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ON THE ORIGIN OF LATE BRONZE AGE SEMI-PRODUCTS FOUND AT CELLDÖMÖLK-SÁGHEGY ACCORDING TO ELECTRON-MIKROPROBE (EPMA) STUDIES

Introduction

After we had finished our researches of geoarchaeological character (CZAJLIK 1993) at the site Velem-Szent Vid-hegy and made investigations on the Late Bronze Age copper raw material supply of the locality (CZAJLIK et al. 1995) we extended our raw material studies to another large Late Bronze Age center of Western Transdanubia, that is to Celldömölk-Sághegy. Though there are well-known similarities between these two sites it is necessary to draw attention to some differences, too, appearing also in the metal raw material supply of the sites, namely 1. Neither the basalt cone of the Sághegy nor its environment could supply any raw material for metallurgical processes. Therefore this metallurgical center had to use imported materials, both primary and auxiliary ones. 2. It is well-known that all the hoard-finds of the Sághegy, are younger than all hoards of Velem[1]. It means that there was a chronological difference between the mass production activities of these two sites, a fact, emphasized recently by T. Kemenczei[2].

Raw material analysis of Late Bronze Age semi-products

Regarding the raw material analysis of prehistoric bronzes most archaeologists used to maintain an attitude of reserve. This attitude can be explained partly by the failure of analyses made so far[3], partly by that widely accepted presupposition that a great part of Late Bronze Age objects was produced by re-use therefore they are unsuitable for analyses to identify their raw material. One of the consequences of this presupposition is that a considerably smaller number of analyses were made on Late Bronze Age objects than on earlier ones[4].

Recently, however, raw material investigations, based already on new theorethical principles and made by new methods, are recommencing[5]. Instead of analyzing series of some objects these new investigations concentrate on ingots, lumps, etc. (that is on semi-products). The cause of this practice is the realisation that within the technological process the position of semi-products is nearer to the original raw material than that of any other objects known from the archaeological record. Moreover, together with a better knowledge of prehistoric copper raw material production (GÜNTHER et al. 1994) it became clear that an overwhelming part of semi-products was produced in copper mining centres, that is they could provide us a theorethical basis to connect archaeological sites and copper raw material sources.

Semi-products found at Celldömölk-Sághegy

In the archaeological material of Celldömölk-Sághegy it is the hoard No. II. which contains semi-products and in addition to this hoard there is also a sporadic find.

The hoard No. II. was found at the Sághegy during quarrying basalt in 1932, near the foundations of prehistoric houses. According to its rescuer, J. Lázár, hoard No. II. was situated near the hoard No. I. of Sághegy, at a 1.5 m distance from it. Because of its composition and of the good condition of its items hoard No. II. was not a hoard prepared for re-melting but it was actually a treasure[6]. It is far the richest among the five hoards known from the Sághegy and the only one which contains ingots which here we are interested in. It contains one ingot and 43 fragments of ingots, though in the original (LÁZÁR 1941) and in the later (LÁZÁR 1943) articles published by J. Lázár still one intact piece and 32 fragments can be seen on the photo. The difference can be explained by the different number of minor fragments[7].

Those fragments of semi-products of Sághegy hoard No. II. which can be identified typologically according to their dimensions form well definable groups since part of the objects in question has an even, relatively smooth surface, their material is mostly free from traces of blowholes and regarding both their form and feature they can be compared to similar objects known from Velem-Szent Vid-hegy (MOZSOLICS 1973–74, fig. 9.1, 2, 5, 6, cf; CZAJLIK 1996, 170) (Velem type, fig. 1.1). Those fragments which have a similarly good raw material but at the same time being conspicuously thick, we may put rather into the group of Nyergesújfalu type ingots of larger size (MOZSOLICS 1973–74, fig. 9.8, fig. 10.5, cf; CZAJLIK 1996, 169) (fig. 1.2). Those pieces which have an uneven, extremely scabrous surface and which do not or only scarcely present even the usual plano-convex form of the ingots we classified into a third group, though we do not know their analogies yet (MOZSOLICS 1973–74, fig. 9.9, 10, 11, 12, fig. 10.3, 4, cf; CZAJLIK 1996, 170) (Sághegy type, fig. 1.3). Therefore during our analyses we tried to answer also the following question; whether there was a difference in the composition of those objects which we had chosen for analysis from the three groups.

