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Karina Grömer, Alexandra Krenn-Leeb und Michaela Binder

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Umschlagbild: Der Goldschatz von Ebreichsdorf in Österreich, 1200-1000 v. Chr. (Foto: A. Schumacher, NHM Wien).

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Prehistoric gold finds in the 2nd and 1st millennium BCE in Europe: Interdisciplinary results and their significance. Foreword to Volume 154 of the MAGW

by

Alexandra Krenn-Leeb – Karina Grömer – Michaela Binder, Vienna

The discovery of the Ebreichsdorf gold treasure in March 2020 in the Bronze Age settlement of Ebreichsdorf, Lower Austria, during archaeological excavations carried out by Novetus GmbH in 2019 and 2020 prior to the extension of the Pottendorfer line of the ÖBB (Austrian Federal Railways) opened the possibility for new perspectives on gold artefacts.

In order to place the prehistoric gold finds from Ebreichsdorf into a wider context, international expert colleagues were invited to contribute. It was the aim to shed light on the material culture of the 2nd and 1st millennium BCE in Europe, especially relating to gold artefacts regarding aspects such as typology, trade and networks, raw material origin or production details.

Therefore, an international symposium "The Gold Treasure of Ebreichsdorf – Prehistoric Gold Finds in the 2nd and 1st Millennium BCE in Europe" was held at the Natural History Museum Vienna from 18 to 20 August 2023. It was organised by the Natural History Museum Vienna, the Department of Prehistoric and Historical Archaeology at the University of Vienna, the Federal Monuments Authority Austria, Novetus GmbH and the Austrian Society for Pre- and Proto History. The symposium included the presentation of the book on the Ebreichsdorf gold ensemble (Grömer – Binder – Krenn-Leeb 2023). During the conference, the gold treasure from Ebreichsdorf was officially donated from the Austrian Federal Railways ÖBB to the Natural History Museum Vienna and thus made permanently accessible to the public.

The present volume 154 of the *MAGW Mitteilungen der Anthropologischen Gesellschaft in Wien* shows the results of the interdisciplinary investigations on the Ebreichsdorf gold ensemble on the one hand and on the other hand the results of the broad discussion about the origin of gold – the gold mines, the use of gold, some gold convolutes of the Bronze Age, some special gold artefacts and types as well as aspects of gold in the Iron Age.

The gold treasure of Ebreichsdorf

This volume starts with a main focus on the gold treasure of Ebreichsdorf. An international and interdisciplinary team of experts analysed aspects of production, processing and cultural importance of the gold ensemble. The results of these analyses were presented for the first time at the symposium.

In the case of the Ebreichsdorf gold find complex, many scientific disciplines were involved in addition to archaeology, such as archaeometallurgy, geochemistry, metallography, textile technology, DNA analysis and specialised conservation. Methods used include computer tomography, microscopy in various qualities, laser ablation, photography, 3D scanning

technology, graphics, typochronology and experimental archaeology, among many others. The interdisciplinary team comprises about 20 scientists from Austria and Germany and was mainly initiated by the Federal Monuments Authority Austria (Martin Krenn), the Novetus GmbH (Michaela Binder), the Natural History Museum Vienna (Karina Grömer) and the Department of Prehistoric and Historical Archaeology at the University of Vienna (Alexandra Krenn-Leeb). The aim was to integrate the gold ensemble of Ebreichsdorf into the phenomenon of Bronze Age metal hoards – especially gold hoards – in the European region.

However, a requirement for such an insight is also the careful conservation of the individual objects. We therefore decided to leave them in the state in which they were found and not to restore them into their original shape – especially the deformed gold sheet bowl. In addition, the gold finds were initially left unrestored so that each team member could still examine them in the original condition. Already during the careful conservation, some scientific analyses were carried out. After the conservation was completed, the remaining analyses were conducted.

Michaela Binder, Özlem Breineder and Alexander Stagl present an insight about the archaeological investigations at the newly discovered site in their article "Setting the stage – The archaeological background of the Ebreichsdorf gold treasure". Especially the excavated Middle and Late Bronze Age settlement of Ebreichsdorf has brought many features to light, such as pits, houses, a ceramic vessel deposition and some wells. Many bronze artefacts, which were deposited into an old arm of the Fischa as objects of ritually motivated activities, display the importance of this site.

The archaeometallurgical investigations by Ernst Pernicka and Moritz Numrich in their article "Composition and provenance of the gold from Ebreichsdorf" provide insights into the region of the possible gold deposit and the metallurgical composition of the various artefacts of the Ebreichsdorf gold find complex. A fundamentally important realisation is that the gold is alluvial and not mined, which significantly expands the possible deposit areas. The geochemical analysis of the trace elements indicates that it originates from the southern slopes of the Slovak Ore Mountains. Furthermore, the gold sheet differs in gold composition from the rest of the gold objects by a higher copper content. On the one hand, this could have been due to the aesthetically or ritually motivated desire to thereby achieve a richer golden yellow. On the other hand, this could also indicate that the gold sheet bowl came from a different metallurgical workshop and that the gold find complex could therefore have been composed of products from different production sites or charges. Whether the production sites were also located in the area of the Slovak Ore Mountains is currently unknown. However, the closest comparable finds to the gold wire spirals and gold wires were found in the Salzkammergut in Upper Austria. At least the wire objects could have been produced in workshops that were definitely more regional.

