Deciphering a Site's Spatial History Through Its Detailed Mapping: Reading the Chauvet Cave Maps

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Chauvet Cave (France) is a large and complex cave with rich archaeological, palaeontological and geomorphological materials on its floors (e.g. charcoal and installations built by people; Cave Bear bones and hibernation hollows; stalagmites); walls (e.g. rock art and charcoal torch marks; Cave Bear scratch marks; speleothems) and ceilings (e.g. speleothems). As part of the research to work out the cave's formation and cultural history, it became essential to draw very detailed, high-resolution maps that would allow all these materials to be both inventoried and cross-referenced, so that their spatial and chronological relationships could be worked out. Two key objectives inform this transdisciplinary mapping: 1) to determine, to the degree possible, the underground landscape as it was at the time of the cave's Pleistocene human and animal activities, along with their roles in the cave's formation and transformation; and 2) to determine how the cave has changed since its final closure c. 21,500 years ago, signalling also the end of its Pleistocene entry by people.

To meet these aims, the floor's surface soft sediments, rocks, speleothems, animal bones, animal paw prints and human footprints, and artefacts and other traces made by people were mapped at high spatial resolution on a 1:50-scale map. Such a cartographic scale was essential to enable the analysis of spatial and chronological relationships between the many of often varied kinds of objects on the ground. Those objects had a broad range of formation histories, and being able to work out how one related to the other was important to determine those formation histories. A key idea was to be able to specify whether individual archaeological objects lay in their original positions, or whether they had been moved. A further important point of interest was to determine how objects and formations had attained their original positions and, if they had since moved, how they had been redeposited, such as through the actions of water (e.g. when parts of the cave may have been flooded), roof-fall, animal movements, or people (Delannoy et al. 2012).

The geomorphological study of the cave made it possible, in most of the cases, to identify actions of geomorphic processes, animals and people from the material remains, their visual markings, and their spatial patterning. Among the clues commonly used in geomorphology is a reading of the landscape based on the morphologies of landforms and their component features such as boulders and sets of rock. In these geomorphological readings, a common distinction is made between: 1) processes of erosion, transport, and sedimentation that have acted on the area or assemblage under investigation; and 2) the specific chemical, mechanical, gravitational, biological, anthropogenic or anthropic forces or agents that caused these processes to act on the part of the landscape under investigation.

Despite their great abilities to elucidate site and landscape formation processes, most geomorphological approaches nevertheless tend to have a weakness: accounting for the various dimensions of human engagement-in-place; people are more than passive bystanders, being both intentional and incidental agents of change and therby creating their environments along the way. Because of this, a stronger pairing of geomorphology with archaeology and other related disciplinary know-how is required. This is the approach we have followed at Chauvet Cave, through what we have called an 'archaeomorphological' approach (e.g. Delannoy et al. 2013). For a detailed exposition of Chauvet Cave's archaeomorphological research, see Delannoy and Geneste (2020).

Archaeomorphology aims to understand and arrange the different agents of change (mechanical, hydrological, physico-chemical, biological, anthropogenic) in time, based on the chronology of changes in the state of the physical environment. At Chauvet Cave, particular attention has been paid to the rich clues of the cave's dynamic processes evident in the archaeological and palaeontological evidence. This level of attention on people and animals is rare in traditional geomorphological research, where the focus is more on alluvial, aeolian, colluvial and chemical processes of transformation. An archaeomorphological map features all kinds of products and by-products of human actions, and so goes beyond a simple inventory of 'natural' materials and processes. An archaeomorphological map instead invites an interpretative reading of

the landscape that goes beyond conventional geomorphology. Archaeomorphology begs for a transdisciplinary approach.

To achieve such a transdisciplinary reading of Chauvet Cave's underground landscape, the mapping of the cave has devised a code by which multiple levels of information can be included on the maps. Details of the morphogenic processes that gave rise to the state of each object, as well as their relative chronologies, feature on the maps via a set of colour codes. Each colour is also given a range of shades representing relative time: the darker that colour, the more recent the formation process. In this way, the history of the cave's materiality can be represented across multiple spatial and temporal scales (Delannoy et al. 2001). It is this exercise of integrated geomorphological-and-archaeological (at Chauvet Cave, and palaeontological) mapping that incorporates the cave's rich and multiple sources of information which has enabled crucial and otherwise unknown or indeterminate aspects of the cave's history to be revealed (see Section 4 of this Element).

