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Pigmented supports in the upper Palaeolithic: Unravelling origins and intentionality on red-pigmented support at the Lagar Velho rock shelter (Portugal)

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ABSTRACT

The ochre, a natural pigment, has been a significant element in prehistoric cultures, particularly during the Palaeolithic, with various applications in artistic, ritual, and domestic contexts. This paper focuses on the red-pigmented support found at the Lagar Velho rock shelter (Portugal) and seeks to elucidate its origin, the processes behind its pigmentation, and its intentionality. The limestone support was found in proximity to the Lapedo child burial, dated to the Gravettian, prompting an investigation into its role and the nature of its pigmentation. Detailed analysis, including visual examination, digital image enhancement, microscopic observation, and Raman spectroscopy, revealed that the pigmentation primarily consists of haematite. The sequence of events leading to the pigmentation on the limestone support involves sediment accumulation, surface abrasion, and finally, the application of red colour. The "barcode"-like design on the support likely resulted from unintentional rubbing or contact with red pigment previously deposited in the shelter, potentially associated with the nearby burial. The analyses carried out on this finding suggest that the red colouration was not a result of deliberate artistic or symbolic behaviour but rather a passive process, either natural or anthropic, linked to the block's movement and its interaction with deposited red pigment.

In summary, the study underscores the importance of a comprehensive and well-grounded approach in examining pigmented supports in Palaeolithic contexts. It demonstrates that understanding the nature and origin of pigmentation involves not only analysing patterns but also considering the specific context and processes that led to its deposition. The examination of the Lagar Velho limestone support serves as an example of how taphonomic processes can influence the appearance of colouration in non-artistic contexts, challenging conventional interpretations of such finds in the European Upper Palaeolithic framework.

1. Introduction

Ochre, primarily composed of iron oxides, notably the mineral haematite, is a natural earth pigment normally reddish in colour with antiseptic properties and often combined with other organic compounds to create adhesives. This pigment was widely used throughout prehistory, particularly during the Palaeolithic, in artistic, ritual and domestic contexts that often occurred simultaneously across time and space (Charrié-Duhaut et al., 2013; Wolf et al., 2018). The utilization of ochre is highly versatile, with a broad spectrum of applications, including direct or indirect (grinded and pulverised) applications (Velliky et al., 2018). Its purposes is wide-ranging, from its use as a

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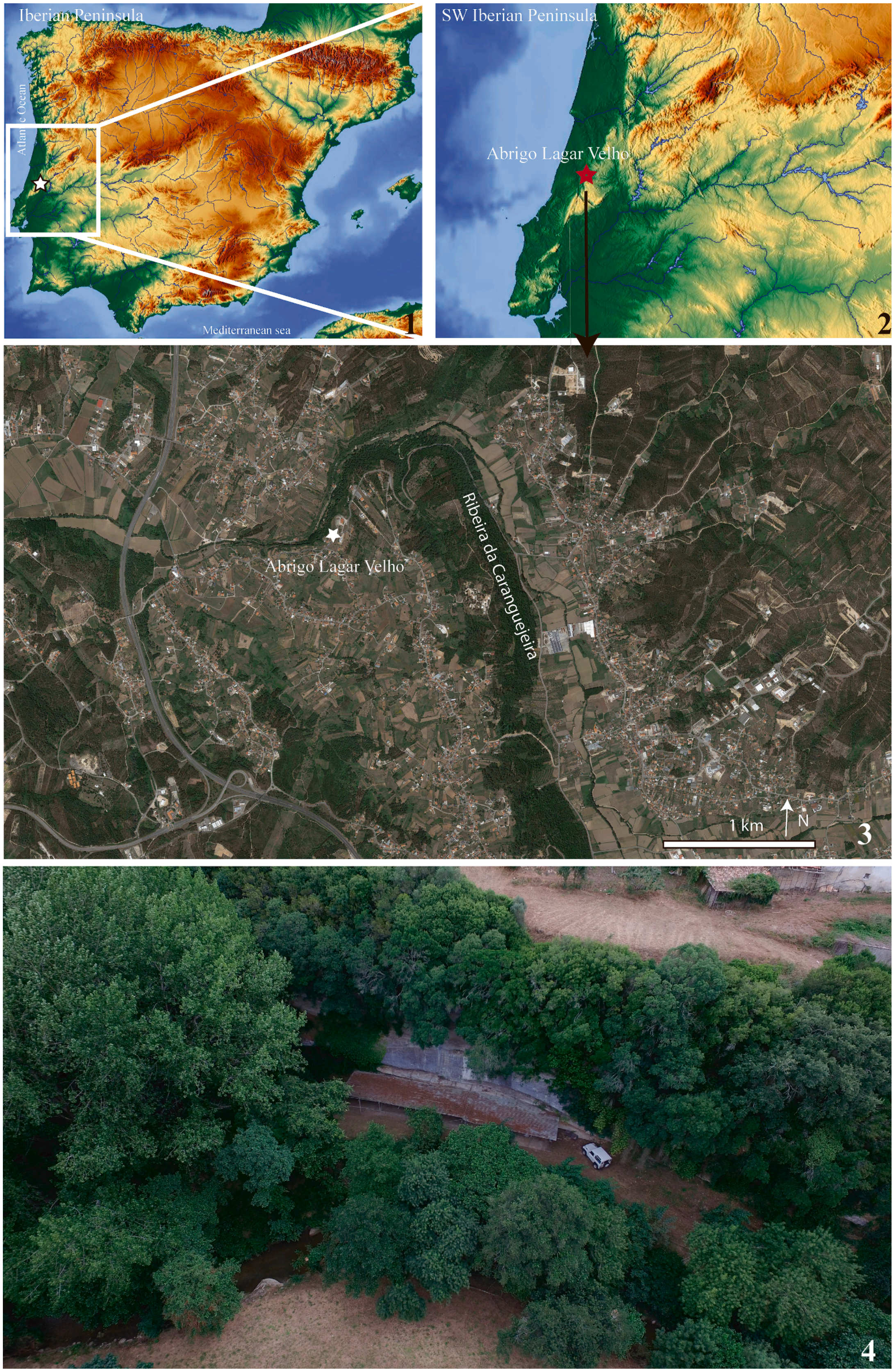

Fig. 1. Lagar Velho site. 1–2: Location of Lagar Velho rock shelter in the Portuguese Estremadura (Central Portugal). 3: The Lapedo valley and the location of the site. 4: Aerial view of the site. DEM model (1 and 2) extracted from OpenStreetMap (CC BY-SA). OpenStreetMap© licensed under ODdL 1.0 (https://www.openstreetmap.org/copyright) by the OpenStreetMap Foundation (OSMF). ©OpenStreetMap contributors (https://www.openstreetmap.org/). The license terms can be found at the following link: http://creativecommons.org/licenses/by-sa/2.0/ (accessed on 21 May 2022). Satellite image (3) is provided by SNIG (Infraestrutura Nacional de Informação Geográfica) and INSPIRE reuse is allowed (Creative Commons Attribution 4.0 International (CC BY 4.0) licence. 4. Drone photography by Pedro Souto.