The metallographic investigations by Robert Linke and Birgit Bühler in their paper "Herstellungstechnische Untersuchungen am Goldfund von Ebreichsdorf" have shown that the known tools and techniques of metal craft of the (Late) Bronze Age were used at the gold find complex of Ebreichsdorf. Exclusively punching and embossing techniques without the loss of material were used to decorate the gold sheet bowl, which thereby ensured an optimal use of the valuable raw material gold. Even though no goldsmith's tools were found in Ebreichsdorf, the hallmarks and the decorative motifs produced with them correspond to the supra-regionally widespread and high-quality metal craft in Europe. However, the typochronological analysis has also shown that the creative use of only a few punches has created a hitherto unique overall decoration of the gold sheet bowl. In the manufacture of gold wire objects, three main types of decorative wire can be distinguished – the notched wire, the twisted wire and the corded wire. Their application is limited to gold wire spirals that were

made from a so-called endless wire. For this purpose, strips of gold sheet of a certain length were slit and then carefully rolled between two ground and finely polished stones to form a double-stranded wire.

In the course of the textile-technological examinations in the article "The gold threads from Ebreichsdorf in Austria – analysis and reconstruction" by Kayleigh Saunderson and Karina Grömer, the gold threads were examined with the most modern technical procedures, which would not have been possible in this way just a few years ago. It was possible to determine that these must have been three different textiles. A gold thread workshop, which took place in February 2022 as a citizen science project at the Natural History Museum Vienna, contributed significantly to experimentally testing various weaving and decoration techniques, but also folding techniques on textiles. Despite the rare but comparable combination of gold-decorated textiles and other gold objects that were intentionally deposited together as an assemblage, the textile remnants can certainly be said to have an effective and fundamentally extraordinary function. Due to the preserved size and the extraordinary craftsmanship with interwoven gold threads, it could have been part of a regalia or a ceremonial garment, which may have covered only a part of a body or a figure.

In "The gold find complex of Ebreichsdorf and its cultural significance", Alexandra Krenn-Leeb emphasises the character of the gold ensemble, consisting of a gold sheet bowl, two large interlocked gold wire spirals, eight small interlocked gold wire spirals, the gold thread bundle as remains of three different textiles and three broken gold wires (probably from the bundle), as components of an exceptional ensemble for ritual practices. Wearing regalia or certain clothing components that defined a regalia and the use of extraordinary gold artefacts, such as the gold sheet bowl and the interlocked gold wire spirals, can only be associated with extraordinary acts because of the exclusivity brought about by the integrated gold. Ritual practices are often characterised by well-considered and outstanding presentations with performance aspects. In addition to precisely defined objects, this also includes correspondingly extraordinary clothing. The typochronological investigations have shown that the gold find complex as a whole follows a supra-regional concept and that therefore also widely comparable actions with a ritual sequence can be assumed with regard to original function and deposition. Due to the motifs and shapes of the individual artefacts, comparable examples can be used to determine an approximate date of their production, use, and finally their deposition in the ground.

The origin of gold – gold mines

Hristo Popov presents "The Late Bronze Age gold mine Ada Tepe in the context of interregional contacts in the North Aegean and the Eastern Balkans in the 2nd millennium BCE". The gold mine situated in the Eastern Rhodope Mountains features all steps and features of the "châine opératoire" of mining and processing gold and the structure of specialised mining societies.

Plamen Georgiev, Stanislav Iliev†, Ivan Ivanov and Hristo Popov show in their article "More than one Ada Tepe gold mine? Non-destructive archaeological investigations of traces of ancient exploitation of mineral deposits in South Bulgaria (preliminary results)" that some recently discovered evidence of gold and copper mining, partially also with traces of underground mining.

Ruslan Stoychev, Stanislav Iliev†, Hristo Popov and Ivan Ivanov introduce "The ancient gold mine Stremtsi-Rani List in Eastern Rhodope Mountains", one of the best-preserved gold mines there, and give an overview of the systematic research since 2017. The detected three periods of activity – the Late Bronze Age/Early Iron Age, the 3rd to 6th and the 10th to 12th centuries CE – indicate that the ancient gold mine near Stremtsi delivers a good perspective for long-term mining-archaeological research.

Overviews of the use of gold: distribution and influences

In Albrecht Jockenhövel's article "Where has all the Ada Tepe gold gone…? Bronze Age gold as a raw metal: A missing link in the *chaîne opératoire* in gold processing – some remarks", he considers whether some gold artefacts, such as semi-finished products, coiled wire rolls, rod-shaped bars, etc., have a pre-monetary character or a jewellery- and weight-based basic form. Recycling would have also played a role.

Petya Penkova and Krastyu Chukalev give an overview of "Late Chalcolithic gold finds from the collection of the National Archaeological Institute with Museum at the Bulgarian Academy of Sciences". In this study, they were examined according to their functional purpose and chronology, also using methods of traceology.

Krasimir Nikov presents "New evidence for relations between Southern Thrace and Anatolia in the late 3rd and early 2nd millennia BCE". A part (pendant) of a gold composite ornament was discovered during rescue excavations in the central part of Southern Thrace. Its manufacturing technique and some features of the overall design bring it close to some of the ornaments, like diadems and earrings, from the treasures of Troy and Poliochni.

Szilvia Guba, Nicklas Larsson, János Dani, Anikó Angyal and Károly Tankó report on some hoards with gold artefacts in their article "Forging – hoarding – burying: Use of gold in North Hungary in the Middle and Late Bronze Age". Concentrations of hoards in fortifications could be observed. Recently found gold jewellery and the result of their analytical examinations (PIXE, XRF) are presented.

Ondřej Chvojka, Markéta Augustýnová, Daniel Hlásek and Jan John present "Gold of the Bronze Age in Southern and Western Bohemia". For the Bronze Age, there is still no clear evidence of the extraction of local gold. Due to the occurrence of gold artefacts in the Bronze Age in graves, hoards, in some settlements and even as isolated finds as well as due to the connection of many sites to gold deposits, the authors assume that local gold extraction already occurred in the Early Bronze Age.