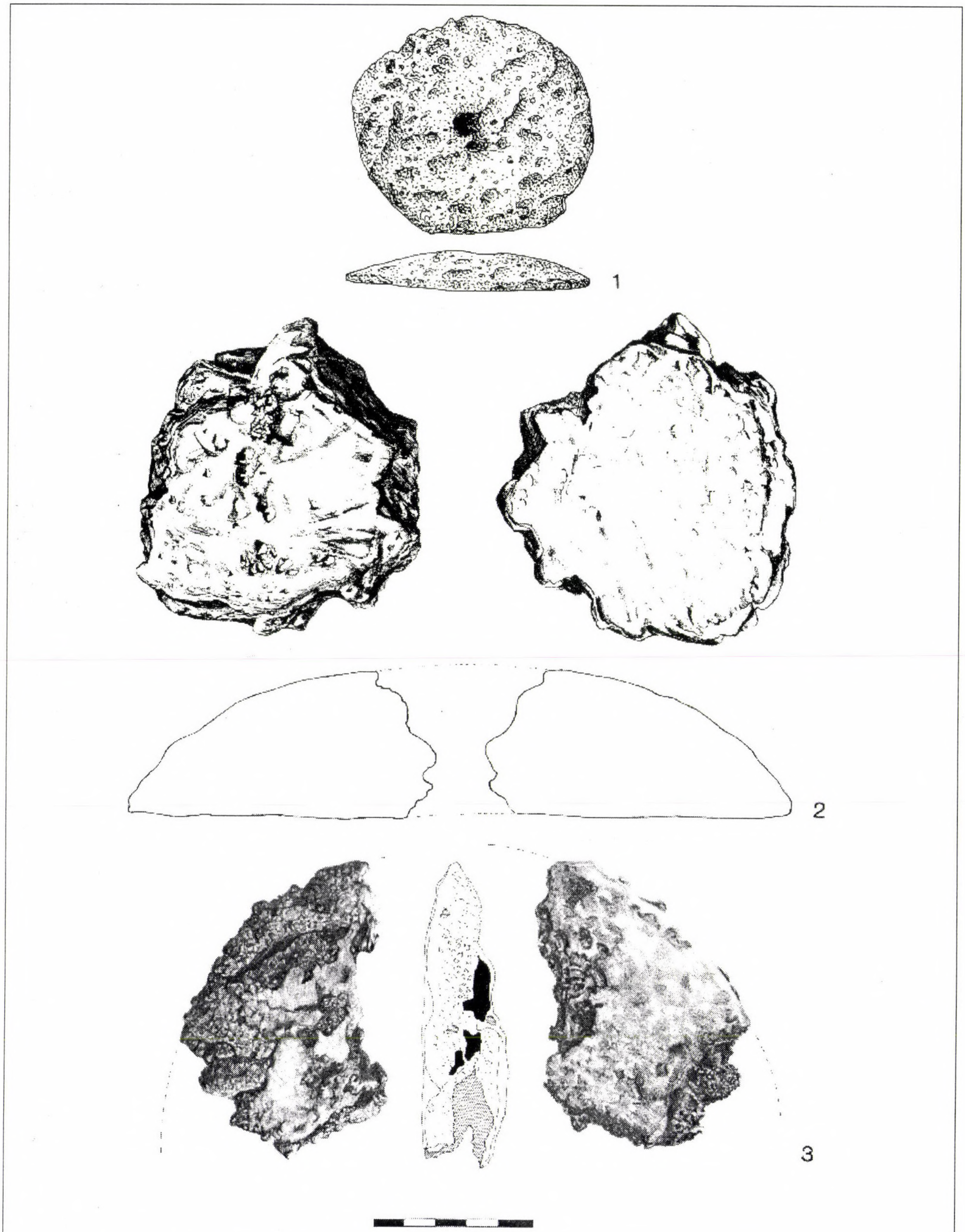

Fig. 1 Ingots of Velem;
1: Nyergesújfalu (reduced); 2: Sághegy; 3: type from the hoard Sághegy II

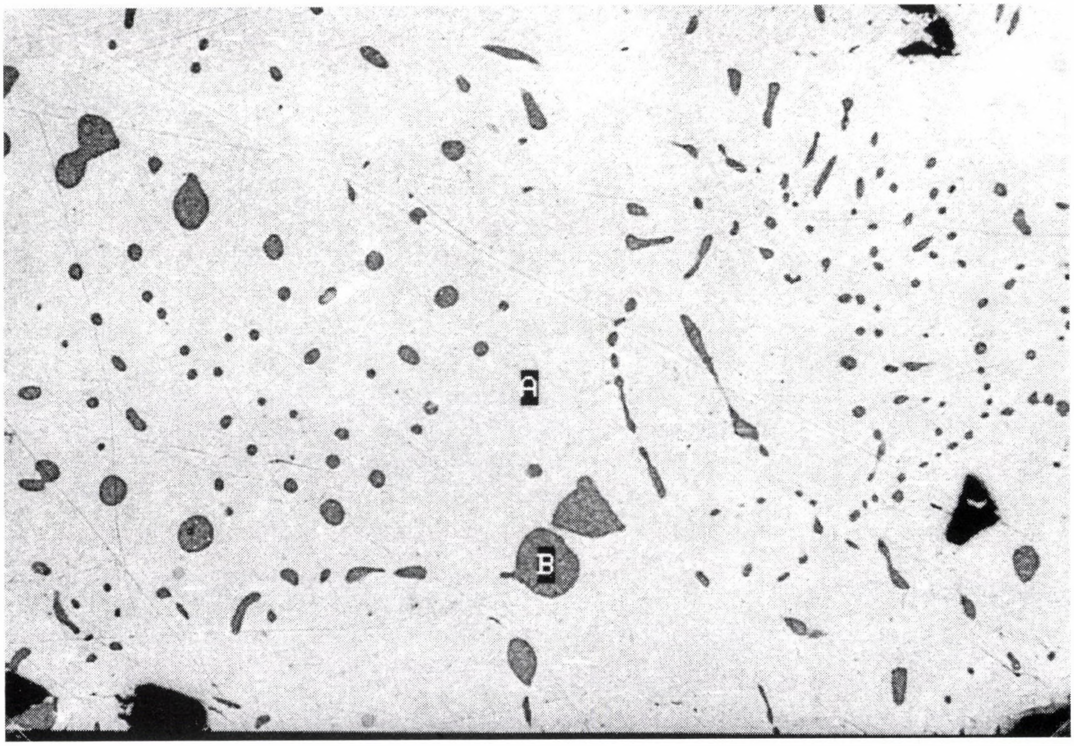

Fig. 2 (photo No. 395)
Inv. No. HNM 25.1949, MOZSOLICS 1973–74, table 9.10, Sághegy type, horizon Románd, HaB2
A=primary material: 100% copper, B=sulphide phase: Cu_2S, CuS

Fig. 3 (photo No. 397)
Inv. No. HNM 25.1949, MOZSOLICS 1973–74, table 9.10, Sághegy type, horizon Románd, HaB2
A=primary material: 100% copper, B=sulphide phase: 62.81% Cu, 1.72% Fe, 35.47% S, D=Pb-Cu inclusion: 28.83% Cu, 71.17% Pb