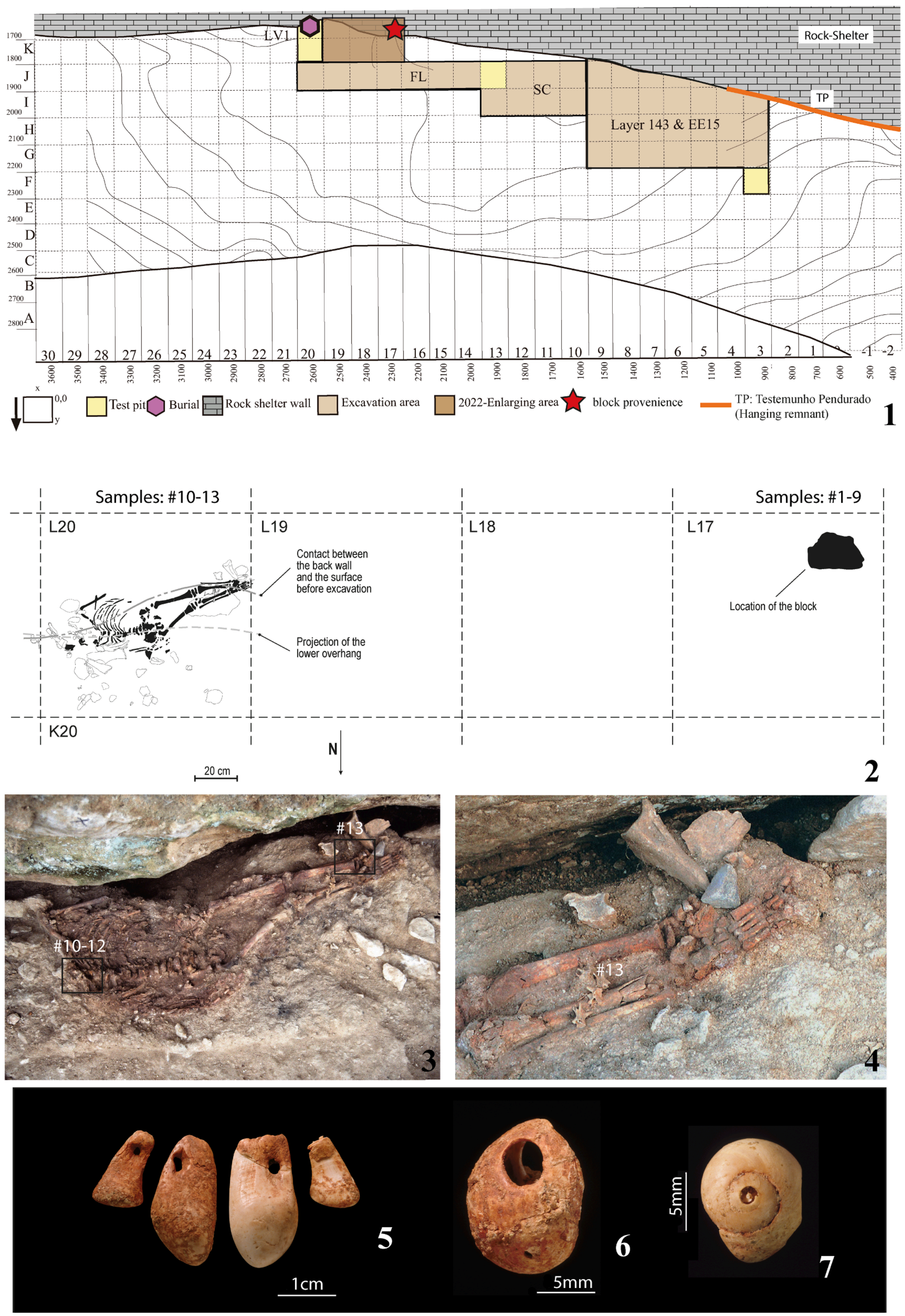

Fig. 2. Lagar Velho and LV1 burial. 1: Plan site signalling the LV1 burial and block analysed here. 2: Detailed plan site with exactly position of the burial and the block (based on plan site from Zilhão and Trinkaus (2002)). 3–4: LV1 burial and analysed samples (burial images from Duarte (2002)). 5–7: Personal ornaments associated with LV1: Reed deer canines (5) and *Littorina obstusata* shell (6–7) (images courtesy of José Paulo Ruas).

pigment in symbolic behaviour (Pike et al., 2012) and body ornamentation (Hoffmann et al., 2018), a practice dating back to the Middle Palaeolithic. The addition of ochre to gum appears to result in the formation of a less brittle product and acts as a desiccant, preventing the dissolution of gum under conditions of dampness (Lombard, 2007; Wadley, 2005; Wadley et al., 2009). Also, is used in a highly diverse set of tasks in funerary (Arenas del Amo et al., 2024; Straus et al., 2015) and domestic (Roper, 1992) contexts. Remarkably, its use as a red pigment in palaeolithic portable art, especially in plaquettes, is relatively rare in the Iberian Peninsula during this period. An exceptional example can be found in the thousands of decorated plaquettes recovered from Parpalló cave (Roldán García et al., 2016), which predominantly exhibit a clear decorative function. In addition, non-figurative use of ochre impregnations has been reported at other Palaeolithic sites (Cortés and Simón-Vallejo, 2008; González et al., 2003), suggesting a broader range of uses that nowadays are not easily definable. In such instances, archaeological and taphonomic analyses are essential for determining the origin and functionality of red pigment on such supports, and whether they resulted from intentional human actions (Fernández-Jalvo et al., 2013), mainly for graphic purposes.

Numerous archaeological sites across Europe have yielded red-ochred or supports adorned with ochre paint, revelling a wide range of activities and contexts (Chlachula and Serikov, 2022). This phenomenon transcends specific cultural or chronological horizon, manifesting as a recurring feature in diverse archaeological sites. For instance, red ochre has been a common feature in Azilian pebbles, as evident in the assemblage from Mas d'Azil Cave (Bahn and Couraud, 1984). Similarly, pebbles from Arena Candide (Gravel-Miguel et al., 2017) also exhibit evidence of ochre. The prevalence of red-ochred materials extends to other sites as well, such as Kostenski (Dinnis et al., 2018) where significant quantities of ochred fragments are documented. Hohle Fels cave (Velliky et al., 2018) presents a remarkable continuity of red-ochre presence across the stratigraphic sequence. Moreover, the application of red pigmentation goes beyond artifacts and extends to burials. Several examples are known across Europe (Arenas del Amo et al., 2024), usually associated with funerary context such as Sungir (Pettitt and Bader, 2000), Cueva del Mirón (Straus et al., 2015) or Lagar Velho (Zilhão and Trinkaus, 2002) among others.

Technological and taphonomic studies focused on artistic and graphic elements from prehistoric contexts have been particularly valuable in identifying its nature and defining functions and activities. For instance, it has played a significant role in discussions about the origins of symbolic behaviour (D'Errico and Villa, 1997; Rosso et al., 2017), especially in African contexts where researchers aim to pinpoint the earliest symbolic manifestations. Other studies have driven to discriminate between the agent (natural or anthropic) of linear grooves present in artefacts and other supports (Bednarik, 2001; García-Diez et al., 2012; Lorblanchet, 2003; Rodríguez-Vidal et al., 2014).

These diverse occurrences of red-ochred materials highlight the significance of red colour in the material culture and symbolic practices of the palaeolithic populations of Europe. They provide a valuable glimpse into the multifaceted uses of red pigmentation in different cultural and chronological contexts across the continent. This paper reports the results of the investigations on the nature and origin of the pigmentation present on the surface of a stone support recovered at the Lagar Velho rock shelter (Portugal). Our objectives are threefold: i) to elucidate the processes involved in the colouring of the support; ii) to ascertain its natural or anthropic source; and iii) to unravel its intentionality.

2. The archaeological site of Lagar Velho rock shelter: location, geological description and brief history of the site

Lagar Velho is a rock shelter (Fig. 1) situated in the Lapedo valley (39°45′20″N; 8°44′5″W – WGS84), in the municipality of Leiria (central Portugal). The valley is an ancient karstic gorge formed by the Caranguejeira stream (also known as Carrasqueira), a tributary of the Lis River, excavated in Upper Cretaceous rocks of Turonian age. The Turonian sedimentary succession is mostly composed by limestone and marly limestone, often fossiliferous, with rare intercalations of sandstone and mudstone (Teixeira and Zbyszewski, 1968). Today, the watercourse is deeply embedded, with the Lagar Velho rock shelter being positioned at a low altitude at the base of an escarpment (85 m a.s.l.). Mechanical erosion of the limestone banks that overhang the valley walls produces large boulders commonly found scattered throughout the valley. The physical processes also causes the detachment of limestone slabs from the overhangs that protect the shelters which became part of the sedimentary infilling. The base of the limestone banks that form overhangs (i.e., the top wall of the shelters) are smoothed due to long exposure to erosional elements. The texture is rougher on areas where recent detachments occurred.