Fraser Hunter and Matthew G. Knight contributed with "A long-term view of gold use in Scotland from the Chalcolithic to the Iron Age". They recognise changes from artefact groups and materials and also regional and technological modifications. The detailed uses varied, with a focus on very visible neck ornaments in the Early Bronze Age and Iron Age, in contrast to the Late Bronze Age, when smaller gold ornaments were worn more widely across the body, and gold was more socially widespread.

Gold convolutes of the Bronze Age

Daniel Neumann, Thomas Terberger, Henning Hassmann and Wiebke Kirleis present "The gold hoard of Gessel (Lower Saxony, Germany) – deposition, landscape and exchange in the Bronze Age", which is one of the most important gold ensembles, discovered during rescue excavation in 2011. Therefore, it offers excellent conditions for multidisciplinary research related to the precious metal, objects and composition as well as the landscape where the hoard was deposited. The eight interlocked gold wire spirals with ten links each are remarkable.

Martin Gamon, Dominik Lane, Timothy Taylor, Maximilian Piniel, Cornelia Hascher, Mathias Mehofer, Daniel Kuen and Friedrich Mayr-Melnhof introduce the relatively new "Gold Finds from the Buchberg, an Urnfield Culture Hillfort settlement on Lake Attersee, Austria". Four remarkable depositions – one with three gold wire spirals and three gold wire fragments – were discovered as part of an intensive metal detection survey of the BeLaVi-Project (FWF I-1693).

Maria Windholz-Konrad presents "Das Golddrahtkonvolut südöstlich von Hallstatt im Hortkontext", which was discovered in 1994. These gold wires seem to be deformed intentionally before being deposited. The author suspects a possible import as early as in the Middle Bronze Age from a milieu of the Aegean Bronze Age and a later deposition in the Koppen Valley.

Carola Metzner-Nebelsick and Ernst Pernicka discuss "Two 8th century BCE gold hoards from Mikhal'kiv, Ukraine, and comparable finds. Their context, composition and results of a laser ablation and QICP-MS analysis". The micro-invasive laser ablation and QICP-MS analyses revealed that the examined objects from both hoards have an identical gold composition. A second series of measurements was carried out on two unprovenanced gold plates acquired from the art market, which correspond stylistically to the Mikhal'kiv-Dalj hoard find complex. But they belong to a different variety of gold.

Nikolaus Boroffka, Marian Neagoe and Oana Neagoe present "Șișești. Ein neuer spätbronzezeitlicher Hortfund aus Rumänien – vorläufige Bemerkungen", which contains bronze and gold objects. A small selection of the objects is presented and placed in a European context by mapping analogies. Thereby a difference is observed between rather local tools and weapons (only from bronze) and the jewellery (of bronze and gold), the find concentrations of which lie predominantly in more distant regions.

Special gold artefacts and types

Barbara Armbruster provides an overview of "Prehistoric precious metal vessels – a brief synthesis" on the basis of case studies from Spain to Scandinavia. Technical aspects of production concerning the tools and the chaîne opératoire, from the ingot to the decorated finished product, are mentioned.

Harald Meller, Oliver Dietrich and Christian-Heinrich Wunderlich discuss "Die Goldschale von Krottorf und ihre Datierung" and the fact that many vessels can only be dated to the Middle and especially the Late Bronze Age by comparing stylistic details. Arguments are presented in favour of a Middle Bronze Age date of the gold sheet bowl from Krottorf.

Matěj Kmošek, Stanislav Stuchlík and Nikola Šuhejová present "A new find of a gold sheet headband of the Urnfield culture from Opava (CZ)", which seems to be a headband or head adornment. It symbolises the exceptional social status of its owner.

In Marina Kalpachka's and Petya Penkova's contribution "Comparative study of two gilding techniques: The rhyton from Zlatinitza and the decorative element from Dolna Koznitza", they focus on the gilding techniques, trying to put a remarkable rhyton in the context of other previously studied examples of Thracian toreutics.

Tomáš Zachar reports about "*Aurum vegetabile*. Das Phänomen des „Goldgewächses" zwischen Alchemie und prähistorischer Archäologie". The early modern alchemists in Central Europe – in most cases in Slovakia and northern Hungary – believed that the gold wires that were sometimes found wrapped around vines or grain grew out of the gold-bearing soil. Predominantly, they correspond to the Middle and Late Bronze Age gold finds of the Pilinyer culture (c. 1500–1100 BCE). An important site for the 'gold plant' is situated near the town of Zvolen. Published in 1850, the gold wire was examined using scanning electron microscopy to determine the manufacturing technology, as an example of *aurum vegetabile* from the collections of the Natural History Museum in Vienna.

In her contribution "Anmerkungen zu den goldenen Doppeldrahtspiralen der Spätbronzezeit in der Lausitz und ihrem Umfeld", Regine Maraszek points out the distribution, classification, chronology, context, function and interpretation of double wire spirals. Jaroslav Peška presents "Ein neuer Hortfund von Golddrahtrollen in Mittelmähren" with four pairs of

interlocked gold wire spirals and a total weight of 630.28 g. The use as a stabilised form of a semi-finished product or a pre-monetary means of payment may seem plausible.

In "Materialtechnologische Untersuchungen zu einem Golddrahtbündel aus Leithaprodersdorf, Kreuzäcker", Robert Linke and Violetta Reiter show that the gold wire spiral with seven links can be compared with the small gold wire spirals with eight links of Ebreichsdorf.

Ina Schneebauer-Meissner and Heiner Schwarzberg present "Bronzezeitliche Goldtextilien aus Bayern – ein Blick in den Bestand der Archäologischen Staatssammlung München". They differentiate between three groups of gold textile components: gold threads, gold leaf and gold tubes. Violetta Reiter reports in her article "Klein aber fein. Gold aus Steyr (OÖ). *Small is beautiful*" about a little gold wire in a grave from the beginning of the Late Bronze Age.

