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ARCHAEOLOGICAL MATERIAL

BRONZE AGE DEER ANTLER PROCESSING WORKSHOP AT SÂNTION – *DEALUL MĂNĂSTIRII* (BIHOR COUNTY, ROMANIA)

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Abstract: This paper aims to analyze an archaeological assemblage consisting of 15 artifacts made from *Cervus elaphus* antlers (no=12), *Bos taurus* bones (no=2), and a *Sus scrofa* tooth (no=1). These artifacts originate from a Bronze Age tell settlement associated with the Otomani pottery style, located at Sântion–*Dealul* Mănăstirii, Bihor County. A technological transformation analysis of the raw materials was conducted, identifying the techniques employed in each of the two primary operations of the technological procedures: debitage and shaping. The presence of intermediate products within the *chaîne opératoire* (preforms and blanks) offered valuable insights into the debitage techniques, which are typically no longer discernible at the finished artifacts. Additionally, the analysis of 11 items from a single archaeological context (Cxt. 35) facilitated the development of a hypothesis regarding the possible operation of a modest workshop dedicated to deer antler processing. The examination of the finished artifacts involved use–wear analysis and an assessment of their potential functions. The assemblage exhibits distinctive characteristics of the osseous industry associated with the Otomani pottery style, particularly in terms of raw materials, typology, and technological methods.

Keywords: *Middle Bronze Age, tell settlement, Otomani pottery style, deer antler workshop, technological procedures, use-wear marks.*

INTRODUCTION

The corpus of Romanian literature has not dedicated significant attention to artifacts processed from osseous materials recovered from Bronze Age contexts, a gap largely attributable to the dominance of other material categories that are perceived as more spectacular. In most excavation reports, the presence of antler and bone tools is merely noted without further elaboration. For example, the report on the 1954 excavations at Sântion in the Bronze Age tell outer settlement states that deer antler was used to produce coulters and hammers, and bones were used to make awls.[1] However, this report lacks specific details regarding the number of artifacts and does not include illustrations. Given these circumstances, it is exceedingly difficult to establish meaningful correlations between the findings, as the various typological categories referenced in these studies are not defined using a consistent terminology. To date, only one publication addresses the processing

[1] ALEXANDRESCU 1955, 489.

of osseous material within the Otomani pottery style[2] on Romanian territory, making it essential for the identification of pieces similar to those examined in this study.

The aim of this study is to present an archaeological assemblage of osseous artifacts recovered from a Middle Bronze Age (MBA) tell settlement associated with the Otomani pottery style, located at Sântion – *Dealul* Mănăstirii, Bihor County. The artifacts were examined under microscope to identify technological marks, and, in the case of unfractured pieces, to reconstruct the development of use–wear patterns. The technological and use–wear marks were analyzed and documented through photography using a Keyence VHX–600 optical microscope (30x to 150x magnification) and an Olympus BX53M metallographic microscope (100x to 500x magnification). For each typological category, comparable Bronze Age artifacts were identified in order to assess how they conform to the characteristic features of the period with regard to raw materials, typology, and technological attributes. This analysis provides valuable insights into the economic and technological practices of the Otomani communities.

THE BRONZE AGE TELL SETTLEMENT

Bronze Age discoveries at Sântion were first reported by F. Rómer in 1871, marking the initial mention of a site later attributed to the so–called Otomani culture of Romania,[3] which is part of the Otomani–Füzesabony Cultural Complex (OFCC).[4] The tell itself was documented in 1936 by F. Ardoș,[5] and its outer settlement was investigated through surface surveys in 1954 by A. Alexandrescu and M. Rusu.[6] Systematic research of the Bronze Age tell at Sântion–*Dealul Mănăstirii* began in 2014 within the framework of the project „Living in the Bronze Age Tell Settlements: A Study of Settlement Archaeology at the Eastern Frontier of the Carpathian Basin" funded by the Ministry of Education through CNCS–UEFISCDI, PN–II–ID–PCE–2012–4–0020 grant.[7] In addition to a series of non–invasive investigations, two excavation units (S1 and S2/2015) were opened to establish the stratigraphy of the site. In S1, after investigating the medieval deposits attributed to the monastery located here, excavations halted at the Bronze Age level. In S2, excavations initiated in 2015 were only completed in 2023, revealing 44 archaeological contexts and a stratigraphy reaching 2.62 meters in depth.[8] Cxt. (Context) 5A represents the earliest Bronze Age layer, which has remained undisturbed by subsequent interventions, while Cxt. 44 corresponds to the latest Bronze Age stratigraphic accumulation in this area.

The 15 artifacts that will be analyzed in this article come from the following archaeological contexts: a bevelled tool created from the basal area of a fallen antler (Fig. 2/a–g) was unearthed at a depth of –1.10 m below the present level of the tell settlement (Cxt. 7B). The context is characterized by a grayish–yellow hue, a more compact structure, and the presence of pebbles. It corresponds to a level of arrangement and consolidation. This phase of construction marks the final stage of tell construction observed within this research unit (Fig. 1/a).[9] A pendant, made from *Sus scrofa* tooth (Fig. 7/a–i), was unearthed at a depth ranging from 1.50 to 1.70 m (Cxt. 9C). This layer, which represents the third phase of construction of the tell, characterized by a darker, more compact, grayish–brown (yellowish–brown towards the west) appearance, contains a relatively limited amount of archaeological material (Fig. 1/a).[10] From Cxt. 35, there are 11 artifacts: a bevelled tool crafted from the basal area of a fallen antler (Fig. 2/h–j), a deer antler beam (Fig. 3/a–e), a preform made out of a tine (Fig. 3/f–j), a tine segmented by a cutting procedure with a bronze axe (Fig. 3/k–l), three blanks in volume made from antler (Fig. 4/g–m), two flat blanks made also from antler (Fig. 5/a–f) and two spatulas made from *Bos taurus* ribs (Fig. 6/a–m). This context is a thin, compact clay floor, which, together with floors Cxt. 31A and 38B, belong to the fifth phase of construction of the tell (Fig. 1/a–b).[11]

A deer antler tine (Fig. 4/a) and another tine segment (Fig. 4/d) are originating from Cxt. 39E (Fig. 1/c), which is a dismantling layer (Fig. 1/a). This layer exhibits a light gray hue and contains a notable quantity of small to medium–sized ash lenses, along with a substantial presence of archaeological material (Fig. 1/c). Cxt. 39E and Cxt. 40B represent the seventh construction phase.[12] Chronologically, the bone and

Table 1. Sântion–*Dealul Mănăstirii*. Composition of the archaeological assemblage according to raw materials and typological categories.

Species	Raw material	Blank type	Degree of processing	Typological category	Number of artifacts
Cervus elaphus	antler	basal area	finished item	bevelled tool	2
		beam	preform	–	1
			blank	–	1
		tine	preform	–	2
			blank	–	5
		branching area	blank	–	1
Bos taurus	bone	rib	finished item	spatula	2
Sus scrofa	tooth	canine	finished item	pendant	1

[2] CHIDIOȘAN 1984.
[3] FAZECAȘ/GOGÂLTAN 2021, 318–320.
[4] FISCHL 2018, 3–4.
[5] ARDOȘ 1936, 66.
[6] ALEXANDRESCU 1955.
[7] GOGÂLTAN 2014; GOGÂLTAN 2016, 88–89.
[8] FAZECAȘ/DEMJÉN/GOGÂLTAN 2023, 23–26; FAZECAȘ/GOGÂLTAN/KÁTOCZ 2024, 253–263.
[9] FAZECAȘ/GOGÂLTAN/KÁTOCZ 2024, 260.
[10] FAZECAȘ/GOGÂLTAN/KÁTOCZ 2024, 256, 260.
[11] FAZECAȘ/GOGÂLTAN/KÁTOCZ 2024, 262, note 38.
[12] FAZECAȘ/GOGÂLTAN/KÁTOCZ 2024, 262–263.