The Lagar Velho rock shelter lies on the left bank of the Caranguejeira river, just before the gorge opens out onto its alluvial plain. It is oriented to the north and comprises a large rocky wall with an overhang of approximately 30 m-long.

The site was discovered in 1998 and, subsequently, the burial of a 4-year-old child (henceforth LV1) was excavated (square L20) (Fig. 2), as well as part of the sediments trapped in a recess of the back wall of the shelter labelled Hanging Remnant (*Testemunho Pendurado / TP*, in Portuguese). Between 2000 and 2009, various archaeological campaigns were undertaken, focusing primarily on excavating the Gravettian levels of the area located further west of the child grave, and referred to as *EE (Excavação em Extensão* in Portuguese*; Excavation in Open Area)* (Almeida, 2005; Almeida et al., 2009; Ferreira et al., 2010). To establish a comprehensive understanding of the site's stratigraphy and spatial relationship between the burial and the primary excavation zone (SE), a large trench (FL) and an elongate pit (SC) were excavated (Fig. 2). In 2012, a small preventive campaign was carried out at the TP, in its richest sector (Araújo and Costa, 2013). A new project started in 2018, with a primary focus in the excavation of the archaeological horizon exposed in the *EE* sector, which had remained unfinished (Araújo et al., 2023; Daura et al., 2022; Ochando et al., 2022; Sanz et al., 2023). It was within the context of this project that the limestone support bearing red pigmentation was recovered.

3. Archaeological background and ochre component

In order to understand the nature of the archaeological evidence, it is essential to undertake a detailed examination and contextualization of its discovery within the archaeological record of the Lagar Velho site. This should focus on elements from the same archaeological horizon which includes only the LV1 sepulture and the block. The limestone fragment was recovered from a yellow sandy in an area located at 2.5 m west from the sepulture (LV1) excavated in 1998–99. The sepulture is very rich in colourant, common in the symbolic and ritual practices during the Upper Palaeolithic (Arenas del Amo et al., 2024). The Lapedo child was stained with red colourant, suggesting that it may have been wrapped in a shroud coloured with pigment before burial (Duarte, 2002) or that the corpse was coated in a thick layer of red pigment. This use of ochre reflects broader Upper Palaeolithic practices with symbolic ritualistic significance. Personal ornament, including four red deer perforated canines and two *Littorina obtusata* shells found in association with LV1 child were also impregnated with red pigment (Duarte, 2002) (Fig. 2).

4. Materials and methods

The limestone block under analysis, georeferenced as ALV22-L17-200-14769, was recovered during the 2022 campaign as a part of westward extension of the area where the infant skeleton (LV1) was identified. After recovering the limestone block at the site, the presence of a reddish pigment was noted on its upper face. In order to conduct

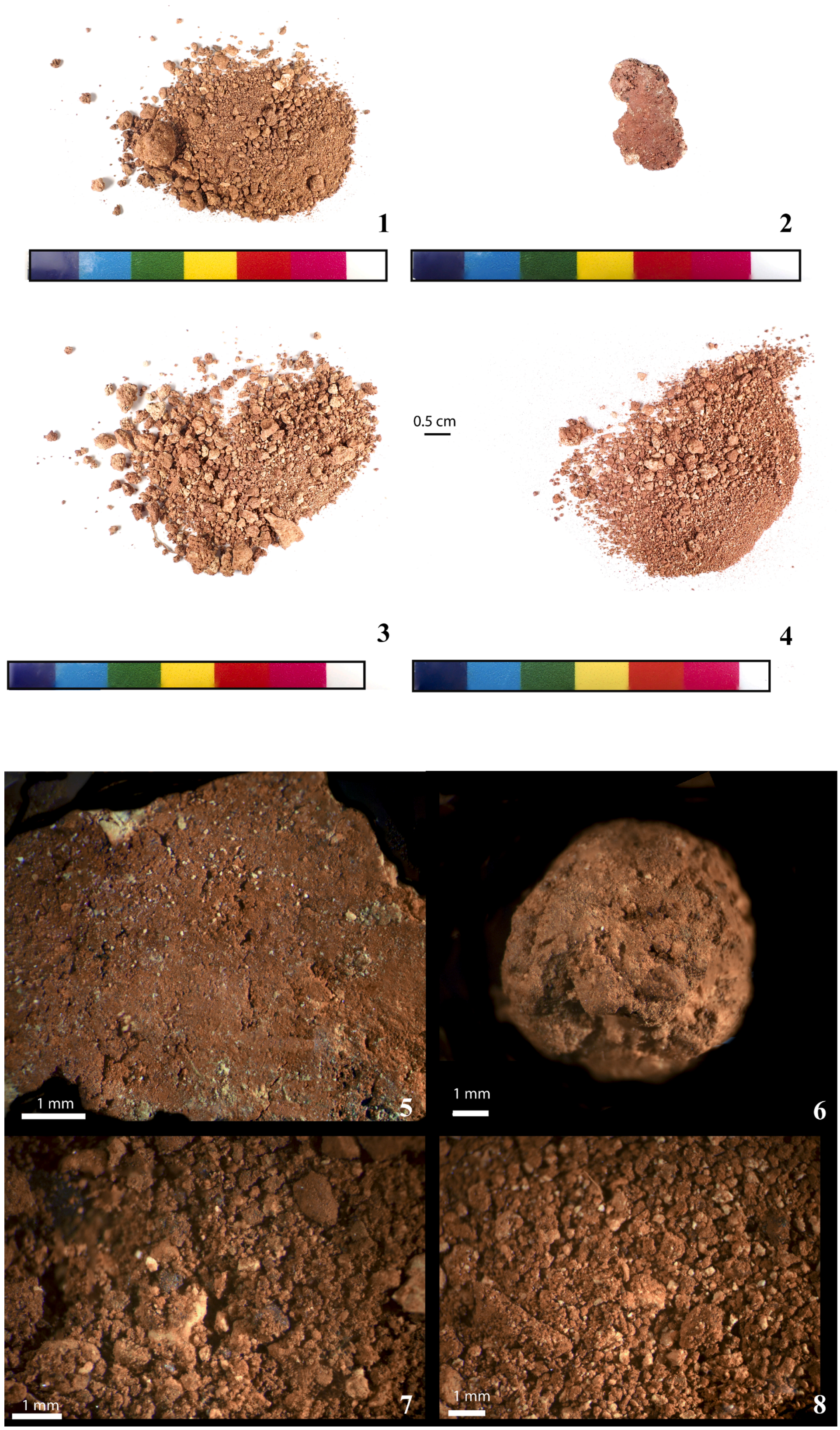

Fig. 3. Additional red colour samples recovered from the LV1 child's burial (1 to 4) and microscopic images (5-8). Sample provenience is indicating Fig. 2. 1: Sample #13. 2. Sample #10. 3: Sample #11. 4: Sample #12. 5: Sample #10. 6-7: Sample #13. 8: Sample #11.

Table 1
List of samples analysed by micro-Raman spectroscopy. n/d – not determined.

