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RESEARCH

Symbolic Use of Clay Before Pottery: Insights from the Palaeolithic Rock Art Site of Cova Dones (Eastern Iberia)

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Abstract

The use of clay for symbolic or ritual activities can be confidently traced back to the Palaeolithic. One of the earliest documented examples is the presence of clay-based paintings at European Upper Palaeolithic cave sites. However, references to such artworks are scarce, and almost no attention has been given to the study of their technical and graphic characteristics. The recent discovery of Cova Dones (Spain), which contains nearly a hundred clay-painted motifs, has enabled us to analyse previously unexplored aspects of this rock art. In this article, we reconstruct the *chaîne opératoire* of these motifs and establish a typology of their various states based on taphonomic alterations. Our aim is to compile, define, and present a series of evidence that can be identified as Palaeolithic clay paintings or associated with different phases of their *chaîne opératoire* based on the rich graphic record of Cova Dones. This catalogue is intended to assist archaeologists in identifying this type of evidence in other cave sites.

Keywords Upper Palaeolithic · Rock art · Clay paintings · Chaîne opératoire · Techniques · Taphonomy

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Introduction

The use of clay in symbolic activities is well recognised in the archaeological record. Prior to the invention of ceramic pottery by hunter-gatherers in East Asia (Boaretto et al., 2009; Cohen et al., 2017; Kuzmin, 2017; Yanshina, 2017), ceramic technology was employed for creating figurines (Bougard, 2010; Farbstein & Davies, 2017). To date, more than 13,000 ceramic fragments have been found at Upper Palaeolithic ('UP') in Europe and in North African Late Stone Age sites (Farbstein, 2023). These finds are relatively rare, as they imply the development of ceramic technology (*i.e.* 'clay that has been fashioned into a desired shape & dried to reduce its water content before being fired or baked to fix its form'; Darvill, 2002), which has allowed their preservation.

The preservation of non-ceramic UP material culture, crafted from or made on clay, is exceptional, due to the inherent properties of the raw material itself. The conditions necessary for preserving these elements include drying after shaping/manipulation and protection from natural elements, as well as human and animal aggressions. It is unsurprising that the majority of such evidence is found in deep caves, where it has been better protected over time. However, what may be less obvious is that most of these artefacts bear a graphic and symbolic character within the context of Palaeolithic Rock Art ('PRA').

Research in PRA has undergone crucial transformations in recent decades, shifting from a subjective search for the ultimate meanings of artworks to a holistic study of the archaeology of deep caves, based on the analysis of the Internal Archaeological Context (henceforth 'IAC') of PRA (Clottes, 1993). Through this approach, all evidence related to explorations and activities undertaken by prehistoric individuals in deep-cave areas is documented and analysed, resulting in an integrated understanding of the use of these particular environments (Medina-Alcaide et al., 2018). In several cases, this has enabled the reconstruction of actions associated with the creation of PRA and other–allegedly—symbolic activities, such as depositing objects on walls (for a compilation, see Peyroux, 2012) or constructing structures (*e.g.* Arias, 2009; Delannoy et al., 2012; Jaubert et al., 2020).

While general knowledge of PRA has significantly benefitted from this paradigm shift, its development remains an ongoing process, with specific contributions further advancing towards the development of its full potential. In this context, this paper targets the particularities of Upper Palaeolithic (UP) clay paintings. The ubiquitous presence and ease of extraction of clay in limestone caves contrast starkly with the limited number of documented UP clay paintings in the archaeological record. We propose that this discrepancy may be linked to difficulties in identifying clay paintings in varying states of preservation. Consequently, questions surrounding their typology and the technical processes involved in their creation may not have been thoroughly addressed. The recent discovery of Cova Dones (Spain), containing almost one hundred UP clay paintings (Ruiz-Redondo et al., 2023), provides an exceptional opportunity for study. This site has enabled the documentation of these artworks in different states of preservation and facilitated the reconstruction of some aspects of the technical process behind their creation.

This paper is structured to establish a basis for future research on UP clay paintings. First, we compile examples of non-ceramic UP symbolic elements featuring clay as a primary material, aiming to be exhaustive for clay paintings in PRA. This will establish the archaeological framework for these artworks. Next, we present our research on the clay paintings of Cova Dones, focusing on two key aspects of these archaeological remains: (1) a definition of their *chaîne opératoire* and (2) the different states of preservation resulting from taphonomic processes, with particular emphasis on elements that may still be found in archaeological sites. Our goal is to provide examples of archaeological evidence linked to the creation and degradation processes of clay paintings, facilitating their identification in different states of execution or preservation in new or previously studied PRA sites.

An Overview of the Upper Palaeolithic Symbolic Use of Clay

Excluding ceramic artefacts, three types of Palaeolithic symbolic elements featuring clay as a principal element can be identified: (1) sculptures and bas-reliefs modelled in clay, (2) engravings on clay surfaces, and (3) paintings using clay as a pigment. We will aim to provide the earliest references for each site discussed in the following sections.

- *Sculptures and bas-reliefs modelled in clay.* The first type is the least frequent; however, clay sculptures have been documented since the early twentieth century. In 1912, François Camel, Max and Louis Bégouën explored the upper galleries of the flooded cave of Tuc d'Audoubert (Ariège, France). Among hundreds of other remains from the Magdalenian period, they discovered clay sculptures of two bison (Bégouën, 1912). These were the first objects of this type ever identified and remain masterpieces of their kind. Subsequent research reconstructed the process of their creation, revealing that they were modelled from single clay plates and even determining the origin of these plates (Bégouën et al., 2009). Despite being exceptional, the practice of modelling clay to create sculptures and bas-reliefs has been documented at other sites in the French Pyrenees, such as Bédeilhac (Bégouën, 1932), Montespan (Bégouën, 1923; Trombe & Dubuc, 1947), Labouïche (Méroc, 1959), Labastide (Clottes, 1977), and Erberua (Larribau & Prudhomme, 1989). Recently, a site with clay-modelled bas-reliefs was identified on the southern side of the Pyrenees at Aitzbitarte IV (Garate et al., 2020) and in northern Italy at Grotta della Bàsura (Sigari, 2022), extending the geographical scope of this phenomenon while confirming its regional character. The only known exception to this restricted geographical distribution is a bas-relief of a bison at La Calévie, Dordogne (Aujoulat, 1984). Tragically destroyed in 1983, this figure, although modelled on a clay surface, may be related to the UP bas-relief tradition of the area.

