MAGYAR NEMZETI MÚZEUM

COMMUNICATIONES ARCHÆOLOGICÆ HUNGARIÆ

2020

COMMUNICATIONES ARCHÆOLOGICÆ HUNGARIÆ

2020

Magyar Nemzeti Múzeum
Budapest 2022

Szerkesztőség
Magyar Nemzeti Múzeum Régészeti Tár
H-1088, Budapest, Múzeum krt. 14–16.

A folyóirat cikkei elérhetők: http://ojs.elte.hu/comarchhung
Kéziratbeküldés és szerzői útmutató: http://ojs.elte.hu/comarchhung/about/submissions

A kiadvány megjelentetését a Nemzeti Kulturális Alap támogatta.

ISSN 0231-133X (Print)
ISSN 2786-295X (Online)

Felelős kiadó
L. Simon László főigazgató

Készült 450 példányban a Pauker Holding Kft. nyomdájában.

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Recensiones

HANDHELD XRF ANALYSIS OF GOLD ARMLETS WITH CRESCENT-SHAPED TERMINALS FROM THE PREHISTORIC COLLECTION OF THE HUNGARIAN NATIONAL MUSEUM

János Gábor Tarbay* – Boglárka Maróti**

In this study, we present the elemental composition results determined with handheld XRF method on the gold armlets with crescent-shaped terminals from the Prehistoric Collection of the Hungarian National Museum. In addition to the new Tápióbicske find, the Dunavecse, Biia, the Géza Kárász Collection find from Transylvania and the Körös area specimens were also included in the analysis. Based on the handheld XRF results, it can be concluded that most of the studied armlets have high Ag (21–24 wt%) and low Cu (0.06–0.17 wt%) content. These objects form a relatively uniform group (Hartmann A3) based on their elemental composition, regardless of their type and presumed date. Lower Ag content was only detected in the Körös area find (ca. 5.8 wt%) (Hartmann B) and in the rivets of the Biia armlet (ca. 12.3 wt%) (Hartmann L/Q2). Our results suggest that the studied armlets had a lower Ag content compared to the previous measurements on the Bilje, Pipea and Boarta armlets, made by different techniques (OES, SR XRF). The applied method is not suitable to determine the origin of the raw materials. Only the material type could be defined as native gold.

A tanulmányban a Magyar Nemzeti Múzeum Őskori Gyűjteményében található, holdsarlós végű arany karpántok kézi XRF elemösszetételi vizsgálatának eredményeit mutatjuk be. Munkánkban az új, tápióbicskei darab mellett vizsgáltuk a dunavecsei, a magyarbényei, az erdélyi (Kárász Géza gyűjtemény) és a Körös vidéki darabot is. A kézi XRF elemzés alapján megállapíthatjuk, hogy a karpántok jelentős része magas Ag (21–24 wt%) és alacsony Cu tartalommal (0,06–0,17 wt%) rendelkezik. E tárgyak típusuktól vagy lehetséges időrendi besorolásuktól függetlenül viszonylag egységes csoportot (Hartmann A3) alkotnak elemösszetételük alapján. Alacsonyabb Ag tartalommal a Körös vidéki darab (kb. 5,8 wt%) (Hartmann B) és a magyarbényei karpánt szegecsei (kb. 12,3 wt%) bírtak (Hartmann L/Q2). Eredményeink alapján a vizsgált karpántok alapanyaga a korábban, részben más módszerekkel (OES, SR XRF) vizsgált példányokhoz képest (Bellye, Pipe, Mihályfalva) alacsonyabb Ag tartalommal bír. Jelen módszer az elemzett tárgyak nyersanyaga eredetének meghatározására nem alkalmas, mindössze a nyersanyag típusát különíthetjük el, amely termésarany lehetett.

Keywords: *handheld XRF, Middle Bronze Age–Early Iron Age, gold armlets with crescent-shaped terminals*

Kulcsszavak: *kézi XRF, középső bronzkor–kora vaskor, holdsarlós végű arany karpántok*

Introduction

The Hungarian National Museum has most of the gold armlets with crescent-shaped terminals in Central Europe. In addition to the new ornament from Tápióbicske (Pest County, HU) (Tarbay 2021), further five gold armlets from Hungary and Romania belong to the Prehistoric Collection: Abrud (Alba County, RO) (Hampel 1892, 375, Fig. 6, 1–2; Mozsolics 1968, 47, Pl. 19, 1), Biia (Alba County, RO) (Hampel 1880, 214–216, Pl. 33, Pl. 35, 3; Mozsolics 1968, 48–49), Dunavecse (Bács-Kiskun County, HU) (Kovács 1991), Géza Kárász Collection – Transylvania (RO) (Hampel 1880, 215, Pl. 35, 1–2, 5; Mozso-

