ Another characteristic type of the Ha A1 period from Kućišta, with an almost equal territorial distribution, is the spearhead with short incised lines around the socket.⁷⁸ The closest parallels were, again, found in the neighbouring depots from Croatia, Serbia, Slovenia and Hungary.⁷⁹ The

60 KÖNIG 2004, Pl. 79.

61 Inv. no. 1793 (Museum Doboj), MA-152351; ŽERAVICA 1993, Pl. 32/434 ('Močila Gornja'). – KÖNIG 2004, Pl. 1/15.

62 WANZEK 1989, 115.

63 VINSKI-GASPARINI 1973, Pl. 27/11 (Otok-Privlaka); Pl. 31/8 (Tenja); Pl. 62/7 (Brodski Varoš); Pl. 67/1 (Podcrkavlje); Pl. 78/3 (Budinišćina).

64 VINSKI-GASPARINI 1973, Pl. 84/7 (Bingula Divoš). – POPOVIĆ 1994, Pl. 8/1 (Dobrinci).

65 MOZSOLICS 1985, Pl. 4/24 (Siógrád); Pl. 47/1 (Pécs); Pl. 60/7 (Peterd).

66 PETRESCU-DÎMBOVIȚA 1977, Pl. 194/15 (Spálnaca II); Pl. 149/5 (Gușterița II).

67 NOVOTNÁ 1970, Pl. 37/654–655.

68 Inv. no. 1794 (Museum Doboj), MA-152352; ŽERAVICA 1993, Pl. 25/339 ('Močila Gornja'). – KÖNIG 2004, Pl. 2/17. – For a general distribution see WANZEK 1989, Pl. 28. – HANSEN 1994, Fig. 107.

69 KÖNIG 2004, Pl. 15/19–21.

70 POPOVIĆ 1975, Pl. 34/2.

71 TASIĆ 1975, Pl. 27/13.

72 GARAŠANIN 1975a, Pls. 8/7; 17/1.

73 GARAŠANIN 1975b, Pl. 78/2.

74 BALEN-LETUNIĆ 1988, Pl. 3/6.

75 MIKLIK-LOZUK 2009, 56.

76 ČERČE, ŠINKOVEC 1995, Pl. 95/63.

77 MOZSOLICS 1985, Pls. 70/15; 97/8.

78 Inv. no. 1804 (Museum Doboj), MA-152353; KÖNIG 2004, Pl. 1/11.

79 HANSEN 1994, Fig. 41. – KÖNIG 2004, 73 and Pl. 81. – GAVRANOVIĆ 2011, Fig. 40. – BLEČIĆ-KAVUR, JAŠAREVIĆ 2014, Fig. 7. – VASIĆ 2015, 51.

59 KÖNIG 2004, 92.



Fig. 3. Sampled spear head from Majdan-Ridžali (Inv. no. 5354, Museum Doboj, MA – 152355) (Photo: M. Gavranović, M. Mehofer).

last sampled object from Kučišta is the socketed chisel with a concave blade, decorated with hanging triangle ornamentation under the mouth.⁸⁰ One similar, yet undecorated, piece was found in the mentioned depot Boljanić near Doboj.⁸¹ Other chisels of this type occur mostly in the depots of the

⁸⁰ Inv. no. 1796 (Museum Doboj), MA-152359; ŽERAVICA 1993, Pl. 43/630 ('Močila Gornja'). – KÖNIG 2004, Pl. 2/20.

⁸¹ KÖNIG 2004, Pl. 18/49.

older Urnfield Culture on the southern edge of the Carpathian Basin, in the area between the rivers Drava and Sava.⁸²

Two of the sampled objects from the oldest chronological group were part of the depot Majdan-Ridžali on the middle course of the Bosna River. The grip-tongue sword with a serrated ricasso is ascribed to the specific regional variant of the Reutlingen type⁸³ and is named after the find from Staro Topolje near Slavonski Brod in Croatia.⁸⁴ Other swords of this variant are documented from the depots of the stage Ha A1 in Slavonski Brod II⁸⁵ and Debeli Vrh (Slovenia),⁸⁶ as well as singular finds from Ritiševo near Vršac in Serbian Banat and from Dolina near Nova Gradiška in northern Croatia.⁸⁷ The second analysed object from Majdan-Ridžali is the spearhead with a ribbed, profiled blade (Fig. 3),⁸⁸ which is a widely distributed weapon type within the time span of Bz D–Ha A1.⁸⁹ The best analogies for the sampled piece from Bosnia again derive from the depots in Hungary,⁹⁰ Croatia,⁹¹ and Serbia.⁹²

Added to the chronological group Ha A1 are: one grip-tongue sickle from Brezovo Polje as well as another sickle and one socketed axe from Grapska. Although both depots contained distinctly younger finds, these three objects reveal clear typological features of the older stage of the Urnfield Culture. The sickle from Brezovo Polje⁹³ has three horizontal ribs on the grip, which can be associated with the Uioara 2a type, as defined for the territory of Romania, Austria and Serbia, with numerous parallels in the depots of the Ha A1 period.⁹⁴

The sickle from Grapska⁹⁵ is related to the widespread type Uioara 8. The nearest comparable finds are known from the Ha A1 depots in the adjacent territory of northern

⁸² HANSEN 1994, 151.

⁸³ Inv. no. 5350 (Museum Doboj), MA-152354; BLEČIĆ-KAVUR, JAŠAREVIĆ 2014, Fig. 3; Pl. 1/1.

⁸⁴ HARDING 1995, 38.

⁸⁵ CLAUSING 2003, Fig. 1/1.

⁸⁶ ČERČE, ŠINKOVEC 1995, Pl. 62/23.

⁸⁷ HARDING 1995, 39 and Pl. 13/92, 94.

⁸⁸ Inv. no. 5354 (Museum Doboj), MA-152355; BLEČIĆ-KAVUR, JAŠAREVIĆ 2014, Pl. 1/3.

⁸⁹ HANSEN 1994, 66–67. – VASIĆ 2015, 53.

⁹⁰ MOZSOLICS 1985, Pl. 1/14 (Bükkaranyos I); Pl. 3/9 (Bükkaranyos II).

⁹¹ VINSKI-GASPARINI 1973, Pl. 31/13 (Tenja); Pl. 50/7 (Gornja Vrba); Pl. 67/15 (Podcrkavlje).

⁹² VASIĆ 2015, Pl. 11/154–158; Pl. 12/159–161.

⁹³ Inv. no. 2752 (Museum Travnik), MA-152336; KÖNIG 2004, Pl. 30/20.

⁹⁴ PETRESCU-DÎMBOVIȚA 1978, 54 and Pl. 176/358 (Uioara de Sus). – MOZSOLICS 1985, Pl. 67/1 (Birján); Pl. 88/10 (Bakóca). – PRIMAS 1986, 91. – VASIĆ 1994, 41.

⁹⁵ Inv. no. 1743 (Museum Doboj), MA-152328; KÖNIG 2004, Pl. 77/9.

Serbia.⁹⁶ The socketed axe with a thickened mouth and three V-ribs without a loop from Grapska⁹⁷ is also a characteristic form for the period between the 13th and 11th centuries BC.⁹⁸ Considering the specific decoration and shape, the sampled axe is very similar to the three axes from the depot Motke near Kakanj in central Bosnia, dated to the end of the stage Ha A1.⁹⁹ In the surrounding regions, axes of this type are also known mostly from the depots of the stage Ha A1.¹⁰⁰

3.2 Ha A2/Ha B1-Group

The transition group Ha A2 Ha–B1 includes eight sampled socketed axes from Brezovo Polje with typologically ambiguous attributes and one short spearhead from the same depot. The dating of Brezovo Polje in the younger stage of the Urnfield Culture (Ha B1), as proposed in some earlier studies,¹⁰¹ seems however somewhat disputable, since most of the objects are still displaying traditional typological features of the older periods. The four axes with a thickened or lightly faceted mouth, vertical loop, and three hanging V-ribs are a good example.¹⁰² Axes of very similar shape and decorations are also appearing in the above mentioned depot of the late Ha A1 period from Motke.¹⁰³ Corresponding pieces from neighbouring regions are also dated to the Ha A1 stage.¹⁰⁴ However, one of the four axes from Brezovo Polje¹⁰⁵ lacks two small lateral holes for the fixture of the cores, which is one of the main technical characteristics of almost all socketed axe types from the older Urnfield period.¹⁰⁶ A typologically younger feature on the four sampled axes is the low position of the loop under the mouth; this is

a characteristic technological trait of the socketed axes from a younger (Ha B1) stage and especially of the late stage (Ha B3) of the Urnfield period.¹⁰⁷

The combination of distinctive older and younger typological elements can also be noted for the further three axes from Brezovo Polje with Y-ribs (Fig. 4).¹⁰⁸ The decoration, a slightly trapezoidal shape of the blade and flat edge, certainly indicates a date in Ha B1;¹⁰⁹ however one of the axes (Fig. 4, right) has still two lateral holes, which is, as already stated, an element predominantly characteristic for the axes of the Ha A1 period.

The slender axe from Brezovo Polje with a wing-like ornament and trapezoidal, moderately spreading blade was also sampled.¹¹⁰ Analogies to this piece are documented in the depots of the Ha A1 stage in neighbouring Croatia¹¹¹ and in several Hungarian depots of the Ha A2 stage (Gyermely horizon).¹¹² Axes with the same ornament but with a much wider blade come from Mačkovac on the Bosnian bank of the Sava River¹¹³ and from Kapelna in northern Croatia.¹¹⁴ Both are dated to an even younger period (Ha B1). The chronological uncertainty also concerns the small spearhead¹¹⁵ from Brezovo Polje; it has parallels pointing to both older and younger stages of the Urnfield Culture.

Hence, it is concluded that, according to typological criteria, the ultimate dating of the depot Brezovo Polje to the older or younger Urnfield stages is actually not supported by any convincing arguments. Due to the lack of other, more reliable methods, the proposed date to the intermediate period Ha A2–Ha B1 or in the time between the end of the 12th and first half of the 11th century BC seems most acceptable.¹¹⁶

3.3 Ha B1-Group

Three of the sampled objects are dated to the younger stage of the Urnfield Culture (Ha B1). Rather unusual for Bosnia-Herzegovina and surrounding countries are trapezoidal

96 POPOVIĆ 1975, Pl. 42/8 (Dobrinč). – POPOVIĆ 1994, Pl. 25/1 (Donji Petrovci). – VASIĆ 1994, Nr. 252–280. – JOVANOVIĆ 2010, Pl. 5/18 (Markovac-Grunjac).

