BRASS BROOCH: A FAKE 'LATE BRONZE AGE VIOLIN-BOW FIBULA FROM ESZTERGOM-DUNAPART'

SÁRGAZRÉZ BROSS: "KÉSŐ BRONZKORI HEGEDŰ ALAKÚ FIBULA" HAMISÍTVÁNYA "ESZTERGOM-DUNAPARTRÓL"•

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Abstract

The study discusses a previously published find, a 'Late Bronze Age violin-bow fibula' from the prehistoric collection of the Hungarian National Museum, Department of Archaeology. The object was bought by the institute in 1948 from a certain Elemér Szabó, who stated that it was found by his son on the bank of the Danube River in Esztergom. In 2021, we re-studied the find by metalwork production and use-wear analysis and X-ray fluorescence spectrometry (XRF). The results of both analyses revealed that this specimen has a highly unusual character regarding its traces of manufacturing and elemental composition. In our opinion, based on these atypical characteristics, this 'artefact' can be determined as a modern forgery and therefore must not be included in further studies on the so called Unterradl type violin-bow fibulae.

Kivonat

A tanulmány egy korábban publikált "késő bronzkori hegedűvonó alakú fibulát" vizsgál a Magyar Nemzeti Múzeum, Régészeti Tárának őskori gyűjteményéből. A tárgyat az intézmény 1948-ban vette egy bizonyos Szabó Elemértől, akinek állítása szerint az ékszert fia találta a Duna esztergomi partszakaszán. 2021-ben, makroszkópos megfigyelésekkel és röntgenfluoreszcencia spektrometriával (XRF) vizsgáltuk újra a leletet. Mindkét elemzés eredménye arra utal, hogy ennek a tárgyak meglehetősen szokatlan készítéstechnikai és elem-összetételi jellemzői vannak. Megítélésünk szerint, atipikus tulajdonságai alapján, ez a "műtárgy" modern hamisítványként határozható meg, ennélfogva a hegedűvonó fibulák Unterradl típusával foglalkozó munkákból ki kell hagyni.

KEYWORDS: FORGERY, XRF (X-RAY FLUORESCENCE SPECTROSCOPY), METALWORK PRODUCTION AND USE-WEAR ANALYSIS, LATE BRONZE AGE, BRASS, UNTERRADL TYPE VIOLIN-BOW FIBULA

KULCSSZAVAK: HAMISÍTVÁNY, XRF (RÖNTGENFLUORESZCENCIA SPEKTROMETRIA), FÉMTECHNOLÓGIAI ÉS HASZNÁLATI NYOM ELEMZÉS, "KÉSŐ BRONZKOR", SÁRGARÉZ, UNTERRADL TÍPUSÚ HEGEDŰVONÓ FIBULA

Introduction

Some may think that it 'makes no sense' to re-examine previously published archaeological artefacts. This statement is incorrect of course, as science goes through a continuous transformation with developing questions, concepts, methods, and analytical techniques. A re-analysis of 'old' finds may reveal some new aspects of these long-known objects and assemblages, which can be radically surprising, as we will see in the case of the following ornament.

In this brief study, a violin-bow fibula will be examined by metalwork production and use-wear analysis (Eőry 2009; Tarbay 2012, 121–122; Szabó 2013, 36–39; Dolfini & Crellin, 2016) and X-ray fluorescence technique. It was purchased by the Hungarian National Museum (HNM) in 1948. According to the inventory book of the HNM, the institute bought the object from Elemér Szabó, who stated that the ornament was found on the bank of the Danube River (Dunapart) in Esztergom (Komárom-Esztergom County, HU) (Inventory Book of the HNM, 1948.6).

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Table 1.: Published dimension and weight of the Unterradl type, Podumci variant violin-bow fibulae

1. táblázat: Az Unterradl típus, Podumci variánsába sorolható hegedűvonó alakú fibulák publikált méret és tömeg adatai

	L (mm)	W / H (mm)	Th (mm)	Wt (g)	Condition	Data
Badacsonytomaj-Korkován hegy	58	17	2×2	4	f	Tarbay 2018, 473, Pl. 1.73
Cornocchio	101.00	14.00	unpubl.	unpubl.	f	Montelius 1895, 151, Pl. 24.2; Riemann 1979, 71
Esztergom-Dunapart	**53.11**	**8.82-11.55**	**3.44×2.61**	**2.20**	**"f"**	
Mosonszolnok-Haidehof-puszta	65	unpubl.	unpubl.	unpubl.	c	Patek 1968, 132, Pl. 46.1
Peschiera del Garda	106	unpubl.	unpubl.	unpubl.	f	von Eles Masi 1986, 1, Pl. 1.1
Peschiera del Garda	93	unpubl.	unpubl.	unpubl.	f	von Eles Masi 1986, 1, Pl. 1.2
Podumci	98	unpubl.	unpubl.	unpubl.	c	Glogović 2003, 4, Pl. 1.1
Servirola	129+	37	unpubl.	unpubl.	f	Säflund 1939, 63, Pl. 55.15; Riemann 1979, 72
Servirola	100+	20	unpubl.	unpubl.	f	Säflund 1939, 63, Pl. 55.16; Riemann 1979, 71
Servirola	100	20	unpubl.	unpubl.	c	Säflund 1939, 63, Pl. 55.17; Riemann 1979, 72

