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RESEARCH

More than a fingerprint on a pebble: A pigment-marked object from San Lázaro rock-shelter in the context of Neanderthal symbolic behavior

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Abstract

The pebble discovered in the San Lázaro rock-shelter (Segovia, Central Spain) is the oldest known non-utilitarian object with a fingerprint made in Europe. Its morphology and the strategic position of an ocher dot, where a dermatoglyphic image has been detected, may be evidence of symbolic behavior. This object contributes to our understanding of Neanderthals' capacity for abstraction, suggesting that it could represent one of the earliest human facial symbolizations in Prehistory. All the analyses carried out suggest an intentional effort to transport and paint the pebble for non-utilitarian purposes, suggesting that it is indeed the work of Neanderthals. The discovery is doubly exceptional because it includes the most complete dermatoglyphic image identified to date, with the exception of the partial fingerprint from Königsaue, both with a comparable minimum age. This dermatoglyphic image is not visible and it was revealed after a multispectral analysis. This method adds significant value to the identification that has been carried out of the human fingerprint, as it is the first time that such an analysis has been conducted with evidence as ancient as this, opening the door to future research and discoveries.

Keywords Middle Palaeolithic · Palaeolithic art · Mousterian · Neanderthals · Fingerprint

Introduction

The origin of human symbolic behavior and its attribution not only to modern humans (*Homo sapiens*) but Neanderthals (*Homo neanderthalensis*), practically at the same time and independently, has been a major topic in prehistoric research for decades (Mellars 1995; Henshilwood and d'Errico 2001; Backwell and d'Errico 2005). Apart from the Châtelperronian technocomplex, where sufficient evidence of symbolic behavior has been identified in the transition between the Middle and Upper Paleolithic (Caron et al. 2011; Rodríguez-Hidalgo et al. 2019), and which is generally attributed to Neanderthals, signs of symbolic behavior dated in the Mousterian period and unquestionably corresponding to Neanderthals are increasingly abundant. These are, for example, pieces of ocher with traces of use and personal adornments found at occupation sites that do not usually generate any doubts or discrepancies (Soressi and d'Errico 2007; Peresani et al. 2011; Cârciumaru et al. 2014; Romandini et al. 2014; Bonjean et al. 2015; Laroulandie et al. 2015; Radovčić et al. 2015).

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Since the 2018 publication of dates older than 60 ky BP for several caves with art in Spain (Hoffmann et al. 2018a) not only sparked debate on the reality of Neanderthal art but also served to consider other forms of evidence and finds of portable objects. These are mainly non-utilitarian osseous remains that were possibly symbolic objects for Neanderthals (Bednarik 1992; Majkić et al. 2017, 2018a, 2018b; Hoffmann et al. 2018b; Peresani et al. 2021). It has gradually been determined that the origin of symbolic behavior and apparently also of art was not exclusive to modern humans but can also be attributed to Neanderthals. Many of these examples of Neanderthal symbolic behavior during the Mousterian have been recorded in Western Europe, where several finds attest complex behavior: from shells with remains of ocher in Cueva de los Aviones (Hoffmann et al. 2018b) to engravings in Gorham's Cave (Rodríguez-Vidal et al. 2014) in a chronological frame of 115 to 40 ky BP. In this context, the Iberian Peninsula is important as one of the last European refugia for Neanderthals and where their most recent presence has been documented (Romandini et al. 2014; Alcaraz-Castaño et al. 2017; Kehl et al. 2018).

Against this background, we present a pebble studied (Fig. 1) that was discovered in July 2022 during the excavation of the level H, at the Mousterian site of San Lázaro rock-shelter (Segovia, Central Spain). Based on the chrono-stratigraphic and archaeological evidence, this pebble was intentionally handled by the last Neanderthals in Iberia, shortly before their complete disappearance. The aim of this work is to present the in-depth analyses carried out by means of a set of sophisticated techniques, the surprising results and the novel interpretations of this unique piece in its context.

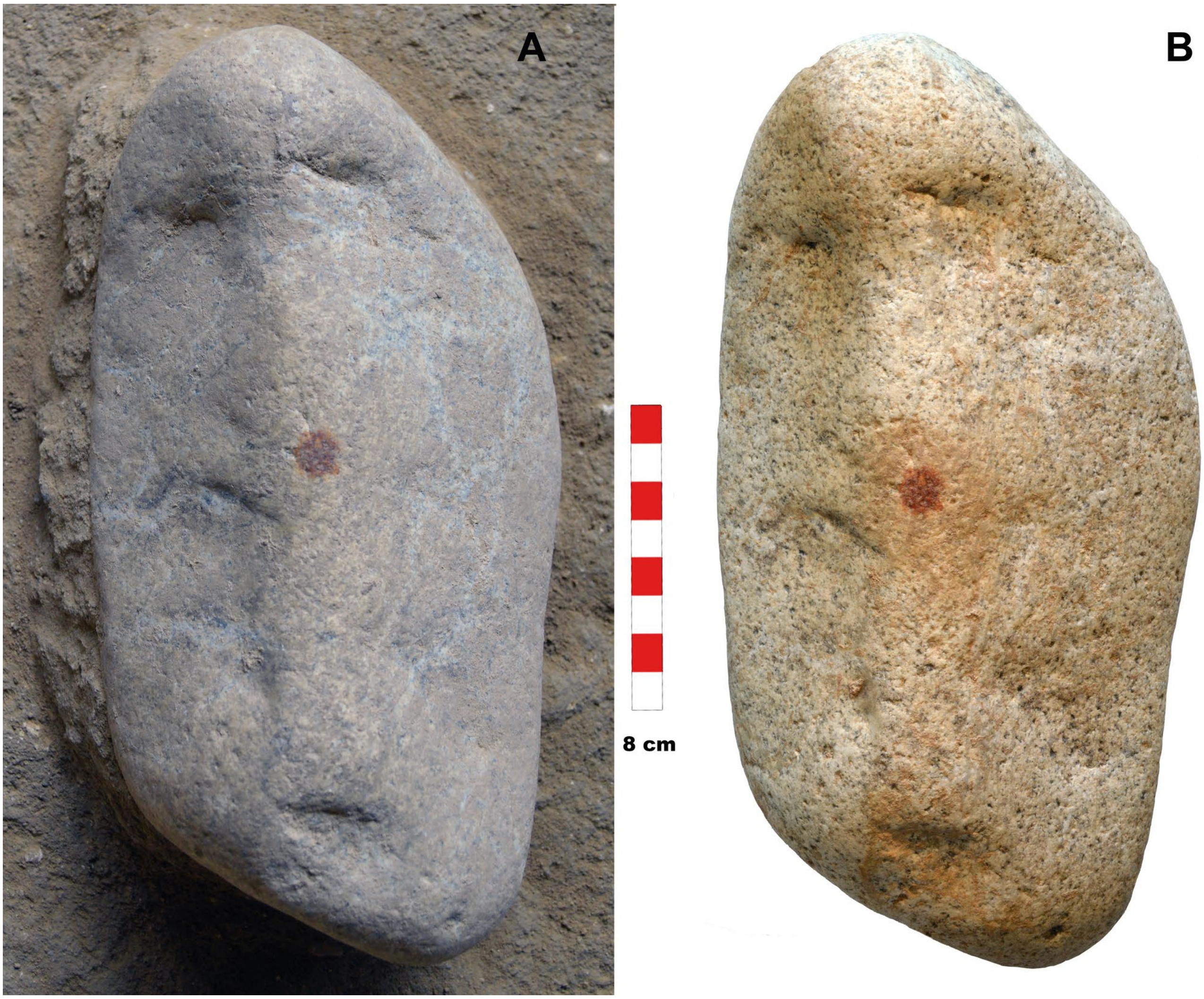

Fig. 1 **A**. The object before being fully excavated; **B.** Once unearthed, it is possible to appreciate the three main cavities and the central position of the red dot

Archaeological context: Mousterian occupations in the Eresma River valley

San Lázaro rock-shelter

San Lázaro is a rock-shelter located in the center of the Iberian Peninsula (Segovia, Spain) in a sector of the Eresma River valley (Douro River basin), its ETRS89 coordinates (Zone 30) are 40º 57′ 16,3'' N, 4º 8′ 10,7'' W (Fig. 2), and it is formed into a karstic massif developed in Cretaceous dolostones. San Lázaro rock-shelter is less than 400 m away to other contemporary Mousterian sites that have revealed occupations dated between 44 and 41 ky cal BP, Abrigo del Molino rock-shelter and Abrigo del Molino superior rock-shelter (Álvarez-Alonso et al. 2018a, 2018b, 2021). Evidence of Paleolithic occupations by *Homo sapiens* has not been found at those sites, which emphasizes the intense presence of Neanderthals in the valley during MIS 3.