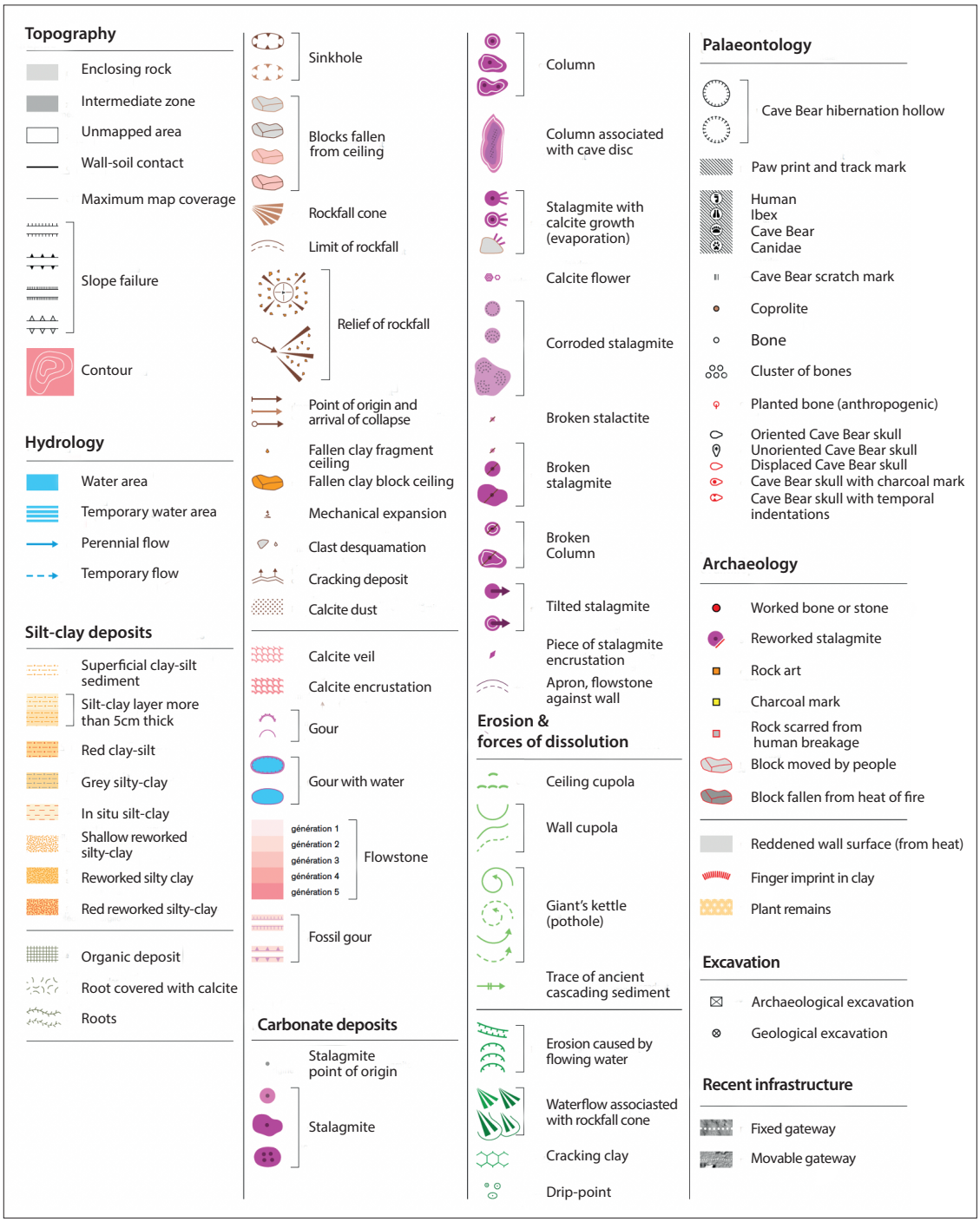

Figure 1. Legend of the Chauvet Cave archaeomorphological maps (figure by Jean-Jacques Delannoy).