97 Inv. no. 1737 (Museum Doboj), MA-152345; KÖNIG 2004, Pl. 37/3.

98 VON BRUNN 1968, 52. – WANZEK 1989, 115. – GAVRANOVIĆ 2011, 130.

99 KÖNIG 2004, Pl. 24/7–8.

100 VINSKI-GASPARINI 1973, Pl. 62/11 (Brodski Varoš). – JACANOVIĆ, RADOJČIĆ 2003, Pl. 1/1 (Šetonje).

101 VINSKI-GASPARINI 1983, 662. – ŽERAVICA 1993, 101–104.

102 Inv. no. 2737 (Museum Travnik), MA-152333; ŽERAVICA 1993, Pl. 28/378. – KÖNIG 2004, Pl. 29/9; Inv. no. 2741 (Museum Travnik), MA-152332; ŽERAVICA 1993, Pl. 28/381. – KÖNIG 2004, Pl. 29/4; Inv. no. 2742 (Museum Travnik), MA-152329; ŽERAVICA 1993, Pl. 28/382. – KÖNIG 2004, Pl. 29/5; Inv. no. 2744 (Museum Travnik), MA-152334; ŽERAVICA 1993, Pl. 28/384. – KÖNIG 2004, Pl. 29/10.

103 KÖNIG 2004, Pl. 25/16.18.

104 VINSKI-GASPARINI 1973, Pl. 73/5 (Mačkovac). – MOSZOLICS 1985, Pl. 70/10 (Palotabozsok); Pl. 97/4 (Rinyaszentkirály); Pl. 107/1 (Lengyelóti); Pl. 111/9 (Szentgáloskér). – BORIĆ 1997, Pl. 5/45 (Futog). – MIKLIK-LOZUK 2000, Pl. 55/21.

105 Inv. no. 2737 (Museum Travnik), MA-152333; ŽERAVICA 1993, Pl. 28/378. – KÖNIG 2004, Pl. 29/9.

106 MAYER 1977, 207. – KÖNIG 2004, 99.

107 KÖNIG 2004, 130.

108 Inv. no. 2747 (Museum Travnik), MA-152330; ŽERAVICA 1993, Pl. 29/386. – KÖNIG 2004, Pl. 30/11; Inv. no. 2749 (Museum Travnik), MA-152228; ŽERAVICA 1993, Pl. 29/387. – KÖNIG 2004, Pl. 30/12; Inv. no. 2750 (Museum Travnik), MA-152331; ŽERAVICA 1993, Pl. 29/388. – KÖNIG 2004, Pl. 30/14.

109 VON BRUNN 1968, 47. – MAYER 1977, 54. – KÖNIG 2004, 101.

110 Inv. no. 2751 (Museum Travnik), MA-152335; ŽERAVICA 1993, Pl. 37/505. – KÖNIG 2004, Pl. 30/17.

111 VINSKI-GASPARINI 1973, Pl. 61/10 (Brodski Varoš). – HARDING 1995, Pl. 62/24 (Slavonski Brod).

112 MOSZOLICS 1985, Pl. 243/23 (Székesfehérvár); Pl. 264/4–5 (Debrecen III).

113 KÖNIG 2004, Pl. 49B/4.

114 VINSKI-GASPARINI 1973, Pl. 110/9.

115 Inv. no. 2754 (Museum Travnik), MA-152337; KÖNIG 2004, 29/1.

116 KÖNIG 2004, 27.



Fig. 4. Sampled socketed axes from Brezovo Polje (A: Inv. no. 2747, MA – 152330 and B: Inv. no. 2750, MA – 152331, both from Museum in Travnik) (Photos: M. Gavranović, M. Mehofer).

socketed axes with horizontal ribs and four hanging V-ornaments, represented through two sampled pieces from Grapska.¹¹⁷ The typologically most equivalent axes are known from the depots of the Horizon Moigrad-Tăuteu (Ha B1) in Transylvania.¹¹⁸

The axe from Derventa in northern Bosnia has a trapezoidal blade, a straight edge, and a combination of horizontal and Y-ribs.¹¹⁹ It represents one of the most significant

bronze types of the Ha B1 stage in the Carpathian Basin and central Europe.¹²⁰ Considering the size, shape and decoration of the sampled piece, the finds which resemble the Derventa axe the most, come from the Bokavić depot some 30 km to the east.¹²¹ Similar axes are, however, also known from more distant places like Jászkarajenő and Debrecen¹²² in Hungary or Zagon¹²³ and Dridu¹²⁴ in Romania.

¹¹⁷ Inv. no. 1738–1739, (Museum Doboj), MA-152343–152344; ŽERAVICA 1993, Pl. 28/375–376. – KÖNIG 2004, Pl. 74/4–5.

¹¹⁸ PETRESCU-DÎMBOVIȚA 1977, Pl. 315/7 (Săcuieni); Pl. 326/3 (Spălnaca I); Pl. 329/10 (Tăuteu).

¹¹⁹ Inv. no. 4605 (Museum Doboj), MA-152356; GAVRANOVIĆ, JAŠAREVIĆ 2016, Fig. 5/1. – The axe was found together with another fragmented axe of the same type and can therefore probably be considered as part of the depot.

¹²⁰ HAMPEL 1886, 11. – VON BRUNN 1968, 47. – NOVOTNÁ 1970, 85. – VINSKI-GASPARINI 1973, 142. – KEMENZEI 1984, 53. – MOZSOLICS 1985, 26. – WANZEK 1989, 106. – ŘÍHOVSKÝ 1992, 206. – KÖNIG 2004, 101. – TARBAY 2014, Fig. 10.

¹²¹ KÖNIG 2004, Pl. 38/29.

¹²² MOZSOLICS 1985, Pls. 250/12; 265/47.

¹²³ PETRESCU-DÎMBOVIȚA 1977, Pl. 338/9.

¹²⁴ ENĂCHIUC 1995, Fig. 1/8.

3.4 Ha B3-Group

Characteristic for the late Urnfield period (Ha B3) is the appearance of the local bronze types with a geographically restricted distribution between the Adriatic coast in the south and the Sava River in the north. The previous, very clear typo-technological affiliation with the Carpathian Basin seems to be almost completely intermittent throughout the course of the 10th century BC. As described in the previous chapter, this period is characterised by the emergence of new production locations in Bosnia-Herzegovina (Varvara, Ripač, and Pivnica).

Eight of the sampled objects are dated to the Ha B3 period (9th century BC). The loop-bow fibula with triangular foot (Fig. 5)¹²⁵ and twisted torques¹²⁶ from the destroyed graves in Klačonica near Travnik in central Bosnia, as well as a fragmented bow fibula, found also in the vicinity of Travnik,¹²⁷ are all regional jewellery types, presumably parts of female burial attire. Both bow fibulae can be assigned to the elaborate Golinjevo type, subdivided into several variants spread throughout the territory of Dalmatia and Bosnia-Herzegovina.¹²⁸ Specific to this fibulae are two, more or less marked, knobs on the bow and the big triangular foot, while typological distinctions can be made mostly on the basis of the different bow profile (round, octagonal, lenticular or flat). The ribbed bow profile, as in the case of the two sampled finds (Fig. 5), is a distinctive feature of the youngest variants from the 10th and 9th centuries BC.¹²⁹ The dating of the fibulae to this time frame is corroborated by the grave finds from the cemetery Jablanica in northeastern Bosnia¹³⁰ and from Gradac-Sokolac in the Glasinac area,¹³¹ as well as by the familiar fibula from the Otok hoard in western Herzegovina.¹³² Oldest among them is Grave 2 from Jablanica with a fully equipped female attire set (torques, bracelets, armband, and pendants) dated to the late 10th century BC, while the other mentioned finds are all typical for the final stage of the Late Bronze Age in the respective territories. Twisted torques with rhombic endings, like the sampled piece from Klačonica, are also a common jewellery type of the Ha B3 stage for the region.¹³³

¹²⁵ Inv. no. 3 (Museum Travnik), MA-52339; GAVRANOVIĆ, SEJFULI 2016, Fig. 1/2.

¹²⁶ Inv. no. 12 (Museum Travnik, MA-152341; GAVRANOVIĆ, SEJFULI 2016, Fig. 1/5.

¹²⁷ Inv. no. unknown (Museum Travnik), MA-52338; GAVRANOVIĆ, SEJFULI 2016, Fig. 5.

¹²⁸ ČOVIĆ 1975, 20. – GLOGOVIĆ 2003, 20. – GAVRANOVIĆ 2013, 177.

¹²⁹ ČOVIĆ 1975, 27.

¹³⁰ GAVRANOVIĆ 2011, Pl. 13/6.

¹³¹ BENAC, ČOVIĆ 1956, Pl. 46/2.

¹³² KÖNIG 2004, Pl. 68/3.

¹³³ RAUNIG 1982, 8. – KÖNIG 2004, 112.

One of the significant bronze types in the western Balkan is that of small socketed axes with a thickened mouth that appear in several local variations.¹³⁴ The sampled objects from Grapska¹³⁵ and from nearby Modriča¹³⁶ both have strongly marked edges between the lateral and front sides, therefore they are best compared with axes from nearby (within a radius of 30 km) depots of the Ha B3 stage in Pašalići and in Tešanj I.¹³⁷

Limited distribution in the same area can also be discerned for the small axes with a thickened, fluted mouth, such as one further sampled axe from Grapska.¹³⁸ The closest analogy is an axe found in the vicinity of Tešanj, some 20 km to the west of Grapska.¹³⁹ Socketed axes with a similar mouth shape but with an additional, wing-like ornament were cast in the settlement of Donja Dolina.¹⁴⁰ So far, without exact parallels, is the last sampled axe from Grapska, which has vertically ribbed sides.¹⁴¹ For this case, measurements are a decisive method for roughly assigning them to the 9th century BC, since axes of this size (8.1 cm) are not documented from Bosnia before the Ha B3 stage.¹⁴²

Among the youngest sampled finds is the lunular razor from Grapska¹⁴³ with a decorated blade (incised hatched triangles with empty zigzag space in the middle). Together with two related razors from the cemetery in Tešanj¹⁴⁴ and one piece from the hilltop settlement Pod,¹⁴⁵ razors of this shape are described as of the Grapska type and dated to the 9th and 8th centuries BC.¹⁴⁶ Especially important for chronological determination is the razor from the long-occupied settlement of Pod; it was found in the layer from the 9th century BC.¹⁴⁷ In Grave 1 from Tešanj the razor was part of a male warrior equipment including a short sword and a socketed axe, both with incised decoration, very similar to

¹³⁴ WANZEK 1989, 199. – ŽERAVICA 1993, 75. – KÖNIG 2004, 132. – GAVRANOVIĆ, JAŠAREVIĆ 2016, Map 5.