Since then, the site has been excavated in the course of five seasons: 2014, 2019 and 2021–2023 (Fig. 3). 16 lithostratigraphic levels have been discriminated, of which six

Fig. 2 **A**. Location of San Lázaro rock-shelter. **B.** 1. Location of San Lázaro rock-shelter; 2. Abrigo del Molino rock-shelter, in the Eresma River valley in the city of Segovia

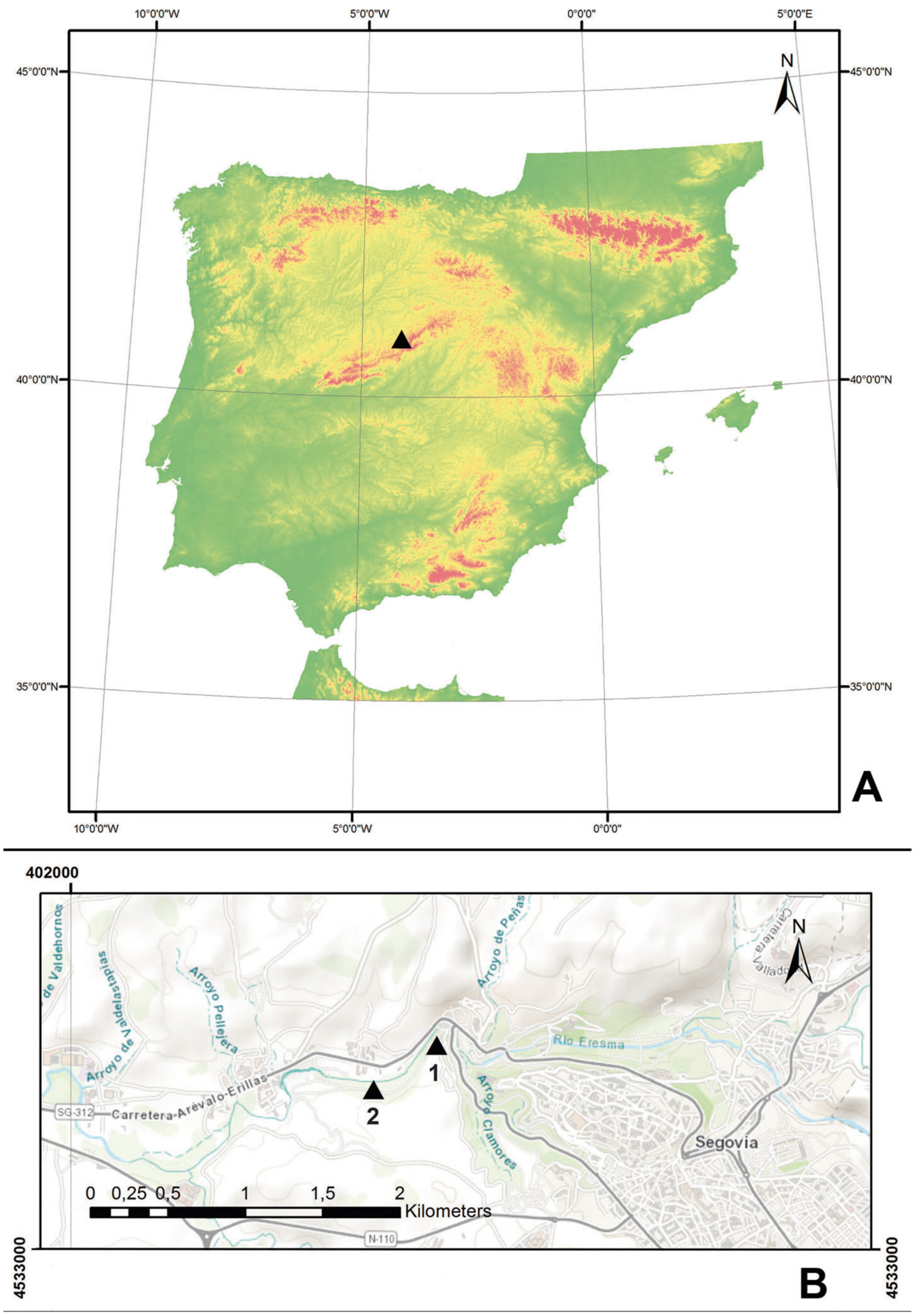

Fig. 3 **A**. View of San Lázaro rock-shelter during the excavations. **B.** San Lázaro rock-shelter at the conclusion of the 2022 excavation

contain archaeological remains, all of them of Mousterian chronology. The base of the sequence has not been reached.

The stratigraphic sequence of the detritic Quaternary sedimentary fill (or carbonate-detritic because of the edaphogenic cementations of calcium carbonate or calcrete in some levels) at the archaeological site of San Lázaro rock-shelter (Eresma valley, Segovia) consists of three units of strata which in turn are sub-divided into 16 litho-stratigraphic levels (designated with the letters A to P) (Fig. 4).

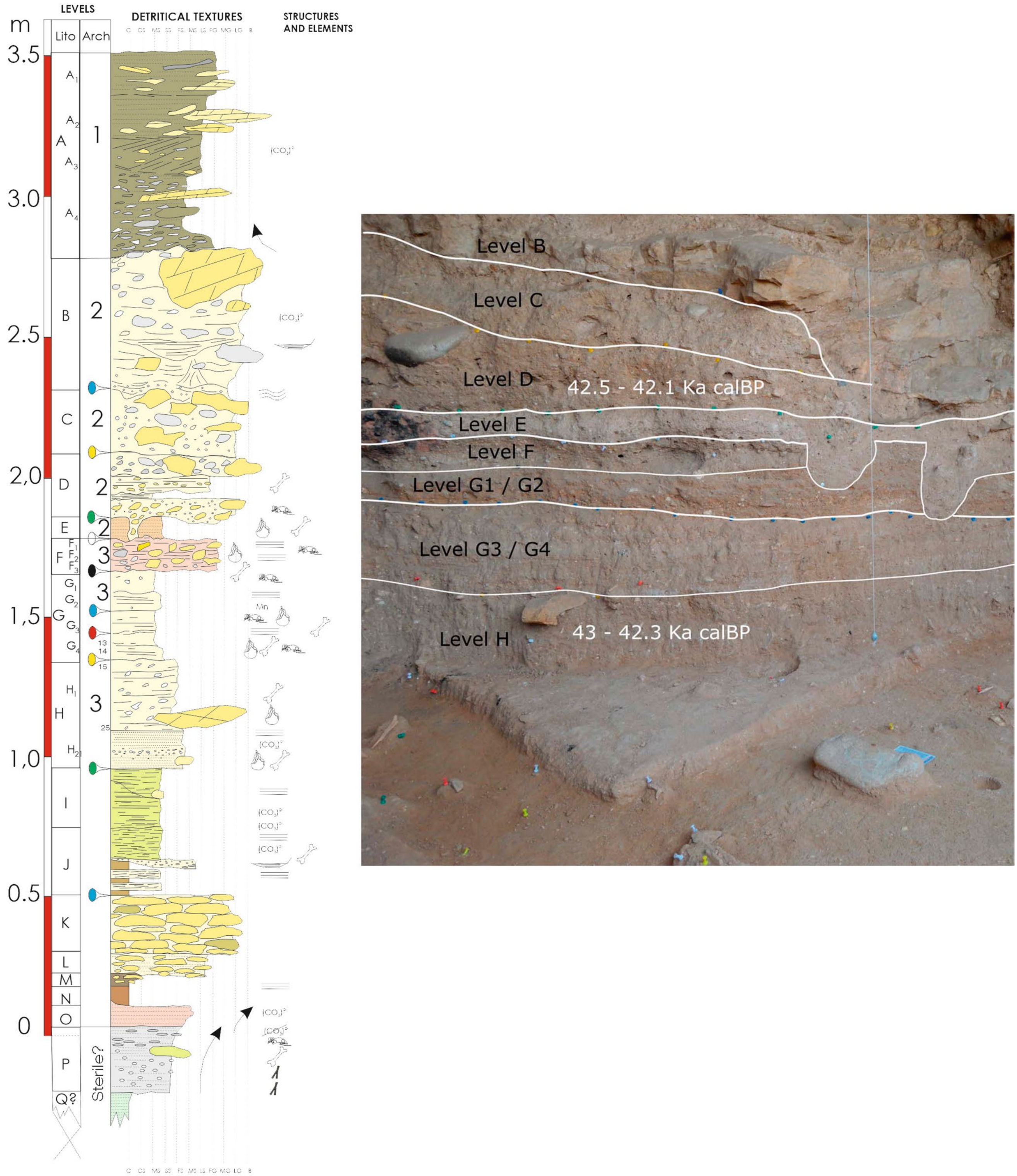

Fig. 4 Left. Litho-stratigraphic section at San Lázaro rock-shelter. Right. Stratigraphy of San Lázaro rock-shelter in which the pebble is visible in the foreground, before it was removed

a) Upper unit, on an unconformity above the two lower groups and formed by only the lithological Level A (between 20 and 30 cm of sand and silt with angular stones and boulders and rounded pebbles. It contains sub-levels of medium to coarse sand with less matrix. Inclined planar lamination; great bioturbation and high organic content).

b) Intermediate unit, on a natural para-conformity above the lower group and formed only by lithological Level B (between 41 and 56 cm of conglomerate of angular and rounded boulders and stones of different sizes, in two modes: dolostone boulders up to 47 cm long, and 1 to 10 cm pebbles of igneous and metamorphic rocks).

c) Lower unit, below the other two groups and formed by litho-stratigraphic levels C to P. This lower unit, the only one with Paleolithic occupation remains in situ (not disturbed), consists of 14 levels (Fig. 4).

