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CINNABAR USE IN THE EARLY BRONZE AGE MORTUARY PRACTICES OF THE NORTHERN BALKANS

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Keywords: North Balkans, Early Bronze Age, barrow graves, Yamna culture, cinnabar, hematite

Abstract: The article presents the results of the SEM and RAMAN analyses as well as the microscopic examination of red pigments from three Early Bronze Age barrow graves from Kriva Bara (Northwest Bulgaria). The results indicate a mixture between hematite and cinnabar used in the mortuary practices. Thus, Kriva Bara barrow presented the earliest use of cinnabar in Early Bronze Age Northern Balkans. Its utilization in Prehistoric Europe and, especially amongst Yamna communities is also discussed.

Cuvinte-cheie: Balcanii de nord, epoca bronzului timpuriu, morminte tumulare, cultura Yamna, cinabru, hematit

Rezumat: În articol sunt prezentate analizele SEM și RAMAN, precum și observațiile la microscop ale pigmentelor roșii din trei morminte tumulare din epoca bronzului timpuriu de la Kriva Bara (Bulgaria de nord-vest). Rezultatele indică un amestec de hematit și cinabru folosit în practicile funerare. Astfel, tumulul de la Kriva Bara reprezintă cea mai veche utilizare a cinabrului în Balcanii de nord din epoca timpurie a bronzului. Se discută, de asemenea, utilizarea acestuia în Europa preistorică și, în special, în cadrul comunităților Yamna.

INTRODUCTION

Cinnabar is a mineral containing mercury (Hg) which, alongside gold (Au), silver (Ag), copper (Cu), iron (Fe), lead (Pb), and tin (Sn), is one of the seven metals known in ancient times. It occurs as an amorphous mercuric sulphide, which subsequently converts to a crystalline red mercuric sulphide (HgS)¹. The word “cinnabar” derives from the Greek’s “κιννάβαρι”, a word that has two components originating from the words “motion” and “weight” which are in fact the main properties of mercury (Hg). Alongside other properties, cinnabar changes its color to black when exposed to sunlight and does not regain it if the exposure was long. A highly intense red dye was produced from cinnabar. Its unique qualities, striking beauty and eye-catching intensity made it one of the most precious pigments to ancient civilisations, symbolising vitality, power, and spiritual significance. Its vibrant colour was often associated with blood, life, and the divine, further elevating its importance in rituals and ceremonial contexts. Its rarity, difficulty of extraction, and refinement added to its allure, making it a luxury item reserved to art, religious

artefacts, and mortuary practices. Ancient cultures, no matter whether Roman, Chinese, or Mesoamerican, valued cinnabar not only for its visual impact but also for its transformative qualities, reflecting the alchemical and mystical belief that it held the power to transcend physical states. This transformative symbolism likely influenced its use in funerary contexts, in tombs, on statues, stelae and ceremonial objects, usage meant to ensure the transition of the soul, and its rebirth in the afterlife².

In daily life, cinnabar “...may have been reserved for special occasions (and people), limited body decoration and tattooing”³. Other than its ritual use, it had practical applications, as well. It is well known that in China and India it was used as a medical remedy taken orally as a „...sedative and to treat fever, insomnia, stroke, trauma to the brain, mouth and tongue ulcers, and other ailments“, and as an ointment – to treat ulcers, syphilis, etc⁴. From the perspective of mortuary practices, it is noteworthy that it delays decomposition “...thanks to its powerful bactericide and insecticide properties”⁵.

² Manova 2021, p. 13–31; Gliozzo 2021.

³ Gliozzo 2021, p. 9.

⁴ Emslie et alii 2019, p. 79–93 with references.

⁵ Cervini-Silva et alii 2013.

¹ Kiplik 1956.

The data existing prior to 2024 showed that in present-day Bulgaria, cinnabar was used from the 4th century BC onwards, and always in religious contexts: in Late Iron Age Thracian tombs (4th – 1st century BC); in Late Antiquity burial structures (the Silistra tomb); during the Middle Ages and the Revival period (in Christian temple paintings, Christian religious books and miniatures)⁶. The only “evidence” for a potential earlier use of cinnabar was the presence of sulfur and iron ions in a sample of the red pigment applied on the inner part of a bowl from an Early Bronze Age (EBA) barrow grave near Drazovo, Yambol region, Thrace⁷. Surprisingly, the presumption of a possible use of cinnabar in the EBA of the northern Balkans was supported also by the discovery in 2024, and the subsequent analyses of the pigments used in the mortuary practices, of a barrow near Kriva Bara (North–West Bulgaria) which makes the main subject of the present report.

KRIVA BARA BARROW

The Kriva Bara barrow was situated in the western part of the Lower Danube region, within present-day north-western Bulgaria, some 15 km south of the Danube River. It is part of the westernmost agglomeration of EBA barrows in the country (Fig. 1/1). The 2024 rescue excavations were prompted by the construction of a gas pipe-line⁸. Before the excavations, the barrow measured a 0.50 m in height and had a diameter of ca 30 m (Fig. 2). Given its location within an actively cultivated agricultural field, it is likely that the original dimensions could have been larger. Six burial structures from the first half of the 3rd millennium BC (Table 1), one Late Iron Age structure and a bovine skull (*Bos taurus*) dated to the 18th–19th centuries AD (Poz-179390 170 ± 30 BP; 1.6%N, 4.6%C, 2.5%coll) were investigated in the barrow area (Fig. 3/1; 4).

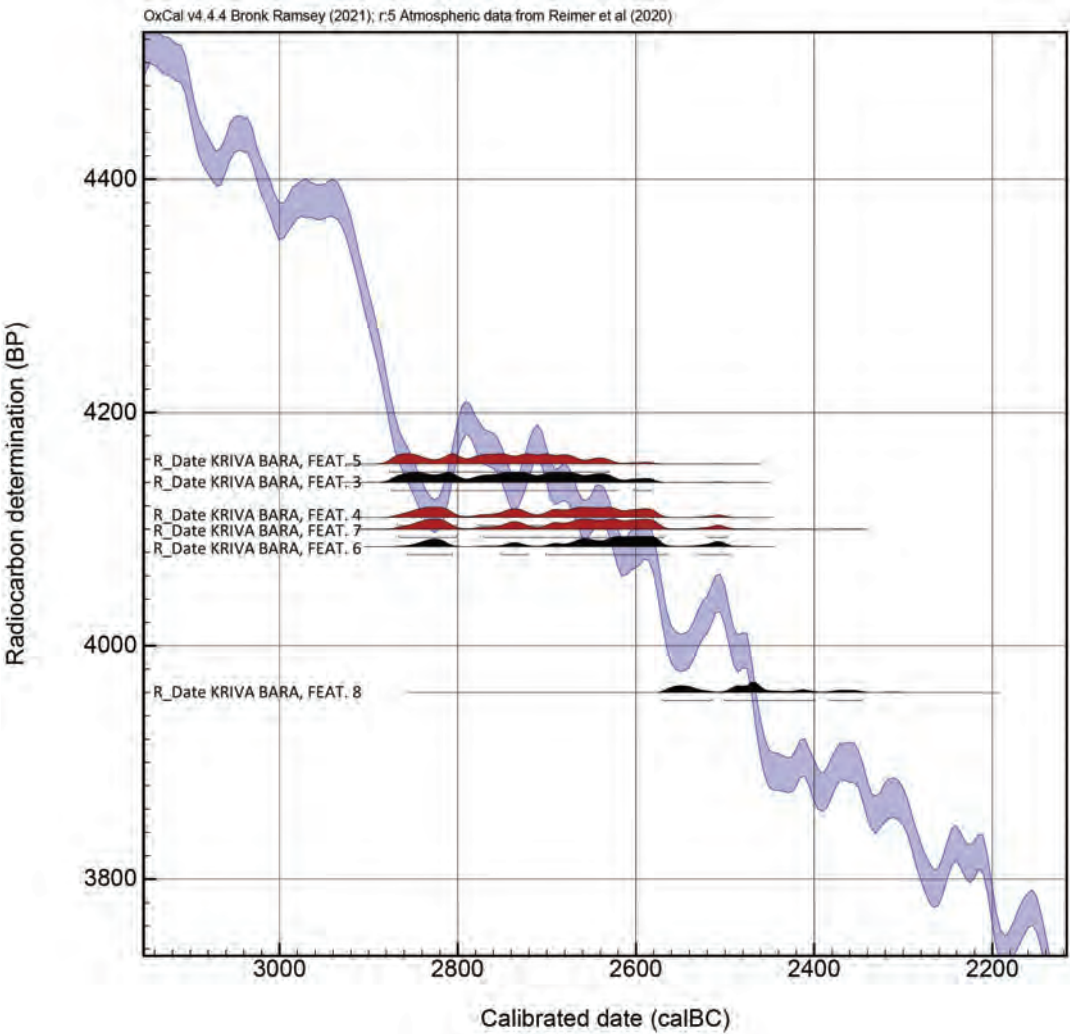


Table 1. Kriva Bara, calibrated AMS dates of the EBA graves on OxCal plot (OxCal v.4.4).

⁶ Manova 2021.
⁷ Manova 2021, p. 65.

⁸ Alexandrov, Włodarczak 2025.

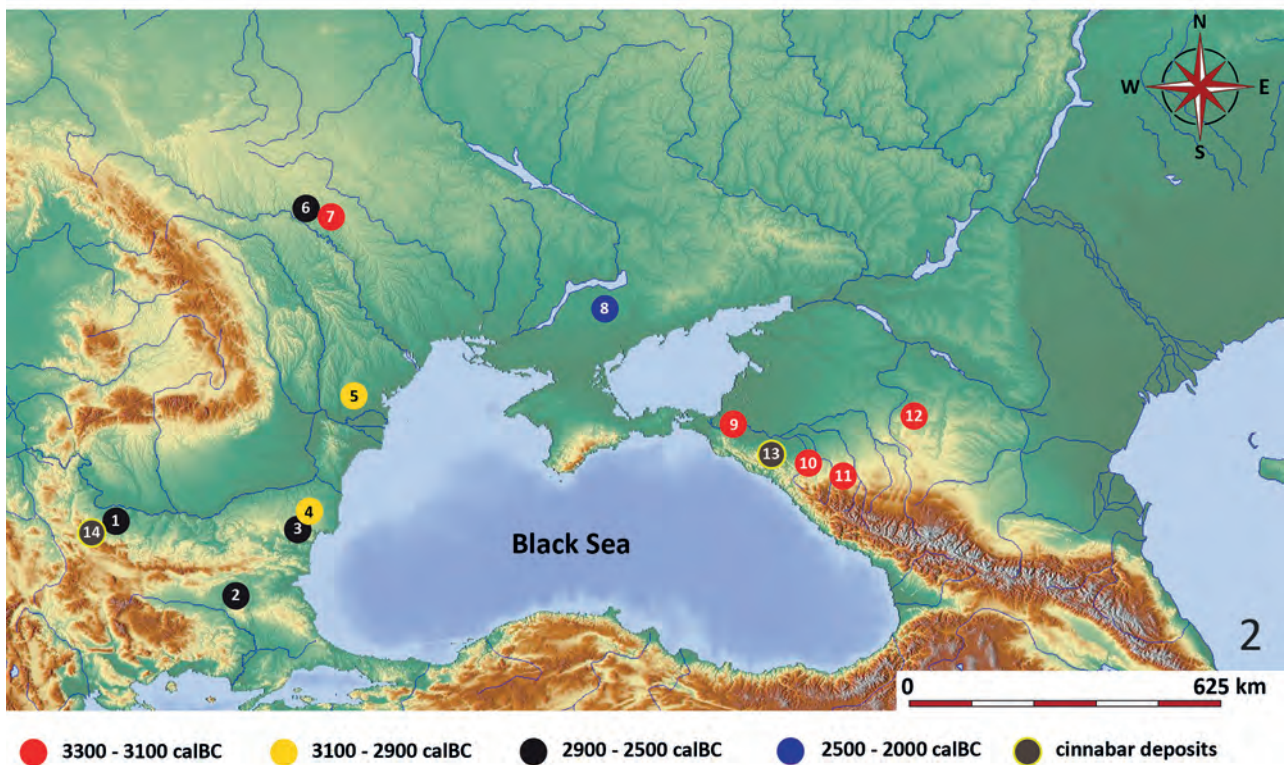
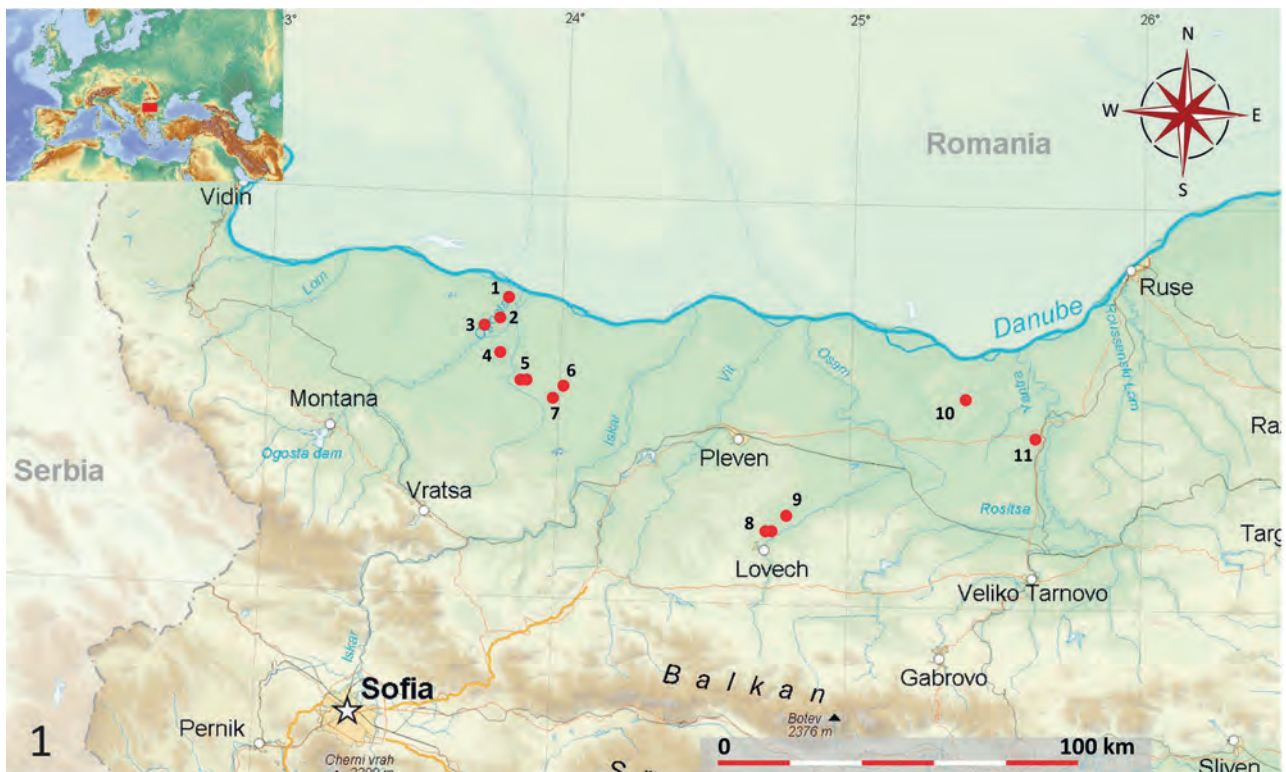


Figure 1. 1. Early Bronze Age barrows excavated in North-West Bulgaria (1. Kozlodui; 2. Butan; 3. Kriva Bara; 4. Manastirishte; 5. Tarnava; 6. Kneza; 7. Tarnak; 8. Goran-Slatina; 9. Vladinya; 10. Kozlovets; 11. Polsko Kosovo). Credit: <https://map.bgmountains.org>; 2. Burial complexes with cinnabar in the Black Sea region mentioned in text (1. Kriva Bara; 2. Mednikarovo; 3. Vetrino; 4. Dobrich; 5. Novosiolovca; 6. Porohy; 7. Prydnistrianske; 8. Zamozhne; 9. Chekon-2; 10. Maykop; 11. Novosvobodnaya (ex Tsarkaya); 12. Mar'inskaya; 13. Krasnodar; 14. Chiprovtsi). Credit: <https://maps-for-free.com/>.