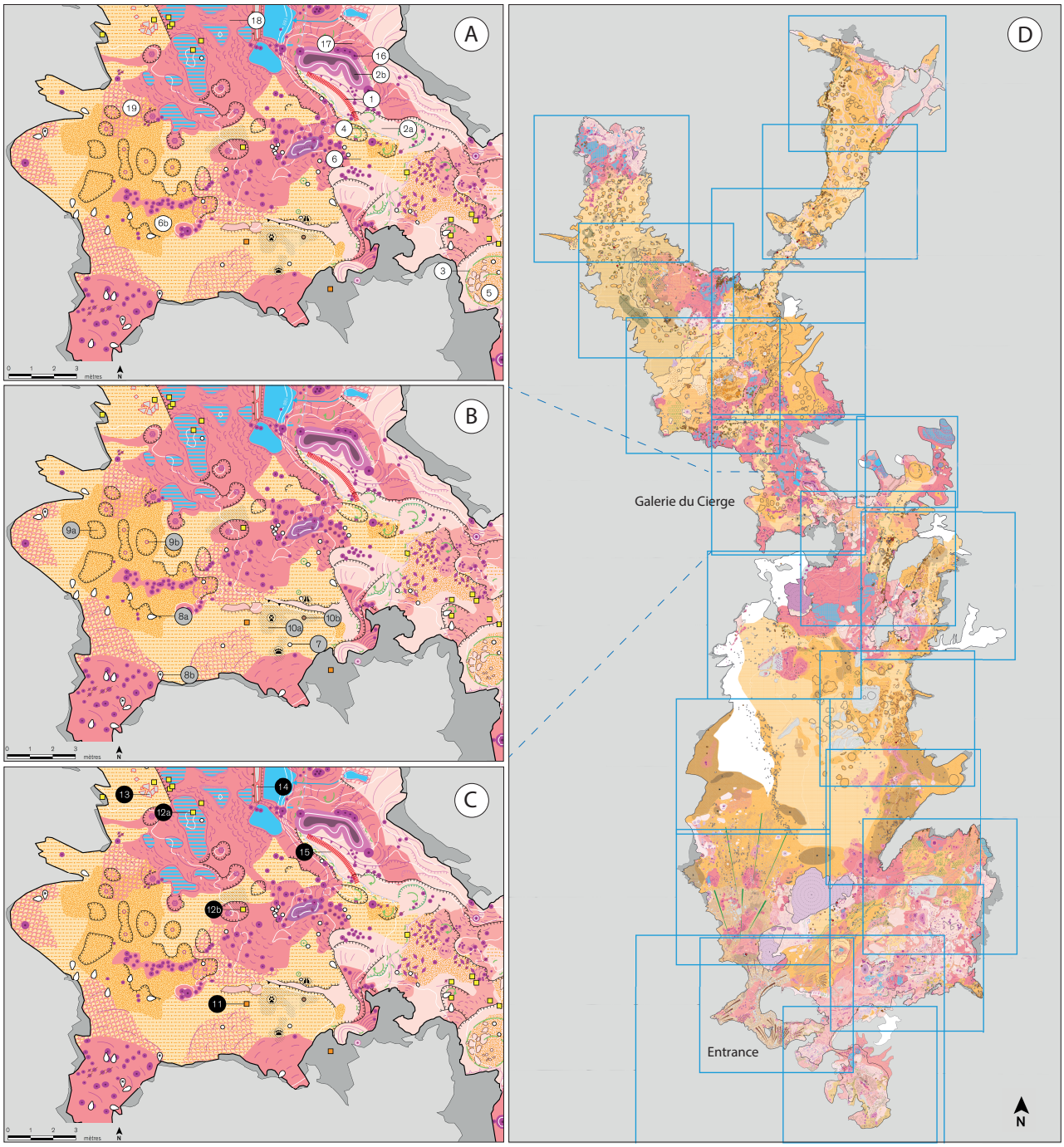

Figure 2. Three renderings of the floor of the Gallerie du Cierge (Candle Gallery) at Chauvet Cave (D), where the cave's formation history has been mapped. These maps separate the features or objects that primarily resulted from geomorphic processes (A), animal activites (B) and human actions (C). The numbers signify specific events or processes, as outlined in-text (figure by Jean-Jacques Delannoy).

The complexity of the maps produced by this integrated approach must necessarily be accompanied by a detailed and clear legend (Figure 1). This legend provides both the lexicon and grammar required to read the maps. A detailed, annotated presentation of each symbol used is essential, as individually and together the archive of codes, and their explanations, enable each object, surface, space and process to be understood both in itself and in relation to the broader (spatial, temporal) whole. Together the coded symbols—their shapes, colours and shades—enable synthetic readings of the maps, as the fundamental renderings of the landscape under investigation. The example presented below is of Chauvet Cave's Candle Gallery (Gallerie du Cierge) (Figures 2, 3).

When making the maps of Chauvet Cave, geomorphic, animal and human processes of soft sediment formation, object deposition and re-deposition and surface modification were differentiated. Here I illustrate

such mappings through the work done on the floor of one part of Chauvet Cave, the Candle Gallery (Figure 2). This allows for a close examination of the distinctive roles that each agent played in producing the cave landscape that can be seen today. These roles are distinguished in the text below, allowing the formation and cultural history of the cave to be elucidated.

