
A 6TH CENTURY IRON SPANGENHELM FROM CAPIDAVA

ALEXANDRU RAȚIU
IOAN CAROL OPRIȘ
LAURENȚIU ANGHELUȚĂ

To the memory of Professor Radu Florescu (1931-2003)¹

ABSTRACT:

The paper presents the discovery of a fragmentary iron helmet (23 fragments), during the 1990 archaeological campaign at Capidava (Constanța County). The helmet was found inside the *horreum*, in a room (an enclosed complex) that ended its functioning during the N2 of Phase IV, in the 580s AD. The *intra muros* granary (*horreum frumentarium*) is a three-aisled building preceded by a portico, close to the Main Gate and Gate Tower no 7. The helmet is a *Spangenhelm* of the *Dair-el-Medineh* type, made entirely out of iron. All 23 fragments belonged to the bowl of the helmet, with none from an eventual aventail, cheek pieces, or nose guard. As a first restoration method, before the physical one, we chose virtual restoration (anastylosis) of the existing fragments and virtual reconstruction of the helmet.

REZUMAT: UN COIF DIN FIER DE TIP SPANGENHELM DESCOPERIT LA CAPIDAVA (SEC. VI P.CHR.)

Articolul prezintă un coif fragmentar din fier (23 de fragmente), descoperit în timpul campaniei arheologice din 1990 la Capidava (județul Constanța). Coiful a fost găsit în interiorul *horreum*-ului, într-o încăpere (un complex închis) care și-a încheiat funcționarea în timpul etapei N2 din faza IV de funcționare a fortificației romane, cândva în penultimul deceniu al sec. VI p.Chr. Grânarul (*horreum frumentarium*) este o clădire *intra muros*, cu trei nave precedată de un portic, aproape de Poarta Principală și Turnul (de poartă) nr. 7. Coiful este un *Spangenhelm*, din tipul *Dair-el-Medineh*, fiind realizat în întregime din fier. Toate cele 23 de fragmente au aparținut calotei coifului, dar niciunul nu provine de la un eventual *avental*, piese de obrăzar sau apărători pentru nas. Ca primă metodă de restaurare, înaintea celei fizice, am ales restaurarea virtuală (anastiloza) a fragmentelor existente și reconstrucția virtuală a coifului.

KEY WORDS: *Spangenhelm*, Early-Byzantine military equipment, *horreum*, Lower Danube *limes*, virtual restoration (anastylosis).

CUVINTE CHEIE: *Spangenhelm*, echipament militar bizantin-timpuriu, *horreum*, *limes*-ul Dunării de Jos, restaurarea virtuală (anastiloză).

Introduction

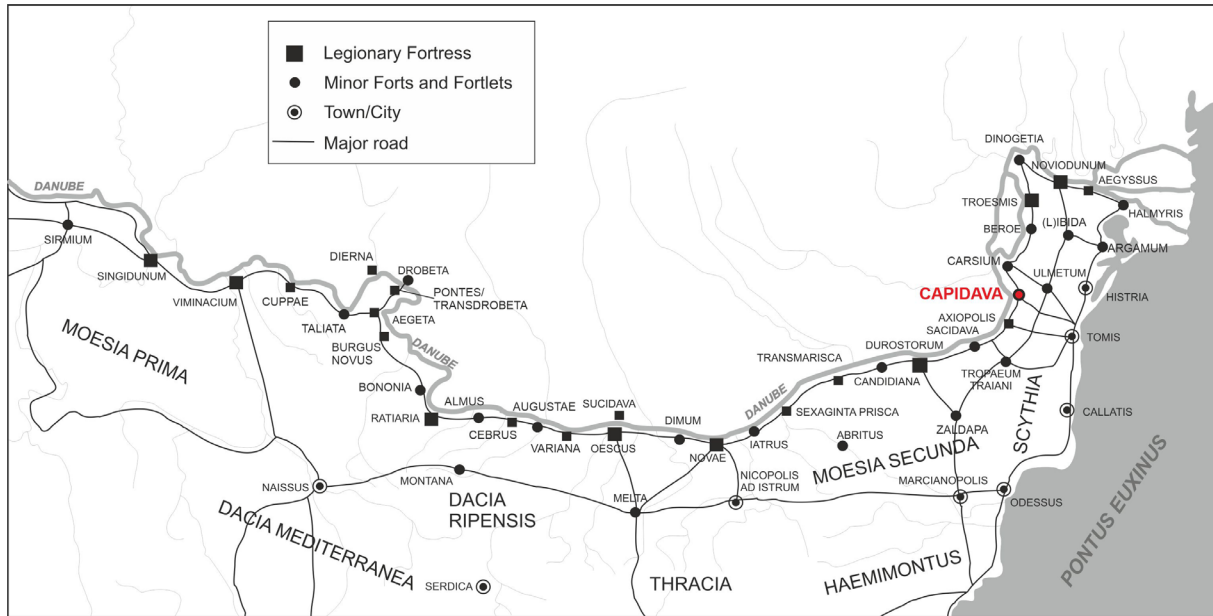
The present paper originated from the discovery of a group of 23 iron fragments that constituted an iron helmet, during the 1990 archaeological campaign at Capidava (Constanța County), in the southern quarter of the local Roman fort, within the local *horreum*.

The Roman fort at Capidava is located at an equal distance of eighteen Roman miles (27 km) between Axiopolis (today Hinog Hill, close to the modern city of Cernavoda) to the south and Carsium (Hârșova) to the north, according to *Itinerarium Antonini Augusti* (224.3) and *Tabula Peutingeriana* (corrupt *Calidava*, Segmentum VII). The *castellum* stood on a high limestone cliff, guarding the local river ford, some 1000 m to the north-west. It was built in the context of the extensive strategic effort to strengthen the Danubian border, during the *bellum Dacicum Traiani*,² or, according to a recent hypothesis, even some decades earlier, under the Flavians.³

¹ Prof. Radu Florescu led the excavations of the *horreum* in Capidava, when the helmet was found.

² Opriș 2006; Opriș 2018; Opriș and Rațiu 2019a; Opriș, Rațiu and Potârniche 2018.

³ Rațiu and Opriș 2021; Rațiu and Opriș 2023.