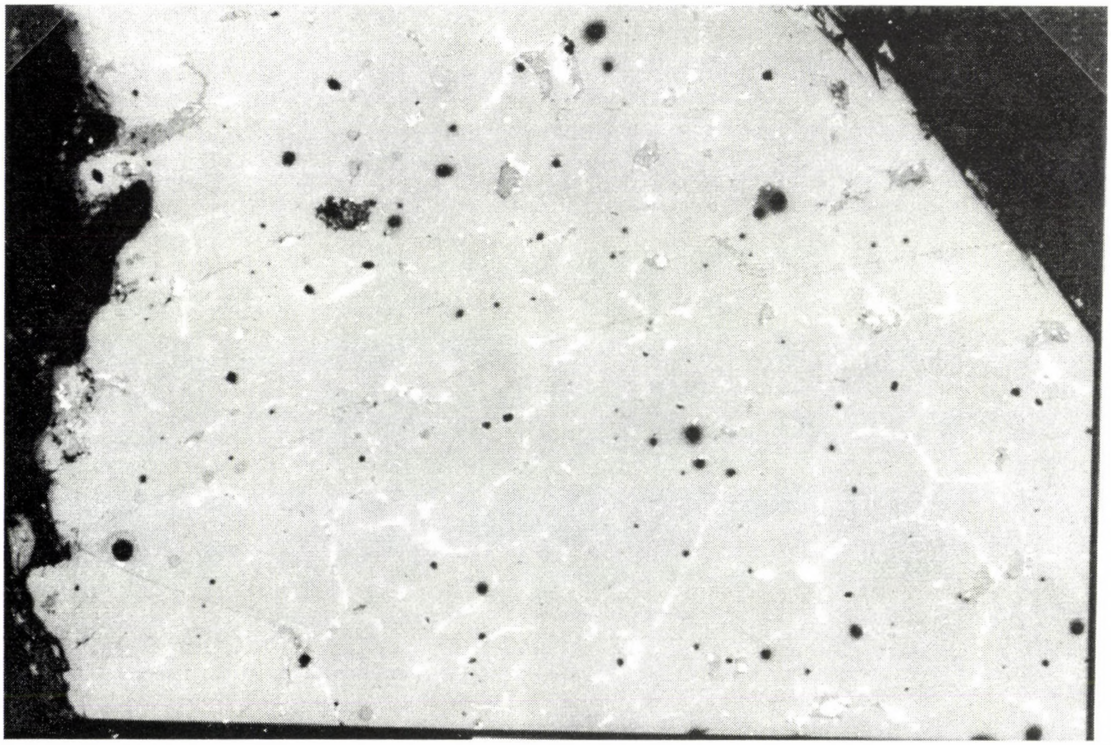

Fig. 4 (photo No. 1513)
Inv. No. HNM 25.1949.48, MOZSOLICS 1973–74, table 9.9, Sághegy type, horizon Románd, HaB2
Primary material: 100% Cu, precipitations: 16.52%, 21.13% Sb, 62.35% Pb

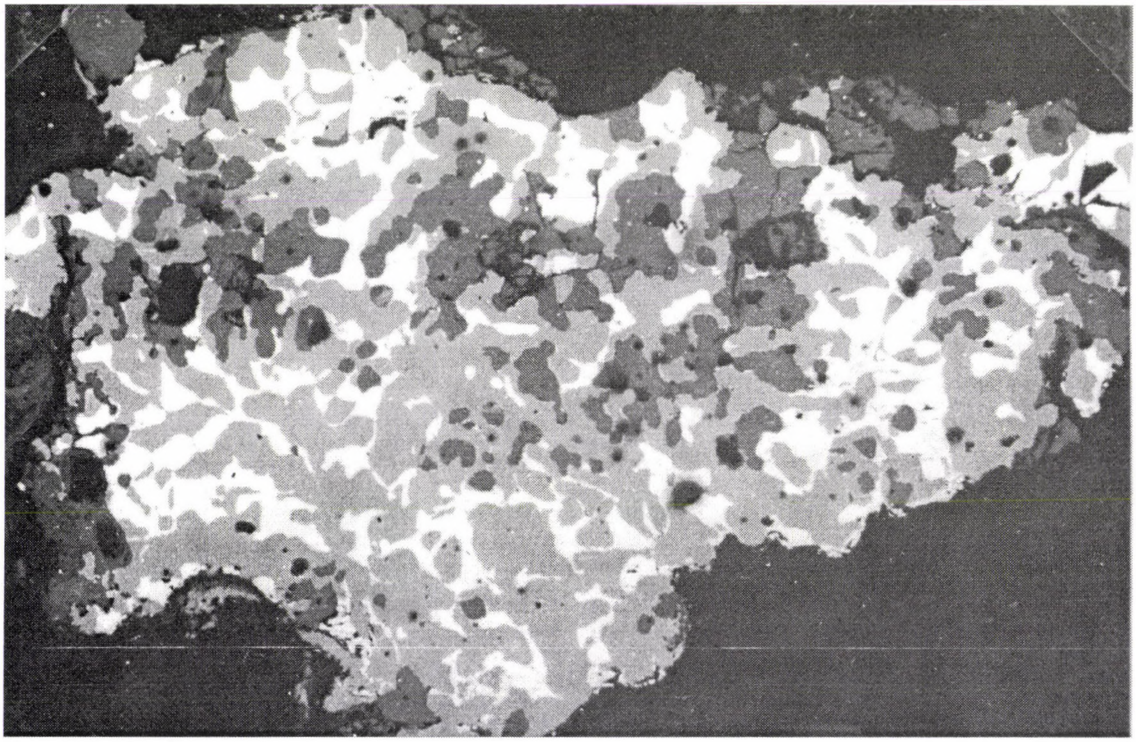

Fig. 5 (photo No. 1499)
Inv. No. HNM 25.1949.47, MOZSOLICS 1973–74, table 10.5, Nyergesújfalu type, horizon Románd, HaB2
Primary material: 93.17% Cu, 2.06% Ni, 0.52% Co, 1.64% As, 2.6% Sb, precipitatons: 58.96% Cu, 1.02% Ag, 9.80% Ni, 2.43% Co, 1.01% As, 21.77% Sb, dark (sulphide) phases: 64.16% Cu, 35.84% S