Id #	Provenience	Field season	Grid	Layer	Site reference #	Description and location
1	Stone support	2022	L17	200	14,769	Central part of the reddish line
2	Stone support	2022	L17	200	14,769	Block control sample
3	Stone support	2022	L17	200	14,769	Central part of the reddish line
4	Stone support	2022	L17	200	14,769	Barcode region
5	Stone support	2022	L17	200	14,769	Barcode region
6	Stone support	2022	L17	200	14,769	Yellow sediment
7	Stone support	2022	L17	200	14,769	Red point in barcode
8	Stone support	2022	L17	200	14,769	Central part of reddish line towards to the end
9	Stone support	2022	L17	200	14,769	Central part of reddish line towards to the end
10	Lapedo Child burial context	1998	K23	n/d	14b	Red pigment between parietal and temporal
11	Lapedo Child burial context	1998	L20	n/d	61(b)	Red pigment from cranial fragment
12	Lapedo Child burial context	1998	L23	n/d	11(b)	Red pigment from cranial fragment
13	Lapedo Child burial context	1998	L20	n/d	434	Red pigment between legs

further analysis, the surfaces were left uncleaned.

Four additional red colour samples, recovered from the child's burial (LV1) (see Fig. 3 and Fig. 2 for sample provenience), located near the parietal and temporal bones, between tibias, and recovered from cranial fragments, were analysed to characterize the pigment and evaluate similarities between colouring materials (Table 1).

Excavations were authorized by the former Directorate General for Cultural Heritage (DGPC) from the Portuguese Ministry of Culture (at present Portuguese Culture Heritage Institute | PC, IP), complying with all permits, legal requirements and regulations. The limestone block and other archaeological remains are stored at the Archaeosciences Laboratory (LARC) of PC, IP, in Lisbon.

A Nexius Zoom 6.7X to 45X stereo microscope was used to observe the reddish colouration of the block. Image Focus Alpha software and a CMEX 10 Pro camera attached to the microscope were also used. Furthermore, a 3D Hirox HR-5000E (20 − 5000x) digital microscope was utilised to analyse and photograph the block, thereby providing detailed imaging and surface characterisation that facilitated a more comprehensive understanding of the colouring. Additionally, Olympus TG-7 (focus BKT function) and Leica microscope digital MZFLIII were used to photograph the red samples from the burial.

The limestone block was photographed using Fuji S-X10 camera and detailed images were created by stacking 30 photographs taken with an Olympus TG-7 (focus BKT function), each focusing on a different area of the scene. This was achieved by utilising the depth of field blending function in Adobe Photoshop 2024. Furthermore, digital image enhancement was performed using the DStretch® plugin for ImageJ© software. The use of DStretch plug-in (filters LDS, LRE, YRD, YRE and YBR) has allowed a clearer and more accurate observation of the reddish motifs, and to identify its natural or anthropogenic origin.

Micro-Raman spectra were obtained using a Jobin Yvon LabRam 800HR dispersive system coupled to an open optical Olympus BXFM microscope to determine the specific composition of the mineral colourant. The charge-coupled device detector was cooled at −70 °C. Measurements were taken with a solid-state laser emitting at a wavelength of 532 nm. The laser was initially operated at a very low power of 0.07 mW, to avoid any possible sample transformation or degradation. Some measurements were also obtained at a laser power of 0.7 mW. Given the large size of the block, the motorized XY microscope stage was dismantled so that the sample could be fitted under the microscope and samples were directly analysed on the support. No sample preparation was needed. The Raman spectra were recorded using a 50x long working distance microscope objective with an acquisition time of 20 s and 10 accumulations.

5. Stone support

5.1. Provenience

The limestone block was found in proximity to the burial (Fig. 4), square L17 (X = 23.701; Y = 16.781), ca. 250 cm to the west, and at the same height (−3.392 m bellow datum). This positioning allows us to relate it chronologically with the burial event, which has been dated to c. 29.0 ka cal BP (28,920–29,410 cal BP at 2 sigma standard deviation) (Araújo et al., 2023). The surface dyed with red pigment (considered as upper face) was found facing downwards, laying on the sediments. The recess in this area was sealed by a cryoclastic deposit, a clast-supported material mostly constituted of centimetric-sized limestone slabs detached from the wall with a fine muddy matrix.

5.2. Description of the object

The red-dyed support – max. width: 28 cm; max. height: 19 cm; max. thickness: 6.5 cm – is made of nodular white (10YR 9/1 Munsell Soil-Colour Charts) marly limestone and presents a trapezoidal-like shape and irregular edges (Fig. 5). These edges remain angular in form, lacking any discernible signs of abrasion or rounding. Upon macroscopic examination the surfaces of both faces are sinuous being the upper (i.e., the pigmented) more pronounced. The upper face is ridged, indicative of physical corrosion, while the lower face does not present any marked ridges. Based on its morphology and location this support could correspond to a fragment that has been detached from the shelter's wall, once is similar to other slabs that have fallen from the top of the shelter (i.e., the base of the limestone bank that form the overhang). Additionally, the absence of typical percussion or pressure marks shows that the support fractured naturally. The red-dyed face (upper face) likely corresponds to the fracture plane of the bedrock, while the other represents the face exposed to external erosional elements (i.e. the lower face) before fracture. The upper face of the block displays a yellowish colour and a sandy character inherited from the sediment where the block was originally deposited.

The presence of red colouration (10R 5/8 Munsell Soil-Colour Charts) is easily apparent in the central-left portion of the limestone upper face (Fig. 5). The pigmentation coincides with the convex region of the block, where the protrusion is pronounced, spanning an area with a maximum width of 7.5 cm and maximum height of 9 cm. The pigment is distributed in the form of colour concentrations of different sizes and intensities, with linear configurations being prominent, as well as others that do not define specific shapes. The linear ones form rectilinear patterns, where two thicker and two thinner linear forms are more evident. Some of the concentrations of non-concrete forms could describe a linear pattern, but their discontinuity does not allow this to be confirmed (Figs. 5 and 6). The two thicker lines terminate in pointed end (right side) but their inner sections present a morphology reminiscent of a "barcode" design, suggesting that a raw red pigment stained the stone

Fig. 4. Location of object in square L17. 1-4: Different views of the origin of the object. Arrows indicate the location of the limestone block 5: Location of object relative to that of the grave. The red star in 5 indicates the point where the stone support was located.

surface in a process characterized by rubbing (friction) and abrading. The thinner linear forms, with width lower than 0.2 mm appear to have a similar origin, likely resulting from the abrasion of the colourant along the support's surface. The difference in width observed between these lines could attributed to the surface properties of the colouring material in contact with the support.

Defining the morphology of the pigmentation of the area beneath the two thicker lines is more complex, due to the low intensity of the reddish hue. However, based on its width and internal distribution, it should not be ruled out as a potential "barcode"-like design similar to the aforementioned thinner lines, possibly classifying it as a wider linear form. Nonetheless its features are not as obvious as those described previously.

5.3. Digital image analysis

The enhancement of the digital image (Fig. 7 and Fig. 8) allowed to recognize three features that had gone unnoticed previously and that would have been difficult to detect through naked-eye observation. First, the digital image revealed a heightened concentration of colourant in the area where the two thicker linear forms are located. This region corresponds to a section of the block with a generally lighter tone than the rest of the upper face, suggesting the abrasion or rubbing of the original limestone surface. Second, the reddish colouring matter lies above the zone that was subject to rubbing, indicating that the contact between the colourant and the support occurred after the sediment had covered the surface and after the abrasion or rubbing had taken place. And third, the narrower lines exhibit an intense "fresh" colouration, suggesting that they lay above the sandy sediment. These observations sheds light on the sequence of events surrounding the colourant's application and sediment deposition.

5.4. Raman analysis

In this study nine different micro-regions in different parts of the limestone block, here entitled as samples, were analysed by micro-Raman spectroscopy. The samples provenience are listed in Table 1 and in Fig. 9. Seven samples (#1, 3–5,7–9) are from the red coloured features. Two control samples from the limestone (#2) and from the yellow sediment (#6) adhered to the block were also analysed (Fig. 10; Table 1). Four additional red-colour pieces (#10–13), recovered from the child's burial context in 1998, located near the parietal and temporal bones (#10), between tibias (#13), and recovered from cranial fragments (#11–12), were analysed to characterize the pigment and evaluate similarities between colouring materials (Table 1).