▹ Received 14 March 2021 | Accepted 20 July 2021 | Published online 3 March 2022

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lics 1968, 57), Körös area (HU/RO) (Mozsolics 1986, 57, Pl. 19, 2) (See Tarbay 2021, Appendix). This provides a unique opportunity to conduct an analysis on most of the published specimens. Furthermore, this also makes it possible to compare our results with previous optical emission spectroscopy measurements of the SAM project (Hartmann 1968a, Tab. 1; Hartmann 1970, 110, Pl. 47, AU201–AU202) and the SR XRF analysis of Bogdan Constantinescu's team (Constantinescu et al. 2012, Tab. 1; Cristea-Stan, Constantinescu 2016, 32, Fig. 7). It is an important task to document and compare the elemental composition of the HNM specimens for the first time and hopefully, it will be a firm base for more advanced analyses on these exceptional objects in the future (See Pernicka 2014, 159; Mozgai 2017, 234–236).

Method

Due to their material value, it often requires thorough organization to transport precious metal artefacts to an external measurement site. However, the handheld X-ray fluorescence (XRF) spectrometer has proved to be a highly effective tool to examine complete museum collections on-site (Karydas et al. 2004). In this study, a handheld Innov-X (now Olympus) Delta Premium spectrometer was used to perform the XRF analysis on one of the most valuable gold artefacts in the Prehistoric Collection of the Hungarian National Museum. This device is equipped with a 4W X-ray tube, a 200 μA maximum current, an Rh anode, and a Peltier cooled silicon drift detector (SDD). The full width at half maximum (FWHM) is 154 eV at Mn $K_α$ energy (5.95 keV). The Alloy Plus Precious Metals factory calibration settings were applied during the measurements. The spot size of the X-ray beam was 3 mm in diameter. The objects were analyzed in various positions, preferably on flat surfaces. All spectra were fitted using bAxil software (Brightspec, bAxil 2014) to check the presence of elements that are not listed by the built-in software of the spectrometer (e.g., Te).

XRF is a surface analytical method, but it is well suited to the analysis of gold or gold-rich alloys (Karydas et al. 2004). Gold as a noble metal is highly resistant to corrosion, but the other alloy components, e.g., silver and/or copper may undergo corrosion mechanisms. The most known phenomenon is the formation of Ag_2S tarnish layer on the surface with thickness in the nm range (Bastidas et al. 2008; Tissot et al. 2015). Since effective penetration depth of XRF for gold-silver alloys of various compositions is from 8–10 μm (Cu $K_α$) to 28–43 μm (Ag $K_α$) (Troalen et al. 2014), the results are not affected by the presence of the tarnish layer and can be extended to the bulk (Karydas et al. 2004; Troalen et al. 2014).

Table 1 The elemental composition in wt% units of the studied armlets with crescent-shaped terminals, as well as their standard deviations. The results are the average of 5–8 measurements
1. táblázat A tanulmányozott karpántok elemösszetétele wt% egységben, standard szórásukkal együtt. Az eredmények 5–8 mérés átlagai

No.	Artefact	Inventory No. (HNM)	Carat	SAM group	Au wt% (std)	Ag wt% (std)	Cu wt% (std)	Literature
1	Abrud (Abrudbánya)	1892.57	18.4 ± 0.3	A3	77(1)	23(1)	0.06(2)	Mozsolics 1968, 47, Pl. 19, 1.
2	Biia (Magyarbénye)	1880.53	18.5 ± 0.1	A3	77.2(4)	22.4(4)	0.17(2)	Mozsolics 1968, 48–49, Pl. 20–21.
3	Biia (Magyarbénye) – rivets	1880.53	21.0 ± 0.2	L/Q2	87.3(8)	12.3(7)	0.081(8)	Mozsolics 1968, 48–49, Pl. 20–21.
4	Dunavecse	1972.5.1	18.4 ± 0.1	A3	76.8(4)	22.8(5)	0.14(1)	Kovács 1991.
5	Géza Kárász Collection, Transylvania	1893.107.1	18.1 ± 0.0	A3	75.1(2)	24.7(2)	0.12(2)	Mozsolics 1968, 57, Pl. 23, 1.
6	Körös area	1968.24.26	22.5 ± 0.1	B	93.8(4)	5.8(4)	0.09(2)	Mozsolics 1968, 57, Pl. 19, 2.
7	Tápióbicske	2016.4.1	18.7 ± 0.1	A3	78.1(5)	21.8(5)	0.10(3)	Tarbay 2022.