- *Engravings on clay surfaces.* The second category encompasses engravings on both walls and floors, created either with tools or directly with fingers ('finger flutings'). The latter are among the most common motifs in PRA, spanning a broad geographical and chronological range (for a compilation, see Bougard, 2010: 3–4). Most are non-figurative, consisting primarily of isolated or clustered straight lines and meanders, which are the most typical forms. For these, Sharpe and Van Gelder

(2006a) proposed a simple typology, defining four forms by combining two variables: the number of fingers used and the movement of the 'fluter' during execution. While some claims made by the authors regarding the information that can be derived from analysing these 'finger flutings' may be exaggerated (Sharpe & Van Gelder, 2006a: 292; Sharpe & Van Gelder, 2006b), their typology remains a useful tool for classifying these motifs. The use of various tools (*e.g.* lithic, vegetal, or bone) to create engravings on clay surfaces is also extremely common and is sometimes combined with 'finger flutings' to produce images. Unlike the latter, tool-based engravings have not received specific attention but have generally been studied in the same manner as other PRA engravings made on different mineral supports (*e.g.* limestone, calcite). Beyond technique, these motifs can also be categorised by their iconography, with the classic division between non-figurative and figurative motifs. While non-figurative engravings are by far the most frequent, there are numerous assemblages with figurative motifs created using this technique. Considering that the list of sites is very extensive and this kind of motifs is not the topic of our research, here we will mention only some of the most emblematic examples: Gargas (Cartailhac & Breuil, 1907: 216), Niaux (Cartailhac & Breuil, 1907: 221), Altamira (Alcalde del Río et al., 1911), Pech-Merle (Lemozi, 1929), Rouffignac (Nougier & Robert, 1959), Las Chimeneas (González Echegaray, 1963), and Chauvet (Chauvet et al., 1995). It should also be noted that engravings preserved on floors are scarce but can be found in areas not frequently accessed by human visitors (*e.g.* Groenen, 2012; Garate & Bourrillon, 2017). This scarcity suggests that such engravings were likely far more numerous in the PRA but have been lost due to human exploration and natural sedimentation processes. While the plasticity of clay was undoubtedly exploited by UP artists, this same characteristic has hindered the preservation of many artworks created on it.

- *Paintings using clay as a pigment.* Although much less known than paintings and drawings created with ochre, charcoal, or manganese, Palaeolithic clay paintings have been documented at several PRA cave sites. At least 18 such assemblages attest to the existence of clay paintings. Their geographic distribution is extensive, encompassing sites from Pays de la Loire in France to Andalucía in Spain (Fig. 1): Mayenne-Sciences (Pigeaud, 2002), Rouffignac (Plassard, 1999; Plassard et al., 2021), Lascaux (Leroi-Gourhan & Allain, 1979), Bernifal (Plassard, 2005), Chauvet (Clottes, 2010: 138–139), La Baume-Latrone (Bégouën, 1941), Cosquer (Clottes et al., 2005), Le Portel (Breuil & Jeannel, 1955), Bédeilhac (Bégouën, 1932), Labastide (Clottes, 1977), Etxeberri (Garate & Bourrillon, 2018), Erberua (Larribau & Prudhomme, 1989), La Pasiega (Garate, 2010), Los Casares (Triguero, 2023), Cova Dones (Ruiz-Redondo et al., 2023), Higuerón (Cantalejo et al., 2007), Ardales (Cantalejo et al., 2006), and La Pileta (Breuil et al., 1915). The chronological distribution of these clay paintings is equally wide, spanning the entirety of the UP, from the Aurignacian (*e.g.* La Baume-Latrone, Chauvet) to the Late Magdalenian (*e.g.* Bédeilhac, Etxeberri). The technical and formal variability of these paintings is comparable to that observed in clay engravings: both non-figurative and figurative motifs are documented, with pigments applied using fingers, palms, or tools. This extensive chronology—covering the entire UP—and wide geographical range, including much of the 'cynosure of PRA' (Ruiz-Redondo, 2024), indicates the