¹³⁵ Inv. no. 1736 (Museum Doboj), MA-153346; ŽERAVICA 1993, Pl. 21/272. – KÖNIG 2004, Pl. 77/7.

¹³⁶ Inv. no. 4440 (Museum Doboj), MA-152357; GAVRANOVIĆ, JAŠAREVIĆ 2016, Fig. 6.

¹³⁷ KÖNIG 2004, Pl. 59B/3; 61B/4.

¹³⁸ Inv. no. 1735 (Museum Doboj), MA-152342; ŽERAVICA 1993, Pl. 21/271. – KÖNIG 2004, Pl. 77/8.

¹³⁹ TRUHELKA 1907, 75. – ŽERAVICA 1993, Pl. 21/273.

¹⁴⁰ ŽERAVICA 1993, Pl. 37/504.

¹⁴¹ Inv. no. 1734 (Museum Doboj), MA-152347; ŽERAVICA 1993, Pl. 37/490. – KÖNIG 2004, Pl. 77/6.

¹⁴² ŽERAVICA 1993, Pl. 21.

¹⁴³ Inv. no. 1747 (Museum Doboj), MA-152349; BENAC 1954, 167. – WEBER 1996, Pl. 54/1.

¹⁴⁴ TRUHELKA 1907, 58.

¹⁴⁵ ČOVIĆ 1983, Pl. 56/5.

¹⁴⁶ JOCKENHÖVEL 1971, 214. – WEBER 1996, 249.

¹⁴⁷ ČOVIĆ 1983, 434. – GAVRANOVIĆ 2011, 257.



Fig. 5. Sampled bow fibula from Klaonica (Inv. no. 3, Museum Travnik, MA – 152339) (Photo: M. Gavranović, M. Mehofer).

the sampled razor from Grapska.¹⁴⁸ The same geometrical ornamentation is typical for a number of the local bronze finds from this period, including a prominent bronze scabbard from Veliki Mošunj in central Bosnia and oversized round belt buckles from the depots Ometala and Krehin Gradac in Herzegovina.¹⁴⁹ The incised decorations with the same motifs (hatched triangles, lunular motifs, and zigzag lines) are also characteristic for the ceramics from this period, which are especially well documented in the layers of the previously mentioned settlement of Pod.¹⁵⁰

4. Archaeometallurgical Analyses (M. Gavranović, M. Mehofer)

The archaeometallurgical investigation aims to generate a broad dataset of artefacts from Bosnia-Herzegovina dating to the Late Bronze Age. Although objects dating to the Chalcolithic and Early Bronze Age from the region under study¹⁵¹ and neighbouring territories¹⁵² have already been examined, a comprehensive series of analyses on Late Bronze Age metal artefacts, as known from e.g. Slovenia, Italy or

Bulgaria,¹⁵³ are still missing. By generating a ‘geochemical fingerprint’¹⁵⁴ of the studied metals and ores, and with the help of the above-mentioned database, the project aims to investigate a possible connection between local workshops and copper ore deposits from the region. The main emphasis of this research is on the question whether the increase of metal artefacts detectable within the archaeological record derived directly from the use of local copper ore resources – as they were accessible at this time period – or, if a long-range, European distribution network¹⁵⁵ was used to cover the need for raw materials. Furthermore, it should be examined if locally distributed bronze objects can be distinguished from supra-regional through not only typological differences but also by analysis of metal composition. With metal analyses it should be investigated if this typological and geographically clustered diversity also has a technological, metallurgical background. This would eventually allow for conclusions on different distribution networks.

¹⁴⁸ HARDING 1995, 59. – ŽERAVICA 1993, Pl. 37/502.

¹⁴⁹ KÖNIG 2004, Pl. 63/2; 67/5;

¹⁵⁰ ČOVIĆ 1983, 422. – GAVRANOVIĆ 2011, Fig. 254.

¹⁵¹ ČOVIĆ 1995, 105–107 and Tabs. 1–3.

¹⁵² BEGEMANN, SCHMITT-STECKER 2005.

¹⁵³ JUNGHANS, SANGMEISTER, SCHRÖDER 1968a, c. – STOS-GALE GALE, HOUGHTON, SPEAKMAN 1995. – TRAMPUŽ-OREL 1996. – TRAMPUŽ-OREL 1999. – PERNICKA et al. 1997. – HOOK 2007. – GIUMLIA-MAIR 2009. – JUNG, MEHOFER, PERNICKA 2011. – MEHOFER 2011. – JUNG, MEHOFER 2013a. – JUNG, MEHOFER 2013b. – See PERNICKA et al. 2016 (this volume).

¹⁵⁴ PERNICKA 1999. – PERNICKA 2014.

¹⁵⁵ SPERBER 2004.

4.1 Methods, Sampling Techniques

First, M. Mehofer conducted analyses of major and minor elements at the VIAS laboratory with a scanning electron microscope (SEM-EDS, Zeiss EVO 60 XVP). These investigations permitted an overview of the chemical composition of the sampled objects and, at the same time, provided the basis for a selection of samples intended for trace and lead isotope analysis.¹⁵⁶ A precondition for the applicability of the here presented methods for the determination of the origin of the metals is that the chemical composition as well as the lead isotope composition¹⁵⁷ of the studied metal has not been changed by manufacture processes, e.g. alloying, recycling, melting together with other metals or the addition of lead.

In the first step, 30 samples, characterised by a low lead concentration at or below 1 mass% by the SEM analyses, were selected. These samples were subsequently subjected to a trace element analysis at the Curt-Engelhorn Centre for Archaeometry in Mannheim under the direction of E. Pernicka (see Tab. 2). In general, it is assumed that such low lead concentrations derive from the smelted copper ore¹⁵⁸ and were not alloyed on purpose. It is important to mention at this point that within the 76 sampled artefacts, examples with higher lead concentrations than 1 mass% have also been found. They were not chosen for the first series of analyses as it is not possible to decide in advance whether the increased concentration of lead can be explained by alloying or whether it entered the copper as an impurity from the used copper ore.

4.2 Discussion of the Analytical Results

The following discussion is based on the outcome of the first analyses on 29 artefacts. The analysis results of object Inv. no. 21 from Klačonica are not included because they are influenced by effects of corrosion (Tab. 2, MA-152340). The analyses show that the sampled items are made of tin bronze with a varying tin concentration between 1.57–12.4 %. The lead concentration is, with the exception of three objects,¹⁵⁹ always below 1 mass% (Tab. 2).

For further discussion, the artefacts were divided according to the age determination in order to be able to describe possible tendencies within the metal supply during the different time periods. By way of qualification, it

should, however, be stated that for each group only a relatively small amount of analyses are on hand at this point. For the periods Ha A1 and Ha A2–B1, only 9 analytical results each can be used; for period Ha B1 only three analyses are available; and for period Ha B3 we have 8 samples (Tab. 2). For this reason the here presented conclusions can only be considered as preliminary.

4.3 Tin Concentration

The first step included the evaluation of the tin concentrations in the objects, as well as a determination of their mean and median values. It is possible to see that the items belonging to group Ha A2–B1 have, with 10.1 %, the highest mean value of tin of all investigated artefacts (Tab. 1). The median value of this group is approximately 11.3 %, while the results of the older and younger dated groups vary between 6.0 % and 7.4 %. The artefacts of group Ha B1 have the lowest values, although the validity of these results is limited due to the small amount of investigated objects. Generally, one can observe that the average concentration of tin increases from period Ha A1 towards Ha A2–B1, whereas from phase Ha B1 toward HA B3 it declines again (Tab. 1).

Considering this outcome, there is the impression that, especially during the periods Ha A1 and Ha A2–B1, a relatively good supply of tin or tin ore for bronze production existed. A detailed view of the results of the individual objects, however, displays that the contents of tin within each of the chronological groups differ significantly. A socketed axe from Kučišta (Ha A1), for example, shows only 4.5 % Sn,¹⁶⁰ while another one from the hoard Grapska¹⁶¹ (Ha B1) has an even lower tin concentration of only 1.57 %. A socketed axe from Modriča¹⁶² (Ha B3) also has a very low tin concentration with a value of 3.2 % Sn. These concentrations are too low to have a significant influence on the hardness¹⁶³ of the metal. A considerable increase in hardness¹⁶⁴ could have been achieved only through intensive cold working. It is possible that re-melted bronze, with a decreased concentration of tin due to the repeated addition of copper, was used to produce these artefacts.

The highest concentrations of tin (up to 12.4 % Sn) can be observed within the group Ha A2–B1. The group consists of artefacts originating from the Brezovo Polje hoard. The varying age determinations (Early to Younger Urnfield

¹⁵⁶ LUTZ, PERNICKA 1996. – NIEDERSCHLAG et al. 2003. – PERNICKA 2014, 250–259, 253, Tab. 11.1.

¹⁵⁷ PERNICKA 2014, 255.

¹⁵⁸ PERNICKA 1987, 700. – JUNG, MEHOFER 2013a, 184.

¹⁵⁹ Inv. no. 1739 (socketed axe, Grapska, MA-152344), Inv. no. 2749 (socketed axe, Brezovo Polje, MA-152328) and a bow fibula from Travnik (without Inv. no., MA-152338).

¹⁶⁰ Inv. no. 1794, MA-152351.

¹⁶¹ Inv. no. 1738, MA-152343. – At the same time the socketed axe from Derventa (Inv. no. 4605, MA-152356), dating to the same period, holds a concentration of 12.4 % tin.

¹⁶² Inv. no. 4440, MA-152357.

¹⁶³ NORTHOVER 1989, 114 and Fig. 13.5. – WANG, OTTAWAY 2004.