L: Length; W: Width; H: Height; Th: Thickness; Wt: Weight; f: fragmented, c: complete

The object was first published by Erzsébet Patek in her seminal monograph on the Transdanubian Urnfield culture in 1968 (Patek 1968, 125, Pl. 64.7).

Metalwork production and use-wear analysis

The object was studied with high-resolution photographs and microscope-camera images made by a dnt DigiMicro mobile camera (image sensor: 5.0MP CMOS, magnification range 20x-500x). In the original publication, the artefact was photographed upside down, from an angle at which it appeared to be a common Late Bronze Age fibula. The unusual technological details of the object were not visible, and these were not described either (see Patek 1968, 125, Pl. 64.7). The object was re-measured (Length 53.11 mm, Width 8.82–11.55 mm, Thickness 3.44×2.61 mm, Weight 2.2 g) as a standard procedure. Even during this process, it was striking that the fibula differed from average Late Bronze Age finds. It is unusually small (see **Table 1.**)

The pin of the fibula is too short to securely fasten. The 'torsion' on its bow part is highly uncharacteristic for prehistoric objects. In the Carpathian Bronze Age, craftsmen applied two different technologies to make torsion-like patterns. Naturally, one of these is *torsion*, which is technically made by twisting a wire with a rectangle cross-section (Armbruster 2000, 107–108). This was most likely the main technology applied for the so-called Unterradl type, where the 'Esztergom fibula' belongs, as most specimens have a rectangle-cross section near to the bow (e.g., Mozsolics 1949, Pl. 22.3; von Eles Masi 1986, Pl. 1.1; Glogović 2003, Pl. 1.1). The other is *pseudo-torsion*. In this case, the twisting was done on a wax model, or the torsion-like patterns were carved into the wax model, and the bronze artefact was cast by lost-wax-casting technique. Patterns could also be engraved into the surface of the cast ornaments, but this process is more time consuming than decorating a wax model. The 'torsion' on the bow of the 'fibula from Esztergom-Dunapart' does not resemble any of the above-mentioned techniques.