The Lower Danube provinces of the Roman Empire (4th – early 7th c. AD)

The initial auxiliary fort underwent three phases of reconstruction, but without altering the original playing card plan and constructive dimensions, i.e. a rectangle oriented on a NW to SE axis measuring 105 m by 127 m. After the Gothic attacks from AD 248–250 it underwent a general (*a fundamentis*) reconstruction, starting under Aurelianus or Probus. Subsequently, two other major constructive interventions (phases III and IV) took place during the last decades of the 4th c. and again in the late 5th c. – beginning of the 6th c. AD, following severe barbarian attacks. Phase IV covered a dating sequence starting from the 6th c. and through the early decades of the 7th c. AD. Its first N1 level corresponds to a building program started by Anastasius, with a *floruit* under Justin I, that lasted until the late 550s; in level N2, the one that interests us notably here, one can observe repairs entailing earth and stone masonry and adobe superstructure, violently ended by AD 580/582–586 (or even later). The final Roman level (noted N3/Phase IV), extremely difficult to observe from the archaeological viewpoint, is related to the last Roman fortlet,

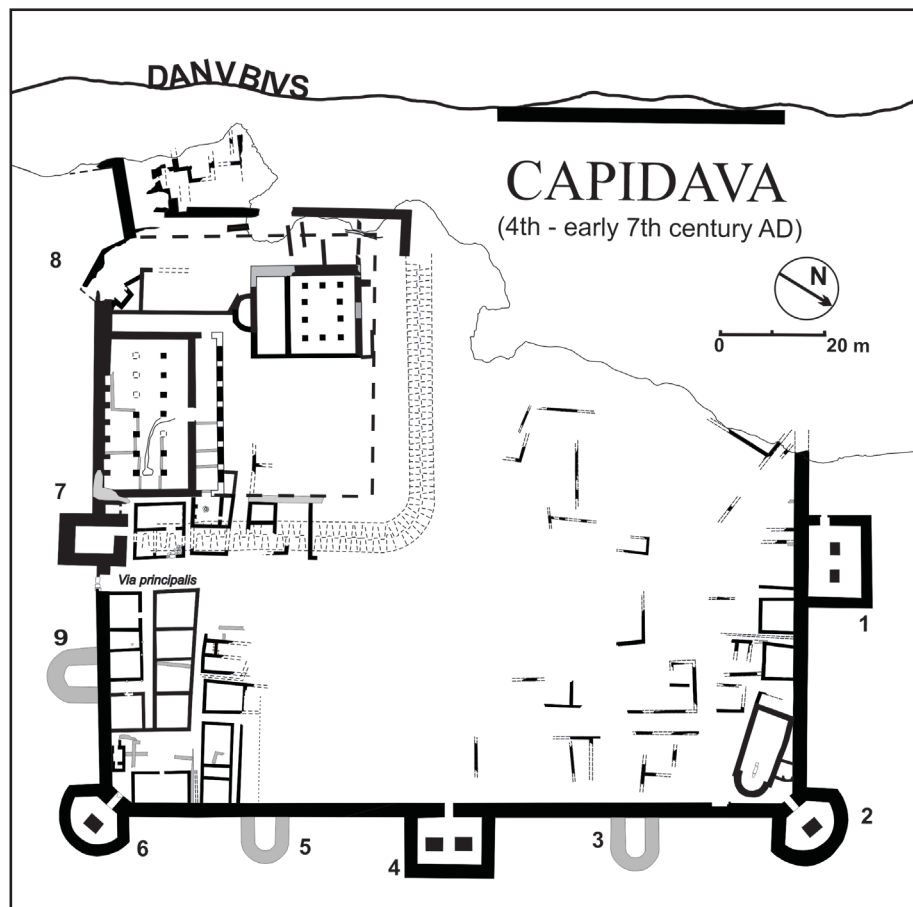


Fig. 2. Plan of Capidava Fort during 4th–7th c. AD.

with the rest of the former *castellum* in ruins.⁴ It was dated during the last decade of the 6th – early decades of the 7th century. The makeshift wall of the late fortlet was hastily erected and covered the southern quarter of the previous fort, post AD 595, possibly even after the revolt of Phocas in 602. It lasted over one decade and possibly even longer. The latest Early Byzantine coin known so far is a follis from the early regnal years of Heraclius (612/613) and this might give us an idea about the end of the Roman presence on the Lower Danube, after the Slavs and Avars attacked in AD 614–616.

The archaeological context of the discovery

The iron helmet presented here was found inside the above mentioned *horreum*, in a room (an enclosed complex) that ended its functioning during the N2 of Phase IV. The *intra muros* granary (*horreum frumentarium*) is a three-aisled building preceded by a portico, close to the main gate and gate Tower no 7.⁵ Such Late Roman storage facilities actually functioned in every city and the ones in Zaldapa, Abritus and newly Kovačevsko Kale, in central position or conveniently built close to the gates, are the best known.⁶ The best analogy for the one in Capidava is to be found in Montana, presenting the same main entrance on the long side.⁷ Built against curtain wall H during the late 3rd-early 4th century, the granary in Capidava covered ca. 750 m². It still is the largest structure investigated so far from the late 3rd-early 4th century general reconstruction of the fort (phase II). The granary measured 23 × 32 × 21.5 m (including the portico); the *horreum* alone covered just 16.25 × 32 × 18.75 m. Its inner space was divided by two rows of seven 1.20 m square pillars. During the third and final stage of its functioning (N2/ Phase IV, in the 6th century), the building was radically remodeled: inner compartment walls made of stone bonded with clay were added to define a central courtyard; the central nave was transformed into a stone-paved court with a central channel meant to capture rain-water (*impluvium*).⁸ Inside its newly-obtained rooms the archaeological material largely consisted of amphorae and kitchenware, along with tableware and drinking vessels (*vasa escaria* and *vasa potatoria*), to a smaller extent.⁹

In addition, one should mention some agricultural implements (two ploughshares, a sickle and a hoe) and weapons – several *umbones* and parts of armors, catapult bolts and the segmented helmet (*Spangenhelm*) in question here. The latter was found in a state of poor preservation, fragmented, badly corroded and deformed, in the south-eastern room, next to the curtain wall H (CAP 1990, □ V 76, inv.no. 3456). It was contained by the final, thick *incendium* level (N2), documented with heavy burning evidence for every category of artifacts, smashed adobe bricks from the collapsed walls or roof tiles, and sealed by the massive stone and mortar rubble from the outer walls. As stated above, the dramatic moment occurred at some point between AD 580/582–586 (or possibly even few years later), during a heavy attack and destruction largely documented¹⁰.