Gold in the Iron Age

Christiane Eluère presents "The gold jewellery of a presumed forerunner of the Early Iron Age chieftains in the grave of Saint-Romain-de-Jalionas (Isère, France)", which contained the most western example of the Hajdúböszörmeny bronze situla type and three pieces of gold jewellery: a torc, a bracelet and a pin. A detailed examination draws the attention to chronological gaps, relations to the Carpathian Basin and the exceptional character of the find.

With their contribution "Material identities: Studies on Early Iron Age gold rings from Southwest Germany", Birgit Schorer and Gerd Stegmaier show that great similarities have been found in terms of design and manufacturing technique. Even the use of identical raw materials could be proved. This points to the production of the pieces in the same workshop as well as other interesting aspects.

Anja Hellmuth Kramberger points out some Western Asian and Assyrian influences in the ornamentation of the golden headdress and the decoration of the robe of the buried person in "Zur vorderasiatischen Komponente in der Tracht aus Grab 27 im Grabhügel I/48 von Stična, Slowenien".

In his article "Gold of the Ancient Celts – A hoard of rings and coins from Neumarkt near Salzburg", Holger Wendling discusses the importance one of the more recent hoards. The Federal Monuments Authority Austria, branch Salzburg (Peter Höglinger) recovered 28 Celtic silver coins (tetradrachms, around the middle of the 1st century BCE), four finger rings, a massive bracelet and a twisted gold torques.

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Where has all the Ada Tepe gold gone…? Bronze Age gold as a raw metal: A missing link in the *chaîne opératoire* in gold processing – some remarks

by

Albrecht Jockenhövel, Emsdetten

Summary

Studies on the gold mine on Ada Tepe hill in south-eastern Bulgaria, which was exploited between the 16th and 13th centuries BCE, enable us to follow the journey of the Ada Tepe gold from its origin to the consumer. Gold in the shape of bun ingots, ingots, bars, semi-finished products, etc. belongs in this context. These are almost exclusively small-sized and low-weight pieces, which are not sufficient to produce larger gold artifacts. Therefore, it can be assumed that certain shapes of wires were used for further gold processing as well. The recycling of gold artifacts ("gold eats gold") certainly played another central role in the *chaîne opératoire* of the most valuable metal of the Bronze Age in Europe and beyond.

Keywords: Later Bronze Age, gold mine, Ada Tepe (SE-Bulgaria), gold as raw metal (ingots, bars, semi-finished products), recycling

Zusammenfassung

Forschungen zum Goldbergwerk auf dem Ada Tepe Hügel in Südost-Bulgarien, das zwischen dem 16.–13. Jahrhundert v. Chr. ausgebeutet wurde, machen es möglich, den Verbleib des Ada Tepe-Goldes auf seinem Weg vom Ursprung bis zum Verbraucher zu untersuchen. In diesen Zusammenhang gehört Gold in Form von Gusskuchen, Rohlingen, Barren, Halbfabrikaten usw. Es sind fast ausschließlich kleinformatige und sehr leichte Stücke, die nicht ausreichen, um größere, schwere und zahlreiche Artefakte aus Gold herzustellen. Es wird daher vermutet, dass auch bestimmte Drahtformen zur Weiterverarbeitung verwendet wurden. Das Recycling von Artefakt-Gold – „Gold frisst Gold" – spielte sicherlich auch in der europäischen Bronzezeit eine zentrale Rolle.

Stichworte: Spätbronzezeit, Goldbergwerk, Ada Tepe (SO-Bulgarien), Gold als Rohmetall (Gusskuchen, Barren, Halbfabrikate), Recycling

I

The exploration of the Late Bronze Age gold mine on Ada Tepe hill in the Eastern Rhodope mountain, southeast Bulgaria, opened a new chapter in the history of Bronze Age mining (Popov – Jockenhövel 2018). The importance of the site does not only derive from the fact that it is the first valid archaeological evidence of Bronze Age gold mining in Europe but also from its geographical position between the advanced civilizations (states) of Anatolia,

the Eastern Mediterranean, the Near East and Egypt and the temperate European "barbarian" societies along the Danube River as far as Central Europe. The gold mine on the Ada Tepe hill was only exploited for a relatively short time, i.e. from the late 16th century to the 13th century BCE (Popov et al. 2024, in print). This short period opens up the possibility of tracing the potentially direct or meandering path of mined gold to the worked gold from the 16th century BCE onwards.