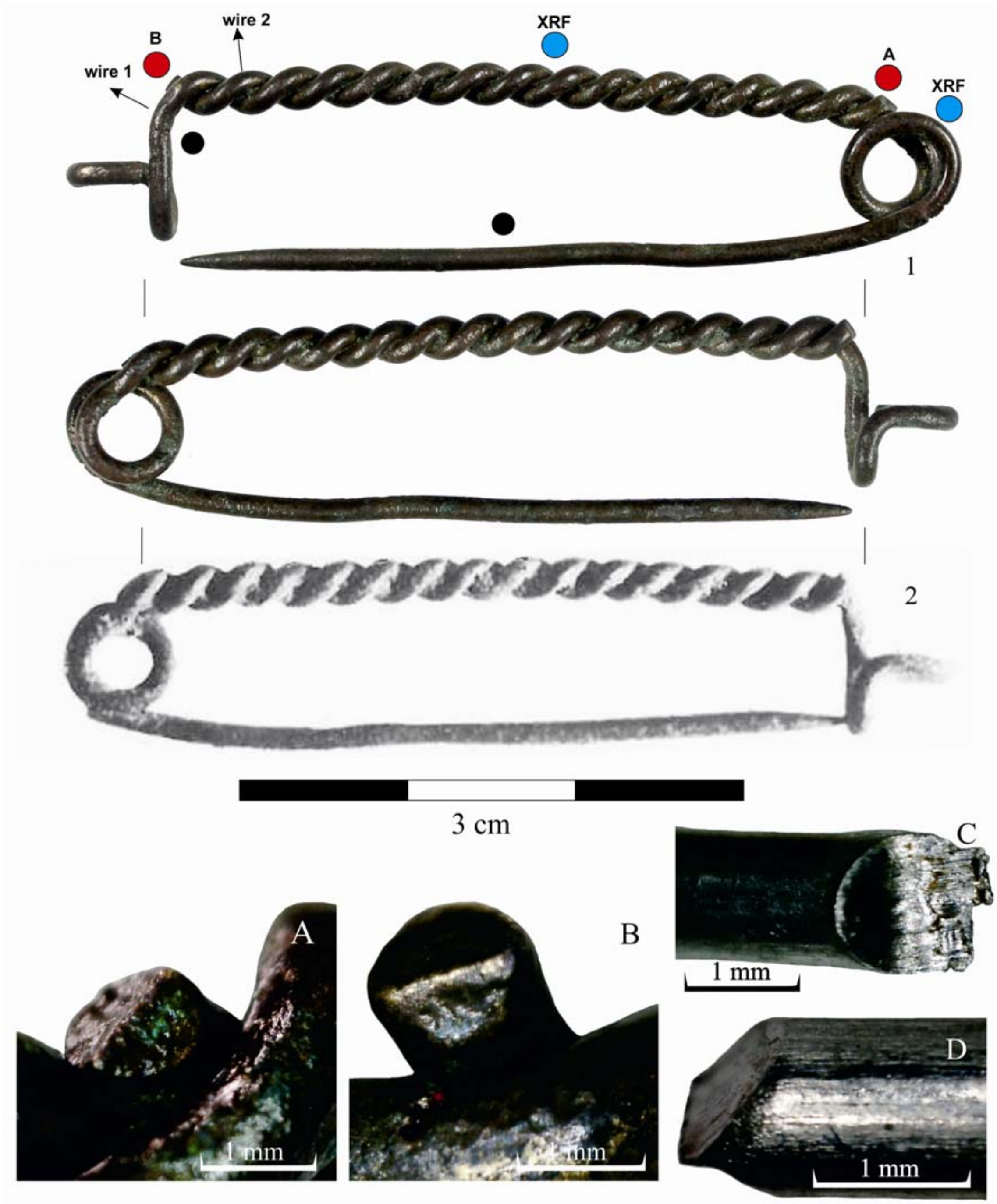

Fig. 1.: 1. The fake fibula from ‘Esztergom-Dunapart’ (Photo: J. G. Tarbay), 2. The photo of the fibula after Erzsébet Patek (Patek 1968, Pl. 64.7), A–B. Asymmetric double cut surface left by end cutting pliers/combination pliers on the fibula from ‘Esztergom’, C. Single cut surface made by straight-edged chisel (modern galvanized steel wire), D. Asymmetric double cut surface left by a combination pliers (modern galvanized steel wire) (Micrographs: J. G. Tarbay).

1. ábra: 1. A hamisított fibula „Esztergom-Dunapartról“ (Fotó: Tarbay J. G.), 2. A fibula képe Patek Erzsébet nyomán (Patek 1968, Pl. 64.7), A–B. Aszimmetrikus, kettős vágási felület az “esztergomi” fibulán, C. Egyenes vésővel ejtett egyenes vágási felület (modern drót), D. Kombinált fogóval ejtett aszimmetrikus kettős vágási felület (modern horganyozott acéldrót) (Mikroszkóp-kamera felvételek: Tarbay J. G.).

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The bow consists of two wires, one forms the body of the fibula with the pin, spring, and hinge (**Fig. 1.,** wire 1) while the other is only present in the bow part (**Fig. 1.,** wire 2). These two wires were simply twisted together, and the terminals of the second were cut off. This 'technique' has no parallels in the known Late Bronze Age material. The cut marks at the two ends of the second wire were not caused by prehistoric tools (**Fig. 1a-b**). During the Late Bronze Age, chisels with straight-cutting edges with or without sockets were mainly used besides gouges, small chisels, and awls (Mozsolics 1985, 38–39; Wanzek 1992, 262, 269–271; Hansen 1994, 150–154; Bălan 2009). Such chisels are still in use, and they are applied for different purposes by silversmiths, bronzesmiths, and woodcarvers. A straight-edged chisel is used with a hammer during partitioning (see Farkas 1981, 96–97) and this tool leaves a single cut surface (**Fig. 1c**). However, on the 'Esztergom fibula' an asymmetrical double-cut surface was observable. Such traces can be created by modern end-cutting pliers or combination pliers (**Fig. 1d**). These are common tools that can be found in almost every 20th century household in Hungary, but obviously they were not used by prehistoric bronzesmiths more than 3,000 years ago.

In brief, the metalwork production and use-wear analysis revealed several unusual characteristics on the object that was found allegedly in Esztergom-Dunapart: 1. atypical dimensions, 2. a bow consisting of twisted wires which poorly imitates torsion technique, 3. modern cut marks made by pliers. These observations suggest that the object is a modern forgery. The interpretation of the results requires further examination of the find's elemental composition to reassure this technological hypothesis.