The Raman spectra obtained for samples #1 and #3 are presented in Fig. 10.1. The spectrum of a reference mineral of haematite was also added to this figure. The comparison between results indicate that the Raman spectra of samples #1 and #3 corresponds to haematite and are in good agreement with other published works (de Faria and Lopes, 2007; Marshall et al., 2020) and with the Raman database (RRUFF database https://rruff.info/). The spectra of samples #2 and #4 to #9 (Fig. 10.2) present a high fluorescence background signal that interferes with the Raman signal. These results are shown in this manuscript to illustrate the difficulty in identifying the different materials presented in these samples using Raman spectroscopy. Different experimental methods such as laser quenching and varying the laser power in the

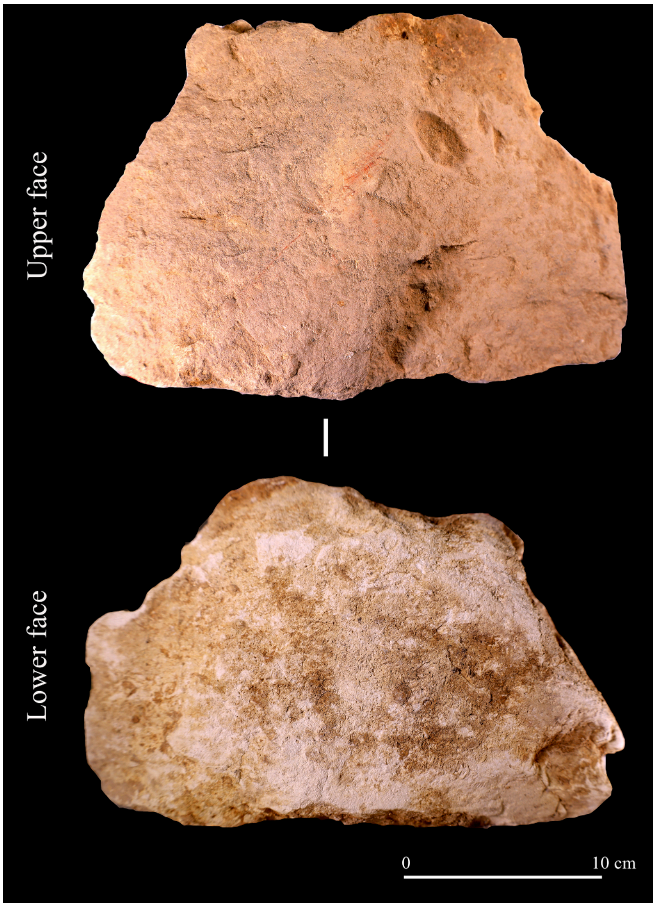

Fig. 5. View of both faces of the stone support. Red colouring is observed in the central area of the upper face and detailed images of identified traces are shown in Figs. 6 and 7.

sample were tested in order to decrease the strong fluorescence background. In some of the spectra presented in Fig. 10.2, a band can be observed at 1086 cm^{-1}, which corresponds to the main Raman band of calcite.

The Raman spectrum of sample #5, obtained in the red region of the "barcode"-like design, was recorded both at lower (0.07 mW) and higher laser power (0.7 mW). Some very weak additional Raman features seem to appear in this last spectrum (Fig. 10.2). The main difference between the two spectra is the existence of an intensity peak at 1086 cm^{-1}, as aforementioned. A subtraction procedure was carried out on the 0.7 mW spectrum of sample #5 to observe other weaker spectral features. Although the signal is quite weak, the subtracted spectrum shows the presence of haematite (Fig. 10.3). Both sample #5 and sample #3 subtracted spectrum were plotted with haematite and calcite references Raman spectra (Fig. 10.4).

Finally, most of the Raman spectra obtained in the four additional red colour samples coming from previous excavations (child's burial context) show the presence of haematite with different degrees of intensity depending on the micro-region analysed (Fig. 10.5/8). Some of these spectra also indicate the presence of calcite. Further, in some few cases, quartz (Fig. 10.8) and amorphous carbon (Fig. 10.5) were also detected.

6. Discussion

The comprehensive analysis conducted in this study shed light on several aspects of the coloured limestone block recovered near the Lapedo child burial (LV1). The large difference in the fluorescence background between the samples #1, #3 and sample #5 can be explained by the fact that the central part of the reddish line is probably denser in haematite than the barcode region and therefore less fluorescence is observed in the reddish line. Furthermore, the comparison of the Raman spectra of samples #1, #3 and sample #5 after baseline correction results in a quite similar haematite spectra. The pigments identified in both the burial context and limestone support primarily consist of haematite, a mineral known for its red hue. Additionally, the presence of other minerals, including calcite, quartz and amorphous carbon, was observed. These minerals are naturally occurring components of the excavated area, suggesting their presence might be incidental rather than intentional.

The Raman analysis does not permit a more precise distinction to be made between the samples from the burial context and that from the block. In both cases, the analysis corroborates the presence of haematite, along with the identification of calcite, a calcium carbonate mineral that typically forms limestone, or the context. Although charcoal may have been employed to create a darker reddish hue or their presence is related to heated treatment (Domingo and Chieli, 2021), the considerable quantity of charcoal (Zilhão and Trinkaus, 2002) in the burial area does not allow to rule out the possibility that its presence may be attributed to archaeological context. In light of these findings, we conclude that the taphonomic analyses provide the most conclusive understanding of the context of these materials.

The digital image analysis, along with naked-eye and microscopic observations, allowed to propose a sequence of events that led to the red colouration accumulated on the support. Its upper face, representing the convex side of the block, accumulated sediment, eventually underwent abrasion or rubbing, resulting in a small area with lighter tonality. Subsequently, a reddish with higher concentration was deposited in this lighter-toned area of the limestone block.

Each linear form, including both the thicker and thinner lines, is interpreted as being originate from a single action of friction or contact with the colouring matter, i.e., they do not result from a repetitive abrasive process. A prolonged and consistent rubbing action would have produced better defined and more complete linear forms, with the inner region being filled in with the reddish hue. Rather, the support exhibits a "barcode"-like design with areas completely lacking of pigmentation, strongly suggesting that the pattern could be the result of natural processes (small displacement of the support) or unintentional human action (as trampling), but it can also result from an human intention (D'Errico, 1994).

The identification of the support in the same area as the infant burial is significant: well inside the recess that forms in the back wall of the shelter, protected by an overhang, at the same level and depth as LV1, whose funerary practice involved significant amounts of red colour material (Zilhão and Trinkaus, 2002). This proximity raises the possibility that the support might have some relation to the burial, although verifying this hypothesis is currently impossible due to the destruction of the sediments overlying the grave by the artificial terracing prior to the site's discovery and the disturbance of potential markers that might have delimited the pit. An alternative hypothesis is that the grave was sealed by limestone slabs to protect the child's body and the burial area, further complicating our understanding. In this context, it should be noted that ochre utilization in Gravettian burials is well-documented across Europe (Arenas del Amo et al., 2024; Ronchitelli et al., 2015; Simon et al., 2014) and flat slabs and pebbles covered with clays and red colourants are present in the Pavlovian record (Vandiver, 1997), for example.

