Response to Aubert et al.'s reply 'Early dates for 'Neanderthal cave art' may be wrong' [J. Hum. Evol. 125 (2018), 215–217]

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Aubert et al. (2018) discuss and criticize age constraints for Paleolithic cave paintings recently published by Hoffmann et al. (2018). Aubert et al. (2018) reiterate the importance of demonstrating the human origin of the painting as well as the stratigraphic relationship between the dated calcite and the art. They argue that (1) in Ardales the red pigment found on curtain formations could be of natural origin, or accidentally transferred onto the speleothem

surface by humans, and (2) in Maltravieso and La Pasiega we have not demonstrated that the dated calcite formations overlie the pigment. Here we clarify why we feel these criticisms are unfounded.

The speculation that the red color could be a result of either a natural process or unintentional contact is contradicted by the position of the motifs and the means of application of the pigment. The position—within narrow recesses—of the pigments associated with the speleothem formations dated at Ardales renders unintentional transfer of pigment by body contact highly unlikely. The most archaeologically significant dates (samples ARD12 to ARD16) were obtained from panel II.A.3 (see Cantalejo et al., 2006)—a large speleothem formation with pigment structured in closely packed stalagmitic 'curtain' formations as shown in Hoffmann et al. (2018:Figs. S11 and S13; see also our Fig. 1). The red paint is located inside the narrow vertical furrows found between drapes, which is hard to reconcile with the notion that they could result from unintentional contact. More importantly, each of the 24 (at least) clearly differentiated motifs on this speleothem formation (II.A) are characterized by: i) a 'central area' (which defines the general shape of the motif) with high pigment density, which appears as a 'thick' color deposit, not a thin layer or color glaze, and ii) by an 'enveloping area', an irregular halo characterized by differential dispersion of the color (splattering), forming small points or fine lines in clear association with the 'central area' (Fig. 1). Even though, as suggested by Cantalejo et al. (2006), finger application cannot be excluded for all areas, this type of pigment distribution is characteristic of application of the pigment by blowing onto the oblique surfaces of the speleothem folds, as shown by experiments (d'Errico et al., 2016). It differs clearly from a technique of application of color with the fingers (either deliberately or accidentally) also shown by experimental studies (García-Diez et al. 1997), and must be anthropogenic and deliberate. We do not see how natural processes (e.g., soil or sediment material infiltrating the cave) would cause such distinct patterns of pigmentation. Ever since the art was first described by Breuil (1921) nearly a century ago, the anthropic origin of these motifs has been accepted by all experts who have assessed the evidence directly on site. This includes Cantalejo et al. (2006), who described the art in detail, and Sanchidrián (2000), who included 94 painted speleothems and 121 motifs without clearly defined morphologies in their corpus of Ardales cave art.

Furthermore, the pigment found on the painted speleothems occurs as a 'layer' found on top of and within the calcite, not as diffuse staining of the calcite itself. The reddening caused by the presence of iron minerals in the dripping water would translate into homogeneous staining of the calcite, as indeed is often seen in endokarst environments, but which is not the case here.

The pigment is visibly of mineral origin (e.g., Hoffmann et al., 2018:Fig. S29) and clearly not the result of bacterial processes. Its mineralogical analysis—currently underway and something Aubert et al. (2018) criticize us for not having done—can indeed potentially provide important details about its specific hue and the geological provenience of the raw material used for the painting, but would likely be insufficient to clarify whether it is cave art as opposed to natural or unintentional staining of the cave wall. Aubert et al. (2018) also question whether we have mistaken colour changes within the calcite for the presence of pigment, and might therefore be sampling the darker 'canvas' on which the painting is made

rather than the calcite overlying the pigment. The importance of unambiguous stratigraphic relationship between the dated speleothem formation and the cave paintings is fully discussed in Hoffmann et al. (2018), who followed a previously presented methodology with strict quality control criteria (Hoffmann et al., 2016). The sampling position is carefully inspected, described and documented prior to, during, and after the sampling, and we emphasize that "to avoid removing unnecessary samples, it must be established that it is highly probable that pigment will be found under the $CaCO_3$ before sampling commences" (Hoffmann et al., 2016:107). Furthermore "The sample collection is stopped as soon as pigment can be clearly seen under the translucent $CaCO_3$, from which we infer that exposure is about to occur' (Hoffmann et al., 2016:108).' In all cases, pigments were unambiguously identified using a portable microscope or hand lens—and documented—directly underlying the sampling position.