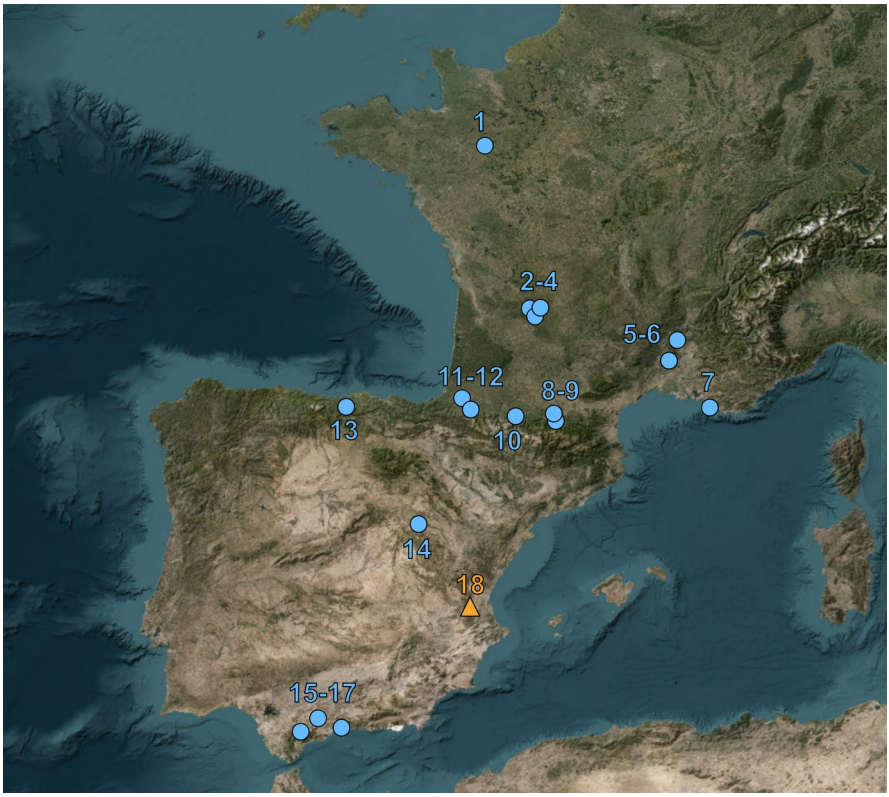

Fig. 1 Cave sites where upper palaeolithic clay paintings have been documented: (1) Mayenne-Sciences, (2) Rouffignac, (3) Lascaux, (4) Bernifal, (5) Chauvet, (6) La Baume-Latrone, (7) Cosquer, (8) Le Portel, (9) Bédeilhac, (10) Labastide, (11) Erberua, (12) Etxeberri, (13) La Pasiega, (14) Los Casares, (15) La Pileta, (16) Ardales, (17) Higuerón, and (18) Cova Dones

widespread occurrence of this phenomenon. Considering this and the easy availability of clay to UP societies, why do only 18 decorated sites among over 400 known in Europe feature clay paintings? Possible explanations must consider factors such as preservation issues, research bias, and maybe other yet unidentified causes.

A Case of Study: Cova Dones

The Prehistoric Site of Cova Dones

The site consists of a single-gallery cave, approximately 500 m deep, that opens onto a steep canyon in the municipality of Millares (Valencia, Spain; UTM coordinates: 30S 692764X 4338785Y, 399 m AMSL) (Fig. 1). Cova Dones is a cave with recurrent use throughout history. The earliest written reference to its existence and frequentation dates back to the eighteenth century (Cavanilles, 1797). It became

known as an archaeological site in the 1960 s due to the discovery of Iron Age materials, which led to its inclusion in the group of so-called 'Iberian cave-sanctuaries' (Aparicio, 1976). Among the materials found are also fragments of Neolithic pottery (Donat, 1969), and recently, our team has discovered, in a chamber located more than 200 m deep, dozens of Roman inscriptions, accompanied by materials from this period, among which it highlights a coin from the first century AD (forthcoming). However, the most significant archaeological discovery was the finding, in 2021, of an exceptional Palaeolithic rock art ensemble (Ruiz-Redondo et al., 2023). This currently includes more than 120 graphical units (henceforth 'GUs') indirectly dated to over 24 ka cal BP. This chronological approach was established through a combination of stylistic analogies and the observation that a claw mark made by a cave bear overlaps some of the GUs. Consequently, we set the minimum age for some of the artworks at the currently known extinction date of that species, approximately 24 ka cal BP (Terlato et al., 2018). The iconography includes figurative representations (horses, deers, bovids) and complex geometric signs, and from a technical perspective, the rock art ensemble features GUs engraved using different techniques as well as painted. The latter represent the most characteristic element of Cova Dones rock art, as they were made using clay as pigment, a purportedly unusual raw material for cave paintings.

Recording the Evidence

In this paper, we present our reconstruction of the human actions that led to the creation of the clay paintings in Cova Dones, and then, we give some keys on how to recognise UP clay paintings in the current archaeological record, after different taphonomic processes affected them. For the latter, we systematised our observations through the use of the concept of *chaîne opératoire* (Leroi-Gourhan, 1943), following the definition by Cresswell (1976) and Lemonnier (1976). The former defines the *chaîne opératoire* as a dialectical process between an individual and an object: a series of operations that transform a raw material into a product, whether it be a consumer good or a tool. At the very beginning of that paper, he explains the central role of analyse technological processes in order to understand social and cultural aspects of a human group:

Le postulat de base, celui qui ne sera jamais mis en doute, est qu'il existe des rapports entre phénomènes techno-économiques et manifestations socio-culturelles. Le maniement gestuel d'un outil, l'agencement d'une chaîne opératoire, l'intégration de différentes chaînes opératoires au sein d'un groupe humain, le rendement d'une technique de transformation, pour ne parler que de certains aspects ne sont pas des phénomènes à finalité limitée, interne, mais des phénomènes qui influencent de façon directe ou indirecte, ponctuelle ou diffuse, les comportements sociaux et individuels des membres d'un groupe.

[The fundamental premise, one that will never be called into question, is that there exists a relationship between techno-economic phenomena and socio-cultural expressions. The gestural handling of a tool, the organisation of a *chaîne opératoire*, the integration of different *chaînes opératoires* within a human group, and

the efficiency of a transformative technique —these are not phenomena with merely limited or internal purposes. Rather, they are processes that directly or indirectly, occasionally or diffusely, influence the social and individual behaviours of the members of a group].

— Creswell, 1976: 8 (authors' translation).

This approach has been previously applied to the analysis of other Palaeolithic cave art sites created using other decorating techniques (*e.g.* Fritz & Tosello, 2016; Garate et al., 2023). As we mentioned before, our research benefits from the development of the IAC methodology, a holistic approach to rock art archaeology, based on the consideration of every evidence potentially linked to the activities that UP individuals carried out in cave art sites (Clottes, 1993; Medina-Alcaide et al., 2018). The data capture workflow for the documentation of every archaeological remain (including both the elements of the IAC and the GUs) consisted of (1) the archaeological survey of all the surfaces (floors, walls, ceilings, and fissures), (2) signal and geo-reference all the identified remains, (3) 2D (photography) and 3D (LiDAR and photogrammetry) record, and (4) creating a database with all the relevant information for each element.