Based on the detailed analysis of the support, the following sequence of events could be proposed: 1) fragmentation of the stone support of the shelter bedrock and subsequently fall to the cave floor; 2) accumulation and compaction of yellowish sandy sediment on; 3) mobilization of the stone fragment promoting abrasion of the upper surface and forming a lighter tone area free of sand; and 4) colouration of the surface of the support with red colour material (putatively following contact with the

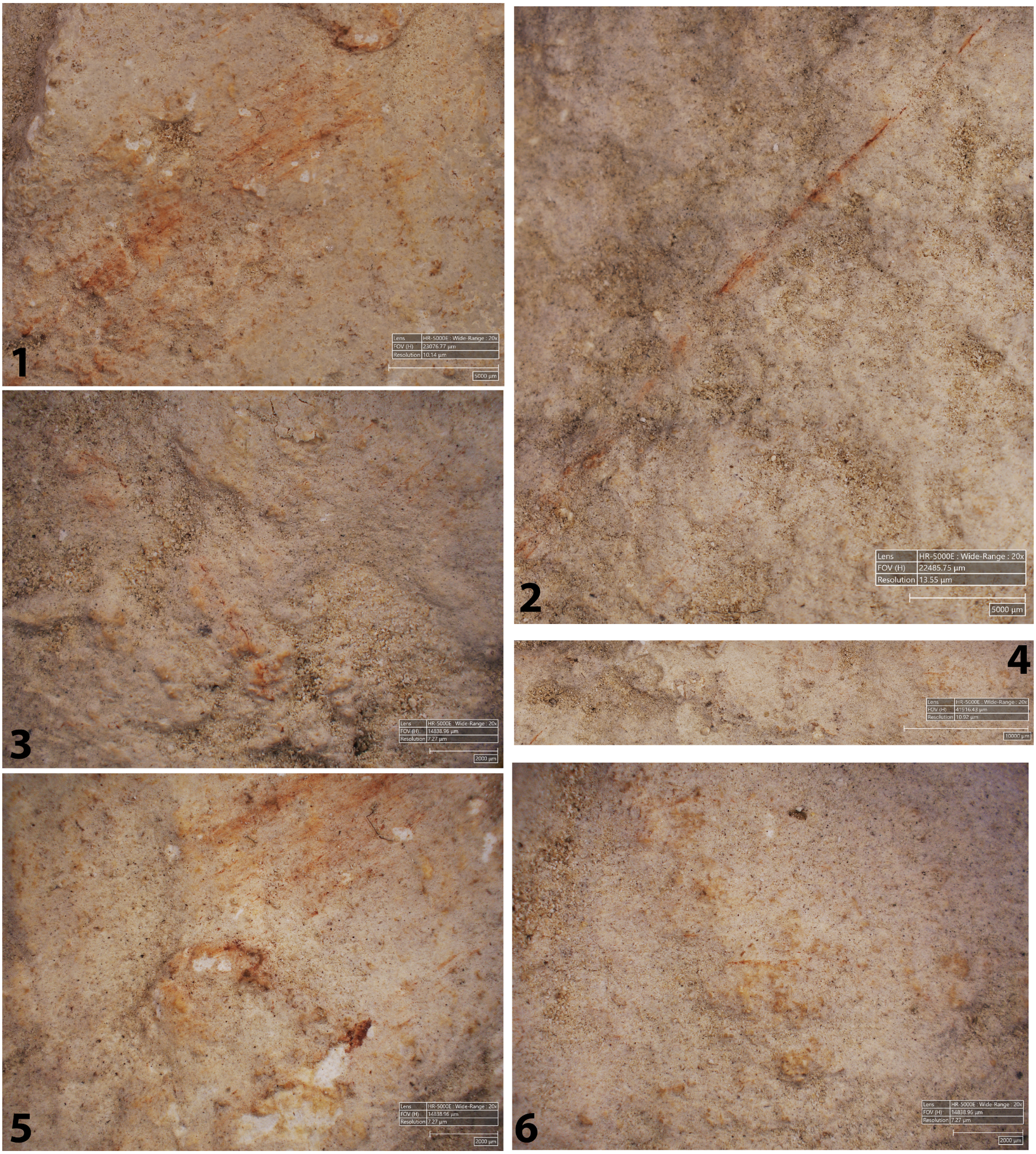

Fig. 6. Images obtained using a 3D Hirox KH8700 digital microscope. Location of images are signalled in Fig. 9 1: Barcode region; 2–3: Thinner linear forms; 4–5-6: Colour concentration without specific shapes. 5: Barcode region and colour concentration.

burial pit). Consideration should be given to the possibility that events 3 and 4 were synchronous. After this sequence of events, the formation of the cryoclastic deposit that sealed the recess where the coloured rock was located occurred, on a date yet to be defined.

In summary, considering all the available information, the most plausible hypothesis for the presence of colouring matter on the upper surface of the support is that it resulted from a process unrelated to any intentional human activity. The most likely explanation is that, at some point during the sequence of events proposed, the block rubbed against a small element (not necessarily greater than 4 mm according to the thickness) of colouring matter (haematite) that was previously deposited on the rock-shelter surface, likely associated with the infant burial. This friction likely occurred due to an undetermined and unintentional anthropic or natural movement of the support, during which the

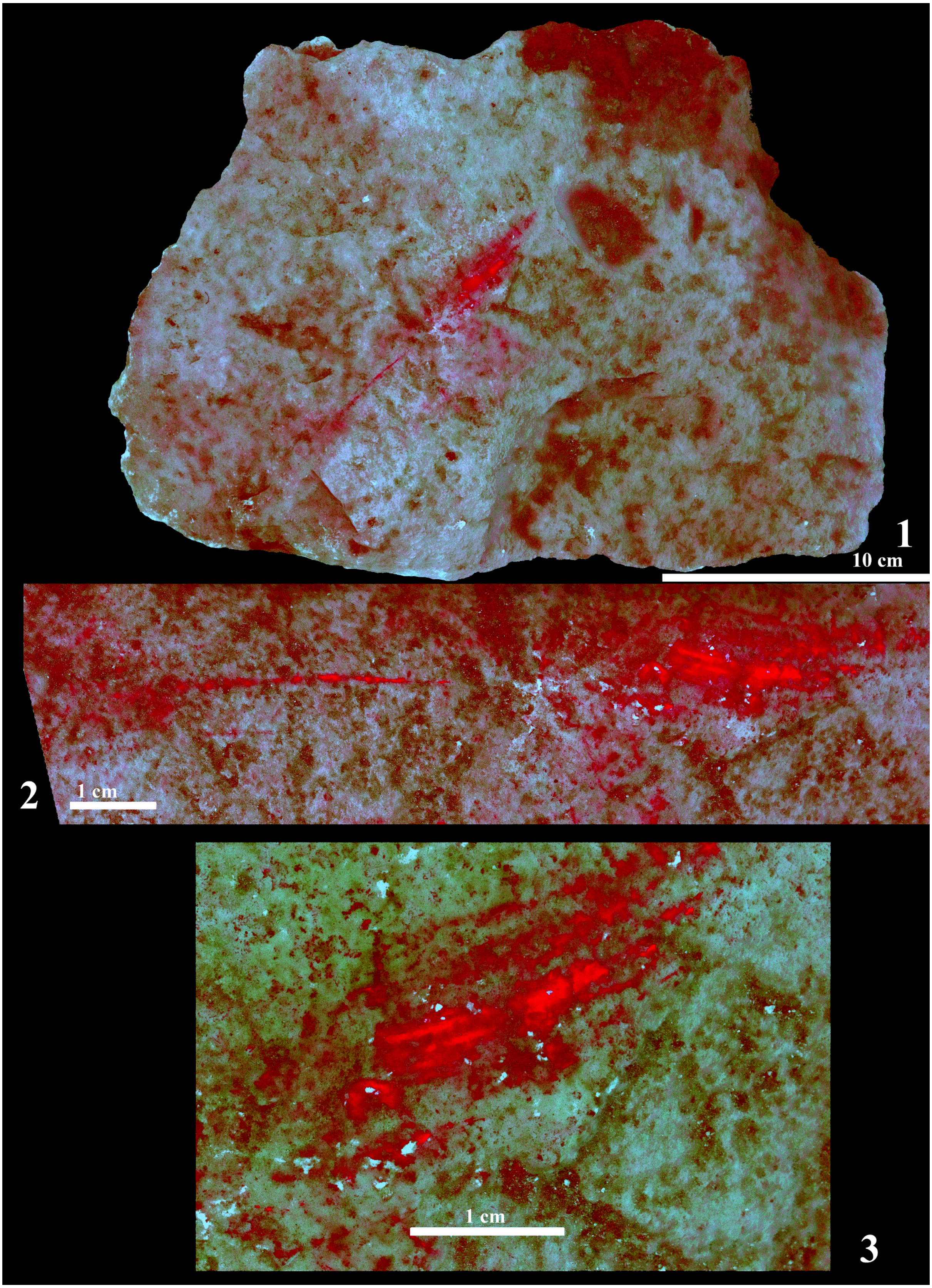

Fig. 7. Image enhanced of red lines of the upper face using DStrecth (Filter YWE, intensity 15). 1: Upper face of the bloc. 2–3 Detail: at the top right are located short, wide lines, while at the bottom left are placed long, narrow lines.