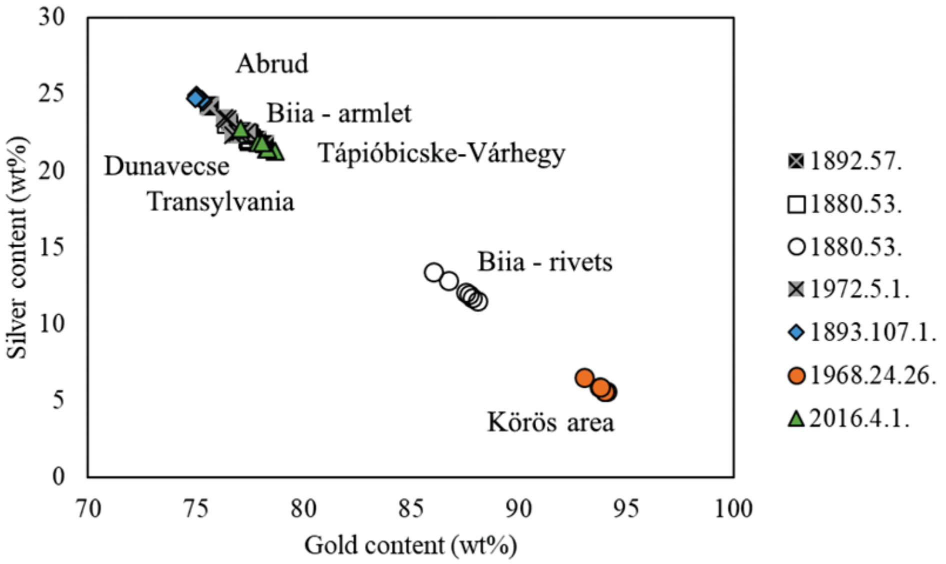

Fig. 1 Gold and silver concentrations of the armlets from the individual handheld XRF measurements. Please note that the uncertainties are smaller than the symbols. The relative uncertainties are 0.25–0.30% and 0.4–0.44% for gold and silver, respectively

1. kép A karpántok arany és ezüst koncentrációi egyedi kézi XRF mérések alapján. A bizonytalanságok kisebbek, mint a szimbólumok. A relatív bizonytalanság mértéke 0,25–0,30% és 0,4–0,44% az aranyat és ezüstöt illetően

Results

The handheld XRF spectrometer has higher detection limits for the possible important impurities in gold that is related to the origin of the raw material or the quality of applied metallurgy. These elements are Sn, Sb, Pb, Te and Cu as listed in earlier studies (Karydas et al. 2004; Cristea-Stan, Constantinescu 2016), their detection limits in wt% unit with the Delta Premium handheld device are 0.1 (Sn), 0.05 (Sb), 0.03 (Pb) and 0.01 (Cu). Te is not reported by the built-in software of the device, but based on the XRF spectra, its detection limit is 0.06 wt%.

Five of the studied gold armlets with crescent shaped terminals (Abrud, Biia, Dunavecse, Géza Kárász Collection from Transylvania, Tápióbicske) contains Ag between 21 and 24 wt%. One specimen from the Körös area has only 5.8 wt% Ag content. The presence of Ag is also significantly lower (12 wt%) in the rivets of the Biia specimen compared to the material of the armlet (*Fig. 1*). Cu also appeared as an impurity in all studied specimens (*Table 1*).