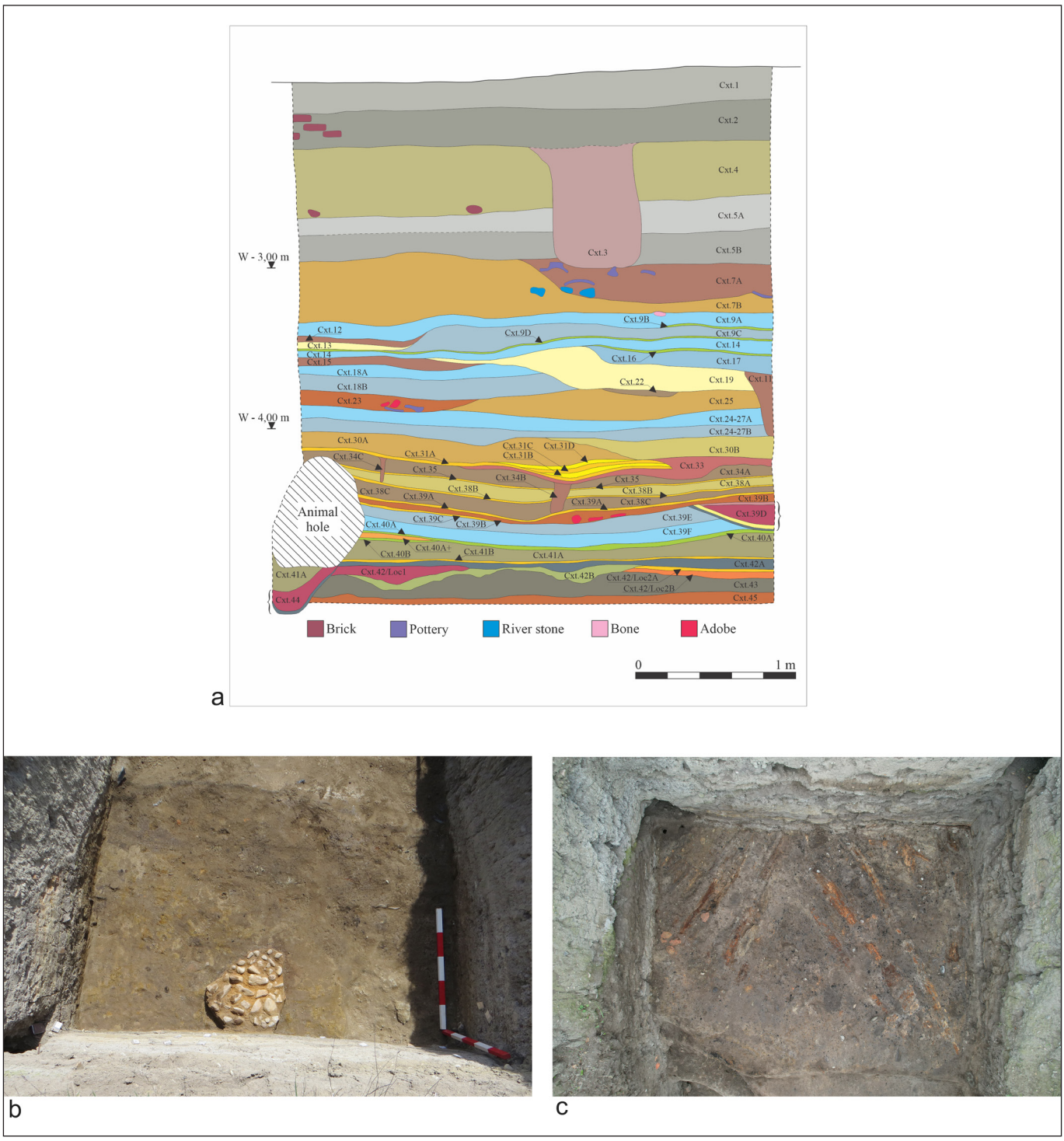

Fig. 1. a. Sântion–*Dealul Mănăstirii.* S2/2015. Northern profile; b. Sântion–*Dealul Mănăstirii.* S2/2015. Overview of the fifth phase of construction; c. Sântion–*Dealul Mănăstirii.* S2/2015. Overview of the Cxt. 39E.

antler tools analyzed in this article date from between 1743–1618 calBC (95.4%) and 1885–1749 calBC (95,4%).[13]

ARCHAEOLOGICAL ASSEMBLAGE

The archaeological assemblage consists of 15 artifacts, of which 12 were processed from *Cervus elaphus* antlers, two from *Bos taurus* ribs, and one from *Sus scrofa* canine (Table 1). Although the sample size is limited, the data has proven invaluable for reconstructing the technological procedures employed by Otomani communities in the processing of osseous materials. This is primarily due to the presence of intermediate products within the *chaîne opératoire*, such as preforms and blanks.

Antler

Bevelled tools (no=2)

The basal area of the shed antler (Fig. 2/a) (S2/2015, Cxt. 7B) has been modified to create a bevelled tool with

[13] FAZECAȘ/GOGÂLTAN/KÁTOCZ 2024, Fig. 7.

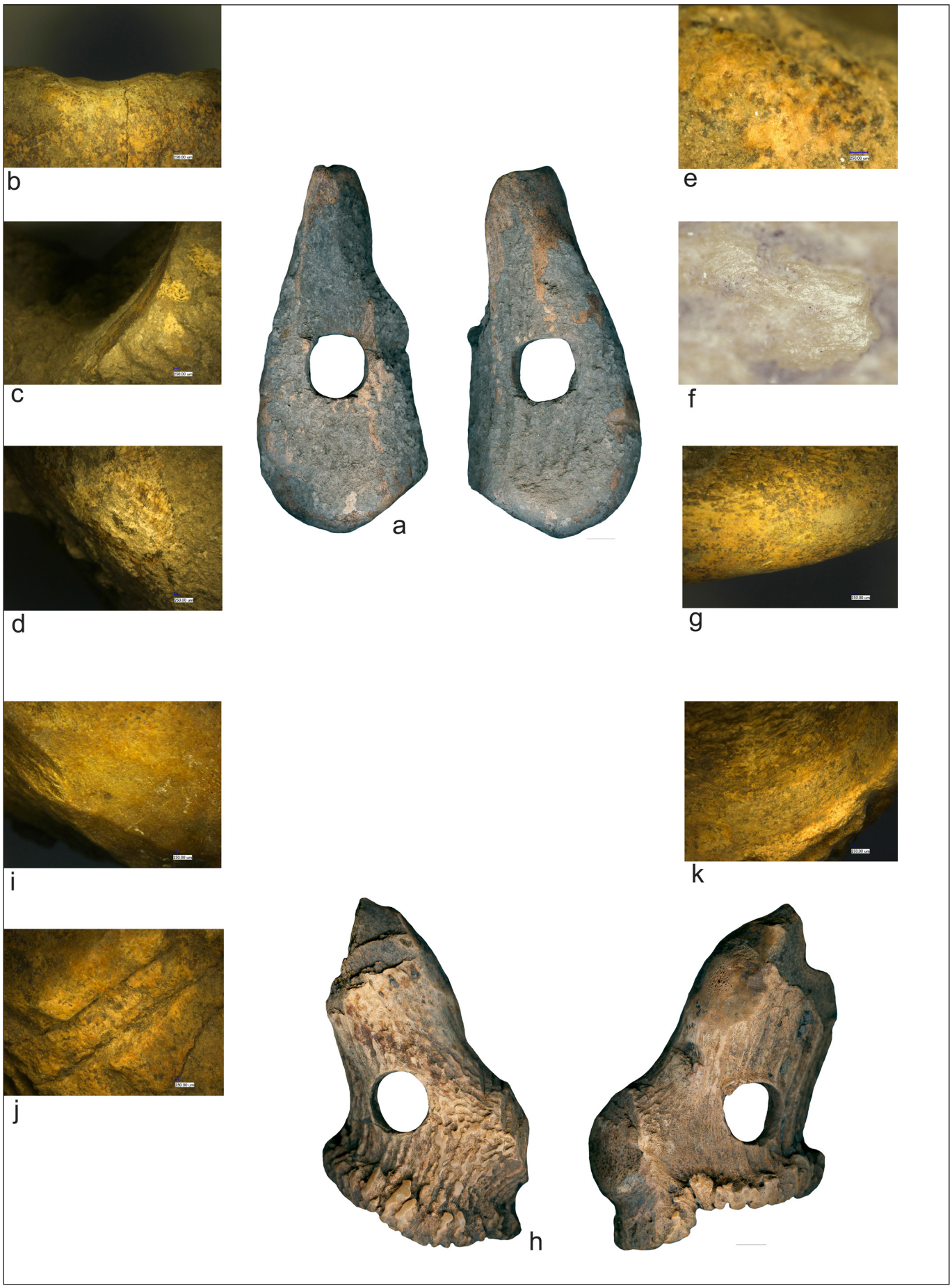

Fig. 2. Sântion–*Dealul Mănăstirii*. a, h. bevelled tools made from the basal area of shed antlers; b. active end morphology; c, k. perforations details; d, i–j. percussion marks; e–f. use–wear at the distal end; g. shaped area.

a transverse gloving system. A substantial area with technological and functional marks are no longer visible due to extensive surface deposits. Additionally, the specimen exhibits a longitudinal fracture at the distal end. The original anatomical volume of the antler has been preserved. At the level of the outer burr, the surface has been regularized through percussion (Fig. 2/d), and it is possible that the debitage edge was shaped, although no technological marks are apparent.

Proximally, a roughly square perforation was created through bifacial cutting (Fig. 2/c). Within the perforation, technological marks are no longer visible, and the surface has been flattened, indicating prolonged use. The active end was produced by successive percussive strikes applied obliquely to the antler surface to shape the specific morphology of a bevelled tool. Subsequently, the percussion edge was shaped, although it is unclear whether this process extended across the entire surface (Fig. 2/g). The active end is significantly affected by use–wear, displaying substantial alteration of the original volume due to repeated, superimposed fractures that have resulted in a minor central concavity (Fig. 2/b). This morphology suggests that the piece was used even after the fracturing process had begun. Microscopic examination revealed the presence of small areas of luster characterized by short, perpendicular marks near the active end (see Fig. 2/e and 2/f). The morphometric data are as follows: length – 134.5 mm; maximum width – 67.8 mm; thickness – 47.5 mm; perforation dimensions – 23 x 22.5 mm.

