Determining the Use-Life of Gold Fibulae: Mission (Im)Possible?

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Abstract
Fibulae are often used as reliable chronological markers in archaeology. Their use-life could vary greatly depending on their shape, size and the material they were made of. Gold fibulae were extremely rare, although they were a sign of authority and wealth. Two miniature Early La Tène type of fibulae from the Early Hellenistic period and four massive Roman crossbow fibulae, all from the collection of the National Archaeological Institute with Museum in Sofia were examined by a non-destructive XRF analysis and microscopic traceological observation. The aim of the present research is to investigate the possibilities to determine if and how long these artefacts were used before their deposition and what happened to them after their discovery.
Keywords: *gold, Early La Tène bilateral fibulae, crossbow fibulae, artefact`s life-cycle (use-life), XRF analysis, optical microscope, traceology, (use-)wear analysis, National Archaeological Institute with Museum in Sofia, Bulgaria*

1. Introduction

Material objects have always been central to archaeological research, as scholars tended to focus on their typology, chronology and deposition, where purely archaeological narratives are prevalent. In recent years, however, the focus has shifted toward the dynamic relationship between artefacts and humans. Each object possesses a distinct history and life-cycle that encompasses its production, exchange, use, and eventual deposition. Nevertheless, reconstructing the full life-cycle of an artefact is often challenging due to the fragmented nature of archaeological evidence.

Fibulae, as functional objects primarily designed to fasten clothing, provide an ideal case for exploring such life-cycles. Their nature bridges two key research perspectives. Firstly, fibulae are invaluable chronological markers. Alongside coins and certain ceramics, they are among the most reliable artefacts for establishing timelines, with their dates often reflecting either the period of manufacture or the end of their use. However, a critical question remains: how much can we rely on their dating, given that fibulae could be deposited at various stages of their "lives"? Secondly, fibulae prompt inquiries about their functional role, enabling the examination of surface wear patterns to estimate their period of use. The challenge in front of us is to adjudge how far such kind of research can reach and how reliable the drawn conclusions would be.

To address these questions, the life-cycle of six gold fibulae from the permanent exhibition in the Treasury Hall of the National Archaeological Institute with Museum at the Bulgarian Academy of Sciences (NAIM–BAS) in Sofia was investigated, beginning with information of their discovery and concluding with interdisciplinary methods of analysis. These fibulae are characterized by different sizes and shapes. Gold was intentionally selected for this study because of its suitability for such analysis; unlike copper alloys, gold resists oxidation and corrosion. In addition, the selected fibulae show distinct cases of varying use-life, providing valuable insights.

Research methods and equipment

The six selected fibulae were examined using two different non-invasive methods – traceological analysis and XRF (X-ray fluorescence). Traceological analysis (Sáez and Lerma, 2015), also known as *use-wear analysis* (Sych, Nowak et al., 2020) or *metalwork wear analysis* (Dolfini and Crellin, 2016), provides essential clues to determine the duration, type and intensity of use by invasively examining traces on the surface of the metal artefacts through an optical microscope. These traces can reflect the actions performed on the object during its production, use and deposition, as well as during the post-depositional processes and conservation. The traceological study of metal artefacts were developed much later than that of lithic microwear research which has been extensively studied over the last 40 years (see Hayden 1979). The reasons for this delay are various and include the possible corrosion processes, recycling, traces from the conservation, etc. (Dolfini and Crellin, 2016: 79). In this sense, the great challenge facing this type of study is to link the observed macroscopic and microscopic traces on the metal surface to a proper action such as manufacture, use or post-deposition.

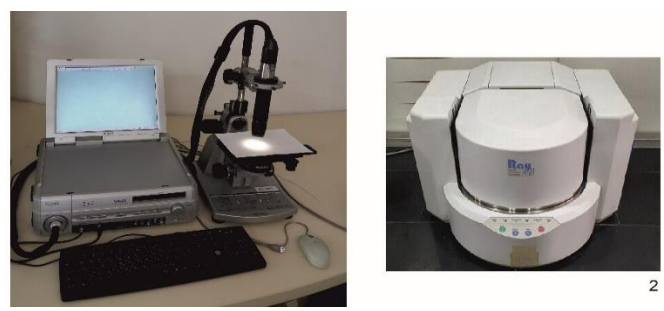

Figure 1. The equipment used for the study: 1. Optical microscope Keyence VHX-100; 2. X-ray fluorescence spectrometer Shimadzu EDX-720. Photos M. Stamberova

The traceological observations were made using a Keyence VHX-100 digital microscope with a magnification range between x25 and x175 (fig. 1.1). In addition, the selected fibulae were examined using an X-ray fluorescence spectrometer model EDX-720 of Shimadzu, Atmosphere: Air; Collimator: 10 mm at the Laboratory of Analyses, Conservation and Restoration of the National Archaeological Institute with Museum at Sofia (fig. 1.2). The used calculation method was Quan-FP (fundamental parameters) with a detection limit of 0.01%.