Figure 2 shows a series of images of stencil GS3b from Maltravieso, dated to >66.7 ka by sample MAL13. Reddish pigment is clearly visible defining the shape of a hand (Fig. 2a, b). The stencil was made onto an existing carbonate layer (rather than limestone bedrock) and the 'canvas', under the palm of the hand at least, is a pale cream color similar to the carbonates that have formed on top of the stencil and not a color that is likely to be confused for pigment (see also Hoffmann et al., 2018:Fig. S8). Some carbonate formations obscure stencil pigment, but sampling of these revealed pigment present underneath (e.g., the case of MAL13 shown in Fig. 2d). Furthermore, the pigment seen under the removed sample is contiguous with pigment visible in between small carbonate deposits adjacent to the sampled deposit (Fig. 2c). To remove any doubt that this is pigment, we have subsequently obtained permission to enlarge our sampling area for MAL13, which shows more clearly that the pigment underlying the sample is contiguous with the exposed pigment of the stencil (Fig. 2e). We acknowledge that the sample from La Pasiega (PAS34) was more difficult to photograph clearly, but sampling was stopped when pigment was exposed. The color of the exposed pigment matches that of the visible pigment (i.e. uncovered by calcite) adjacent and surrounding the calcite formation, and is a distinctly different color to the color of the 'canvas' (i.e., the cave wall; Fig. 3).

Our working philosophy is also outlined in Hoffmann et al. (2016:118): "The conservation and protection of the precious and unique cave art obviously has highest priority and is the underlying principle of our work. It is essential to avoid any damage to the cave art, and to minimise our impact on the cave environment to ensure the preservation of this global heritage for future generations". It is true that in cases where no non-destructive alternative is feasible, a decision has to be made whether—and to what extent—destructive methods should be allowed to proceed to gain important scientific information. However, drilling or cutting a core through a covering calcite crust and the painting into the 'canvas' has a huge impact on the cave art. The drilling or cutting itself does not only leave a hole behind (e.g., see Aubert et al., 2018:Fig. 1B, C), but the process can have subsequent, significant and catastrophic damage where the cave wall ('canvas') turns out to be too fragile to withstand the sampling. Of course such a core can sometimes provide additional information such as a maximum age by dating the underlying canvas. This is rarely possible when the pigment is left untouched, but maximum ages are not always archaeologically relevant (e.g., when they are very old). It

is also much easier to take subsamples from a core in a laboratory than in situ in a cave. However, the essential minimum age can be obtained without the impact on the art of cutting or coring, and we stand by our philosophy.

Contra Aubert et al. (2018), we can categorically state that (1) we did not unintentionally date carbonate deposits that were a part of the rock face or 'canvas,' (2) there is no question that the $CaCO_3$ crusts dated do provide minimum ages for the associated art since underlying pigment has been demonstrated in all cases, (3) the anthropogenic nature of the red pigment found on curtain formations at Ardales cave is demonstrated by technical criteria that imply human activity, and (4) there is no need to destructively sample the paintings for further laboratory analyses of a drill core. The early emergence of cave art at La Pasiega, Maltravieso and Ardales is demonstrated by calcite dates that are correct and that stratigraphically constrain the age of the motifs they are associated with.

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Figure captions

Figure 1 Selected areas of pigment on speleothem formation II.A in Ardales cave. Arrows indicate areas of pigment spray and splatter which are consistent with the blowing or spitting of pigment. a) Pigment spray and splatters associated with sample ARD13. b, c) Pigment sprays and splatters from other areas of the speleothem formation II.A.

Figure 2. Relationships between carbonate samples and pigment at Maltravieso: a) Hand stencil GS3b (Maltravieso) prior to sampling; b) the same stencil after sampling (image after application of DStretch, correlation LAB 15%; Clogg et al. 2000); c) MAL13 (stencil GS3b) prior to sampling; d) MAL13 after original sampling; pigment is clearly visible at the bottom left of the sampled area and is contiguous with the adjacent partially obscured pigment; e) MAL13 after further sampling to enlarge the sample area to highlight that the pigment originally revealed is contiguous with the adjacent partially obscured pigment and the exposed pigment of the hand stencil. Abbreviations: E = exposed pigment; O = obscured pigment; P = partially exposed pigment.

Figure 3. Sample PAS 34 from La Pasiega Cave. Pigment is exposed at the base of the sampling area (enlarged in inset) and matches the colour of the exposed pigment on the cave wall. Abbreviation: E = exposed pigment