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OBSERVATIONS ON THE PRODUCTION TECHNOLOGY OF THE TÁPIÓBICSKE AND ABRUD GOLD ARMLETS

János Gábor Tarbay* – Balázs Lukács**

The study discusses the technological traces of the Middle Bronze Age gold armlets with crescent-shaped terminals from Tápióbicske (Hungary, Pest County) and Abrud (Romania, Alba County). Our aim was to conduct in-depth analyses of these finds' production technological, and use-wear traces, as well as the identification of their modern damages. Several tools, e.g., a bronze chisel, stone hammers, bronze, and hardwood awls, were used to make these exceptional finds based on surface traces. The parallels of these tools are well-known from the contemporaneous archaeological material. Our results suggest that both ornaments can be described as finished products. In the case of the Tápióbicske armlet, it was possible to identify abrasion traces related to long or intensive use. We also propose that the craftsmen working on these ornaments had an advanced technological knowledge. This statement can be applied particularly to the Tápióbicske armlet whose ornaments were made by a highly experienced, professional metal smith.

A tanulmányban a középső bronzkori tápióbicskei (Pest megye) és abrudbányai (Románia, Alba megye) arany, holdsarlós végű karpántok technológiai nyomait vizsgáltuk. Célunk a leletek készítéstechnológiai sorának, használati nyomainak és modern sérüléseinek leírása volt. A tárgyak létrehozásához a korabeli fémművesek számos eszközt (pl. bronzvéső, kőkalapácsok, bronz és keményfa poncolók) használtak, melyek nyomai megfigyelhetők ezeken az ékszereken, a szerszámok párhuzamai pedig ismertek a régészeti leletanyagban. Eredményeink alapján mindkét ékszer készítermékként írható le. A tápióbicskei karpánt esetében sikeresen azonosítottunk hosszú idejű vagy intenzív használathoz köthető kopásnyomokat is. Munkánkban rámutattunk arra, hogy a karpántok készítői magas technikai ismeretekkel bírtak, különösen a díszítések kivitelezését figyelembe véve feltételezhetjük azt, hogy a tápióbicskei karpánton tapasztalt mester dolgozhatott.

Keywords: *production technology, use-wear traces, gold armlets with crescent-shaped terminals, Middle Bronze Age (Br A2–Br B1)*

Kulcsszavak: *készítéstechnológia, használati nyomok, holdsarlós végű arany karpántok, középső bronzkor (Rei. Bz A2–Rei. Bz B1)*

The armlets with crescent-shaped terminals which are similar to the Middle Bronze Age gold find from Tápióbicske have been discussed by archaeology since the late 19th century (Hampel 1880). Numerous works have been published on the typological classification, the relative chronology, the parallels and the cultural relations of this object type (Mozsolics 1951; Mozsolics 1968; Hänsel 1969; Kovács 1991; Kemenczei 2005; David 2010; Tarbay 2021). Apart from the typo-chronological issues, some works have been published that identified the chemical composition of armlets with crescent-shaped terminals by means of archaeometric analyses. As an example, the chemical compositions of the items from Bellye and Pipe published by Axel Hartmann (Hartmann 1968, Tab. 1; Hartmann 1970, 110, Pl. 47, AU202) or the results of the analyses done by a Romanian research team on the Iron Age armlet from Boarta (Cristea-Stan, Constantinescu 2016, 32, Fig. 7) can be quoted. These works pointed out that some of the gold arm-

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lets with crescent-shaped terminals were not made of pure gold. The objects investigated so far contain a considerable amount of silver and a little copper and tin, which led Axel Hartmann to the conclusion that their basic material must have come from Transylvania (See Hartmann 1968).

The aforementioned works provided progressive results as the exact chronological classification of the armlets with crescent-shaped terminals has not been concluded yet, although the typo-chronological analysis of the item from Tápióbicske seems to suggest its dating to the Middle Bronze Age (Br A2–Br B1, time of deposition: Br B1, 1600–1450 BC) (Tarbay 2022). The metals should also be analysed as it is indispensable for analysing the ductility, the physical characteristics and the origin of the object as well as the whole production process. According to the findings of the new handheld XRF spectrometer done by Boglárka Maróti (Centre for Energy Research, Nuclear Analysis and Radiography Department), the armlet from Tápióbicske had considerable silver (ca. 21.8 wt%) and smaller copper (ca. 0.10 wt%) content. The Abrud armlets yielded quite similar results: Ag ca. 23 wt%, Cu ca. 0.06 wt%. This chemical composition indicates that the armlet must have been made of native gold. Its relatively high content of 18 carat gold may indicate a soft and easily pliable basic metal (Tarbay, Maróti 2022). However, even the progressive analyses cannot make up for the lack in research history that we do not have a detailed basic analysis on the production technique of armlets with crescent-shaped terminals based upon the surface traces or a description of the traces of their use. Both approaches are considered basic, possibly providing important information and opening up new prospects in the research of this group of objects.

The aim of our work is to make up for this lack in research history to some extent by analysing the surface traces of production technology on the item found in Tápióbicske and to reconstruct in great outlines the possible production method, techniques and tools of this armlet. The wear and damages on the surface of the object are also analysed as they can provide further information concerning its use and the condition at the time of depositing. Besides the Tápióbicske armlet, the Abrud one is also presented in short, as it is considered significant by Amália Mozsolics in terms of its production technology (Mozsolics 1968, 23). In our research paper we intend to set up observation-based working hypotheses that can be fine-tuned by analysing new finds and by archaeometric and experimental archaeological methods.

Traces of the production technology and the process of production

The armlet from Tápióbicske is supposed to have been made by casting. The exact method of its casting cannot be described based upon the surface traces as all the casting characteristics were removed during the phase of shaping. The thin, rectangular-cuboid raw cast sheet constituting the base of the object can be manufactured by means of numerous techniques, whose three possible variants are highlighted here.