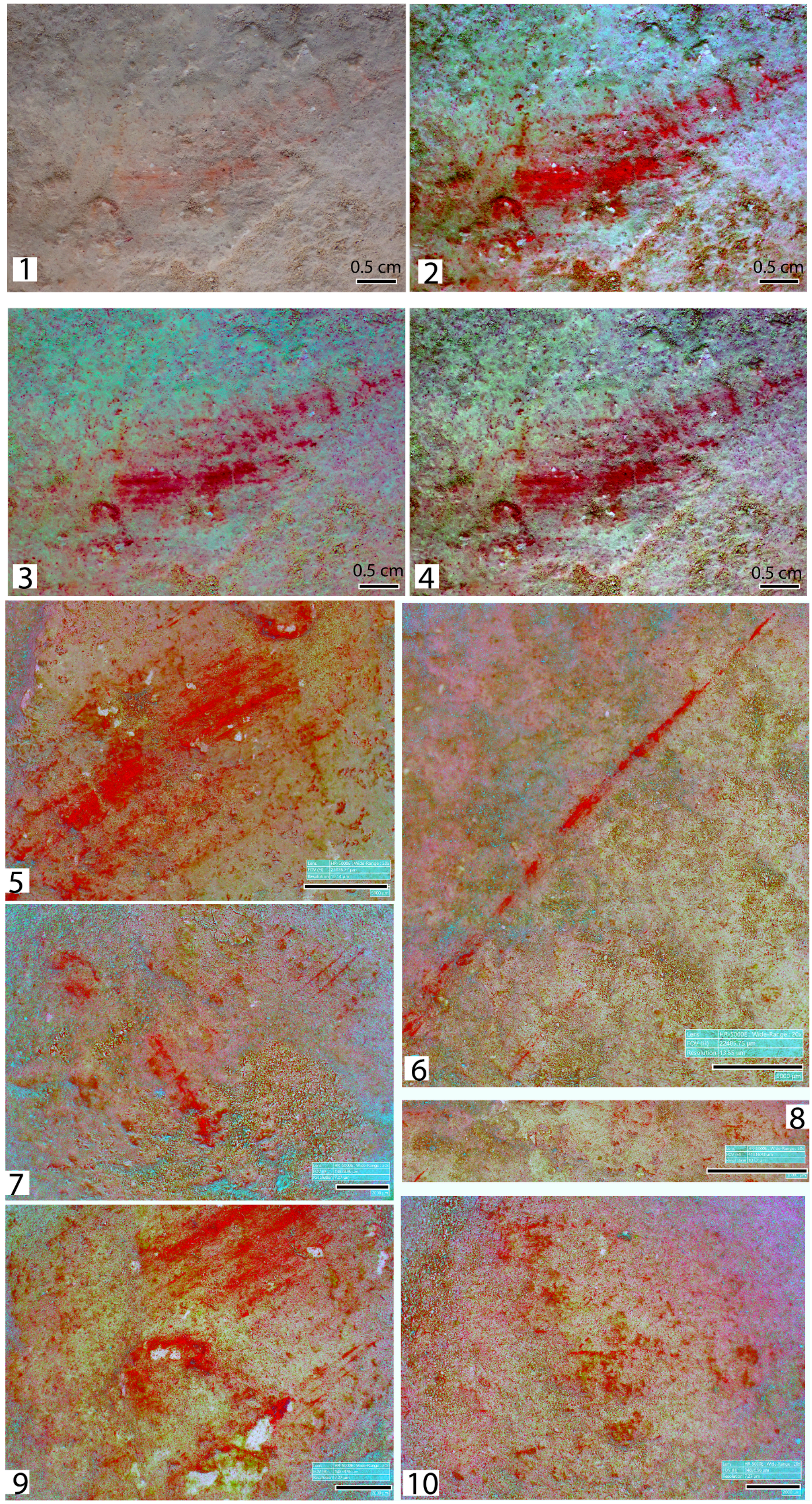

Fig. 8. Detailed image using DStrecth. 1: Image created by stacking 30 photographs. 2–3-4: Digital image enhancement was performed with filters YWE (2), YRE (3) and YRD (4), to facilitate clearer and more accurate observations.5–10: Images processed with the YWE filter applied at an intensity of 15 to enhance the Hirox microscope images.