The second bevelled tool (Fig. 2/h) (S2/2015, Cxt. 35) was also processed from the basal area of a shed antler. The artifact is fractured at the distal end, preventing the reconstruction of the active end's morphology and the assessment of the degree of use–wear development. Percussion (Fig. 2/i–j) with bronze tools produces regular cutting edges characterized by narrow, well–defined marks and smooth walls, which contrasts with the jagged appearance observed when using stone tools. Experimental data indicate that the width of the active end of the bronze axe and the striking angle are the primary factors influencing the morphology of debitage edges.[14] The sharpness and thinness of the tool generate a concentrated cutting force that effectively penetrates raw material, rather than merely propagating along the surface of the bone. It can be stated that stone axes primarily cause fragmentation, whereas bronze axes are primarily used for cutting. The width of the active end directly correlates with the tendency of the material to be crushed and pushed into the incision. A perforation with a cylindrical morphology was created in the proximal area through rotation (Fig. 2/k). The artifact's actual length is 126 mm, with a maximum width of 78.6 mm, a maximum thickness of 74.8 mm, and a perforation diameter of 21 mm.

Preforms (no=3)

The deer antler beam (Fig. 3/a) (S2/2015, Cxt. 34A) can be considered in an intermediate stage of processing, with the procedure to create an active end already initiated. The blank is in volume, and the segmentation of the branch was achieved through cutting with a bronze tool. As the cutting progressed, both the traces of the cutting and the rotation direction of the piece became visible (Fig. 3/b–c). The cutting procedure produced a uniform pattern of bronze blades, characterized by V–shaped wall profiles and lacking fine parasitic striations. This differs from the pattern observed during the use of stone tools.[15] At the opposite end, the segmentation procedure of the branch remains unclear, as the active end was intended to be positioned in this area. The technological procedure involved creating a pointed tip by thinning the entire circumference of the piece. A chipping technique was employed on the surface (Fig. 3/d–e), but the piece did not reach the finishing stage. The length of the artifact measures 131.5 mm, with a maximum diameter of 45 mm.

The second preform was made from a tine (Fig. 3/f) (S2/2015, Cxt. 35). The blank is in volume and was produced through segmentation at both ends. The procedure was carried out by cutting with a bronze tool, resulting in a segmentation edge characterized by the same features described previously (Fig. 3/g–i). At one end, the spongy tissue was perforated using a rotation technique (Fig. 3/j), likely intended to provide a longitudinal gloving. The following morphometric data were recorded: length – 35 mm; maximum diameter – 19.5 mm; perforation diameter – 9.4 mm.

The third piece in this category (Fig. 3/k) (S2/2015, Cxt. 35) was a tine that had been segmented through a cutting procedure using a bronze axe (Fig. 3/l). At the apex, the active end was initially shaped with a series of small bifacial percussion blows (Fig. 3/m). The procedure was not yet completed; therefore, the specimen is classified as a preform. The length of the preform is 130.4 mm, with a maximum diameter of 27 mm.

Blanks (no=7)

A deer antler tine (Fig. 4/a) (S2/2015, Cxt. 39) was segmented through cutting (Fig. 4/c) applied on two–thirds of the circumference using a bronze axe. The final detachment was achieved by applying bending forces, resulting in a longitudinal fracture. The blank preserved the original anatomical volume. The tip of the tine was also removed by cutting (Fig. 4/b), with the same final bending evidenced by a small, characteristic fracture. No traces of shaping are apparent. The length of the blank is 142.2 mm, with a maximum diameter of 21 mm. An identical procedure is observed at another tine segment (Fig. 4/d) (S2/2015, Cxt. 39). Segmentation was performed by cutting with a metal tool, which bears characteristic marks (Fig. 4/f). Additionally, the tip of this tine was similarly removed by the same technique (Fig. 4/e). The final bending was performed with precision to avoid creating characteristic fractures, as observed at the previous piece. No shaping marks are visible. The dimensions of this piece are as follows: length – 117 mm; maximum diameter – 27 mm.

A third tine segment (Fig. 4/g) (S2/2015, Cxt. 35) was also classified within the category of blanks, despite its small size, which would typically suggest a debris piece from debitage. This classification was facilitated by the presence of a small preform as well (e.g., Fig. 3/f). Once again, the piece retains

[14] OKALUK/GREENFIELD 2022.

[15] GREENFIELD 2005.

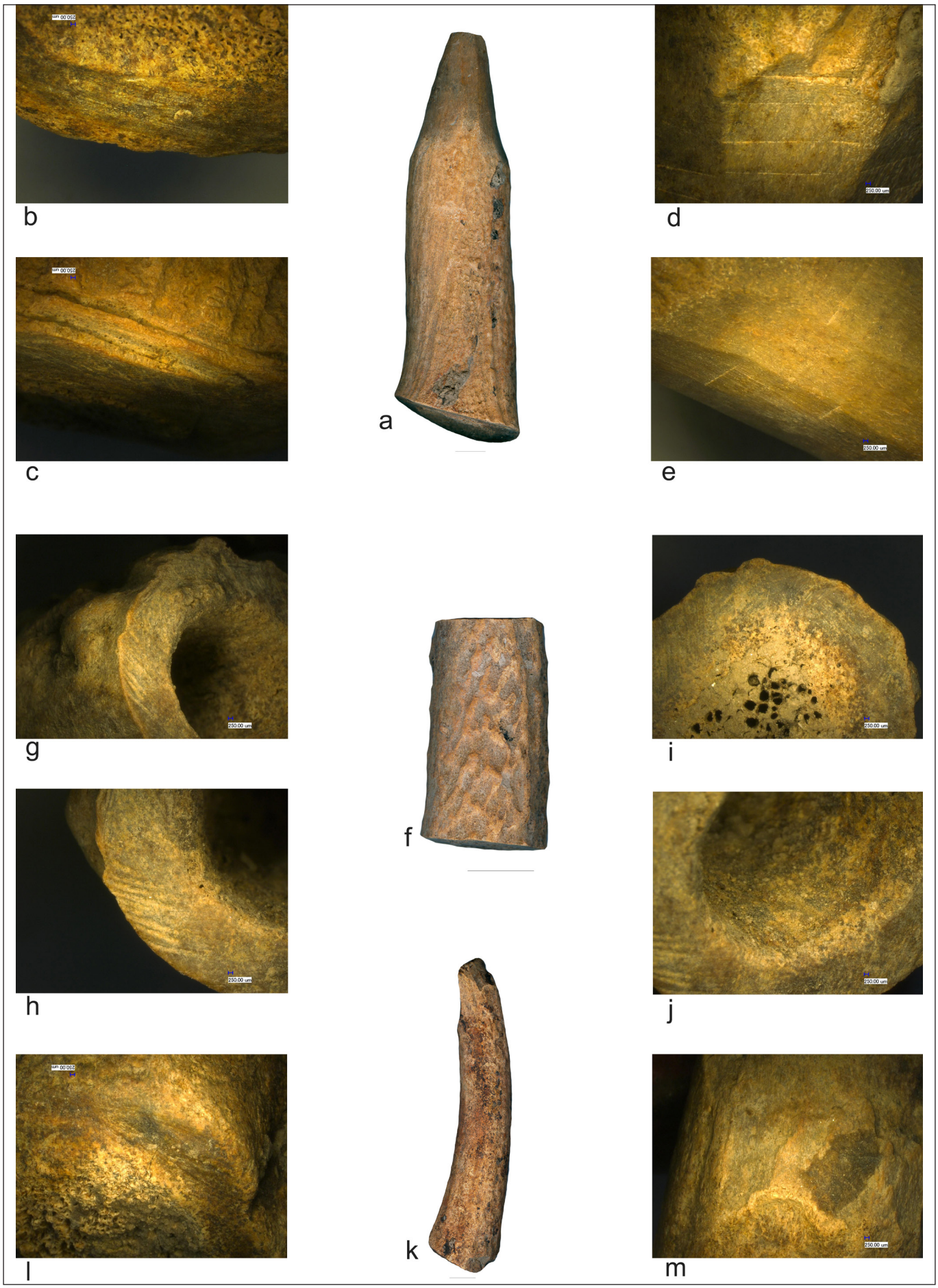

Fig. 3. Sântion–*Dealul Mănăstirii.* a, f, k. preforms made from antler; b–e, g–i, l. cutting marks; j. perforation detail; m. percussion marks.