1) The possibility cannot be excluded that the metal smith did not use a mould to manufacture the rectangular-cuboid raw cast sheet constituting the base of the armlet. If so, the negative must have been carved in the floor or in other prepared surfaces of the foundry. This technology was applied in the Middle Bronze Age in the Carpathian Basin to make moulds in the shape of a loaf, plano-convex or cylinder as was excellently demonstrated by Éva F. Petres and Gábor Bándi in the case of the foundry excavated in Lovasberény-Mihályvár (Fejér county) (F. Petres, Bándi 1969, 174, Fig. 6). This technique is really effective to produce these types of moulds, it has been proved in practice by conducting experimental archaeological founding when moulds were cast with the help of Csaba Bíró, bronzesmith (See Tarbay 2018, Fig. 72). Besides this relatively simple technique, we may as well reckon with 2) *open mould casting* (See Ersfeld 1990, 11–12; Ottaway 1994, 117; Armbruster 2000, 70) (*Fig. 1, 1*), or 3) *closed mould casting with two-piece moulds and one negative* (Armbruster 2000, 37–39) (*Fig. 1, 2*). In the latter case, the negative of the rectangular-cuboid object was carved in one half of the mould, which was completed with a conical-shaped pouring cup cut either on the shorter or on the longer end of the mould. The other half of the mould was completely flat, perhaps with the other half of the pouring cup on it. This technique was widespread during the Middle Bronze Age. Sickles with buttons and crescent-shaped, disc and disc-shaped pendant with spike manufactured in large numbers must have been made in similar moulds. Based upon the Bronze Age finds unearthed in Hungary, these moulds could be made of stone (sandstone, aleurolit, pyroclastit/tufa, metamorph slate) or specially tempered ceramic (Péterdi 2004). Among the aforementioned three techniques we

consider the *closed, two-pieced mould casting with one negative* the most likely as when this technique is applied the edges are not rounded by the cohesive force and the exiting gases do not leave behind surface craters and bubbles on the surface of the casting facing the inlet (Ersfeld 1990, Abb. 5). So the result will be an as-cast with an even smooth surface which can be formed more precisely with less energy investment.

On the inner surface (*Fig. 3, 5*), on the edge (*Fig. 3, 3–4*) and between the ribs of the crescent-shaped arcs of the Tápióbicske armlet the imprints of the strokes of the hammer can clearly be visible. The traces mentioned above suggest that after being cast, the metal plate was shaped by hammering (*Fig. 1, 3–7, 9*). The tool must have been made of stone as the plate is matte with a little textured surface (*Fig. 3, 4*). This phenomenon can be observed when using stone tools, fine powder is created between the surface of the object and the hammer. The possibility that stone tools and stone hammers were used are in accordance with Middle Bronze Age finds. Basically, bronze hammers were not characteristic in this period, similar metal tools became widespread in various forms in the Late Bronze Age in the Carpathian Basin (Gogâltan 2005; Găvan 2015, 64; Ilon 2015, 231–233, Fig. 23). There are numerous examples of stone hammers used to work on metals not just in the high-level near-eastern metallurgy (Oberfrank 1986, 24–25; Scheel 1989, 28–32) and in the Western areas from the European Bronze Age (Armbruster 2000, 47–48; Kuijpers 2008, 101–103), but also in the Carpathian Basin from the Middle Bronze Age (Horváth 2004, 59–61). Based upon the size and the texture of the traces of shaping, in our opinion, the object was worked on with a stone tool that had a slightly convex face (*Fig. 1, A*).

On the surface of the object, the imprints of the surface refining methods and tools (chisels, polishing materials/tools) applied during the metallurgical procedure are more difficult to observe. It is important to highlight that the front and back sides of the object are different, while the traces of polishing by fine grains are to be seen on the front side (*Fig. 4, 1*), surface grinding is less obvious on the back side (*Fig. 4, 2*), which is well attested by the extant compass (*Fig. 7, 1*) and guiding lines on the find (*Fig. 4, 3–8*).

In our opinion, at an early stage of forming the object, the thick sheet must have been incised into a V-shape on its side (*Fig. 1, 4*). In the Middle Bronze Age, the various *bronze chisel types with straight edges* could be used as cutting and chopping tools (*Fig. 1, B*). Both their moulds and the tools themselves have been discovered in the Carpathian Basin (Mozsolics 1967, 63; Farkas 1981,