Discussion

In 1968, Axel Hartmann published optical emission spectroscopy data on the Bilje (Osijek-Baranja County, HR) (Arneth 1850, 40, no. 266, Pl. GVII) and Pipea (Mureș County, RO) (Hampel 1880, 215, Pl. 34, Pl. 35, 4) gold armlets (Hartmann 1968a, Table 1; Hartmann 1970, 110, Pl. 47, AU201–AU202) (*Table 2, 1–2*). Both armlets were classified into his A3 material group that can be characterized by high Ag content (ca. 25 wt%) and by the presence of Cu (ca. 0.30 wt%). Objects belonging to this group have low Sn content (0.006–0.025 wt% / 0.1–0.2 wt%) or they lack this element completely. According to Axel Hartmann, the A3 group is characteristic in the Carpathian Basin and its raw material is originated from Transylvania (Hartmann 1968a, 66–67, 72–73; Hartmann 1982, 10–11, 33–34; Borg 2010, 743, Fig. 8). An SR XRF analysis on the Early Iron Age Boarta (Sibiu County, RO) (Nestor 1934, 175, Fig. 1, 1, Fig. 2, 1, Fig. 3) specimen revealed inhomogeneity in the composition of the object. According to Bogdan Constantinescu and his colleagues, this object may have been put together from different gold nuggets by heating and hammering, which caused different elemental composition on the white and yellow surfaces of the object (Oberfrank 1986, 11, 24; Constantinescu et al. 2012, 2077, Tab. 1; Constantinescu, Cristea-Stan 2019, 61). Apart from these analyses, the literature does not contain any more results on gold armlets with crescent-shaped terminals that would be comparable.

In general, the new handheld XRF results correlate well with the previous studies and the general picture of the gold finds from the Danube River area

Table 2 Previously studied gold armlets with crescent-shaped terminals by Bilje, Pipea (after Hartmann 1968a, Tab. 1) and Boarta (after Constantinescu et al. 2012, Tab. 1)
2. táblázat Korábban elemzett arany holdsarlós végű karpántok Bellyéről, Pipéről (Hartmann 1968a, Tab. 1) és Mihályfalváról (Constantinescu et al. 2012, Tab. 1)

No.	Artefact	Method	SAM group	Au	Ag	Cu	Sn	Ni
1	Bilje (Bellye)	optical emission spectroscopy	A3	[ca. 69.712]	ca. 30	0.27	0.018	–
2	Pipea (Pipe)	optical emission spectroscopy	A3	[ca. 69.701]	ca. 30	0.29	0.009	–
3.1	Boarta (Mihályfalva)	SR XRF ('central part')	A3C	63	34	2	–	
3.2		SR XRF ('terminal, white')		55	44	2.6	–	
3.3		SR XRF ('terminal, yellow')		79	19	1	Traces	

(Riederer 1984, 29). The Abrud, Tápióbicske, Dunavecse, Biia, and the Géza Kárász Collection (Transylvania) armlets show a relatively high Ag content (more than 21 wt%), and they also contain Cu in a minor amount between ca. 0.6 and 0.17 wt% (*Fig. 1, Table 1, 1–2, 4–5, 7*). The amount of Ag is particularly close in the Tápióbicske, Dunavecse, and the Biia finds. It is hard to clearly compare these results to emission spectroscopy analytical data, but it seems that the raw material of the Bilje and Pipea ornaments had around 10 wt% higher Ag content (Hartmann 1968a, Tab. 1) (*Table 2, 1–2*). It is important to cite here the case study of Richard B. Warner and Mary Cahill, who demonstrated the unreliability of Axel Hartmann's Ag values. According to their conclusions, "*…Hartmann silver results are advised to append to the Hartmann value an uncertainty of 25% of that value.*" (Warner, Cahill 2011, 47–48, 50–51). Following their suggestion, the Bilje and Pipea Ag measurements should be interpreted as ca. 30±8wt% which agrees within an uncertainty margin (ca. 22 wt%) with the main Ag group proposed here by handheld XRF analysis (see *Fig. 1, Table 1*).

Even within this uncertainty value, most of the studied objects (Abrud, Biia armlet, Dunavecse, Géza Kárász Collection – Transylvania, Tápióbicske) belong to Hartmann's A3 group. Due to the handheld XRF spectrometer's 0.1 wt% detection limit for Sn, this element cannot be considered in the grouping, but according to Hartmann's 1982 work, the absence of Sn is also characteristic of the above group. The Cu content (ca. 0.06–0.17 wt%) of the above-mentioned specimens also strengthens the idea that they belong to the A3 group (*Table 1*) (Hartmann 1968a; Hartmann 1970; Hartmann 1982), as it does not match with the Cu values of the later proposed A3C and A3D subgroups (Hartmann 1982; Borg 2010, 743, Fig. 8; Borg et al. 2019, 59–60, Fig. 3).