The sedimentological interpretation of the units and levels is based on the sedimentary conditions and environments:

Upper unit, with an endokarst origin, formed by the insoluble residue of the sandy dolostone and dolomitic sandstone (sand and silt) moved by non-Newtonian hyperconcentrated flow (mud flows) in wet periods in local streams; greatly bio-disturbed with organic matter from troglobite and trogloxene organisms.

Intermediate unit, with a gravitational endokarst origin owing to the collapse and fall of rocks from the cave roof, either by them simply breaking off or by the collapse of a doline or shaft that formed a boulder cone inside the cave (Level B).

Lower unit, succession of deposits in an endokarst environment, with alternating and co-existing non-Newtonian hyperconcentrated flow of the mud flow or solifluction type: surface streams with low flow and depth from karst springs in wet periods; gravitational introduction of rocks broken off the roof and walls of the cave, especially near the rock-shelter entrances; exokarst deposits in paleo-flooding events (Level P) or introduced through caves and fissures in the karst from the overlying alluvial terraces of the Eresma River, which became mixed with the mud flows.

Level H, in which the pebble was found, is a 22 cm (with a maximum thickness of 23 cm) of fine sand and sandy-silt, with fragments of loose gravel and abundant macrofauna remains. In the lower part, a dolostone boulder is matrix-supported. Dry color: HUE 5Y 5/6. Upper boundary is flat and gradual. Grain size increases towards the top across the whole level, with a base of silty-sand (12 cm) and upper 10 cm with gravel. Massive, with no structures.

Regarding the techno-typological characterization of Level H, the lithic assemblage identified so far displays a predominance of Levallois and discoid reduction. Among the retouched elements, sidescrapers, denticulates and notches predominate, with a significant number of Mousterian points (Fig. 5).

Several ^{14}C-AMS dates have been obtained to contextualize the find chronologically, both for Level H itself and for one of the upper archeological strata, Level D. The results range from 43 ky cal BP for Level H to 42.5–42.1 ky cal BP for Level D, on samples of horse teeth. It should be noted that one of the samples from Level H, on charcoal, fell outside the range of ^{14}C, with an uncalibrated date of > 43.5 ky BP (Table 1).

Other Mousterian sites around

Primarily, the data from the immediate Mousterian context come from Abrigo del Molino rock-shelter (400 m far away from San Lázaro rock-shelther) which is located in ETRS89 coordinates (Zone 30) 40º 57′ 6,4’’ N, 4º 8′ 28,2’’ W, on the left bank of the Eresma River in its course round the city of Segovia (Fig. 2b). The site was discovered in 2012 completely filled by Pleistocene sediment. The excavations began in 2013 and continued during six seasons until 2018 (Álvarez-Alonso et al. 2013, 2018a, 2021; Álvarez-Alonso and Andrés-Herrero 2019; Kehl et al. 2018). Several barren levels were documented at the base of the stratigraphic sequence that were deposited in paleo-flooding events caused by large inundations of the Eresma River (Álvarez-Alonso et al. 2014) and which were dated by OSL to between 48,200 and 41,500 BP.

The human occupations were dated by two different techniques: OSL in the laboratories of the Universities of Cologne (Germany) and Sheffield (United Kingdom) and ^{14}C-AMS in the laboratories of the Universities of Cologne and Oxford (United Kingdom). Collagen was extracted from the radiocarbon samples following the method of Rethemeyer and colleagues (2013). Ultrafiltration was used for two samples (COL2715 and COL2716) but it was noted that the difference in the results of ultrafiltered and non-ultrafiltered samples was minimal (Fülöp et al. 2013).

The results obtained with the two dating methods (OSL and ^{14}C) coincide and overlap chronologically in some cases, and therefore the dates can be regarded as reliable (Kehl et al. 2017, 2018). The AMS ages of the archaeological Mousterian levels confirm that the two upper layers in the rock-shelter with human occupation, correspond to a period between 44.6 and 41.5 ky cal BP (Table 2).

Materials and methods

The object to be analyzed in detail is a quartz-rich granite pebble, with a sub-ellipsoidal-planar morphology (21.4 × 11.3 × 7.6 cm). On one of its faces, the pebble has three small cupules and at the center of these, positioned centrally relative to the three marks, a subcircular red dot is visible on its surface (Fig. 1).

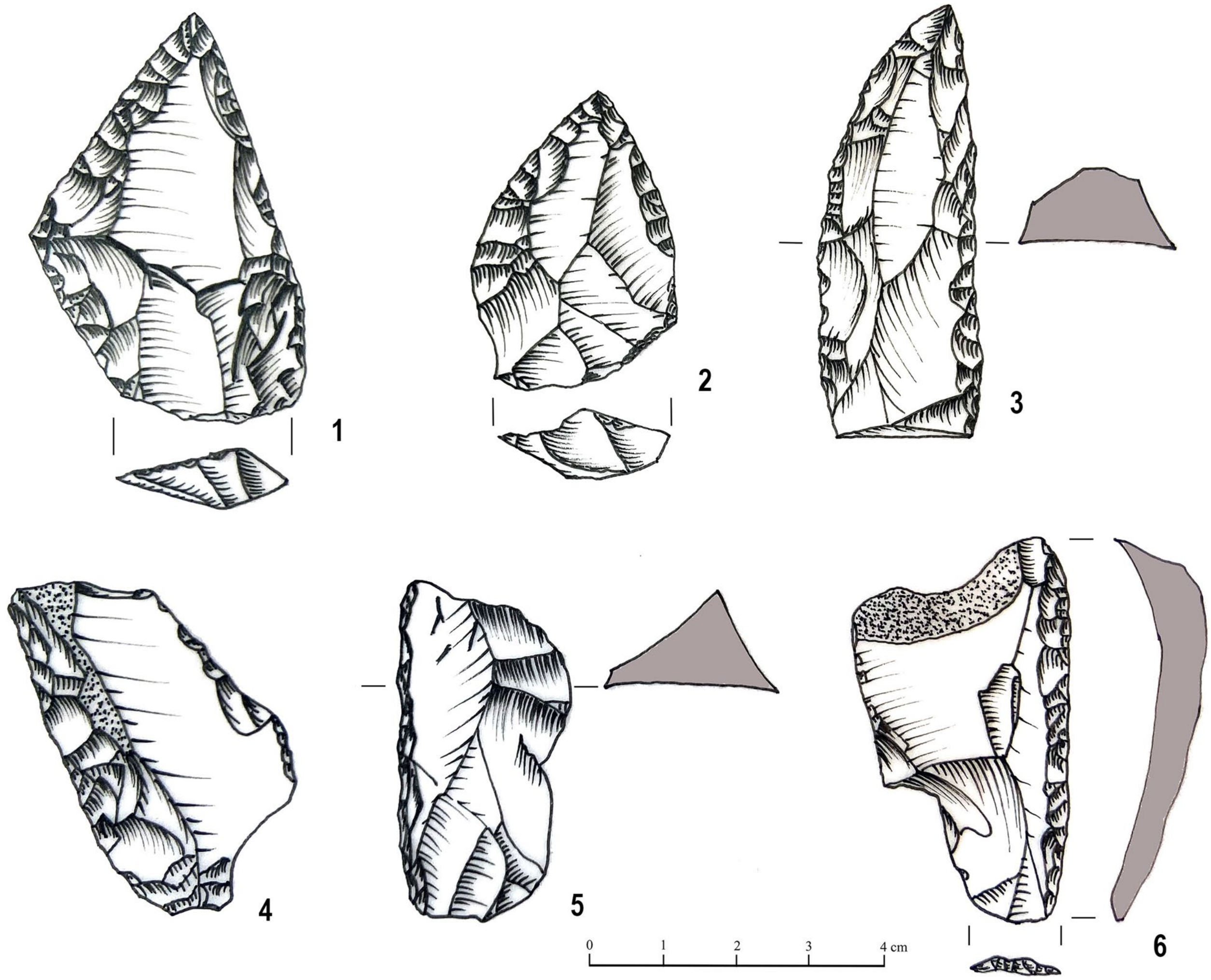

Fig. 5 Lithic remains from Level H. 1–2: Mousterian points; 3: convergent double scraper; 4–6: side scrapers

Table 1 Radiocarbon determinations at San Lázaro rock-shelter using IntCal 20 curve (Reimer et al. 2020)

Lab. code	Radiocarbon age	SD	2σ Calibration BP	Sample	Level	Z
Beta-635920	38,210	210	42,522—42,156	Dental collagen (Equus caballus)	D	920.186
Beta-422248	39,000	410	43,038—42,305	Dental collagen (Equus caballus)	H	919.873
Beta-658549	> 43,500			charcoal	H	919.862

Table 2 Radiocarbon determinations at Abrigo del Molino rock-shelter (Kehl et al. 2018) using IntCal 20 curve (Reimer et al. 2020)

Lab. code	Radiocarbon age	SD	2σ Calibration BP	Sample	Level	Z
COL2714.1.1	39,500	600	44,067—42,380	Bone	2 (D)	919.015
COL2715.1.1	38,600	500	42,955—42,115	Bone	2 (D)	918.910
COL2715.3.1*	40,700	600	44,625—42,895	Bone	2 (D)	918.910
COL2716.1.1	40,100	600	44,353—42,645	Bone	2 (D)	918.731
COL2716.3.1*	40,000	500	44,207—42,654	Bone	2 (D)	918.731
COL4018.1.1	39,900	400	44,046—42,656	Bone	3 (G)	918.438
COL4019.1.1	37,200	300	42,245—41,469	Bone	3 (G)	918.574
COL4021.1.1	40,200	400	44,196—42,821	Bone	3 (G)	918.460

*Ultrafiltration of collagen fraction.