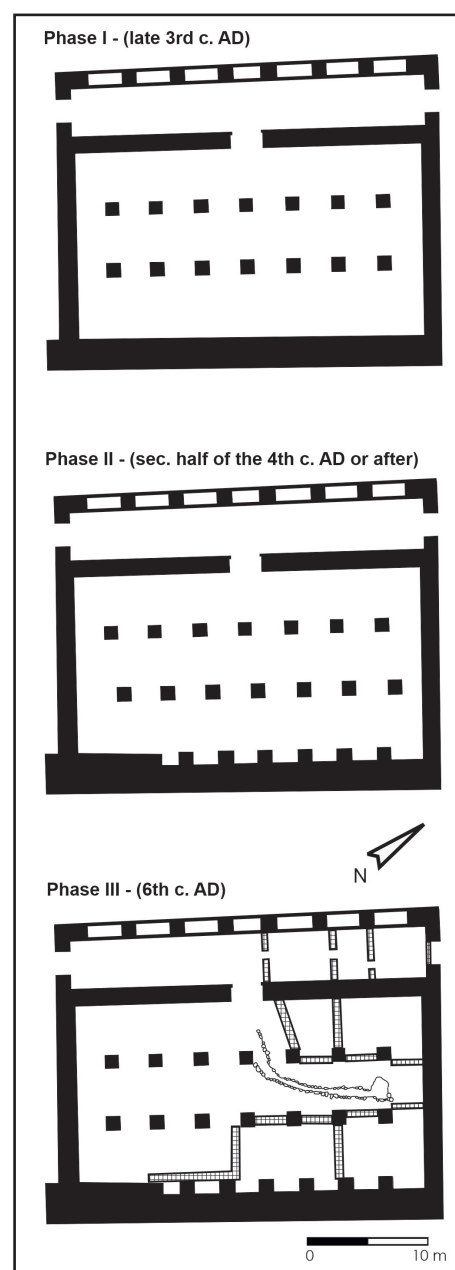


Fig. 3. The Horreum in Capidava (phases I – III).

⁴ Opreș and Rațiu 2017, 17–18; Opreș and Rațiu 2018.

⁵ Opreș 2003, 26–33, pl. IV.1–3, with bibliography; Opreș and Rațiu 2017, 19–21, Fig. 8; Opreș 2023, 72–74, fig. 2–3.

⁶ For Late Roman *horrea* on the Lower Danube and in the Balkans, see Rizos 2013; Carrié and Moreau 2015, 603, 606; Aleksandrov 2017.

⁷ Dintchev 1999, 165–174, esp. 168–169, fig. 2 D and n. 25.

⁸ Opreș 2003, pl. IV.3; Opreș and Rațiu 2017, 28, Fig. 8 (right); Opreș 2023, 74, fig. 3 (bottom).

⁹ See Opreș 2003, *passim* (and pl. VII–XII, XIV–XVI); Opreș and Rațiu 2019b, Fig. 9a–b.

¹⁰ Opreș and Rațiu 2017, 17, 43 and note 84; Opreș and Rațiu 2018, 769; Opreș and Rațiu 2019b, 144 and note 46. See also

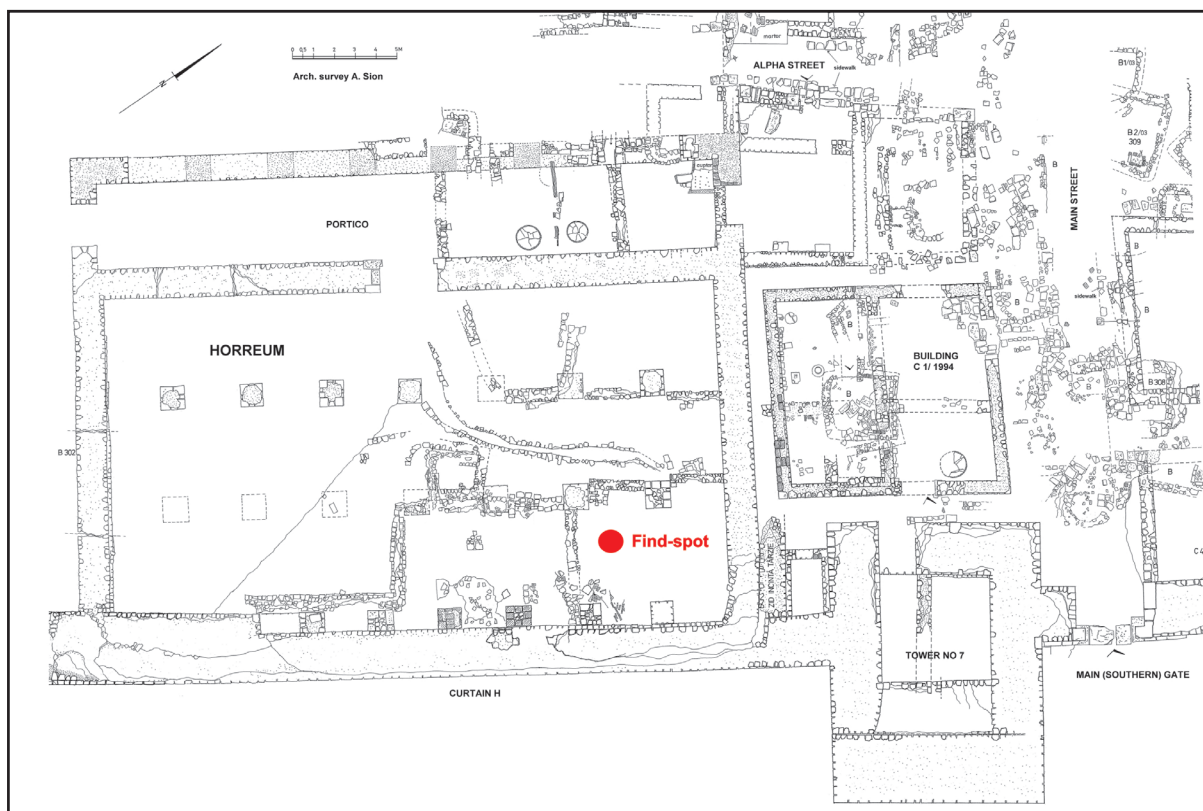


Fig. 4. The architectural plan of the horreum, with the indication of the find-spot (red dot). (Plan by Arch. A. Sion)

The state of preservation of the find was that poor that it was put aside at that time, being deemed unrestorable. Recently our team reevaluated the finds from the early 1990s and decided to restore and publish the helmet. Following a visual evaluation, it became evident that the helmet was a *Spangenhelm*, made entirely out of iron. All pieces belonged to the bowl of the helmet, with none from an aventail, cheek pieces, or nose guard. As a first restoration method, we chose virtual restoration (anastylosis) of the existing fragments and virtual reconstruction of the helmet as it would have looked like, as it aligned with our expertise and offered insights for a potential physical restoration.