We used colour temperature and power-adjustable lights controllable via Bluetooth network: four Aputure MC with a range of 3200 to 6500 K. This allows for maximum control over the lighting used for graphic documentation. The interpretation of the archaeological remains was performed in situ, with the naked eye, with the help of portable magnifying glasses and a handheld Dinolite microscope, and through the image enhancement using the Dstretch Plug-In for ImageJ when required for parietal motifs. The photographic documentation was carried out with a Canon R5 using Canon RF 24–70 mm F2.8L IS USM and Canon RF 35 mm F1.8 IS Macro STM lenses. The images were taken with the focus stacking method, processed with the Affinity Photo software. Photogrammetric models were created with Agisoft Metashape and LiDAR models with the Scaniverse software for iPad Pro.

The *Chaîne Opératoire* of Clay Paintings

The technical processes involved in the creation of UP clay paintings have not been previously explored in detail, although they have been addressed in relation to other UP symbolic clay productions (*e.g.* Bégouën et al., 2009; Bougard, 2010). An exception is an early, incomplete attempt undertaken in Cosquer Cave (Clottes et al., 2005). This site, located in the Mediterranean basin and with a chronology similar to that estimated for Cova Dones, also features both clay and moonmilk deposits in its walls and fissures, akin to those in the Iberian cave. J. Clottes and collaborators noted traces of harvesting these materials and provided several examples (Clottes et al., 2005: 208–233). Although they suggested that further investigations on the topic should be conducted, their preliminary hypotheses for the use of these materials include parietal painting, body painting, and even medicinal purposes. Unfortunately, these valuable observations regarding raw material procurement were never systematised into a comprehensive technical study of the clay paintings.

In this paper, we adopt the concept of the *chaîne opératoire* (Leroi-Gourhan, 1943; 1945) to assess the various stages of production for these graphic elements. While this theoretical approach has been more extensively developed in the study of personal ornaments within Palaeolithic symbolism (*e.g.* Taborin, 1993; White, 1995, 2002; Vanhaeren, 2010), its application has also extended to the analysis of portable art (*e.g.* d'Errico, 1994; Fritz, 1999; Rivero, 2015) and parietal art (*e.g.* Lorblanchet, 1981; García, 1999; Fritz & Tosello, 2000, 2015; Garate, 2002; 2007; Ruiz-Redondo et al., 2019; Garate et al., 2023). Nevertheless, studies dedicated to reconstructing the *chaînes opératoires* of PRA remain comparatively rare. Indeed, due to the scarcity of these artworks in the archaeological record and the limited focus they have received in scholarly research, no specific studies of this nature currently exist for UP clay paintings.

Building on previous research, we have divided the process of graphic creation into three stages: (1) selection, (2) preparation, and (3) execution.

Stage 1: Selection

This phase involves the selection of the location, iconography, and its graphic characteristics (*i.e.* size, technique, graphic conventions). The adaptation of many PRA artworks to their specific surfaces highlights the importance of this process (Sauvet & Tosello, 1998). Additionally, the presence of compositional models and schemes for locating graphic motifs within caves has been a subject of study since Leroi-Gourhan's *caverne participante* (Leroi-Gourhan, 1965), and in recent years, it has received a significant boost through multiproxy analyses addressing the visibility and accessibility of the artworks (Villeneuve & Hayden, 2007; Pastoors & Weniger, 2011; Ruiz-Redondo, 2014; Jouteau et al., 2019; Intxaurbe et al., 2022). Unfortunately, these activities leave minimal material traces in the archaeological record, and the potential evidence that may be preserved (*e.g.* lighting remains, canvas testing marks, cave-progression marks) is virtually indistinguishable from those associated with subsequent stages. In the case of Cova Dones, the only positively documented association is the placement of clay paintings in chambers with permanent water presence (Fig. 2 (1)). However, the adaptation of some of these paintings to the cave surface is highly remarkable (Fig. 2 (2)), indirectly highlighting the importance of the selection stage.

Stage 2: Preparation

This stage encompasses the procurement of raw materials and the preparation of tools and the area designated for the graphic activity. Some of the tasks in this phase are more easily identifiable in the archaeological record. Evidence of raw material extraction (*e.g.* iron oxide, manganese, clay) has been documented at numerous PRA cave sites (see Medina-Alcaide et al., 2018: Table 1, for a compilation). At Cova Dones, we have identified the extraction of clay from at least 28 fissures and cavities in the SN.L4 panel (Fig. 3(1)). The distinction between ancient and modern extraction marks is based on physical and morphological

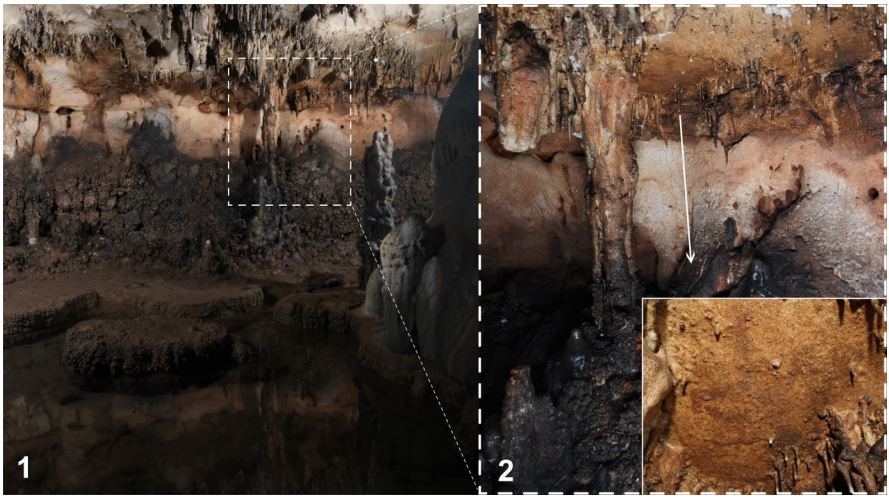

Fig. 2 (1) Location of the panel SN.l3 close in relation to the first lake. (2) Detail of the auroch painting in that panel