Archaeological Material

I. Bilateral La Tène fibulae

The first group of the studied artefacts was represented by a pair of double spring (bilateral) fibulae, referred to in this paper as Seuth 1 and Seuth 2 (fig. 2.3; fig. 3). They were discovered in 1949 in a brick grave 2 in Tumulus 2 near the Thracian city of Seuthopolis in south-central Bulgaria (fig. 2.1–2).

Figure 2. 1. Map of Bulgaria with the location of the Thracian city of Seuthopolis, close to present-day town Kazanlak (after Nankov, 2008: 17, fig. 2); 2. The brick grave 2 in Tumulus 2 (after Чичикова, Димитров 2016: 188, fig. 108); 3–5. Inventory from grave 2: 3. Gold bilateral fibulae; 4. Gold necklace; 5. Gold medallion. Photos NAIM–BAS

The burial rite was inhumation of a young girl[1]. According to the researchers, the grave contained a gold necklace (fig. 2.4), a gold medallion (fig. 2.5), two silver Thracian type fibulae, silver and two iron bilateral fibulae, an iron ring, clay unguentaria and alabastron (Dimirov and Čičikova, 1978:54). Unfortunately, not all objects were published.

Both bilateral fibulae (fig. 3) are extremely small in size – they are 1.7 cm long. They were made from a gold bar shaped into a flat, leaf-shaped plate at the bow and hammered into wire form at the ends. The bilateral spring has ten coils and an external chord. The upper part of the foot consists of two parallel non-functional bilateral springs and an external chord as well. Its end is shaped as a decorative number eight. They are dated to the first quarter – the beginning of the second quarter of the 3rd century BC (Stamberova, 2023: 289–290; 455, cat. Nos LT 44–45).

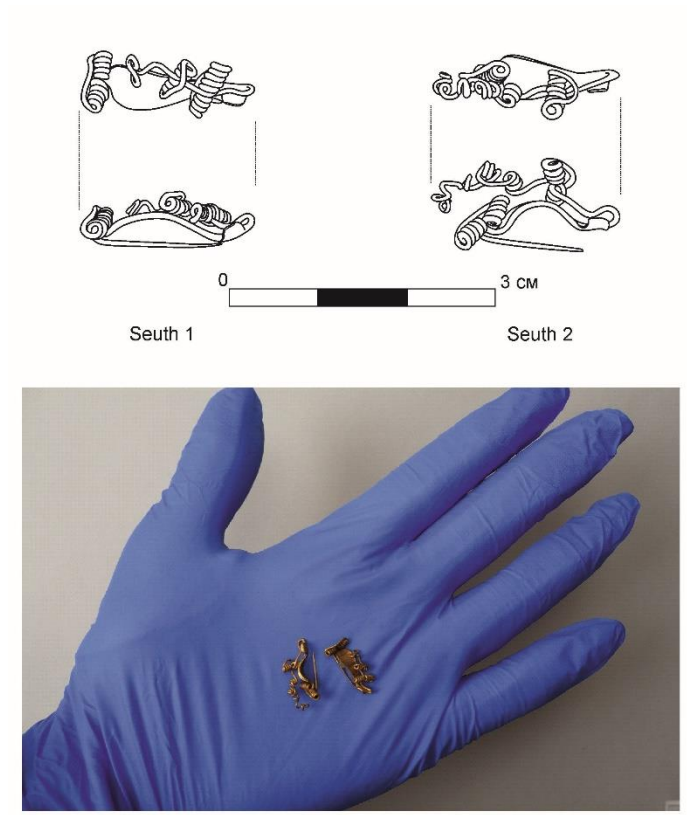

Figure 3. Gold bilateral fibulae with a non-functional spring at the end of the foot from grave 2 in Tumulus 2 next to the city of Seuthopolis, inv. No 7856 (NAIM–BAS). Design and photo M. Stamberova

The bilateral fibulae with a non-functional spring at the end of the foot are the most popular Early La Tène type brooches in Ancient Thrace (Stamberova, 2023: 301). Some scholars have defined them as "Pestrup" type because of the parallels among the specimens found in the basins of the rivers Weser (Germany), Marne and Moselle (France), in the Hungarian Plain and in Moravia (Czech Republic and Slovakia) from the LT B2 period (Anastassov, 2006: 16; 2011: 229). However, they show a great variety in size, shape and cross-section of the bow, which suggests their local development and production in Thrace (Stamberova, 2023: 276).

The XRF analysis of the two fibulae determined concentrations

[1] Anthropological analysis was not performed. Gender determination had been conditionally based on the gracile bones and the grave goods.

of gold, silver and copper (table 1). The concentration of gold is identical – 91.8% and 91.6%. The amount of silver is also almost the same as well – 6.8% and 7.2%. The copper content is 1.4% and 1.1%. Copper in amounts of up to 2% or 3% is considered the maximum limit for natural impurities (Ogden, 1992: 262), so it can be assumed that the gold was natural. Early Hellenistic metalwork usually contains between about 90% and 99% gold and has a copper content bellow about 2.7% (Ogden, 1993: 44).