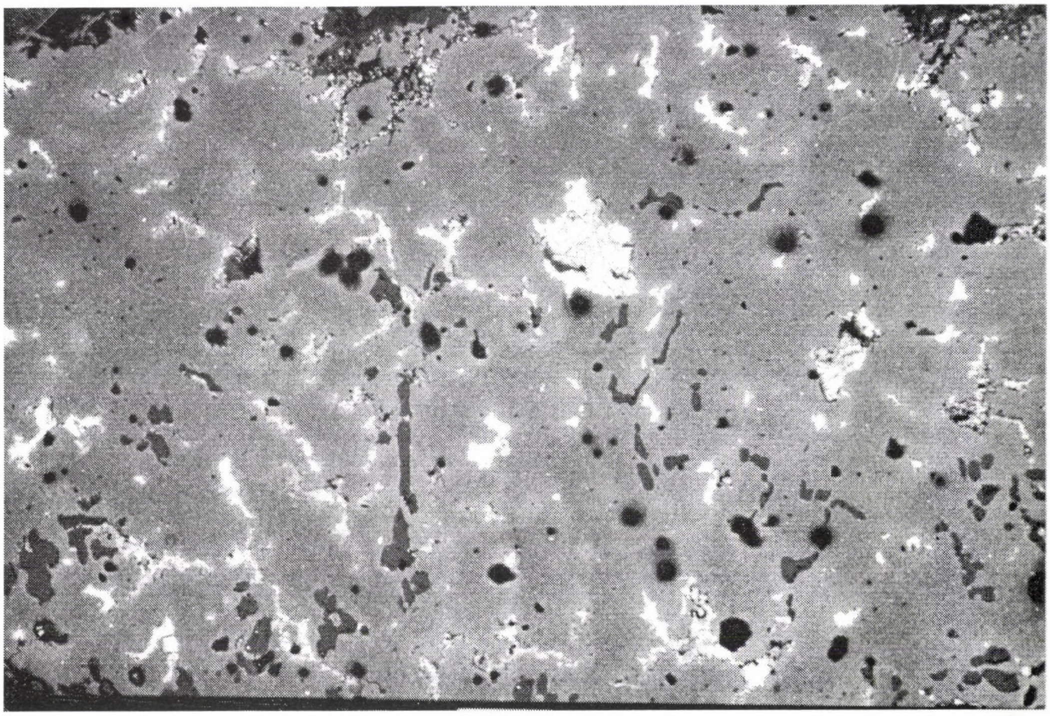

Fig. 6 (photo No. 1508)
Inv. No. HNM 25.1949, MOZSOLICS 1973–74, table 9.8, Nyergesújfalu type, horizon Románd, HaB2
Primary material: 94.28% Cu, 0.7% Ag, 2.64% Ni, 2.38% Sb, precipitations: 66.64% Cu, 2.69% Ag, 5.91% Ni, 3.64% As, 21.11% Sb, dark phases: sulphide

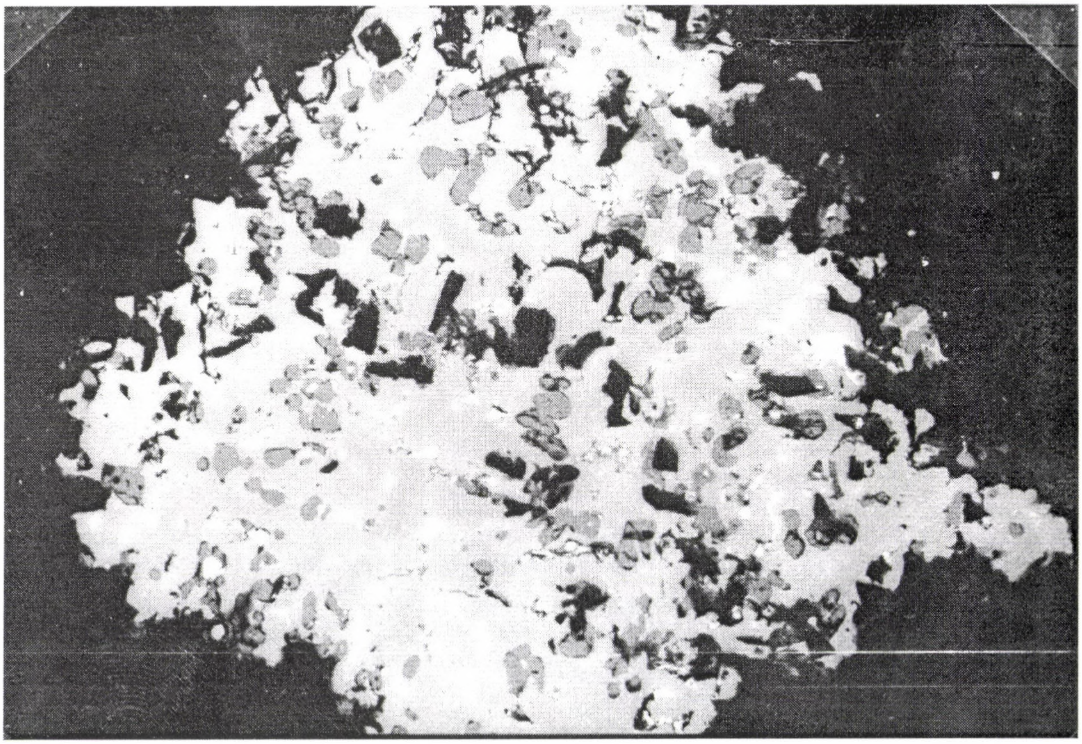

Fig. 7 (photo No. 389.)
Inv. No. HNM 25.1949, MOZSOLICS 1973–74, table 9.2, Nyergesújfalu type, horizon Románd, HaB2
Primary phase: 94.03% Cu, 0.34% Ag, 3.11% Ni, 0.70% Co, 1.83% Sb, precipitations: 66.11% Cu, 9.32% Ni, 1.99% Co, 22.58% Sb, dark (sulphide) phase: 63.4% Cu, 36.6% S, black phase: quartz

Method[8]

The measurements were performed on an AMRAY 1830 I/T6 scanning electron microscope equipped with an energy dispersive – (PV9800) and a wavelength dispersive spectrometer, operating at an accelerating potencial of 20 KeV and beam current of 1–2 or 15–20 nA respectively[9].

Results of analyses

The ingots had been already analyzed, most probably by wet chemical method (LÁZÁR 1941, LÁZÁR 1943). J. Lázár writes about the analyses of several copper "lumps" though the find contains only one ingot on which traces of sampling can be identified.

The unique position of the Sághegy type was demonstrated also by the analyses: its primary material is pure copper in which copper sulphide inclusions as characteristic accessory phases can be observed with a composition close to that of chalcocite (Cu_2S) (fig. 2) The deviation from stoichiometry may refer to the infiltration of some covellite (CuS)[10] while the presence of iron demonstrated in one of the sulphide inclusions most probably refer to a chalcopyrite component of the original raw material. This type can be characterized by few accessory phases and besides copper inclusions only a few tiny inclusions with Pb content were found (fig. 3). In a single inclusions also with Pb and Pb-Sb content were observed (fig. 4). The piece analyzed in the 30-s belongs into this group[11].

On the basis of analyses the Velem type and Nyergesújfalu type ingots found at the Sághegy cannot be separated from each other. Their primary material can be characterized by a 1–3% Ni content and except one case, also by Sb content. The primary material of several samples contains Co as well, the ratio of Ni-Co is 4–5:1 (see fig. 11).

As compared to Sághegy type ingots the quantity of accessory phases had considerably increased (figs 5, 6, 7). In addition to copper sulphide inclusions the appearance of copper phases rich in Sb is typical and these phases frequently display characteristic exsolution (figs 8, 9). Ag and occasional As content of the samples is connected also to this phase. We found also some inclusions with Si content which can be identified most probably with that quartz which is originated from the primary material (fig. 10).