Fig. 3 (1) Panel SN.l4 showing the location of fissures with traces of clay procurement (red) and those corresponding to the close-up images in Fig. 4 (1 and 2) (green). (2) Trace of a gesture involving the extraction of clay from a cavity, continuing into the creation of a painted motif. (3) Clay with signs of preparation discarded at the bottom of the panel

features such as sheen, moisture levels, patina, and residual burrs. Ancient extraction marks are characterised by lower sheen and moisture, the presence of a darker patina, and the absence of burrs (Fig. 4). Although we cannot state with certainty that painting was the sole purpose of clay extraction, there is evidence to suggest that it was at least one of the intended uses. Indirectly, a clear spatial relationship exists between the cavities where ancient extractions have been documented and the location of the paintings. More directly, there is a compelling example of clay being extracted from a cavity that continues seamlessly into a painted motif, *i.e.* the same gesture used to extract the clay appears to have been extended to create a meandering sign (Fig. 3 (2)).

Regarding the preparation of the colouring matter itself, several possibilities can be considered. The first is that the creators used the clay in its raw form, as they collected it, without any further processing. The second involves the addition of water to the clay to increase the fluidity of the pigment. These two options would be difficult to distinguish based on their chemical signatures, as water would be present in both cases. Therefore, a comprehensive experimental

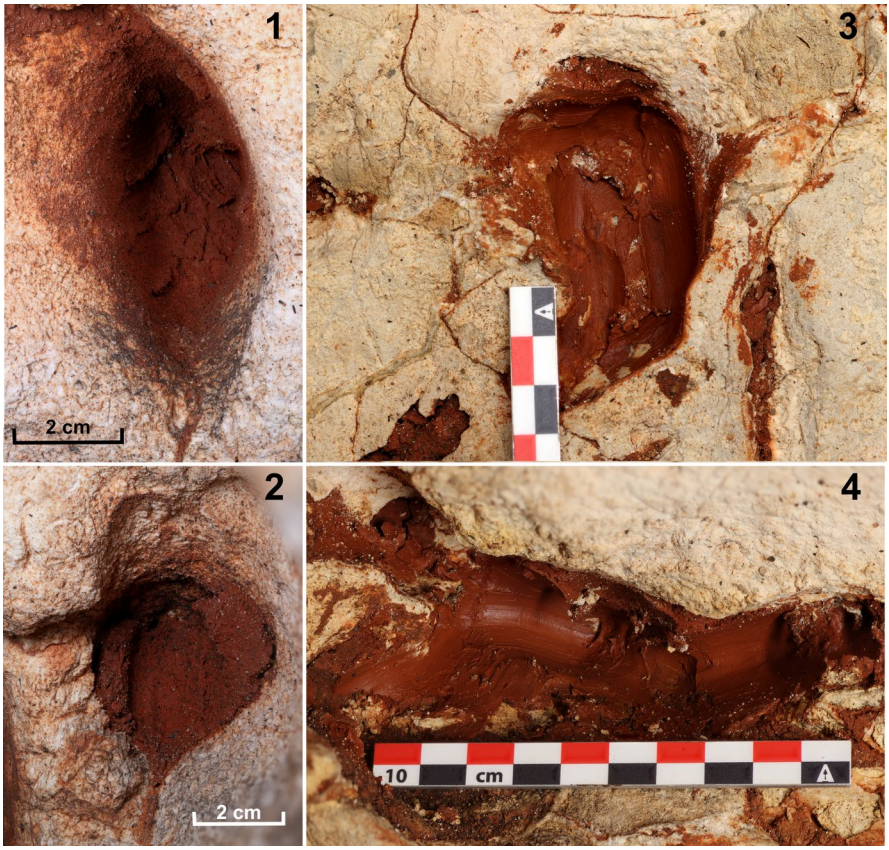

Fig. 4 Comparison between old marks of clay extraction (1 and 2) and more recent ones (3 and 4)

programme would be necessary to establish a referential framework for comparing the traces left by the use of raw versus diluted clay as pigment.

A third possibility is that the preparation involved mixing the clay with other substances. This appears to be the case with the Etxeberri clay paintings, where small fragments of charcoal seem to have been added to the clay (Garate et al., 2012: 646). A sampling programme involving XRD, XRF, and granulometric analyses of both the clay sources (cavities and floors) and the clay paintings, as well as an experimental programme aimed at comparing the properties of different 'recipes' for the colouring matter, is currently underway to help clarify these questions in the case of Cova Dones.

Tasks related to the preparation of surfaces are not unknown in parietal rock art. On some occasions, such interventions may be marginal and difficult to distinguish from actions related to the execution of the paintings. In other cases, extensive preparations have been documented—for instance, in the 'Panneau des Chevaux' in Chauvet Cave (Clottes, 2010: 112–117) or in panels II.2 and II.4 of Altxerri A (Ruiz-Redondo, 2014: 176–177). Although we did not document any clear evidence of surface preparation at Cova Dones, such practices may form part of the preparatory stage at other sites featuring clay-based paintings.

Our preliminary observations point to the fact that the tools used for creating the clay paintings in Cova Dones were predominantly fingers and hands, possibly along with some vegetal elements (*i.e.* sticks). These purported vegetal tools have not been preserved, and no lithic tools that might have been used for sharpening or shaping them have been found so far in the decorated areas. We have not recorded any undeniable evidence of canvas/surface preparation; hence, there are no potential tools to be related to this task in the specific case of Cova Dones, but they could exist in other sites.

In terms of lighting material procurement (*e.g.* wood and/or bone marrow), we have not documented any activity areas related to animal bone processing in or around the decorated zones. The procurement of wood for torch or fixed-lamp production—likely the most common lighting methods (Medina-Alcaide et al., 2021)—would have occurred outside the cave, with minimal archaeological trace that can be identified in the site, beyond the preferential selection of certain species and characteristics. At Cova Dones, in addition to anthracological analysis, an extensive radiocarbon dating program is required to identify the remains associated with the PRA, given the continued use of the cave from Prehistory to the present. Both studies are currently underway.