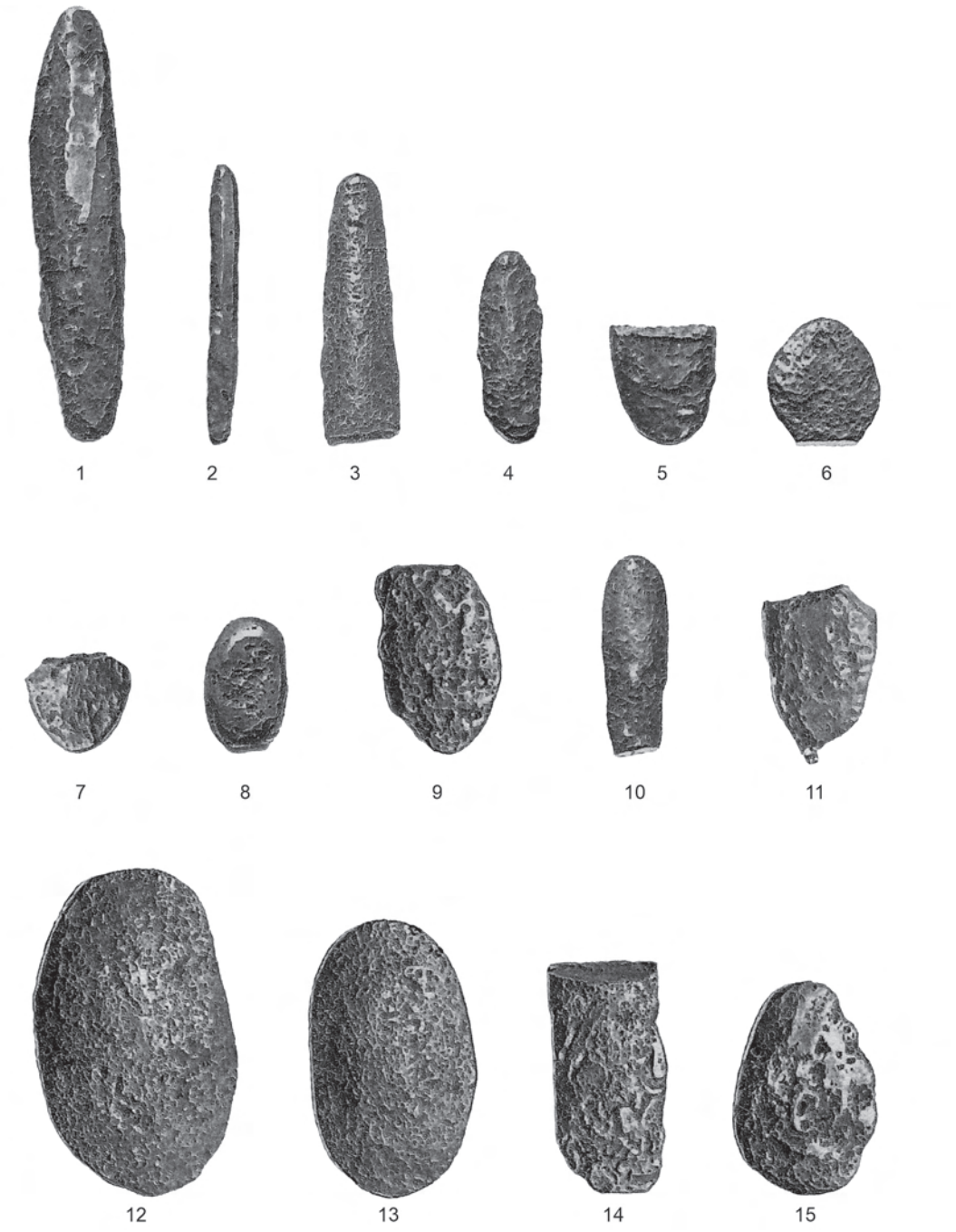

Fig. 1: Sázsádány (HU) (Mozsolics 1950, Taf. 10,24–38). – Scale 1:1,25 (image: R. Roling).

According to the EDXRF-analyses available so far from the Ada Tepe mine, it is a deposit of hard rock gold with an average of 83.4 % Au (gold), 15.4 % Ag (silver) and 1.1 % Cu (copper) (Prof. Z. Tsintsov †, Sofia, pers. comm.). It is therefore likely that some European gold artifacts of the 16th–13th centuries BCE were made from Ada Tepe gold or at least contain it.

Several artifacts which can be interpreted as remains from the *chaîne opératoire* of the local gold metallurgy have survived inside the large settlement at Ada Tepe hill: a piece of gold slag, a small, smelted gold ball (fig. 2/8) and a biconical gold bead as well as stone moulds for casting bar-shaped ingots. In addition to traces of bronze, the negatives of these moulds also contain traces of gold and silver, which proves a mutual use of the moulds or an intentional gold-copper alloy (Dr. Petya Penkova, Sofia, pers. comm).

II

In what form did the gold enter the Bronze Age metal circulation? Like other metals, gold circulated as raw metal, ingots, semi-finished products (blanks), recycling or scrap material of gold artifacts, Several textual and iconographic sources from Ancient Egypt – then the richest country in the ancient world of gold – bear witness to how huge gold was stockpiled in the so called "treasure houses " in form of shapeless lumps, heavy rings ("ring gold") or bags filled with gold dust (Wreszinski 1935, pl. 33; Klemm – Klemm 1989, 227–228, fig. 26.2) The peak of Egyptian gold mining in the New Kingdom (Klemm – Klemm 2013, 25) coincides with the mining on Ada Tepe hill. The natural gold came from several main mining regions in Ancient Egypt and Nubia. In the Homeric world of "Dark Age" Greece, local "kings" stored their gold treasures in their "palaces" and gave needed gold to their commissioned goldsmiths (Od. 3, 436–438).

In clear contrast to this, in the European Bronze Age, despite its often very extensive and heavy bronze hoards rich in raw metal (bun ingots, bar ingots, etc., cf. "*Brucherzfunde*"), gold is seldom found as a raw metal in the archaeological record. This is demonstrated by a review of the relevant literature from across Europe as well as by an evaluation of finds on the Portable Antiquities Scheme (PAS) database covering England and Wales. This lack of evidence for gold as a raw metal was initially due to the generally poor find records relating to gold discoveries. Many gold finds were dug up by individuals with criminal or at least opportunistic motivation. Due to the limited space in this contribution, only gold objects from the technological intermediary position between mined gold and worked gold, which up until now have rarely been examined, are considered below.

Apart from a few exceptions (Eluère 1982, 112, 272), gold as a raw material is always found in small pieces and light weights. The gold hoard from Sárazsadány (Borsod-Abaúj-Zemplén, Hungary), originally weighing approximately 12–13 kg, of which only approx. 1.8 kg remain, is a key find for the recognisability of gold as a raw metal (fig. 1).