A higher Ag (19–44 wt%) content than the studied finds was also detected on some parts of the Boarta specimen by SR XRF (Constantinescu et al. 2012, Tab. 1) (*Table 2, 3.1–3.3*). Another characteristic of this find is that its Cu content is relatively high (1–2.6 wt%) (Constantinescu et al. 2012, Tab. 1). Finds with similar Cu content were sorted into the A3C subgroup by Axel Hartmann. These objects were mainly identified among the Aegean material. Only a handful of specimens are known in Romania, Serbia, and Slovakia dated between the end of the Middle Bronze Age and the first half of the Late Bronze Age (Hartmann 1970, Tab. 16a; Hartmann 1982, 10–11, Tab. 33; Borg 2010, Fig. 8; Borg et al. 2019, Fig. 3). Therefore, we cannot relate this Early Iron Age object to the studied finds. The differences between the above-mentioned finds and the new series could be caused by the incompatibility of the so-far applied measurement techniques. Therefore, it would be essential in the future to obtain a complete series of all armlets with crescent-shaped terminals with an identical analytical technique. Until this goal is achieved, only limited conclusions can be drawn.

The results of the Carpathian Bronze Age gold analysis were summarized by Szathmári et al. in 2019 (Szathmári et al. 2019, Tab. 1–2). The above-described group of armlets with crescent-shaped terminals seems to have a similar elemental composition to the hair-rings from Zsennye Grave 15 (Nagy 2013, 104, fn. 275) and Vinča (Hartmann 1968a, Tab. 1). Also, the Ag content in these armlets is nearly identical to other Koszider period (Rei. Br B1, 1600–1450 BC) hair-rings from Komárom-Ószőny, Pincehely-Görbő, Pécs and Biia (D, E, F) (Hänsel, Weihermann 2000; Szathmári et al. 2019, Tab. 1). The similarities between the studied gold armlets and the Middle Bronze Age hair rings from Pincehely-Görbő, Biia can also be illustrated by the principal component analysis of the handheld XRF measurement data published in 2019 (Szathmári et al. 2019, Tab. 1) (*Fig. 2*). Currently, it seems that the above-discussed armlets with high Ag content form a coherent group (Hartmann A3) in terms of elemental composition (*Table 1, Fig. 1–2)*. There are no differences between subtypes, geographical origins, or possible chronological groups (Mozsolics 1968; Kovács 1991; Hänsel 1996; Kemenczei 2005, 81–82) (*Fig. 1, Table 1, 1–2, 4–5, 7*). As mentioned, this result alone does not necessarily prove that the objects can be dated to the same period (Koszider Horizon) or produced in the same workshop (Kovács 1991), but it presupposes a close relationship between these armlets and hair-rings in terms of raw material composition. Their possible connection and chronological simultaneity can be clearly supported by in-depth production technological and typological analyses, an increase in comparative elemental composition data, as well as the use of a more sensitive elemental composition analysis method (Borg et al. 2019, 60–61).

Several parts of the armlets were individually measured like in the case of Boarta, but no differences were observed in their elemental composition (Constantinescu et al. 2012, Tab. 1). It is also evident that this relatively high Ag content was not the result of intentional alloying, as Ag (2/10–40/50 wt%) and Cu (ca. 0.01–1.5 wt%) appear as impurities in native gold. Thus, the observed elemental composition pattern refers to the raw material (Riederer 1984, 26; Oberfrank 1986, 11; Hartmann 1970, 9; Pernicka 2014, 159–160; Mozgai 2017, 232–233). The origin of this raw material cannot be determined by handheld XRF analysis, and the high Ag content is also not suitable to draw conclusions on the gold placer deposit (Pernicka 2014, 159; Mozgai 2017, 232; Szathmári et al. 2019, 308–309). The hypothesis of Axel Hartmann that these finds may originate from Transylvania (Romania) still seems plausible because most of the gold ores and rivers can be found in this region, where gold planning was practiced by local inhabitants through the centuries: e.g., Baia Mare, Roşia Montană, Metaliferi Mountains. Nonetheless, Transylvania is not the only place where gold could be extracted, as other parts of the Carpathian Basin (e.g., the Banská Štiavnica area, Danube River) could also be potential sources (Uzsoki 1959, 74; Czajlik 2012, 38–40; Nagy 2013, 105). So far, there is no archaeological evidence for Bronze Age gold mining in primary gold ores prior