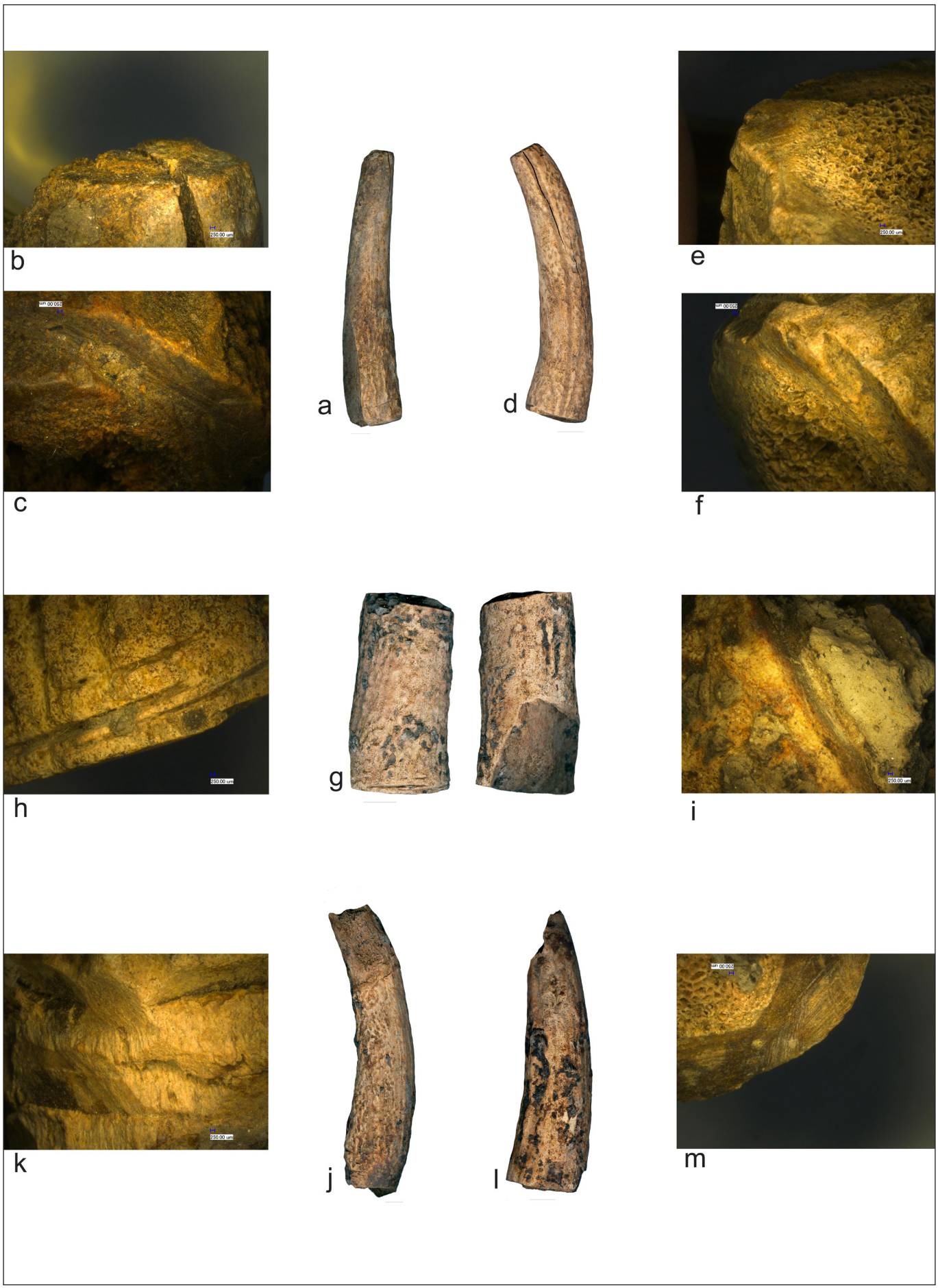

Fig. 4. Sântion–*Dealul Mănăstirii.* a, d, g, j, l. blanks made from antler; b–c, e–f, i, m. cutting marks; h, k. percussion marks.

its volume. The detachment from the branch was achieved through percussion (Fig. 4/h). Marks are visible along the periphery of the segmentation edge, where the tool missed the correct percussion direction. The cuts are deep, featuring a straight plane on the wall, which is a characteristic of segmentation performed with a bronze tool. Ultimately, the bending procedure was conducted prematurely, as the spongy tissue had not yet been reached, resulting in a longitudinal fracture. At the apex, the detachment was performed through cutting (Fig. 4/i), again with a bronze tool. Once more, a minor fracture occurred during the final bending phase. The blank measures 65.2 mm in length and has a maximum diameter of 36 mm.

The assemblage is complemented by a tine segmented through percussion, applied around its entire circumference (Fig. 4/j) (S2/2015, Cxt. 35). The marks (Fig. 4/k) were clearly made with a bronze axe. The fracture at the tip does not appear to be of anthropogenic origin. The original anatomical volume of the antler has been preserved. The length of the piece is 153 mm, with a maximum diameter of 38 mm.

The final blank in volume (Fig. 4/l) (S2/2015, Cxt. 35) is also a tine that was segmented by cutting with a bronze tool (Fig. 4/m). The tip is fractured, and the artifact measures 87 mm in length with a maximum diameter of 27 mm.

Two flat blanks are also present. The first was processed from the upper branching area (Fig. 5/a) (S2/2015, Cxt. 35). Its production involved both transversal and longitudinal debitage. At all three ends, segmentation was achieved through cutting (Fig. 5/b–c) with a bronze tool. The antler was split longitudinally by percussion (Fig. 5/d–e), with visible marks. No signs of shaping are evident, leading to the conclusion that it is a blank. Its length is 130.2 mm, with a maximum width of 101 mm and a maximum thickness of 26.4 mm.

The second flat blank (Fig. 5/f) (S2/2015, Cxt. 35) was obtained from a deer antler beam. Initially, segmentation at both ends was performed by cutting (Fig. 5/g). Subsequently, a longitudinal bi–partitioning was performed through percussion (Fig. 5/h). No evidence of shaping is apparent. The morphometric data are as follows: length – 88.5 mm; maximum width – 43 mm; maximum thickness – 25.2 mm.

Bone

Spatulas (no=2)

In both cases, the spatulas were made from *Bos taurus* ribs. The first piece (Fig. 6/a) (S2/2015, Cxt. 35) is a meso–distal fragment, preserving the original anatomical volume. To create the active end, a unifacial percussion was applied, accompanied by abrasion of the debitage edge (Fig. 6/b). The abrasion marks are largely obscured by use–wear marks. For its production, a bronze axe was employed, and its marks are visible under the metallographic microscope (Fig. 6/c). Macroscopically, the active end exhibits a convex, notched morphology (Fig. 6/d), resulting from small fractures that did not impair the functionality of the item. These features are overlaid by a macroscopic luster, indicating continuous use despite the degradation of the original volume of the active end. Microscopically, fine parallel striations perpendicular to the active end are observable (Fig. 6/e). These are associated with small areas of flattening that display macroscopic luster (Fig. 6/f). Function–related striations are also present at the periphery of the active end, but in this case, they are longer and deeper (Fig. 6/g). The surface of the piece shows moderate use–wear, most likely due to hand rubbing. These data suggest that the piece was used with a longitudinal movement to work a harder material, producing the laced morphology observed at the distal end. The overall length of the piece is 92.2 mm, with a maximum width of 33.5 mm and a maximum thickness of 6.8 mm.

The second specimen (Fig. 6/h) (S2/2015, Cxt. 35) is a meso–proximal fragment that preserves the original anatomical volume of the bone. The appearance of the active end is unknown, as the piece was fractured; however, it is a finished artifact, evidenced by visible technological modifications and highly developed use–wear. Under the microscope, traces of a bronze tool are observable (Fig. 6/j). The surface use–wear data indicate that it was a spatula. Proximally, bone segmentation was achieved through percussion. The debitage edge was subsequently abraded (Fig. 6/i). No other technological interventions are evident. Instead, the entire surface is covered with a strong luster, accompanied by surface flattening and superficial alterations of the external structure (Fig. 6/m). Under microscopic examination, the luster is associated with fine, irregularly distributed longitudinal striations of varying depth (Fig. 6/k–l), which indicate the direction of the item's use. The morphometric data are as follows: length – 118 mm; maximum width – 30.2 mm; maximum thickness – 9 mm.

Tooth

Pendant (no=1)

A flat blank was utilized to process the specimen, using the tip of the tooth (Fig. 7/a) (S2/2015, Cxt. 9C). In the initial stage, the tooth was cut longitudinally through direct percussion (Fig. 7/b). Percussion marks are visible, and the debitage edge was not subsequently shaped. It is assumed that the piece was originally a scraper. The active area, positioned laterally and displaying a concave morphology, overlaps with the natural wear area of the tooth. Longitudinal scraping marks are evident along the periphery of the active area (Fig. 7/c–g). The morphology of the scraping striations – long, deep, with a clearly defined wall profile – supports the hypothesis of bronze tool use. It is evident that the tool was repeatedly resharpened to maintain an effective cutting edge. At a later stage, the piece was likely recycled into a pendant, accomplished through a one–sided rotation from the inferior side (Fig. 7/h). The striations remain visible, but the surface along the perforation has begun to flatten, gaining a macroscopic luster, and the technological marks have started to disappear (Fig. 7/i). The use–wear around the perforation is less intense than that on the active side, suggesting that the perforation was made subsequently, after the piece had already used as a scraper. The overall length of the piece is 80 mm, with a maximum width of 18.5 mm and a maximum thickness of 6 mm.