3D scanner

For the 3D documentation of the site and the exact location of the archaeological artifact, multiple photographs were taken following a photogrammetric data capture protocol. These images were then processed with the open-source photogrammetric reconstruction software GRAPHOS (Integra Photographic Suite) to generate a 3D model and an orthophotograph of the area (Gonzalez-Aguilera et al. 2018) (Fig. 6). After the pebble was discovered, it was scanned with a David SLS-3 Scanner to obtain a 3D model, allowing for a detailed analysis of its characteristics and possible surface alterations resulting from use. Different scans of the artifact (with abundant overlap between scans) were taken with the calibrated instrument and subsequently merged to obtain the complete object (Fig. 7a). A detailed study of the marks on the artifact was carried out to evaluate them more precisely. For this purpose, different profiles of the Digital Surface Model (DSM) of the element were made for the three pits or cupules, and the contour lines of the DSM, and other measurements were obtained (See Supplementary material).

X-ray fluorescence spectroscopy (XRF)

Since it was impossible to fit the pebble, due to its size and shape, into a large laboratory XRF analyzer (with high resolution and accuracy), a handheld XRF analyzer had to be used; specifically, an Olympus VANTA M Series™ XRF analyzer by Innov-X Systems, Inc. belonging to the Geological and Mining Institute of Spain (IGME, CSIC). This model delivers fast and precise identification and analysis for elements from magnesium to uranium (Mg to U).

Several "shots" were taken to analyze different surfaces of the object, both the surface of the leucogranite clast

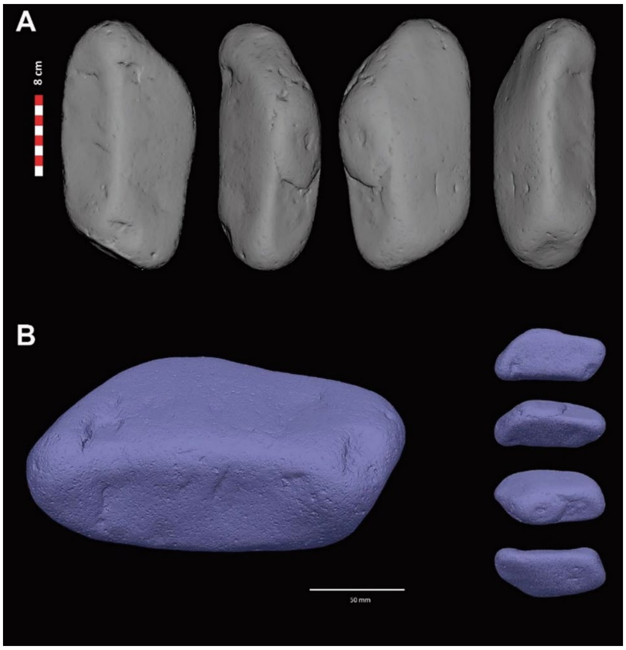

Fig. 7 **A**. 3D model of the untextured artefact obtained with David SLS-3 Scanner **B.** Mesh of the 3D model of the pebble, rendered with Agisoft Metashape. Laboratory of the Image Technology Section in the General Headquarters of the Forensic Police (Spain)

Fig. 6 Left, orthophoto of the excavation in the San Lázaro rock-shelter where the archaeological artefact was found. Right, image of the 3D model obtained for the documentation of the excavation

("leucogranite"), the quartz veins ("Q veins"), and the zone where the red dot appears.

Scanning electron microscopy (SEM)

Was used for the elemental composition and chemical characterization of the red dot. The SEM equipment belongs to the 'Geological Techniques Unit' in the 'Research Support Centre' (CAI, in Spanish) in the Earth Sciences and Archaeometry Laboratory at the Complutense University of Madrid (Spain).

Several micro-samples were taken from the edge of the red dot using a magnifying glass and sterilized tweezers, taking care to minimize damage to the element to be analyzed. Three micro-samples were selected using a digital microscope based on their suitable size and shape for SEM analysis, called upper and lower (1 and 2) sample zones (Fig. 8).

Prior to study, they were coated with gold (Cressington 108auto metallizer) to ensure good conductivity of the electron beam. The study was carried out with a Jeol JSM-820 microscope operating at 20 kV and equipped with Oxford EDX analysis. The sample was prepared on a cylindrical brass holder and fixed with double-sided carbon tape.

Multispectral analysis

This study was carried out in the Image Technology Section of the Central Unit of Operative Coordination at the General Headquarters of the Forensic Police (Madrid, Spain). The objective was to identify evidence of human manipulation, or to be precise, if a dermatoglyphic print existed in the red dot (Fig. 9) (See Supplementary material).

Dermatoglyphic analysis

The photographic image obtained with multispectral techniques was sent to the Central Identification Unit for its study by specialists in dermatoglyphic identification in the General Headquarters of the Forensic Police.

To verify if the observed image is compatible with a dermatoglyphic print, studies have shown that three markers should be assessed: 1) breadth of the epidermal ridge, 2) *minutiae*, and 3) ridge morphology (Králik et al. 2020) (see Supplementary material).

Results

Comparison with other pebbles found at the same level

Twenty-three pebbles of leucogranite and gneiss have been found in level H, most of them used as hammerstones, showing extensive evidence of percussion marks. These pebbles have been analyzed for comparison with the leucogranite pebble studied in this paper. All pebbles with traces of use as hammerstones are predominantly sub-rounded or small oval shapes, with none exceeding 11 cm in their longest axis. No other pebble displays traces or remains of ocher, nor do they have natural concavities or cupules (Supplementary material Fig. 25).

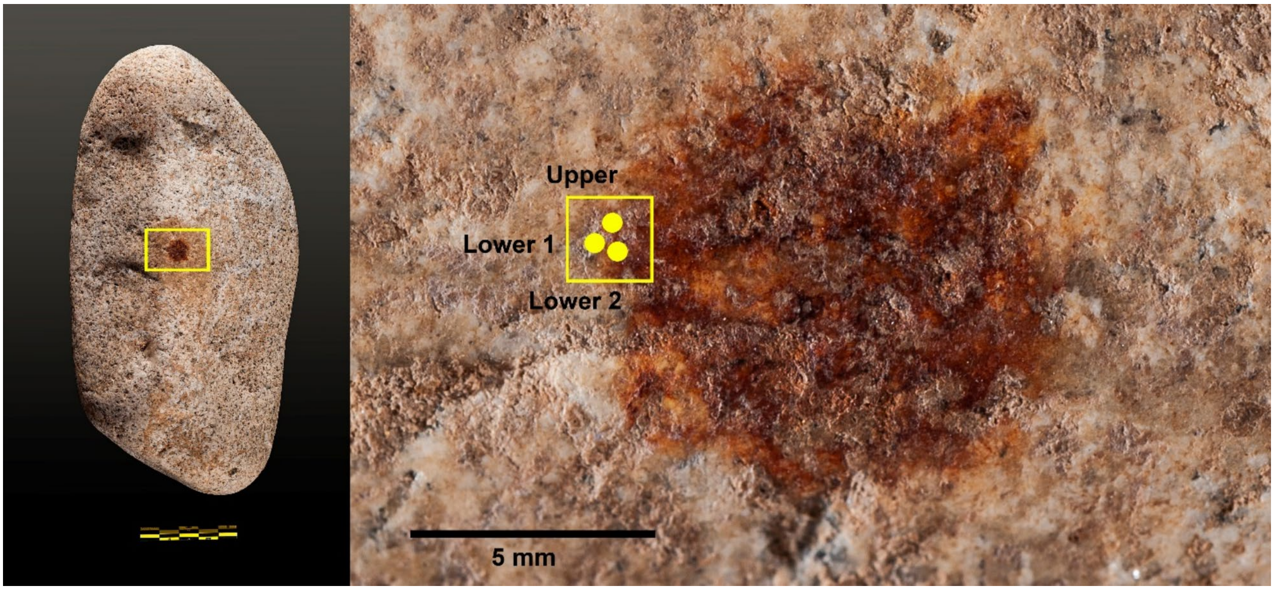

Fig. 8 Sample zones in the red dot. (Photos by Pedro A. Saura Ramos)

