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241,000 to 335,000 Years Old Rock Engravings Made by *Homo naledi* in the Rising Star Cave system, South Africa

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Abstract

The production of painted, etched or engraved designs on cave walls or other surfaces is recognized as a major cognitive step in human evolution. Such intentional designs, which are widely interpreted as signifying, recording, and transmitting information in a durable manner were once considered exclusive to Late Pleistocene *Homo sapiens*. Recent work has demonstrated that other hominin groups also made such marks, including Neanderthals (Rodríguez-Vidal et al., 2014; Hoffmann et al., 2018), and possibly Middle-Pleistocene *Homo erectus* (Joordens et al., 2015). Such durable signs indicate an intentionality characteristic of meaning-making (Kissel and Fuentes 2018) which has been argued to require significant levels of cognitive abilities not found in species with smaller brain sizes (Parkington, 2010). In fact, the evolution of such meaning-making symbols is thought to be a core aspect of what it means to be "human" (Henshilwood, 2009). Here we present the first known example of abstract patterns and shapes engraved within the Dinaledi subsystem of the Rising Star Cave in South Africa. We identified markings incised into the dolomitic limestone walls of the cave. The engravings described here are deeply impressed cross-hatchings and other geometric shapes. The surfaces bearing these engravings appear to have been prepared and smoothed. In some areas there is residue that creates a sheen on the surface possibly indicating repeated handling or rubbing of the rock, and there is evidence of the application of dirt or sand to the surface by non-natural processes. *Homo naledi* entered this part of the cave system and buried bodies within the both the Dinaledi Chamber and adjacent Hill Antechamber between 241 and 335 ka (Dirks et al., 2017; Robbins et al., 2021, Berger et al, 2023a). The engravings described here are found on a pillar in the Hill Antechamber that extends into the natural fissure corridor that links the two chambers and we associate them with *H. naledi*.

eLife assessment

This paper presents **important** information about potentially *Homo naledi*-associated markings discovered on the walls of the Hill Antechamber of the Rising Star Cave system, South Africa. If confirmed, the antiquity, intentionality, and authorship of the reported markings will have profound archaeological implications, as such behaviors are otherwise widely considered to be unique to our species, *Homo sapiens*. As it stands, the study is **incomplete**, and the evidence presented does not support the claims about the anthropogenic nature, age, and author of the engravings. While it is appreciated that this report concerns preliminary findings, all reviewers agree that: a) the initial nature of the reported results must be more clearly indicated, b) the anthropogenic nature of the engravings must be adequately demonstrated, c) ideally the chronology of the claimed engravings has to be established for any age estimate to be reliable, and d) the claim about *H. naledi* being the author of the reported engravings requires robust association.

Introduction

The Rising Star cave system, South Africa, is located within a small promontory situated to the south and east of the course of the Blaaubankspruit stream. The cave system is situated within the dolomitic limestone of the Malmani Subgroup, a Precambrian marine rock bedded with chert bands and containing abundant stromatolite fossils (Dirks et al. 2015; Eriksson et al. 2006). The system includes more than 3 km of mapped passages comprising multiple levels within a west-dipping dolomite horizon. Abundant remains of *Homo naledi* (Berger et al., 2015) occur within several localities in the system, including the Dinaledi subsystem, which lies at a depth of ~30 m below the present surface and ~120 m through the cave system from the nearest present entrance (Hawks et al, Elliot et al., 2019). Here, burials and other remains of *H. naledi* have been recovered and excavated from the Dinaledi Chamber, Hill Antechamber, and adjacent spaces and fissures (Berger et al. 2015; Berger et al. 2023; Brophy et al. 2021). These spaces are challenging to enter and navigate, and exploration of them is ongoing (Elliott et al. 2021).

On July 28, 2022, during a survey of the Dinaledi Subsystem, we identified what appear to be engraved markings on the southern and northern faces of a natural pillar that forms the entrance and exit of a passage connecting the Hill Antechamber with the Dinaledi Chamber (Figure 1). Most of these marks are linear features between ~5 and ~15 cm in length. Many of these intersect to form geometric patterns such as squares, triangles, crosses, and X's, while some are isolated lines. The engravings are located on three dolomitic panels, which we have labelled *A*, *B* and *C*. Seen as a triptych, these engravings are in a location where they can be viewed during access and egress to the Dinaledi Chamber when entering the system from the Hill Antechamber. The Hill Antechamber is the likely point of access by *Homo naledi* to the entire subsystem, and the passage is the natural linkage between the two main chambers of the subsystem (See Figure 1, also Elliott et al. 2021).