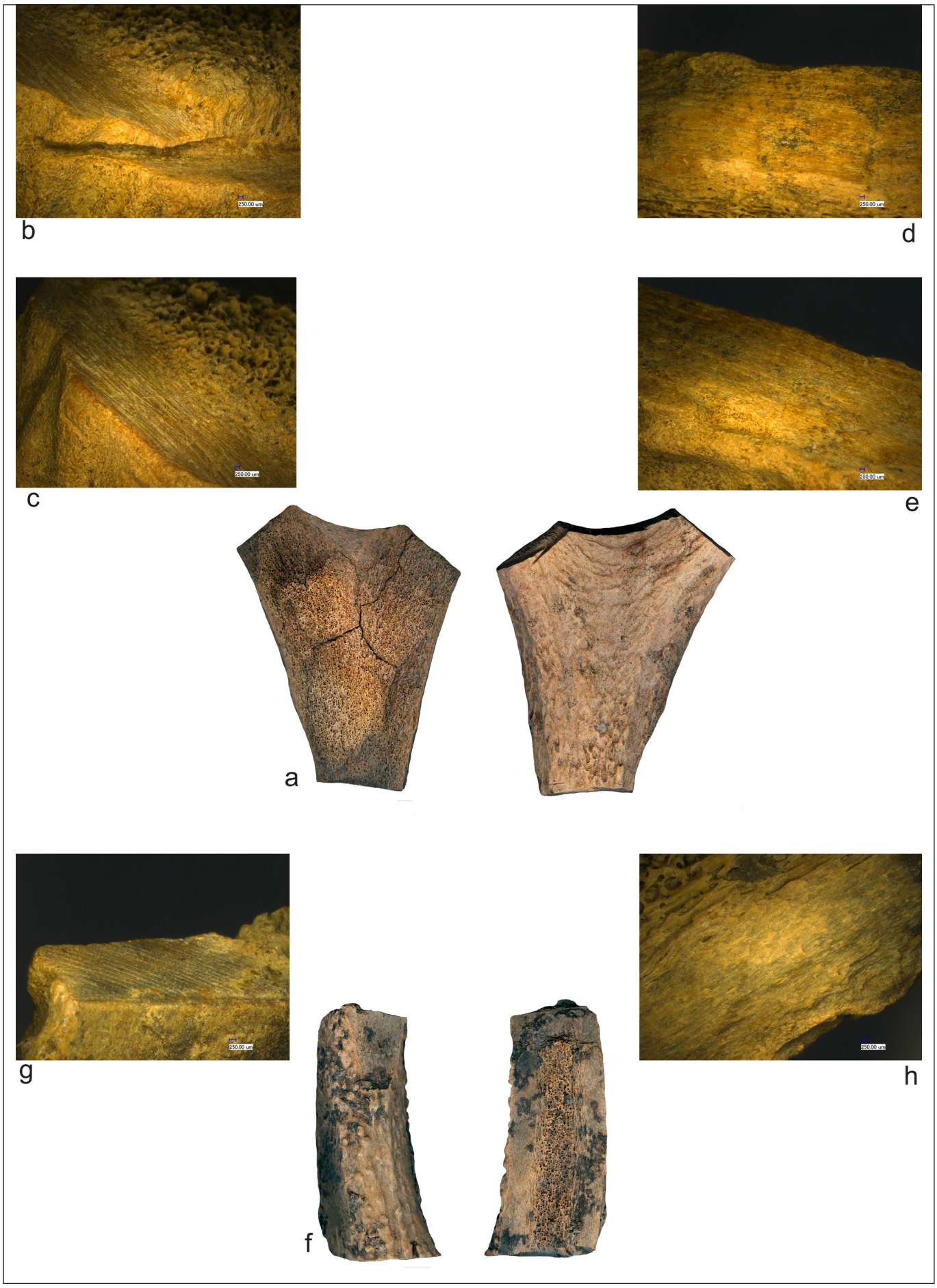

Fig. 5. Sântion–*Dealul Mănăstirii.* a, f. blanks made from antler; b–c, g. cutting marks; d–e, h. percussion marks.

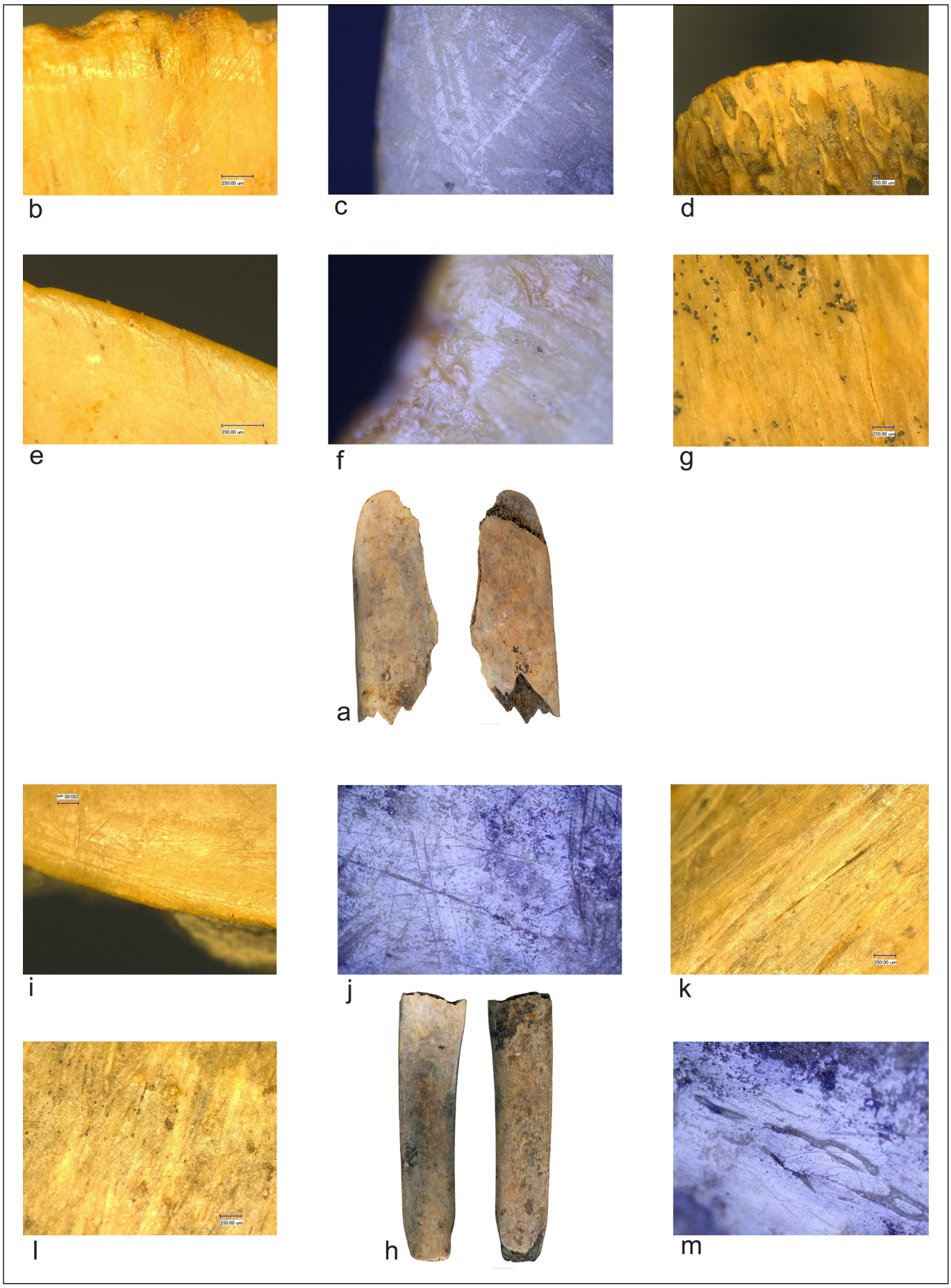

Fig. 6. Sântion–*Dealul Mănăstirii.* a, h. bone spatulas; b, i. abrasion marks; c, j. traces left by a bronze piece; d. active end morphology; e–g, k–m. use–wear area details.