X-ray fluorescence spectroscopy (XRF)

The application of X-ray fluorescence method to ancient bronzes in various states of preservation divided the archaeological scientific community in the last two decades of the 20th century (Szabó 2010; Szabó et al. 2019). The experts who were aware of the limits of the technique were concerned about handling and publishing XRF results without proper interpretation and considering the presence of the surface patina, previous chemical treatments on the object, and the inhomogeneities of the alloy (Szabó 2010; Shugar & Mass 2013; Pearce 2019). Nowadays, researchers are more familiar with the technique, its possibilities and limits (Maróti et al. 2018, Nørgaard 2017, Maróti et al. 2020; May 2020; Mozgai et al. 2020; Charalambous et al. 2021).

The application of the X-ray fluorescence technique in museum collections, especially on ancient bronzes, received a second boost with the appearance of commercially available handheld XRF spectrometers a decade ago. The non-destructive nature of the method makes it attractive for use in the analysis of cultural heritage objects. The semi-quantitative or qualitative compositional information that can be obtained with the help of the device is often more important than the analytical accuracy. Due to the quick measurement time, numerous objects can be analysed within a relatively short period of time, which allows the on-site examination of complete assemblages (Shugar 2013). It is also a good choice for identifying poor quality forgeries with an atypical elemental-composition pattern (Rózsa et al. 2019).

The elemental composition of the fibula was determined with a handheld Innov-X (now Olympus) Delta Premium XRF spectrometer (**Table 2.**). This device was used earlier in the analysis of numerous Bronze Age objects to determine their alloy-type and to gain preliminary compositional information before the application of different analytical techniques (e.g., prompt gamma neutron activation analysis; Maróti et al. 2018).

The XRF results revealed that the fibula was made of brass instead of bronze (**Fig. 2., Table 2.**). Brass-making probably emerged around the 3rd millennium BC somewhere in the Caucasus and the Middle East (Morton 2019, 3–27). The appearance of brass objects in Central Europe was not typical during the Late Bronze Age. According to Z. Czajlik, zinc-containing objects are unknown in the Carpathian Basin.

Table 2.: Semi-quantitative elemental composition results determined with the handheld XRF spectrometer (Alloy Plus mode)

2. táblázat: Kézi XRF spektrométerrel (Alloy Plus üzemmóddal) végzett mérések félkvantitatív eredményei

Fe	Fe +/-	Cu	Cu +/-	Zn	Zn +/-	Pb	Pb +/-	*Zn / Cu*
0.42	0.02	**89.37**	0.13	**9.75**	0.04	**0.31**	0.01	*0.11*
0.114	0.007	**89.48**	0.13	**9.90**	0.04	**0.41**	0.02	*0.11*
0.249	0.009	**93.82**	0.14	**5.49**	0.04	**0.41**	0.02	*0.06*

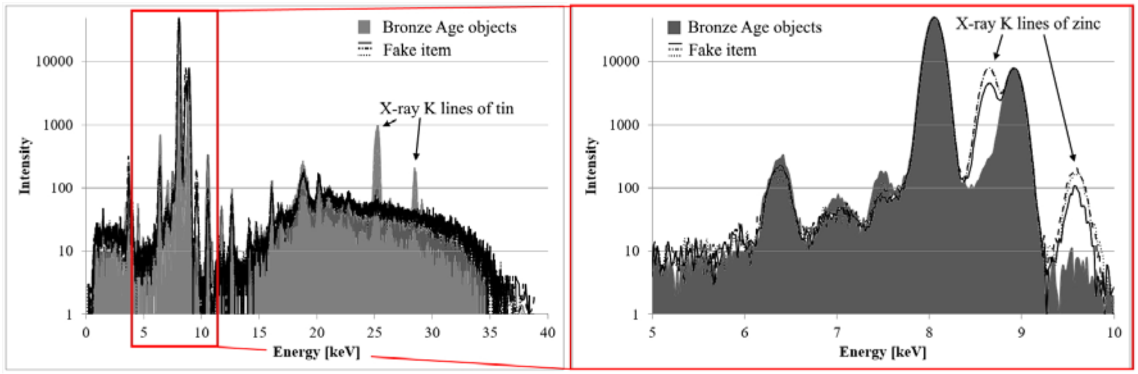

Fig. 2.: XRF spectra of Bronze Age objects from an authentic excavation (gray colour) and the studied 'fibula' (black continuous and dotted lines).
2. ábra: Hiteles ásatásból származó bronzkori tárgyak (szürke színnel) és a jelen tanulmányban vizsgált "fibula" (folytonos és szaggatott fekete vonalak) XRF spektrumai.