Based on the very close results, we can conclude that both fibulae were made in one workshop from the same natural source of gold, without the deliberate addition of silver or copper.

Table 1. Results of the XRF analysis of both La Tène fibulae conducted by P. Penkova

Sample	Au (gold)	Ag (silver)	Cu (copper)
Fibula Seuth 1	91.8%	6.8%	1.4%
Fibula Seuth 2	91.6%	7.2%	1.1%

Both bilateral fibulae were also examined using a digital optical microscope. Fibula Seuth 1 showed no signs of wear on the inner part of the catch-plate (fig. 4.1). Surprisingly deep and dense lines were visible on the edge of the inner surface of the catch-plate of the fibula Seuth 2 (fig. 4.2). They can be interpreted as marks from the catching of the end of the pin. The presence of these fresh traces can be linked to a later deformation that occurred under unclear circumstances. In the first publication (Dimitrov and Čičikova, 1978: fig. 91) it is visible that this fibula had a pin attached to the catch-plate and was not deformed. At present it has deformed functional and non-functional springs and decorative element in the shape of number "eight".

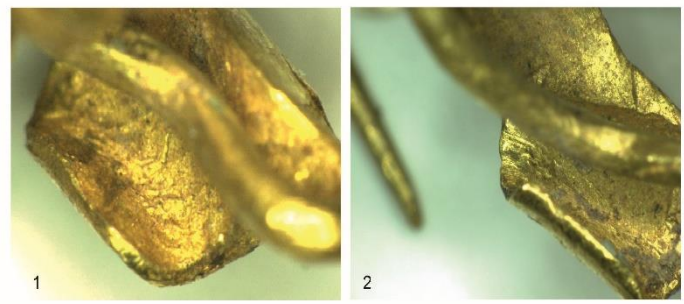

Figure 4. Microphotograph of the inner part of the catch-plate of fibula Seuth 1 (x100 magnification); 2. Microphotograph of the inner part of the catch-plate of fibula Seuth 2 (x75 magnification). Photos M. Stamberova

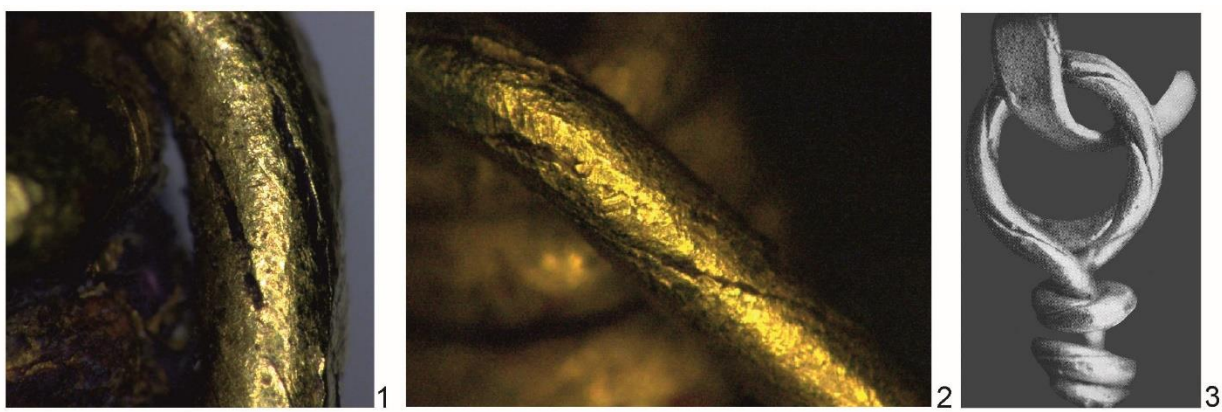

Figure 5. 1–2. Microphotographs of the chords of fibulae Seuth 1 and Seuth 2 with spiral seams that testify using of the strip-twisting technique (x175 magnification); 3. Loop of a Roman earring (about x20 magnification) (after Ogden, 1991: 95, fig. 1)