The elementary composition of Velem type and of Nyergesújfalu type ingots, demonstrated by phase analysis, suggests that the processed ore was most probably rich in fahl ores, explicitly in tetrahedrite-tennantite ($(Cu,Fe)_{12}(Sb,As)_4S_{13}$ – $(Cu,Fe)_{12}(As,Sb)_4S_{13}$), or it might belong to that type of mineral paragenesis in which the main component was chalcopyrite ($CuFeS_2$). The presence of the elements (Ni,Co(Bi) may refer to other kinds of minerals in the paragenesis namely to Ni(Co)-arsenids, -sulphides (bisulphides). Ag may derive partly from fahl ore or may refer to the presence of some silver minerals (acanthite (Ag_2S), native silver). The inclusions having a chalcocite-covellite character suggest that the ore used for processing the ingots originated from the cementation zone of a deposit.

The elementary assocation of the Velem type and of the Nyergesújfalu type ingots found at the Sághegy refers to the so-called five element ore formation, containing Cu-Ni-Co-Bi-Ag, a composition found earlier in some of the ingots of Velem-Szent Vid-hegy[12].

The origin of the Sághegy ingots

During our discussion regarding the studies made on Velem finds we already mentioned that a considerable quantity of the pieces found at that site came to light from different part of the site as sporadic finds and while this made the determination of the chronological position of the pieces themselves rather difficult it also helped to get series of data easier to interpret statistically. On the other hand the chronological position of the Sághegy ingots is beyond doubt, but – in addition to those differences which we have mentioned in the introduction – we have to take into consideration that in this case only the analysis of certain objects of a single closed find assemblage had been made, therefore its results cannot be generalized for the whole of the locality. That is we made the analysis of only those pieces large-size ingot fragments which already on the basis of their external appearance we thought to be semi-products originated from primary raw material sources. This hypothesis was verified by the results of the analyses. All morphological characteristics (traces of sulphides, mineral residues, the absence of alloying material) suggest that these pieces had gone through only a few phases of processing that is their element association reflect the composition of that ore which was processed at the original mining site.

The 100% copper content of the Sághegy type and some traces of iron found in it refer to a chalcopyritic origin. Its source, however, at present cannot be determined even within a wider range of possibilities. Though a Late Bronze Age mining of chalcopyrite ore deposits are well known and for the Austrian Alps it is believed to be almost axiomatic, moreover, considering cultural connections, this hypothesis would be very plausible, we must not forget that chalcopyrite, frequently occuring even in mass quantity, can be found in several other rich geoarchaeologically far less known ore deposits of the Carpathian Range.

As we have mentioned related to the analysis of Velem ingots (CZAJLIK et al. 1995), Cu-Ni-Co-Bi type ore deposits occur generally rarely in the Carpathian Basin and adjacent areas, moreover they are not characteristic of the geologically young Carpathian-Balkan metallogenic province at all. Therefore we have to look for the sources in geologically older regions. The fact that both the Velem type and the Nyergesújfalu type ingots of the Sághegy hoard contain Ni(Co) is very important from this point of view as well, since this geologically special composition indicates an origin connected to the above-mentioned peculiar raw material province. The same seems to be true for the pieces found at Velem.

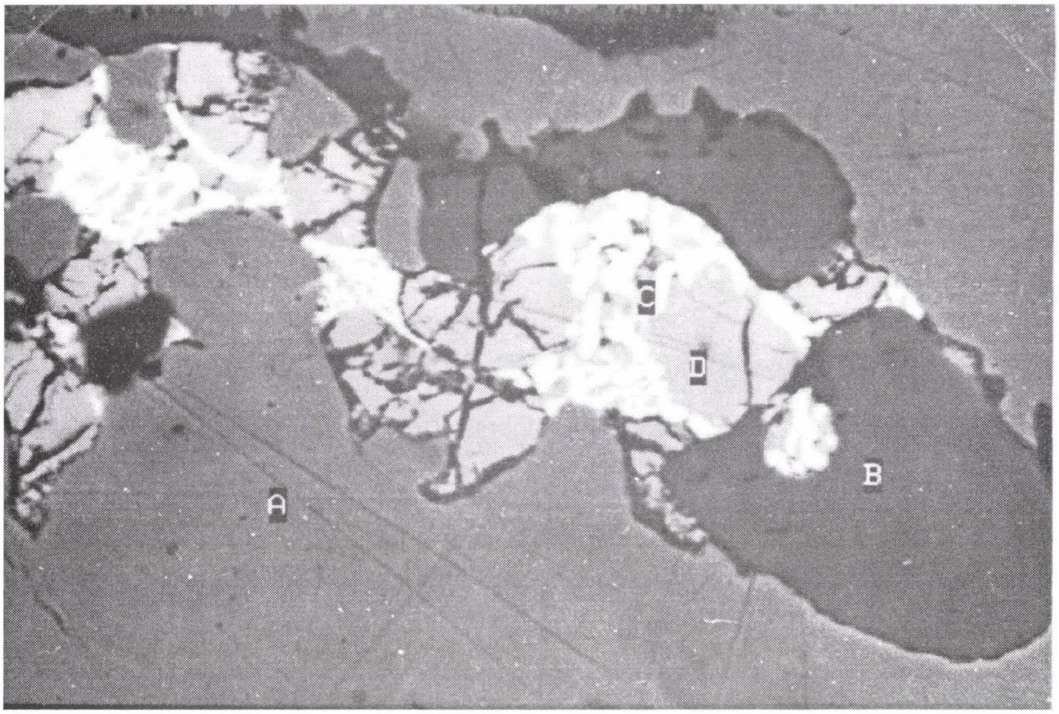

Fig. 8 (photo No. 387.)
Inv. No. HNM 25.1949, MOZSOLICS 1973–74, table 9.2, Nyergesújfalu type, horizon Románd, HaB2
A=primary material: 94.03% Cu, 0.34% Ag, 3.11% Ni, 0.70% Co, 1.83% Sb, B=sulphide phase: 63.4% Cu, 36.6% S, C=Ag-precipitations: 71.57% Cu, 0.74% Ag, 3.27% Ni, 0.70% Co, 23.59% Sb, D=precipitations: 66.11% Cu, 9.32% Ni, 1.99% Co, 22.58% Sb