High zinc content became common in Central Europe during the Late Iron Age and the Roman Period (Czajlik, 2012, 53, 98). However, there are sporadic cases when zinc also appears in Bronze Age materials, because of zinc's occurrence as an impurity in the copper mineral used for casting (Tylecote 1992, 57; Czajlik 2012, 53, 98). Based on the fibula's zinc content obtained with surface XRF (between 6–10 wt%), the alloy is possibly CuZn10 which has good cold working properties. The material itself is cheap and easily accessible, which makes it a good raw material to produce ornaments and other decorative objects (http://copperalliance.org.uk. /uploads/2018/03/cuzn10-cw501l-datasheet-d2.pdf, last accessed: 25.02.2021, 13:18). Brass has several fine characteristics compared to bronze; brass objects have a rich yellow-golden colour. They are harder and stronger but malleable and ductile as well, which makes them a perfect choice for wire objects in modern industry and silversmithing (Morton 2019, 1).

Discussion

The XRF analysis revealed that the studied fibula consisted of a CuZn10 alloy, i.e., brass, a modern material. There is no need for further detailed comparison with original artefacts to conclude that, along with the result of the production and metalwork use-wear analysis, this object can be identified as a poor-quality forgery. It most likely imitated the violin-bow fibula of similar length and style from Mosonszolnok-Haidehof-puszta (Győr-Moson-Sopron County, HU), which was re-published several times at that time and has certainly been known to the public as well (Sőtér 1892, 207, Pl. I.7; Hampel 1896, 132–133, Pl. 186.7; Reinecke 1899, 249, Pl. 9.5; Márton 1911, 334–336, Pl. 1.2). The studied 'fibula from Esztergom-Dunapart' has uncharacteristic manufacturing traces and was made of a material used in modern metallurgy. The results of our analysis allow us to formulate two conclusions:

First, Elemér Szabó intentionally sold a fake artefact from a fictional site to the Hungarian National Museum back in 1948. In this case, it is important to know the research historical context as well. In the 1940s and 1950s, Late Bronze Age archaeological research focused primarily on the typo-chronological evaluation of artefacts. Seminal typological syntheses and archaeometric studies with large series suitable for comparison have not yet been completed (Czajlik 2012, 11–24; Szabó 2013, 7–27; Szabó et al. 2019). Metalwork production and use-wear analysis in the current archaeological sense were not practiced in Hungary. The possibility to acquire a unique, relative chronologically important fibula had great significance, which could have blinded the expert who made the deal with Elemér Szabó. This is also highly likely because even the exact class ('*arco di violino*') of the object appears in the inventory book (Inventory Book of the HNM, 1948.6). This data was usually not recorded. It should be noted that the alleged provenance also seemed believable, as two original Late Bronze Age swords and a socketed axe have been recovered from the Danube River in Esztergom (See von Kenner 1860, 351, Fig. 34; Mozsolics 1975, 10, Fig. 2.3; Horváth, Kelemen, Torma 1979, 223, no. 8/133).

Second, the sale of the fake fibula created a chain of damage in the archaeological literature dealing with Italian connections or ornament typo-chronology. All conclusions made about this fibula should be dismissed in the future. In the following, we shall briefly discuss the most relevant publications where this ornament has appeared. Erzsébet Patek published it as an original find, and she also catalogued the 'Esztergom-Dunapart' as a Br D/Ha A1 site. Erzsébet Patek has also suggested that this fibula, along with the one from Mosonszolnok, is closely related to the Italian Peschiera metalwork, as both are decorated with torsion (Patek 1968, 74, 77, 84–85, 125, Pl. 64.7). It should be noted that the Italian connection had already been proposed in 1899 in the case of the fibulae from Hungary (e.g., Mosonszolnok) by Moriz Hoernes (See Hoernes 1899, 97–98). His concept was later discussed and rejected by Paul Reinecke (Reinecke 1899, 250) and Lajos Márton (Márton 1911, 334). The forgery fibula was also catalogued in the 5th volume of the Hungarian Archaeological Topography, where it has been mentioned as an original find after Erzsébet Patek with the provenance of Esztergom-Dunapart. However, in this version, it was not the son but Elemér Szabó himself who found the fibula (Horváth, Kelemen, Torma 1979, 226, fn. 26). In 1971, Amália Mozsolics mentioned the object as a violin-bow fibula made of two twisted wires among the characteristic Peschiera types. It is worth noting that she refers only to the plates of Erzsébet Patek's monograph. The otherwise correct statement of Erzsébet Patek, according to which these Transdanubian violin-bow fibulae can be related to their Italian counterparts, particularly to the finds from Peschiera, was not quoted, nor the original idea of Moriz Hoernes (Hoernes 1899, 97–98; Patek 1968, 84–85; Mozsolics 1971, 70–71, fn. 93; Pabst 2011, 219). In 1985, the fake fibula was compared to the specimen from the Badacsonytomaj hoard by Amália Mozsolics (Mozsolics 1985, 68, fn. 92). Tiberius Bader listed the 'Esztergom-Dunapart' find as an original fibula belonging to the Unterradl 'variant' of Paul Betzler (Betzler 1974, 16–21; Bader 1983, 17, fn. 23). In 1988, Frigyes Kőszegi also catalogued and discussed the fibula under the provenance of 'Esztergom-Dunapart'. He connected it to the metal products of the 2nd phase of the Transdanubian Urnfield culture and, without citing the work of T. Bader, he identified the studied specimen as an Unterradl 'type' after the classification of P. Betzler (Kőszegi 1988, 35, fn. 223, 138, no. 358). Recently, the object was catalogued as 'Esztergom-Donauufer' among the 'Podumci' variant of the Unterradl type by Sabine Pabst. Then the distribution map of the Podumci variant with the Esztergom find was then republished at least four times (Pabst 2011, 219, List 1B, Fig. 1.2; Pabst 2012, 317, fn. 6, Map 32; Pabst 2014, 91, fn. 24, Fig. 2; Pabst 2018, 168, Fig. 2).