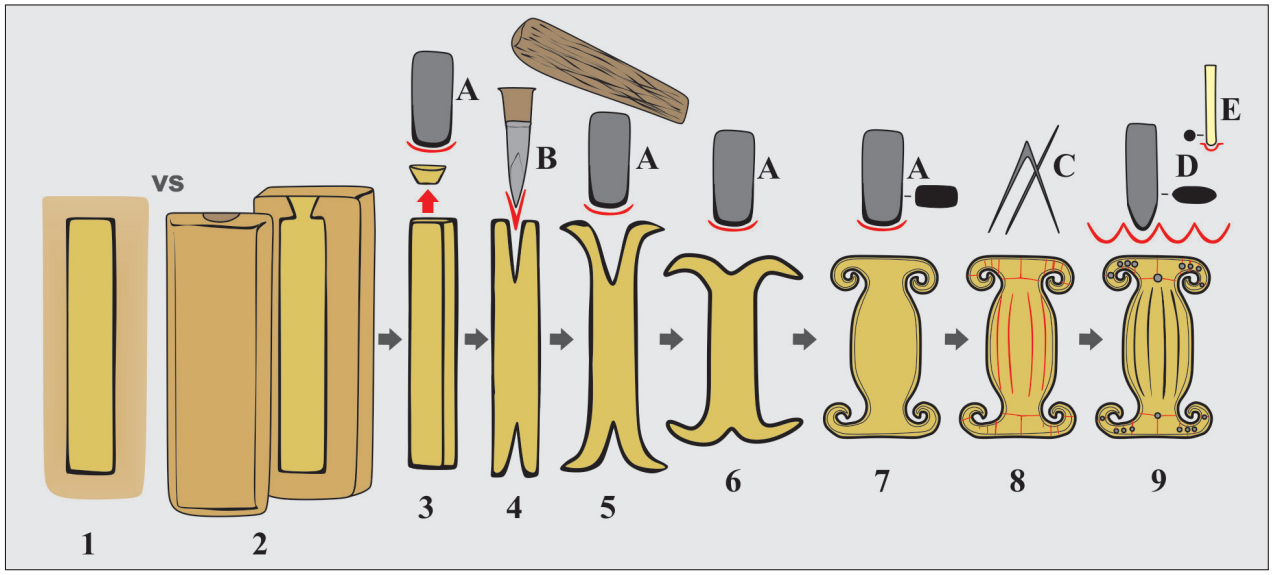

Fig. 1 A sketch of the used tools (A – stone hammer with rounded face, B – bronze chisel, C – scriber and a scratching tool, D – stone hammer with roof-shaped face, E – spherical-headed awl made of hardwood or antler) and production technological phases of the Tápióbicske armlet (Graphic: J. G. Tarbay)

1. kép A tápióbicskei karpánt öntési és alakítási fázisainak sematikus rajza és eszközei (A – kőkalapács, lekerekedő téglalap alakú ütőlappal, B – bronzvéső, C – körző és vonalzó eszközök, karctű, D – kőkalapács, keskeny fejű, ívelt élű, E – gömbfejű fa/agancs poncoló) (Grafika: Tarbay J. G.)

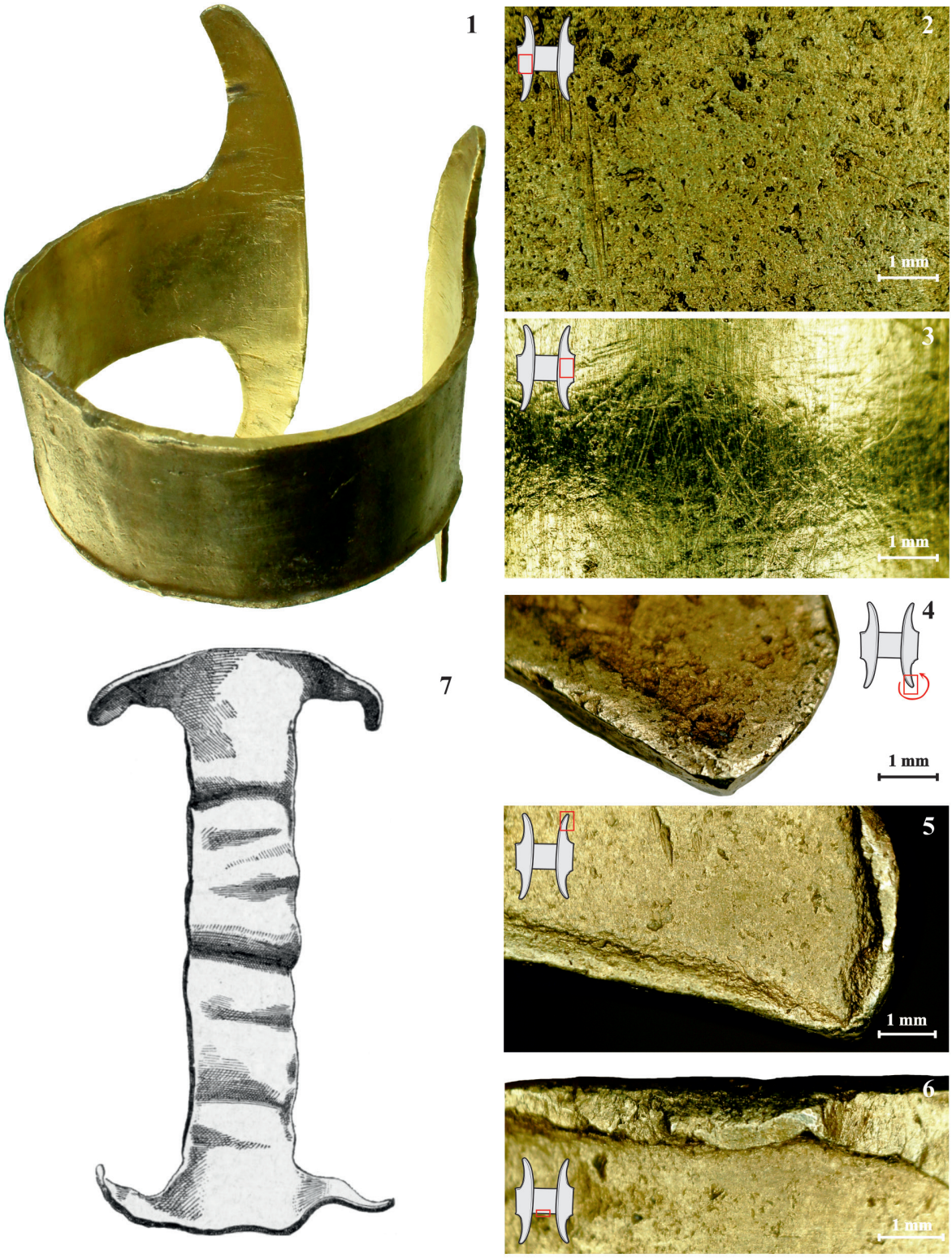

Fig. 2 Production technological traces on the Abrud (Romania) armlet. 1: Prehistoric hammer impacts, and modern, horizontal polishing marks on the inner surface; 2: As-cast surface; 3: Modern polished surface; 4: Hammered edge, inner surface; 5–6: Hammered edge, outer surface (Photos and micrographs: J. G. Tarbay); 7: original acquisition condition (after Hampel 1892, 375, Fig. 6, 2)

2. kép Az abrudbányai (Abrud, Románia) karpánt készítéstechnikai megfigyelései. 1: Őskori kalapácsnyomok és horizontális irányú modern csiszolásnyomok a karpánt belső részén; 2: Öntvényfelszín; 3: Modern, csiszolt felszín; 4: Kalapált perem, belső oldal; 5–6: Kalapált perem, külső oldal (Fénykép, mikroszkópkamera-felvételek: Tarbay J. G.); 7: Az eredeti kihajtott, gyűjteménybe vételi állapot (Hampel 1892, 375, 6. kép 2)