A half of a cast bun ingot (weighing 91.86 g) was found in the famous gold treasure of Eberswalde (Brandenburg, Germany) (Schuchhardt 1914, pl. II. XI; Tolstikov – Kuzminych – Hänsel 2013) (fig. 2/7). Amorphous raw metal objects are known from Hungary and Romania (fig. 2/4–6. 12. 15. 16), France (fig. 2, 2/8), Western Europe, Britain and Ireland (fig. 2/1. 9, 10. 17). In the shipwreck of Uluburun (Turkey), raw gold was found in the form of a flat discoid raw piece (23.94 g), a small disc (2.12 g) and a ring blank (60.61 g) (fig. 2/ 3;12; 4, 12). This crude ring is comparable with a ring from Esposende (Portugal) (82 g) (fig. 4/11). The tiny gold drop from Válvölgy, hoard II (Hungary) shows that the smallest piece of gold was preserved (fig. 2/15).

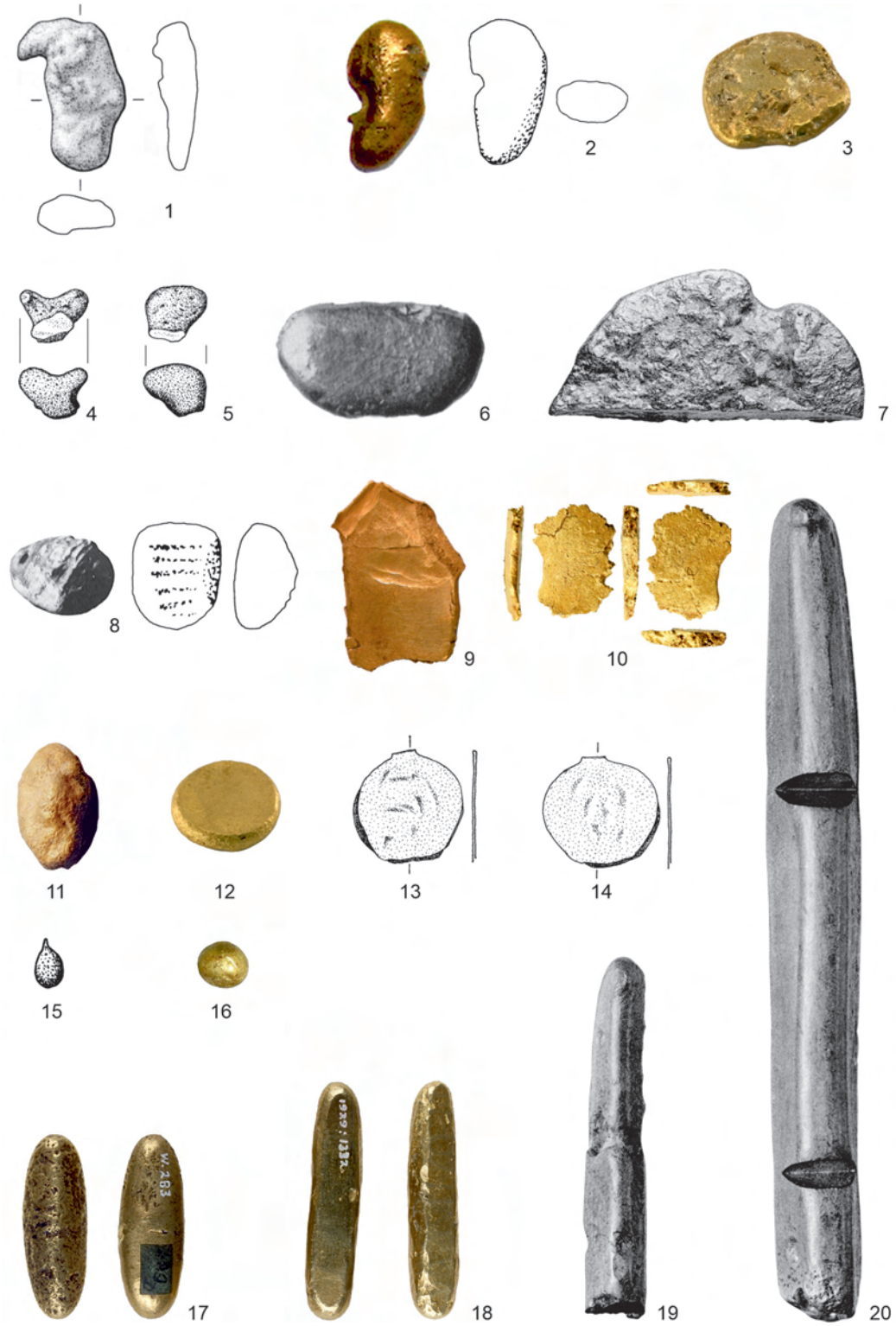

Fig. 2: (w. = weight/g; PAS = Portable Antiquities Scheme: https://finds.org.uk). 1 Whitesands Bay (GB) (w. 22.68 g) (Aldhouse-Green – Northover 1996, 225 fig. 2,b). – 2 Dép. Morbihan ou Finistère (F) (w. 17.90 g) (Eluère 1982, 273; Hermann et al. 2021, 227, fig. 5). – 3. 12 Uluburun (TR) (w. 23.94 g; 2.12 g) (Yalcin et al. 2005, 612 Nr. 141. 142). – 4. 5. 13–15 Várvölgy, hoard II (HU) (w. 3.6 g; 3 g; 0.1 g; 1 g; 1 g) (Müller 2013, 85 fig. 3, 7–10). 10). – 6 Șmig (RO) (w. 41.94 g) (Mozsolics 1968, pl. 15, 13). – 7. 19. 20 Eberswalde (D) (w. 91.86 g; 286.24 g; 46.36 g) (Schuchhardt 1914, pl. II. 2; XI). – 8 Saint-Jean-Trolimon (F) (w. 19.82 g) (Eluère 1982, 113 fig. 132,1). – 9 Sennen (GB) (w. 10.34 g) (PAS: CORN-ECECE2). – 10 Winteringham (GB) w. 3.69 g) (PAS: NLM-C0A809). – 11 Troy, Treasure L (TR) (Tolstikov 1996, 171 fig. 217 bottom right). – 16 Ada Tepe (BG) (w. 0.6 g) (Hristo Popov, © NAIM). – 17 Ireland (IRL) (w. 19.24 g) (© Mary Cahill). – 18 Askeaton (IRL) (w. 21.77 g) (© Mary Cahill). – 1–10. 13. 14. 17–20 Scale 1:1; 11. 12. 15. 16 Scale 2:1; 11 Scale ? (image: R. Roling).