Conclusions

In this study an old find, a 'violin-bow fibula' allegedly 'from the bank of the Danube River in Esztergom' was re-studied by metalwork production and use-wear analysis and X-ray fluorescence technique (XRF). The results of our analyses suggest that this ornament can be identified as a modern forgery based on its modern manufacturing technological traces and elemental composition (CuZn10). In future analysis, the object should not be included in analytical studies dealing with Rei. Br D–Ha A1/Ha A1 site topography or ornaments, particularly the so-called Unterradl type violin-bow fibulae.

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References

ARMBRUSTER, B. R. (2000): *Goldschmiedekunst und Bronzetechnik. Studien zum Metallhandwerk der Atlantischen Bronzezeit auf der Iberischen Halbinsel*. Monographies instrumentum 15, Edition Monique Mergoil, ISBN: 2-907303-27-9, Montagnac. 107–108.

BADER, T. (1983): *Die Fibeln in Rumänien.* Prähistorische Bronzefunde XIV/6, C. H. Beck'sche Verlagsbuchhandlung, München. 17 pp.

BALĂN, G. (2009): Cronologia şi tipologia dălţilor de bronz cu toc de înmănuşare din România – Chronology and Typology of the Bronze Socketed Chisels from Romania. *Apulum* **46** 1–40.

BETZLER, P. (1974): *Die Fibeln in Süddeutschland, Österreich und der Schweiz I. (Urnenfelderzeitliche Typen).* Prähistorische Bronzefunde XIV/3. C. H. Beck'sche Verlagsbuchhandlung, München. 16–21.

CHARALAMBOUS, A., PAPASAVVAS, G. & KASSIANIDOU, V. (2021): Enkomi (Cyprus): Using pXRF spectroscopy to identify LBA copper alloys. *Journal of Archaeological Science: Reports* **35 102726** https://doi.org/10.1016/j.jasrep.2020.102726

CZAJLIK, Z. (2012): *A Kárpát-medence fémnyersanyag-forgalma a későbronzkorban és a vaskorban*. Talentum könyvek, ISSN 2063-7837, Budapest. 11–24, 53, 98 pp.

DOLFINI, A. & CRELLIN, R. J. (2016): Metalwork wear analysis: The loss of innocence. *Journal of Archaeological Science* **66** 78–87.

VON ELES MASI, P. (1986): *Le fibule dell'Italia settentrionale*. Prähistorische Bronzefunde XIV/5. München. 1 pp.

EŐRY, B. (2009): Késő bronzkori fibula rekonstrukciója – Rekonstruktion einer spätbronzezeitlichen Fibel (Posamenteriefibel). *Ősrégészeti Levelek* **11** 135–138.

FARKAS, L. (1981): *A vésnök*. Ipari szakkönyvtár. Műszaki könyvkiadó, Budapest. 96–97.

GLOGOVIĆ, D. (2003): *Fibeln im kroatischen Küstengebiet (Istrien, Dalmatien).* Prähistorische

Bronzefunde XIV/13, Franz Steiner Verlag, Stuttgart. 4 pp.

HANSEN, S. (1994): *Studien zu den Metalldeponierungen während der älteren Urnenfelderzeit zwischen Rhônetal und Karpatenbecken.* Teil 1-2. Universitätsforschungen zur prähistorischen Archäologie 21, Dr. Rudolf Habelt GmbH, Bonn. 150–154.

HAMPEL, J. (1896): *A bronzkor emlékei Magyarhonban. III. rész: áttekintő ismertetés*. Orsz. Rég. és Embertani Társulat, Budapest. 132–133.