Stage 3. Execution

This stage involves the materialisation of the paintings. The micro—and macro—morphological analysis of the strokes provides insight into the techniques and technologies employed. Technologically, the use of fingers and palms for pigment application appears to have been the most common practice, based on the preliminary observation of the strokes (Fig. 5 (1–3)). However, we have identified certain imprints that do not correspond to fingers or palms. Certain marks left in the clay suggest the use of a fibrous, possibly vegetal, element for executing some paintings.

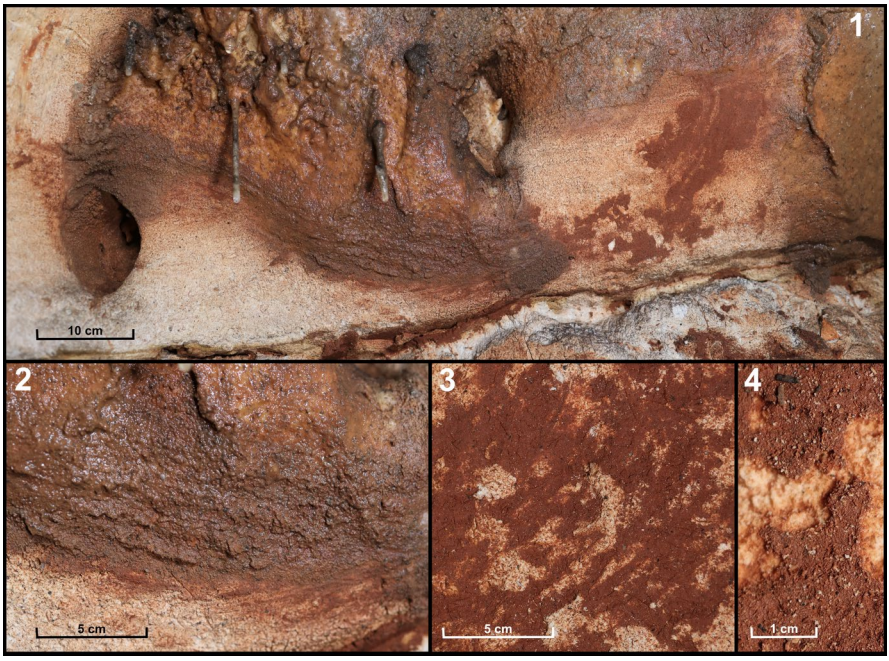

Fig. 5 (1) Meander painted with clay. (2) Detail of the calcite layer 'fossilising' the grooves of the painting. (3) Detail of the stroke revealing that was probably painted with the fingers. (4) Detail of the pigment with calcite crystals formed on its surface (focus-stacking compiled image)

Additionally, these include grooves left by a sharp instrument (stalagmite? stick?) in some paintings made on moonmilk surfaces. These observations are consistent with the thickness of some strokes, which appear too fine to have been produced by fingers. These types have been documented in the 'phantoms' defined in the following section (Fig. 7 (2–3)).

Regarding the techniques, imprinting and dragging are clearly documented, possibly in combination with infill in certain motifs. Imprinting is documented in some series of dots painted on several speleothems. Dragging, whether using tools, palms, or one or more fingers, was the most common technique: it was implemented to create both figurative and non-figurative motifs, varying in morphology, size, and complexity.

Taphonomic Alterations: Identifying Clay Paintings in the Archaeological Record As is well established, the archaeological record is a present-day element which reflects activities that occurred in the past. Its current appearance and characteristics are shaped by the original elements, which have been altered by natural taphonomic processes and modifications resulting from human and animal activity. The parietal record, as part of the broader archaeological record, is no exception. Due to its antiquity and exposure, PRA undergoes extensive and diverse transformations (Bednarik, 1994). Five primary agents are responsible for alterations in the paint and substrate: temperature, solar radiation, water, wind, and human/biological actions (Ozán et al.,

2024). These factors may interact synergistically to produce changes in the appearance and properties of rock art (Garate et al., 2025). At Cova Dones, due to its location within a deep-cave environment, the rock art is minimally, if at all, affected by solar radiation and wind, and extreme temperature changes are likely only the result of human activities (*e.g.* bringing a heat source close to the artworks). Consequently, water and human or biological factors are likely responsible for the alterations observed in the clay paintings or their substrate. The aim of this paper is not to explore these alterations and their causes in detail but rather to demonstrate their manifestation in the archaeological record. In this section, we compile and describe the various conditions observed in the clay paintings at Cova Dones, with the objective of creating a typology that may serve as a reference for identifying clay paintings at other UP cave sites.

We distinguish five states of preservation in the clay paintings of Cova Dones, with several often combined within a single figure. Some of them are the result of different taphonomic processes, and others can be produced by the same taphonomic process in different stages of development:

1. 'Minimally altered'. These are paintings where the pigment still adheres to the parietal surface, retaining its original colour and consistency. Even if they are well preserved, the paintings exhibit evident taphonomic alterations. The clay pigment appears much drier, less shiny, some fragments could have flaked off, and there is an absence of excess material compared to recently made clay paintings. These criteria allow us to differentiate between older and more recent paintings, and the differences are also easily observable in the clay extraction marks (Fig. 4). This state frequently enables the assessment of techniques and the possible use of the fingers or tools in the graphic creation (Fig. 5 (3)).
2. 'Calcited'. A significant number of paintings exhibit calcium carbonate formations in varying stages of development, from scattered millimetric formations (Fig. 5 (4)) to almost total coverings (Fig. 5 (2)). In the latter case, an unusual phenomenon occurs: while similar layers of calcium carbonate would typically impede the identification and analysis of other rock paintings, this is not the case with clay paintings. The substantial amount of pictorial material results in a pronounced relief that is fossilised by the calcite layer, preserving the reliefs that indicate the position of the strokes and even their technical characteristics (Fig. 5 (1–2)).
3. 'Human/animal altered'. The primary alterations consist of various forms of contact with the wall and paintings. In the case of human interference—whether intentional or not—these include impacts, abrasions, and alphabetic or iconic 'graffiti' over the paintings. These are the most significant and easily recognisable alterations. They can deform or destroy motifs and entire panels, as seen on the left side of panel SN.L4 in Cova Dones (Fig. 3 (1)). Animal-related alterations may involve rubbing against the decorated areas, but in almost all cases, they are 'claw marks' or 'scratches' produced by various mammals. Tentatively, based on size and location, three main types of authors can be distinguished: bats, other small carnivores, and bears. These marks appeared either isolated (few parallel lines) or grouped into chaotic bundles of lines. They are typically arranged