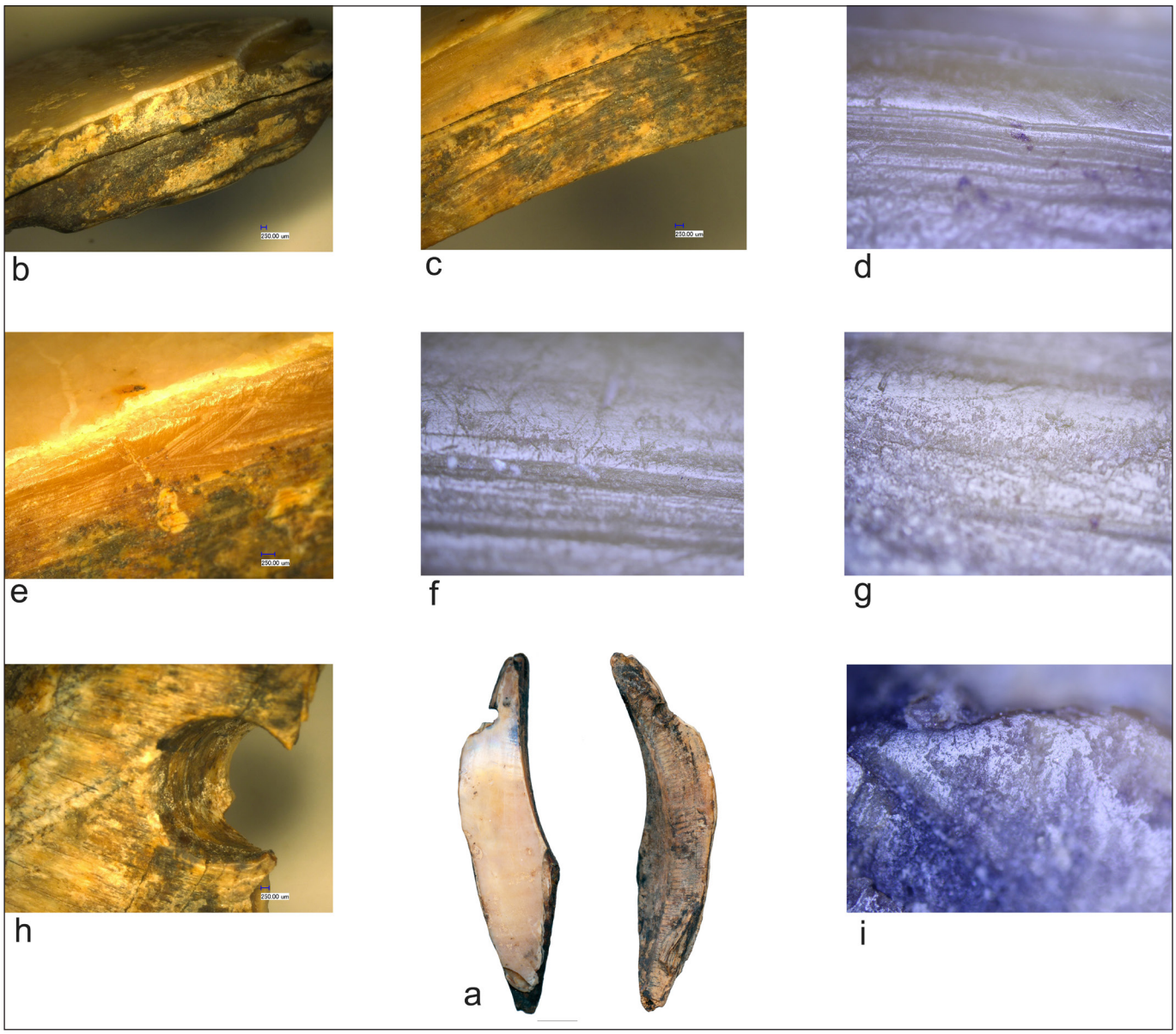

Fig. 7. Sântion–*Dealul Mănăstirii*. a. pendant made from *Sus scrofa* tooth; b. percussion marks: c–g. scraping marks; h. perforation detail; i. use–wear area at the perforation level.

DISCUSSION

Raw materials

Animal husbandry was an important occupation for the Otomani communities in the eastern Carpathian Basin, with cattle being the primary livestock.[16] In the Otomani area, although hunting was a secondary activity, a wide range of mammals has been attested, including red deer, roe deer, wild boar, bison, brown bear, fox, wolf, among others.[17] The preference for hunting cervids and wild boar is evident, as observed in other MBA sites in Hungary.[18] The selection of raw materials for osseous tool production does not entirely align with economic realities, since within the studied assemblage, *Cervus elaphus* antler was the most frequently used raw material (see Table 1), rather than bones from domesticated animals, as might be expected. Therefore, in this case, it is possible that the cultural value attributed by the community played a dominant role in the choice of raw materials. Knowledge of which parts of the animal skeleton could be utilized was embedded in the community's myths,[19] resulting in minimal variation in raw material selection over long periods, despite fluctuations in species availability or economic options.[20] Although most Bronze Age sites in the Carpathian Basin primarily contain antler artifacts,[21] there are also assemblages, such as at Kakucs–*Turján*[22], where the majority of finds were made of bone. In such cases, economic factors appear to be the primary determinant.[23] Consequently, it is not possible to define a general paradigm

[16] ORDENTLICH 1974; HAIMOVICI 1987; BÖKÖNYI 1988; EL SUSI 2002; GĂVAN *et alii* 2022, 77–80; NOLDE 2024.
[17] CHIDIOȘAN 1984; BÖKÖNYI 1988; EL SUSI 2002; FAZECAȘ 2003.
[18] CHOYKE 1987; TUGYA 2018.
[19] CHOYKE 2010; CHOYKE/DARÓCZI–SZABÓ 2010.
[20] CHOYKE/VRETEMARK/STEN 2004, 184–188; LUIK 2009, 2011; NICODEMUS/LEMKE 2016, 109–113, Tab. 3–4.
[21] CHOYKE 1984, 34–35, Tab. 8.
[22] GÁL 2018.
[23] BILLER 2018.

for raw material selection throughout the entire Bronze Age in the Carpathian Basin; each site must be analyzed individually to determine whether economic or cultural considerations prevailed.

According to specialists, among all osseous materials, antler possesses the optimal elasticity–to–hardness ratio, making it, from this perspective, the most suitable material for the manufacture of various artifacts associated with prehistoric tools.[24] Antler can be obtained either through hunting wild animals or by collecting naturally shed antlers. If obtained from a hunted animal, the primary goal was food, the acquisition of this raw material being secondary. Conversely, if collected from shed antlers, the acquisition was made purely for technical purposes, without any relation to food, in order to ensure a sufficient supply of this material. Based on a series of experimental studies, shed antler is considered more suitable for processing because, when at its maximum development, the area of sections with compact tissue (the area used for tool production) is more extensive.[25]

Within the analyzed assemblage, only two pieces originate from the basal area of the antler, providing insights into the type of antler used. In both cases, these are shed antlers from mature individuals. However, we cannot conclusively support the exclusive exploitation of shed antlers by the Otomani communities, as evidence from the *Cetatea de Pământ* tell–like settlement indicates that antlers were also cut from the skulls of hunted animals.[26] Similarly, at the MBA tell settlement of Jászdózsa–*Kápolnahalom*,[27] a comparable situation to that at Sântion–*Dealul Mănăstirii* has been identified. Here, the most prevalent finds are pieces made from processed deer antlers, including both large fragments and preforms, as well as relatively significant amounts of debris. Since the majority of identifiable pieces appear to derive from shed antlers, this suggests that antler supplies were important for economic purposes, likely indicating that more material was procured than was immediately necessary to meet the local population's needs. Specialists have hypothesized that this stockpile was used for trade in finished products that exceeded community requirements.[28] Furthermore, it has been established that most of the tools were produced in a specific area of the settlement, which may indicate that access to antlers was limited to certain individuals responsible for the gathering, storage, manufacture, and trade of antler objects.

The second raw material used is the *Bos taurus* rib, which is the most representative domestic species among the osteological remains from Otomani settlements. The selection of this type of bone blank reflects a thorough knowledge of its morphological and mechanical properties. Ribs possess increased elasticity and provide flat, wide blanks that cannot be obtained from other types of bones. They are most suitable for the production of spatulas.

Finally, the *Sus scrofa* canine was obtained as a by–product of hunting, as wild boar was one of the primary mammals targeted. This type of tooth exhibits a triangular morphology in section, is curved, and oriented outward. In the root area, the tooth is hollow internally. The lower canines – those used for tool–making – display a natural wear facet near the distal end, resulting from friction with the upper canines.[29] The piece from the analyzed assemblage was fashioned from the distal portion of the tooth, including a section of the wear facet.

Technical transformation scheme

Based on the analysis of the three technological categories described above (finished pieces, preforms, blanks), the procedures involved in carrying out both operations specific to the operational scheme – debitage and shaping – were reconstructed. In the case of antler, debitage resulted in the production of two types of blanks: volumetric and flat. A preference is evident for the use of anatomical volumetric blanks (no=10) over flat blanks (no=2). Starting from the debitage blocks (blanks) and preforms, we identified two detachment procedures: a transversal debitage, guided by a segmentation transformation scheme, and a longitudinal debitage, guided by a bipartition transformation scheme. In the first case, the techniques employed include cutting, generally combined with bending and direct percussion. For the longitudinal debitage procedures, the sole technique used was percussion. Regarding the bone material, only volumetric blanks are present. For the debitage operation, a segmentation transformation scheme applied by percussion was identified. The tooth piece was fashioned from a flat blank, produced using a bipartition transformation scheme achieved through percussion.

Surface modification procedures are observed on only a few pieces, as blanks predominate in the archaeological assemblage. For example, in the case of spatulas, evidence of abrasion is present. The shaping of the tooth artifact was accomplished through scraping. Regarding volume modification, the only technique applied was perforation, with variants including bifacial rotation and cutting. Such procedures – debitage by percussion or cutting,[30] perforation by percussion or rotation, and shaping by abrasion – are widespread throughout the MBA across the Carpathian Basin.[31]

For various procedures, particularly within the debitage operation, the use of bronze tools is documented. The morphology of the cutting or percussion marks aligns with descriptions found in the scholarly literature.[32] This observation has also been noted by other specialists in studies of Otomani assemblages from Romania[33] and MBA assemblages from Hungary.[34]

[24] BILLAMBOZ 1977; MICHELS/ZURBUCHEN 1991; AVERBOUH 2000; VERCOUTÈRE *et alii* 2007.
[25] AVERBOUH 2000.
[26] HAIMOVICI 1987, Fig. 4.
[27] CHOYKE 2005, 134, Fig. 5; CHOYKE/BARTOSIEWICZ 2009, 361, Fig. 5.
[28] CHOYKE 2005, 144; CHOYKE/BARTOSIEWICZ 2009, 368.
[29] MARQUEBIELLE 2014.
[30] NICODEMUS/LEMKE 2016, 114.
[31] CHIDIOȘAN 1984, 29–30; CHOYKE/BARTOSIEWICZ 2000, 55–59; NICODEMUS/LEMKE 2016, 113–114, Fig. 3.
[32] GREENFIELD 2005; CHRISTIDOU 2008; OKALUK/GREENFIELD 2015.
[33] CHIDIOȘAN 1984, 29–30.
[34] CHOYKE 2005, 143; CHOYKE/BARTOSIEWICZ 2009, 367.