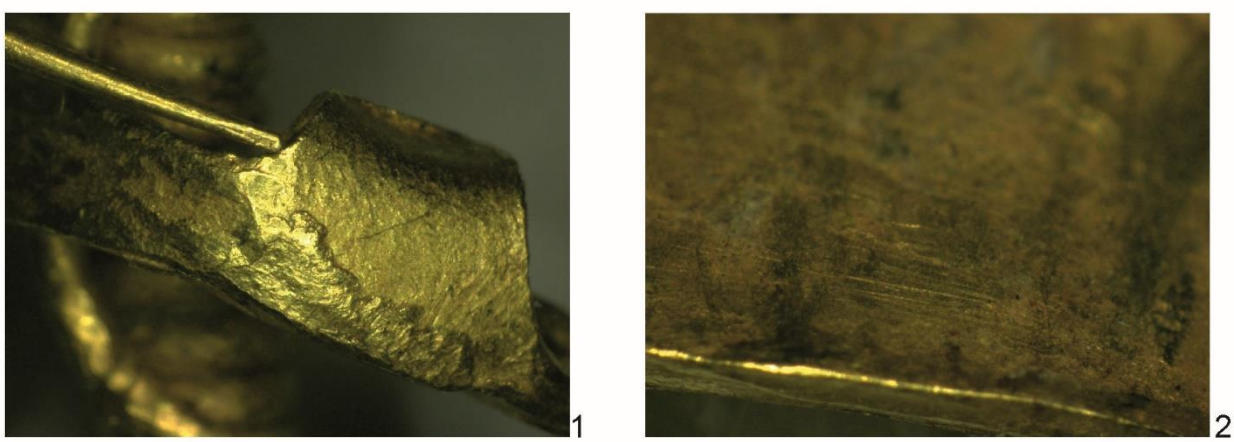

Figure 6. 1. Results of the production process on the lower part of the catch-plate of fibula Seuth 1 (x60 magnification); 2. Result of a contemporary (?) intervention on the lower part of the bow of fibula Seuth 1 (x175 magnification). Photos M. Stamberova

Most of the visible marks on the surface of both fibulae could be related to the manufacturing process. The chords show spiral lines along the length of the wire (fig. 5.1–2). They attest to the use of the strip-twisting technique (fig. 5.3), which was the very common in antiquity, in contrast to the wire-drawing technique that was widespread in the early Middle ages. The wire was made from narrow strips cut from a sheet of gold, twisted into a round shape and then twisted between two flat surfaces (Ogden, 1991: 95–100).

A dense layer of excess gold was visible on the lower part of the catch-plate of fibula Seuth 1 (fig. 6.1). This was probably added during production to support the drawn pin holder. Only some traces of a contemporary (?) intervention can be seen on the upper surface of the bow – they are dense, bright and appear fresh (fig. 6.2).

Although the two miniature fibulae from Seuthopolis could have been used to pin thin fabrics or two edges together, the observations made provide clear evidence that there are no signs of their intensive use. This conclusion is also supported by the small size of the specimens. All this leads to the conclusion that these miniature brooches were made specifically for the burial and were not used in the real life. Therefore, the use-life of the fibulae was very short only during the funeral and their date can be linked to the date of their deposition in the grave. However, this does not exclude the possibility that they may have been made earlier and kept as a family treasure for some time.

II. Crossbow fibulae

The second group of fibulae examined is represented by four gold crossbow fibulae (fig. 7). They entered the collection of the National Archaeological Museum in the first third of the 20th century as stray finds and purchases of unknown provenance[2]. At present, a large number of bronze, silver and gilt-bronze fibulae are known from the territory of present-day Bulgaria (Gencheva, 2004: 61–65), while the brooches presented in this work are the only gold ones known so far. They remained unpublished, as only recently the smallest one was included in the Catalogue of the Museum (Boyadzhiev et. al, 2023: 110, Cat. No 61).

Figure 7. Four gold crossbow fibulae from the collection of the National Archaeological Museum at Sofia. Photo NAIM–BAS

The existence of the early crossbow brooch can be reliably confirmed in the second half of the 3rd century, with secure contexts placing these initial brooches between AD 250 and 280, though they may have appeared somewhat earlier (Van Thienen, 2017: 117–118). The gold crossbow fibulae were in fashion between the 4th and the 6th century AD and were highly valued for their splendour and decorative techniques. Scholars conclude that these brooches were worn exclusively by men—military officers, members of the imperial army, and officials within the administration – or by those destined for such roles (Van Thienen, 2017: 101). In some cases, even 12-year-old boys wore them, as evidenced by an early Christian inscription from Aquileia (Beschi, 1980: 419). The brooches were part of the chlamys attire, typically fastened to the right shoulder with the foot pointing upward (Van Thienen, 2017: 101).

The smallest crossbow gold fibula (fig. 8.1) was found in the region of Sofia and is distinguished by its size of 5 cm length and 19.32 g weight. It features arched bow with quadrangular cross-section, a short foot, a hexagonal transverse bar with two ovoid and one pointed central knob. The crest of the bow was decorated with a linear pattern with inlay of black paste (*niello*) and six deep transverse grooves were carved at both ends of the foot. The pin was not preserved.

The XRF analysis displays chemical composition with amounts of 84.8% gold, 13.9% silver and 1.3% copper (table 2).