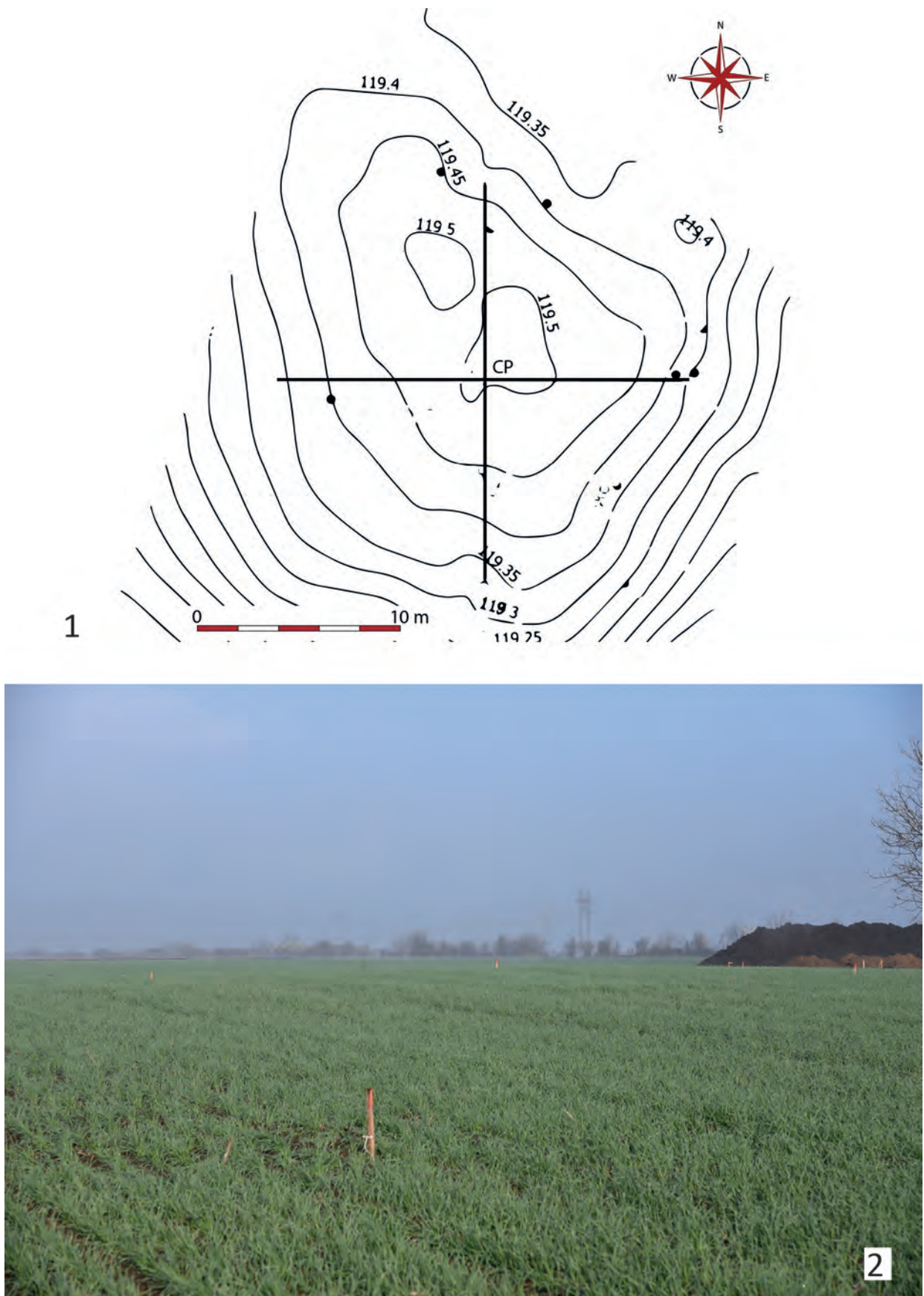


Figure 2. Kriva Bara barrow. **1.** Topographic map (credit: Tomasz Oberc); **2.** The barrow before the excavations (credit: Stefan Alexandrov).

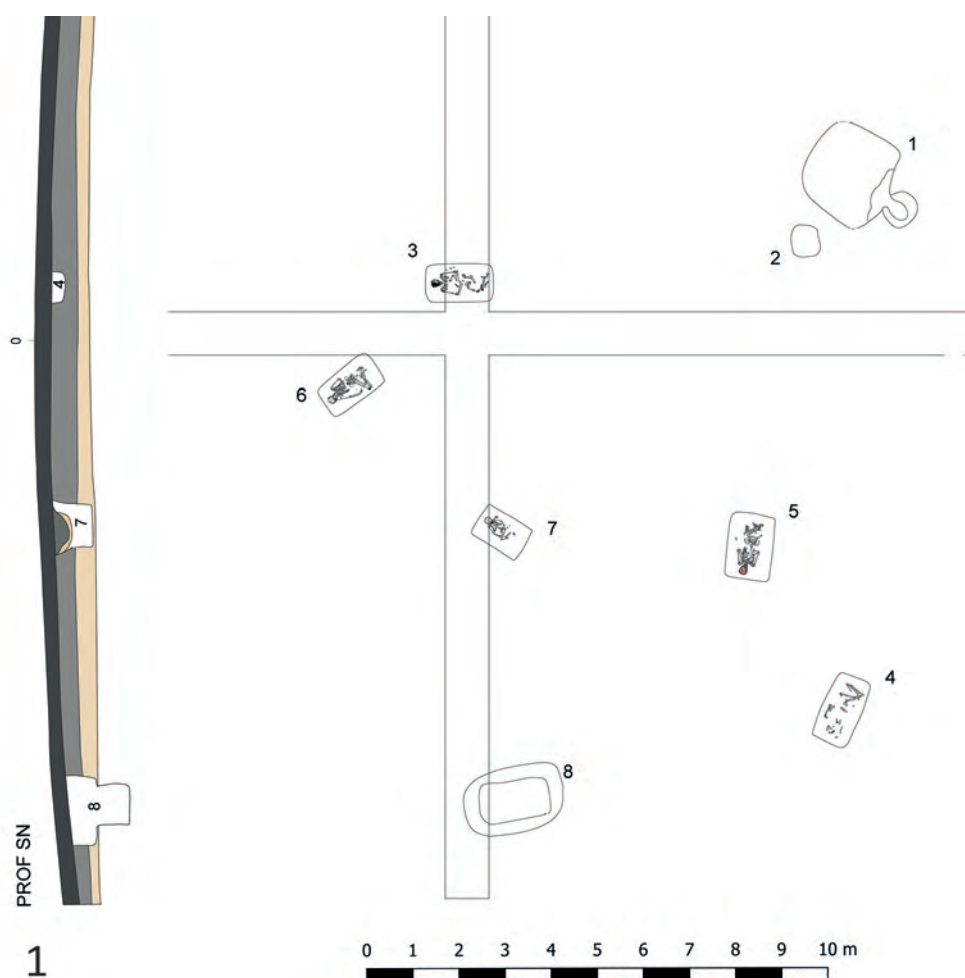


Figure 3. Kriva Bara barrow. 1. Plan of the features investigated (credit Michał Podsiadło); 2. Aerial view of the EBA graves in the southern sector (credit: Piotr Włodarczak).

The EBA features include five inhumations and one cremation, divided into three burial groups. The first one includes two inhumation graves (feature nos. 3 and 6), located in the central part of the barrow fill (Fig. 3). Both graves represent secondary inhumations with the pits dug into the already existing barrow fill. Feature no. 3 consisted of the poorly preserved remains of a male (40–50 years old). The body was placed in an articulated supine position with flexed legs, the arms bent at the elbows with the palms on the abdomen, oriented west–east. The ^{14}C date Poz-179391 returned the result 4140 ± 35 BP; 2.3%N, 7.6%C, 3.3%coll (Fig. 5). Feature no. 6 contained a well-preserved articulated skeleton of a female (25–30 years old), in a semi-supine position, slightly on the right side, with flexed legs, the right arm along the body and the left one flexed at the elbow with the palms on the abdomen. The orientation was southwest–northeast. The ^{14}C date Poz-179393 indicated the interval 4085 ± 30 BP; 0.9%N, 4.4%C, 6.5%coll (Fig. 6/1–3).

The second group of burials is represented by feature no. 8, a cremation grave, located in the southern part of the barrow fill; the radiocarbon date is Poz-178946: 3960 ± 30 BP; 0.4%N, 1.5%C, carbonate (Fig. 6/4–5). No grave inventory or use of pigments in mortuary practices were recorded in these three features presented above.

The three remaining graves (features nos. 4, 5, and 7) that are the main subject of the present study, were located in the south-eastern sector of the barrow. Feature no. 4 was partly destroyed by modern agricultural activities. However, most of the skeleton remained intact allowing the reconstruction of the position of the 50–55 years old male: supine position with flexed legs (collapsed to the right side), the left arm flexed at the elbow while the right arm was missing. The orientation was southwest–northeast and the radiocarbon date Poz-179395: 4110 ± 35 BP; 1.2%N, 6.7%C, 1.5%coll (Fig. 7). No inventory was found in the grave, but a strip of red pigment was noted on the posterior side of the right tibia while traces of red pigment were visible on the anterior side as well (Fig. 10/1–3). Red colouring was clearly visible inside all areas of the cancellous bones of the upper and lower limbs (Fig. 11/1–4).

Feature 5 comprised the inhumation of a male individual aged 20–30 years, placed in supine position with flexed lower limbs and the arms bent at the elbows, the forearms resting across the chest area. Both palms were absent. The burial was oriented south–north. Radiocarbon analysis: Poz-179394 reads 4156 ± 30 BP; 0.7%N, 3.9%C, 1.6%coll (Fig. 8). Although no grave goods were recovered, the burial is notable for the extensive use of red pigment. Traces were recorded on several extracranial areas of the skull: on the right maxilla above the first molar and the first and second premolars; on the left maxilla above the first molar and second premolar (Fig. 12/1–4); on the left zygomatic bone; on the upper part of the left temporal region; around the

external acoustic meatus; on the upper portion of the left mandible; and across the parietal area (Fig. 13/1–4). Red pigment was also observed on the endocranial surface, particularly on the right and left parietal bones around the lambda point (Fig. 14/1–4). Additional traces were visible at the roots of the teeth, specifically the upper right first premolar and the lower right third premolar (Fig. 15/1–3). Red colouring was likewise detected within the cranial bone structure in areas corresponding to the extracranial pigment application. Furthermore, a cuprorivaite-based blue pigment was identified on the left mandible (Fig. 16).

Feature no. 7 was the well-preserved inhumation of an infant (5–6 years old). The body was placed in supine position with flexed legs, arms along the body and orientation northwest–southeast. Radiocarbon analysis Poz-179392 reads 4100 ± 35 BP; 4.1%N, 11.3%C, 7.5%coll (Fig. 9). A lump of red pigment (roughly 7 x 3 cm) was found near the left shoulder (Fig. 17/1–4).

ANALYSES OF THE PIGMENTS FROM KRIVA BARA BARROW

Methods and equipment:

To analyse the nature of the red pigments found in the three graves, SEM-EDS, RAMAN, optical stereomicroscopy and spectral analyses were carried out as follows:

a) **Scanning Electron Microscopy.** Analyses with much higher magnifications concerning the detailed structure of the samples and their elemental composition were carried out on a JEOL JSM-26390 scanning electron microscope (secondary electrons mode) equipped with an energy-dispersive detector. The analysis of the samples intended to provide details for the elemental composition present on the surface of the samples. The methodology was related to the need for purity of the investigated pigments in which soil components were present;

b) **Raman spectrometer analyses** with a *inVia Qontor Microscope* with *Leica* lens, and *CCD* detector (21°C operating room temperature). Each sample was analysed on a 2mm glass slide, scanned from 10–15 to 180s using *Wire 5.6* software. For excitation, a 532 nm laser with 50 mW output power was used. Depending on the specimen concentration, the nominal power used during the analysis was 2.5 and 5 mW. A 785 nm line laser with an output power of 300 mW with a nominal power of 1 mW was also used. X50 lens were used to focus the laser beam and collect the scattered light in a backscatter configuration. The diameter of the illuminated spot on the specimen surface was about 3 μm . The spectral range studied was between 100.00 cm^{-1} and 2000.00 cm^{-1} .

c) **Magnification observation** of samples was carried out with an Optical Stereomicroscope *Stem 305* equipped with a *ZEISS Axiocam 208 color* camera.

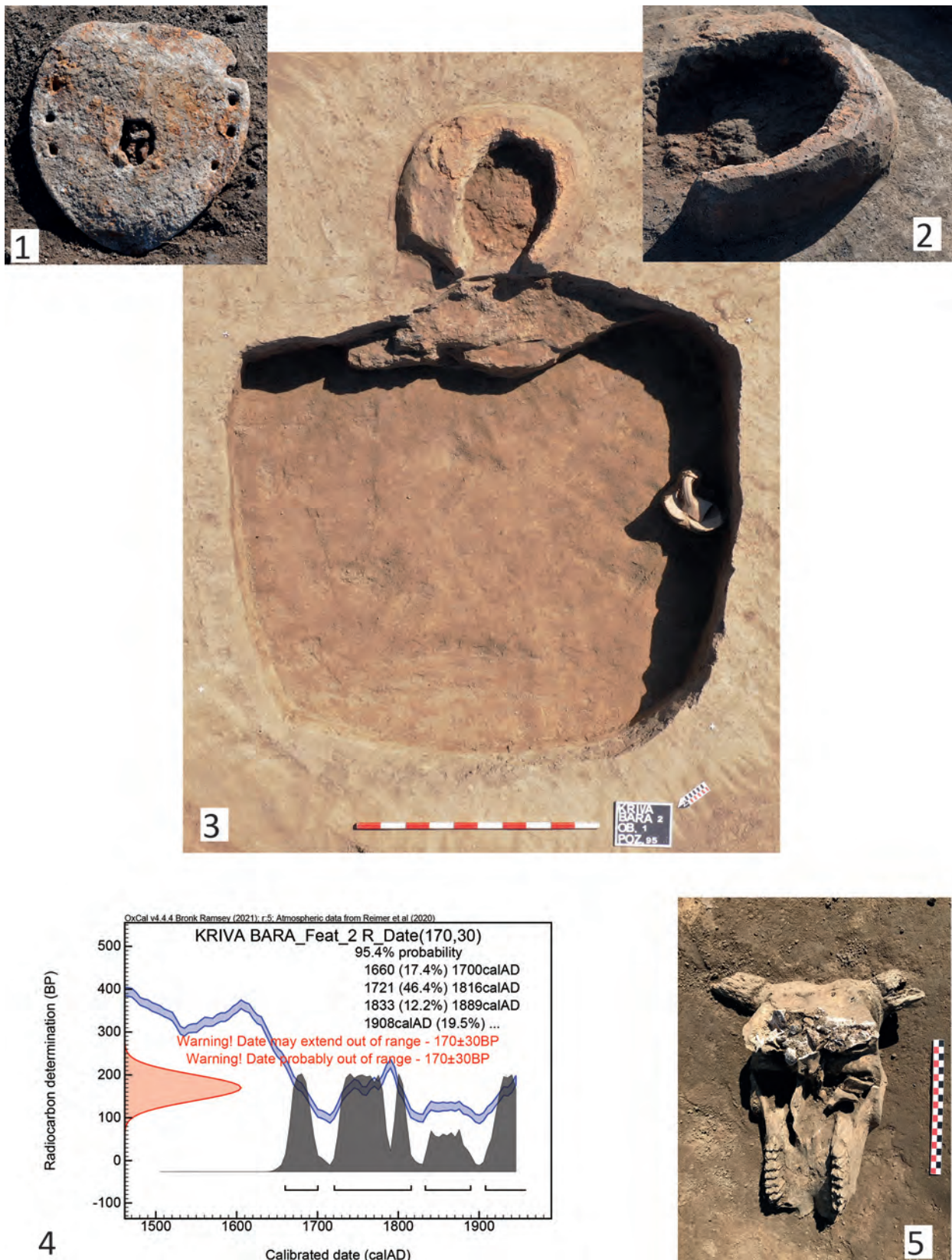


Figure 4. Kriva Bara barrow. 1–3. Feature no. 1 (credit Piotr Włodarczak); 4. Feature no. 2 calibrated AMS date (OxCal v.4.4); 5. Feature no. 2 (credit Piotr Włodarczak).