A broader perspective about MBA osseous industries in the Carpathian Basin

First of all, we must emphasize the atypical composition of the assemblage from Sântion–*Dealul Mănăstirii*. Generally, in prehistoric assemblages, finished artifacts predominate; however, in this case, the most numerous are the blanks. A similar situation has been reported for the tell settlement from Pecica–*Șanțul Mare*, where only 4% of the processed antler fragments are finished items.[35] Experimental studies have demonstrated the exceptional resistance of antler and tools, and as observed, there was a stockpile of raw material consisting of unprocessed blanks. These blanks display a standardization of dimensions, which may suggest preferential gathering. Furthermore, at the hunting level, evidence of game selection is also recorded, with a preference for adult males.[36] The fact that 11 pieces originate from a single archaeological context has led us to hypothesize the existence of a small antler processing workshop. We can speak of careful management of the raw material by collecting antlers and maintaining stocks to ensure a continuous supply, allowing for the quick and efficient replacement of damaged equipment.

Consequently, only the finished artifacts reveal the ways in which tools made from hard animal materials were used. Both bevelled tools were crafted from deer antler. The generic term „bevelled tools" encompasses items characterized by shaping the active end through the intersection of two converging sides (*en biseau*).[37] Based on the marks present at the distal end of the only intact bevelled tool – namely, a smoothed end with fractures, a radical modification of the initial volume to create a concavity in the median area, a strong surface luster, including microscopic and functional striations – it can be inferred that it was used in percussion activities, most likely for woodworking. Massive pieces fashioned from the basal area of fallen antlers, equipped with a glove hole, are attested at Vărșand–*Movila dintre vii=Lapóshalom*,[38] Girișu de Criș–*Alceu*/Toboliu–*Dâmbul Zănăcanului*,[39] Otomani–*Cetățuie=Várhegy*,[40] Sălacea–*Dealul Vida=Vida hegy*,[41] Pir–*Cetate=Vársziget*,[42] Carei–*Bobald*,[43] Mediești Aurit–*Ciucaș*[44] in the area of the Otomani communities, but also in other MBA tell and tell–like settlements: Periam–*Movila Șanțului*,[45] Pecica–*Șanțul Mare*,[46] Socodor–*Căvăjdia*,[47] Derșida–*Dealul lui Balotă*,[48] Tiszafüred–*Ássotthalom*,[49] Tard–*Tatárdomb*,[50] Jászdózsa–*Kápolnahalom*,[51] Százhalombatta–*Földvár*,[52] Kakucs–*Turján*,[53] Pákozdvár–*Várhegy*[54] or in the fortified settlement of Maszkowice at the northern edge of the Otomani–Füzesabony world,[55] illustrating similar percussion and perforation (by rotation and cutting) procedures.

The spatulas were considered (based on morphology and marks) to be tools for processing soft materials.[56] The presence of a relatively thin active end with an oblique inclination, whose strong luster is the primary indicator of use, also appears to be evidence supporting this interpretation. In the category of soft materials, in addition to leather, bark or green wood can also be included.[57] Because the morphology of the active end on the only spatula that preserves it is jagged, we support the hypothesis that these tools were used for processing such materials rather than leather, which would not typically produce such microfractures. Spatulas made from cattle ribs are also known from other MBA tell and tell–like settlements: Bakonszeg–*Kádárdomb*,[58] Derșida–*Dealul lui Balotă*,[59] Jászdózsa–*Kápolnahalom*,[60] Kakucs–*Turján*,[61] Pákozdvár–*Várhegy*,[62] Százhalombatta–*Földvár*,[63] Tiszafüred–*Ássotthalom*[64], and Tószeg–*Laposhalom*.[65]

The pendant made from *Sus scrofa* canine was originally used as a scraper, and items of this type have been documented at other Otomani settlements.[66] Publications, primarily based on ethnographic comparisons with data collected from Indonesia[67] and supplemented by experimental replication,[68] indicate that these pieces were used for scraping wood and removing bark. Scrapers of this type are also found at the site of Jászdózsa–*Kápolnahalom*,[69] and perforated teeth made from *Sus scrofa* canines, some of which may have originally served as scrapers, are attested at the MBA tells of Jászdózsa–*Kápolnahalom*,[70] Pákozdvár–*Várhegy*,[71] Periam–*Movila Șanțului*,[72] and Tószeg–*Laposhalom*.[73]

Starting from some of the blanks with specific shapes, we can infer their transformation into trapeze-shaped cheekpieces (Fig. 5/a) and rod–shaped cheekpieces (Fig. 4/a, d), which were used to divide straps and attach the bit and reins at various points on horse bridles (Fig. 8).

[35] NICODEMUS/LEMKE 2016.
[36] HAIMOVICI 1987.
[37] PROVENZANO 1998.
[38] POPESCU 1956A, Fig. 76/10–13.
[39] CHIDIOȘAN 1984, Pl. 4/2.
[40] ORDENTLICH 1963, Рис. 9/17–18; ORDENTLICH/LIE/GHEMIȘ 2014A, Pl. V/20–22.
[41] ORDENTLICH/GĂVAN/GHEMIȘ 2014, Pl. XIII/3–15.
[42] SZÉKELY 1966, Fig. 4/3, 6.
[43] BÓNA 1975, Abb. 20; NÉMETI/MOLNÁR 2012, Táb. 23/139.
[44] BADER/DUMITRAȘCU 1970, Fig. 4/8.
[45] ROSKA 1913, Kép. 57–58; ROSKA 1914, Kép. 38/5.
[46] ROSKA 1912, Kép. 44, 76; NICODEMUS/LEMKE 2016, Tab. 2, Fig. 3/C.
[47] POPESCU 1956B, Fig. 4/1–3, 9; 5; 19/7.
[48] CHIDIOȘAN 1980, Pl. 39/4–13.
[49] CSÁNYI/TÁRNOKI 1992, 194, no. 219, 222–223.
[50] FISCHL *et alii* 2014.
[51] CSÁNYI/TÁRNOKI 1992, 194, no. 221; CHOYKE 2005, 141, Fig. 14, Pl. I/18, 20; II/11–12; III/20–21; V/13–14; CHOYKE/BARTOSIEWICZ 2009, 365–366, Fig. 7, Pl. II/a–b.
[52] CHOYKE/VRETEMARK/STEN 2004, 185, Fig. 13; CHOYKE/SCHIBLER 2007, Fig. 14.
[53] GÁL 2018.
[54] CHOYKE 1979, 12–13.
[55] PRZYBYŁA/JĘDRYSIK 2018, 289–292 (hafted chopping tools).
[56] CHRISTIDOU/LEGRAND 2005.
[57] VAN GIJN 2007.
[58] MÁTHÉ 1988, Pl. 9/2.
[59] CHIDIOȘAN 1980, Pl. 39/14–15.
[60] CHOYKE 2005, 136; CHOYKE/BARTOSIEWICZ 2009, 362, Pl. I/a.
[61] GÁL 2018.
[62] CHOYKE 1979, 17 (6230, 6235).
[63] CHOYKE/VRETEMARK/STEN 2004, 185, Fig. 14; CHOYKE/SCHIBLER 2007, Fig. 13.
[64] CSÁNYI/TÁRNOKI 1992, 200, no. 287–288.
[65] CSÁNYI/TÁRNOKI 1992, 196, no. 239–240.
[66] CHIDIOȘAN 1984, 35, Pl. 9/1–2.
[67] SIDÉRA 2000; MAIGROT 2001; LEGRAND/SIDÉRA 2007.
[68] MĂRGĂRIT/BORONEANȚ 2021.
[69] CHOYKE 2005, 139; CHOYKE/BARTOSIEWICZ 2009, 363.
[70] CSÁNYI/TÁRNOKI 1992, 210, nr. 398.
[71] CHOYKE 1979, 20, 6215.
[72] ROSKA 1913, Kép. 61.
[73] CSÁNYI/TÁRNOKI 1992, 210, no. 397.

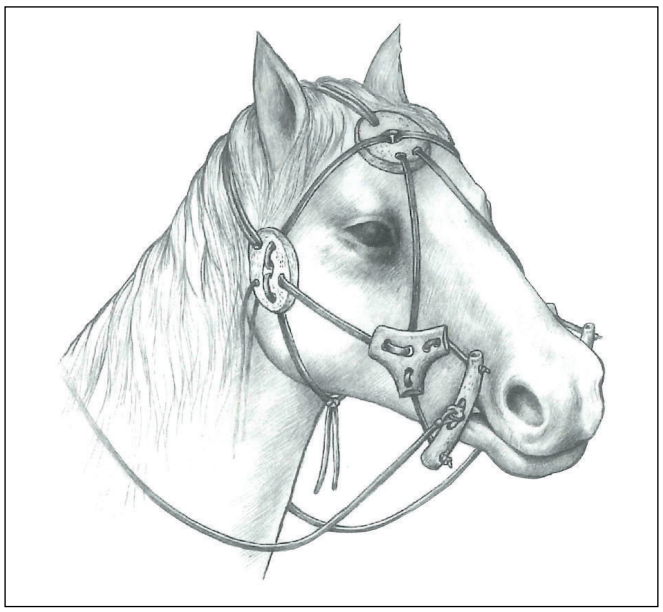

Fig. 8. Reconstruction of the horse bridles (drawing by Pál Raczky and Ágostan Dékány, after BÓNA 1992).