Table 2. Results of the XRF analysis of the smallest crossbow fibula found in Sofia region conducted by P. Penkova

Sample	Au (Gold)	Ag (Silver)	Cu (Copper)
Sofia region	84.8%	13.9%	1.3%

This fibula does not find identical parallel but it is similar to a specimen found in a brick grave at Romuliana (present-day Gamzigrad, eastern Serbia) dated to the end of the 3rd – the beginning of the 4th century AD (Živić, 2009: 278, 294, pl. IIa-4, cat. no. 4; Petković, 2010: 278, cat. no. 1367, T. LIV, 2; Sl. 80–82). The earlier date of the fibula from Sofia is supported by the smaller size, the geometric ornaments and the combination of two ovoid and one pointed knob (cf. Deppert-Lippitz, 2000: 44). According to the inventory record, the other three massive crossbow fibulae originate from Archar, Vidin region (fig. 8.2), Malko Gradishte[3], Haskovo region (fig. 8.3) and Laka, Burgas region[4] (fig. 8.4). They are similar, as the length is respectively 7.8 cm, 7.2 cm and 7.7 cm, and the weight is 28.88 g, 62.56 g and 51.59 g. They were pre-manufactured from different gold parts and assembled together (see Deppert-Lippitz, 2000: 41). The bow is massive, trapezoidal in cross section and it was probably cast in multiple-use stone mould or by the lost-wax process. The crossbar is a hexagonal and hollow, its upper surface is completely covered by elaborate moulded appliqués. Three hammered bulbous knobs, smooth or faceted, were attached to each end and to the centre of the faceted crossbar. The places of joining of the foot and the three bulbous knobs were fitted with a decorative collar with small granules-like elements. The three specimens feature decorations along the edges of the foot – incised lunulas, arranged in pairs, and volutes. Solely the crest of the bow and the centre of the foot of the fibula with unknown provenance are covered with elaborately engraved decoration of repeating circles separated by lines inlaid with *niello*. The pin was attached by a hinge to a thin bronze rod inserted through the crossbar. It was the weakest point on brooches so only the pin of the fibula from Archar has been completely preserved and those of the others only partially. They were all made of bronze.

[2] Only one of the specimens is known to have been discovered by chance in a grave, with no other details.

[3] The former name of the village was Alvandere. With this provenance indication the fibula was entered in the museum's inventory book in 1903.

[4] The previous name of the village was Eski Pasli.

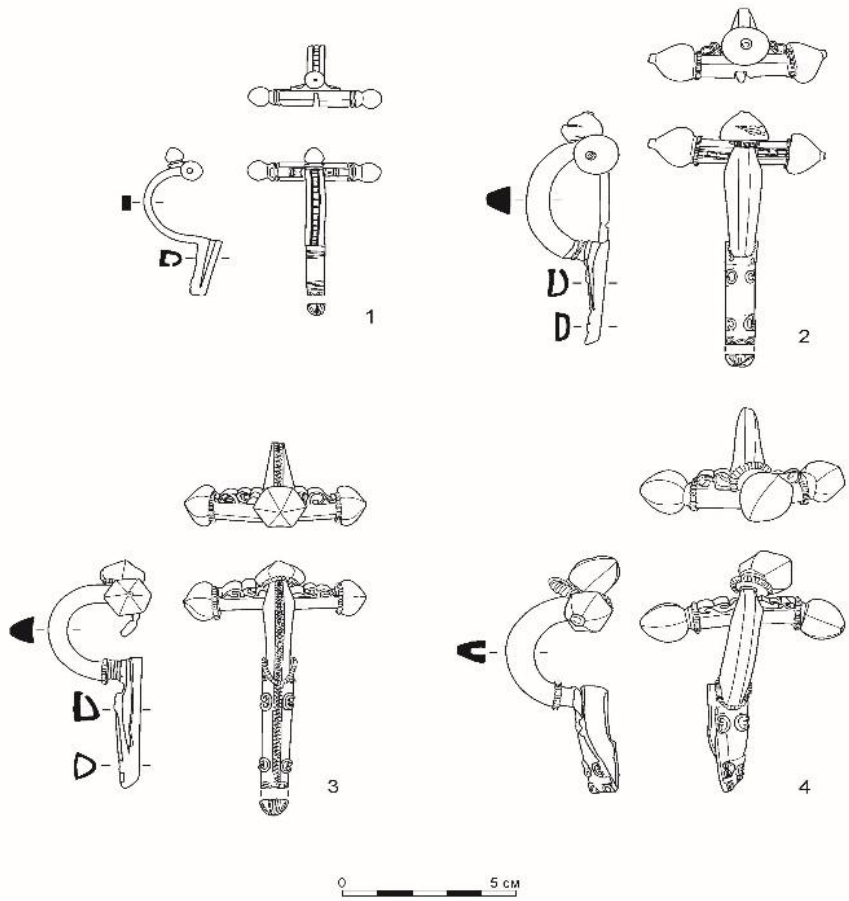

Figure 8. Gold crossbow fibulae from the National Archaeological Museum: 1. Fibula from Sofia region, inv. No 6185; 2. Fibula from Archar, Vidin region, inv. No 4590; 3. Fibula from Laka, Burgas region, inv. No 6649; 4. Fibula from Malko Gradishte, Haskovo region, inv. No 3226; Drawing M. Stamberova

As expected, the fibulae from Archar and Malko Gradishte, which have very similar decoration display very close chemical compositions with 96.9% and 96.2% gold and 3.1% and 3.8% silver respectively. The composition of the third fibula from Laka with *niello* inlay is slightly different with 87.3% gold and 12.7% silver (table 3). These results correspond to the recorded variation of gold in Roman jewellery between 80% and 97% (Ogden, 1993: 45).