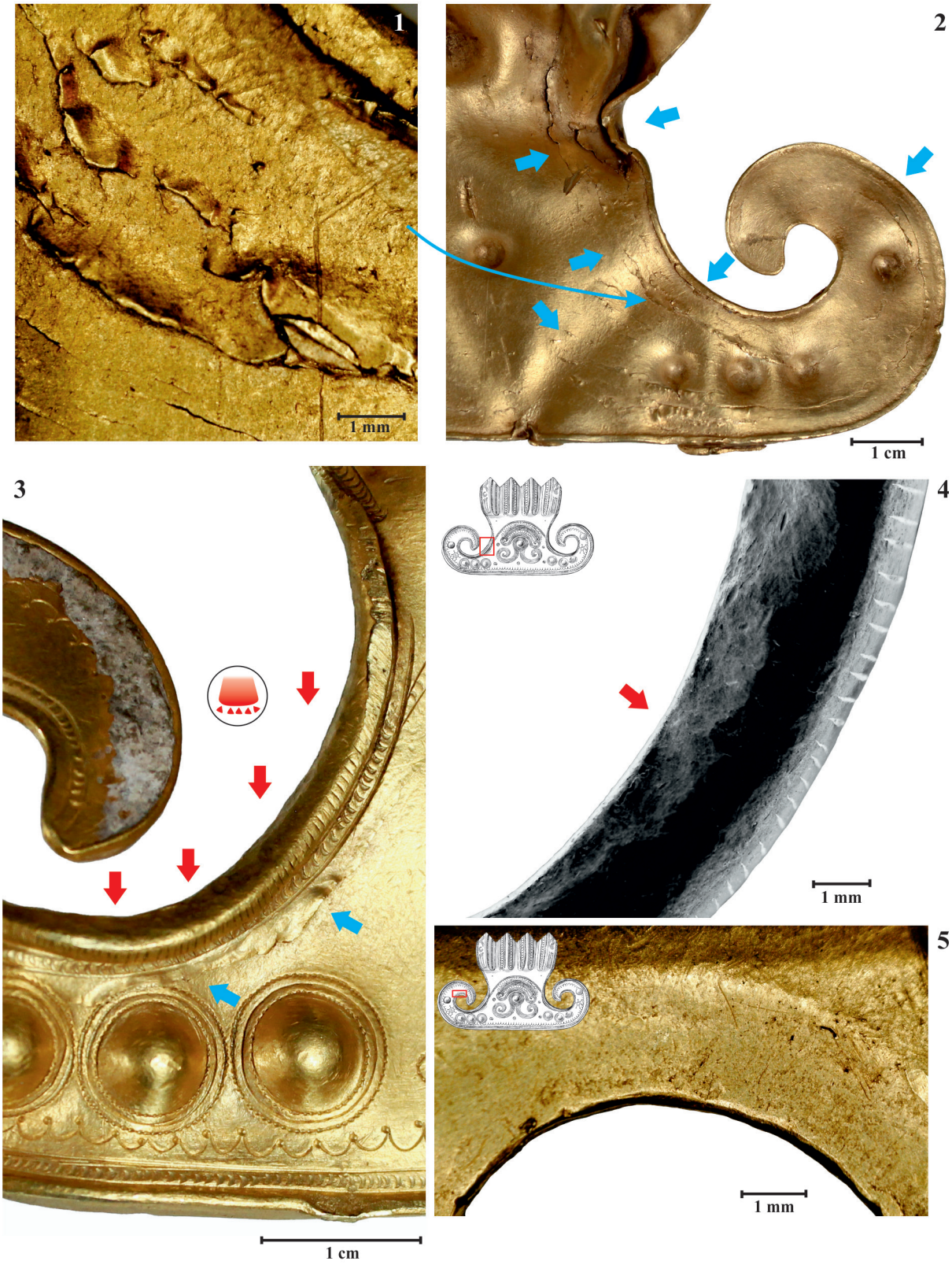

Fig. 3 Production technological traces on the Tápióbicske armlet. 1–2: Cracks along the inner surface of the armlet; 3: Hammer impacts (red arrows), cracks along the outer surface (blue arrows); 4: Textured hammered surface; 5: Hammering traces along the inner parts of a crescent-shaped terminal (Photos and micrographs: J. G. Tarbay)
3. kép A tápióbicskei karpánt készítéstechnikai nyomai. 1–2: Repedéssorozat a karpánt belső részén; 3: Kalapácsnyomok (vörös nyilak), repedéssorozat a karpánt külső részén (kék nyilak); 4: Textúrált felületű kalapácsnyom; 5: Kalapált él a holdsarlós vég belső részén (Fényképek, mikroszkópkamera-felvétel: Tarbay J. G.)

96–97; Bălan 2009; Găvan 2015, 107–110; Jockenhövel 2019, 443; Găvan, Lie 2020, 160–164, Fig. 5). The crescent-shaped terminals of the armlets could have been produced from the four pieces created by cutting (*Fig. 1, 4–7*). It is quite likely that at this early stage, the two ends of the metal sheet were incised from above, vertically to the sheet, and the base of the parts folded back were folded out from here. Working on the four crescent-shaped terminals and straightening them must have been tedious work. It may be indicated by the series of cracks in the direction of lengthening on their inner (*Fig. 3, 1–2*) and outer (*Fig. 3, 3,* blue arrows) sides. A similar phenomenon can be observed, when in the process of lengthening, some extra material is produced and they try to smooth it by bending back or by further hammering. Nevertheless, this trace cannot be eliminated completely as the raw metal will never be homogeneous, it will not fit in organically without seams. The surface traces visible on the ribs of the armlet are not clear. It is supposed that this part was shaped by using a *stone hammer with a narrow head and a curved edge* (*Fig. 1, 9*). The ribs were shaped starting from the inside and going outward, as the guiding lines (see below) can be found inside (*Fig. 4, 7*), and a clear-cut line resembling one left by a tool can be observed on the inner side of the ribs, on the edge of the „upper arch". The other arches are soft and without edges both outside and inside.