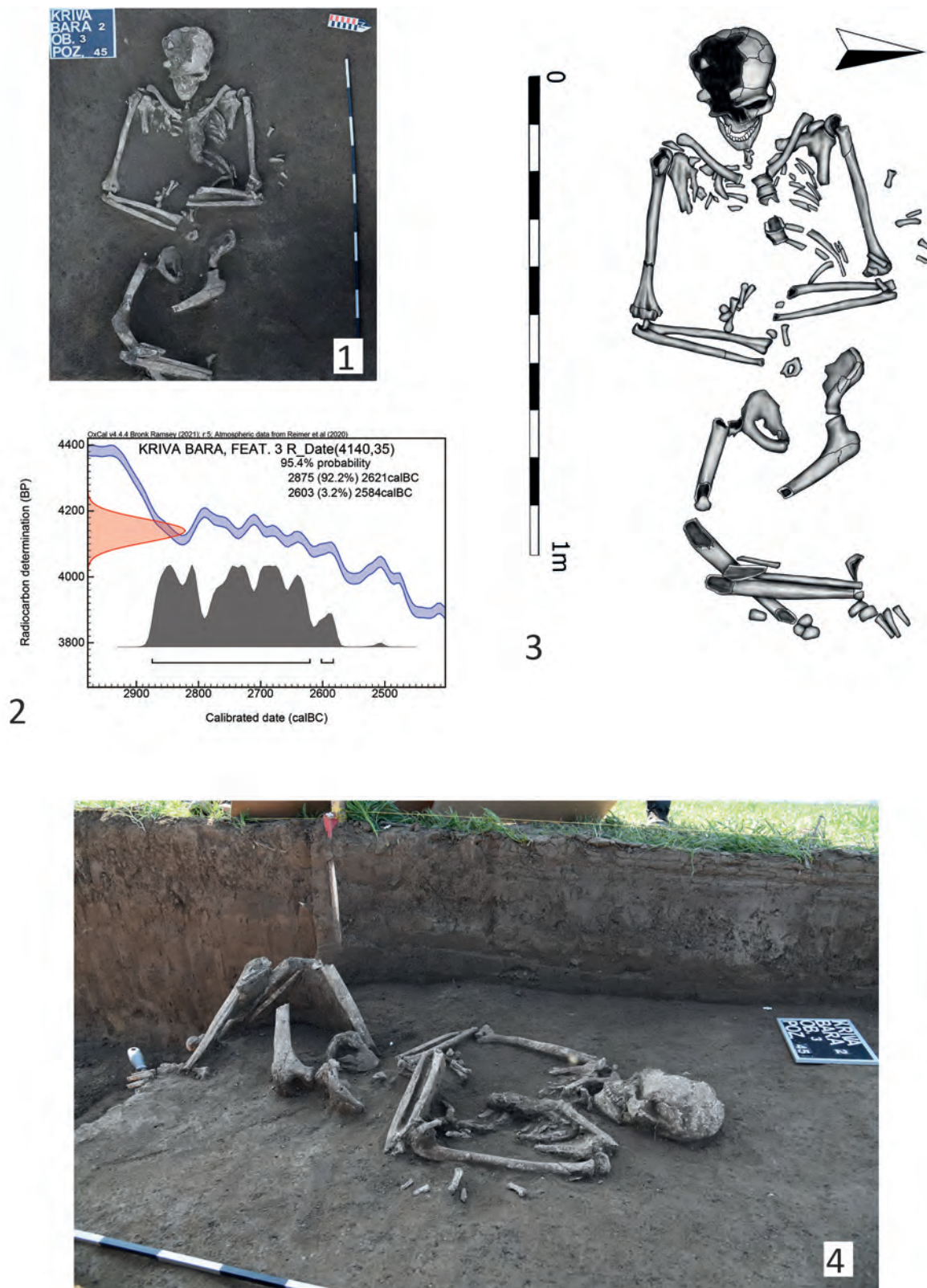


Figure 5. Kriva Bara barrow, feature no. 3. 1, 4. (credit Piotr Włodarczak); 2. (credit Michał Podsiadło); 3. calibrated AMS date (OxCal v.4.4).

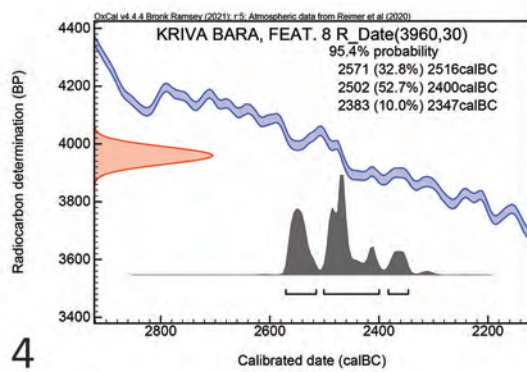
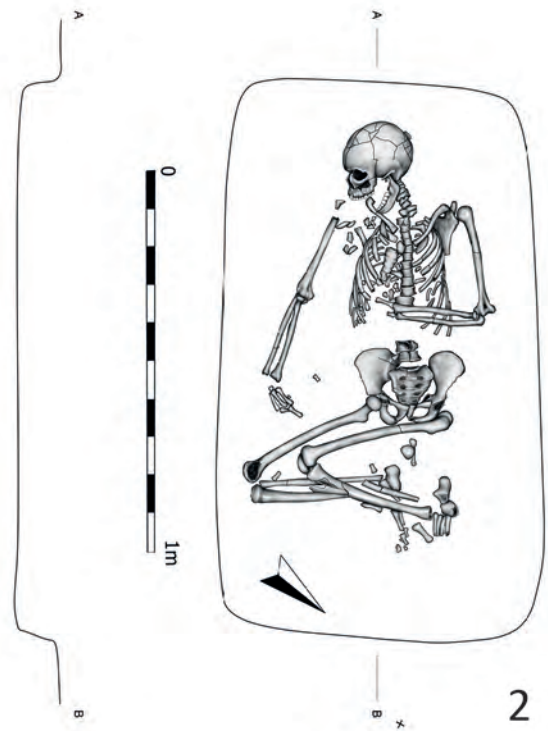
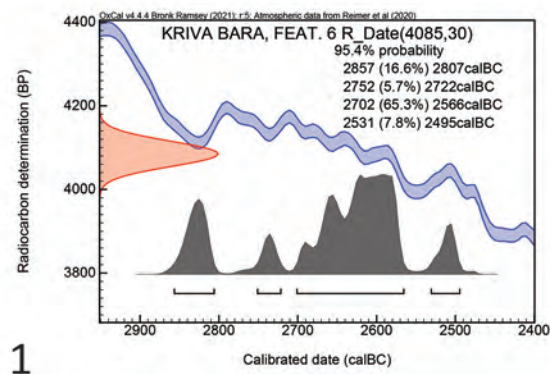


Figure 6. Kriva Bara barrow. 1–3. feature no. 6; 4–5. feature no. 8. 3, 5. (credit Piotr Włodarczak); 2. (credit Michał Podsiadło); 1, 4. calibrated AMS dates (OxCal v.4.4).

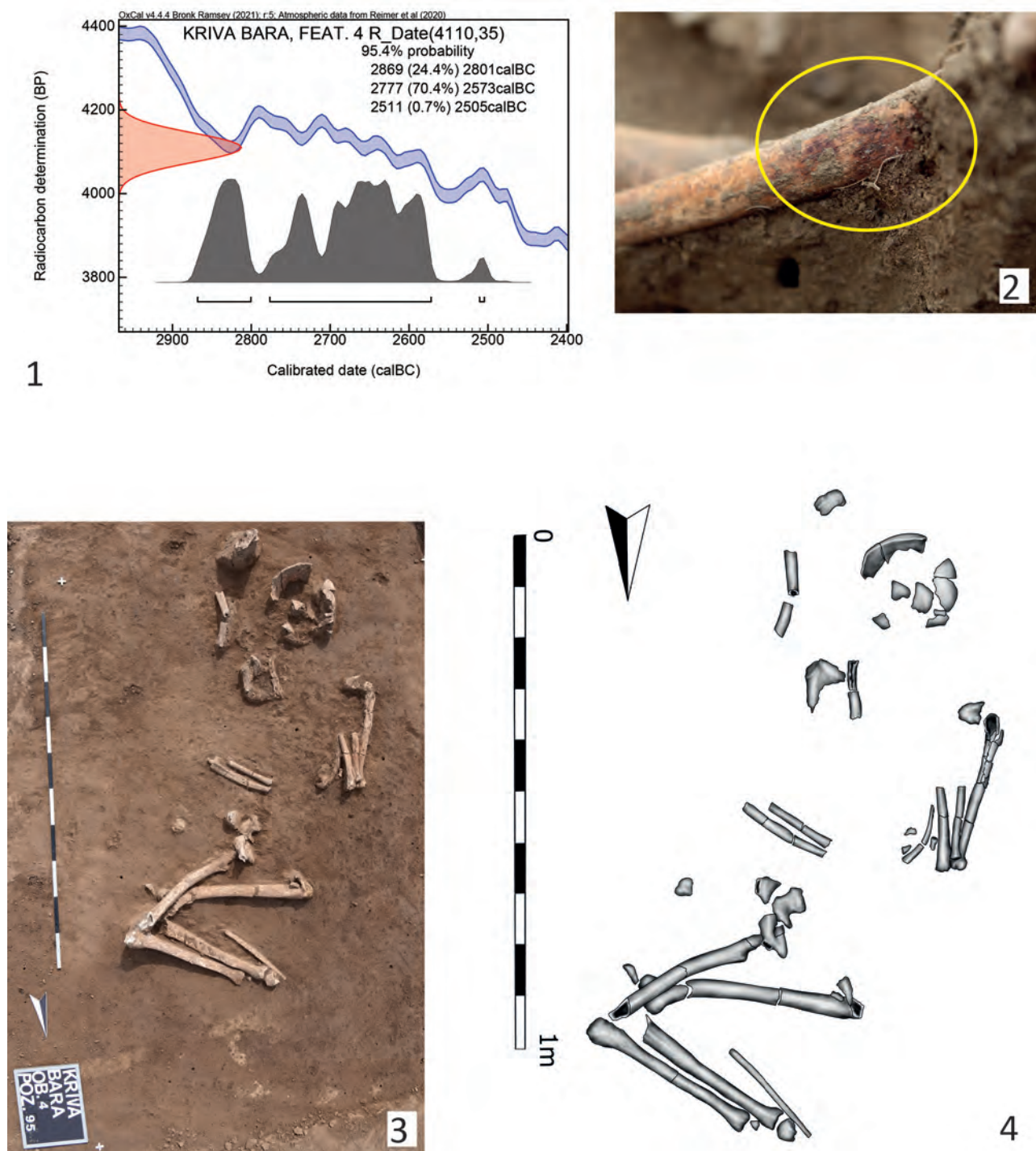


Figure 7. Kriva Bara barrow, feature no. 4. 1. Calibrated AMS date (OxCal v.4.4); 2, 3. (credit Piotr Włodarczak); 4. (credit Michał Podsiadło).

Results

Feature no. 4

The pigments on the tibia as well as the staining of the cancellous long bones were analysed.

• Pigments on the tibia

– SEM analyses (Fig. 10/5; Table 2): the main elements in the sample are carbon (C), oxygen (O), and calcium (Ca), which should be associated with bone composition,

and iron (Fe). The high amount of phosphorus (P) may be interpreted as a mineral component in human bones, but its appearance could also be related to modern soil fertilization. Trace elements – silicon (Si), aluminum (Al), and sodium (Na) were detected in the samples as well, the last one as part of the elemental composition of the human bone. In the spectra nos. 31 and 32, the presence of iron (Fe) was recorded as 44.57 and 43.47 (weight %),

Result Type		Weight %							
Spectrum Label	Spectrum 24	Spectrum 25	Spectrum 26	Spectrum 27	Spectrum 29	Spectrum 30	Spectrum 28	Spectrum 31	Spectrum 32
C	15.24	7.44	7.92	14.48	11.15	5.57	11.51	13.89	12.49
O	51.50	36.04	37.30	45.72	49.50	52.97	49.37	21.40	22.53
Na	0.54	0.50	0.59	0.39	0.65	0.31	0.64	0.17	0.15
Al	0.05	0.41	0.46	0.13	0.12	3.78	0.06	0.42	0.36
Si	0.07	0.34	0.30	0.07	0.05	6.20	0.06	0.19	0.13
P	9.72	15.39	14.72	11.29	11.41	0.00	11.33	0.00	0.00
Ca	22.88	39.54	38.51	27.76	27.03	27.59	26.99	18.66	20.56
Fe	0.00	0.00	0.17	0.00	0.05	3.34	0.03	44.57	43.47
Hg	0.00	0.33	0.03	0.16	0.04	0.24	0.00	0.70	0.31
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Result Type		Atomic %							
Spectrum Label	Spectrum 24	Spectrum 25	Spectrum 26	Spectrum 27	Spectrum 29	Spectrum 30	Spectrum 28	Spectrum 31	Spectrum 32
C	23.50	14.05	14.71	23.43	18.20	9.47	18.73	30.50	27.61
O	59.60	51.12	52.00	55.54	60.66	67.59	60.31	35.28	37.40
Na	0.43	0.50	0.57	0.33	0.55	0.28	0.54	0.19	0.17
Al	0.03	0.35	0.38	0.09	0.09	2.86	0.05	0.42	0.36
Si	0.05	0.28	0.24	0.05	0.04	4.51	0.04	0.18	0.12
P	5.81	11.28	10.60	7.08	7.22	0.00	7.15	0.00	0.00
Ca	10.57	22.39	21.43	13.46	13.22	14.05	13.16	12.29	13.63
Fe	0.00	0.00	0.07	0.00	0.02	1.22	0.01	21.06	20.67
Hg	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.09	0.04
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 2. Kriva Bara, feature 4. SEM/EDS analyses of the red pigment at the tibia.

and 21.06 and 20.67 (atomic %) respectively. Some of the spectra, especially nos. 25, 31 and 32 show the presence of mercury (Hg). No sulfur (S) was detected in the specific measurements, which we attribute to the low level of the element compared to the higher levels of the other elements.

– *RAMAN analyses* (Fig. 10/4): the peak at 284 cm^{-1} (very weak) coincides with that of the soil at 279 cm^{-1} , interpreted as degenerate E vibrations of cinnabar (HgS)⁹. Therefore, we may presume this is cinnabar in very low concentration.

Considering all the above we suggest that the red pigment sample from the tibia contains hematite (Fe_2O_3) and very small amounts of cinnabar (HgS).

- **The staining of the cancellous long bones**

– *SEM analyses* (Fig. 11/5; Table 3): the elemental composition includes calcium (Ca), magnesium (Mg), and phosphorus (P), which are components of the human

bones. The high percentage of phosphorus (P), measured in spectra nos. 11, 12, and 14, could be related to phosphate fertilizers, as above. Iron (Fe), silicon (Si), aluminum (Al), the trace element titanium (Ti), as well as the minimal concentration of mercury (Hg) measured in the spectra nos. 13, 19, and 22, may be associated with the cancellous bone staining.

– *RAMAN analyses* (Fig. 11/5): two distinct peaks at 1088 cm^{-1} and 1618 cm^{-1} are observed. The one at 1088 cm^{-1} is to be related to the (Si-O-Si) stretching vibration, triggered by mineral components in a siliceous environment. The band at 1088 cm^{-1} can be attributed to the symmetric stretching of bone carbonated hydroxyapatite (CO_3). The very weak peak at 284 cm^{-1} may be interpreted as degenerate E vibrations of cinnabar (HgS)¹⁰. Therefore, we may interpret this as cinnabar in a very low concentration.

Considering all the above, we suggest that the staining of the cancellous long bones contains hematite with the microelement titanium (Ti) and cinnabar (HgS).

⁹ Scheuermann *et alii* 1969.

¹⁰ Scheuermann *et alii* 1969.