¹⁶⁴ NORTHOVER 1989, 114 and Fig. 13.5.

Tab. 1. The table presents the mean and median values for the tin and lead concentrations of the artefacts under study. All values are given in mass percent.

Period	Sn (%)	Sn (%)	Pb (%)	Pb (%)
	mean value	median value	mean value	median value
Ha A1 (n=9)	7.3	7.4	0.28	0.25
Ha A2–Ha B1 (n=9)	10.1	11.3	0.45	0.25
Ha B1 (n=3)	6.6	6.0	0.59	0.34
Ha B3 (n=8)	6.8	6.7	0.74	0.51

period) of the individual socketed axes correlates well with the observable varying minor element and trace element concentrations, which for their part also suggests different places or times of production. Even typologically similar classified objects from this hoard – e.g. the socketed axes with V-Ribs¹⁶⁵ – show differences, as their tin concentrations vary between 5.7 % and 12.4 %. Of particular note is the fact that almost all analysed socketed axes from Brezovo Polje have high tin concentrations exceeding 10 % (Tab. 2) which is comparable with a socketed axe from Derventa (Tab. 2, Inv. no. 4605). Although trace element concentrations distinguish them easily from one another, three axes from Brezovo Polje (Inv. no. 2742, 2747, 2750) have a common typological feature with the axe from Derventa – they are all decorated with variations of Y-Ribs, a distinctive ornamentation of socketed axes between Ha A2 and Ha B1.

The widest differences in tin concentrations (1.57–12.4 % Sn) are observable within the Ha B1 group. The metal objects dated to the latest period (Ha B3) show a regular tin concentration below 10 %, nevertheless one socketed axe from Grapska¹⁶⁶ still has a tin concentration of 9.8 %.

Subsequently, these results were combined with the outcome of the analyses conducted by N. Trampuž-Orel on objects from Slovenia. The emphasis of this investigation was placed on the results of the analyses of finished products since the ingots partly show a very high concentration of lead – up to 50.2 mass%,¹⁶⁷ and were not alloyed with tin, which is why they are not directly comparable with the finished products and therefore had to be excluded. The results of the investigation of bronzes from the Slovenian hoards of Čermožiše (Ha A1), Kanalski Vrh I (Ha B1) and Šempeter (Ha B1)¹⁶⁸ show a similar variability in the concentration of tin, fluctuating between 0 % and 20 %. The average tin con-

centration of the artefacts found in the hoard from Šempeter is, e.g. at 4.04 %.¹⁶⁹ A. Giunlia-Mair describes a similar phenomenon for the bronze artefacts found in northeastern Italy,¹⁷⁰ which are dated to the Final Bronze Age.

4.4 Trace Element Analyses

The evaluation of the trace element concentrations revealed further noteworthy insights into metal consumption during the Late Bronze Age. Within the items analysed until now, no objects with a significantly higher antimony or arsenic concentration could be found, so that fahlore can be largely excluded as a primary ore. The copper was probably sourced primarily from the mining regions, which largely mined and smelted chalcopyritic ores.

While the earlier artefacts of the groups Ha A1 and Ha A2–B1 show a relatively broad variance, the objects of groups Ha B1 and Ha B3 seem to have a narrower variance¹⁷¹ between their trace element concentrations (Fig. 6). These groups also contain artefacts with differing typology and function, including socketed axes, fibulae, razors, and torques.

Although it is far too early to draw conclusive results on the provenance of artefacts or the copper used, some interesting observations can be pointed out, regarding the possible foreign origin of some artefacts. As an example, we can mention two typologically almost identical socketed axes of stage Ha B1 from Grapska (Tab. 2, Inv. nos. 1738–1739). Somewhat unexpected is, however, their disparity in tin concentration. Generally speaking, this is a very atypical axe form for the area under study with nearest analogies occurring in Transylvania and northern Hungary. One could only speculate if the technological variance is somehow connected to the different region of origin, or if one or both

¹⁶⁵ See Chapter 2.2 Ha A2/Ha B1-Group.

¹⁶⁶ Inv. no. 1735, MA-152342.

¹⁶⁷ TRAMPUŽ-OREL 1996, 227–229.

¹⁶⁸ TRAMPUŽ-OREL 1996, 213–214, 225–227, 233.

¹⁶⁹ TRAMPUŽ-OREL 1996, 233.

¹⁷⁰ GIUNLIA-MAIR 2009, 152 and Fig. 2.

¹⁷¹ The trace element patterns of the finds within group Ha B1 seem to follow the same model, nevertheless the amount of data, which is based on three analysis results only, is too small to allow further interpretations.

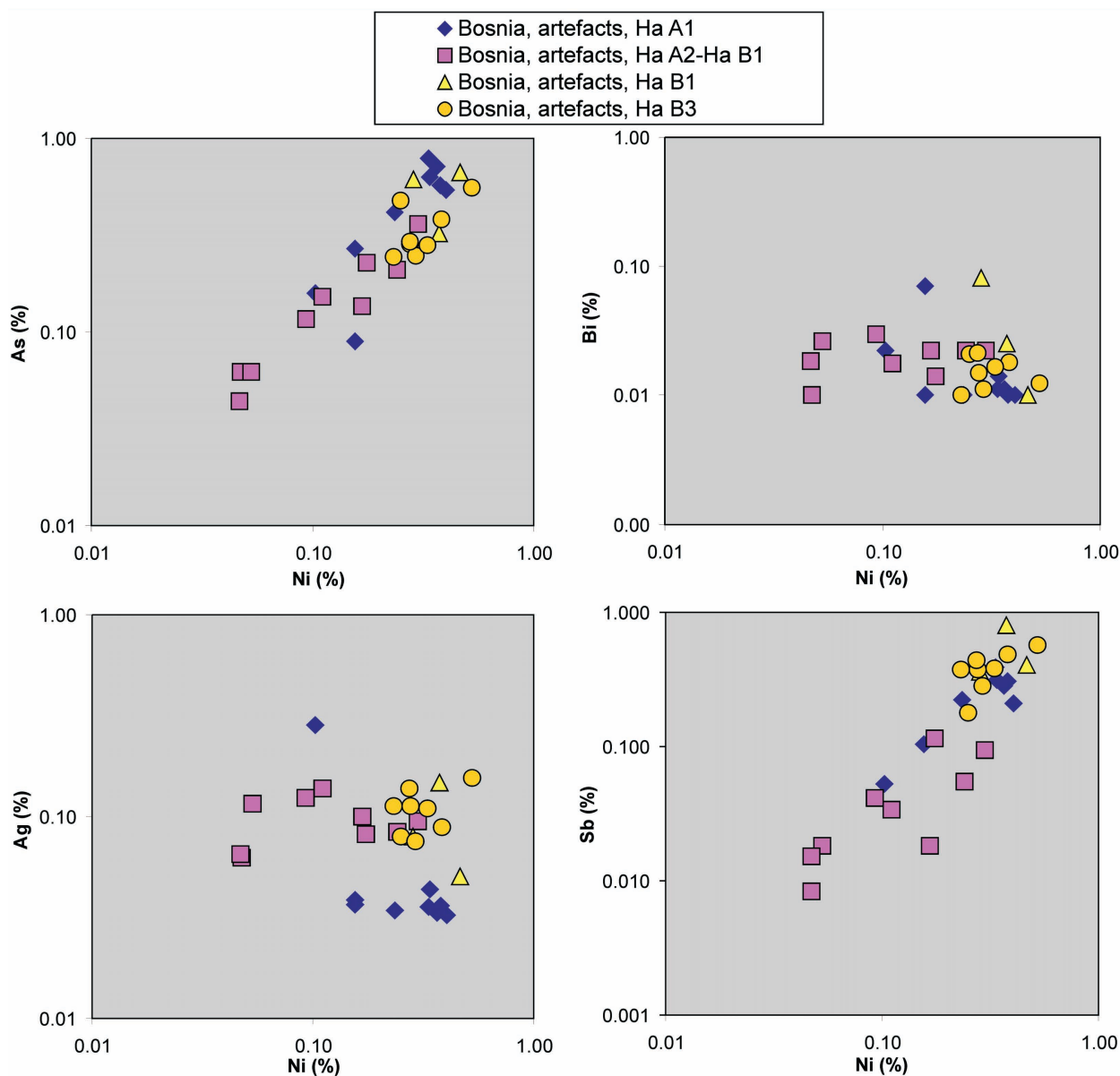


Fig. 6. Concentration of arsenic, silver, nickel, antimony and bismuth in the archaeological artefacts analysed. Note that the results of the finds dating to the stage Ha B3 form a relatively closed group in all diagrams (Graphics: M. Mehofer).

axes were locally produced. However, without supplementary analysis it is hard to provide any kind of reasonable explanation for now.

Additionally, the trace element concentrations were again compared with the ones from the hoards from Čermožiše, Kanalski Vrh I, and Šempeter in Slovenia. The trace element concentrations of the artefacts coming from these hoards have a wider variation range than the objects from Bosnia, with partly remarkable differences. For instance, the concentrations of silver¹⁷² of the finished products com-

ing from Čermožiše (Ha A1) and Kanalski Vrh I (Ha A1) are so low that they were actually beneath the detection limit of the used measuring device (Fig. 7). Only the metal artefacts from Šempeter (Ha B1) show a similar concentration of silver. These observable differences in the concentrations of antimony and especially silver¹⁷³ between the Slovenian

¹⁷² TRAMPUŽ-OREL 1996, 213–214, 225–227, 233.
¹⁷³ Observing the relatively low silver concentrations of the bronze items dating to the Ha A1 period from Bosnia-Herzegovina, it would be enticing, of course, to assume similar copper sources for them and the Slovenian hoards – nevertheless this would be a bit of a stretch at this point of research.