When analysing the production technology of the armlet unearthed in Tápióbicske, it is important to make a detour by mentioning the gold find in Abrud (*Fig. 2*). This armlet with crescent-shaped terminal was defined by Amália Mozsolics as a semi-finished product (Mozsolics 1968, 23), if one accepts the technological classification made by her, the Abrud find must not be neglected in the analysis of the production technology of finds similar to the one found in Tápióbicske. The undecorated armlet from Abrud was flattened and folded out when it arrived at the collection of the Hungarian National Museum. The find was folded back again at an unknown point in time to assume its "original shape", which, according to the creases on the object, (*Fig. 2, 1, 7*) must have been armlet-shaped (Hampel 1892, 375, Fig. 6, 2). As opposed to the object discovered in Tápióbicske, the outer surface of this find is fine, grainy, which evinces that it was made by casting (*Fig. 2, 2*). In this case no series of cracks can be detected either on the outer or on the inner surface of the object. The casting surface can clearly be observed on the crescent-shaped terminals too. Based upon this, the object must have been made in a fashion different from the Tápióbicske armlet. Instead of making a V-shaped incision, originally the shape of an armlet with crescent-shaped terminals, shorter than the flattened end-product, must have been cast, which was shaped after casting. Marks that could be connected to hammering can mostly be seen on the front (*Fig. 2, 5–6*) and back side (*Fig. 2, 7*) of the uneven sharp edge of the object. Sharp, elongated, pointed-oval imprints can be observed on the inner surface of the armlet too, which are likely to be connected to a hammer with a roof-shaped face. These traces and imprints can be connected to the phase of lengthening the sheet metal, a similar phenomenon can be seen on the inner surface of bronze vessels, such as situlas (*Fig. 2, 1*) dating from the Late Bronze Age. Besides the marks of shaping, other surface treatments can also be observed. On the inner surface of the armlet and on certain points of its outer surface, horizontal marks of abrasion are visible. The microscopic photos seem to prove that these marks can probably be connected to modern metal brushes used to polish the object and they are not the imprints of Bronze Age polishing tools (*Fig. 2, 1, 3*). The Bronze Age shaping imprints suggest that the manufacturer must have considered the size of the Abrud find final and he did not intend to lengthen it to the size of the objects found in Bilje and Tápióbicske. In this state, it is suitable to be worn on the wrist comfortably. Based on the aforementioned arguments, its interpretation as a semi-finished product seems less acceptable. We are to presume that the Abrud armlet could have been a finished product, which was simply undecorated. The traces of the production technology seem to reveal that it was manufactured in a fashion different from the armlet from Tápióbicske.

When the base sheet of the object took its final size and shape, the patterns were created by the goldsmith on the inner and outer surfaces of the object (*Fig. 1, 8*), which is a work phase still retained by modern goldsmithery (Farkas 1981, 31–37; Oberfrank 1986, 26). The parallel circular motifs on the outside (*Fig. 7, 1*) were created by means of *compass* and *scriber*, on the inner side the places of the patterns in the shape of sphere-sections (*Fig. 4, 3–6, 8*) and the lines of roof-shaped ribs (*Fig. 4, 7*) must have been drawn with a scriber and a *ruler* tool *(Fig. 1, 8, Fig. 4, 8*). The guiding lines indicating the sphere-