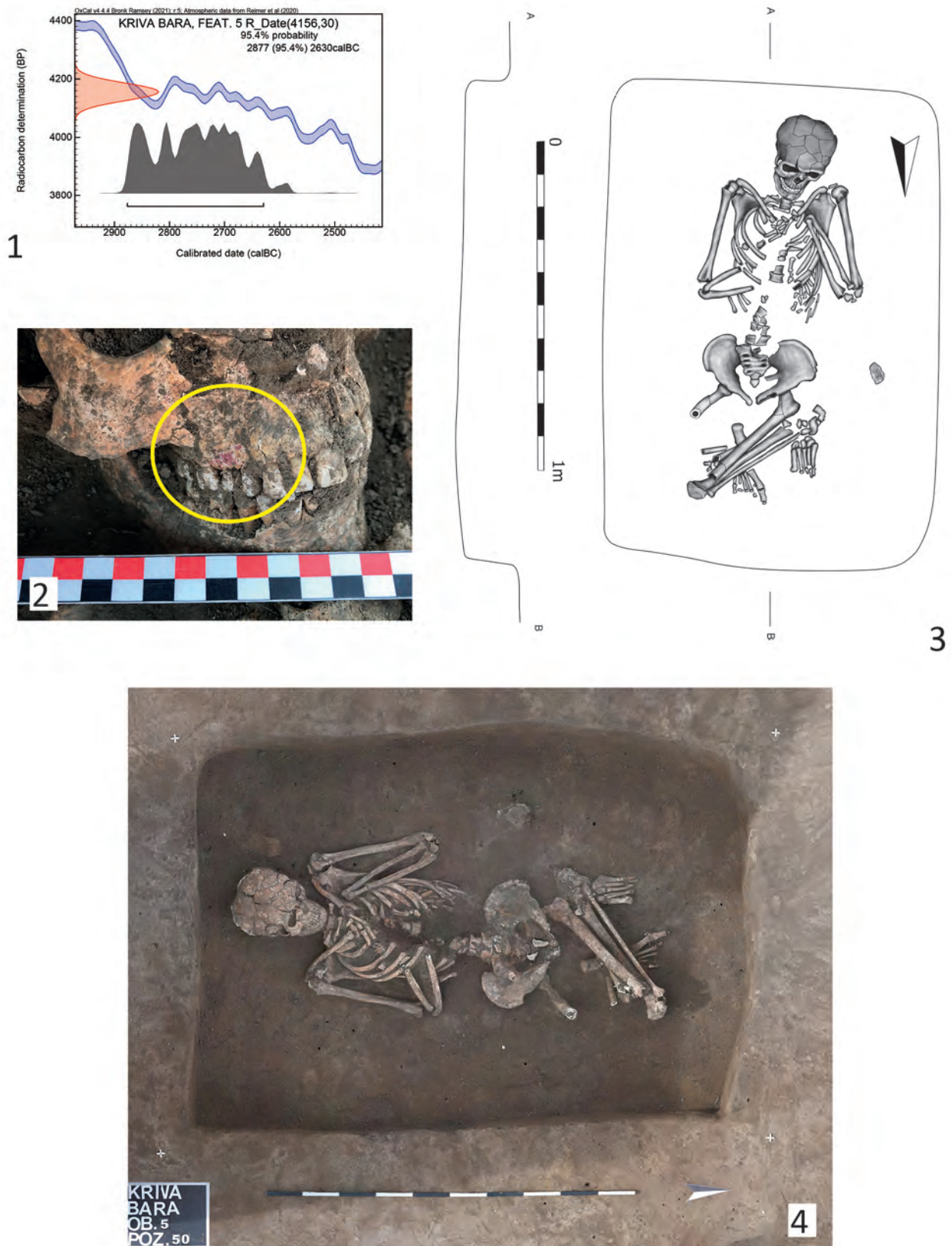


Figure 8. Kriva Bara barrow, feature no. 5. **1.** Calibrated AMS date (OxCal v.4.4); **2, 4.** (credit Piotr Włodarczak); **3.** (credit Michał Podsiadło).

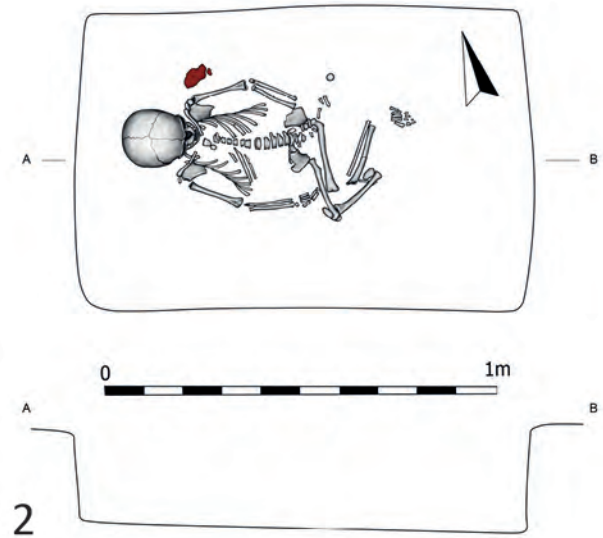
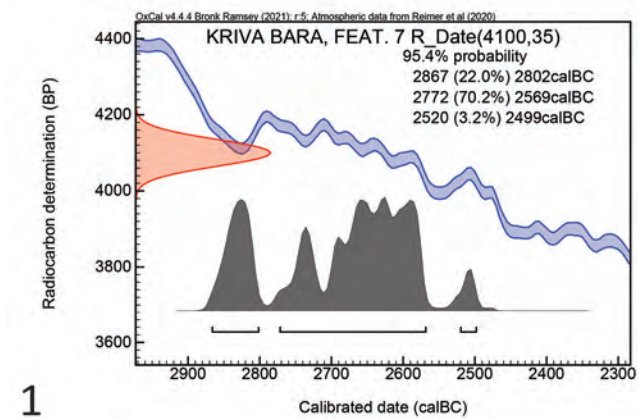


Figure 9. Kriva Bara barrow, feature no. 7. 1. Calibrated AMS date (OxCal v.4.4); 2. (credit Michał Podsiadło); 3–5. (credit Piotr Włodarczak).

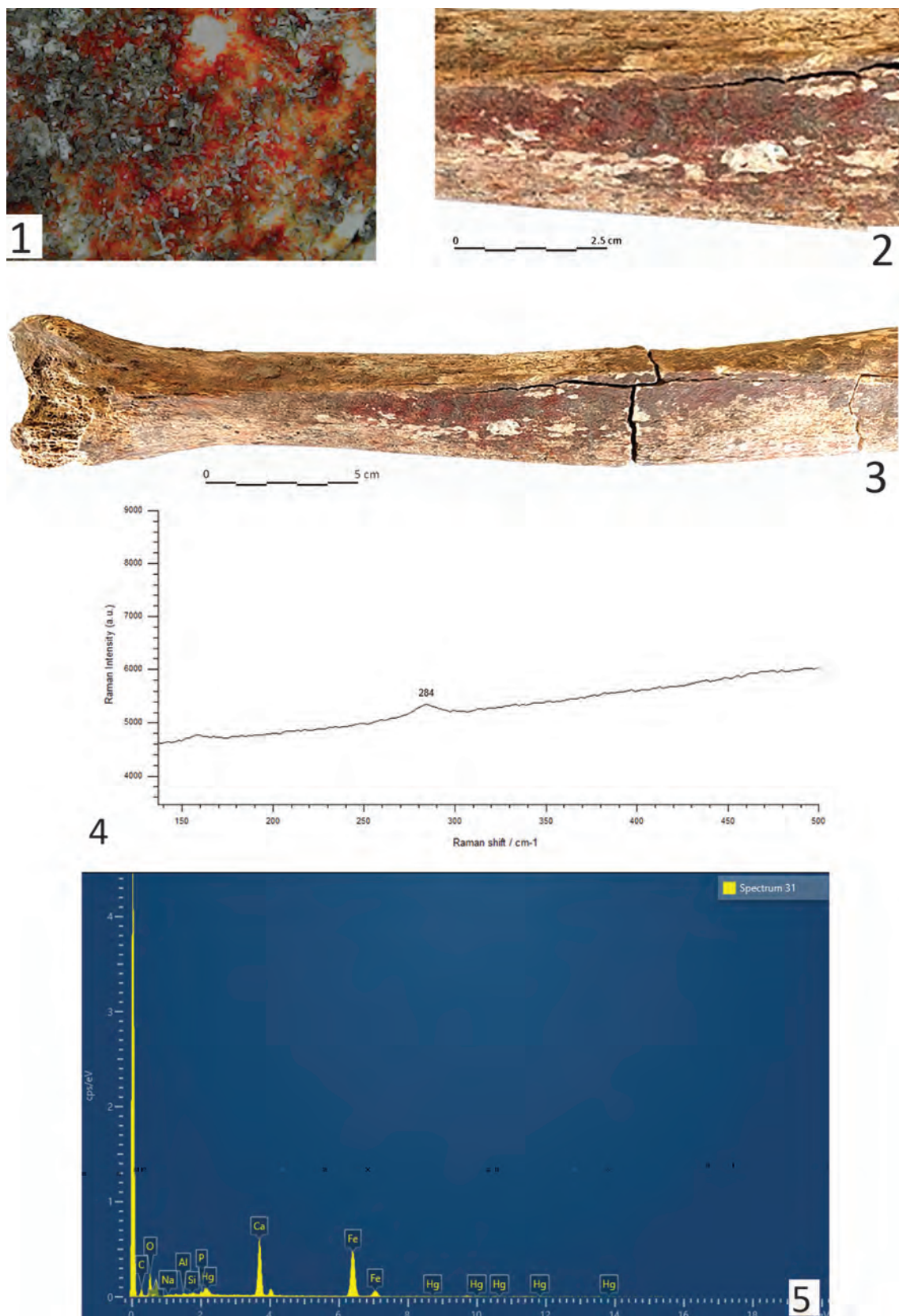


Figure 10. Kriva Bara barrow, feature no. 4, red pigment on the tibia. **1.** Macro photo (credit Rositsa Manova); **2–3.** photo (credit Stefan Alexandrov); **4.** RAMAN image (inVia Qontor Microscope); **5.** SEM/EDS image (JEOL 6390 and INCA Oxford).

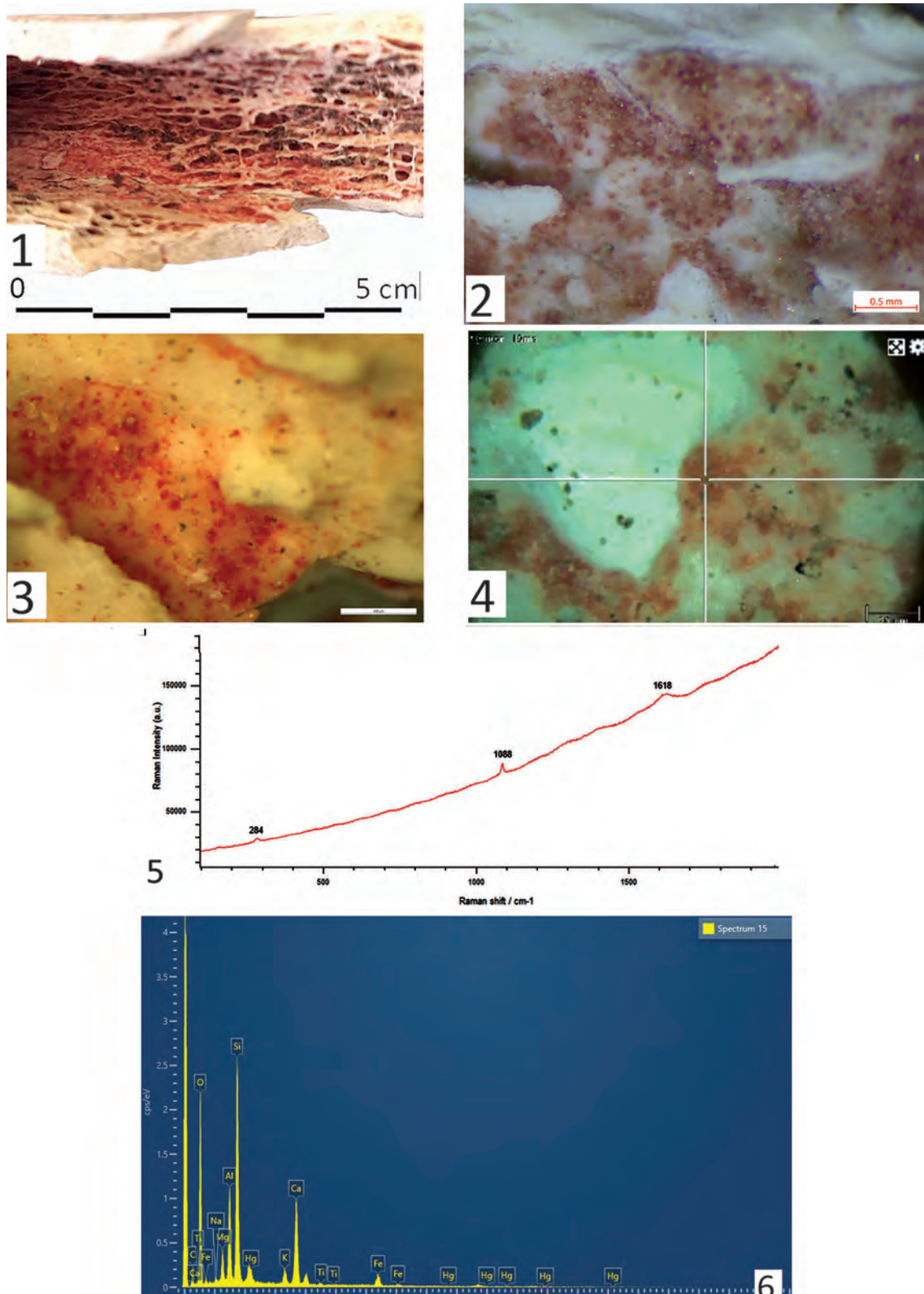


Figure 11. Kriva Bara barrow, feature no. 4, staining of the cancellous long bones (tibia). **1.** Photo (credit Stefan Alexandrov); **2–4.** Optical microscopy (JEOL 6390 and INCA Oxford); **5.** RAMAN image (inVia Qontor Microscope); **6.** SEM/EDS image (JEOL 6390 and INCA Oxford).

Result Type		Weight %										
Sp. Lab	Spectrum 11	Spectrum 12	Spectrum 13	Spectrum 14	Spectrum 15	Spectrum 16	Spectrum 17	Spectrum 18	Spectrum 19	Spectrum 20	Spectrum 21	Spectrum 22
C	9.26	4.83			16.83	14.87		16.67	18.29	16.77	25.47	20.95
O	41.39	38.51	61.78	44.72	49.16	52.21		54.89	59.51	56.07	58.87	61.28
Na					0.47							
Mg					2.09		93.13					
Al					5.59					0.38	2.75	
Si					13.13							
P	12.58	10.75		12.69						2.46		0.56
K					1.23							
Ca	36.77	45.92	37.31	42.59	8.15	32.92		28.28	22.14	24.32	12.91	15.86
Ti					0.27							
Fe			0.51	0.00	3.07		6.87	0.16				
Hg	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	1.34
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Result Type		Atomic %										
Sp. Lab	Spectrum 11	Spectrum 12	Spectrum 13	Spectrum 14	Spectrum 15	Spectrum 16	Spectrum 17	Spectrum 18	Spectrum 19	Spectrum 20	Spectrum 21	Spectrum 22
C	16.47	9.34			25.25	23.26		25.11	26.27	24.93	34.06	29.10
O	55.26	55.95	80.39	65.49	55.35	61.31		62.07	64.19	62.57	59.12	63.89
Na					0.37							
Mg					1.55		96.89					
Al					3.73					0.25	1.64	
Si					8.42							
P	8.68	8.07		9.60						1.42		0.30
K					0.57							
Ca	19.60	26.63	19.38	24.90	3.67	15.43		12.77	9.53	10.83	5.17	6.60
Ti					0.10							
Fe			0.19	0.00	0.99		3.11	0.05				
Hg	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.11
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 3. Kriva Bara, feature 4. SEM/EDS analyses of the red pigment in the cancellous bone of the tibia.

Feature no. 5. Pigments on the endo- and exocranial parts of the skull and on the root of a molar of the deceased were analysed.

- **Pigments on the right maxilla**

– *SEM analyses* (Fig. 12/5; Table 4). The elemental composition in the spectra nos. 27 and 28 includes calcium (Ca), potassium (K), magnesium (Mg), all components of hydroxyapatite. The high percentages of phosphorus (P) could be equally related to the individual's diet and phosphate fertilizers. Iron (Fe), silicon (Si), aluminium (Al), and the trace element titanium (Ti) are characteristic elements of the red pigment hematite from Bulgaria. The presence of mercury (Hg) in all the spectra, and especially in spectrum 27 is to be mentioned as well. In conclusion, a mixture of hematite and cinnabar was probably used to color the right maxilla.