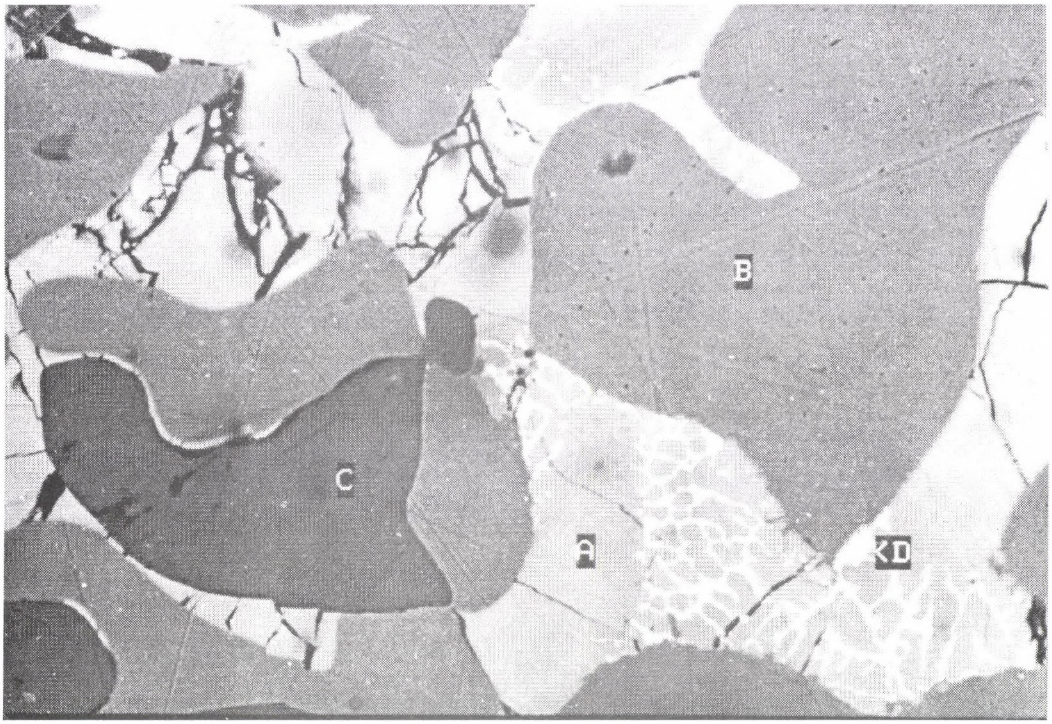

Fig. 9 (photo No. 1497.)
Inv. No. HNM 25.1949, MOZSOLICS 1973–74, table 9.2, Nyergesújfalu type, horizon Románd, HaB2
A=primary material: 94.03% Cu, 0.34% Ag, 3.11% Ni, 0.70% Co, 1.83% Sb, B=sulphide phase: 63.4% Cu, 36.6% S, D=precipitations: 66.11% Cu, 9.32% Ni, 1.99% Co, 22.58% Sb

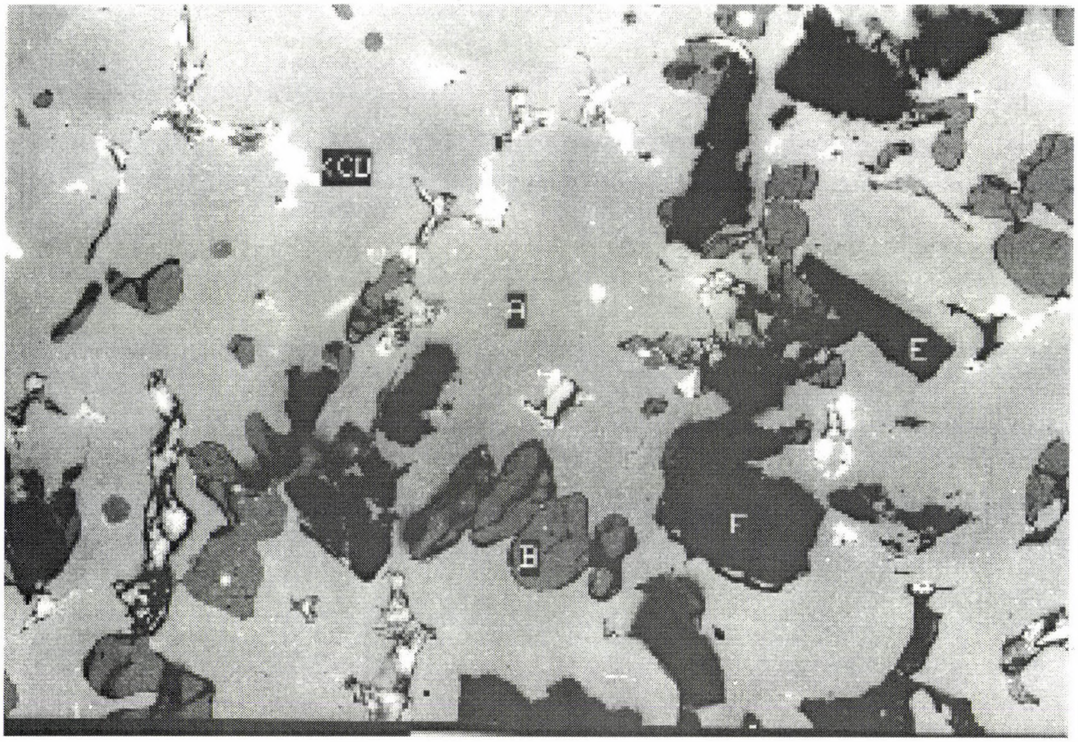

Fig. 10 (photo No. 388.)
Inv. No. HNM 25.1949, MOZSOLICS 1973–74, table 9.2, Nyergesújfalu type, horizon Románd, HaB2
A=primary material: 94.03% Cu, 0.34% Ag, 3.11% Ni, 0.70% Co, 1.83% Sb, B=sulphide phase: 63.4% Cu, 36.6% S, CD=Ag-precipitations, E=quartz

In our earlier study, considering geological, cultural data, our knowledge of the history of mining as well as geographic conditions from the aspect of transport and traffic, we could denote only two possible sources of copper raw material with nickel content. They are the Špania Dolina-Piesky-Lubietova (Slovakia) and Mitterberg-Kitzbühel (Austria) regions. Since then we can add to them another potential area, the one near Liezen-Schladming (Austria) (PROHASKA 1993, 12, PRESSLINGER–EIBNER 1993a, 32, PRESSLINGER–EIBNER 1993b, 39, PROCHASKA–PRESSLINGER 1989, 10–14).

1. Špania Dolina-Piesky-Lubietova area

Several hundred tools connected with local mining activity were found at the site. Together with the researches related to them they are well-known from literature (LIPTAKOVÁ 1973; TOČIK-BUBLOVÁ 1985). On the basis of some indirect data it is supposed that mining activity was continuing in the site even during the Late Bronze Age (TOČIK-ŽEBRÁK 1989, 75).