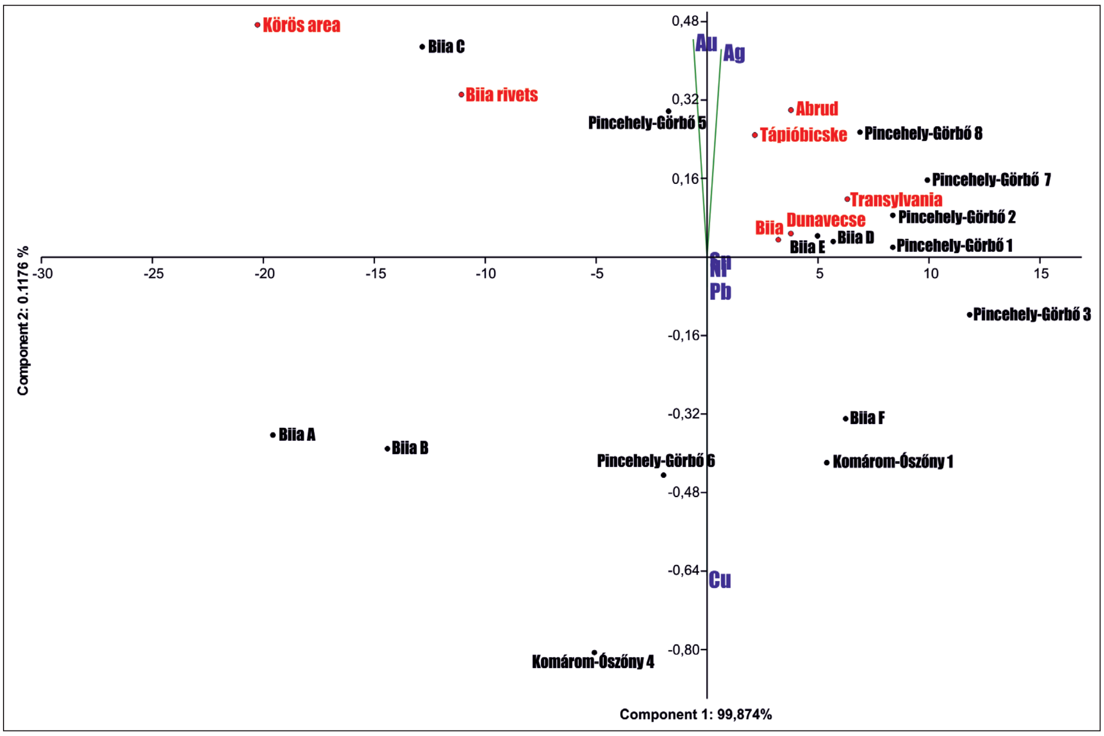

Fig. 2 Principal component analysis of the studied gold armlets' and Middle Bronze Age hair rings' elemental composition (Szathmári et al. 2019, Tab. 1) (Made by Past software version 2.17c.)

2. kép A vizsgált arany karpántok és középső bronzkori hajkarikák főkomponens-elemzése (Szathmári et al. 2019, Tab. 1) (Készült Past Szoftver 2.17.c verzióval) to the Late Iron Age in this territory. Thus, research hypothesizes the extraction of secondary alluvial and eluvial gold placer deposits as the main gold sources during the Bronze Age (Uzsoki 1959, 74; Hartmann 1968b, 19; Riederer 1984, 26; Oberfrank 1986, 11; Pernot 2004, 16; Czajlik 2012, 36–37). The presence of a low amount of Sn (0.002–0.4 wt%) in prehistoric gold objects could indicate the use of the aforementioned gold deposit types (Hartmann 1968b, 20; Hartmann 1970, 11; Riederer 1984, 28; Constantinescu, Cristea-Stan 2016, 60, 63; Dube 2006, 111), but our method is not sensitive enough to detect Sn in quantities less than 0.1 wt%.

Only the Körös area armlet and the rivets of the Biia armlet differ from this coherent group. The Körös area armlet contains ca. 5.8 wt% Ag, and 0.09 wt% Cu, which is low compared to the rest of the analyzed armlets with crescent-shaped terminals (Hartmann 1968a, Tab. 1; Constantinescu et al. 2012, Tab. 1) (*Table 1, 6; Table 2; Fig. 1–2*). This armlet can be sorted into the B-type (Berggold) of Axel Hartmann (Ag lower than 10 wt%, Cu 0.01–1.2wt%, Sn: 0 or 0.003–0.006%). B-type raw material is a primary characteristic between the Copper Age and the Early Bronze Age (Hartmann 1968b, 23, Fig. 2; Hartmann 1970, 41; Csedreki et al. 2011, 44, Tab. 2). It should be noted that similar Ag content was detected in one of the Middle Bronze Age Biia gold hair-rings by an identical method (Szathmári et al. 2019, Tab. 1, Biia A).