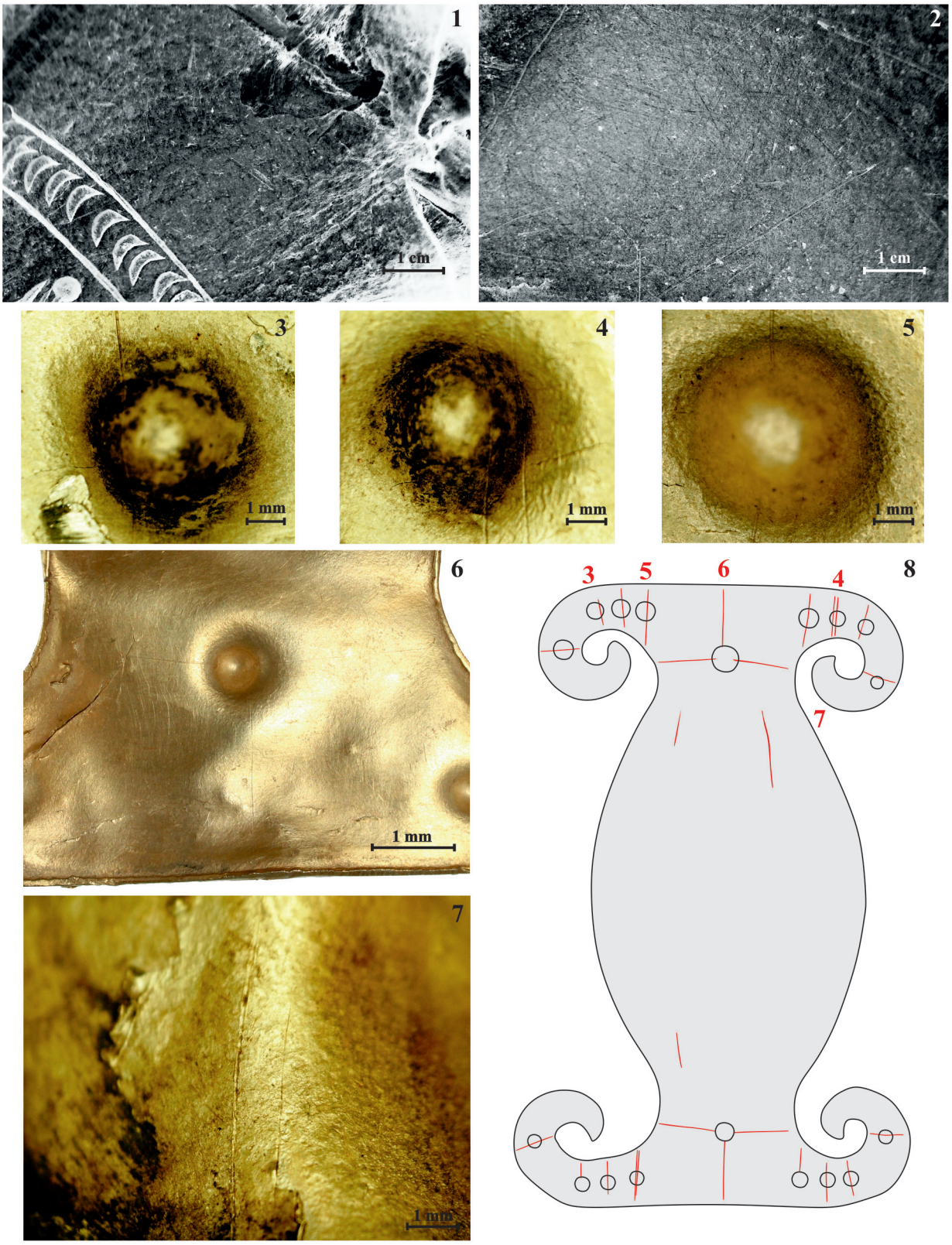

Fig. 4 Production technological traces on the Tápióbicske armlet. 1: Outer surface; 2: Inner surface; 3–6: Guiding lines of the embossed dots, inner surface; 7: Guiding lines of the ribs; 8: Guiding lines, inner surface (Micrographs and graphic: J. G. Tarbay)

4. kép A tápióbicskei karpánt készítéstechnikai nyomai. 1: Külső felszín; 2: Belső felszín; 3–6: Gömbszelet alakú, poncolt dudordíszek jelölővonalai, belső rész; 7: bordázat jelölővonala; 8: Jelölővonalak a karpánt belső oldalán (Mikroszkópkamera-felvételek és grafika: Tarbay J. G.)

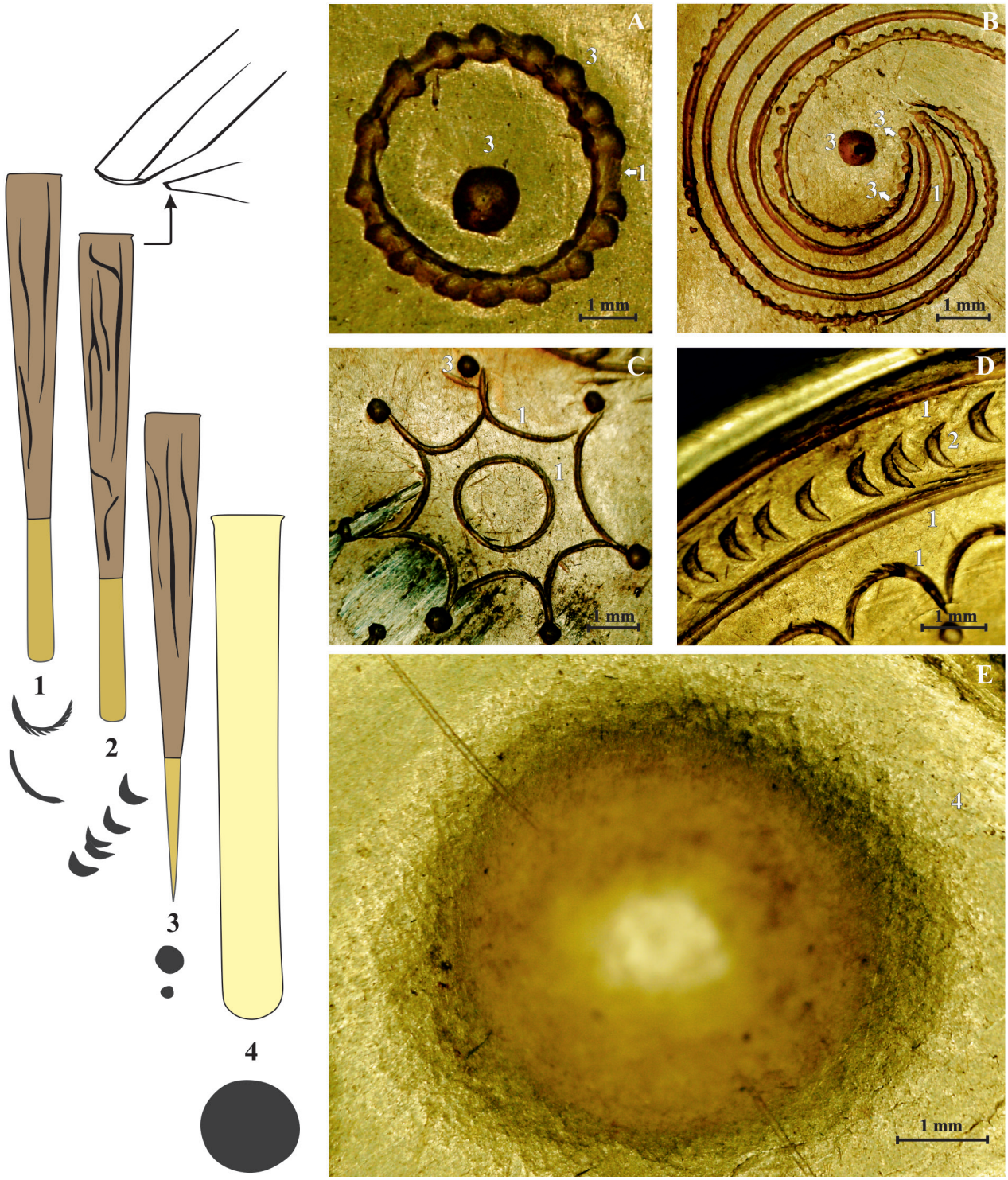

Fig. 5 Awl imprints on the Tápióbicske armlet. 1: Awl with straight edge (A–D); 2: Awl with curved edge (D); 3: Awl with pointed end (A–C); 4: Awl with spherical head (E) (Micrographs and graphic: J. G. Tarbay)
5. kép Poncolólenyomatok a tápióbicskei karpánton. 1: Egyenes élű poncoló (A–D); 2: Ívelt élű poncoló (D); 3: Kúpos fejű poncoló (A–C); 4: Gömbfejű poncoló (E) (Mikroszkópkamera-felvételek és grafika: Tarbay J. G.)