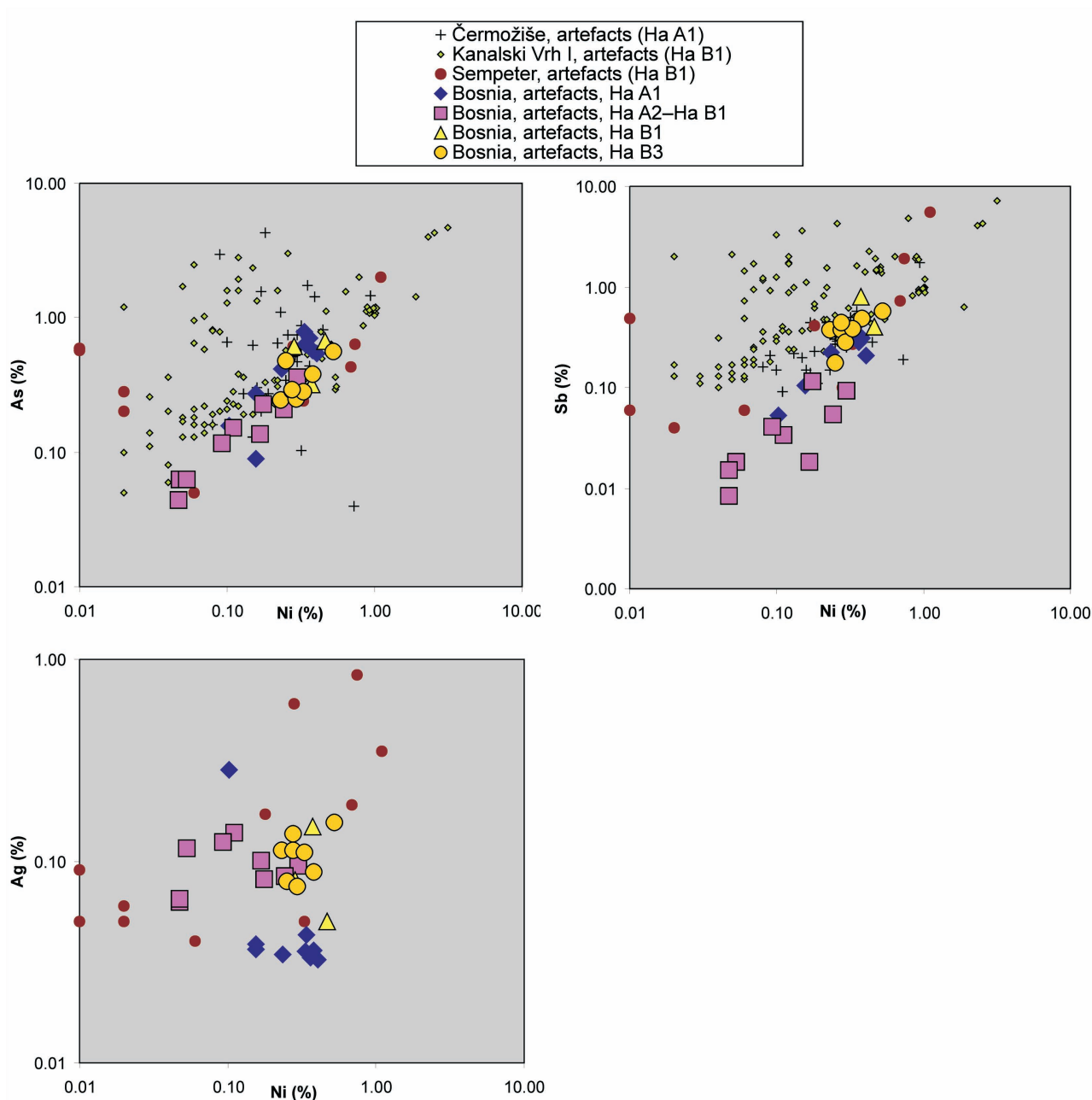


Fig. 7. Concentration of arsenic, silver, nickel and antimony in the analysed objects and in artefacts from Slovenian hoards. It is worth pointing out that in the data set of the Slovenian artefacts the silver and bismuth concentrations were below the detection limit of the used measuring device (TRAMPUŽ-OREL 1996, 213–233) (Graphics: M. Mehofer).

and Bosnian artefacts allow for the hypothesis that their producers were taking part in different metal exchange networks.

5. Conclusions (M. Gavranović, M. Mehofer)

The analyses conducted for the first time on artefacts from Bosnia-Herzegovina provide a first assessment of metal

supply during the Late Bronze Age. With regard to trace element analysis and tin concentration, a few preliminary statements can be made as well. The evaluation of the average tin concentrations shows that the tin supply seems to be sufficient during the stages Ha 1 and Ha A2/Ha B1, whereas in the following period the tin amount decreased. This generally falls into line with the already stated observations that

Tab. 2. Chemical compositions of the analysed artefacts (ED-XRF). All values are given in mass percent. In all samples Zn and Se were below the detection limit of 0.01 % and Cd and Te were below 0.005 %.

Inv. no.	Artefact	Site	Date	Lab. no.	Cu	Sn	Pb	As	Sb	Ag	Ni	Fe	Co	Bi
1737	socketed axe	Grapska	Ha A1	MA-152345	90	8.0	0.32	0.63	0.31	0.043	0.34	<0.05	0.03	0.01
1743	sickle	Grapska	Ha A1	MA-152348	92	7.4	0.15	0.27	0.105	0.039	0.16	0.05	0.06	0.07
1793	socketed axe	Kučišta	Ha A1	MA-152351	92	7.2	0.09	0.09	0.105	0.036	0.16	0.11	0.02	<0.01
1794	socketed axe	Kučišta	Ha A1	MA-152352	94	4.5	0.56	0.42	0.22	0.034	0.24	0.13	0.03	<0.01
1798	chisel	Kučišta	Ha A1	MA-152350	93	4.9	0.34	0.71	0.28	0.033	0.36	0.09	0.10	0.01
1804	spearhead	Kučišta	Ha A1	MA-152353	91	7.8	0.25	0.57	0.31	0.036	0.38	<0.05	0.02	<0.01
2752	sickle	Brezovo Polje	Ha A1	MA-152336	90	9.4	0.12	0.16	0.053	0.284	0.10	<0.05	0.02	0.02
5350	sword	Majdan/Ridžali	Ha A1	MA-152354	92	6.2	0.49	0.79	0.39	0.036	0.34	<0.05	0.02	0.01
5354	spearhead	Majdan/Ridžali	Ha A1	MA-152355	88	10.2	0.17	0.54	0.21	0.030	0.40	0.06	0.04	<0.01
2737	socketed axe	Brezovo Polje	Ha A2–Ha B1	MA-152333	88	11.5	0.06	0.04	0.015	0.065	0.05	<0.05	<0.01	0.02
2741	socketed axe	Brezovo Polje	Ha A2–Ha B1	MA-152332	88	10.8	0.70	0.21	0.054	0.084	0.24	<0.05	0.02	0.02
2742	socketed axe	Brezovo Polje	Ha A2–Ha B1	MA-152329	87	12.4	0.13	0.06	0.008	0.063	0.05	<0.05	<0.01	<0.01
2744	socketed axe	Brezovo Polje	Ha A2–Ha B1	MA-152334	93	5.7	0.41	0.23	0.114	0.082	0.18	0.05	0.02	0.01
2747	socketed axe	Brezovo Polje	Ha A2–Ha B1	MA-152330	87	12.0	0.18	0.36	0.094	0.094	0.30	0.15	0.05	0.02
2749	socketed axe	Brezovo Polje	Ha A2–Ha B1	MA-152328	90	8.0	1.28	0.14	0.018	0.100	0.17	<0.05	0.02	0.02
2750	socketed axe	Brezovo Polje	Ha A2–Ha B1	MA-152331	86	12.4	0.25	0.15	0.034	0.138	0.11	0.63	0.05	0.02
2751	socketed axe	Brezovo Polje	Ha A2–Ha B1	MA-152335	88	11.3	0.23	0.06	0.018	0.116	0.05	0.18	0.02	0.03
2754	spearhead	Brezovo Polje	Ha A2–Ha B1	MA-152337	92	6.9	0.81	0.12	0.041	0.124	0.09	<0.05	0.02	0.03
1738	socketed axe	Grapska	Ha B1	MA-152343	96	1.57	0.34	0.61	0.36	0.080	0.29	0.11	0.18	0.08
1739	socketed axe	Grapska	Ha B1	MA-152344	91	6.0	1.41	0.32	0.80	0.148	0.37	<0.05	0.06	0.02
4605	socketed axe	Kula, Derventa	Ha B1	MA-152356	86	12.4	0.01	0.67	0.40	0.050	0.47	0.12	0.03	<0.01

Tab. 2. continued.

Inv. no.	Artefact	Site	Date	Lab. no.	Cu	Sn	Pb	As	Sb	Ag	Ni	Fe	Co	Bi
3	bow fibula	Klaonica. Travnik	Ha B3	MA-152339	88	8.2	1.99	0.48	0.177	0.080	0.25	0.21	0.16	0.02
21**	belt buckle	Klaonica. Travnik	Ha B3	MA-152340	74	20.7	2.22	1.01	0.88	0.243	0.21	0.77	<0.01	0.05
1734	socketed axe	Grapska	Ha B3	MA-152347	91	7.5	0.19	0.24	0.37	0.113	0.23	0.31	0.06	<0.01
1735	socketed axe	Grapska	Ha B3	MA-152342	89	9.8	0.43	0.25	0.28	0.075	0.29	0.05	0.05	0.01
1736	socketed axe	Grapska	Ha B3	MA-152346	91	7.0	0.52	0.38	0.49	0.088	0.38	<0.05	0.11	0.02
1747	razor	Grapska	Ha B3	MA-152349	92	5.8	0.75	0.28	0.38	0.110	0.33	<0.05	0.06	0.02
4440	socketed axe	Modriča	Ha B3	MA-152357	95	3.2	0.30	0.29	0.44	0.137	0.27	0.08	0.07	0.02
/	neck ring	Klaonica. Travnik	Ha B3	MA-152341	91	6.4	0.49	0.56	0.573	0.156	0.53	<0.05	0.039	0.012
/	bow fibula	Travnik	Ha B3	MA-152338	91	6.1	1.23	0.29	0.38	0.113	0.28	0.05	0.05	0.01

** The results of this artefact are influenced by corrosion processes; therefore they are not included in the text.

with the beginning of the 9th century BC a general shortage of tin¹⁷⁴ can be identified.

It is also worth pointing out that, in terms of chemical composition all eight objects dated to Ha B3 form a close group in the trace element diagrams (Fig. 6). Despite the fact that these eight objects represent functionally and typologically very different items (axes, razors, and jewellery) and come from different sites, the technological aspect behind their production seems to be somehow comparable. The common characteristic of all eight bronze objects is their regional, restricted distribution within the western Balkans. Further analysis (lead isotope analyses) and an expansion of the dataset will certainly reveal whether the chemical resemblance of the eight regional bronze forms of the 9th century BC is just a coincidence or indeed a product of a similar archaeometallurgical background.