The six rivets of the Biia armlet (Mozsolics 1968, 48, Pl. 20, a–b) were separately measured. The handheld XRF results on these parts revealed an Ag content of around 12.3 wt% and 0.081 wt% Cu content (*Table 1, 3*). This result clearly differs from the armlet (*Table 1, 2, Fig. 1–2*) and it points out that the rivets were made from a different, softer gold material. The elemental composition of the rivets is most similar to Axel Hartmann's L/Q2 subgroup. Besides low Ag and Sn content, the main characteristics of the Q2 subgroup is its Cu amount (0.71–0.89 %). According to the results of the Stuttgart group this gold raw material type appeared at the end of the Middle Bronze Age, and it was used mainly during the Late Bronze Age (Hartmann 1970, 34, 37–39, 42–43, 109, 129, Diagram 14–15, 19–20, Tab. 15; Hartmann 1982, 6–10, 23). Objects with nearly identical Cu content to the Biia rivets also reflect well on this trend, such as the Middle Bronze Age stray find hair rings from Sisak and Jászberény (Hartmann 1970, Tab. 15, Pl. 428.AU1680, AU1703), a ring from the Coruia hoard (Rei. Br D), (Mozsolics 1973, 197; Hartmann 1970, Tab. 15, Taf. 46.AU1501), two rings from Sighetu Marmaţiei (Rei. Br D) (Mozsolics 1973, 199; Hartmann 1970, Tab. 15, Pl. 45.AU1453, AU1459), and a chased ring from the Ha B1 Somotor settlement (Pastor 1958; Hartmann 1970, Tab. 15, Pl. 28, AU167, AU169).

The Biia rivet results are also significant from a production technological standpoint. The rivets of a prehistoric metal product (vessel, sword, dagger, etc.) are usually made of a softer material compared to the object because they need to be formed extensively by plastic deformation. Applying a softer material will make this process easier. In the case of the Biia armlet, this was particularly important as the six rivets had to be hammered completely flat on the inside of the object to make the final product comfortable to wear (See Mozsolics 1968, Pl. 20, b) The choice of a material with high gold content for the rivets of the Biia armlet was clearly intentional. If the possibility of intentional alloying with silver is excluded, it shows that the craftsman recognized and "classified" the gold raw materials for different purposes, probably based on their color (See Mozgai 2017, Fig. 2). It is also worth noting, regarding the composition of the Biia rivets, that one hair-ring from Biia correlates well with their elemental composition, as well (See Szathmári et al. 2019, Tab. 1, Biia C) (*Fig. 2*). It can further support the idea that the armlet and the hair-rings may have belonged to the same assemblage.

Conclusions

The handheld XRF elemental composition analysis on the gold armlets with crescent-shaped terminals from Tápióbicske, Dunavecse, Biia, Transylvania (Géza Kárász Collection) and the Körös area revealed some new results. It can be concluded that most of the studied armlets (Tápióbicske, Dunavecse, Biia, Transylvania (Géza Kárász Coll.) have a high Ag (between 21 and 24 wt%) and a low Cu content (between 0.06 and 0.17 wt%). These objects form a relatively coherent group (Hartmann A3) based on their elemental composition, regardless of their type, geographical origin, and presumed date. Lower Ag content was only detected in the case of the Körös area find (ca. 5.8 wt%) (Hartmann B) and in the rivets of the Biia armlet (ca. 12.3 wt%) (Hartmann L/Q2). The latter points out the possibility of conscious use of different gold raw materials in the case of the Biia armlet. Our results suggest that all studied armlets had a lower silver content then the previously measured finds like Bilje, Pipea, Boarta, which could a result of the incompatibility of applied techniques and measurement tools, and the unreliability of the SAM analyses' Ag content (see Warner, Chaill 2011). Also, the new results seem to correlate with the elemental composition regarding silver content and/or copper amount to some Middle Bronze Age hair-rings from Hungary (Komárom-Ószőny, Pincehely-Görbő, Pécs, Zsennye Grave 15), Serbia (Vinča) and Romania (Biia). This similarity is an encouraging result in favor of the Middle Bronze Age dating of the armlets, but it is in itself still not decisive in terms of relative dating. This XRF series should be expanded in number and also compared to data from Late Bronze Age and Early Iron Age gold objects. The applied method is not suitable to determine the exact origin of the raw materials. Only the armlets' raw material type can be concluded as native gold.