in series of two to five perfectly parallel lines, featuring a distinct 'V'-shaped cross-section (Fig. 6 (2)). If ancient, their appearance and patina can sometimes be mistaken for anthropogenic marks (Camarós et al., 2017; Lorblanchet & Le Tensorer, 2003; Martinón-Torres et al., 2024). We find two types of alterations to the clay paintings depending on their extent: incisions marked on the pigment surface (the grooves are visible on top of the surface of the pigment) and those that caused pigment loss. A combination of both can be observed in one of the horses in the panel SN.L4 (Fig. 6 (2)).

4. 'Faded'. The drying of the clay used as pigment can trigger a flaking process affecting the artworks. At Cova Dones, we have identified this process in several figures. One of the key pieces of evidence suggesting that what we perceive today

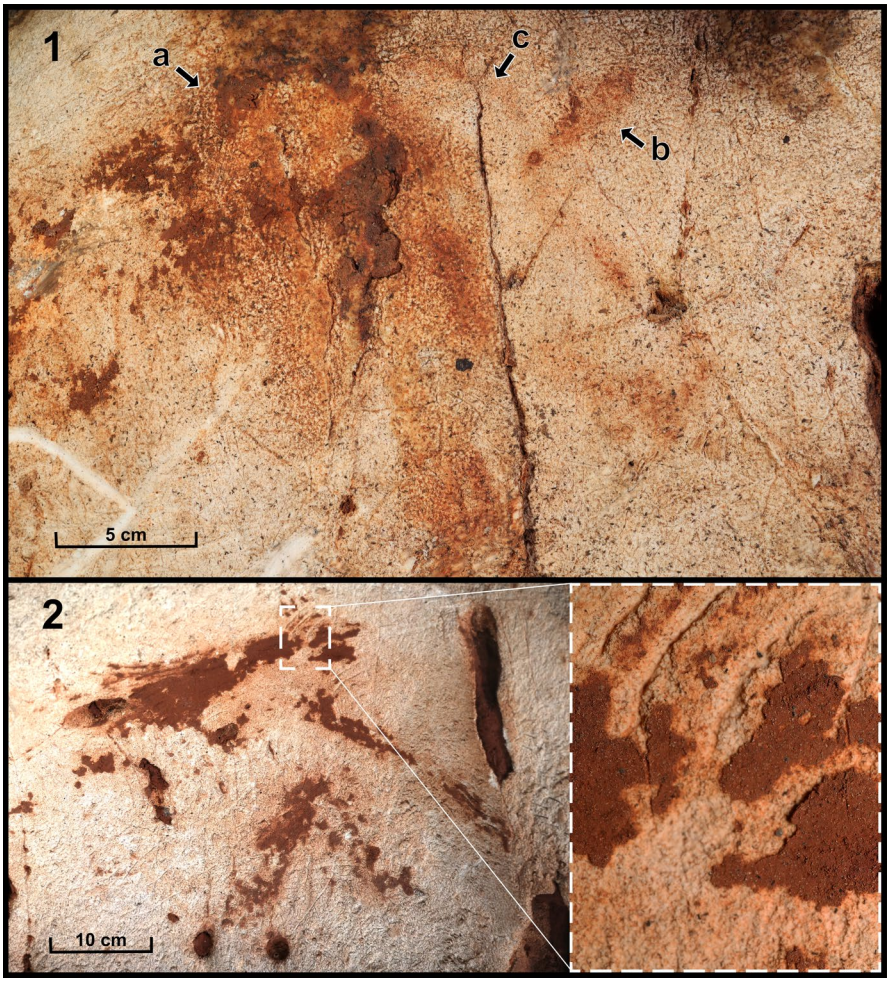

Fig. 6 (1) Horse head showing three different states of preservation of the clay painting. (2) Horse painting heavily affected by animal scratches

as 'shadows' of reddish colour are remains of clay paintings is the documentation of different degradation stages within the same stroke (Fig. 6 (1)). Thus, in some areas, the stroke retains a substantial amount of clay (a), while in others, macroscopic particles are scattered among a reddish 'shadow' formed by clusters of microscopic particles (b), and in other sections, only the reddish 'shadow' produced by the microparticles is visible (c). After confirming that these reddish 'shadows' are due to the presence of microparticles of pigment, we have noted the existence of entire motifs—or a large portion of them—in this latter state.

5. 'Phantoms'. The last category presents the greatest difficulties for recognising and documenting the paintings. It seems to be a produced by similar taphonomic processes to the previous category, but in a more advanced stage. It is characterised by an almost complete absence of the reddish pigmentation of the clay. At Cova Dones, the motifs included in this category blend with the parietal surface of moonmilk, which is why we named them 'phantoms'. The typology and appearance of these motifs vary from some that preserve texture and even some red/brown colouring (Fig. 7 (1)) to others almost imperceptible. The thicker strokes seem to have been made with fingers. Others show finer lines, which appear to indicate the use of pointed tools. Some of these tools seem to have left grooves in the soft moonmilk surface of the ceiling where they are located, creating partially 'engraved' figures (Fig. 7 (2–3)). There are several possibilities concerning the execution of these 'phantoms': (1) they are red clay paintings that have undergone some form of weathering process, (2) they are a pigment mixture of clay with some other element (moonmilk?) that gives them their lighter tone, or (3) the clay pigment has been almost completely lost, and the observable traces are the imprint of the original paint on the moonmilk. We leave this question open until future analyses will solve this issue.