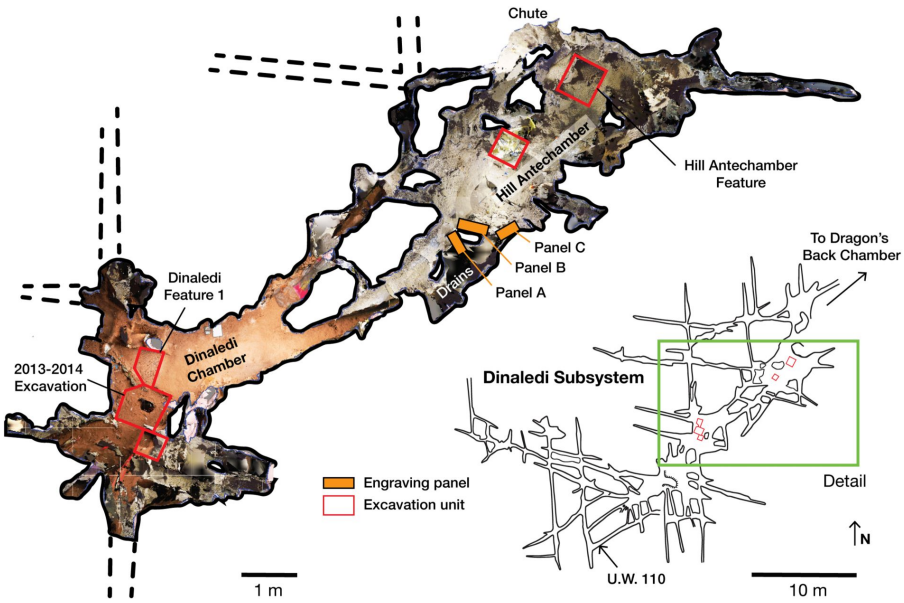


Figure 1

A photogrammetric map of the Dinaledi Subsystem of the Rising Star Cave system, South Africa. Orange bars mark the positions of the Engravings panels on the walls of the cave. Red boxes outline areas where excavations have been undertaken in the floor of the chambers. The green box outlines the area enlarged and colorized.

In this paper, we describe detailed observations of Panel A within the passage linking the two main chambers. We present illustrations of Panels B and C within the Hill Antechamber and discuss their contextual relationship with Panel A, while recognizing that identifying all engraved lines within these panels will require further study in this difficult to access space. We also provide additional contextual data demonstrating the attribution of these etchings and engravings to *H. naledi*, hypothesise how the Panel A etchings and engravings were created, and discuss implications of our findings for *H. naledi* culture and cognition. We have not carried out any invasive or destructive sampling of these panels. This description is intended to document the discovery and provide spatial and contextual information prior to any further analyses that may require invasive sampling.

Panel A

Panel A is found on the southern face of the natural pillar that forms the southern edge of the entry from the Hill Antechamber into the southern of two passages leading to the Dinaledi Chamber (Figures 1, 2). The panel is notable as an area of discoloured rock that appears to have been smoothed by both percussive blows by a hard object, as is evidenced by micro and macro pitting of the surface alien to the adjacent natural rock surfaces (Figures 3 and 4) and by the possible application of sand and grit both before and after etchings and engravings were made (Figures 5 and 6). The adhering sediment and polishing of the surface of all three panels is unique to these surfaces relative to other surfaces in the chambers, and we thus hypothesize that it may result from intentional action. This sediment or pigment may have been used either as a material to create visual contrast on the grey dolomite, to abrade the surface as a form of polish, to enhance or obscure some aspects of the engraved lines, or all of these. This material is present on the surface as a micro-layer and is evident within some of the grooves of the lines, indicating its application after some of the marks were made. The appearance of time-ordering between engraved lines and the surface treatment may imply an origin of the engravings in multiple episodes (Figure 6).