shaped patterns are not at equal distances from one another and they are not always vertical to the edge. Although the corrected scratches (double parallel lines) seem to show (*Fig. 4, 4, 7, 8*) that the producer tried to create a regularly distributed pattern, the places of the sphere-shaped seem to have been aligned with the irregular shaped crescent terminals of the armlets and not with one another (*Fig. 4,*

Fig. 6 Awl marks on the Tápióbicske armlet (Micrographs: B. Lukács)
6. kép Poncolónyomok a tápióbicskei karpánton (Mikroszkópfelvételek: Lukács B.)

8). The use of similar guiding lines and tools is not unique in European Bronze Age metallurgy, some spectacular examples can be seen on prestige objects made of sheet bronze and gold and decorated with complex motifs such as gold or bronze vessels or defensive weapons (Armbruster 2000, 111–112; Tarbay 2015, Fig. 9, 5–6). The appearance of these technological traces on the find dug up in Tápióbicske attest the manufacturer's professional knowledge in goldsmithery and it also indicates the fact that the decorations on the object (Tarbay 2022) were not improvised patterns. The patterns must have been carefully designed motifs, thought over and created within the system of rules of symbolic thinking of that age, whose shape and composition must have had important meaning for the manufacturing master, for the "person who ordered/wore it", and for the whole community.

The surfaces of the lines of the patterns are bright with clear boundaries, which indicates that they must have been created by means of bronze tools, so called *awls* (*Fig. 6*). Based upon the imprints, the tools can be divided into three types: *straight awl with a slightly curved edge* (*Fig. 5, 1, A–D*), *curved awl with a straight edge* (*Fig. 5, 2, D*), *small awl with a slightly tapering head* (*Fig. 5, 2, A–C*), *big sphere-*

headed awl (*Fig. 5, 3, E*). The design is extremely rich in details and fine. The awls were probably applied by the master with little hits. It is indicated by the frequent misplaced hits in the „bending lines" (*Fig. 7, 1–2*). The straight awl must have had a small and sharp pattern-forming head with curved profile, it did not have sharp corners. On a bronze awl, the corners disappear quite soon due to the heavy duty. They become blunt and bend upwards. The lines on the object all end gradually without sharp edges, which may attest that the awl used here could have been in such condition. Among the finds from the Middle Bronze Age, both the straight-headed awls (e.g., Gogâltan 1999, Fig. 23, 2–5), and the ones with slightly tapering heads (e.g., Szathmári 2018, 58, Fig. 5, 1) can be found. These two basic types can be found in the entire area of the Carpathian Basin (Mozsolics 1967, 63; Găvan 2015, 114–115). It is highly likely that curved awls can also be found among the finds dating from this age, but this tool cannot be identified in the literature due to the schematic illustrations published. The Bronze Age items preserved with accessories made of organic materials suggest that they were fastened to wood or bone handles (Gedl 2004, 103–104, Pl. 24, 451, 451A, 458; Speciale, Zanini 2010, 44, Fig. 3.B, GO3, GO4). The 18 big bumps on the hinge were created with the big sphere-headed awl. It is supposed that this tool was not made of bronze as the inside of the embossed motifs did not become glossy and even the guiding lines have been preserved (*Fig. 5, 4.E*). The interior shape of the ribs seems to show that the tool could not have been made of metal but antlers or hard wood.

Marks of use

Because there is no *in situ* clothing context in graves, at the moment, it cannot be decided how the armlet unearthed in Tápióbicske was worn. In the Middle Bronze Age spiral, sheet metal or cast jewellery were worn on the wrist, the forearm, the ankle or the lower part of the shin in sets, depending on their size (Schumacher-Matthäus 1985). It is thought to be likely that the Middle Bronze Age crescent-shaped armlets were worn in different fashions. For instance, the diameter of the armlet found in Abrud may indicate that it was worn on the wrist, whereas the size of the item from Tápióbicske (Tarbay 2022) raises the possibility that it may have been worn on the forearm or above the ankle.

The item from Tápióbicske is a unique, large, representative jewel, decorated with many symbolic motifs possibly depicting celestial bodies. In connection with such objects, the question may justly have been raised by József Hampel whether they were worn at all (Hampel 1880, 215). Were they worn regularly or just occasionally, at ceremonies? The analysis of surface marks of use found that on the outer and inner edges of the front side of the four crescent-shaped terminals bending backward, marks of intensive wear can be observed (*Fig. 7, 7*), and in consequence of it, the frame motif made up of slanting punched lines partly or completely disappeared (*Fig. 7, 5–6*). This area must have been covered with decorations. Marks of similarly intense wear may raise several possibilities. The object could have been worn by a person for a longer period of time or it can be considered as a piece worn occasionally by several generations. It is important to take into account that the chemical composition may also have contributed to the creation of these conspicuous imprints (Tarbay, Maróti 2022). An 18-karat item is much softer, its material is not so resistant to scratches and wear, and it does not necessarily have to be worn through generations to produce similar marks. (Similar wear can be observed on the terminals of the Dunavecse armlet that bend backward, on the areas between its ribs, and on the item in the collection of Géza Kárász. These marks will be described in our next work.)

Modern wear

The circumstances under which the Tápióbicske armlet was found are not documented. Its original condition can be inferred from the surface wear and the information gained after the object was brought into the collection (*Tarbay, J. G., Adatok a tápióbicskei karpántról*. Budapest, 2021.10.04. Magyar Nemzeti Múzeum, Régészeti Tár, document registry number RT/251). The object was found in a folded state with its terminals fitting under the hinge (Tarbay 2022, Fig. 3). It was harshly folded out locked in a vice, which was crude amateur work. When it was folded out, the crescent-shaped terminals of the armlet were turned more outward than the position observable on the original item from Bilje. On the surface of the object many sharp and deep incisions were discovered, which are not the results of intentional prehistoric damaging but can be considered as characteristic wear caused by a ploughshare.