Acknowledgements

We are grateful to Ildikó Szathmári, the former head of the Prehistoric Collection in the Hungarian National Museum for kindly allowing us to publish the handheld XRF results on the Tápióbicske and Dunavecse finds.

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A MAGYAR NEMZETI MÚZEUM ŐSKORI GYŰJTEMÉNYÉBEN TALÁLHATÓ HOLDSARLÓS VÉGŰ ARANY KARPÁNTOK KÉZI XRF ELEMZÉSE

Összefoglalás

A tanulmányban a Magyar Nemzeti Múzeum Őskori Gyűjteményében található holdsarlós végű arany karpántok kézi XRF elemösszetételi vizsgálatának eredményét tettük közzé. A vizsgált szériába magyarországi és romániai darabokat válogattunk be, függetlenül azok lehetséges korától: Tápióbicske, Dunavecse, Magyarbénye, Erdély (Kárász Géza gyűjt.), Körös vidéke. A vizsgálat eredménye alapján megállapíthatjuk, hogy az ékszerek többsége (Tápióbicske, Dunavecse, Magyarbénye, Erdély – Kárász Géza gyűjt.) magas ezüsttartalommal (21–24 wt%) és alacsony réztartalommal (0,06–0,17 wt%) jellemezhető. E tárgyak egy hozzávetőlegesen összefüggő csoportot alkotnak elemösszetételük szempontjából, mely független típustól, találási helytől vagy a feltételezhető relatív kronológiai helyzettől. Ez az Axel Hartmann-féle A3-as arany nyersanyag csoport, a Kárpát-medence egyik legjellemzőbb aranytípusa (Hartmann 1970; Hartmann 1980). A Körös vidéki leletben ugyanakkor alacsony az ezüsttartalom (kb. 5,8 wt%), csakúgy, mint a magyarbényei karpánt hat szegecsében (kb. 12,3 wt%). A Körös vidéki lelet a Hartmann-féle B típusba sorolható, mely elsősorban a rézkorban és a kora bronzkorban jelent meg (Hartmann 1970), de újabb vizsgálatok alapján később, a középső bronzkorban is előfordulhatott (Szathmári et al. 2019). A magyarbényei szegecsek a Hartmann-féle L/Q2-es arany nyersanyag alcsoportba tartoznak, melyek megjelenése a középső bronzkor végétől keltezhető, elterjedése ugyanakkor a késő bronzkorban válik jellemzővé (Hartmann 1970). Utóbbi eredmények alapján a magyarbényei karpánt készítése során a kézműves tudatosan különböztethetett meg és használhatott eltérő arany nyersanyagokat. A kapott adatok alapján a vizsgált holdsarlós végű arany karpántok ezüsttartalma összességében alacsonyabb a korábban vizsgált bellyei, pipei és mihályfalvi darabokhoz képest, aminek oka lehet a különböző vizsgálati módszerek és alkalmazott technikák közötti eltérés is (lásd Warner, Cahill 2011). A karpántok elemösszetétele az ezüsttartalom, illetve és/vagy réztartalom tekintetében kapcsolatba hozhatók néhány korábban vizsgált, középső bronzkori, magyarországi (Komárom-Ószőny, Pincehely-Görbő, Pécs, Zsennye, 15. sír), szerbiai (Vinča) és romániai (Magyarbénye) arany hajkarikával.

A korábbi, kompatibilis XRF mérések főkomponens-elemzése alapján leginkább a pincehely-görbői és magyarbényei arany hajkarikák mutatnak hasonlóságot összetételükben a Hartmann féle A3-as csoportba sorolható, magas ezüsttartalmú karpántokkal (Abrudbánya, Dunavecse, Erdély /Kárász Géza gyűjt./, Magyarbénye, Tápióbicske). Ez a hasonlóság biztató lehet a karpántok középső bronzkori keltezése mellett, ugyanakkor önmagában nem szolgáltat elég érvet a leletek egyértelmű datálására, ugyanis a jelenlegi XRF szériát számban növelni kell, az elemzett aranyleletek adatbázisát pedig ki kell terjeszteni a késő bronzkorra és a kora vaskorra is. A kézi XRF elemzés nem alkalmas arra, hogy az arany karpántok nyersanyagának forrását egyértelműen meghatározzuk, mindössze annyit állapíthatunk meg, hogy a tárgyak termésaranyból készültek.