Fig. 3: (w. = weight/g; PAS = Portable Antiquities Scheme: *https://finds.org.uk*). 1 Brabourne (GB) (w. 12.9) (PAS: KENT-ED8F86). – 2 Llanarmon-yn-Iâl (GB) (w. 28.5 g) (Green 1983, 385 fig. 13,4). – 3 East Claydon (GB) (w. 22.8 g) (PAS: HESH-092511). – 4 Wembury (GB) (w. 26.22 g) (PAS: DEV-587171). – 5. 6 Mooghoun (IRL) (w. 41.21; 112.3 g, after Wilde 1862, 50–51) (Armbruster 2021, 95 fig. 93). – 7 Eberswalde (D) (w. 19.59 g) (Schuchhardt 1914, Taf. XI; Piotrovski 2013, 15 fig. 214.15c). – 8 Cornwall (GB) (w. 3.99 g) (PAS: CORN-5B1674). – 9 Chalvington-with-Ripe (GB) (w. 5.7 g) (PAS: SUSS-9B87C3). – 10 Trowse-with-Newton (GB) (w. 4.07) (PAS: NMS743). – 11 Elsted (GB) (w. 4.32 g) (PAS: KENT-D83432). – 12 Padstow (GB) (w. 1.53 g) (PAS: CORN-199400). – 13 Eastbourne (GB) (w. 22.8 g) (PAS: SUSS-22E3A5). – 14–17 Trevalyn Farm (GB) (w. 11.61g; 11.14 g; 12.68 g; 46.59 g) (Gwilt 2005). – 18 Sedgeford (GB) (w. 3.4 g) (PAS: NMS-9533FB). –19 Isle of Wight (GB) (w. 4.98 g) (PAS: IOW-BD19F8). – 20 Buryan (GB) (w. 4.84 g) (PAS: CORN-AE219D). – 21 Berwick St. Leonard (GB) (w. 4.4 g) (PAS: BERK-73615E). –22 Ystradowen (GB) (w. 22.3 g) (Aldhouse-Green – Northover 1996, 225 fig. 2a). –23 Rochegude (F) (w. ?) (Eluère 1982, 113 fig. 134). – 24 Saint-Babel (F) (w. 390.10 g; 49.13 g) (Eluère 1982, 275 fig. 137). – Scale c.1:1 (image: R. Roling).

Fig. 4: (w = weight/g; PAS = Portable Antiquities Scheme: https://finds.org.uk). 1 Troy II (w. ?) (Müller-Karpe 1994, 136 fig. 90, 1). – 2 New Newbury (GB) (w. 13.04 g) (PAS: BERK-8F40E07). – 3–8 Dép. Morbihan ou Finistère (F) (w. 1.08 g; 1.84 g; 1.52 g; 11.13 g; 5.28 g; 7.96 g) (Eluère 1982, 273; Hermann et al. 2021, 227 fig. 5). – 9 Belmez (ESP) (w. 76.85 g) (Armbruster 2000, 200 f. pl. 31, 6). – 10 Mörigen (CH) (w. ?) (Hartmann 1980 Tab. 13; Taf. 41 Au 448). –11 Esposende (ESP) (w. 82 g) (Armbruster 2021, 177 fig. 181). – 12 Uluburun (TR) (w. 60.61 g) (Yalçin et al 2005, 612 Nr. 138). – 13 Troy II, Treasure L (TR) (w.?) (Tolstikov 1996, 170 f. fig. 217). – 14 Basingstoke (GB) (w. 3 g) (PAS: BH-149F18). – 15–19 Troy II, Treasure F (w.10.40 g; 10.21 g; 10.45 g; 10.39g; 9.87 g) (Tolstikov 1996, 118 f. fig. 128–132). – Scale ca. 1:1. – (image Renate Roling).

Gold bar ingots already occur in a standardised form. The heaviest bar ingots are known from Eberswalde (286.24 g; 46.36 g) (fig. 2/20), together with two fragments of bar ingots (fig. 2/19; 3/7) and the other gold lumps they weighed a total of more than 400 g (Schuchhardt 1914, 35). One gold lump was wrapped in wire (109.35 g) (fig. 5/1). All eight beaten gold vessels (total weight 555.83 g) from this enigmatic find could have been made from this stock of raw metal (fig. 5/4–19). An approximately bar ingot (L. 22 cm) made of electrum (an natural alloy of gold and silver) is known from Troy II (Müller-Karpe 1994, 136, fig. 90.1) (fig. 4/1).

A few bar-like ingots (also termed as "finger ingots") are known from Britain and Ireland (fig. 2/17. 18; 3/1–6. 8). As a hypothesis, we consider thin or solid, undecorated gold bands as semi-finished products or blanks (fig. 3/24. 25).