The Spangenhelm (German, pl. *Spangenhelme*) is a type of composite helmet characterized by its segmented construction, and it is typical for the period between Late Antiquity and the early Middle Ages. The term *Spangenhelm* derives from the German word *Spangen*, meaning ‘braces’ or ‘strips’, referring to the metal bands that form the structural framework of the helmet. Its design reflects the shift from the monolithic cast helmets of the Early Roman period to a more modular and easily repairable form of headgear.

The *Spangenhelm*, or the ‘ribbed helmet’ gained predominance from during the 5th century AD, a period marked by the transition from Roman imperial dominance to the fragmented political and military landscape of Late Antiquity.¹¹ By the last decade of the 5th century and the whole 6th century AD the spangenhelm was the helmet most used by the roman troops.¹² As the Western Roman Empire collapsed, various barbarian kingdoms rose to power, and the Eastern Roman Empire faced constant threats from nomadic invasions, especially from Huns, Goths, and Sassanid Persians. This turbulent period necessitated innovations in military equipment, especially personal armor, to counter increasingly mobile and aggressive forms of warfare.

The Framework (Spangen). The defining features of a *Spangenhelm* are the *Spangen*, which are typically made from iron or cooper alloy. These metal strips are riveted together to form the skeleton of the helmet, which normally consists of four or six segments, although rare variations exist. The bands run both longitudinally from the base of the helmet to its apex (in a vertical direction) and laterally around the circumference of the helmet at the base, forming a rigid framework. The longitudinal bands meet at a central point at the top of the helmet, where they are sometimes capped by a roundel or *umbonal* knob, providing extra protection at the helmet’s apex and contributing

Oprîș 2003, 32-33 and note 40; lately, Oprîș 2023, 74, 76.

¹¹ Stephenson 2006, 26-27.

¹² Robinson 1967, 137.

to the overall structural integrity. Usually, the roundel is provided with a socket for the plume, sometimes the socket is replaced with a ring, or in some cases, as is the case of the Capidava helmet, neither.

Helmet Plates (*Kuppeln* or *Panels*). The spaces between the *Spangen* are filled with protective plates, typically made of iron but sometimes of bronze or hardened leather. These plates are riveted to the bands and form the main protective surface of the helmet. Each plate covers one section of the segmented design, contributing to the overall dome shape. The use of multiple plates allows for greater flexibility in the production process, as individual sections can be crafted separately before assembly.

Nasal Guard. Many Spangenhelms include a *nasal*, a single strip of metal that extends from the front of the helmet down over the wearer's nose. This component is typically riveted to the frontal *Spangen* and serves as a form of facial protection, primarily against sword strikes or projectiles.

Cheek Pieces and Neck Guard. In some examples, spangenhelms feature cheek pieces that are attached to the lower rim of the helmet via hinges and rivets. These components are typically made from the same materials as the helmet's plates. In some cases, an *aventail* or mail curtain is attached to the back of the helmet, offering additional protection for the neck and shoulders. Aventails could be made from chainmail or leather, and they are often fastened to the lower edge of the helmet via loops or rivets. These elements show regional variation, with some helmets omitting cheek or neck guards altogether.

Decorative Elements. Many *Spangenhelm* helmets, of the Baldenheim Type, especially those used by elite warriors or members of the Byzantine or the Germanic Kingdoms armies, exhibit decorative elements such as engraved patterns, silver or gold inlay, and sometimes gems. Some spangenhelms are gilded or covered with silver foil. Archaeological finds have also revealed helmets with intricate geometric or zoomorphic engravings, particularly in the helmets of nomadic groups such as the Avars or the Sassanian elite. The iconography is mainly Christian, being made in the *fabricae* from Italy or Thrace, but also exhibit traces of Germanic mythological traditions.¹³



Fig. 5. Typical Baldenheim type helmets from: 1. The Caucasus region; 2. Saône River near Trévoux, France. (both items belong to The Metropolitan Museum of Art, New York, images are open source)

Materials and Metallurgy. The primary materials used in the construction of spangenhelms were iron and bronze, though leather may have been used in some cases for non-metallic plates. Archaeological metallurgical analysis of surviving helmets shows that the plates and bands were often made from iron that was either forged or, in rare cases, pattern-welded for additional strength.

The use of rivets, both iron and bronze, was crucial in fastening the helmet components together. The construction technique of riveting is evidenced by the presence of rivet holes, with some archaeological finds showing instances of multiple rivet replacements, suggesting repairs or reinforcements carried out after damage.

¹³ D'Amato and Negin 2017, 271.

The Spangenhelm from Capidava is made from four strips of iron (the *Spangen*) riveted on a circular base (crown-strip) and on top on a central roundel. The protective plates are riveted from the inside of the bowl of the helmet. Their margins are irregular, but being rivetted from the inside the irregularities are not visible. The estimated diameter of the crown band of the helmet is somewhere between 19 and 20 cm and the reconstructed height is around 19 cm. The width of the crown band is just under 4.3 cm and the width of the bands is between 4 (at the roundel) and 12 cm (at the crown). The interval iron strips are thinner than the main bands, between 2 and 8 cm. The top iron roundel measures 5 cm in diameter and the rivet holes about 0.35-0.4 cm with the head of the rivets

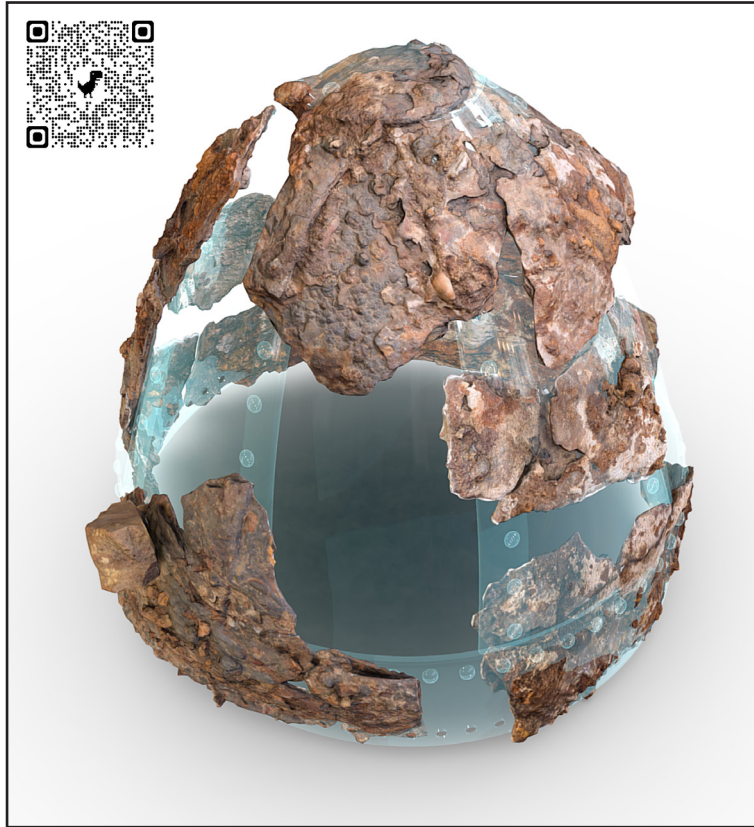


Fig. 6 The Iron Spangenhelm from Capidava
(for the interactive model see the QR code)