Fig. 7 Production technological and use-wear traces on the Tápióbicske armlet. 1: A potential scriber mark; 2: Awl marks; 3: Imprints of an awl with pointed head and an awl with straight edge struck at a flat angle; 5–6: Abrasion; 7: Distribution of abrasion marks along the edges (Micrographs and graphic: J. G. Tarbay)
7. kép A tápióbicskei karpánt készítéstechnikai és használati nyomai. 1: Lehetséges körző jelölő nyom; 2: Kanyarozó vonalak elülései; 3–4: Kúpos fejű poncoló és lapos szögben beütött egyenes poncoló lenyomatai; 5–6: Kopásnyomok; 7: Kopásnyomok eloszlása a tárgy külső élein (Mikroszkópkamera-felvételek és grafika: Tarbay J. G.)

Summary

The Middle Bronze Age gold armlet discovered in Tápióbicske is a casting which was further shaped on its crescent-shaped terminals by incisions made with a chisel and by hammering. Its decorative motifs were carefully planned, designed and then created on the surface of the object by using punches. Based upon the various surface wears and imprints, the following set of tools could have been used to produce the object after casting it: I. shaping tools – *stone hammer with a slightly curved face* (surface, crescent-shaped terminals), *stone hammer with a narrow, slightly curved edge* (ribbed hinge), *straight-edged bronze chisel, hammers, anvil*, II. planning tools – *compass and ruler tools, scriber* (composing punched motifs), III. decoration – *awls (straight with a slightly curved edge, curved with a straight-profiled edge, a small one with tapering terminal, a big one with sphere-shaped head), wooden hammer* (*Fig. 1*).

The technological observations allow us to draw some conclusions concerning the knowledge of the master or masters manufacturing the Tápióbicske armlet. Although the base sheet is nicely shaped, the damages on it (*Fig. 3, 1–3*) may indicate that the manufacturer was less expert in shaping sheet metals. These phenomena may also raise the possibility that the casting person may not have been practiced since a lot of air and bubbles were left in the sheet, which unavoidably came to light during the hammering process. It is important to stress that the motifs on the object were exact and carefully designed. Despite slight mistakes, the design of the motif is fine and detailed. The lines are smooth just like the pace of beating and its strength, which indicates that the person producing the motifs must have been a craftsman practiced and well acquainted with the sets of motifs. Taking all these into consideration, it can be stated that either specialists with different levels of knowledge worked in the different production phases of the armlet or if it was manufactured by one master, he must have had exceptional knowledge of decorating technique.

The strong tear and wear along the edges of the gold jewel seem to show that the object was not an occasionally worn armlet or one that was not worn at all, but it could have been an item worn intensively for a long time. Modern traces of wear (the trace of a ploughshare, bent by the finder) are visible on the object, probably that it was originally deposited in a folded state.

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KÉSZÍTÉSTECHNOLÓGIAI MEGFIGYELÉSEK A TÁPIÓBICSKEI ÉS ABRUDBÁNYAI ARANY KARPÁNTON

Összefoglalás

A tanulmányban két középső bronzkori, arany, holdsarlós végű karpánt készítési technológiáját mutatjuk be: Tápióbicske (Magyarország, Pest megye) és Abrudbánya (Románia, Fehér megye). Munkánk az első olyan műnek tekinthető, mely a szóban forgó arany ékszertípust készítéstechnológiai és használati nyomok szempontjából elemzi. A tápióbicskei karpánt öntvény, melyet valószínűleg nyitott formában, vagy kétrészes, zárt, egynegatívos öntőformában készítettek. Nem zárhatjuk ki annak a lehetőségét sem, hogy a nyersöntvényt az öntőműhely padkájában kialakított vájatokba öntötték, ahogy ez a lovasberény-mihályvári (Magyarország, Fejér megye) telep esetén ismert. A nyersöntvényt kalapálással formálták. A holdsarló alakú végeket valószínűleg egy bronzvéssővel vághatták ki, majd kalapálták el a kívánt alakra. A tárgy belső oldalán finom, karcolt jelölővonalak láthatók, melyek segítették a készítőt a szimmetrikus dudordíszek és bordák kialakításában. A külső felszínen szintén finom jelölések találhatók meg, melyek a külső minták szabályos beütését szolgálták. A szerszámnyomok alapján úgy véljük, hogy a tápióbicskei karpánt készítéséhez különböző eszközöket, eltérő ütőlappal bíró kőkalapácsokat, három bronz poncoló árat, egy keményfa vagy csont trébelőt használtak. Annak ellenére, hogy a karpánt nagy méretű és gazdagon díszített, a kopásnyomok alapján valószínűleg hosszú ideig vagy intenzíven hordták az őskorban. Az abrudbányai példányt Mozsolics Amália félkész termékként határozta meg (Mozsolics 1968), ezért vizsgálatát szükségesnek láttuk a tárgytípus készítéstechnológiájának jobb megértéshez. A szerszámnyomok alapján úgy véljük, hogy az abrudbányai karpánt valójában egy díszítetlen késztermék lehetett. A tárgy nyersöntvény-felszínei alapján valószínűleg a tápióbicskeihez hasonló módon, öntéssel készülhetett. Végső formáját kalapálás által nyerte el, melynek karakteres nyomai jól megfigyelhetők a tárgy belső oldalán és a peremei mentén. A tanulmányban vizsgált karpántok készítői valószínűleg magas szintű fémműves-tudással bírtak. Ez a megállapítás különösen igaz a tápióbicskei karpántra, melynek készítéstechnológiai sora, de leginkább díszítéseinek kivitele rendkívül gyakorlott, professzionális kézművest feltételez.