- **Pigments on the exocranial part of the right parietal bone**

– *RAMAN analyses* (Fig. 13/5): The peaks at 148 cm^{-1} and 159 cm^{-1} in human bone are typically associated with various molecular characteristics that influence bone quality characterization. The peak at 148 cm^{-1} is usually attributed to bending vibrations of various molecular modes, often associated with vibrations in minerals present in bones, such as hydroxyapatite or carbonate substitutions in the mineral structure. The peak at 159 cm^{-1} is often associated with vibrations related to amides, particularly those associated with collagen, the main organic matrix protein in bones. The peak at 248 cm^{-1} belongs to cinnabar (HgS), and the one at 285 cm^{-1} is due to the subsequent degenerate E vibrations of cinnabar (HgS). Therefore, we may conclude that this is cinnabar in a very

Result Type	Weight %					
Spectrum Label	Spectrum 23	Spectrum 24	Spectrum 25	Spectrum 26	Spectrum 27	Spectrum 28
C	11.11	10.41	17.68	20.68	16.53	15.91
O	39.48	61.35	46.55	46.51	35.06	40.53
Na					0.18	0.29
Mg					1.00	1.09
Al					4.47	4.97
Si					9.30	10.09
P	13.72	3.99	8.85	7.89	1.75	4.21
K	0.11	2.11	0.39	0.40	1.24	1.33
Ca	34.95	15.46	24.63	22.46	11.88	15.39
Ti					0.33	0.21
Fe	0.25	5.79	1.27	1.33	3.39	2.89
Hg	0.38	0.89	0.63	0.74	14.88	3.09
Total	100.00	100.00	100.00	100.00	100.00	100.00

Result Type	Atomic %					
Spectrum Label	Spectrum 23	Spectrum 24	Spectrum 25	Spectrum 26	Spectrum 27	Spectrum 28
C	19.61	16.12	27.69	31.41	29.66	26.05
O	52.32	71.30	54.71	53.03	47.23	49.83
Na					0.17	0.25
Mg					0.89	0.88
Al					3.57	3.62
Si					7.14	7.07
P	9.39	2.39	5.37	4.64	1.22	2.67
K	0.06	1.01	0.19	0.19	0.69	0.67
Ca	18.49	7.17	11.56	10.22	6.39	7.55
Ti					0.15	0.09
Fe	0.09	1.93	0.43	0.43	1.31	1.02
Hg	0.04	0.08	0.06	0.07	1.60	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table 4. Kriva Bara, feature 5. SEM/EDS analyses of the red pigment at the right maxilla.

low concentration. The peaks at 500 cm^{-1} and 912 cm^{-1} are due to phosphates typical of bones at different wave frequencies.

- **Pigments on the endocranial part of the skull**

– SEM analyses (Fig. 14/5; Table 5): In spectra nos. 13, 17, and 5 were detected characteristic elements of hydroxyapatite, with high concentration of phosphorus (P), possibly related to the individual's diet. Magnesium (Mg) is also a bone component, usually strengthening the

bone structure. On spectrum no. 17, the microelement titanium (Ti) is observed in combination with silicon (Si), aluminum (Al), and iron (Fe), which are characteristic elements of the red pigment hematite from Bulgaria. Spectrum no. 16 shows manganese (Mn), which may be related to the individual's diet (cereal plants) or soil acidity. The low concentrations of mercury (Hg) again indicate the connection between red hematite and cinnabar used in a mixture to color the inside of the skull.

Result Type	Weight %							
Spectrum Label	Spectrum 12	Spectrum 13	Spectrum 16	Spectrum 17	Spectrum 21	Spectrum 23	Spectrum 6	Spectrum 5
C	12.76	11.94	12.40	10.81	19.86	15.63	3.36	12.12
O	55.17	37.08	51.24	48.95	33.13	27.02	18.40	49.43
Mg		0.37		0.94				1.22
Al		1.39		4.52				3.71
Si		2.61		7.57			15.46	8.72
P	9.11	10.53	9.38	6.08	2.81	2.84		
K		0.45		0.88				1.08
Ca	21.67	31.48	21.67	14.55	43.62	54.06	1.55	21.38
Ti				1.12				
Mn			4.64					
Fe	0.86	3.99	0.43	4.35	0.20	0.17	61.22	2.34
Hg	0.45	0.15	0.23	0.22	0.38	0.27	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Result Type	Atomic %							
Spectrum Label	Spectrum 12	Spectrum 13	Spectrum 16	Spectrum 17	Spectrum 21	Spectrum 23	Spectrum 6	Spectrum 5
C	19.81	21.24	19.96	17.58	33.69	29.34	8.98	19.40
O	64.30	49.51	61.93	59.76	42.18	38.08	36.92	59.42
Mg		0.32		0.76				0.96
Al		1.10		3.27				2.65
Si		1.99		5.26			17.67	5.97
P	5.48	7.27	5.86	3.84	1.85	2.07		
K		0.25		0.44				0.53
Ca	10.08	16.78	10.46	7.09	22.17	30.41	1.24	10.26
Ti				0.46				
Mn			1.63					
Fe	0.29	1.53	0.15	1.52	0.07	0.07	35.19	0.81
Hg	0.04	0.02	0.02	0.02	0.04	0.03	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 5. Kriva Bara, feature 5. SEM/EDS analyses of the red pigment in the endocranial part of the skull (parietal zone).

• **The sample from the right maxillary first premolar**

– SEM analyses (Fig. 15/4; Table 6). In spectra nos. 33, 34, 36, and 37, were detected the characteristic elements of hydroxyapatite, with a high concentration of phosphorus (P), already noted at the other samples. Magnesium (Mg) is also a component of bone, usually strengthening its

structure. On spectrum no. 17, the microelement titanium (Ti) is again observed in combination with silicon (Si), aluminum (Al), and iron (Fe), which are characteristic elements of the red pigment hematite from Bulgaria. High concentrations of mercury (Hg) again indicate the connection between red hematite and cinnabar used in a mixture and probably ingested through the oral cavity.

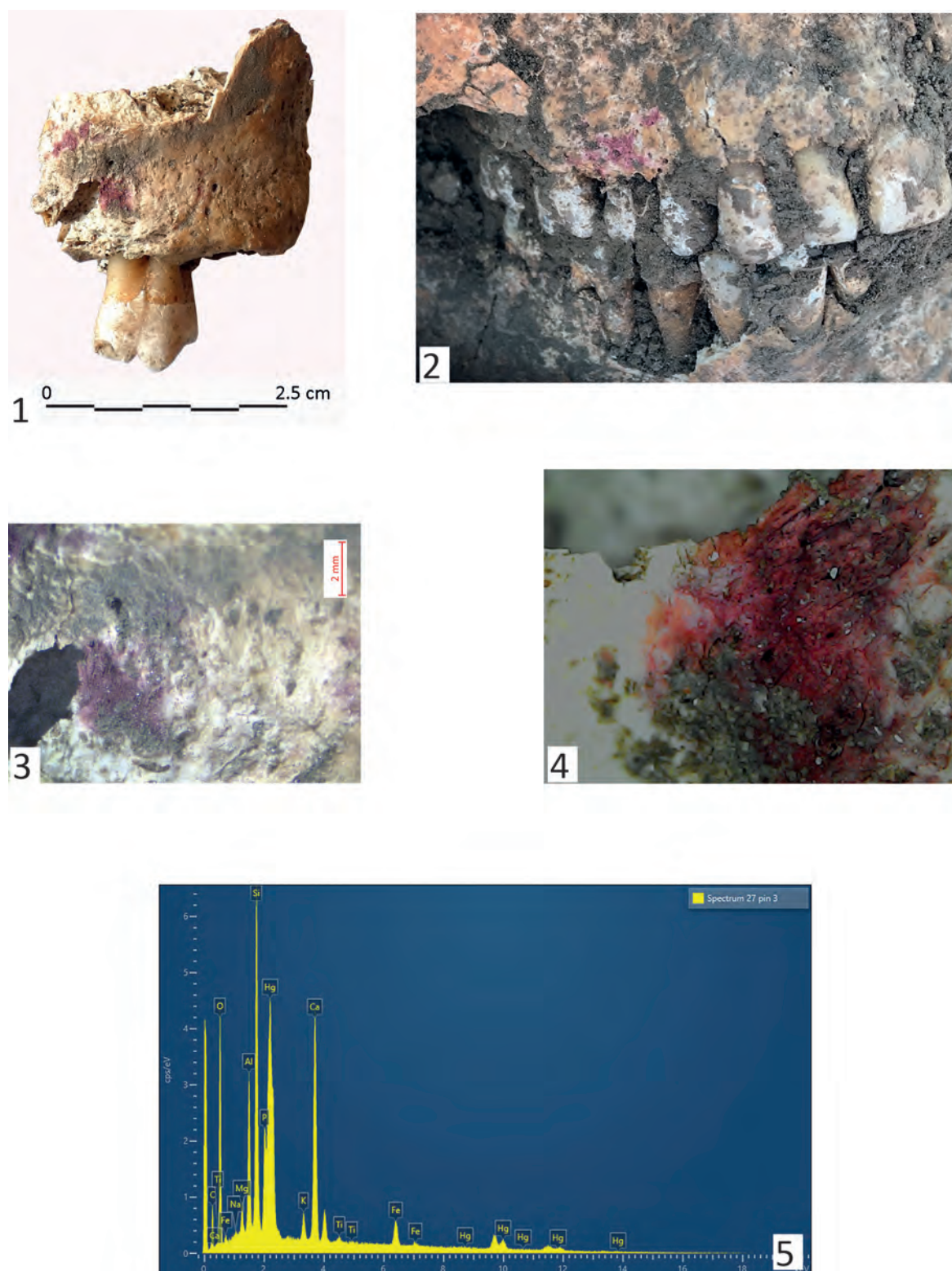


Figure 12. Kriva Bara barrow, feature no. 5, red pigments on maxilla and mandible. 1–2. Photo (credit Stefan Alexandrov); 3. Optical microscopy (JEOL 6390 and INCA Oxford); 4. Macro photo (credit Rositsa Manova); 5. SEM/EDS image (JEOL 6390 and INCA Oxford).

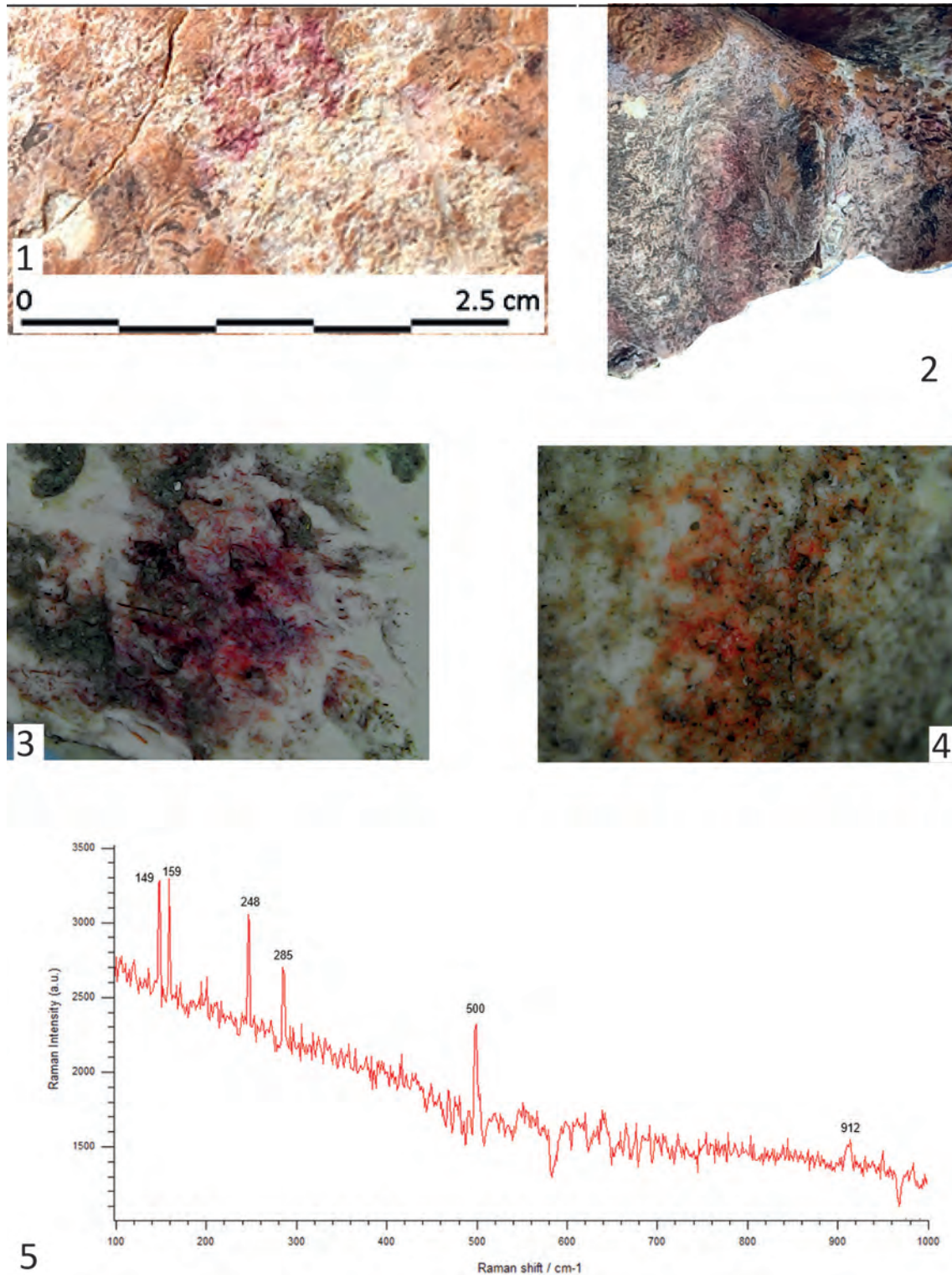


Figure 13. Kriva Bara barrow, feature no. 5, red pigments on the exocranial parts of the skull. **1, 3.** Parietal bone; **2, 4.** Left temporal zone (1, 2 – credit Stefan Alexandrov; 3, 4 – credit Rositsa Manova); **5.** RAMAN image (inVia Qontor Microscope).

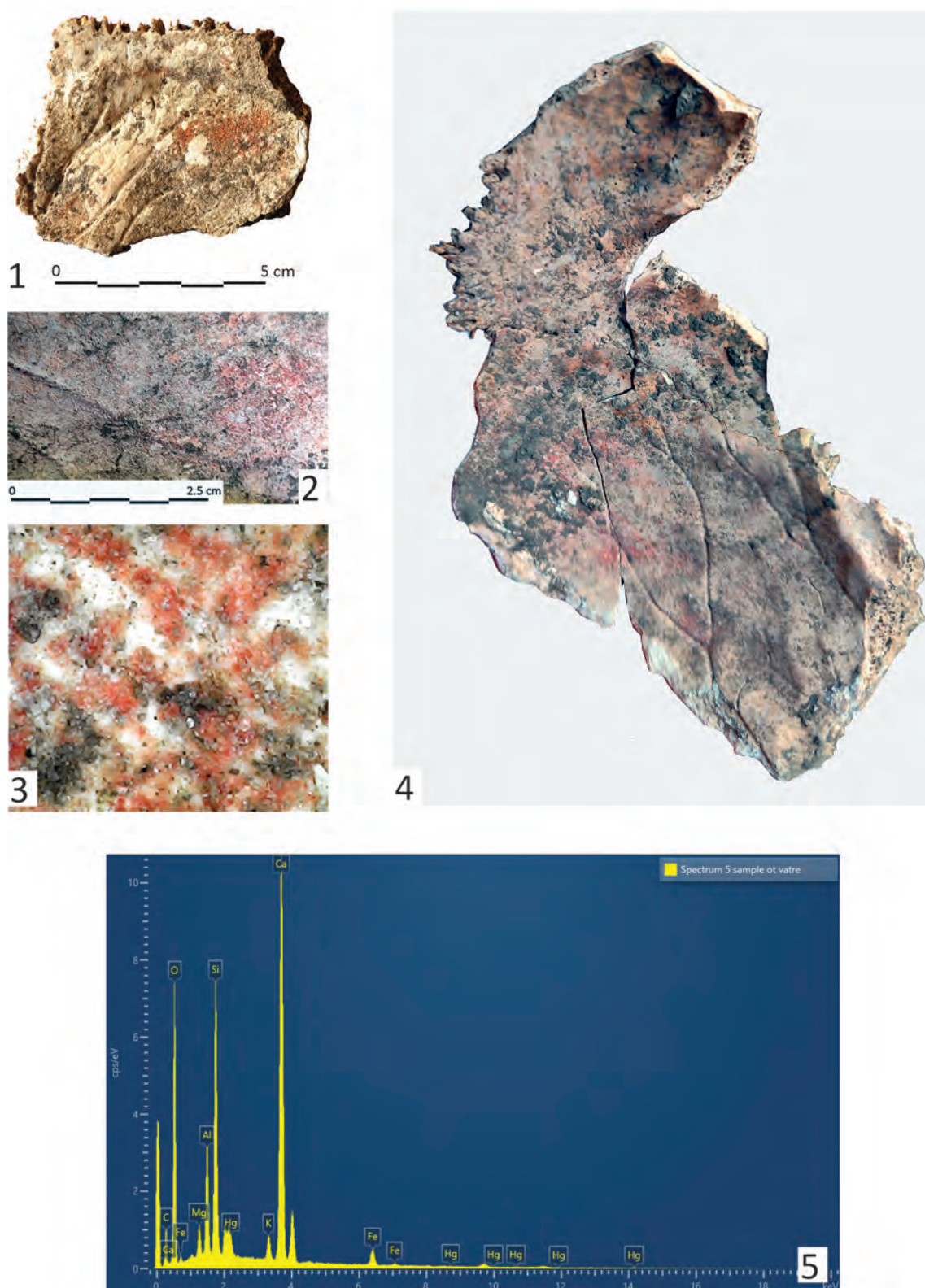


Figure 14. Kriva Bara barrow, feature no. 5, red pigments on the endocranial parts of the skull. **1, 4.** Photo (credit Stefan Alexandrov; **2, 3.** Macro photo (credit Rositsa Manova); **5.** SEM/EDS image (JEOL 6390 and INCA Oxford).