HOERNES, M. (1899): Ueber den Ursprung der Fibel. In: *Serta Harteliana*. Verlag von F. Tempsky, Vienna, 97–103.

HORVÁTH, I., KELEMEN, M. H. & TORMA, I. (1979): *Komárom megye régészeti Topográfiája. Esztergom és a Dorogi Járás. Magyarország Régészeti Topográfiája 5*, Akadémiai Kiadó, Budapest. 223, 226 p.

VON KENNER, F. (1860): Beiträge zu einer Chronik der archäologischen Funde in der österreichischen Monarchie (1856–1858). *Archiv für Kunde österreichischer Geschichts-Quellen* **24** 225–423.

KŐSZEGI, F. (1988): *A Dunántúl története a késő bronzkorban*. BTM Műhely 1, Budapesti Történeti Múzeum, Budapest. 35, 138 p.

MAY Z. (2020): Tíz év a hordozható XRF társaságában, azaz egy archeometriai utazás története / Ten years using portable XRF. Our story of a journey in archaeometry (in Hungarian with English abstract). *Archeometriai Műhely* **XVII/3** 229–242.

MARÓTI, B., RÉVAY, Zs., SZENTMIKLÓSI, L., KLESZCZ, K., PÁRKÁNYI, D. & BELGYA, T. (2018) Benchmarking PGAA, in-beam NAA, reactor-NAA and handheld XRF spectrometry for the element analysis of archeological bronzes. *Journal of Radioanalytical and Nuclear Chemistry* **317** 1151–1163 https://doi.org/10.1007/s10967-018-5990-2

MARÓTI, B.; SZILÁGYI, V.; HARSÁNYI, I.; KASZTOVSZKY, Zs. & SZENTMIKLÓSI L., (2020): Régészeti kőeszközök és bronztárgyak vizsgálata hordozható készülékekkel - Investigation of stone arfacts and bronze objects with portable devices. *Archeometriai Műhely* **XVII/3** 243–252.

MÁRTON, L. (1911): A magyarhoni fibulák osztályozása. *Archaeologiai Értesítő* **31** 329–352.

MONTELIUS, O. (1895): La Civilisation Primitive en Italie. Stockholm. 151 p.

MORTON, V. (2019): *Brass from the past. Brass made, use and traded from prehistoric times to 1800*. Archaeopress, Oxford. 1, 3–27.

MOZGAI, V.; BAJNÓCZI, B.; MAY, Z. & MRÁV, Zs., (2020): A hordozható XRF alkalmazási lehetőségei és korlátai római ezüsttálak archeometriai vizsgálatában / Possibilities and limitations of the use of handheld XRF in the archaeometric study of Roman silver platters, *Archeometriai Műhely* **XVII/3** 253–270.

MOZSOLICS, A. (1949): Két dunántúli bronzlelet a Hallstattkorból – Deux trouvailles de bronze Hallstattiennes, retrouvées en Transdanubie. *Archaeologiai Értesítő* **76** 26–29.

MOZSOLICS, A. (1971): Some remarks on 'Peschiera' bronzes in Hungary. In: BOARDMAN, J. & BROWN, M. A. (eds.), *The European Community in Later Prehistory. Studies in honour of C. F. C. Hawkes*, Routledge, ISBN 9781138817098, London, 59–76.

MOZSOLICS, A. (1975): Bronzkori kardok folyókból. – Bronzezeitliche Schwertfunde aus Flüssen. *Archaeologiai Értesítő* **102** 3–24.

MOZSOLICS, A. (1985): *Depotfundhorizonte von Aranyos, Kurd und Gyermely*. Akadémiai Kiadó, Budapest. 38–39, 68 p.

NØRGAARD, H. (2017) Portable XRF on prehistoric bronze artefacts: limitations and use for the detection of Bronze Age metal workshops. *Open Archaeology* **3/1** 101–122.

PATEK, E. (1968): *Die Urnenfelderkultur in Transdanubien*. Akadémiai Kiadó, Budapest. 7, 77, 84–85, 125, 132 p.

PABST, S. (2011): Die Grossräumige Ausbreitung der Brillenfibeln am Übergang von der Bronze- zur Eisenzeit – Kommunikationswege und Soziale Hintergründe. In: JOCKENHÖVEL, A. & DIETZ, U. L. (eds.), Bronzen im Spannungsfeld zwischen praktischer Nutzung und symbolischen Bedeutung. Beiträge zum internationalen Kolloquium am 9. und 10. Oktober 2008 in Münster. Prähistorische Bronzefunde XX/13, Franz Steiner Verlag, ISBN 978-3-515-09918-9, Stuttgart, 199–234.