having a diameter of 0.5 cm. Studying the rivet holes from the bottom row of the crown it is impossible to establish an eventual existence of a nasal guard or cheek pieces. Nevertheless, we may well presume that at least the cheek pieces were attached to the helmet, thru hinges riveted in the crown. Also, there is no information about the padding.

Being made out of iron there is no information about an eventual decoration. The x-ray did not reveal anything that would indicate the presence of decoration. The top disc has no trace for a plume attachment. The conservation state of the helmet is poor, especially due to the corrosion in the soil from Capidava, a fact similar for most iron finds from the site. As mentioned above, the context of discovery is an incendiary level, all the artifacts being subjected to a severe fire. Due to its preservation state the conservation and restoration process is going very slow, but steady, and with the help of the 3D reconstruction model, we hope to rescue the artifact.

Typological and Chronological Variations

In the roman 'contexts' the earliest representation of a *Spangenhelm* is on Trajan's column. Here they appear on the base of the monument, among the representations of arms and armor captured from the enemy. Also, they appear on scenes depicting units of archers wearing spangenhelms. The time-span of the more than 50 discovered spangenhelms¹⁴ date to the Late Roman and Early-Byzantine period (5th to 6th century AD).¹⁵ The majority of the experts agree that the *Spangenhelm* succeeds the ridge helmets, namely the Berkasovo type used during the Dominate and the Late Roman period. I. P. Stephenson, on the other part argues that the *Spangenhelms* and the Berkasovo type helmets were used in the same time by the Roman army in the Byzantine period.¹⁶

There are two main types of *Spangenhelms*, very distinct and independent and only somewhat similar. The first type, the better represented one, is the Baldenheim type, named after the first such helmet found and published in a scientific manner.¹⁷ Helmets of this type were found in both Europe and Central Asia, showing their wide distribution¹⁸. The Baldenheim *Spangenhelms* are the more often discovered probably because they were usually made from cooper alloy, therefore better preserved. Usually, the strips are thinner on their upper side and wide at the crown, almost like an inversed letter 'T'. The Baldenheim type was made usually by six *Spangen* made from

¹⁴ Vogt 2006, 177-189.

¹⁵ Vogt 2006, 46.

¹⁶ Stephenson 2006, 25.

¹⁷ Henning 1907.

¹⁸ For a complete gazetteer of the spangenhelms, up until the year 2006, see Vogt 2006.



Fig.7 Representations on Trajan's Column of the similar type of Spangenhelms with four Spangen

copper alloy (with the plates made sometimes of iron), usually highly decorated often gilded. More than 40 items of this type were found from the Urals to the Iberian Peninsula, and from the northern Africa to Scandinavia¹⁹. The earlier items are found in different contexts and are in various states of preservation. The early Medieval ones are often found in funerary context²⁰ and are highly decorated, some silvered or gilded, probably kept and worn as a prestigious relic from a time long gone.

The second type of *Spangenhelms* is the Dar-el-Medineh/Leiden Type or the more palatable the Egyptian Type. This is also the type to which the Capidava helmet belongs to. Up until our discovery there were only three such helmets: the six-stripped Dar-el-Medineh helmet,²¹ now preserved at Cairo, the four-stripped helmet,²² now at Leiden and the St. Vid/Narona V helmet, from Croatia,²³ a four stripes fragmentary helmet. The first two were both 'discovered' in Egypt, in uncertain conditions, without proper context, more than a century ago. Although they were first published as Early Byzantine their dating is very much doubted. Lacking the context, they were dated in the late 3rd century AD, being close to the Trajan's Column representations from the beginning of the 2nd century. The context of the Narona V helmet is also vague,²⁴ therefore the dating proposed for the Egyptian Type remained as was. In this respect, the Capidava *Spangenhelm* is with certainty dated in the 6th century AD, which in our opinion opens to interpretation the dating of the other three.

Origin. The origin of the Egyptian *Spangenhelms* is somewhat disputed among the Roman military experts that have approached this subject. Klumbach argues²⁵ that the *Spangenhelm* has evolved from the Late Roman ridge helmets, from the 4th and 5th centuries AD. He states that the link between the two types is the Concești helmet

¹⁹ Vogt 2006, 177-178.

²⁰ Vogt 2006, 177.

²¹ Dittmann 1940, 54-58.

²² Ebert 1909, 163-170. As a context it mentions only that was found in an Egyptian grave.

²³ Cambi 1980, 148, Abb. 31.

²⁴ Cambi 1980, 148.

²⁵ Klumbach 1973, 14.

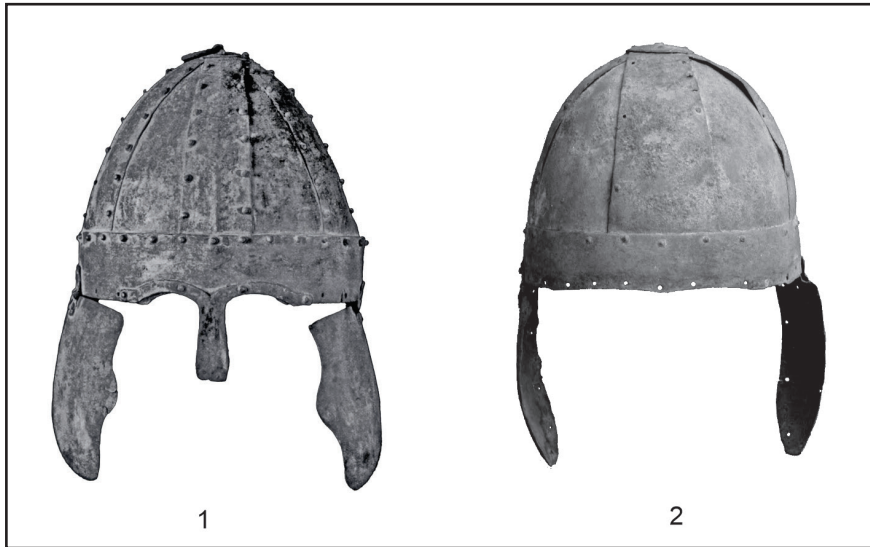


Fig. 8. 1. The iron Spangenhelm from Dar-el-Medineh (after Dittman 1940, Taf. 15);
2. The iron Spangenhelm from Leiden (after Vogt 2006, Farbtafel 7)