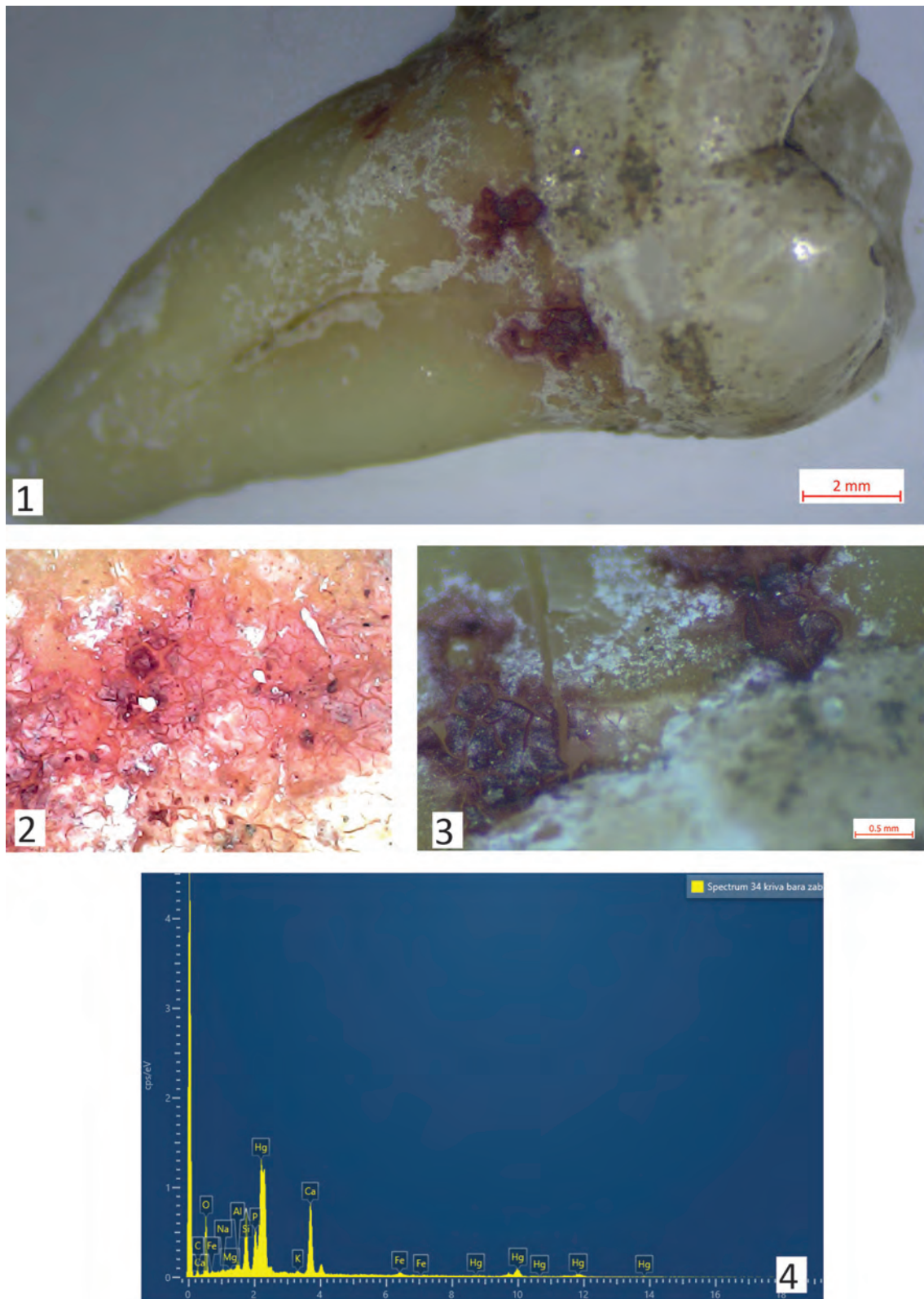


Figure 15. Kriva Bara barrow, feature no. 5, red pigments on the root of the right maxillary first premolar. **1, 3.** Optical microscopy; **2.** Macro photo (credit Rositsa Manova); **4.** SEM/EDS image (JEOL 6390 and INCA Oxford).

Result Type	Weight %			
Spectrum Label	Spectrum 33	Spectrum 34	Spectrum 36	Spectrum 37
C	9.96	10.38	10.68	12.69
O	23.29	29.82	29.44	22.51
Na	0.00	0.34	0.26	0.19
Mg	0.24	0.07	0.23	0.10
Al	0.63	1.03	1.37	0.99
Si	1.32	5.21	1.98	0.89
P	5.68	3.10	2.34	3.54
K	0.13	0.49	0.88	0.04
Ca	38.14	13.49	31.95	14.94
Fe	0.47	0.86	8.99	0.30
Hg	20.13	35.21	11.89	43.80
Total	100.00	100.00	100.00	100.00

Result Type	Atomic %			
Spectrum Label	Spectrum 33	Spectrum 34	Spectrum 36	Spectrum 37
C	22.96	23.94	22.30	32.44
O	40.30	51.64	46.16	43.21
Na	0.00	0.41	0.28	0.25
Mg	0.27	0.08	0.24	0.13
Al	0.64	1.06	1.27	1.12
Si	1.30	5.14	1.77	0.98
P	5.08	2.77	1.89	3.51
K	0.09	0.35	0.56	0.03
Ca	26.34	9.32	19.99	11.45
Fe	0.23	0.42	4.04	0.17
Hg	2.78	4.86	1.49	6.71
Total	100.00	100.00	100.00	100.00

Table 6. Kriva Bara, feature 5. SEM/EDS analyses of the red pigment at the right maxillary first premolar.

Feature no. 7

• *The lump of red pigment*

– *SEM analyses* (Fig. 17/6; Table 7): the elemental composition includes calcium (Ca), potassium (K), magnesium (Mg) which are components of hydroxyapatite. Iron (Fe), silicon (Si), and aluminium (Al) could be related to hematite. The presence of mercury (Hg) in all spectra is to be mentioned as well, probably, indicating a mixture of hematite and cinnabar.

– *RAMAN analyses* (Fig. 17/5). The peaks at 214 cm^{-1} and 279 cm^{-1} should be related to lattice vibrations in the soil and correspond to a band of hematite (Fe_2O_3)

with 88.8% content. The peak at 267 cm^{-1} is, most likely, due to the presence of cinnabar (HgS), as it is known that, depending on the concentration, its peak can shift by 10 cm^{-1} in different types of samples¹¹. Therefore, we may conclude that the pigment is composed of hematite mixed with a very low amount of cinnabar.

The results of the archaeometric analyses presented above point towards a mixture of hematite and cinnabar used in the mortuary practices: a) as a lump, placed near

¹¹ Scheuermann *et alii* 1969.

Result Type	Weight %						
Spectrum Label	Spectrum 1	Spectrum 2	Spectrum 8	Spectrum 22	Spectrum 28	Spectrum 30	Spectrum 31
C	13.63	8.19	6.65	17.53	10.71	17.73	18.45
O	36.25	30.86	36.18	37.38	51.25	61.97	45.75
Mg	1.70	1.23	1.41	1.20	2.00	2.14	4.98
Al	4.48	3.36	3.15	3.95	10.35	4.97	8.56
Si	8.30	5.97	8.20	7.72	15.74	7.85	16.60
S	0.10	0.16	0.03	0.03	0.22	0.56	0.04
K	0.87	0.71	0.31	0.64	3.91	0.89	1.27
Ca	0.51	5.11	0.38	0.75	2.06	2.45	0.83
Fe	34.02	43.95	43.43	30.56	3.41	0.99	3.26
Hg	0.14	0.46	0.23	0.24	0.36	0.45	0.26
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Result Type	Atomic %						
Spectrum Label	Spectrum 1	Spectrum 2	Spectrum 8	Spectrum 22	Spectrum 28	Spectrum 30	Spectrum 31
C	24.77	17.31	13.58	30.08	16.69	24.51	27.32
O	49.47	48.98	55.43	48.16	59.97	64.32	50.85
Mg	1.52	1.29	1.43	1.02	1.54	1.46	3.64
Al	3.62	3.16	2.86	3.02	7.18	3.06	5.64
Si	6.45	5.40	7.16	5.67	10.49	4.64	10.51
S	0.07	0.13	0.02	0.02	0.13	0.29	0.02
K	0.49	0.46	0.20	0.34	1.87	0.38	0.58
Ca	0.28	3.24	0.23	0.38	0.96	1.01	0.37
Fe	13.30	19.98	19.06	11.28	1.14	0.29	1.04
Hg	0.02	0.06	0.03	0.02	0.03	0.04	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 7. Kriva Bara, feature 7. SEM/EDS analyses of the red pigment near the shoulder.

the shoulder of the child from feature no. 7; b) applied on the body: lower leg (as suggested by the tibia in feature no. 4) and head (as suggested by the skull in feature no. 5); c) applied on the side of the head (as indicated by the endocranial part of the parietal bone of the skull in feature no. 5). The absorption of the red pigments into the long bones of the individual from feature no. 4 may suggest possible exposure or its digestion. The latter hypothesis is to be presumed for the individual from feature no. 5 as well, based on the presence of the pigment on the roots of its teeth.

Our investigation focused on the elemental compositions of the red pigments, their raw material source remaining a goal for future investigations. However, considering the location of Kriva Bara and the presence of cinnabar, it is noteworthy to mention that the nearest deposits are in “Lukina Padina” locality near Chiprovtsi, ca 70 km

southwest from the barrow¹². Other cinnabar-rich areas in Bulgaria are concentrated in its south-western part (Tran and Kyustendil regions and Southern Rila mountain), the Eastern Rhodopes, Sakar and Strandja mountains¹³.

CINNABAR IN PREHISTORIC EUROPE

Kriva Bara results presented above are the first clearly documented evidence for the use of cinnabar in the EBA mortuary practices in the Balkans. So far, the earliest known use of cinnabar comes from the Near East and Anatolia. The information was summarized by Elisabetta Gliozzo: cinnabar was used as a pigment in mortuary practices (applied on the body/burial masks) or on the

¹² Abramson *et alii* 1991, p. 47–49, fig. 1.

¹³ Vitov, Marinova 2007.

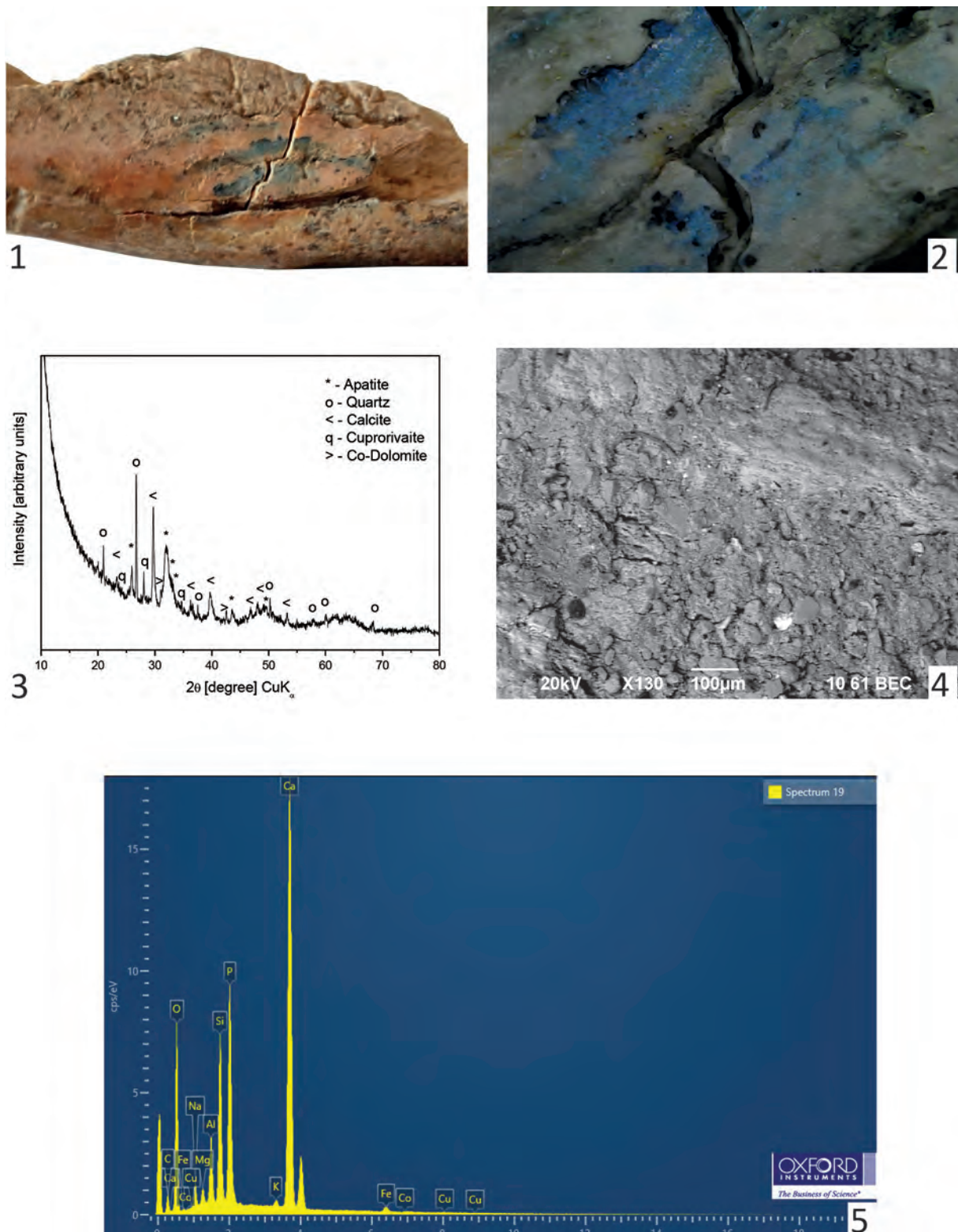


Figure 16. Kriva Bara barrow, feature no. 5, blue pigments on left mandible (after Manova et alii 2026). **1.** Photo (credit Stefan Alexandrov); **2.** Macro photo (credit Rositsa Manova); **3.** Mineral composition **4.** Surface morphology – secondary electron image (JEOL 6390 and INCA Oxford); **5.** SEM/EDS image (JEOL 6390 and INCA Oxford).