Geomorphic processes. A number of deposits on the floor, walls and ceilings have left traces of geomorphic processes on the Chauvet Cave environment. The numbered items below correspond with the same numbers on Figures 2 and 3:

1) Red clay deposits were produced during one of the earliest phases of Chauvet Cave's formation. This layer is nearly absent on the archaeomorphological map because it is covered by later flowstone and stalagmites ('2'). The red clay ('1') is most clearly visible in an area from which people had extracted clay for use ('15') (see Section 4 of this Element for details).
2) Early formation of calcareous mineral deposits (speleothem) produced flowstone ('2a') and a stalagmite column ('2b'). These speleothems sealed the earlier red clay deposit ('1') but were subsequently partially eroded ('3').
3) A sinkhole formed through intensive water-flow that eroded the stalagmite floor.
4) As clay deposits on the cave floor were eroded by flowing water ('3'), the relatively rigid flowstone that lay above the clay became suspended 1.5 m above the (now-lower) cave floor.
5) Thick silty-clay was deposited during paragenesis (redeposition of mineral phases), by which the sediment particles of the earlier cave floor was sorted and redistributed.
6) Pleistocene animals and people walked across the silty-clay floor of the cave, leaving their footprints in the mud along the way ('6a'). Afterwards, natural processes of sediment movement resulting from gravity and water-flow disturbed the archaeological floors ('6b'), in some cases sealing the traces of animal and human activities on the floors with a thin layer of redeposited carbonate.

Labels 1–6 record geomorphic processes active in the Pleistocene, when animals and people began to leave traces of their presence in the cave. Labels 16–19 indicate geomorphic processes that occurred after the closure of the cave entrance c. 21,500 years ago; both animals and people then stopped entering the cave as its entrance had become closed to the outside world. The growth of numerous stalagmites during the terminal Pleistocene and Holocene ('16' and '18') was followed by the formation of rimstone pools ('17') which also produced pellicular crusts and calcite veils ('19'). These speleothems now partially cover Pleistocene artefacts and other evidence of human and animal presence, as detailed below.

The impacts of animals. Animals have also left their marks on the floor of the cave, as well as on its walls:

7) Fragmented or whole bones, including large Cave Bear skulls, are distributed across the silty-clay cave floor.
8) The orientations of some of the Cave Bear skulls can be determined ('8a'), while those of others cannot ('8b').
9) The Cave Bears dug hibernation hollows ('9a') into the soft clay of the Pleistocene cave floor. Calcite deposits ('9b') then formed around and above some of these hibernation hollows.
10) Canid footprints ('10a') are well preserved on the silty-clay floor. Coprolites ('10b') have also been found.

The actions of People. People have also been agents of accumulation and transformation in the cave:

11) Incisions and finger flutings were pressed into the soft surface of the cave wall.
12) A charcoal torch-mark was made on a wall ('12a'), and another on a limestone pendant hanging from the ceiling ('12b').
13) Stone blocks were moved by people to make a hearth. Charcoal fragments from the hearth have been radiocarbon dated to 33,791–35,234 cal BP (29,980 ± 360 BP, GifA-13227 (SacA-34351); calibration at 95.4% probability, calculated on Calib 8.20 using Intcal20 Curve Selection).
14) Other stone blocks were also moved by people.
15) People left their handprints on the floor, imprinted in the red clay that had accumulated during the very early phase of cave formation ('1').