Conclusion

In this paper, we aimed to lay the foundations for the identification and technical analysis of UP clay paintings. These particular artworks have been comparatively understudied within the research on PRA. We based our study on insights on the archaeological record of the recently discovered site of Cova Dones. We are aware of the limitations of using a single site to formulate hypotheses of general application in archaeology. However, the number of parietal motifs of this type and the variability they exhibit at this site provide an excellent starting point for constructing a morphological catalogue of these graphic productions. Furthermore, the identification of evidence related to the procurement of raw material and the possible tools and techniques used at Cova Dones for the creation of these paintings invites reflection on the *chaînes opératoires* that led to their production. Our goal was to show and describe (1) the creative process of these symbolic productions and (2) the different states in which archaeologists may currently find UP clay paintings in cave sites, due to the combination of technical features and taphonomic processes. The

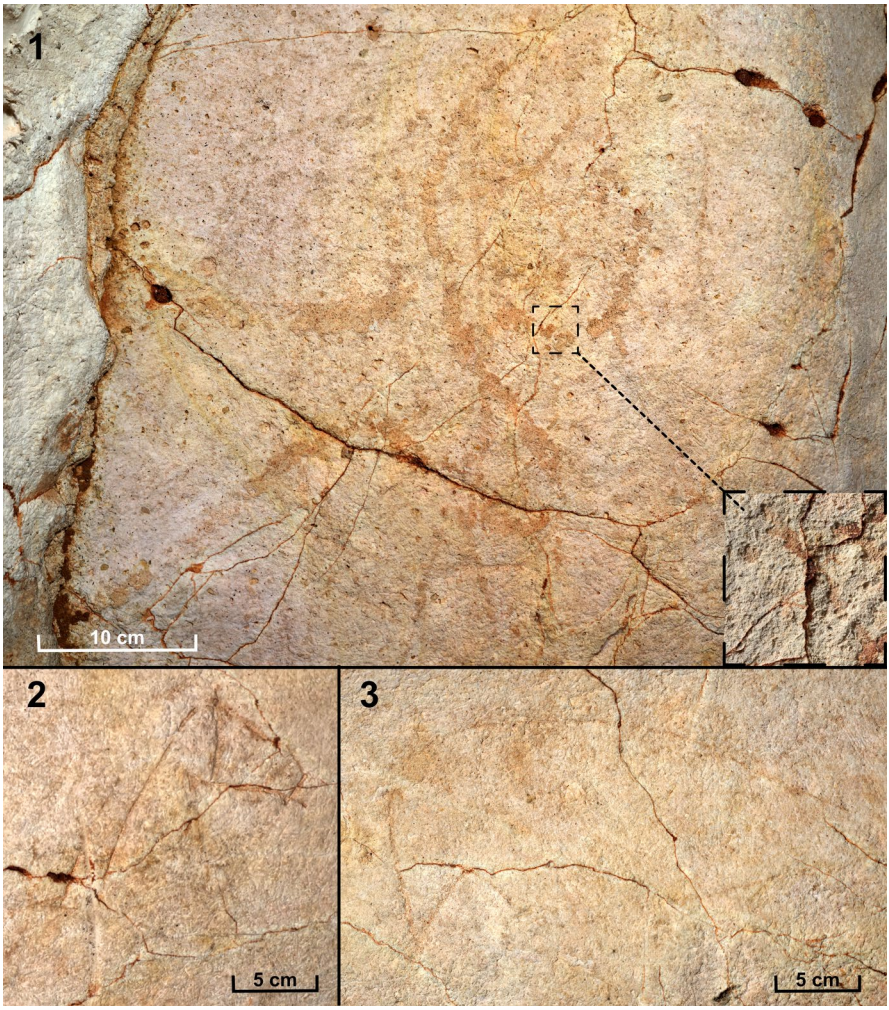

Fig. 7 'Phantoms'. (1) Red deer (stag) with detail of an area preserving brown colour. (2) and (3) Horse head and acephalous hind showing accidentally 'engraved' areas on the moonmilk surface. the morphology and size of the visible marks are consistent with the use of a sharp tool

easy availability of the raw material, its high suitability as a pigment, and the extensive geographical and chronological distribution of clay paintings within the PRA suggest that their number can be significantly greater than currently documented. In this context, the aim of this paper is to draw attention to this observation and provide some key insights for the identification of these graphic elements and other potentially related evidence within the archaeological record. We consider this a necessary endeavour, as, even in the best-case scenario, some of these elements are challenging to identify, even for the trained eye; in other cases, they have entirely vanished due to the passage of time and human activity. Some questions remain

open, such as certain technical determinations, the development of an experimental programme, or assessing the nature of the taphonomic processes that affected the paintings, among others. Future research will aim to resolve these and other questions. For the time being, we are content to describe them and demonstrate the existence of these paintings (in their various states of preservation) and other evidence of the technical process for its creation, with the aim of facilitating their identification at other new or previously studied PRA sites. We argue that the implementation of the protocol we have described will lead to further discoveries of UP clay paintings and related elements, thereby revealing the actual role that clay played within PRA and, consequently, contributing to a deeper understanding of UP symbolic practices.

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Author Contribution A.R.R., V.B. and X.M. designed the research program and studied the rock art. A.R.R. and V.B. designed and conceptualised the study and prepared the figures as well as the manuscript draft. A.R.R., V.B., X.M., M.D. and X.G. collected the fieldwork data for the analysis IAC and the techniques of clay paintings in Cova Dones. All authors were involved in the discussion of the results, conducted the fieldwork and reviewed the manuscript.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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