Table 3. Results of the XRF analysis of the three crossbow fibulae of large dimensions conducted by P. Penkova

Sample	Au (Gold)	Ag (Silver)
Archar	96.9%	3.1%
Malko Gradishte	96.2%	3.8%
Laka	87.3%	12.7%

Determining the accurate date of the artefacts is difficult when the depositional context is lost. In such cases, we turn to their morphological and decorative features as well as to the iconographic sources and close parallels from well-dated burials. From the 4th century AD onwards, crossbow fibulae appeared in a wide range of artworks, such as sculptures, mosaics and frescoes (Van Thienen, 2017: 104). Compared to the already discussed crossbow fibula from the Sofia region, these three are distinguished by several significant features. These are the greater length and massiveness, the larger bulbous knobs, the longer foot, and stepped appliqués along the crossbar instead of small supports. These changes took place during the three decades of the Tetrarchy between 293 and 324 AD (Deppert-Lippitz, 2000: 46).

The presented crossbow fibulae could be defined as unique finds. They do not find exact parallels among the known specimens of the ancient world. Nevertheless, some similarities can be noted. For example, the fibulae from Archar and Malko Gradishte are comparable to two fibulae found in a wooden coffin at Carsium (modern-day Hirsova, Romania), which have been dated to ca. 318–320 AD (Deppert-Lippitz, 2000: 52–53, fig. 13). Remarkably, the bronze and gilt bronze parallels of our fibulae bear the later date of the midd – second half of the 4th century AD (Riha, 1990: 169, Taf. 55:1485; Buora, 1992: 11, n. 546, tav. II:1; Gencheva, 2004: 64). The fibula from Laka finds a good parallel with the gold brooches with *niello* inlay and pseudofiligree on the base of the bow discovered in a grave at Taraneš near Debar, Republic of North Macedonia, dated to ca. 317–324 AD (Deppert-Lippitz, 2000: 51, fig. 12). Such *niello* decoration, but with no lunulas, has the fibula from Turin with an inscription from the period 306–307 AD (Deppert-Lippitz, 2000: 48–49, fig. 10). Based on this data, the three crossbow fibulae kept in the National Archaeological Museum in Sofia can be dated to the first quarter of the 4th century AD.

The context of discovery of the four crossbow fibulae is disputable. In the first half of the 4th century AD, fibulae were increasingly deposited in graves rather than being recycled or

passed on to another owner (Van Thienen, 2017: 118). This suggests a funerary context of provenance for all specimens. In this sense, we are also unable to determine the possible workshops of manufacture of these brooches, which show individualism under a certain standardization. We can assume some imperial workshops located in Lower Danubian centres or some regional production centre in the Roman province of Thrace.

The microscopic examination of the presented four crossbow fibulae shows different traces on the surface. Most of them could be connected to the production process (fig. 9). The inner part of the bow of the fibula from Malko Gradishte is rough, probably due to the chisel used (fig. 9.1). In the surface of the grooves of the fibula from Sofia region deep parallel lines are visible, left by the tool used to make them (fig. 9.2). On the lunula of the fibula from Archar and Malko Gradishte, several small and shallow triangular traces can be seen. Some of these may be the result of line slippage (fig. 9.3) and others probably indicate where the decoration was to be applied (fig. 9.4–5). Traces of a rasp (fig. 9.6) and a dapping punch tool (fig. 9.7) are visible between some of the ornaments of the fibula from Archar. Shallow parallel dense lines, the result of the mechanical polishing at the end of the production process, are visible on the upper part of its foot (fig. 9.8). On the fibula from Archar, a small gold plates were put on a crack on the place of soldering of the knob (fig. 9.9–10) and on the edge of the opening of the transverse bar for the pin (fig. 9.11) forming a sort of patches. Unfortunately, it is not possible to determine whether these are the result of changes made during the production or some kind of subsequent correction.

The microscopic observation allowed us to study in detail the beaded circles around the base of the bow and the base of each bulbous knob of the three massive crossbow fibulae (fig. 9.12–13) and to connect them to the so-called beaded wire (Williams and Ogden, 1994: 23–24, fig. 20). It was manufactured from a plain wire, which was pressed with a double-edged tool to produce a series of grooves (fig. 9.14). These beaded wires covered and reinforced the joints between the various elements of the fibula.