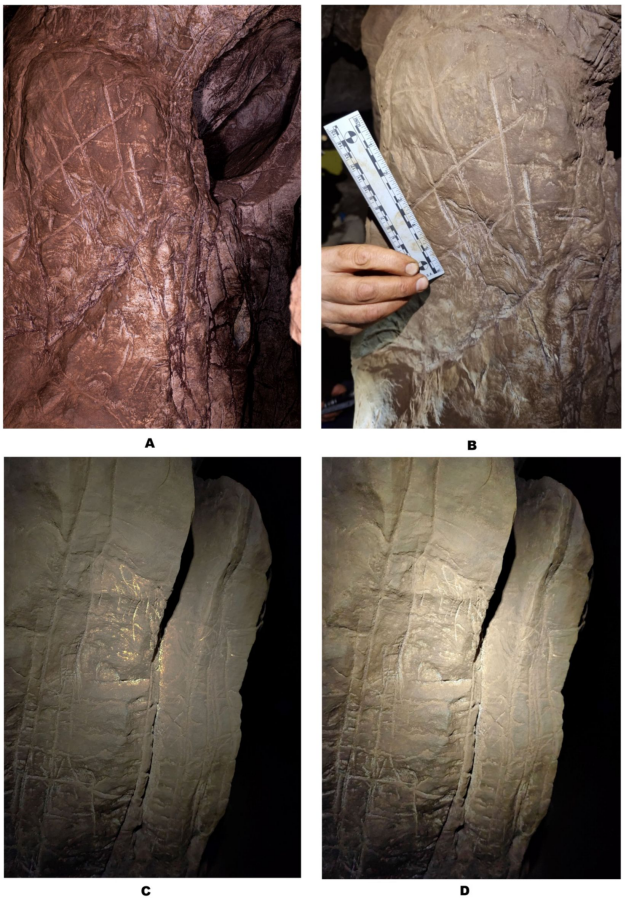


Figure 2

Engraving Panel A (Images A and B) and Engraving Panel B (Images C and D). Image A is taken with a polarizing filter as described in methods. Image B taken using only LED lights and approximates natural coloration. Image C shows the results of increasing contrast while lowering light on Panel B while Image D illustrates Panel B under LED lighting.

Figure 3

Crosshatched etchings in Panel B. The white circle outlines areas of the engraving that may indicate hammer blows or pounding marks as evidenced by pitting not seen on other surfaces.

Figure 4

Crosshatched etching comparing polarized images (bottom) with non-polarized imaging of the same area highlighting pitting marks that appear to be non-natural in origin.

Figure 5

Closeup of non-geometric figure at the top of Panel B. Note the cross like etching to the left of the figure as well as the X etched to the right. The non-geometric figure uses in part a natural fracture as an extension of the line beneath it before an inverted Y is etched at the terminus of this line. The material causing discoloration of the surface has not been analysed.

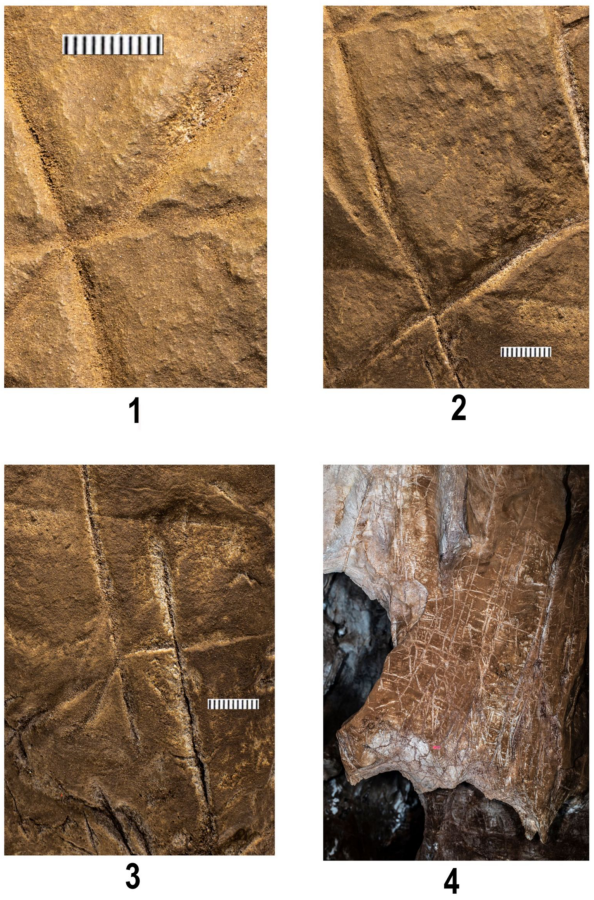


Figure 6

Evidence for sediment covering lines on Panel A. Image 1 shows lines 2,3 and 4 of Panel A (See Figure X for map). Note small sediment granules in base of lines to the left of the image, while line rising to the upper right shows penetration to the native underlying rock by the carving action. Image 2 illustrates a position slightly lower on the crosshatch marks on Panel A imaging lines 3,4,6,11 and 13. Note the difference between etching marks on the lower part and right of the image of this section of the engraving showing the difference between highly etched lines versus one presumably covered by a light layer of sediment post their creation. Note also likely pitting or presumed hammerstone marks in the central part of Image 2 between the carved lines. Image 3 illustrates lines 6, 17 and 18. Note the sharply carved lines on the right and the lines on the left that appear to be obscured by a light application of coarse sediment. Image 4 illustrates a wider shot of Panel B showing the discoloration of the area containing the engravings compared to the native rock with no sediment visible in the upper left of the image.