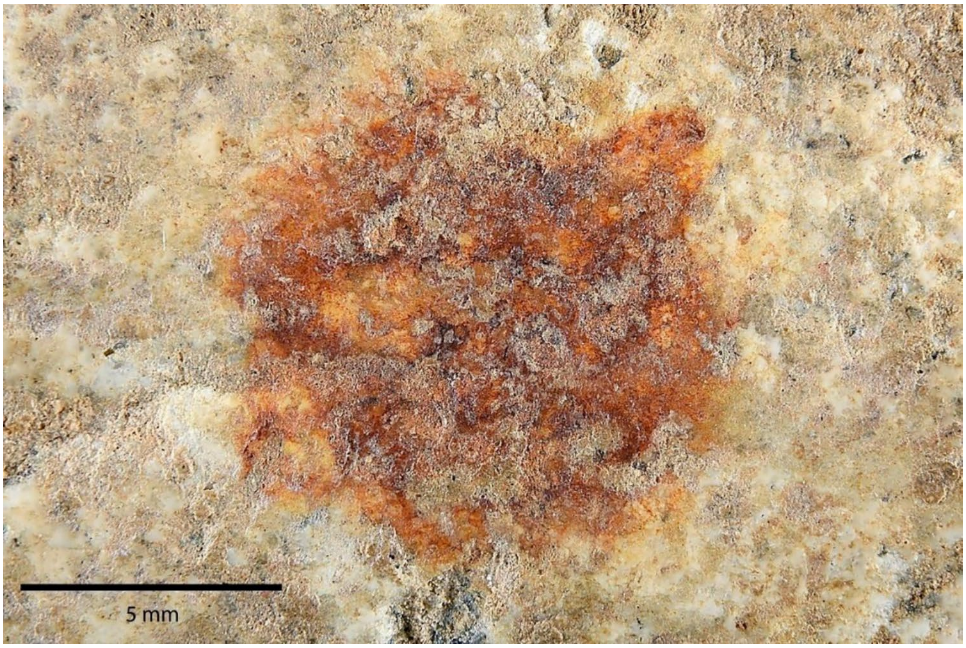

Fig. 9 Detail of the red dot obtained after using a photogrammetric process to document the pebble in 3D

The piece analyzed in this study (Fig. 1) is the largest pebble found in the level H, more than twice the size of the other pebbles (Supplementary material Fig. 25).

As observed (Supplementary material Fig. 26), the area with evidence of alteration (marked in red with the letter A) is far from any of the potential active zones that might indicate use as a hammerstone (zones B and C, marked in yellow, and even D). Based on the morphology of the pebble and the hammerstones documented at the same level, there does not appear to be a correlation between the marked area (A in red) and any potential hammerstone use that could explain this alteration.

The analysis of these other potential zones (B-C yellow) has not provided evidence of use as hammerstone similar to those identified on the other pebbles from level H (Supplementary material Fig. 26).

3D scanner results

In addition to the previous observations, both macroscopic analysis and 3D analysis of the surface discarded evidence of use, such as a hammerstone, anvil, or through abrasion, impact, etc. Both macroscopic observations with the naked eye and 3D model analysis revealed no evidence of any of these uses, and therefore, the possibility of its functional utilization was discarded.

A microtopography (Figs. 10a-b) showed that the profiles of the two smaller cupules were straight and very regular at their base (Fig. 10a) and therefore any human action that would have caused a more irregular profile was ruled out. These cupules are thus completely natural. In contrast, the third and largest cupule at the opposite end of the pebble has a more irregular profile, which is particularly evident in Sects. 2 and"3D scanner"(Fig. 10b), and appears less natural compared to the other two. Based on this analysis and macroscopic observation with a stereomicroscope (Supplementary material Fig. 26), and after a comparison between this area and the rest of the edge surface, it was suggested that this part of the pebble could had been modified, unlike the rest of the surface, which showed no similar evidence. This alteration, as previously indicated, does not seem to have been made with its use as a hammerstone. For this reason, the pebble was subjected to detailed multispectral analysis.

The 3D model also allowed measurements to be taken of the pebble surface in relation to the three cupules and the red dot. Although the position of the cupules on the pebble is natural, their arrangement is very particular as the measurements showed (Fig. 10c), because the two cupules at one end (Fig. 10a) are practically at identical distances from the third cupule (Fig. 10b). The red dot on the surface of the pebble is in an intermediate position relative to the cupules.

The analysis of the geometric relationships between the points (Fig. 10c) reveals several interesting aspects, such as the proportional relationship between the three cupules and the red dot (C). The distances A-C and B-C are nearly identical, suggesting that point C is almost equidistant from A and B, forming an almost isosceles triangle. Additionally, the distances A-D and B-D show an apparent symmetry. The proportions between the distances AC/AB and BC/AB are very similar, suggesting a logic of simple proportions, especially in relation to CD, which reinforces the hypothesis of an intentional placement of C to create symmetry and regularity in the arrangement (see supplementary material). It seems to have been placed intentionally to create a

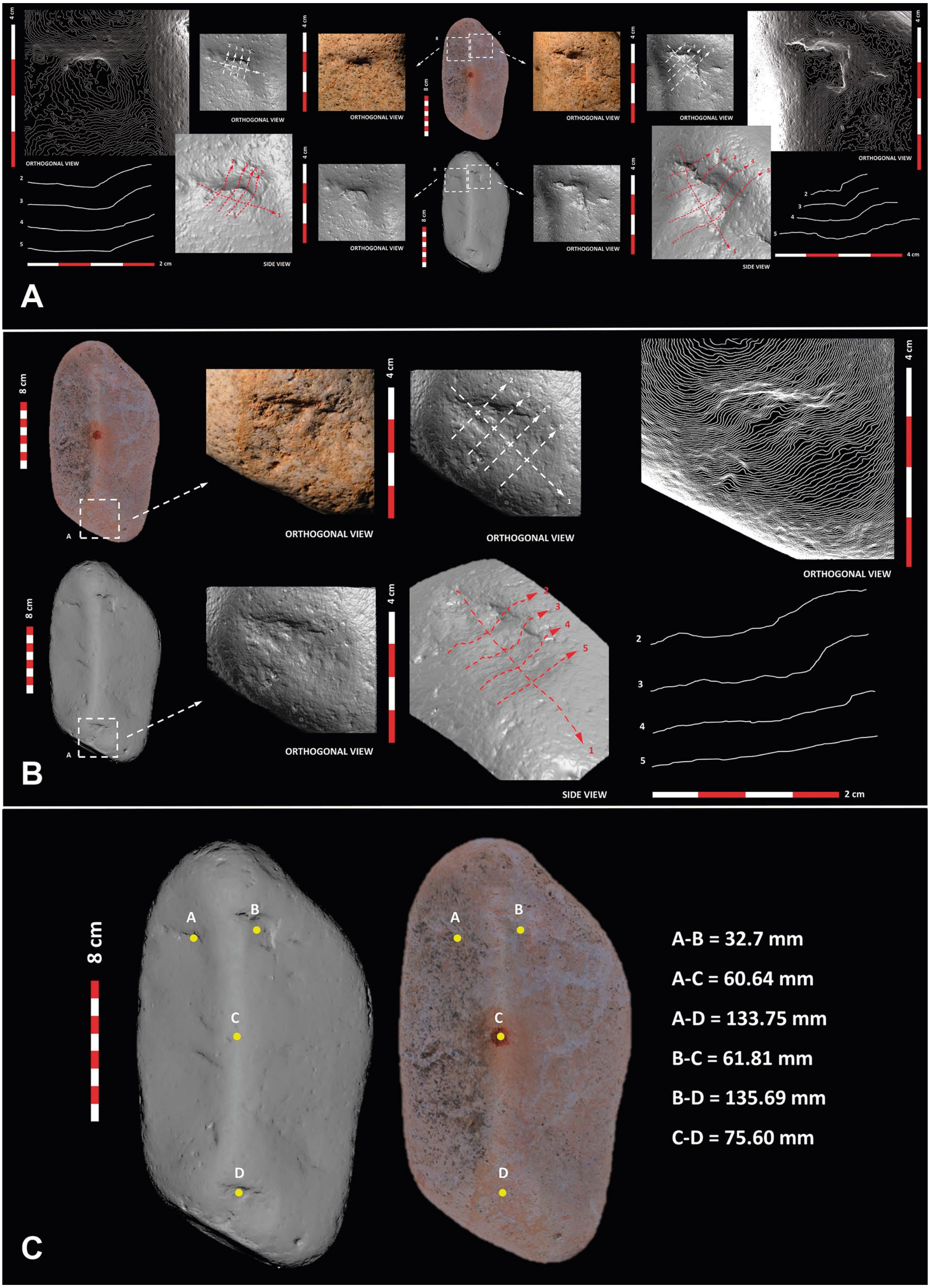

Fig. 10 **A**. Detail of the “eyes” área; **B.** Detail of the “mouth” área; **C.** Measurements of the distances between the three cupules and the red dot

composition by occupying a central position as regards the three cupules.

On the other hand, the results obtained through different statistical methods strongly suggest that the location of the red dot is not random. The Monte Carlo simulation indicates a probability of only 0,31% that a configuration of the red dot on the pebble, like the one we observed, would occur by chance. This result is supported by the Clark-Evans test and the analysis using Ripley's K function, both of which seem to suggest that the location of the red dot is likely intentional and not random (see supplementary material).

X-ray fluorescence spectroscopy results

This non-invasive analysis (see supplementary material) was a preliminary study to determine the nature of the red dot and to characterize the granite. It confirmed that, geochemically, the red dot was an anomaly and could be an addition. Consequently, SEM analysis was performed to establish the composition of red dot and determine if it might be a pigment.