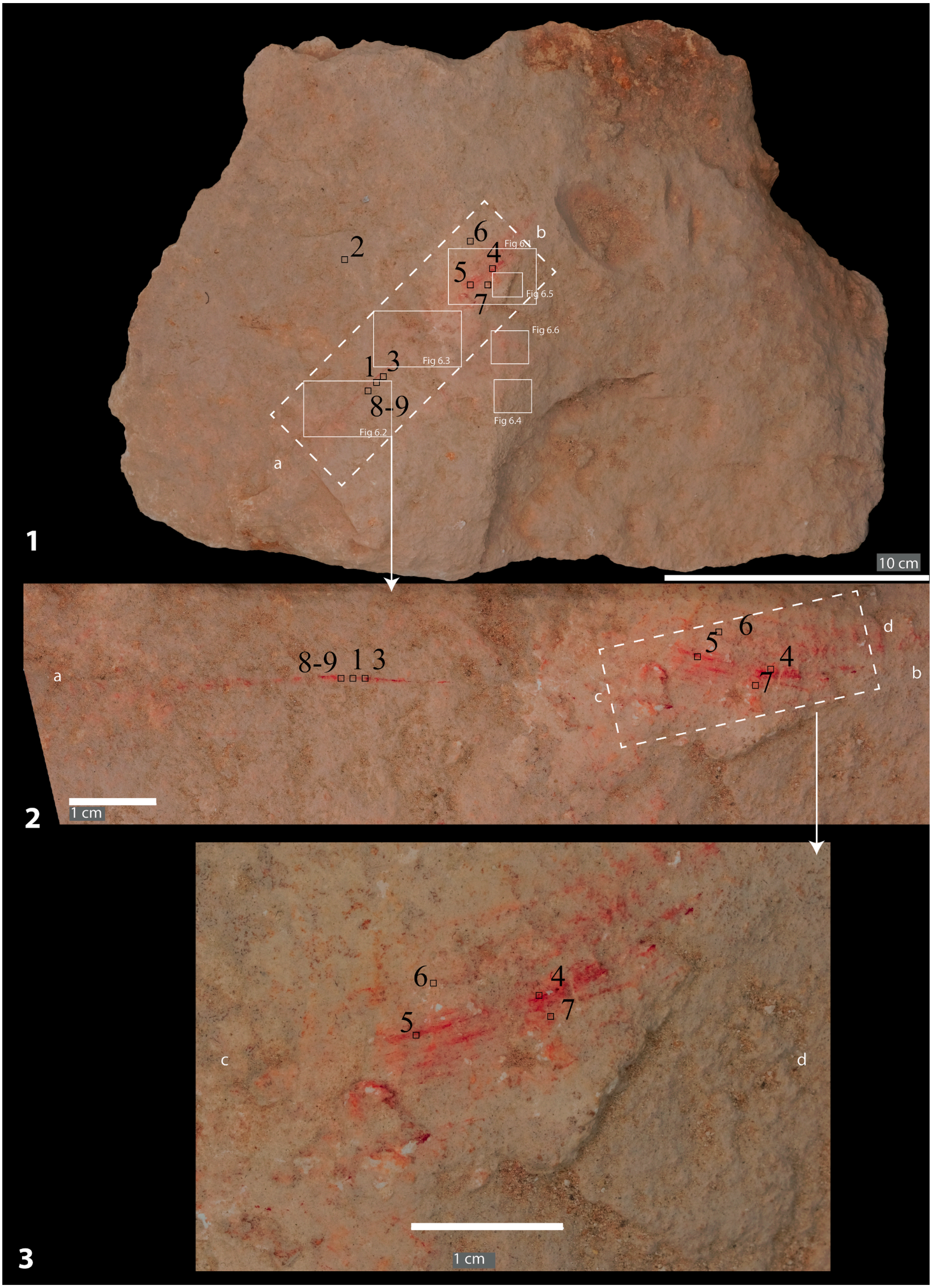

Fig. 9. Locations of the samples of at the limestone upper face analysed by micro-Raman spectroscopy and Hirox Image. Picture has been modified using Photoshop red hue filter enhance colouration.

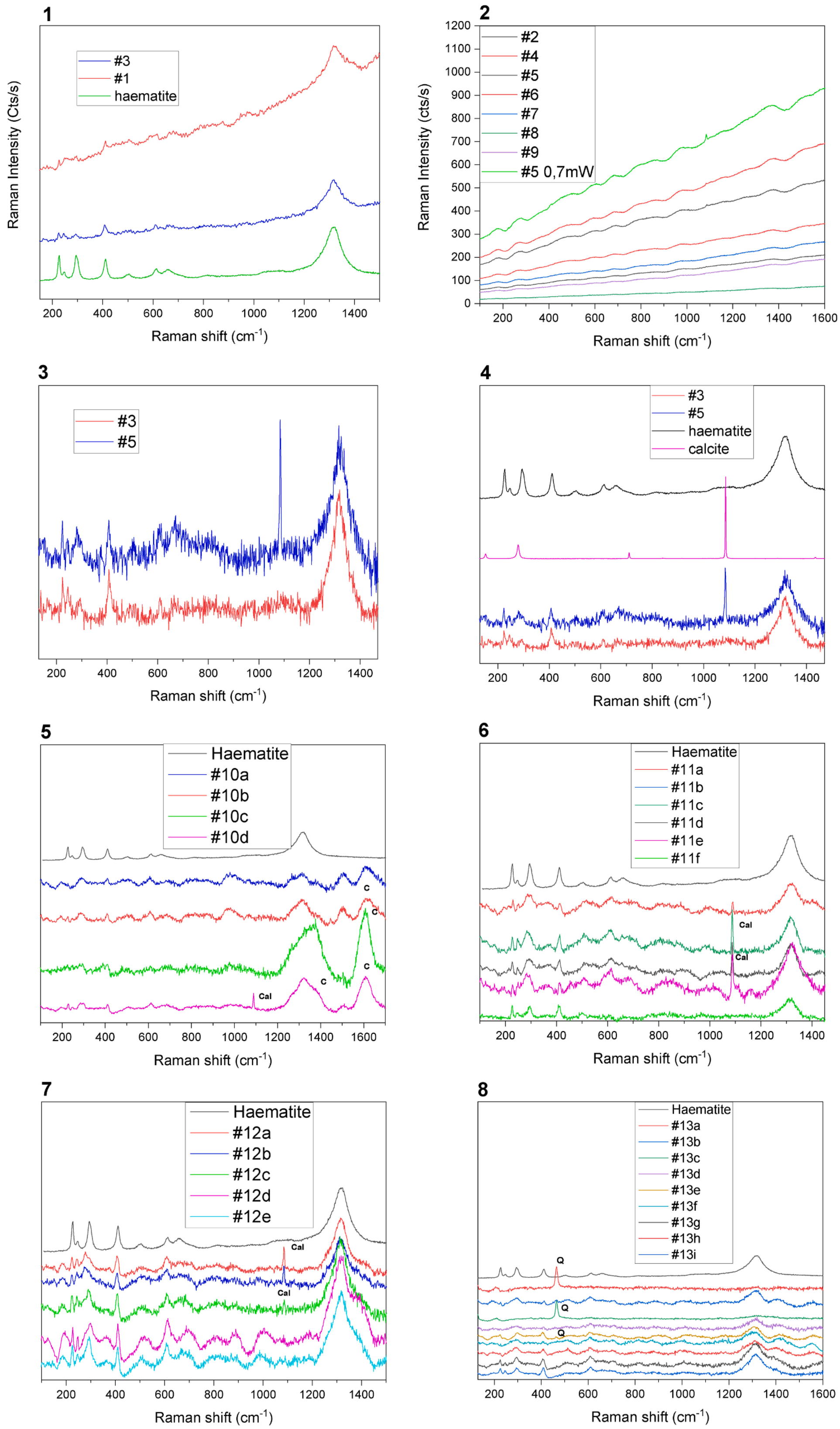

Fig. 10. Raman spectra of the selected samples described in Table 1. The main Raman bands of calcite, carbon and quartz are indicated in some of these spectra as Cal, C and Q, respectively.

pigment adhered to the block's surface. This resulted in the formation of linear traces, some of which resemble a "barcode" design, where friction was more pronounced, and thinner linear traces where the friction was less pronounced.

7. Conclusion

In the broader contexts of ochre utilization during the Palaeolithic, this study underlines the importance of a comprehensive and well-founded approach when examining pigmented support in archaeological context. Beyond merely examination of form and patterns of pigmentation, it is important to conduct a systematic reconstruction of the technical processes and gestural actions that contributed to the deposition of these coloured materials. Equally significant is the need for a nuanced understanding of the specific context in which these pigments are discovered, considering their spatial relationship with artifacts and the conditions of recovery.

To discern the origins of pigmentation, i.e. whether deliberate or unintentional, it is necessary to evaluate all available data, particularly for simple patterns like small dots and lines. This analysis not only helps to distinguish between natural and anthropic sources but also enables us to contemplate the intentionality or unintentionality of these actions.

The examination of the red colouring matter on the limestone support from the Lagar Velho rock shelter has led to a remarkable conclusion. Contrary to the prevailing notion of deliberate artistic or symbolic behaviour, the presence of this pigment more likely results from passive processes. These processes, whether natural or anthropic, are closely associated with the movement and friction of the limestone support in proximity to the colourant.

The prevalence of stone with pigmentation traces in the European Upper Palaeolithic framework has been associated with artistic motifs or domestic functions in colourant processing (Roldán García et al., 2016). However, this study introduces a novel perspective examining less-explored processes related to the nature of support colouration, as exemplified by the Lagar Velho limestone support.

In summary, the case of the Lagar Velho limestone highlight the potential role of taphonomic and passive processes. This contemplative exploration enriches our understanding of pigments involved in a non-artistic colouring of limestone supports during the Upper Palaeolithic. Rather than adhering to the traditional view of intentional and symbolic colouration, this work advocates for a more nuanced and holistic approach to studying pigmented materials.

CRediT authorship contribution statement

Joan Daura: Writing – review & editing, Writing – original draft, Investigation, Conceptualization, Supervision. **Marcos García-Diez:** Writing – review & editing, Writing – original draft, Investigation. **Montserrat Sanz:** Writing – review & editing, Investigation. **Tariq Jawhari:** Writing – original draft, Investigation, Writing – review & editing. **Ana Maria Costa:** Writing – review & editing, Investigation, Writing – original draft. **Ana Cristina Araújo:** Writing – review & editing, Investigation, Writing – original draft.

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Data availability

All data is contained in the paper.

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