Observing the trace element concentrations of all four groups, it could be determined that, due to the low antimony concentrations, chalcopiritic ore was probably used for the manufacturing of the copper. To date, the question remains: from which mining regions was the used copper obtained? In order to enhance the knowledge about the extent of exchange and metal trade, the geological samples from the collection of the Travnik museum were sampled as well.

On the one hand, various fahlores,¹⁷⁵ and on the other hand, chalcopiritic ores were already analysed with SEM-EDS. In the next step, the focus will be placed upon the geochemical characterisation of these ore samples. As a consequence, specific mining regions can be confirmed or eliminated as possible regions of production for the copper used.

Thus, it is to conclude that the next stage of this research project will include not only the localisation of the mining regions from which the used copper came from, but also the enactment of further comparative analyses of copper ores and metals objects from Bosnia-Herzegovina and neighbouring regions.¹⁷⁶ Only then we will be able to gain a more comprehensive insight into the hitherto almost unknown Late Bronze Age metallurgical processes in this part of the European continent.

¹⁷⁵ As mentioned before, e.g. in the region of the village of Mračaj also modern mines on these ores can be found. – KATZER 1905, 374. – ČOVIĆ 1995, 108, 109 and Tab. 4.

¹⁷⁶ This e.g. comprises the famous mines of Bor, Rudna Glava, and Majdanpek in eastern Serbia as well as artefacts found in the neighbouring regions. – JUNGHANS, SANGMEISTER, SCHRÖDER 1968a, b, c. – PERNICKA et al. 1993, 38–50 and Tabs. 8–9. – BEGEMANN, PERNICKA, SCHMITT-STRECKER 1995, 145 and Fig. 1b. – TRAMPUŽ-OREL 1996. – PERNICKA et al. 1997. – BEGEMANN, SCHMITT-STECKER 2005. – See also E. PERNICKA et al. 2016 (this volume).

¹⁷⁴ TRAMPUŽ-OREL 1996, 233. – SPERBER 2004, 335.

Acknowledgements

The idea for the project had been drafted in 2012, when Mario Gavranović was giving an invited lecture at the Vienna Institute for Archaeological Science, University of Vienna. The investigations are carried out within, and gratefully financed by, an ongoing fruitful cooperation between the Institute for Oriental and European Archaeology (OREA), Austrian Academy of Sciences, and the Vienna Institute for Archaeological Science (VIAS), University Vienna. Due to their support, sincere thanks are given to OREA director Barbara Horejs and VIAS director Timothy Taylor.

References

- BALLEN-LETUNIĆ
D. BALEN-LETUNIĆ, Nekoliko ostava iz kasnog brončanog doba na području Srijema, Vijesnik Arheološkog muzeja u Zagrebu 21, 1988, 5–21.
- BASLER 1999
Đ. BASLER, Rudnici i metalurški pogoni rimskog doba u Bosni i Hercegovini (s osobitim osvrtom na pogone u dolini rijeke Japre). In: Radovi sa simpozijuma rudarstvo i metalurgija Bosne i Hercegovine od prahistorije do početka XX vijeka u Zenici 1973. Zenica 1999, 89–118.
- BEGEMANN, PERNICKA, SCHMITT-STRECKER 1995
F. BEGEMANN, E. PERNICKA, S. SCHMITT-STRECKER, Searching for the ore sources of Eneolithic and Early Bronze Age copper artefacts from Serbia. In: P. PETROVIĆ, S. ĐURĐEKANOVIĆ (Eds.), Ancient Mining and Metallurgy in Southeast Europe. Archaeological Institute, Museum of Mining and Metallurgy, Belgrade – Bor 1995, 143–149.
- BEGEMANN, SCHMITT-STRECKER 2005
F. BEGEMANN, S. SCHMITT-STRECKER, Kupfer- und bronzezeitliche Artefakte vom Westbalkan: Zur Frage nach den Quellen ihres Kupfers, Prähistorische Zeitschrift 80, 2005, 49–65.
- BELIĆ 2010
B. BELIĆ, Topolovaca Bregovi kod Odžaka / Topolovaca Bregovi near Odžak, Glasnik Zemaljskog muzeja u Sarajevu 52, 2010, 225–229.
- BENAC 1967
A. BENAC, Kameni kalupi sa Pivnice, Glasnik Zemaljskog muzeja u Sarajevu 17, 1967, 21–40.
- BENAC, ČOVIĆ 1956
A. BENAC, B. ČOVIĆ, Glasinac: Teil I Bronzezeit. Katalog der vorgeschichtlichen Sammlung des Landesmuseums in Sarajevo 1, Sarajevo 1956.
- BLEČIĆ-KAVUR, JAŠAREVIĆ 2013
M. BLEČIĆ-KAVUR, A. JAŠAREVIĆ, Kasnobrončanodobna ostava Majdan/Ridžali, Godišnjak Centra za balkanološka ispitivanja 43, 2013, 35–49.
- BOJANOVSKI 1999
I. BOJANOVSKI, Antičko rudarstvo u Bosni i Hercegovini u svjetlu epigrafskih i numizmatičkih izvora. In: Radovi sa simpozijuma rudarstvo i metalurgija Bosne i Hercegovine od prahistorije do početka XX vijeka u Zenici 1973, Zenica 1999, 133–175.
- BORIĆ 1997
D. BORIĆ, Ostava kasnog brončanog doba iz Futoga, Rad muzeja Vojvodine 39, 1997, 41–93.
- CLAUSING 2003
C. CLAUSING, Ein urnenfelderzeitlicher Hortfund von Slavonki Brod, Kroatien, Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz 50/1, 2003, 47–205.
- ČERČE, ŠINKOVEC 1995
P. ČERČE, I. ŠINKOVEC, Katalog depojev pozne bronaste dobe / Catalogue of Hoards of the Urnfield Culture. In: B. TERŽAN (Ed.), Depojske in posamezne kovinske najdbe bakrene in bronaste dobe na Slovenskem I / Hoards and Individual Metal finds from the Eneolithic and Bronze Ages in Slovenia I. Catalogi et Monographiae 29, Ljubljana 1995, 129–333.
- ČURČIĆ 1902
V. ČURČIĆ, Gradina an der Ramaquelle im Bezirke Prozor, Wissenschaftliche Mitteilungen aus Bosnien und Herzegowina 8, 1902, 48–61.
- ČURČIĆ 1908
V. ČURČIĆ, Prilozi poznavanju prehistorijskog rudarstva i talioničarstva brončanog doba u Bosni i Hercegovini, Glasnik Zemaljskog Muzeja Bosne i Hercegovine 20, 1908, 77–90.
- ČOVIĆ 1975
B. ČOVIĆ, Zwei spezifische Typen der westbalkanischen Bogenfibel, Wissenschaftliche Mitteilungen des Bosnisch-Herzegowinischen Landesmuseums 5, 1975, 19–33.
- ČOVIĆ 1983
B. ČOVIĆ, Srednjobosanska grupa. In: A. BENAC (Ed.), Praistorija Jugoslovenskih Zemalja IV: Bronzano doba. Sarajevo 1983, 433–461.
- ČOVIĆ 1995
B. ČOVIĆ, Mittelbosnische Fahlerzlagerstätten und die spätkupferzeitliche Metallurgie. In: P. PETROVIĆ, S. ĐURĐEKANOVIĆ, B. JOVANOVIĆ (Eds.), Ancient Mining and Metallurgy in Southeast Europe. Archaeological Institute/Museum of Mining and Metallurgy, Belgrade – Bor 1995, 103–110.
- ČOVIĆ 1999
B. ČOVIĆ, Prahistorijsko rudarstvo i metalurgija u Bosni i Hercegovini. Stanje i problemi istraživanja. In: Radovi sa simpozijuma rudarstvo i metalurgija Bosne i Hercegovine od prahistorije do početka XX vijeka u Zenici 1973. Zenica 1999, 57–88.
- DURMAN 1983
A. DURMAN, Metalurgija vučedolskog kompleksa, Opuscula Archaeologica 21, 1983, 7–14.
- ENĂCHIUC 1995
V. ENĂCHIUC, Der Bronzefund von Dridu, Kr. Ialomița. In: T. SOROCEANU (Ed.), Bronzefunde aus Rumänien I. Prähistorische Archäologie in Südosteuropa 10, Berlin 1995, 279–310.
- GARAŠANIN 1975a
Д. ГАРАШАНИН, Остата из Брестовика I–V. In: М. ГАРАШАНИН, Н. ТАСИЋ (Eds.), Праисторијске оставе у Србији и Војводини I, Археолошка грађа Србије. Belgrade 1975, 8–14.
- GARAŠANIN 1975b
Д. ГАРАШАНИН, Остата из Рудника. In: М. ГАРАШАНИН, Н. ТАСИЋ (Eds.), Праисторијске оставе у Србији и Војводини I, Археолошка грађа Србије. Belgrade 1975, 90–93.
- GAVRANOVIĆ 2011
M. GAVRANOVIĆ, Die Spätbronze- und Früheisenzeit in Bosnien. Universitätsforschungen zur prähistorischen Archäologie 195, Bonn 2011.
- GAVRANOVIĆ 2013
M. GAVRANOVIĆ, Urnenfelderzeitliche Gussformen aus dem westlichen Balkan. In: S. BERECKI, R. NEMETH, B. REZI (Eds.), Bronze Age Craftsmen in the Carpathian Basin. Proceedings of the International Colloquium from Târgu Mures (5th–7th October 2012), Târgu Mures 2013, 149–167.