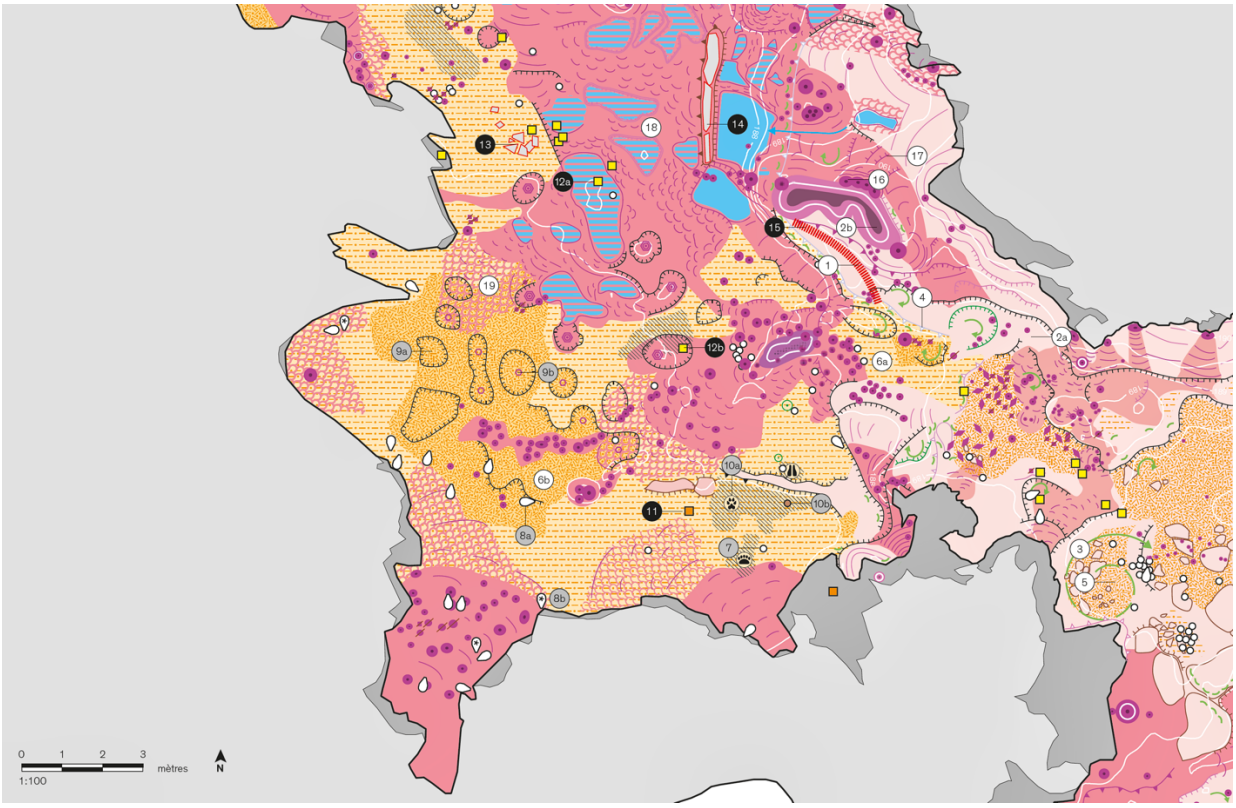

Figure 3. Composite map that brings together the layers of information presented in the three maps of Figure 2 and discussed above. Aggregation of these layers allows the visualisation and analysis of spatial associations between materials and traces that were created by geomorphic processes, animal or human activites across the Candle Gallery. For example, the exposed red clay layer ('1') that was deposited in the first phases of the Galleries' formation history is spatially associated with the much later extraction of clay by people in Pleistocene times ('15').

Reading the map is a journey through both space and time. Moving across the cave, and through time, is facilitated by the colour palette that has differentiated between the various agencies (geomorphic, animal, people) and symbols and shades of darkness (the lighter the colour, the older the phenomenon) by which the cave's transformations can be deduced.

While small archaeological excavations have also been undertaken in the cave to reveal sub-surface details by which to better understand how some site formation processes relate to each other, such as the period between episodes '4' (when clay deposits were eroded by the action of flowing water) and '5' (when silty-clay sediments on the cave floor were reworked and redeposited across the cave), at this site sub-surface investigations have been very limited due to the desire to preserve as much of the cave as possible for future generations. Nevertheless, archaeomorphological mapping of this kind can also be enriched with additional stratigraphic details where these are not apparent or sufficient from the surface.

Conclusion

The multiple geomorphic processes, animal and human activities in Chauvet Cave have each made their own contributions to the formation of the cave's landscape (Figure 2) and to its present-day disposition. Some of these events, actions or processes occurred over very long periods of time (e.g. the growth of stalagmites on the cave floor), while others resulted from momentary actions (e.g. canid footprints impressed into the ground) followed by long periods of gradual change and preservation. The detailed mapping of the cave landscape allows these processes to be spatially and temporally disentangled. Of equal or greater significance in the archaemophological mapping, however, is the *reintegration* of the now distinguished objects and processes (Figure 3). The development of an archaeomorphological map with its detailed legend presents the cumulative contributions of these different, and now re-aggregated but clarified agents of change in the formation of the cave floors. This specialised cartographic format offers a means to represent the rich archaeological, palaeontological and geomorphological materials on the floors of Chauvet Cave and to

highlight the interfaces and interactions between geomorphic, animal and human activities over time. A similar exercise can (and has) been done for the rock walls, and for the ceilings, so that bringing them all together ultimately renders a richer spatial history of the cave's biography.

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