(deposited in the 5th c. AD), which has similar features with both types of helmets. Simon James disagrees with the German scholar and offers another theory, namely that the Egyptian Spangenhelms are of a Danubian origin,²⁶ and they existed in the use of the local population even from the beginning of the 2nd c. AD. His assertion is based solely on representations on the Trajan's Column where units of archers are rendered wearing Spangenhelms. James also states that if other archers appearing on the Column are wearing Syrian helmets (and other Syrian apparel)

represent the Syrian archer units, or the Roman archers wearing simple Roman helmets, and that these troops that wear the Spangenhelm are probably from the *cohors I Thracum sagittariorum*, recruited from the local population displaying their own equipment.²⁷ Bishop and Coulston argue²⁸ that most definitely the rigged helmets and the spangenhelms had a parallel evolution, and that is fairly possible that the Spangenhelm has a barbaric influence from the populations north of Danube in the Lower Danube area.

We agree that the idea of an evolution from the ridge helmets to the *Spangenhelm* is a bit far-fetched, but also remain prudent about an possible Danubian origin for the Spangenhelms, although this paper presents a new helmet found in a military context, precisely on the Danube. The resemblance of the Capidava *Spangenhelm* with the Leiden Egyptian one is, at least in part, confirming the latter's dating. It also confirms the statement of Simon James²⁹ according to which the Egyptian helmets may be discussed in a different regional context (European) rather than the one in which they were found.

Two more Late Roman / Early Byzantine helmets are known to date in the Lower Danube province, a 6th century infantry *Bandehelm* found at Halmyris³⁰ and an earlier 4th c. *Kammhelm* from Telița-Amza.³¹ As regards for instance the blades, guards and grips of *spathae*, they are far more numerous and distributed either on the Danube limes, or in the interior of Scythia, at Capidava, Carsium, Dinogetia, Aegyssus, Telița and Babadag-Topraichioi.³² A comprehensive survey of all equipment finds was recently offered by C. Balla in a monograph on the elements of military organization and strategies for the province of Scythia during the late 3rd – early 7th century AD.³³ The abundance of military equipment is obvious and such a situation is hardly surprising for a heavily militarized border province, in the first line of defense of the Diocese of Thrace, blocking above all the access to the capital.

The 94 cm long *spatha*, with grip and pommel, recently found at Capidava (2019)³⁴, particularly draws our attention. It came out from an *extra-muros* context, some 150 m East - South-East of the Main Gate of the *castellum*, in an area later occupied by the Middle Byzantine necropolis; it was accompanied by 6th - 7th century pottery fragments, as well as a ½ precious follis minted in Nicomedia in the 8th regnal year of Justin II (i.e. 572-573). Though heavily corroded, it represented an exceptional double-edged weapon, with all constitutive elements - blade and tip, grip and pommel - preserved. As for the grip, one could even notice the nervures from the wooden material of the hilt. According to the publishers, "it is very likely it was lost in a fighting against barbarians outside the walls, in

²⁶ James 1986, 128-130.

²⁷ James 1986, 129.

²⁸ Bishop and Coulston 2006, 215.

²⁹ James 1986, 128.

³⁰ Zahariade 2009, 125-126, 128, figs. 1-3; Balla 2022, 267.

³¹ Baumann 1995, 330, 377 = pl. LXIV; Glad and Nuțu 2010, 133; Balla 2022, 269.

³² Balla 2022, 281.

³³ Balla 2022, 262-283.

³⁴ Pinter and Yotov 2021a; Pinter and Yotov 2021b.

the civilian settlement.³⁵ That violent occasion, subsequent to AD 572-573, might be the same heavy attack that destroyed and burnt the whole southern part of Capidava, next to curtains G and H.

Historical conclusion

The *Spangenhelm* played an important role in the development of military headgear during Late Antiquity and the Early Medieval period. Its distinctive, modular design allowed for practical and effective protection in a variety of military contexts, making it one of the most widespread helmets of its time. The *Spangenhelm* not only reflects the adaptive nature of armor design in response to the demands of warfare but also stands as a symbol of the broader transitions in European and Near Eastern military history. Its legacy is seen in the evolution of medieval armory and the continued fascination with the martial cultures of Late Antiquity.

The Capidava find brings to light a new dating for this type, namely the late dating, and the coexistence with the Baldenheim type. This helmet is the first of its kind with a firm dating and a clear context.

Virtual restoration and reconstruction

Virtual Restoration. Primarily used for heritage objects, enables digital reconstruction of an artifact or structure in a historical form, relying solely on its surviving fragments. Proposed by Gianfranco Fiaccadori in 1994, this approach provides a means to virtually “intervene” on deteriorated heritage elements without physically altering them. According to the Seville Principles (International Principles of Virtual Archaeology, adopted in 2011),³⁶ virtual restoration is defined as “the use of a virtual model to reorganize existing material fragments to visually recreate something that existed in the past” (Seville Principles, Article 7). This practice is pivotal to digital heritage preservation, emphasizing authenticity, reversibility, and transparency in all virtual reconstructions.

A related technique, virtual anastylosis—derived from the Greek word meaning “reassembly” of original fragments—enables historians to hypothesize stylistic aspects and visualize potential reconstructions. Through virtual anastylosis, specialists propose reconstructions that would be impractical or even impossible to execute physically with the original materials, while ensuring that all digital interventions remain recognizable and distinct from authentic fragments. This approach aligns with the Seville Principles’ guidelines, which advocate that any digital reconstruction be based on rigorous analysis, remain scientifically transparent, and avoid misleading viewers about the artifact’s authenticity.

3D digitization. A total of 11 fragments (8 big fragments and 3 smaller ones) were digitized in 3D using photogrammetry. Colour and white balance cards were used to capture the correct colours of the surface. Photogrammetric processing was carried out using Agisoft Metashape PRO 1.8. To use the results in a virtual restoration project, all the objects were optimized to smaller polygon count by baking higher details to lower detail meshes in normal maps.³⁷

Physical examination. The helmet fragments were investigated using X-ray imaging to assess the shapes and features hidden under the corrosion and deposition layers, using an ISOVOLT 160 M1 system capable of generating X-ray radiation varying from 20 to 160 KeV and reusable high-resolution films. The method is extremely useful in assessing the conservation status of the objects.³⁸ The results showed important elements like rivets and rivet holes or metal band overlapping areas which allowed for a generic digital restitution of the original shape of the helmet.