There are three ore deposits near Lubietova, two of them, namely Svätodusná and Kolba, contain also Co, Ag and Ni besides their Cu(Fe) content. In the Podlipa deposit Co, Ag and Ni content are less rich. For all the three deposits Slovak literature indicates Bronze Age mining activity (KODERA 1990, 731–741).

The ores of the Podlipa deposit occur either diseminated or as veins with ankerite-siliceous content within the Permian sequence. In the primary deposit chalcopyrite, fahl ore (tetrahedrite) and pyrite are the main ore minerals, though galena, sphalerite and stibnite, too, may occur.

A highly intensive extraction of the Svätodusna deposit is suggested by the presence of those spoil-banks which are the largest ones over the the whole Lubietova area, though their exact age is still unknown. The ore veins run within migmatites and phyllites near Permian granite-granodiorite intrusions. The veins have a carbonate filling, their dominant ore minerals are quartz, tennantite, chalcopyrite, cobaltine (CoAsS), arsenopyrite (FeAsS) and gersdorffite (NiAsS).

The ore veins and lenses of the Kolba deposit[13] run in the Permian granite-granodiorite porphyritic intrusions. The main ore minerals are arsenopyrite, pyrite, cobaltine, and chalcopyrite, associated with quartz and carbonates.

All the three ore deposits display considerable oxidation-cementation zones which contain chalcocite, covellite, cuprite, native copper, tenorite, malachite and other minerals partly containing As.

Finally it would be instructive that according to J. Kiss' data (KISS 1982, 229–230) the average composition of the Lubietova ore mined at the present time contains also 0.29% Ni besides its Cu, Pb and Sb.

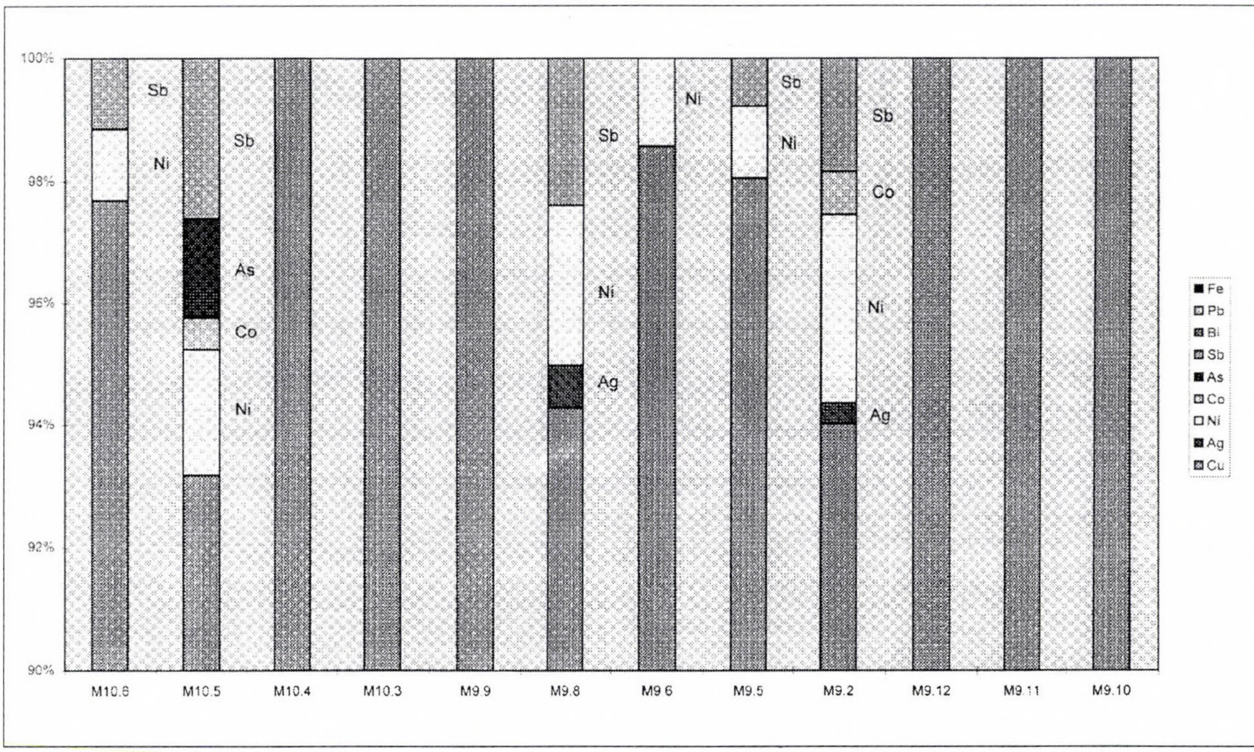

Fig. 11
Comprehensive table. The analysis of 12 ingot fragments from the hoard No. II. from Sághegy. The column chart represent the composition of the primary material (Legend: based on MOZSOLICS 1973–74, tables 9–10).

2. Mitterberg-Kitzbühel area

There are numerous prehistoric mining sites in that part of the so-called Grauwacke zone which is situated between Bischofshofen and Kitzbühel. Though the peak production of this area can be connected with the München-Luitpold park type Ösenhalsring-finds (MOOSLEITNER–MOESTA 1988), that is to the Early Bronze Age of the Voralpenland still on the basis of analyses mining activity remained continuous during the whole Bronze Age (KRAUSE–PERNICKA 1998, 194–195), too (GÜNTHER et al. 1994, 30–31). An indirect archaeological proof of the latter we may consider the distribution of Late Bronze Age hoards in this zone as well as the presence of Tüllenpickel occuring both in mining zones and in hoards. They can be dated for BzD/HaA1 and can be regarded as mining tools (HÖGLINGER 1996, 43–45).

The veins of the local ore deposit are situated in Paleozoic metamorphosed schist, phyllithe and carbonates. Among the ore minerals of the veins chalcopyrithe and tetrahedrite are the most widespread but Ni- and Co-sulphides and Ag-minerals are present as well. Siderite, ankerite and quartz are the most frequent gangue minerals (GÜNTHER et al. 1994, 42–50).

3. Liezen-Schladming area

Recent montan-archaeological researches demonstrated the presence of prehistoric ore mining also in the eastern part of the Grauwacke zone, in the catchment area of the river Enns. Most famous is the smelting workshop excavated at the site Trieben-Versunkene Kirche which belongs to the Urnfield period (WALACH 1993, 23–24).