- GAVRANOVIĆ in press
- M. GAVRANOVIĆ, Überregionale Netzwerke und lokale Distribution: Verteilungsmuster einiger Bronzeobjekte im westlichen Balkan während der jüngeren und späten Urnenfelderzeit. In: D. LOŽNJAK DIZDAR, M. DIZDAR, (Eds.), Late Urnfield Culture between the Eastern Alps and the Danube. Proceedings of the International Conference in Zagreb, 7.–8. November 2013. Zagreb in press.
- GAVRANOVIĆ, JAŠAREVIĆ 2016
- M. GAVRANOVIĆ, A. JAŠAREVIĆ, Neue Funde der Spätbronzezeit aus Nordbosnien, *Prilozi Instituta za arheologiju u Zagrebu* 34, 2016, 135–178.
- GAVRANOVIĆ, SEJFULI 2016
- M. GAVRANOVIĆ, A. SEJFULI, Einige bislang unpublizierte Bronzefunde aus dem Laštval in Zentralbosnien, *Godišnjak Centra za balkanološka ispitivanja* 44, 2016, 67–95.
- GIUMLIA-MAIR 2009
- A. GIUMLIA-MAIR, Ancient metallurgical traditions and connections around the Caput Adriae, *Journal of Mining and Metallurgy* 45/2, 2009, 149–163.
- GLOGOVIĆ 2003
- D. GLOGOVIĆ, Fibeln im kroatischen Küstengebiet: (Istrien, Dalmatien). *Prähistorische Bronzefunde XIV/13*, Stuttgart 2003.
- GOVEDARICA, PERNICKA, RITTERSHOFFER 1995
- B. GOVEDARICA, E. PERNICKA, K. F. RITTERSHOFFER, Neue Metallanalysen aus dem Westbalkangebiet. In: P. PETROVIĆ, S. ĐURĐEKANOVIĆ, B. JOVANOVIĆ (Eds.), Ancient Mining and Metallurgy in Southeast Europe. Archaeological Institute, Museum of Mining and Metallurgy, Belgrade – Bor 1995, 265–279.
- HAMPEL 1886
- J. HAMPEL, A bronzekor emlékei Magyarhonban I / Altértümer der Bronzezeit in Ungarn. Budapest 1886.
- HANSEN 1994
- S. HANSEN, Studien zu den Metalldeponierungen während der älteren Urnenfelderzeit zwischen Rhönental und Karpatenbecken. *Universitätsforschungen zur prähistorischen Archäologie* 21, Bonn 1994.
- HARDING 1995
- A. HARDING, Die Schwerter im ehemaligen Jugoslawien. *Prähistorische Bronzefunde IV/14*, Stuttgart 1995.
- HOOKE 2007
- D. HOOKE, The composition and technology of selected Bronze Age and Early Iron Age copper alloy artefacts from Italy. In: A. M. BIETTI SESTIERI, E. MACNAMARA (Eds.), Prehistoric Metal Artefacts from Italy (3500–720 BC) in the British Museum. London 2007, 308–323.
- HRVATOVIĆ 1999
- H. HRVATOVIĆ, Geological guidebook through Bosnia and Herzegovina, *Geološki glasnik* 24, 1999, 203.
- JACANOVIĆ, RADOJČIĆ 2003
- Д. ЈАЦАНОВИЋ, Н. РАДОЈЧИЋ, Праисторијска остата металних предмета из села Шетоње код Петровца на Млави, *Viminacivm* 13–14, 2003, 7–45.
- JOCKENHÖVEL 1971
- A. JOCKENHÖVEL, Die Rasiermesser in Mitteleuropa. *Prähistorische Bronzefunde VIII/1*, Munich 1971.
- JOVANOVIĆ 2010
- D. JOVANOVIĆ, Ostave vršačkog gorja: Markovac-Grunjac. Vršac 2010.
- JUNG, MEHOFER 2013a
- R. JUNG, M. MEHOFER, Mycenaean Greece and Bronze Age Italy: cooperation, trade or war? *Archäologisches Korrespondenzblatt* 43, 2013, 175–193.
- JUNG, MEHOFER 2013b
- R. JUNG, M. MEHOFER, Analisi archeologiche ed archeometriche di una Punta di giavellotto del BR. In: A. CAZZELLA, M. MOSCOLONI, G. RECCHIA, Coppa Nevigata e l'area umida alla foce del Candelaro durante l'età del Bronzo. *Foggia*, 2013, 453–456.
- JUNG, MEHOFER, PERNICKA 2011
- R. JUNG, M. MEHOFER, E. PERNICKA, Metal exchange in Italy from the Middle to the Final Bronze Age (14th–11th cent. BCE). In: P. P. BETANCOURT, S. C. FERRENCE (Eds.), *Metallurgy: Understanding How, Learning Why*. Prehistory Monographs 29, Philadelphia 2011, 231–248.
- JUNGHANS, SANGMEISTER, SCHRÖDER 1960
- S. JUNGHANS, E. SANGMEISTER, M. SCHRÖDER, Metallanalysen kupferzeitlicher und frühbronzezeitlicher Bodenfunde aus Europa. *Studien zu den Anfängen der Metallurgie* 1, Berlin 1960.
- JUNGHANS, SANGMEISTER, SCHRÖDER 1968a
- S. JUNGHANS, E. SANGMEISTER, M. SCHRÖDER, Kupfer und Bronze in der frühen Metallzeit Europas: Die Metallgruppen beim Stand von 12000 Analysen. *Studien zu den Anfängen der Metallurgie* 2/1, Berlin 1968.
- JUNGHANS, SANGMEISTER, SCHRÖDER 1968b
- S. JUNGHANS, E. SANGMEISTER, M. SCHRÖDER, Kupfer und Bronze in der frühen Metallzeit Europas: Tafeln, Tabellen, Diagramme, Karten. *Studien zu den Anfängen der Metallurgie* 2/2, Berlin 1968.
- JUNGHANS, SANGMEISTER, SCHRÖDER 1968c
- S. JUNGHANS, E. SANGMEISTER, M. SCHRÖDER, Kupfer und Bronze in der frühen Metallzeit Europas: Katalog der Analysen Nr. 985 – 10 040. *Studien zu den Anfängen der Metallurgie* 2/3, Berlin 1968.
- JUNGHANS, SANGMEISTER, SCHRÖDER 1974
- S. JUNGHANS, E. SANGMEISTER, M. SCHRÖDER, Kupfer und Bronze in der frühen Metallzeit Europas: Katalog der Analysen Nr. 10 041–22 000 (mit Nachuntersuchungen der Analysen Nr. 1–10 040). *Studien zu den Anfängen der Metallurgie* 2/4, Berlin 1974.
- JURKOVIĆ 1958
- I. JURKOVIĆ, Kasiterit, stamin i molibdenit u rudnoj pojavi Vrtlasce kod Klisca, *Geološki glasnik* 4, 1958, 304–320.
- JURKOVIĆ, HRVATOVIĆ 2014
- I. JURKOVIĆ, H. HRVATOVIĆ, Geochemical characteristics and genesis of Mačje Jame and Vranjski Potok: As-Cu-Iron occurrences west and southwest of the town Busovača, Mid-Bosnian Schist Mountains (MBSM), *Geologia Croatica* 67/2, 2014, 145–161.
- KARAVANIĆ 2006
- S. KARAVANIĆ, Metallverarbeitung und -produktion in der Siedlung Mačkovac-Crišnjevi (Nova Gradiška), *Prilozi Instituta za arheologiju u Zagrebu* 23, 2006, 29–52.
- KARAVANIĆ 2009
- S. KARAVANIĆ, The Urnfield Culture in continental Croatia. *BAR International Series* 2036, Oxford 2009.
- KATZER 1905
- F. KATZER, Über die Quarzporphyre der Vranica planina in Bosnien und über einen Fund von Rillenstein in einem alten Bergbau am Westfuße desselben Gebirges, *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1905, 366–377.