Measurements derived from the radiographs provided dimensions for the metal bands, which varied from top to base. At the top, they measured 3.1 cm, while at the base they expanded to 8.35 cm. The estimated circumference of the helmet was calculated based on an oval length of 20 cm (front to back) and a width of 19 cm (temple to temple), resulting in a total circumference of 61.27 cm. After subtracting the sum of the base widths of the bands (51.2 cm) and dividing by four, we obtained an estimated panel width of 6.96 cm. Including the measured overlap width (~2 x 1.2 cm), the base width of each full panel was approximately 9.36 cm.

The crown band rivet holes were spaced irregularly, ranging from 1.7 to 2.2 cm (measured from the centre of each hole). The distance between rivets for metal bands and plates varied from 1.5 to 3.4 cm. Rivets on the metal bands were placed 1.7 to 2.2 cm apart. Bottom rivet holes were located ~0.47 cm from the bottom edge of the crown band, while top rivets were situated ~0.3 to 0.4 cm from the edge.

³⁵ Pinter and Yotov 2021a, 170-171; Pinter and Yotov 2021b, 65.

³⁶ <https://icomos.es/wp-content/uploads/2020/06/Seville-Principles-IN-ES-FR.pdf>

³⁷ Angheluță et alii 2023.

³⁸ Angheluță et alii 2022.

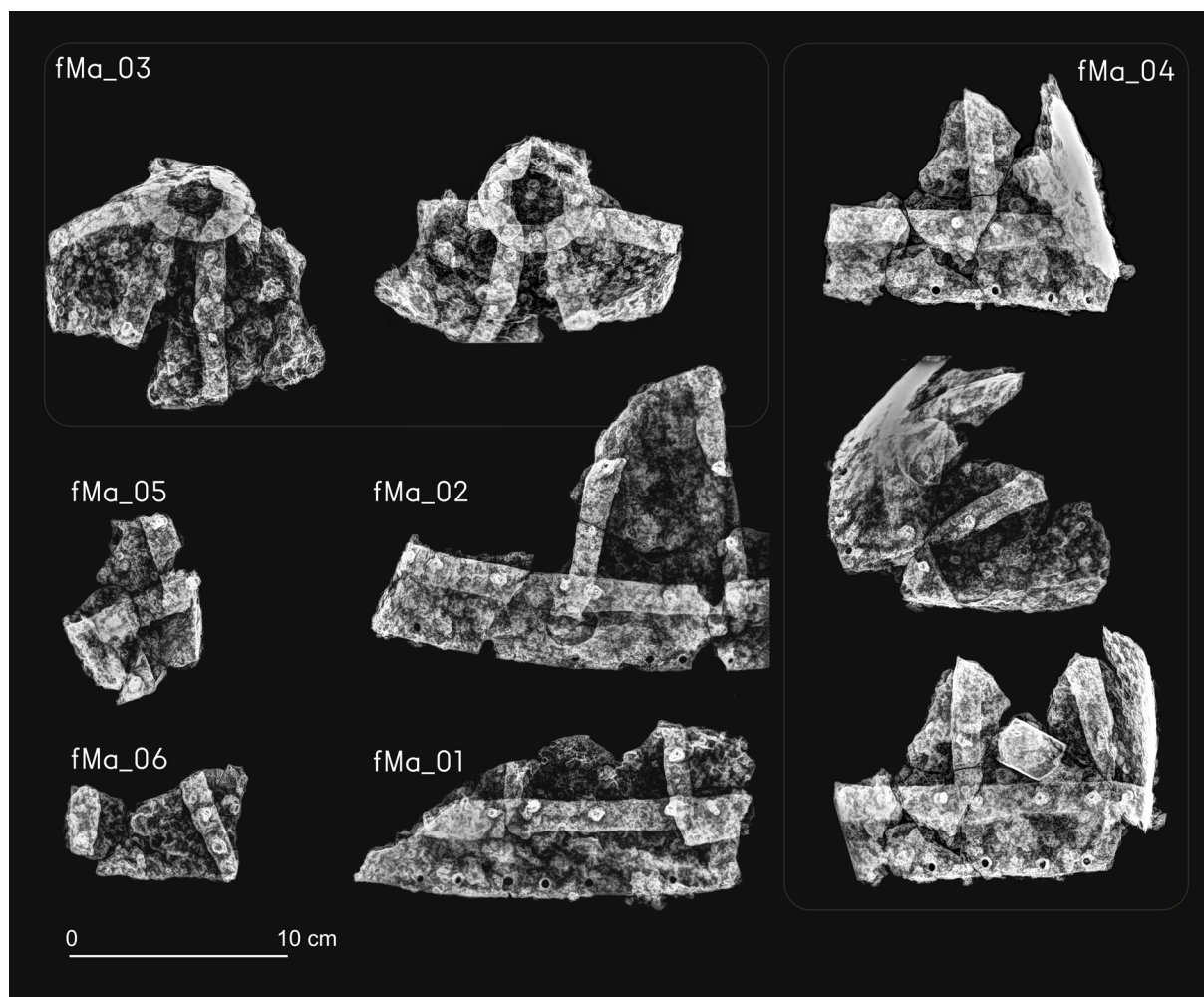


Fig. 9. X-Ray imaging results for the helmet fragments.

Results

A virtual anastylosis was performed trying to reposition in a digital medium all the 3D digitized fragments. The smaller fragments could not be repositioned, excepting for two of them, while the greater fragments could be aligned based on the X-ray imaging information. The top fragment (fMa03) radiograph indicated the way the bands and plates were overlapped at the top of the helmet. The crown band fragments were hypothetically repositioned in relation with the top fragment but without a 100% certainty.

The virtual reconstruction by 3D modelling was carried out based on the presented measurements and the virtual anastylosis. Both workflows made use of Blender 4.2 LTS, a free 3D modelling software and the textures were baked (for the restoration process) and created (for the 3D modelling process) with Substance Painter 2.83.