SEM results

The results show that the samples of the red dot contain iron oxides and clay minerals, with no evidence of organic binders. Thus, it is an ocher added to the surface of the pebble. No significant amounts of (C) were found in any spot analysis, nor did the backscattered electron images (BSE) show the presence of C-rich pastes or waxes between the different particles (see Supplementary material Figs. 8–16, Tables 6–7).

Multiespectral results

The multispectral analysis carried out showed that the components present in the largest cupule reacted through photoluminescence in the infra-red region, while this luminescence was not observed in any other part of the pebble's surface (Supplementary material Fig. 1c) (Uzal 2019; Goicoechea-Telleria et al. 2019; Crowther 2022; Miralles-Mosquera et al. 2022).

Furthermore, following UV reflectography, it was possible to observe the absorbance reaction of chemical components exclusively located at the ocher dot. This reaction was not present in any other part of the pebble. To increase the contrast between the latent trace and the pebble's surface where it is located, the image was processed using RawTherapee software by applying different decorrelation algorithms through a remote sensing program.

The result was the identification of an image compatible with a dermatoglyphic print (Fig. 11). To confirm or refute this potential dermatoglyphic match, the image was analyzed

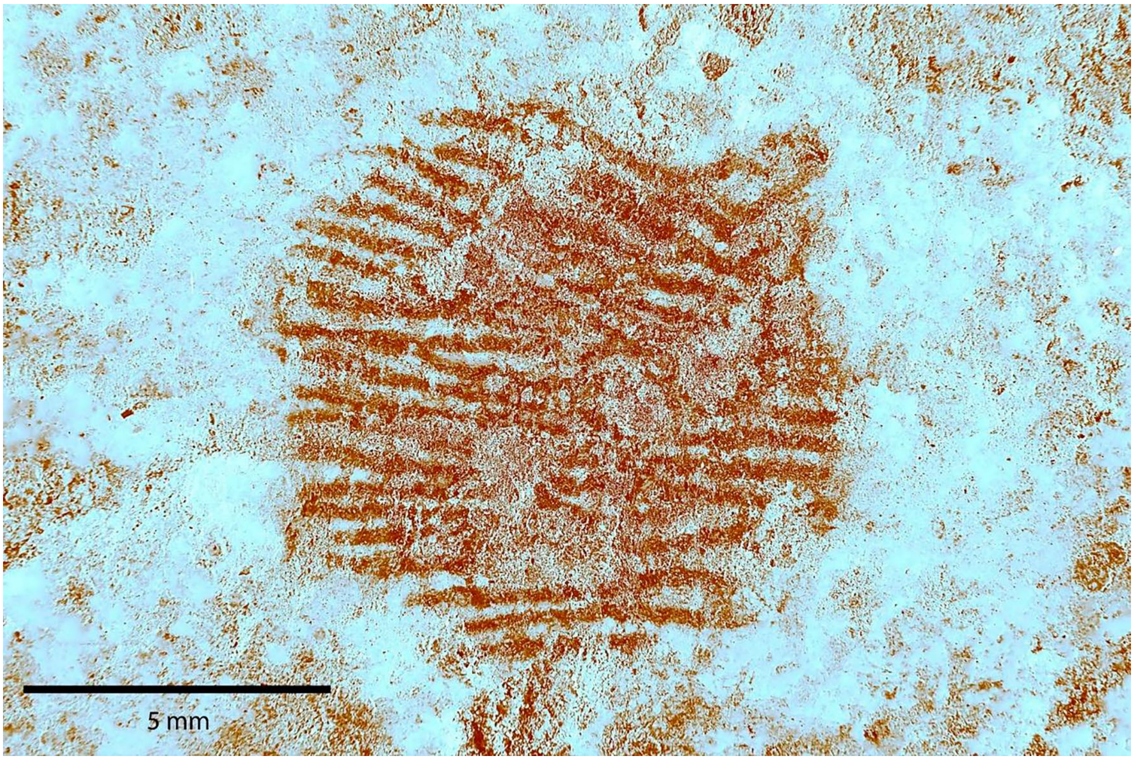

Fig. 11 Dermatoglyphic image obtained by the multispectral analysis of the red dot

in detail at the Central Identification Unit of the General Headquarters of the Forensic Police.

Dermatoglyphic results

Compatibility with a dermatoglyphic image has also been confirmed through ridge count and specific compatibility with the hand area after comparison with police databases (see Supplemetary material).

The photograph obtained using multispectral techniques shows a series of reddish lines separated from one another by white lines that follow the same direction (Fig. 11). These lines are more or less parallel and are irregular at the ends, as well as displaying deviations and other particularities (Suplemetary material Fig. 4).

The average width of the reddish lines is 0.48 mm, with minimum and maximum widths of 0.39 mm and 0.61 mm, respectively.

Two images (Suplementary material Figs. 17–18) show the characteristic identification points marked by specialists in the ABIS system. A total of 13 points were marked, of three kinds; six abrupt ends, two bifurcations and 5 convergences (terms used in the Specific Identification Procedure for the examination and comparison of dactylograms and chirograms in the General Headquarters of the Forensic Police) (see Supplementary material Fig. 19).

It can be observed that the morphology of the ridge is not perfectly smooth; both sides are irregular, which may be assimilated to the morphology described as pearling or beading. Fourteen ridges were counted on the diagonal line of the 25 mm^2 square drawn over the sample (Supplementary material Figs. 6 and 21).

The candidates that the ABIS system proposed, and which were used to make the graphic demonstrations possess *minutiae* compatible with those in the paleo-dermatoglyphic images. The coincidences have been found in different areas, both in the nuclear system of the distal phalanx of a finger (Fig. 12a) and in the palm (Fig. 12b). The coinciding points are shown in squares and numbered in the figures.

The morphological assessment of the image supplied by the Image Technology Section shows that its description agrees with the morphology and description of a fingerprint (see supplementary material).

Discussion

The object was found in litho-stratigraphic Level H (Fig. 4), a well-preserved *in-situ* Mousterian archeological context with abundant remains of Levallois lithic industry, Mousterian points and Quina sidescrapers (Fig. 5), as well as numerous faunal remains showing cut and percussion marks.

The pebble, sub-ellipsoid to parallelepiped in shape, consists of medium grain-size leucogranite (quartz-rich granite) (Supplementary material Tables 1–5) and was sourced from the alluvial deposits in the gravel bed of the Eresma River. Although leucogranite pebbles of this type are fluvial in origin and can be found in the current riverbed of the Eresma River, they are relatively uncommon in the immediate vicinity of the site. Among of all the main river basins and watersheds surrounding the archaeological site (Juncal-Nieves-Ciguiñuela, Eresma, Clamores, Tejadilla, Frío-Milanillos), most have a substratum composed of metamorphic rocks (gneisses and migmatites). Only the Eresma River flows transversally through quartz-rich granitoid dykes. In fact, about 5 kms upstream from the site, the Eresma River flows through several Variscan leucogranite dykes with an aplitic texture (known as ‘aplites’) with thickness ranging from a few decimetres to several metres. These dykes have been eroded in the Quaternary period, generating decimetric quartz-rich granite pebbles within the Eresma river’s alluvial deposits (Supplementary material Figs. 23–24). The presence of this type of pebble in the archeological layer is due to human selection and transport from the river to the rock-shelter, which was about + 10 or 8 m above the level of the river in MIS 3. San Lázaro rock-shelter is now + 15 m above the river, which has cut down during the Upper Pleistocene and Holocene. On the other hand, the archeological levels documented at the site are formed by endokarst detritic sediment and no evidence has been found in Levels D-H of depositional agents with sufficient energy to bring this pebble to the interior of the rock-shelter naturally at the time of the Mousterian occupation (Fig. 4). As we have seen, there are other pebbles of granite and gneiss brought to the site, showing unmistakable signs of use as hammers, but all with a different morphology and significantly smaller size (Supplementary material Fig. 25). This seems to indicate that the pebble presented here deviates from the pattern observed in level H regarding the use of pebbles in tasks such as lithic tool production or bone fracturing.

Finally, unlike the other pebbles found in Level H, no signs of its use as a hammerstone, anvil or any other evidence associated with lithic reduction have been found on it, nor any signs of abrasion. Therefore, this seems to have been a non-utilitarian object. After all the analyses conducted, we have not documented any marks on the surface of the stone that we could interpret as functional.

So, we should ask ourselves what the reason was for transporting this stone to the rock-shelter. It far exceeds the size of the documented hammerstones at the same level and shows no signs of use on any of its potential striking surfaces, which would suggest it was used as a hammerstone. In this case, we can indicate that the peculiarity of this pebble compared to the others is not only its above-average size but also that it is the only one in which ocher has been identified.