A comprehensive analysis of geoarchaeological data suggests clearly the use of polymetallic ores (PRESSLINGER–EIBNER 1993a, 32). The nickel-cobalt ores with arsenopyrite, cobalt-arsenids, löllingite, Bi-minerals and chalcopyrite can be found in the Zinkwand-Vöttern-Giglach region, to the South of Schladming, bound to the so-called Schladming crystalline formation, a formation of extremely complex development (PROCHASKA 1993, 12).

Summary

The Sághegy ingots are primary semi-products and not those products which were made by re-use. Some of them still preserve features indicating that their condition is still not so far from the "ore state" (Sághegy type). The other pieces, too, have a well recognizable "circle of pastry" form (which can be produced only in those smelting furnaces which are near the ore deposits) and this, together with the sound, homogenous results of their analyses which can be geologically well interpreted also exclude that they were re-used. Similarly, with absolute certainty we can say that every piece was a semi-product made of sulphide copper ore[14], which was not alloyed either with tin or antimony.

On the basis of their typology the Sághegy ingots can be classified into three groups. The two main groups are separated also in the analyses while the difference between the sub-groups (Velem and Nyergesújfalu types) is not significant. Therefore the Sághegy type and the Velem and Nyergesújfalu type ingots could be of different origin as well; the origin of the latter ones can be connected with either the large mines of the Eastern Alps (Mitterberg, Schladming) or with the Špania Dolina (Úrvölgy) area (there more specifically with Lubietova (Libetbánya).

The inferior, though not negligible Sb-As-Ag content of these ingots may refer to the supplement of some material with fahl ore which can be explained well by the ore geological conditions of the above-mentioned ore mines - just like in the case of the Velem pieces.

The Ni-content of one of the groups of the closed find assemblage from Sághegy, the great number of ingots with Ni content at Velem which have a heterogeneous origin but typologically belong to the same circle – considering first of all the central role of the two, not contemporaneous(!) sites – make us suppose that semi-products with nickel-content which can be connected to the above-mentioned raw material sources were steadily present in the copper raw material supply and traffic of the region.

According to analyses made in Slovenia[15] and in neighbouring countries Ni-Co-Bi type copper raw materials are not unique in this region[16]. Such materials can be found in the Velem and Nyergesújfalu type ingots at Silovec and Hočko Pohorje as well as in the mould cast raw materials at Hočko Pohorje, Kanalski Vrh, Pekel, Jurka vas, Debeli Vrh and Veliki Otok.

According to our opinion purposeful trace element analyses would help to clear up which of these mining areas, namely Mitterberg, Kitzbühel, Schladming and Špania Dolina-Piesky, was the one which provided at least a part – and quite a significant part – of copper raw material for Western Transdanubia during the Late Bronze Age[17].

Notes

1 For the chronology of the hoards in Transdanubia see: KEMENCZEI 1996a; KEMENCZEI 1996b. All Sághegy hoards (see MOZSOLICS 1973–1974; KEMENCZEI 1996a, 84 and KEMENCZEI 1996b, 252–253): Hortfundstufe IVb (Mozsolics BVIa, horizon Románd). At the same time 5 Velem hoard (see CZAJLIK 1993, 326–327, MOZSOLICS 1985; 211–213 and KEMENCZEI 1996a, 77) Hortfundstufe III (Mozsolics BVc, horizon Gyermely) and there is only one younger hoard in Velem (see MOZSOLICS 1985, 213; KEMENCZEI 1996a, 84; KEMENCZEI 1996b, 249): Hortfundstufe IVa.

2 ECSEDY et al. 1994, 53–54. In P. Turk's system all these hoards are 'hoards of mixed composition' (Turk's horizon III.), unseparatable on the basis of the Slovenian material (TURK 1996, 115–118).

3 See (OTTO-WITTER 1952; SAM I–III, for the R. Pittioni analyses; MACZEK et al. 1952–53) to mention only the best known ores. For they criticism see e.g. (BOOMERT 1975).

4 The introduction of systematic Late Bronze Age object analyses in Hungary was due to Gábor Ilon: (ILON 1989; BAKOS–BORSZÉKI 1989 and KÖLTŐ–KIS VARGA 1992; KÖLTŐ 1996).

5 The most important new results on analyses of semi-products: TRAMPUŽ et al. 1991; TRAMPUŽ et al. 1993, RYCHNER–KLÄNTSCHI 1995; TRAMPUŽ et al. 1996; VERNEY–BOCQUET 1998; FRÁNA–JIRÁN 1996.

6 T. Kemenczei claims the hoard to be the objects of a local merchant (ECSEDY et al. 1994, 54).

7 Unfortunately all pieces are inventorized under three(!) inventory numbers altogether MNM 25.1949. 47–49. Therefore there was only one possible way for a sound identification, that is numbering of the photo-tables of the first publication MOZSOLICS 1973–74 as a starting point. We made analyses of 12 pieces altogether, they are: Table 9.2, 5, 6, 8, 9, 10, 11, 12 and Table 10.3, 4, 5, 6.

8 On testing EPMA-analysis see NORTHOVER–PERNICKA 1998, 26–27.

9 The financial background of analyses was provided by the Hungarian National Research Fond (OTKA) No. F006968, No. F023585.

10 This, however, does not mean at all that the used ore raw material had either chalcocite or covellite content.

11 The name of the analyst and the laboratory are unknown, the results are the following: 99.52% Cu, 0.46% Pb.

12 See CZAJLIK et al. (1995), fig 4.: ingots MNM 45.1896.1, 3. and fig 3. 2–3. old analysis.

13 By the way, the name means cobalt.

14 Therefore they were made of primary ore material and not of the secondary copper ore originated from the nearsurface oxidation zone, a practice characteristic of the Copper Age and in certain areas also of the Bronze Age.

15 Neva Trampuž Orel (Narodni Muzej, Ljubljana) was so kind to let me study Slovenian ingots and the results of analyses. Here I should like to express my thanks for being acquainted with the material before its publication. In the meantime the results have been published: (TRAMPUŽ et al. 1996, especially 178–181.

16 To bronzes with nickel-content already E. Bácskay, too, had drawn attention in her article (BÁCSKAY 1985, 565).

17 A detailed description of the known analyses from Transdanubia and neighbouring areas is forthcoming (World Archaeometry Congress, Budapest, 1998, manuscript ready for publication).

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