Another specific type are small cuboidal gold objects which were apparently separated from larger pieces (bracelets, torcs, etc.) and hammered flat at one or both ends. A number of them are known from England and weigh only a few grams (3–5 g) (fig. 3/9–13. 18–20). These pieces lead on to larger pieces of chipped or bent gold artifacts (i.e. torcs) that were no longer usable (cf. fig. 3/14–17; 4/2–8. 14).

The gold treasure from Saint-Babel (Puy-de-Dôme, France), weighing approximately 1.311 kg, with its heavy bracelet (206 g), a chain of "*anneaux-lingots*"(Eluère 1982, 114) and semi-finished bands as well as individual coiled bands, can be regarded as a stocked hoard for further processing (fig. 3/24) (see also Rochegude, France: fig. 3/23).

Long-narrow rods from Troy II (Treasure F) were mentioned as bars (Tolstikow – Trejster 1996, 118–119 Nos. 128–132; 215–216) (fig. 4/15–19).

Gold melted from artifacts, i.e. recycled gold (scrap gold, "old gold") (Belmez, Spain: fig. 4/9) or residues from this melting process (Mörigen, Switzerland: fig. 4/10) are certainly quantitatively significant, but are archaeologically often overlooked: The conglomeration of tiny gold, silver, faience and glass objects, all precious materials, from Troy II (Treasure L), including the aforementioned small gold nugget (fig. 2/11), can be similarly regarded as scraps or waste (fig. 4/13).

III

With a few exceptions, the gold found as raw metal, as listed above, usually weighs only a few gramms. When we compare these light weights with the weight of heavier gold artifacts, it becomes clear that considerably more gold in other forms was used to produce them. In this case, gold from several charges of the same or different gold deposits (rock gold, placer gold) was presumably processed together with a lasting effect on the gold alloy (i.e. colour) and especially on provenance analyses.

Other possible forms of gold supply can be deduced from a special object from the approximately 2.5 kg famous gold treasure from Eberswalde: A "golden yellow" (Schuchhardt 1914, 42) lump of raw gold (weighing 109.35 g) was totally wrapped and tied in wire (fig. 5/1). The other 20 wire structures from the Eberswalde hoard reflect the entire range of tightly wrapped balls, bundles and spirals, some of which are tied with wire (fig. 5/4–19).

Comparable to the Eberswalde find, a round wire ball with wire fragments and wire spirals inside is known from Kröslin (Western Pomerania) (32.146 g) (fig. 5/3). These wires shapes draw attention to other wires or wire forms that are recognisably not used or preserved as jewellery. They appear on sites particularly concentrated in the Danube region (Hungary, Romania), in its neighbouring regions (Mozsolics 1950, 1973, 1981; von Brunn 1968, 189, 320; Gruber 2008; Hänsel 2009; Wetzel 2013; Torke 2012; Schmidt 2019; Bartík

Fig. 5: (w. = weight/g). 1. 4–19: Eberswalde (D); 1 a (obverse).1 b (reverse) (w. 109.35 g): 4–23 (w. approx. 500 g) (Schuchhardt 1914, Taf. XII, 2; Piotrovski 2013, 217 fig. 214.17). – 2. Bad Aussee, Koppental (A) (w. 33 g) (Gruber 2008, 176 Abb. 4.2.4). – 3 a–d Kröslin (D) (w. 32.146) (Schmidt 2019, 20 Abb. 5). – 1–3 Scale c. 1:1; 4–23 Scale approx. 1:2.7 (image: R. Roling).

– Čambal – Lieskovský 2020) and in a very high density and in large numbers in Eastern Bohemia (Lehrberger et al. 1997, 170–174).

IV

For over 180 years, the additional function of weight-regulated spirals as a unit of value, a precursor or early form of Bronze Age "money", has been postulated for spirals (Mozsolics 1950; Hänsel 2009; Torke 2012 [with reference to Preusker 1844, 77]; Wetzel 2013). It is not necessarily an irresolvable contradiction between jewellery and the unit of value, because gold was certainly more protected on the human body than in private spaces.

This also includes other forms of gold from archaeological contexts, which have been referred to as "ring-money" or primitive money since the middle of the 19th century at the latest (Betham 1842, 101–120; Kiss 1859; Mozsolics 1963, 1973, 86–89; Taylor 1980, 64–65; Eiwanger 1989; Northover 2000) or forms of ingots.

It is obvious that for spirals standardised value units and scales were needed. It is therefore certainly no coincidence that small beam scales and associated weights are documented as an innovative artifact group in the Early Urnfield period of Central Europe in the context of a more clearly recognisable weight system across the ancient Bronze Age world (Ialongo – Rahmstorf 2019; Hermann 2022). The evidence in two warrior graves of the Bz D/Ha A period from eastern France is revealing for their social context as there is a specific combination of small gold scrap with weights (Migennes, grave 298; Marolles-sur-Seine, grave 5). Small wooden boxes contained beam scales and small weights with little fragments of gold and amber, all BA precious objects (Roscio – Delor – Muller 2011).

Final remarks

A comprehensive overview of gold as a raw metal in the European Bronze Age cannot be given in the text above. The archaeological records in form of ingots, bars, etc. are very limited. Almost exclusively small-size and light-weight pieces (fig. 1–4) are currently available. This leads to the conclusion that in contrast to non-ferrous metallurgy there must have been other ways of supply with the most precious metal of the Bronze Age. One group of these finds consists of specific wire shapes (fig. 5). Although the production of wires, especially long wires, is very labour-intensive (like hard rock gold mining itself), its advantage and benefit lies in their foreseeable availability for further manufacturing. Unlike non-ferrous metals, gold survives in a perpetual cycle of "gold feeds gold": Finished gold objects (such as "*hackgold*", object ingots, out-of-use or out-of-fashion artifacts) were certainly recycled on a large scale in the European Bronze Age, though it is difficult to identify them as recycled objects in the archaeological record.

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