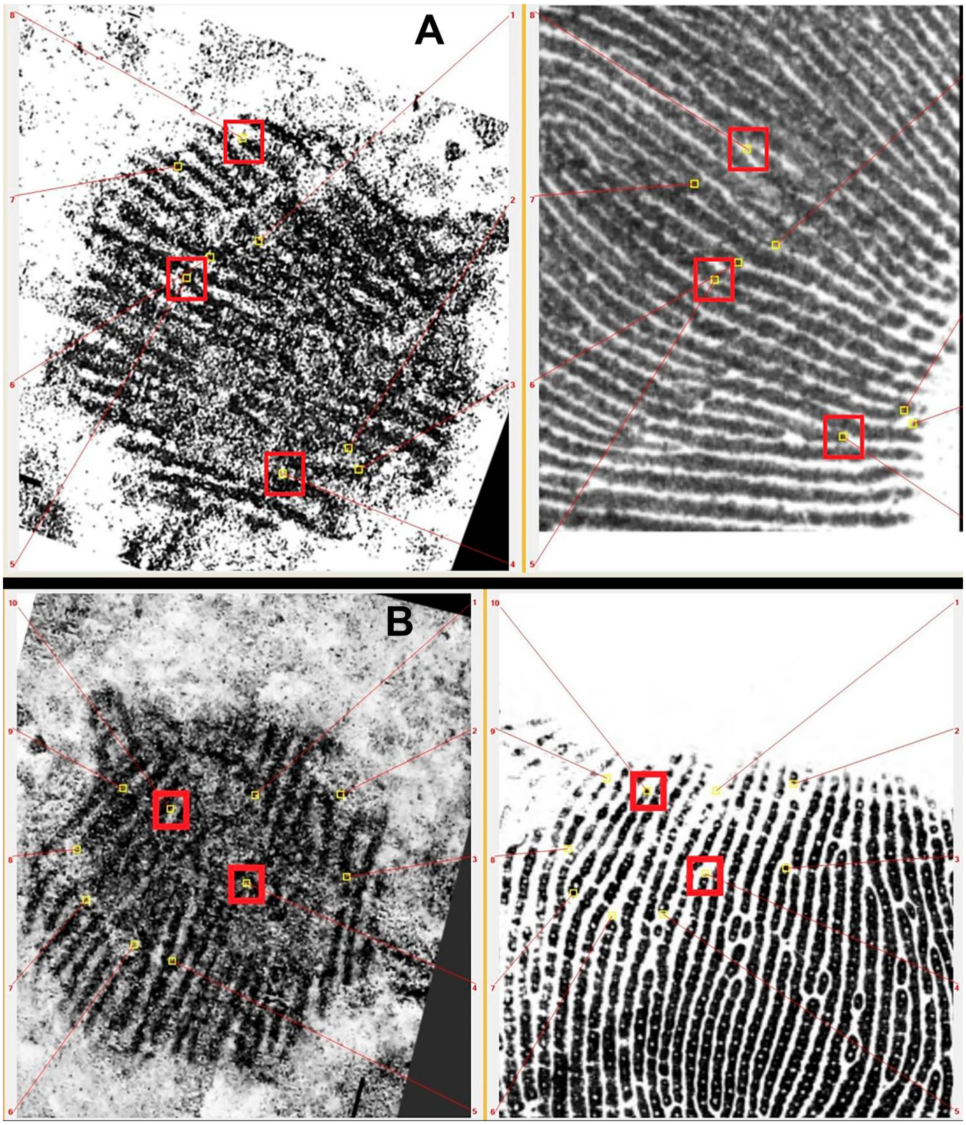

Fig. 12 **A**. Characteristic points detected by the ABIS system coinciding with the central part of a finger of a candidate. **B.** Characteristic points detected by the ABIS system coinciding with the palm of a candidate

Moreover, the ocher dot does not appear as a shapeless addition or a mere stain; rather, it contains a fingerprint that implies the pigment has been applied specifically with the tip of a finger soaked in pigment.

Based on this and considering the data obtained from various analyses, we can interpret this piece, for which two hypotheses could be considered. The following interpretations are presented as working hypotheses, compatible with the available data and open to discussion and future testing. They aim to explore one of several possible explanatory frameworks: A) the red dot is something casual or accidental, like when grasping or using the pebble; B) the red dot is the result of an intentional action and, therefore, premeditated.

In the first case, if we consider the red dot is the accidental result of using the pebble, for example as a hammerstone, when a person with ocher-stained hands might have inadvertently left a mark on the surface of the pebble, it should show signs of having been used as a hammerstone. As we have said, the pebble does not present marks like those we have identified on the other hammerstones found at the same level.

Additionally, in this case, it would be necessary to explain why there is only one fingerprint in a central position of the surface of the pebble, and there are no more fingerprints. We should find a satisfactory answer to explain why, if Neanderthal hands were stained with ocher, there are no more stains in the same pebble, especially when there is neither ocher inside the shelter, nor have we found ocher remains at the same level, nor in the immediate surroundings. This possibility is not supported by the statistical analyses, which assign a low likelihood to chance as the reason for the red dot's current position in relation to the three cupules.

The second possibility is that the red dot does not respond to an accidental circumstance and that it is the result of an intentional action. This hypothesis is primarily supported by the geometric and statistical analyses conducted on the position of the red dot. Furthermore, in this case, we must aim for the following evidence as indicated in the results analysis:

The pebble was collected in the river environment and transported to the interior of the rock-shelter. The pebble has three small natural pits or cupules on one of its faces which make it distinctive (Fig. 1a-b). A microtopographical analysis (Fig. 10a-b) revealed that the profiles of the two smaller cupules were straight and displayed a notably regular base (Fig. 10a), thereby excluding the possibility of human activity, which would likely have produced a more irregular profile. Conversely, the third and largest cupule, located at the opposite end of the pebble, displays a notably irregular profile, especially prominent in Sects. 2 and"3D scanner"(Fig. 10b), potentially indicating anthropogenic modification. Both the microtopographic and multispectral analyses carried out on the pebble surface show that at this point (Supplementary material Fig. 1c) a possible alteration was made to the pebble surface. On the other hand, the pebble is larger than other pebbles used and has a peculiar morphology. Could this have influenced the Neanderthal's selection of this piece?

In this instance, the presence of a red dot applied with a fingertip on the surface of the object, coupled with the absence of use marks typical of a hammerstone, suggests both a lack of functional purpose and a deliberate intent in marking the pebble with ocher. If we consider that the pebble is not a functional object, but that the red dot is indeed intentional, we have two main hypotheses to explain this circumstance:

A) The addition of the red dot is an intentional act but devoid of meaning. In this case, it would be an action lacking symbolic complexity, as there is no encoded message or meaning; B) The selection of this pebble and the addition of the red dot may have served a purpose unknown to us. In this case, it would imply the existence of a visual symbol with a specific meaning, which motivated this action. This would form the basis for accepting a symbolic purpose behind this act.

In Case A, before accepting this hypothesis, it would be necessary to explain why a pebble with this particular morphology and size was chosen, rather than any of the others present in the rock shelter. It seems that the characteristics of the piece play a significant role in its selection. Thus, a specific pebble has been selected and marked with a red dot, suggesting this choice was not random, as suggested by the observed geometric relationship. This pebble stands out due to its size, morphology, and surface characteristics (three cupules) compared to all others documented at level H. Additionally, it would be necessary to explain why there are no other pebbles with different morphologies featuring a red dot or simply impregnated with ocher. As shown in the results (Fig. 10), the red dot is not randomly located on the pebble but rather on the face that displays a particular peculiarity. For this reason, we propose that there is a relationship between morphology, the characteristics of the pebble's surface, and the location of the red dot. Could these circumstances occur without there being a motivation to carry it out? It seems possible that there is an intentionality in placing the red dot on a specific area, implying that there must be a reason and an explanation for this choice. Therefore, we propose the hypothesis that this action is the result of intentional planning. If there is action and planning involved, it cannot be ruled out that this might constitute a visual sign and, therefore, that a meaning or message exists, however simple the object and action may appear.

Following hypothesis B, the pebble has been intentionally selected due to its morphology, and the red dot has also been consciously and deliberately placed in its position. This is not random and appears to clearly reflect a deliberate action. If we accept that there is not only intentionality in placing a red dot with the finger on the piece but also a level of planning that entails selecting and transporting a specific pebble, this aligns with the minimum requirements for the creation of a visual symbol, an object that would convey a particular meaning or message through this action (Panofsky 1955; Leroi-Gourhan 1965; Hall 1966; Eco 1975). To this end, our approach is grounded in the following items: the pebble has been selected and transported; the pebble exhibits unique dimensions and characteristics, different from the other pebbles at the same level; there is a manipulation of the raw material; there is an intentional impression of pigment; the red dot is not placed randomly and there is a deliberate composition.

We propose that this may constitute a visual symbol, a composition potentially involving intentional creation, thereby conveying a specific motivation and, consequently, an inherent meaning. Thus, this object appears to meet several criteria often associated with symbolic artifacts, wherein intentionality, representational capacity, durability, and the transformation of raw material are well-established elements that justify considering such questions (Cassier 1957; Durand 1960; Eliade 1965; Noble and Davidson 1996; Mithen 1996; Clottes 2016). On the other hand, the presence of objects created or marked with ocher for symbolic purposes in the Paleolithic is associated with the notion of prehistoric art, these being among the earliest evidence of such non-figurative manifestations (Leroi-Gourhan 1965; Villaverde 2020: 168–169).