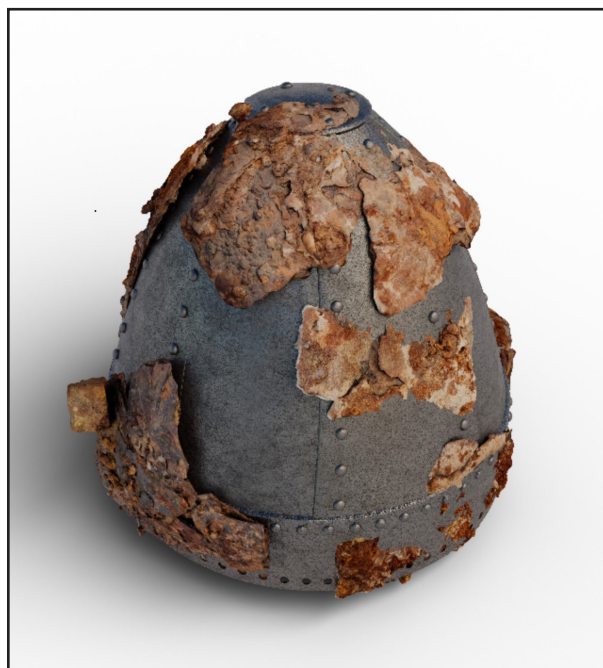


Fig. 10. Virtual anastylosis of the helmet fragments

Conclusions

The virtual anastylosis in a digital medium of the 3D digitized fragments belonging to the iron made *Spangenhelm* from Capidava represents an advanced and rather unfamiliar approach for the Romanian literature. Publishing this valuable artifact in the best possible way, despite its precarious state of conservation, was undoubtedly important, if taking into consideration its rareness and the unique well dated context for a helmet belonging to that category. For the time being our *Spangenhelm* is subject to a complex restoration process. A thorough publication of the entire military equipment and the agricultural implements found within the 6th century rooms of the former *horreum* with portico at Capidava is also envisaged.

The dramatic events affected excavated storage rooms and civil habitations, the *horreum*, the building C1 and the whole Eastern Sector, sometime after AD 580/2 – 586, or possibly even a couple of years later, as mentioned above. Both finds in their undisturbed contexts, the *Spangenhelm* and the *spatha*, actually plead for a battleground at that late 6th century point, right in front of Capidava's main gate. Moreover, even if typologically pertaining to a different category, the Halmyris *Bandeheilm*'s dating (11th level, AD 559-584/5) dovetails nicely with those events, suggesting that the river line and the province as a whole were affected at that time.

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Fig. 11. The virtual reconstruction proposal of the Capidava *Spangenhelm*.

ALEXANDRU RAȚIU

National Museum of Romanian History
sandu_ratiu@yahoo.com

IOAN CAROL OPRIS

University of Bucharest – Faculty of History
ioan_opris@yahoo.com

LAURENȚIU-MARIAN ANGHELUȚĂ

National Institute for Research and Development in Optoelectronics INOE 2000
laurentiu@inoe.ro

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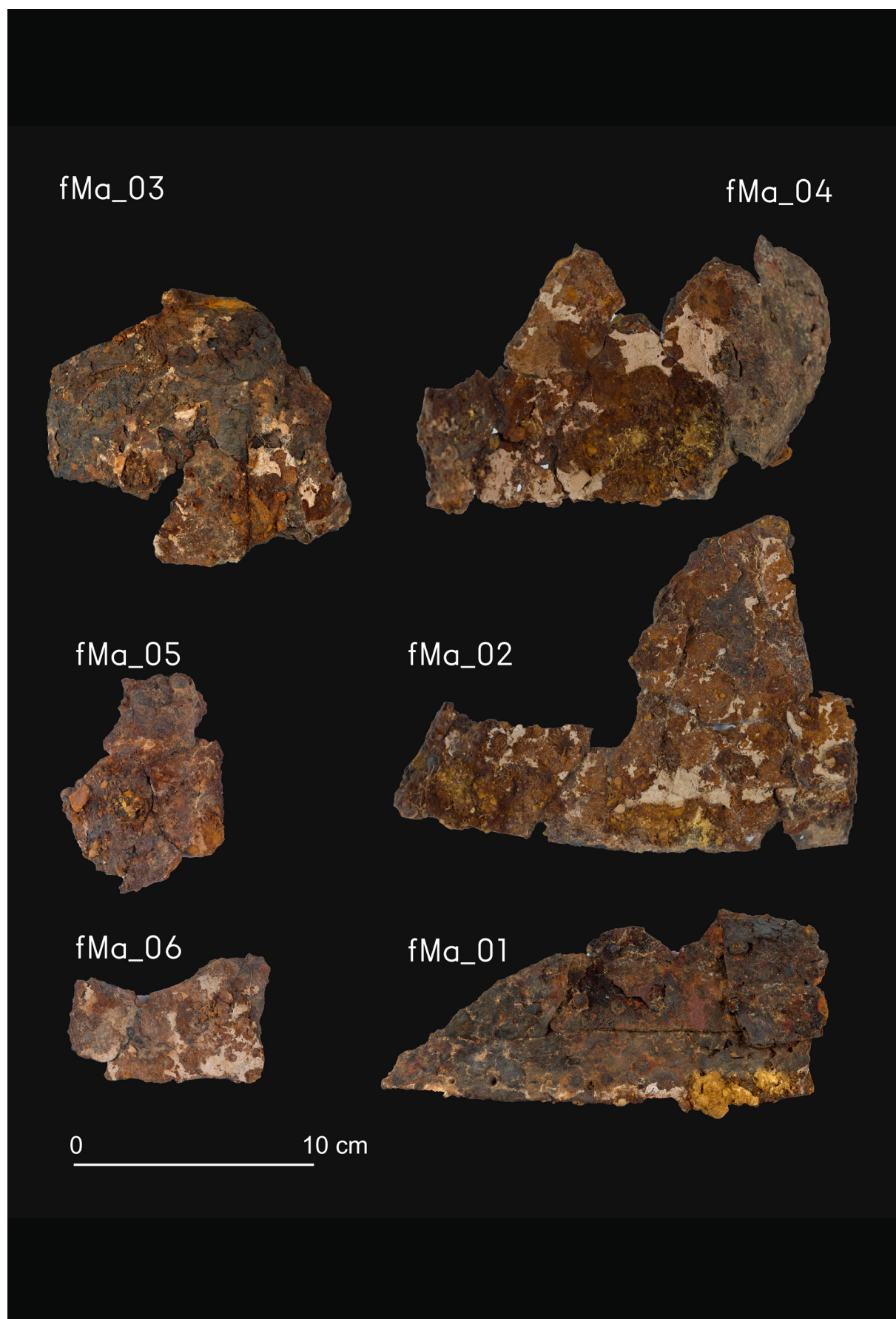
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