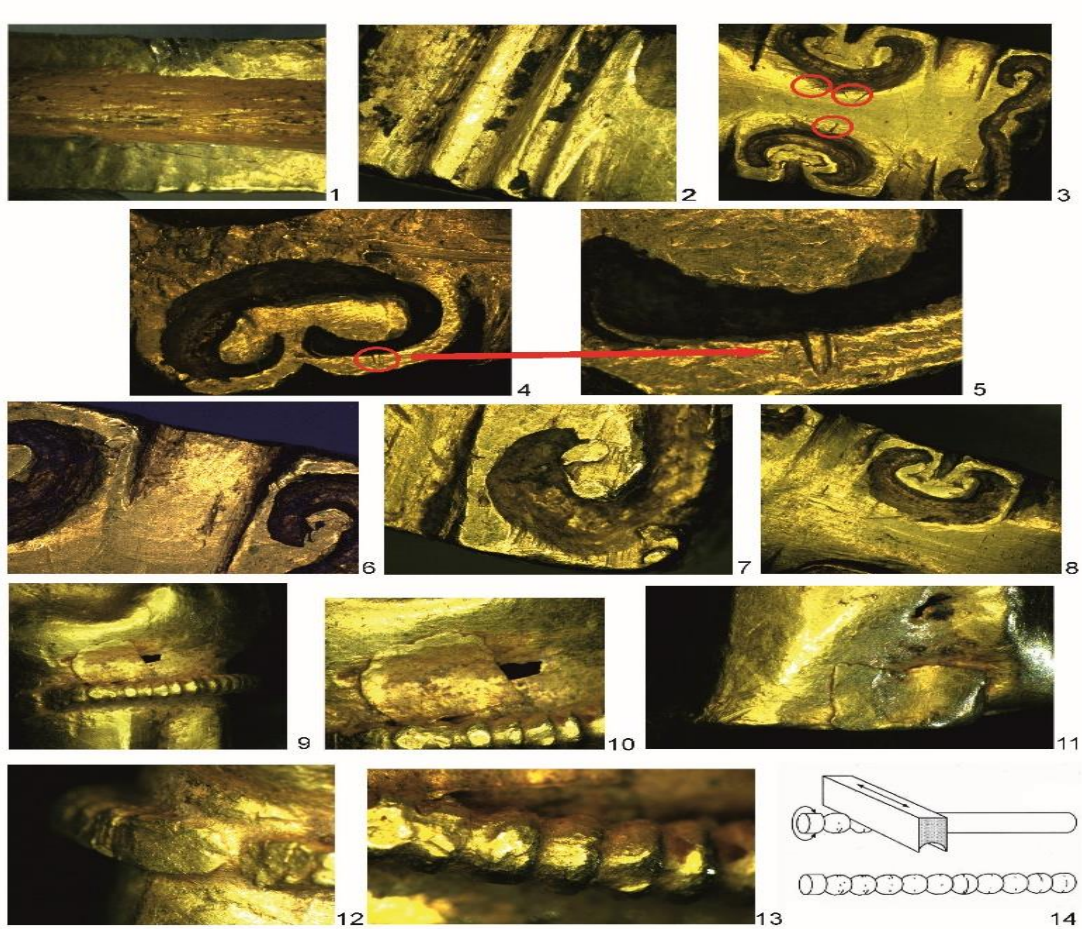

Figure 9. Microphotographs of traces associated to the production processes: 1. The inner part of the bow the fibula from Malko Gradishte (x25 magnification); 2. The surface of the grooves of the fibula from Sofia region (x50 magnification); 3. Small and shallow lines originate from the lunulas of the fibula from Archar (x25 magnification); 4–5. Sign for the places of the decoration of the fibula from Malko Gradishte (x50 magnification and x175 magnification); 6. Traces of a rasp on the foot of the fibula from Archar (x75 magnification); 7. Traces of dapping punch tool on the foot of the fibula from Archar (x100 magnification); 8. Dense lines resulting from the mechanical polishing at the end of the production process on the upper part of the foot (x30 magnification); 9–10. A small gold plate put on the place of soldering of the knob of the fibula from Archar (x25 magnification and x75 magnification); 11. A small gold plate put on the edge of the opening of the transverse bar of the fibula from Archar (x50 magnification); 12–13. Beaded circles around the base of the bulbous knob of the fibulae from Archar (x75 and x100 magnification). Photos M. Stamberova; 14. Reconstruction of the production of beaded wire (after Williams, Ogden, 1994: 23–24, fig. 20)