PABST, S. (2012): *Die Brillenfibeln. Untersuchungen zu spätbronze- und ältereisenzeitlichen Frauentrachten zwischen Ostsee und Mittelmeer*. VML Verlag Marie Leidorf GmbH, Marburger Studien zur Vor- und Frühgeschichte 25, Rahden/Westf. 317 pp.

PABST, S. (2014): Der Beginn der Fibeltracht im Karpatenbecken und das Verhältnis der Bz D/Ha A A1-zeitlichen Hortfundhorizonte. In: LOŽNJAK DIZDAR, D. & DIZDAR, M. (eds.), *The Beginning of the Late Bronze Age between the Eastern Alps and the Danube. Proceedings of the International conference in Osijek, October 20-22, 2011*, Serta Instituti Archaeologici 1, Archaeological Institute, ISBN 978-953-6064-16-8, Zagreb 2014, 83–99.

PABST, S. (2018): Spätbronzezeitliche Violinbogenfibeln zwischen Donau, mittlerer Adria und Ägäis – Poznobronastodobne fibule v obliki violinskega loka med Donavo, srednjim Jadranom in egejskim prostorom. *Arheološki vestnik* **69** 135–178.

PEARCE, M. (2019): The Curse of the pXRF: the Negative Consequences of the Popularity of Handheld XRF Analysis of Copper-Based Metal Artefacts. *Metalla* **24/2** 81–85.

REINECKE, P. (1899): Tanulmányok a magyarországi bronzkor chronologiájáról (Első közlemény). *Archaeologiai Értesítő* **19** 225–251.

RIEMANN, HANS (1979): Studien zu den Violinbogenfibeln. *Mitteilungen des Deutschen Archaeologischen Instituts Roemische Abteilung* **86** 5–86.

RÓZSA, Z., TÓTH, Sz. & MAY, Z. (2019): Preliminary archaeometric studies and results of fake denars from Friesach found in the inheritance of a community in the Árpád-era dealing with money exchange, *Archeometriai Műhely* **XVI/1** 57–62.

SÄFLUND, G. (1939): Le Terremare delle Provincie di Modena, Reggio Emilia, Parma, Piacenza. Skrifter Utgivna av Svenska Institutet i Rom 7, Lund/Leipzig. 66 pp.

SHUGAR, A. N. (2013): Portable X-ray Fluorescence and Archaeology: Limitations of the Instrument and Suggested Methods To Achieve Desired Results, *Archaeological Chemistry VIII.* **January 1**, 173-193. https://doi.org/10.1021/bk-2013-1147.ch010

SHUGAR, A. N. & MASS, J. L. (2013): Handheld XRF for Art and Archaeology. Leuven: Leuven University Press, muse.jhu.edu/book/24930.

SŐTÉR, Á. (1892): Mosony-Szolnok és Mosony-Jessehofi bronz kori leletek. *Archaeologiai Értesítő* **12** 207–212.

SZABÓ, G. (2010): Az archaeometallurgiai kutatások gyakorlati és etikai kérdései – Practical and ethical issues of archaeometallurgical research. *Archeometriai Műhely* **VII/2** 111–122.

SZABÓ, G. (2013): *A dunántúli urnamezős kultúra fémművessége az archaeometallurgiai vizsgálatok tükrében – The Metallurgy of the Transdanubian Urnfield Culture in Light of Archaeometallurgical Investigations*. Specimina Electronica Antiquitatis – Libri 1, Pécs. 7–27, 36–39 p.

SZABÓ, G., BARKÓCZY, P., GYÖNGYÖSI, Sz., KASZTOVSZKY, Zs., KÁLI, Gy., KIS, Z., MARÓTI, B. & KISS, V. (2019): The possibilities and limitations of modern scientific analysis of Bronze Age artefacts in Hungary – Lehetőségek és korlátok a bronztárgyak modern műszeres vizsgálatában Magyarországon. *Archeometriai Műhely* **XVI/1** 1–12.

TARBAY, J. G. (2012): Újabb paszományos fibulák a Dunántúlról: Kesztölc és Dunaújváros – New passementerie fibulae from Kesztölc and Dunaújváros in Transdanubia. Ősrégészeti Levelek 12 (2010 [2012]) 115–136.

TARBAY, J. G. (2018): A gyermelyi típusú kincsek és koruk. Eötvös Loránd Tudomány-egyetem, PhD Disszertáció. Budapest. 473 p. DOI: 10.15476/ELTE.2018.167

TYLECOTE, R. F. (1992): *A History of Metallurgy.* 2nd Edition. Maney for the Institute of Materials, London. 57 p.

WANZEK, B. (1992): Der älterurnenfelderzeitliche Hortfund von Lengyeltóti („Lengyeltóti II”) Komitat Somogy, Ungarn. Eine Vorlage. *Acta Praehistorica et Archaeologica* **24** 249–288.