- KEMENZEI 1984
T. KEMENZEI, Die Spätbronzezeit Ungarns. *Archaeologia Hungarica* 51, Budapest 1984.
- KNEZ 1958
T. KNEZ, Das Depot aus Osredak, *Glasnik Zemaljskog muzaj u Sarajevu* 13, 1958, 255–262.
- KÖNIG 2004
P. KÖNIG, Spätbronzezeitliche Hortfunde aus Bosnien und der Herzegowina. *Prähistorische Bronzefunde XX/11*, Stuttgart 2004.
- LUDAJIĆ 2010
N. LUDAJIĆ, Sječakovo, *Glasnik Zemaljskog muzeja u Sarajevu* 52, 2010, 115–139.
- LUTZ, PERNICKA 1996
J. LUTZ, E. PERNICKA, Energy dispersive X-ray fluorescence analysis of ancient copper alloys: empirical values for precision and accuracy, *Archaeometry* 38, 1996, 313–323.
- MARIĆ 1964
Z. MARIĆ, Donja Dolina, *Glasnik Zemaljskog muzeja u Sarajevu* 19, 1964, 5–128.
- MAYER 1977
E. F. MAYER, Die Äxte und Beile in Österreich. *Prähistorische Bronzefunde IX/9*, Stuttgart 1977.
- MEHOFER 2011
M. MEHOFER, Die Kammhelme vom Typ Pass Lueg: Archäologische und archäometallurgische Untersuchungen zur spätbronzezeitlichen Handwerkstechnik. In: A. LIPPERT (Ed.), *Die zweischaligen ostalpinen Kammhelme und verwandte Helmformen der späten Bronze- und frühen Eisenzeit*. *Archäologie in Salzburg* 6, Salzburg 2011, 119–130.
- MIKLIK-LOZUK 2009
L. MIKLIK-LOZUK, Ostave kasnog brončanog doba iz Poljanaca. *Slavonski Brod* 2009.
- MOZSOLICS 1985
A. MOZSOLICS, Bronzefunde aus Ungarn: Depotfundhorizonte Aranyos, Kurd und Gyermely. Budapest 1985.
- NIEDERSCHLAG et al. 2003
E. NIEDERSCHLAG, E. PERNICKA, T. SEIFERT, M. BARTELHEIM, The determination of lead isotope ratios by multiple collector ICP-MS: a case study of Early Bronze Age artefacts and their possible relation with ore deposits of the Erzgebirge, *Archaeometry* 45/1, 2003, 61–100.
- NORTHOVER 1989
J. P. NORTHOVER, Properties and use of arsenic – copper alloys. In: A. HAUPTMANN, E. PERNICKA, G. A. WAGNER, (Eds.), *Old World Archaeometallurgy, Der Anschnitt Beiheft 7*. Veröffentlichungen aus dem Deutschen Bergbau-Museum 44, Bochum 1989, 111–117.
- NOVOTNÁ 1970
M. NOVOTNÁ, Die Äxte und Beile in der Slowakei. *Prähistorische Bronzefunde IX/3*, Munich 1970.
- PALINKAŠ, ŠOŠTARIĆ, PALINKAŠ 2008
L. A. PALINKAŠ, S. B. ŠOŠTARIĆ, S. S. PALINKAŠ, Metallogeny of the northwestern and central Dinarides and southern Tisia, *Ore Geology Reviews* 34/3, 2008, 501–520.
- PAŠALIĆ 1954
E. PAŠALIĆ, O antičkom rudarstvu u Bosni i Hercegovini, *Glasnik Zemaljskog muzeja u Sarajevu* 9, 1954, 52–71.
- PERNICKA 1987
E. PERNICKA, Erzlagerstätten in der Ägäis und ihre Ausbeutung im Altertum. *Geochemische Untersuchungen zur Herkunftsbestimmung archäologischer Metallobjekte*, *Jahrbuch des Römisch-Germanischen Zentralmuseums* 34, 1987, 607–714.
- PERNICKA et al. 1993
E. PERNICKA, F. BEGEMANN, S. SCHMITT-STRECKER, G. A. WAGNER, Eneolithic and Early Bronze Age copper artefacts from the Balkans and their relation to Serbian copper ores, *Prähistorische Zeitschrift* 68, 1993, 1–54.
- PERNICKA et al. 1997
E. PERNICKA, F. BEGEMANN, S. SCHMITT-STRECKER, H. TODOROVA, I. KULEFF, Prehistoric copper in Bulgaria: its composition and provenance, *Eurasia Antiqua* 3, 1997, 41–180.
- PERNICKA 1999
E. PERNICKA, Trace element fingerprinting of ancient copper: a guide to technology or provenance? In: S. M. M. YOUNG, A. M. POLLARD, P. BUDD, R. A. IXER (Eds.), *Metals in Antiquity*. BAR International Series 792, Oxford 1999, 163–171.
- PERNICKA 2014
E. PERNICKA, Provenance determination of archaeological metal objects: short history of provenance analysis of archaeological metal objects. In: B. W. ROBERTS, C. P. THORNTON (Eds.), *Archaeometallurgy in Global Perspective*, New York 2014, 239–268.
- PERNICKA et al. 2016
E. PERNICKA, B. NESSEL, M. MEHOFER, E. SAFTA, Lead isotope analyses of metal objects from the Apa hoard and other Early and Middle Bronze Age items from Romania, *Archaeologia Austriaca* 100, 2016, 57–86.
- PETRESCU-DÎMBOVIȚA 1977
M. PETRESCU-DÎMBOVIȚA, *Depozite de bronzuri din România*. Bucharest 1977.
- PETRESCU-DÎMBOVIȚA 1978
M. PETRESCU-DÎMBOVIȚA, Die Sichel in Rumänien mit Corpus der jung- und spätbronzezeitlichen Horte Rumäniens. *Prähistorische Bronzefunde XVIII/1*, Munich 1978.
- POPOVIĆ 1975
D. POPOVIĆ, Остава из Шимановаца. In: M. ГАРАШАНИН, Н. ТАСИЋ (Eds.), *Праисторијске оставе у Србији и Војводини I*, Археолошка грађа Србије. Belgrade 1975, 43–52.
- POPOVIĆ 1994
D. POPOVIĆ, Остава из Доњих Петроваца. In: M. ГАРАШАНИН, Н. ТАСИЋ (Eds.), *Праисторијске оставе у Србији и Војводини II*, Археолошка грађа Србије. Belgrade 1994, 25–35.
- PRIMAS 1986
M. PRIMAS, Die Sichel in Mitteleuropa I: Österreich, Schweiz, Süddeutschland. *Prähistorische Bronzefunde XVIII/2*, Stuttgart 1986.
- RADIMSKÝ 1893
W. RADIMSKÝ, Die römische Befestigung auf der Crkvenica und das Castrum bei Doboј, *Wissenschaftliche Mitteilungen aus Bosnien und Herzegowina* 1, 1893, 262–273.
- RADIMSKÝ 1897
W. RADIMSKÝ, Der prähistorische Pfahlbau von Ripač bei Bihać, *Wissenschaftliche Mitteilungen aus Bosnien und Herzegowina* 5, 1897, 20–123.
- RAMOVIĆ 1999
M. RAMOVIĆ, Nalazišta ruda zlata, bakra, kalaja, željeza, srebra, olova, žive, antimona i arsena u SR BiH. In: *Radovi sa simpozijuma rudarstvo i metalurgija Bosne i Hercegovine od prahistorije do početka XX vijeka u Zenici* 1973. Zenica 1999, 9–20.
- RAUNIG 1982
B. RAUNIG, Grob ranog željeznog doba iz Ostrožca kod Cazina, *Glasnik Zemaljskog muzeja u Sarajevu* 37, 1982, 2–13.
- ŘÍHOVSKÝ 1983
J. ŘÍHOVSKÝ, Nadeln in Westungarn. *Prähistorische Bronzefunde XIII/10*, Stuttgart 1983.

- ŘÍHOVSKÝ 1992
J. ŘÍHOVSKÝ, Die Äxte, Beile, Meisel und Hammer in Mähren. Prähistorische Bronzefunde IX/17, Stuttgart 1992.
- SPERBER 2004
L. SPERBER, Zur Bedeutung des nördlichen Alpenraumes für die spätbronzezeitliche Kupferversorgung in Mitteleuropa: mit besonderer Berücksichtigung Nordtirols. In: G. WEISGERBER, G. GOLDENBERG (Eds.), Alpenkupfer – Rame delle Alpi, Der Anschnitt Beiheft 17. Veröffentlichungen aus dem Deutschen Bergbau-Museum 122, Bochum 2004, 303–345.
- STOS-GALE, GALE, HOUGHTON, SPEAKMAN 1995
Z. STOS-GALE, N. GALE, J. HOUGHTON, R. SPEAKMAN, Lead isotope data from the Isotrache Laboratory, Oxford: Archaeometry Data Base 1, ores from the western Mediterranean, Archaeometry 37, 1995, 407–415.
- TARBAY 2014
G. TARBAY, Late Bronze Age depot from the foothills of the Pilis Mountains. Dissertationes Archaeologicae ex Instituto Archaeologico Universitatis de Rolando Eötvös Nominatae, Ser. 3. No. 2, Budapest 2014, 179–299.
- TASIĆ 1975
H. ТАСИЋ, Бронзана остава из Јакова – Економија Сава. In: М. ГАРАШАНИН, Н. ТАСИЋ (Eds.), Праисторијске оставе у Србији и Војводини I, Археолошка грађа Србије. Belgrade 1975, 27–34.
- TRAMPUŽ-OREL 1996
N. TRAMPUŽ-OREL, Spektrometrične raziskave depojskih najdbe pozne bronaste dobe / Spectrometric Research of the Late Bronze Age Hoard finds. In: B. TERŽAN (Ed.), Depojске in posamezne kovinske najdbe bakrene in bronaste dobe na Slovenskem II / Hoards and Individual Metal Finds from the Eneolithic and Bronze Ages in Slovenia II. Catalogi et Monographiae 30, Ljubljana 1996, 165–243.
- TRAMPUŽ-OREL 1999
N. TRAMPUŽ-OREL, Archaeometallurgic investigations in Slovenia: a history of research on non-ferrous metals, Arheološki Vestnik 50, 1999, 407–429.
- TRUHELKA 1904
Ć. TRUHELKA, Der vorgeschichtliche Pfahlbau im Savabette bei Donja Dolina (Bezirk Bosnisch - Gradiška), Wissenschaftliche Mitteilungen aus Bosnien und Herzegowina 9, 1904, 3–171.
- TRUHELKA 1907
Ć. TRUHELKA, Prehistorijski nalazi u Bosni i Hercegovini (Nalazi brončane dobi iz Tešnja i okolice), Glasnik Zemaljskog muzeja Bosne i Hercegovin 19, 1907, 62–75.
- VASIĆ 1982
R. VASIĆ, Spätbronzezeitliche und älterhallstattzeitliche Hortfunde im östlichen Jugoslawien. In: B. HÄNSEL (Ed.), Südosteuropa zwischen 1600 und 1000 v. Chr. Prähistorische Archäologie in Südosteuropa 1, Berlin 1982, 267–285.
- VASIĆ 1994
R. VASIĆ, Die Sicheln im Zentralbalkan: (Vojvodina, Serbien, Kosovo und Makedonien). Prähistorische Bronzefunde XVIII/8, Stuttgart 1994.
- VASIĆ 2015
R. VASIĆ, Die Lanzen- und Pfeilspitzen im Zentralbalkan (Vojvodina, Serbien, Kosovo, Mazedonien). Prähistorische Bronzefunde V/8, Stuttgart 2015.
- VON BRUNN 1968
W. A. VON BRUNN, Mitteldeutsche Hortfunde der jüngeren Bronzezeit. Römisch-Germanische Forschungen 29, Berlin 1968.
- VINSKI-GASPARINI 1973
K. VINSKI-GASPARINI, Kultura polja sa žarama u sjevernoj Hrvatskoj. Zadar 1973.
- WANG, OTTAWAY 2004
Q. WANG, B. OTTAWAY, Casting experiments and microstructure of archaeologically relevant bronzes. BAR International Series 1331, Oxford 2004.
- WANZEK 1989
B. WANZEK, Die Gußmodel für Tüllenbeile im südöstlichen Europa. Universitätsforschungen zur prähistorischen Archäologie 2, Bonn 1989.
- WANZEK 1997
B. WANZEK, Nordica im bronzezeitlichen Südosteuropa. In: C. BECKER, M. L. DUNKELMANN, C. METZNER-NEBELSICK, H. PETER-RÖCHER, M. ROEDER, B. TERŽAN (Eds.), Χρόνος, Festschrift für Bernhard Hänsel. Studia Honoria I, Berlin 1997, 527–541.
- WEBER 1996
C. WEBER, Die Rasiermesser in Südosteuropa: (Albanien, Bosnien-Herzegowina, Bulgarien, Griechenland, Kroatien, Mazedonien, Montenegro, Rumänien, Serbien, Slowenien und Ungarn). Prähistorische Bronzefunde VIII/5, Stuttgart 1996.
- ŽERAVICA 1993
Z. ŽERAVICA, Äxte und Beile aus Dalmatien und anderen Teilen Kroatiens, Montenegro, Bosnien und Herzegowina. Prähistorische Bronzefunde IX/18, Stuttgart 1993.

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