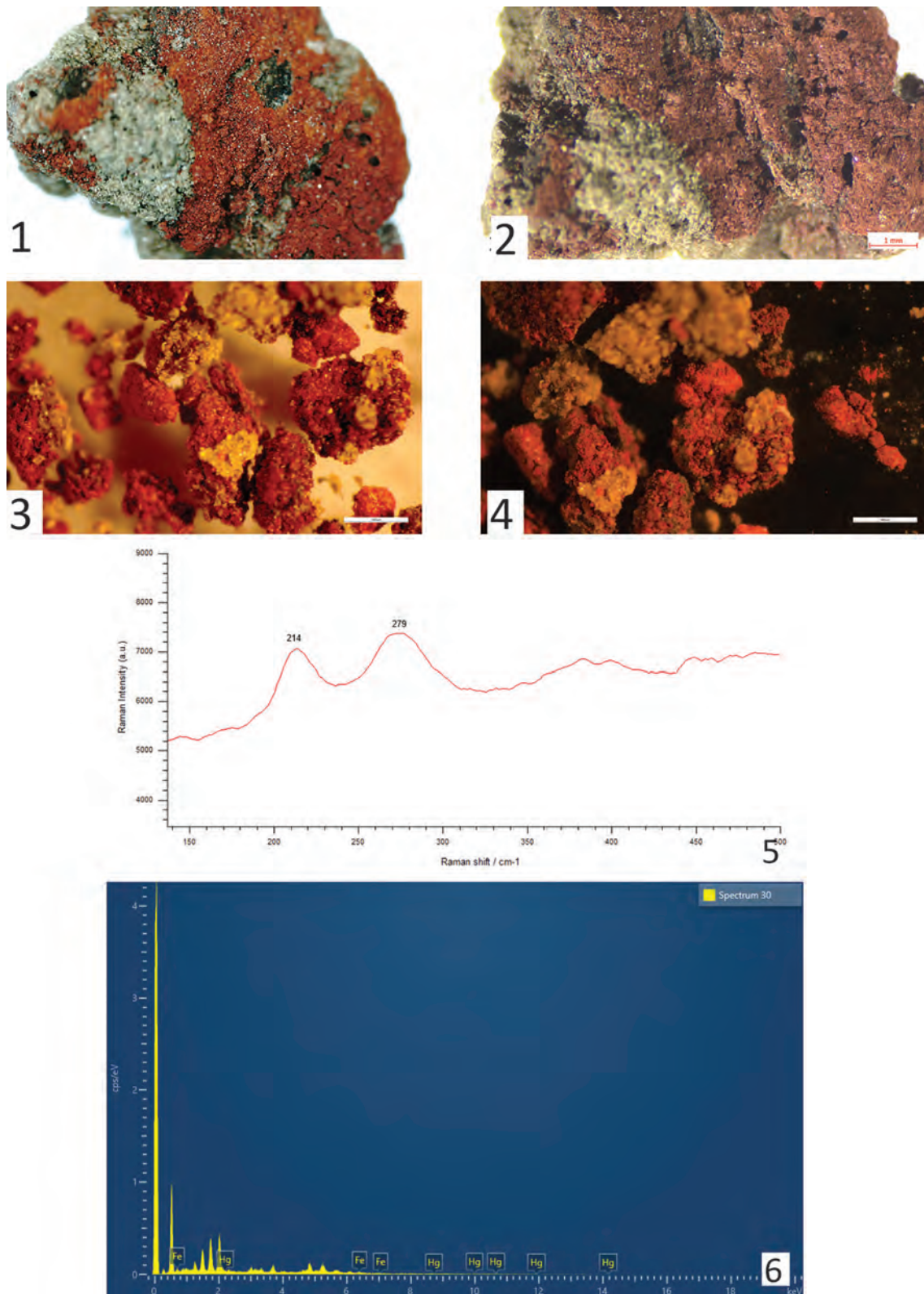


Figure 17. Kriva Bara barrow, feature no. 7, red pigments left of the shoulder. **1–4.** Optical microscopy (JEOL 6390 and INCA Oxford); **5.** Raman image (inVia Qontor Microscope); **6.** SEM/EDS image (JEOL 6390 and INCA Oxford).

walls of dwellings during the 9th millennium BC in Israel (Kfar HaHoresh site) and the 8th–7th millennia BC in Syria (Tell Abu Hureyra) and Turkey (Çatal Hüyük)¹⁴.

In Europe, the earliest use of cinnabar is attested in the west Mediterranean area. In Italy, it appears in settlement contexts in the mid-6th millennium BC at La Marmotta (Lazio region)¹⁵. It is well known in the Iberian Peninsula from the second half of the 6th millennium BC, in various contexts¹⁶. Its presence in megalithic monuments is attested in the 5th millennium BC in Spain: on bones, the floor and walls of the burial chambers in the dolmens near Alberite, Cueva de los Murciélagos, Gavá mine, the menhir of Casas de Don Pedro etc¹⁷. Cinnabar was used as a pigment, mainly for painting figurines, in the Central Balkan Vinča culture between the end of the 6th and the first half of the 5th millennium BC¹⁸. Occasional use in pottery decoration was documented in Tuscany (Italy) and Dalmatia (Croatia) in the 5th millennium BC, as well¹⁹. During the first half of the 4th millennium BC, it is reported at the Velilla dolmen (Osorno, Palencia) as well as at some monuments in southern Portugal, such as Anta Grande do Zambujeiro²⁰. Further east, cinnabar was used as a dye covering the engraved decoration and edges of the anthropomorphic *stelae* from Bastidonne, Beaucet and Gargas, in Provence (south-east France), dated to the 3900–3600 BC period²¹.

During the EBA period (second half of the 4th–3rd millennium BC), two areas document the use of cinnabar in mortuary practices – Southwest Europe and the Black Sea region. Its use in the former area is attested in large quantities in megalithic structures, where it was applied on the body and clothes of the deceased, on the grave goods, or on the walls of the burial chambers. In the circular dolmen of La Velilla – counting over 100 burials and dated to the second half of the 4th millennium BC, it covered the bodies of the deceased; a large amount of cinnabar, estimated at “...several hundreds of kilograms” was recovered during the excavation. “Pure” cinnabar was found on the floor and the grave goods in Chan de Armada, El Redondil and other dolmens in the region. Cinnabar mixed with red ochre was applied on the walls of some of the grave chambers, as well²².

Probably the most expressive example of the use of cinnabar in the Iberian Peninsula during the EBA is the Valencina mega-site (south-west Spain). This spectacular monument described as “...the largest Iberian settlement” from that period is dated to 2900–2650 calBC. There, in the “Montelirio” tholos and tomb for example, cinnabar was attested on human remains and grave goods (including clay figurines), on the floor, as well as on the inner walls of the

chamber²³. Undisputed remains of cinnabar have also been found in Bell-Beaker and Bronze Age burials dating to the late 3rd and early 2nd millennium BC²⁴. Several ore deposits were mined including the famous Almadén ones²⁵.

The earliest use of cinnabar in Bronze Age mortuary practices in the Black Sea region (the last quarter of the 4th–beginning of the 3rd millennium BC) is attested in Novosvobodnaya variant of the Maykop culture (north Caucasus). There, cinnabar was utilized in three different ways: applied on the body of the deceased; on the inner walls/floor of the burial chambers or on the clothes of the deceased. The cinnabar was used there both individually or mixed with red ochre²⁶.

Cinnabar applied on the body was found in four Maykop graves. The first one is the eponymous kurgan (Oshad). The main grave complex there yielded three individuals lying in supine position with flexed legs. Y. Piotrovsky states that “...skeleton no. 1, as well as the area around it, was covered with a layer of red paint – cinnabar”, “...skeletons nos. 2 and 3 were covered with red paint (cinnabar), but to a lesser extent than skeleton no. 1”²⁷. According to V. Trifonov, the body of the deceased was first painted with red ochre; the cinnabar being sprinkled on the body and the grave goods after their arrangement on the floor of the burial chamber²⁸. The bones of the deceased in the two graves from Novosvobodnaya (formerly Tsarskaya) barrows nos. 1 and 2 excavated by N. Veselovsky in 1898, were also painted with cinnabar; they were dated to 3300–3000 BC and 3350–2700 BC (95% probability) respectively²⁹. To this moment, the last Maykop feature that revealed the presence of cinnabar on bones is Marinskaya 3, barrow 1, grave 18 (male, 40–44 years old) dated 3430–3330 BC. The head of the buried individual was painted with bright red pigment; found also on the elbows, as thin strips 3–5 mm wide on the knees and spots on the feet bones. The analyses of the pigment from the skull showed that “...the os frontale of the “Maikop chief” was painted with unadulterated cinnabar”³⁰.

The inner walls and floors of the Maykop burial chambers were painted with red pigments as well. In the primary grave (no. 4) from Novosvobodnaya, barrow no. 1 (excavations 2017–2018) cinnabar was found on the floor, as well as on a flint arrowhead. The grave dates to 3350–3100 calBC³¹. The rear wall of the tomb in barrow no. 11 from the same necropolis displayed a 40 cm wide red band of cinnabar, and the remaining three walls – with red ochre³². In two cases, clothes used in the ritual were also painted with cinnabar. A fragment of a “fur coat” made of

¹⁴ Gliozzo 2021; Schotsmans *et alii* 2022.

¹⁵ Pannocchia *et alii* 2024.

¹⁶ Domingo *et alii* 2012; Gliozzo 2021.

¹⁷ Prieto *et alii* 2020, p. 19.

¹⁸ Gajić-Kvaščev *et alii* 2012.

¹⁹ Grifoni 2001, p. 428; Kaiser, Forenbaher 2016, p. 148–150.

²⁰ Gleba *et alii* 2021.

²¹ D’Anna *et alii* 2015; Masson 2020.

²² Rodríguez *et alii* 2020 ; Prieto *et alii* 2020, p. 19; Gleba *et alii* 2021.

²³ García Sanjuán *et alii* 2024.

²⁴ Lettow-Vorbeck 2016.

²⁵ Hunt *et alii* 2011.

²⁶ Trifonov *et alii* 2017, p. 1043.

²⁷ Piotrovsky 2020, p. 65, 68, fig. 3.

²⁸ Trifonov *et alii* 2015, p. 46.

²⁹ Trifonov *et alii* 2014, p. 511; Trifonov *et alii* 2017, p. 1043.

³⁰ Mednikova 2013, fig. VII; Mednikova 2015, p. 52, fig. 1.

³¹ Trifonov *et alii* 2019.

³² Trifonov *et alii* 2014, p. 511.

squirrel hide with “...fibres dyed bright carmine-red”, was found in the grave from barrow no. 2 near Novosvobodnaya (formerly Tsarskaya) excavated by N. Veselovsky in 1898. The pigment was defined as “...true cinnabar i.e. mercury sulphide”.³³ A radiocarbon date on the fur place it between 3335 and 2932 calBC³⁴. During 1979–1980 excavations of the barrow no. 31 from the same necropolis, in grave no. 5 was found a fragment of cloth preserved on the exterior part of a bronze dish. A red, mercury-based pigment (montroydite) was used to colour the cloth by “...painting or sprinkling technique”³⁵. Recent investigations proved that the raw material had a local origin – near Krasnodar in the Maykop area³⁶.

Further north, cinnabar was found in the pre-Yamna grave no. 3 from barrow 3, near Prydnistrianske, Podillia Region (Ukraine). A small lump had been placed alongside rich grave goods in an infant(?) burial dated between 3363 and 3041 calBC³⁷. Three more barrow graves from the same region – Porohy, barrow 3A, graves no. 7 (*adultus/maturus*, male?), no. 11 (25–30 years old, male), and no. 12 (*adultus*, female) yielded cinnabar, as well. All the samples analysed – small lumps, were retrieved from the floors of the grave pits. The SEM results showed very high values of mercury (Hg) in graves nos. 7 and 11 – between 50% and 60% (atomic weight). The three graves were dated to the Late Yamna period, between 2900 and 2450 calBC³⁸. To our knowledge, the latest use of cinnabar during the EBA in the North Black Sea region dates to the second half of the 3rd millennium BC, observed in barrow 7 near Zamozhne (Ingul culture, southern Ukraine) where the clay mask on the skull of the deceased was decorated with a pigment composed of a mixture of hematite and cinnabar³⁹.

Outside the two regions discussed, cinnabar was used for the decoration of marble female figurines in the late EB I period in the southern Cyclades⁴⁰.

DISCUSSION

As mentioned above, the Kriva Bara results are the first documented evidence for the use of cinnabar in EBA Balkans, between 2900–2500 calBC, a period that corresponds to the “Late Yamna” chronological horizon. However, Kriva Bara is not the only site that provided data for the use of cinnabar in the EBA mortuary practices. As mentioned above, similar data came from the Drazovo grave (Thrace). In addition, SEM analyses of the red pigment from the pit-floor in Mednikarovo, barrow 6, grave 3 (Thrace) also revealed very small amounts of mercury (Hg)⁴¹. Recent

EDS analyses of the red pigments on long bones from graves nos. 3 and 9 in barrow 4, Vetrino – Necropolis 3 (north-eastern Bulgaria) presented mercury (Hg) particles as well⁴². Although indirect, these data could be regarded as “evidence” for the potential use of cinnabar in these graves that also date to the “Late Yamna” chronological horizon, characterised by a change in burial customs and pigment use. As already discussed, this period introduces the practice of mixing different pigments such as hematite and cinnabar. This innovation, documented also in Ukraine and Moldova, suggests advanced technological efforts and supports the idea of increased interactions between the late Yamna populations and the local communities, resulting in a “...cultural exchange and resource-sharing practices”. The analytical results from Kriva Bara emphasize that the choice of pigments was not only a technical matter but also a cultural and economic one. The circulation of high-value pigments like cinnabar suggests that “...their role in exchange networks, and their symbolic importance is reflected in the meticulous selection and preparation of materials”⁴³.

The red pigment found on the endocranial part of the skull of the male individual from feature 5 is direct evidence for the dismemberment of the body, considering that applying pigments to the inner part of the skull is impossible without separating it from the body. A similar ritual is documented also in feature no. 6 from barrow 20, Vetrino – Necropolis 1 (3100–2900 calBC) where the inner face of the parietal bones of the skull of a child (age group *Infans I*) was coated with calcium carbonate (CaCO₃)⁴⁴. Another example comes from the Maykop culture, Chekon-2 site (3300–3100 calBC) where the inner surface of the frontal and all the inner elements of the parietal bones of an adult male were painted with cinnabar⁴⁵. The dismemberment of the body (also known as “*demembration*”) is a common practice for the EBA Yamna communities and is also attested in other regions during Bronze Age Europe, as well⁴⁶.

Considering the accumulation of mercury (Hg) in the cancellous long bones of the individual from feature no. 4, some conclusions could also be drawn. The analytical results presented above suggest an exposure to cinnabar. Generally, three possible ways of such exposure have been discussed: environmental pollution; pre-mortem use and manipulation of mercury and associated compounds (cinnabar), and post-mortem diagenetic processes⁴⁷. The analyses on mercury exposure of 70 individuals from the EBA Valencina site showed that most of the high mercury values (>10 µg/g) were recorded in the *humeri*, followed by the *femora* and *tibiae*. According to the authors, the

³³ Trifonov *et alii* 2015.

³⁴ Trifonov *et alii* 2018, p. 119.

³⁵ Shishlina *et alii* 2003, p. 337.

³⁶ Trifonov *et alii* 2017, p. 44.

³⁷ Klochko *et alii* 2015b, p. 207–213; Alexandrov *et alii* 2026.

³⁸ Klochko *et alii* 2015a, p. 78–141; Alexandrov *et alii* 2026.

³⁹ Mednikova 2015, p. 53, fig. 2.

⁴⁰ Carter 2008, with references to Higgins 1972 and Hendrix 1998.

⁴¹ Alexandrov *et alii* 2026.

⁴² Unpublished data from rescue excavations in 2024 directed by Stefan Alexandrov.

⁴³ Alexandrov *et alii* 2026.

⁴⁴ Manova *et alii* 2025.

⁴⁵ Korenevsky *et alii* 2015, p. 35–38.

⁴⁶ Manova *et alii* 2025, with references.

⁴⁷ García Sanjuán *et alii* 2024.