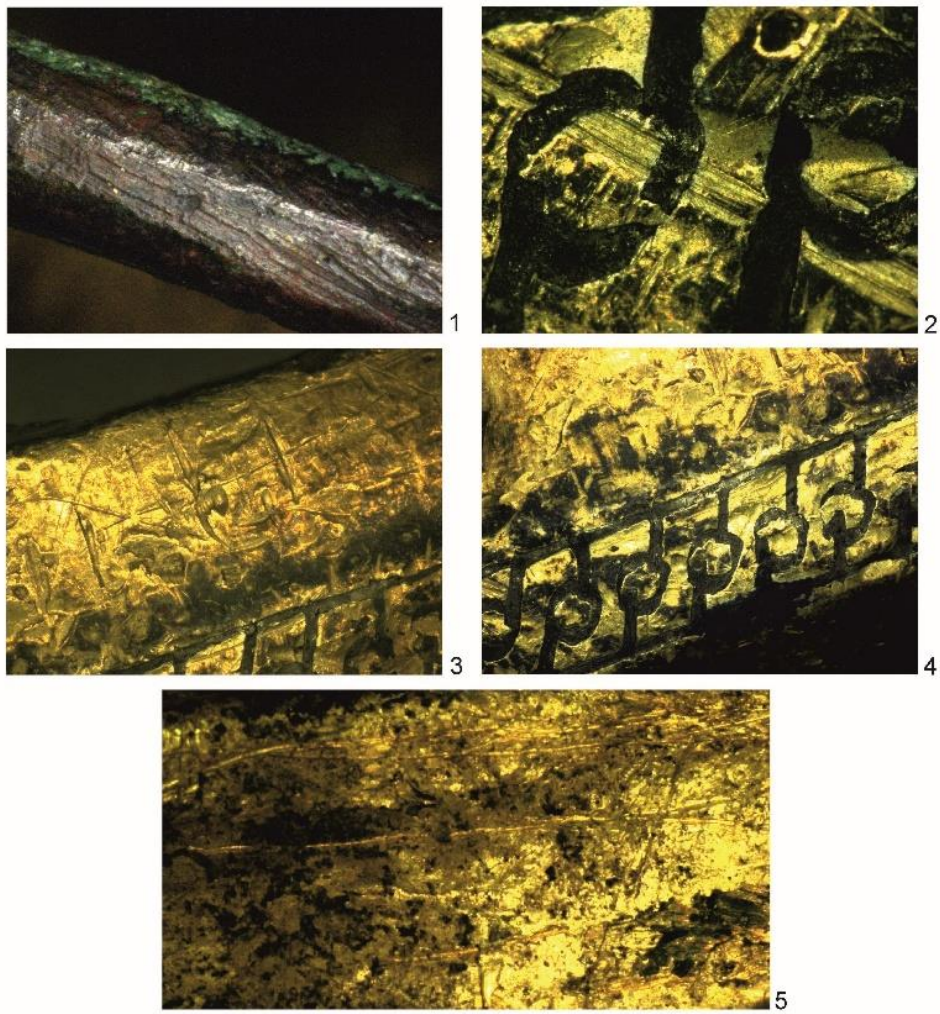

Figure 10. Microphotographs of traces associated with use, post-depositional processes and contemporary intervention: 1. Bronze pin of the fibula from Archar (x50 magnification); 2. Scratches that pass over the niello lines on the fibula from Laka (x175 magnification); 3–4. Rough surface and circles copied in a row over those with niello decoration on the foot of the fibula from Laka (x50 magnification); 5. Fresh scratches in the inner part of the catch-plate of the fibula from Malko Gradishte (x70 magnification). Photos M. Stamberova

Some traces associated with the use can also be established. The bronze pins of two of the fibulae are clear signs of the intensive use. Bellow the patina on the bronze pin of the fibula from Archar, long scratches were visible (fig. 10.1). It is also interesting to note some scratches across the niello lines on the fibula from Laka (fig. 10.2), which may also be further evidence of ancient use.

The rough surface (fig. 10.3) and the circles copied in a row over those with *niello* decoration (fig. 10.4) on the foot of the fibula from Laka could be related to the post-depositional processes, possibly due to prolonged contact with organic matter at high temperatures. Several fresh scratches on the inner part of the catch-plate of the fibula from Malko Gradishte (fig. 10.5) could be interpreted as a result of a contemporary cleaning from the soil.

2. Conclusion

The results of microscopic analysis presented here, in combination with other interdisciplinary methods, represent a modest attempt by the authors of this study to look beyond the standard archaeological approach. Sometimes long use is obvious from the condition of the artefact, but the examination under a microscope provides more detailed information that may be missed such as repairs, modern alterations, etc. The presented two different cases of fibulae use-life demonstrate the challenges in front of such a study. In the first case, the fine bilateral gold fibulae were specifically made for the deceased female, most probably immediately before her burial. In the second case, there is evidence of prolonged use, as evidenced by the size and importance of the crossbow fibulae. At present, we are unable to determine how long these artefacts have been in use and whether their condition is indicative of intensive and/or prolonged use. We hope that further experimental studies will shed more light on this question.

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Résumé - Détermination de la durée de vie des fibules en or mission (im)possible ? : Les fibules sont souvent utilisées comme marqueurs chronologiques fiables en archéologie. Leur durée de vie peut varier considérablement en fonction sur leur forme, leur taille et le matériau dont ils sont faits. Les fibules en or étaient extrêmement rares, même si elles constituaient un
signe d'autorité et de richesse. Deux fibules miniatures de type La Tène précoce de la période hellénistique primitive et quatre fibules d'arbalète romaines massives, toutes provenant de la collection de l'Institut archéologique national avec musée à Sofia ont été examinés par analyse XRF non destructive et observation traceologique microscopique. Le but de la présente recherche vise à étudier les possibilités de déterminer si et pendant combien de temps ces artefacts ont été utilisés avant leur déposition et ce qui leur est arrivé après leur découverte.
Mots-clés : *or, fibules bilatérales de La Tène ancienne, fibules d'arbalète, cycle de vie de l'artefact (durée de vie), analyse XRF, microscope optique, traçabilité, analyse de l'usure, Institut archéologique national avec musée à Sofia, Bulgarie.*

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