Thus, if we accept the intentionality and the nature of the object as a visual symbol, we must turn our attention back to the selection of the pebble, where its characteristics have played an important role. Could the morphology of the piece, with the presence of three cupules on the same surface and the positioning of the red dot in relation to them, represent a composition explained by the phenomenon of pareidolia? Pareidolia is a phenomenon widely recognized in the Paleolithic (Lorbranchet 1999; d'Errico and Nowell 2000; Azéma and Rivère 2012; Bednarik 2016; Taubert et al. 2017; Wisher et al. 2024). Furthermore, could this be a representation or abstraction of a human face in this case? like other similar objects that have been associated with faces, masks or figurines (Dart 1975; d'Errico and Nowell 2000; Marquet and Lorblanchet 2003; Pettitt 2003; Marquet et al. 2016). This is because the pebble could resemble a human face, with eyes, a mouth, and a ridge shaped like a nose. This is the hypothesis we propose as a possible interpretation for the selection of the pebble and its transformation into a visual symbol through the application of the red dot.

Pareidolia refers to a well-known psychological process through which the human mind identifies familiar patterns, such as faces or figures (Kahlbaum 1866; Arnheim 1954; Rock 1983; Sagan 1995). When the phenomenon involves the identification of faces in inanimate objects, it has specifically been known as Face Pareidolia for the past few years and has been widely studied. From a neurocognitive perspective, it appears that the brain employs pre-existing facial recognition patterns when interpreting ambiguous objects, thereby generating what are known as"false positives". This is because the human brain is highly specialized in facial recognition, even in stimuli that only partially contains features associated with faces, such as symmetry, the arrangement of the eyes, or the presence of a nose or mouth. In this context, face recognition is interpreted as an essential evolutionary strategy for survival, with facial pareidolia emerging as a product of a visual system oriented toward pattern recognition -especially of faces- resulting in an automatic tendency to perceive and identify faces where none exist (Kanwisher et al. 1997; Rieth et al. 2011; Liu et al. 2014; Kato and Mugitani 2015; Wardle et al. 2020; Zhou and Meng 2020). Studies with non-human primates suggest that pareidolia is a widely distributed phenomenon among primates and may have evolved progressively, ultimately becoming common in modern humans (Caruana and Seymour 2022; Romagnano et al. 2024). Although all studies conducted provide evidence of facial recognition in objects by non-human primates, differences in cognitive processing compared to humans appear to underscore the evolutionary nature of this phenomenon (Taubert et al. 2017, 2022; Tomonaga and Kawakami 2023). For this reason, we cannot exclude the possibility that both *Homo sapiens* and *Homo neanderthalensis* possessed similar capacities for interpreting Face Pareidolia.

Does the piece under study correspond to the phenomenon of Face Pareidolia? Is it a representation of a face? There are grounds to suspect so; however, it is important to consider that, as an object over 40,000 years old interpreted from our present-day perspective, it is unlikely that all doubts surrounding this hypothesis can be fully dispelled. The pareidolia hypothesis is introduced not as a definitive claim, but as a possible cognitive mechanism guiding the perception or selection of the pigment-marked surface. This interpretation is grounded in the spatial arrangement analysis and discussed in relation to analogous phenomena documented in modern human cognition. Nevertheless, as with all previously cited cases of this nature, it remains a compelling working hypothesis.

Conclusions

The disappearance of the Neanderthals in the Iberian Peninsula took place from north to south, beginning at the end of the Mousterian in the north in about 45 ky cal BP (Higham et al. 2014). It continued in inland Iberia in about 44 to 42 ky cal BP (Alcaraz-Castaño et al. 2017; Kehl et al. 2018) in a context in which the first evidence of anatomically modern humans occurs after a hiatus, several thousands of years later than in the north or on the Mediterranean coast (Alcaraz-Castaño et al. 2021). Archaeological and chronological data from the interior of the peninsula currently rule out the possibility of the superposition, continuity or mixing between Mousterian levels and Early Upper Paleolithic levels produced by *Homo sapie*ns (such as the Aurignacian technocomplex). Those circumstances have not been observed at any known site in the area of study, because the first *Homo sapiens* arrived thousands of years after the Neanderthals disappeared (Mallol et al. 2012; Alcaraz-Castaño et al. 2017, 2021; Álvarez-Alonso et al. 2018a, 2018b, 2024; Kehl et al. 2018; Aubry et al. 2020; Cascalheira et al. 2021; Klein et al. 2023; Sala et al. 2024).

Consequently, in addition to its association with a level containing undeniably Mousterian remains, there can be no possible doubt about either the archaeological context or the Neanderthal production of all the material evidence found in Level H at San Lázaro rock-shelter; unless anyone should question that Neanderthals were the only creators of the Mousterian technocomplex in the Iberian Peninsula.

The pebble from San Lázaro rock-shelter presents a series of characteristics that render it exceptional, based on which we have deemed it a visual symbol that could be considered a piece of portable art in some contexts. We use the term 'portable art' here in the broad archaeological sense, referring to deliberately modified or marked objects with possible symbolic significance, rather than implying figurative representation or aesthetic intention. In this sense, several circumstances make the object quite singular: a) it was found in a level formed by a human occupation; b) it was brought to the rock-shelter deliberately; c) the pebble was found with the cupules and ocher dot upwards (Fig. 6); d) an ocher dot was painted on its surface (Figs. 1, 8–9); e) a dermatoglyphic image was identified in the ocher dot (Fig. 11; Fig. 4 Supplementary material). The pebble was indisputably handled by a Neanderthal, and the print could possible correspond to an adult male, considering that, although there is no record of Neanderthal fingerprints in modern forensic databases, it is likely that morphological characteristics—such as size, stature, and robustness—which show significant variability in contemporary populations, do not differ substantially from those observed in Pleistocene populations of *Homo sapiens* and Neanderthals.

Finally, the fact that the pebble was selected because of its appearance and then marked with ocher shows that there was a human mind capable of symbolizing, imagining, idealizing and projecting his or her thoughts on an object. Furthermore, in this case, we can propose that three fundamental cognitive processes are involved in creating art: the mental conception of an image, deliberate communication, and the attribution of meaning. These are the basic elements characterizing symbolism and, also prehistoric -nonfigurative- art. Furthermore, this pebble could thus represent one of the oldest known abstractions of a human face in the prehistoric record, according to the hypothesis of Face Pareidolia.

Regarding the San Lázaro paleodermatoglyphic print, it should be noted that this is not the first Neanderthal fingerprint to be identified. One of the two resin remains from Königsaue, discovered in 1963, exhibits a partial fingerprint made by impression on the resin, in an utilitarian context. The chronology remains somewhat unclear, as despite being assigned an age of over 80 Ka (Mania and Toepfer 1973; Koller et al. 2001) different AMS datings give a minimum age of approximately 43 Ka cal BP (Hedges et al. 1998; Grünberg 2002). This fingerprint was studied at the State Police Department in Magdeburg (Germany) and although it was probably made with the edge of a thumb, there is no more details about it (Grünberg 2002). This circumstance makes the data presented here as the one of the two oldest known information about a Neanderthal human fingerprint, and the oldest obtained in association with a pigment.

Neanderthal symbolic behavior has been documented on objects manipulated anthropically and even in both portable and parietal representations. These range from the painted depictions in the caves of La Pasiega, Ardales and Maltravieso (Hoffmann et al. 2018a), engravings in Gorham's Cave (Rodríguez-Vidal et al. 2014) and the motifs on an osseous object from Einhornhöhle (Leder et al. 2021), among other singular objects from a Europe occupied by Neanderthals. Bones with non-functional marks at La Ferrassie, Pešturina and Zaskalnaya VI (Majkić et al. 2017, 2018b); the evidence of shells with ocher in Cueva de los Aviones and Cueva Antón (Zilhão et al. 2010; Hoffmann et al. 2018b); the probable use of pigments in the caves of Pech de l'Azé, Cisarei and Scladina (Soressi and d'Errico 2007; Cârciumaru et al. 2015; Bonjean et al. 2015); cutmarks on eagle talons and the use of feathers probably as adornments in the caves of Fumane and Krapina (Peresani et al. 2011; Radovčić et al. 2015); the engraved pebble from Axlor and the engraved stone from Kiik Koba (García-Diez et al. 2013; Majkić et al. 2018a); and other examples of motifs on portable objects older than the Upper Paleolithic (Mellars 1995; García-Diez and Ochoa 2020) complete this wide array of evidence of symbolic behavior in Neanderthal populations.

This evidence is varied, diverse and increasingly apparent. The pebble from San Lázaro, by comparison with many other Upper Paleolithic cases, could similarly be described as a portable art object. Few or no doubts are expressed about the existence of symbolic behavior in Neanderthals (d'Errico et al. 2003; Zilhão 2007, 2011, 2012, 2020; Jaubert et al. 2022), although their artistic capacity has been the subject of controversies (Aubert et al. 2018; White et al. 2020; Hoffmann et al. 2020). The existence of art made by Neanderthals, obviously different from that of Upper Paleolithic populations and not figurative (Rodríguez-Vidal et al. 2014; Hoffmann et al. 2018a; García-Diez and Ochoa 2020; Villaverde 2020; Marquet et al. 2023), should similarly not raise any doubts. This finding represent a new example of Neanderthal symbolic object in the Iberian Peninsula.

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Declarations

Competing interests The authors declare no competing interests.

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