“...accumulation of mercury in long bones would directly disprove the diagenetic contamination hypothesis, as the post-mortem incorporation of Hg from the cinnabar sprayed in the tombs would not ‘select’ which bones to accumulate in”⁴⁸. Such conclusion can be applied to the Kriva Bara individual, as well. We can also exclude the environmental pollution since three of the individuals from Kriva Bara (feature nos. 3, 6, and 8) showed no traces of pigments at all. Thus, the pre-mortem use of cinnabar for the discussed individual seems quite possible. The hypothesis is supported by the presence of cinnabar at the dental roots of the individual from feature no. 5, suggesting the digestion of a mixture of hematite and cinnabar. Thus, we think that the two male individuals from Kriva Bara (features nos. 4 and 5) were probably either involved in the production of cinnabar or they digested it directly and, thus, according to some authors, they could have been “...part of a small group of religious specialists and elite members who perhaps inhaled or consumed cinnabar as part of their lifestyle”⁴⁹.

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⁴⁸ García Sanjuán *et alii* 2024.

⁴⁹ García Sanjuán *et alii* 2024, p. 1050.

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ABREVIERI / ABRÉVIATIONS / ABBREVIATIONS

- AAC – Acta Archaeologica Carpatica, Kraków
ACMI – Anuarul Comisiunii Monumentelor Istorice, București
ActaArchHung – Acta Archaeologica Academiae Scientiarum Hungaricae, Budapest
Acta Classica Univ. Scient. Debrecen – Acta Classica Universitatis Scientiarum Debreceniensis, Debrecen, Ungaria
ActaMN – Acta Musei Napocensis, Cluj
ActaMP – Acta Musei Porolissensis, Zalău
ActaPraehistA – Acta praehistorica et archaeologica
AIGR - Anuarul Institutului Geologic al României, București
AIIAC – Anuarul Institutului de Istorie „George Barițiu”, Cluj
AJA – American Journal of Archaeology, Boston
AJPA – American Journal of Physical Anthropology
Alba Regia – Alba Regia. Annales Musei Stephani regis, Székesfehérvár
Anatolia Antiqua – Anatolia Antiqua. Revue internationale d'archéologie anatolienne. Institut Français d'Etudes anatoliennes d'Istanbul
Anatolica – Anatolica. The Netherlands Institute for the Near East in Leiden
AnB – Analele Banatului, Muzeul Banatului, Timișoara
AncNearEastSt – Ancient Near Eastern Studies, Leuven, Belgia
Angustia – Angustia. Arheologie, Etnografie, Sfântu Gheorghe
Anmed – Anmed. Anadolu Akdenizi Arkeoloji Haberleri, Antalya, Turcia
AnSt – Anatolian Studies. British Institute of Ankara
AnUCraiova – Analele Universității din Craiova, Craiova (seria Istorie)
AnUVT – Annales d'Université “Valahia” Târgoviște, Section d'Archéologie et d'Histoire
Apulum – Acta Musei Apulensis. Muzeul Național al Unirii, Alba Iulia
ArchBulg – Archaeologia Bulgarica, Sofia
ArchÉrt – Archaeológiai Értesítő, Budapest
ArchHung – Archaeologia Hungarica, Acta Archaeologica Musei Nationalis Hungarici, Budapest
ArchKorr – Archäologisches Korrespondenzblatt, Mainz
ArchMűh – Archeometriai Műhely
ArchRozhledy – Archeologické Rozhledy, Praha
Argesis – Argesis. Muzeul Județean Argeș. Pitești
Arheologia Medievală. Complexul Muzeal Bistrița-Năsăud, Bistrița
ArheologijaSSSR – Arheologija SSSR. Svod Archeologičeskikh Istočnikov, Moscova
Arheološki vestnik – The Research Center of the Slovenian Academy of Sciences and Arts
ArhMold – Arheologia Moldovei, Iași
AS – Archeologica Slovaca, Bratislava
AST – Eski Eserler ve Müzeler Genel Müdürlüğü, I. Araştırma Sonuçları Toplantısı, Istanbul / General Directorate of Ancient Monuments and Museums
AȘUI – Analele științifice ale Universității Alexandru Ioan Cuza, Iași
BA – Biblioteca de Arheologie, București
BaBesch – Bulletin antieke beschaving. Annual Papers on Classical Archaeology
BAI – Bibliotheca Archaeologica lassiensis, Iași
Baltic-Pontic Studies – Adam Mickiewicz University, Poznań, Institute of Archaeology, Institute of Eastern Studies, Poland
Banatica – Banatica. Muzeul Banatului Montan, Reșița
BarBrSer – British Archaeological Reports. British Series, Oxford
BARIntSer – British Archaeological Reports. International Series, Oxford
BCMI – Buletinul Comisiunii Monumentelor Istorice
Be-Ja – Bulgarian e-Journal of Archaeology
BerRGK – Bericht der Römisch-Germanischen Kommission des Deutschen Archäologischen Instituts, Frankfurt am Main
BIAA Monograph – British Institute of Archaeology at Ankara
BiblEphemNap – Bibliotheca Ephemeris Napocensis, Cluj-Napoca
BiblMemAnt – Bibliotheca Memoriae Antiquitatis, Piatra-Neamț
BiblThrac – Bibliotheca Thracologica, București

- BMC – *Coins of the Roman Empire in the British Museum*, Londra; II, *Vespasian to Domitian*, 1930; IV, *Antoninus Pius to Commodus*, 1968; V, *Pertinax to Elagabalus*, 1950 (H. Mattingly)
- BMI – Buletinul Monumentelor Istorice, București
- BMJT – Buletinul Muzeului Județean Teleorman, Alexandria
- BMTAG – Buletinul Muzeului Județean „Teohari Antonescu”, Giurgiu
- BSA – British School at Athens, Athens
- BSNR – Buletinul Societății Numismatice Române, București
- BSPF – Bulletin de la Société Préhistorique Française, Paris
- BSSC – Buletinul Societății de Științe din Cluj
- București-MIM – București. Materiale de Istorie și Muzeografie. Muzeul Municipiului București
- BYZAS – German Archaeological Institute of Istanbul
- CA – Cercetări Arheologice. Muzeul Național de Istorie a României, București
- CAB – Cercetări arheologice în București. Muzeul Municipiului București
- Caiete ARA – Caietele ARA, Revistă de Arhitectură. Restaurare și Arheologie, Asociația ARA, București
- Carpica – Carpica. Complexul Muzeal „Iulian Antonescu” Bacău, Bacău
- CCA – Cronica Cercetărilor Arheologice din România, București
- CCDJ – Cultură și Civilizație la Dunărea de Jos, Călărași
- Cerclst – Cercetări Istorice, Muzeul de Istorie a Moldovei, Iași
- CN – Cercetări numismatice, București
- CollAn – Colloquium Anatolicum. Anadolu Sohbetleri, Institutum Turcicum Scientiae Antiquitatis, Istanbul
- Crisia – Crisia. Muzeul Țării Crișurilor, Oradea
- Cuadernos del Museo Geominero – Museo Geominero, Instituto Geológico y Minero de España, Madrid
- Current Anthropology – Current Anthropology. University of California, Merced
- Dacia – Dacia (Nouvelle Série). Revue d'archéologie et d'histoire ancienne. Académie Roumaine. Institut d'archéologie « V. Pârvan », Bucarest
- Danubius – Danubius, Revista Muzeului de Istorie Galați
- Documenta Praehistorica – Documenta Praehistorica, University of Ljubljana, Faculty of Arts, Department of Archaeology, Ljubljana
- DolgCluj – Dolgozatok az Erdélyi Nemzeti Múzeum Érem- és Régisígtárából, Kolozsvár
- DTKFD – Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi
- EJA – European Journal of Archaeology
- ERAUL – Études et Recherches archéologiques de l'Université de Liège
- ÉtAlex – Études Alexandrines, Centre d'Études Alexandrines
- ÉtTrav – Etudes et travaux. Studia i prace. Travaux du Centre d'archéologie méditerranéenne de l'Académie Polonaise des Sciences
- EurAnt – Eurasia Antiqua. Deutsche Archäologisches Institut, Berlin
- FrC – Fragmenta Comica
- FolArch – Folia Archaeologica. A Magyar Nemzeti Múzeum Évkönyve. Annales Musei Nationalis Hungarici, Budapest
- FSI – Forensic Science International
- Germania – Germania. Anzeiger der Römisch-Germanischen Kommission des Deutschen Archäologischen Instituts, Frankfurt
- Geoarchaeology – Geoarchaeology. An International Journal
- Hesperia – Hesperia. Journal of the American School of Classical Studies at Athens, Cambridge
- HOMO – HOMO. Journal of Comparative Human Biology, Stuttgart
- Human Evolution – Human Evolution, International Institute for Humankind Studies and University of Florence
- Ialomița – Ialomița. Studii de cercetări de arheologie, istorie, etnografie și muzeologie, Slobozia
- IJO – International Journal of Osteoarchaeology
- Iran – Iran. Journal of the British Institute of Persian Studies
- IstMitt – Istanbul Mitteilungen, Istanbul
- Istros – Istros, Muzeul Brăilei, Brăila
- IzvestijaVarna – Izvestija na Archeologiceskii Institut, Sofia
- JAHA – Journal of Ancient History and Archaeology, Cluj-Napoca
- JAnat – Journal of Anatomy
- JAS – Journal of Archaeological Science
- JAS: Reports - Journal of Archaeological Sciences: Reports
- JDAI.AA – Jahrbuch des Deutschen Archäologischen Instituts, Archäologischer Anzeiger, Berlin
- JFS – Journal of Forensic Sciences

- JHE – Journal of Human Evolution
 JRA – Journal of Roman Archaeology
 JRGZM – Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz, Mainz
 JRS – The Journal of Roman Studies
 KST – T. C. Kültür Bakanlığı, Eski Eserler ve Müzeler Genel Müdürlüğü, I. Kazı Sonuçları Toplantısı, Ankara / Republic of Turkey, General Directorate of Ancient Monuments and Museums, Ankara, Turkey
 LIMC – Lexicon Iconographicum Mythologiae Classicae, Zürich, München, Düsseldorf
 Litua – Litua, Studii și cercetări, Târgu-Jiu
 LRBC – *Late Roman Bronze Coinage A.D. 394-498*, Londra, 1965: I, *The Bronze Coinage of the House of Constantine A.D. 324-346* (P. V. Hill, J. P. C. Kent); II, *Bronze Roman Imperial Coinage of the Later Empire A.D. 346-498* (R. A. G. Carson, J. P. C. Kent).
 Macedoniae Acta Archaeologica – Macedonian Archaeological Society, Skopje, Republic of Macedonia
 MAMA – Monumenta Asiae Minoris antiqua. Publications of the American Society for Archaeological Research in Asia Minor
 Marisia – Marisia. Studii și materiale. Arheologie – Istorie – Etnografie, Târgu Mureș
 Marmatia – Muzeul Județean de Istorie și Arheologie Maramureș, Baia Mare
 MarNero – Il Mar Nero. Annali di archeologia e storia
 MCA – Materiale și Cercetări Arheologice, București
 MDOG – Mitteilungen der Deutschen Orient Gesellschaft
 MemAnt – Memoria Antiquitatis, Piatra Neamț
 MFMÉ – A Móra Ferenc Múzeum Évkönyve, Szeged
 Mousaios – Mousaios. Buletinul Științific al Muzeului Județean Buzău
 MuzNaț – Muzeul Național, București
 NAC – Numismatica e Antichità Classiche, Lugano-Pregassona
 OIP – Oriental Institute Publications, University of Chicago
 OJA – Oxford Journal of Archaeology, Oxford
 Olba – Mersin University Publications of the Research Center of Cilician Archaeology, Mersin, Turkey
 PALMA – Papers on Archaeology of the Leiden Museum of Antiquities, Leiden, Olanda
 PAS – Prähistorische Archäologie in Südosteuropa, München-Berlin
 PBF – Prähistorische Bronzefunde, Münster
 Peuce – Peuce. Studii și cercetări de istorie și arheologie, Institutul de Cercetări Eco-Muzeale, Tulcea
 Phoenix – Phoenix. The Journal of the Classical Association of Canada
 Plural – Journal of the History and Geography Department „Ion Creangă” Pedagogical State University, History, Culture. Society. Seria Archaeologica II, Chișinău
 PMMB – Publicațiile Muzeului Municipiului București
 Pontica – Pontica. Studii și materiale de istorie, arheologie și muzeografie, Muzeul de Istorie Națională și Arheologie Constanța
 PZ – Prähistorische Zeitschrift, Berlin-Mainz
 Quaternary International – Quaternary International. The Journal of the International Union for Quaternary Research
 Quaternary Science Reviews – Quaternary Science Reviews. The International Multidisciplinary Research and Review Journal
 RA – Revue Archéologique, Paris
 RAASI – Revista de Arheologie, Antropologie și Studii Interdisciplinare, Institutul de Cercetări Bioarheologice și Etnoculturale, Republica Moldova
 Radiocarbon – An International Journal of Cosmogenic Isotope Research, Cambridge
 RCAN – Revista de Cercetări Arheologice și Numismatice, Muzeul Municipiului București
 RevBistr – Revista Bistriței. Complexul Muzeal Bistrița-Năsăud, Bistrița
 RevMuz – Revista Muzeelor, București
 RGZM – Römisch-Germanisches Zentralmuseums Mainz, Mainz
 RIC – *The Roman Imperial Coinage*, Londra: I², *From 31 BC to AD 69*, 1984 (C. H. V. Sutherland); II, *Vespasian to Hadrian*, 1926 (H. Mattingly, E. A. Sydenham); II.1, *From AD 69-96. Vespasian to Domitian*, 2007 (I. A. Carradice, T.V. Buttrey); II.3, *From AD 117-138. Hadrian*, 2019 (R. A. Abdy, P. F. Mittag); III, *Antoninus Pius to Commodus*, 1930; IV.1, *Pertinax to Geta*, 1968 (H. Mattingly, E. A. Sydenham); IV.2, *Macrinus to Pupienus*, 1938; IV.3, *Gordian III – Uranius Antoninus*, 1949 (H. Mattingly, E. A. Sydenham, C. H. V. Sutherland); V.1, 1927 (reimprimat 1968; P. H. Webb); VII, *Constantine and Licinius A.D. 313-337*, 1966 (P. M. Bruun); VIII, *The Family of Constantine I A.D. 337-364*, 1981; X, *The Divided Empire and the Fall of the Western Parts A.D. 395-491*, 1994 (J. P. C. Kent)
 SAA – Studia Antiqua et Archaeologica, Iași
 Sargetia – Sargetia. Acta Musei Devensis. Buletinul Muzeului județean Hunedoara, Deva

SAV – Študijné zvesti Archeologicky ústav SAV, Nitra
 Sci Rep – Scientific Reports
 SCIV(A) – Studii și Cercetări de Istorie Veche (și Arheologie), București
 SCN – Studii și Cercetări de Numismatică, București
 Seleucia – Seleucia. Olban Excavations Series
 SP – Studii de Preistorie, București
 SprawArch – Sprawozdania Archeologiczne, Warsaw
 SRMKA – Seramik Araştırmaları Dergisi, The Journal of Ceramic Research
 StArchBrno – Studia Archaeologica Brunensia, Masaryk University, Brno
 Starinar – Starinar. Arheološki institut Beograd
 StComPitești – Studii și Comunicări, Seria Istorie, Muzeul Județean Argeș, Pitești
 StudCom Satu Mare – Studii și comunicări Satu Mare
 Studia Praehistorica – National Archaeological Institute with Museum of the Bulgarian Academy of Sciences
 Syria – Syria. Archéologie, art et histoire. Institut Français du Proche-Orient
 Terra Sebus – Terra Sebus. Acta Musei Sabesiensis, Anuarul Muzeului Municipal „Ioan Raica”, Sebeș
 Th-D – Thraco-Dacica, București
 Thracia – Thracia, Sofia
 TIB – *Tabula Imperii Byzantini*, Wien
 Transylvanian Review – Transylvanian Review. Centrul de Studii Transilvane, Cluj-Napoca
 TÜBA-AR – TÜBA-AR Türkiye Bilimler Akademisi arkeoloji dergisi (TÜBA-AR Turkish Academy of Sciences Journal of Archeology)
 UPA – Universitätsforschungen zur Prähistorischen Archäologie, Bonn
 VAH – *Varia Archaeologica Hungarica* V. Redigit Csanád Bálint. Publicationes Instituti Archaeologici Academiae Scientiarum Hungaricae, Budapest
 Varia Anatolica – *Varia Anatolica*. L'Institut Français d'Études Anatoliennes, Istanbul
 Ziridava – Ziridava. Studia Archaeologica, Arad