Bridle components have also been published from MBA tell and tell–like settlements of the central Carpathian Basin such as Ároktő–*Dongóhalom*,[74] Bakonszeg–*Kádárdomb*,[75] Berettyóújfalu–*Szilhalom*,[76] Füzesabony–*Öregdomb*,[77] Jászdózsa–*Kápolnahalom*,[78] Mende–*Leányvár*,[79] Pákozdvár–*Várhegy*,[80] Százhalombatta–*Földvár*,[81] Tiszafüred–*Ássotthalom*,[82] Tószeg–*Laposhalom*,[83] Túrkeve–*Terehalom*,[84] as well as from Köröstarcsa,[85] Lovasberény–*Mihályvár*,[86] Mezöcsat–*Pástidomb*,[87] Nyergesúyfalu–*Téglagyár*,[88] Palotas–*Homokos*.[89] In western Romania, discoveries include other MBA tell and tell–like settlements: Pecica–*Șanțul Mare*,[90] Socodor–*Căvăjdia*,[91] Vărșand–*Movila dintre vii=Lapóshalom*,[92] Sântandrei–*Fosta grădină C.A.P.*,[93] Carei–*Bobald*,[94] Otomani–*Cetatea de pământ*,[95] Sălacea–*Dealul Vida=Vida hegy*,[96] or Derșida–*Dealul lui Balotă*.[97] A direct evidence of the use of trapeze-shaped cheekpieces comes from the MBA site at Oarța de Sus–*Ghiile Botii*, where two such pieces were found next to the skull of one of the two horses laid down ritually.[98] Additionally, their existence and use are indirectly supported by the study of pathologies observed on horse skulls, such as the specimen from Tompa (Hungary) from the second phase of the MBA in the Carpathian Basin,[99] or through miniature clay models of four–wheeled wagons from the Otomani–Füzesabony Cultural Complex (OFCC).[100]

Moreover, these discoveries align with the archaeological contexts of the MBA in the Carpathian Basin, a period during which these types of pieces were first used as part of a widespread phenomenon that appears to have originated with the communities of the Pokrovska–Abashevo and Sintashta–Petrovka complexes (late 3rd and early 2nd millennium BC),[101] from where they spread westward, eastward, and southward[102]. In their region of origin, these items were made from elk antler (*Alces alces*),[103] but in this case, we observe an imitation of these pieces produced locally, utilizing a readily available raw material – red deer antler (*Cervus elaphus*). This is not an isolated case; east of the Carpathians, within the Monteoru culture area, a shield–shaped cheekpiece made from red deer antler has been documented at the site of Răcătău–*Cetățuia*,[104] while within the same culture, the disc–shaped antler cheekpieces from Sărata–Monteoru were crafted from elk antler.[105]

Recently, according to Stanislav Grigoriev, the theory regarding the northern Pontic origin of chariots and the breeding of horses used for this purpose or for riding needs to be reconsidered. A comparison of absolute data suggests that „the penetration of Near Eastern chariots into Greece, central and northern Europe is more probable, but this happened through the Carpathians, at a time close to the formation of the Sintashta Culture or somewhat earlier. This process was not associated with steppe Eurasia…”.[106] This theory regarding the appearance of chariots in the Near East is not new, as it is also supported by other specialists.[107] Moreover, Stefan Burmeister and Peter Raulwing discuss

[74] BÁNDI 1963, Kép. 2/5.
[75] MÁTHÉ 1988, Pl. 9/3.
[76] MÁTHÉ 1988, Pl. 28; BÓNA 1992, Abb. 35; CSÁNYI/TÁRNOKI 1992, 2002, no. 317–318.
[77] MOZSOLICS 1953, Fig. 1–2; BÁNDI 1963, Kép. 1/2–5; HÜTTEL 1981, Taf. A/35, Taf. 3/24; 4/35–36; 5/37–38; 6/51; 12/121–122; BÓNA 1992, Abb. 37; CSÁNYI/TÁRNOKI 1992, 201, no. 305–306; 202, no. 319–321.
[78] CSÁNYI/TÁRNOKI 1992, 202, no. 316; CHOYKE 2005, Pl. V/1; CHOYKE/BARTOSIEWICZ 2009, Pl. II/g.
[79] KOVÁCS 1969, Fig. 2, 4, 6/3, 5.
[80] MOZSOLICS 1953, Fig. 4–5; BÁNDI 1963, Kép. 2/4; CHOYKE 1979, 16; HÜTTEL 1981, Taf. 5/40–41.
[81] KOVÁCS 1969, Fig. 1, 5. 6/1–2; HÜTTEL 1981, Taf. 10/102, 12/115; CHOYKE/TÓTH 2023, Fig. 6.1.4.
[82] MOZSOLICS 1953, Fig. 3, 7–8, 17; BÁNDI 1963, Kép. 2/2–3; BÓNA 1975, Taf. 195/1, 3–4, Taf. 196/4–5; HÜTTEL 1981, Taf. 3/24A, 6/49–49A, 56, 9/94, 12/116; CSÁNYI/TÁRNOKI 1992, 201, no. 309; 202, no. 311–314; 203, no. 325–327.
[83] MOZSOLICS 1953, Fig. 9–12, 13(?), 16, 19–20; BÁNDI 1963, Kép. 1/6; 2/1; HÜTTEL 1981, Taf. A/26, 76; 3/25, 25A, 26; 4/27–28; 6/54–55; 7/58–59, 59A; 8/76; 9/89A; 10/95; BÓNA 1992, Abb. 37; CSÁNYI/TÁRNOKI 1992, 201, no. 307–308; 203, nr. 322–324.
[84] CSÁNYI/TÁRNOKI 1992, 202, no. 315; 203, no. 328.
[85] MOZSOLICS 1953, Fig. 15; HÜTTEL 1981, Taf. 6/52.
[86] KOVÁCS 1969, Fig. 3, 6/4.
[87] MOZSOLICS 1953, Fig. 14; HÜTTEL 1981, Taf. 6/53.
[88] BÁNDI 1963, Kép. 1/1.
[89] HÜTTEL 1981, Taf. 6/50.
[90] SOROCEANU 1991, Abb. 23/7, 10.
[91] ROSKA 1944, Kép. 4/3–4; HÜTTEL 1981, Taf. 5/42; BOROFFKA 1998, Abb. 6/1.
[92] ROSKA 1941, Kép. 19/3; HÜTTEL 1981, Taf. 5/45; BOROFFKA 1998, Abb. 6/3.
[93] DUMITRAȘCU/TĂUTU 1968, Pl. III/8; FAZECAȘ 2014, 233–234.
[94] NÉMETI/MOLNÁR 2012, Táb. 21/158.
[95] ORDENTLICH 1963, Рис. 9/10, 12; HÜTTEL 1981, Taf. 12/117–118; CHIDIOȘAN 1984, Fig. 11/3; BOROFFKA 1998, Abb. 7/6–7; ORDENTLICH/LIE/GHEMIȘ 2014A, Pl. III/1.
[96] BOROFFKA 1998, Abb. 6/11–12, 11/23.
[97] CHIDIOȘAN 1980, Pl. 39/40; DAVID 1997, Taf. 8/1.
[98] BOROFFKA 1998, Abb. 9/1–2; KACSÓ 2013, 112, 115, Fig. 15/1–2.
[99] BOZI/SZABÓ 2022; GERBER *et alii* 2025.
[100] ORDENTLICH/CHIDIOȘAN 1975; MÁTHÉ 1984, Fig. 6/1–a–c; BÓNA 1992; CSÁNYI/TÁRNOKI 1992, 203, no. 330; 211, no. 425; BONDÁR 2012, 77–81; MOLNÁR/KATÓCZ 2019.
[101] CHECHUSHKOV/EPIMAKHOV/BERSENEV 2018; CHECHUSHKOV/OVSYANNIKOV/USMANOVA 2020; GRIGORIEV 2021.
[102] BOZI/SZABÓ 2022; LIBRADO *et alii* 2024.
[103] POPESCU *et alii* 2024.
[104] POPESCU/MĂRGĂRIT/ISTINA 2025.
[105] POPESCU *et alii* 2024.
[106] GRIGORIEV 2023, 172–173.
[107] LITTAUER/CROUWEL 1979, 68–71; HÄUSLER 1994, 228; BOROFFKA 1998, 116; DREWS 2017, 141.

the appearance of chariots around 2000 BC in three distinct regions: the Trans-Ural steppe, the Near East, and the Carpathian Basin.[108] This hypothesis is supported by the chronological position of the workshop for the production of bridle components in the tell at Sântion. The use of horses is closely associated with the emergence of warrior elites, political centralization, and social differentiation.[109]

CONCLUSION

The overall picture, based on the technological and functional data, suggests the existence at Sântion–*Dealul Mănăstirii* of a small workshop for the processing of hard animal materials at a household level. The types of artifacts, both in terms of finished pieces and those intended to be finished (where the finalization of the technical transformation can be reasonably assumed), appear to be primarily related to domestic activities. Although it is estimated that, during the Bronze Age, elites increasingly gained control over the manufacture and distribution of key resources,[110] we consider that this is not a workshop that managed the production of tools for the entire community, as the number of blanks should have been significantly higher. Most likely, the owner personally crafted the components of his toolkit. We have also determined that the finished items were primarily used in woodworking activities. Thus, we can infer some of the activities for which tools made of osseous materials were employed by the Otomani communities. Based on the correlations established with contemporary sites across the Carpathian Basin, it is evident that these are common pieces that, both in terms of technology and typology, conform to the series of artifacts characteristic of the Bronze Age.

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[109] NICODEMUS 2014; KANNE 2022; MAKAROWICZ *et alii* 2022; KANNE 2025.
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