Figure 7

Boc like etchings on Panel B seen under ultraviolet light. Note the slight white appearance of the etched lines indicating the presence of a reflective or slightly fluorescing material in the engraved lines similar to the fluorescence of pure CaCO3.

Figure 8

The Dinaledi Subsystem etched crosshatch found on Panel A between the Hill Antechamber and Dinaledi Chamber (Top) compared to the crosshatch engravings found on the cave floor of Gorham's Cave, Gibraltar and attributed to manufacture by a neanderthal circa 60k years ago.

Figure 9

Line tracing of the Panel A Dinaledi Subsystem engraving (top in grey), compared to a line tracing of the Gorham's Cave engraving (bottom in black). Tracings not to scale.

The most visible engraved lines, when viewed together are crosshatched, give the impression of a rough hashtag figure (Figures 10 and 11). The lines appear to have been made by repeatedly and carefully passing a pointed or sharp lithic fragment or tool into the

grooves. This excludes the possibility of an unintentional or utilitarian origin. In addition, there are scratches that fall outside of identifiable designs, which may either be mistakes, unfinished designs, or form part of the design not interpretable by us. Several of the grooves overlap geological features native to the rock including fossil stromatolites (Figures 12 and 13). In many instances, it is possible to identify which lines were made first by examining the point where they cross another line (e.g. Figures 14 and 15). As has been interpreted for other discoveries of early geometric shapes etched or engraved by larger-brained species, this discovery demonstrates the capacity of *H. naledi* for expression through the use of geometric forms.

Figure 10

Non-polarized (left) and polarized (right) image of the crosshatched engraving on Panel A, Dinaledi Subsystem. Scale in millimeters.

Figure 11

Polarized image of the Panel A engraving (left) with the most visible lines (interpreted as the most recent etchings) traced (right). Scale in millimeters.

Figure 12

LED light images of the Panel A primary engravings. Scales in millimetres.

Figure 13

Lines 2,6,11, 14, 15,16,18, 21,25,27,33,38,39 and 40. Note that etching 18 overcuts line 17 and line 30 overcuts line 25 indicating an order of creation. Note also that all line engraved on the left side of the image cut through the fossil stromatolite visible as horizontal wavy lines in the rock.

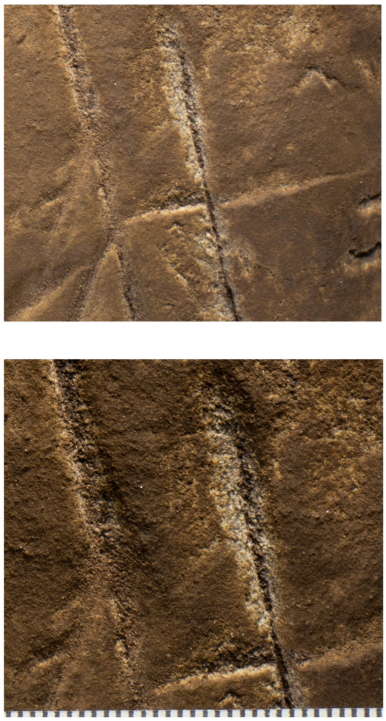


Figure 14

Magnified views of Lines 6, 17 and 18. The bottom image is a slightly higher magnification of the top image. It is clear from these images that the engraving of line 17 preceded the engraving of line 18. Scale at bottom in millimetres.

Figure 15

Magnified views of lines 16, 25 and 30. Note it is clear line 25 was etched first, followed by line 30. The lateral edge of line 31 can be seen at bottom left and the left edge of line 15 at top right. Note also the deep incision through the stromatolites layers by all lines. Scale in millimeters.

We identify at least 46 non-natural engraved marks on panel A (See Figure 16). The most prominent markings on Panel A are a series of intersecting lines (Figures 10,11 and 12).

There appears to be a temporal span involved in the creation of the engraved lines as some seem more recently engraved and show clean etching, while others have been obscured either by slight weathering or by the application of sediment. The most easily identifiable engravings, based on their clarity, are Lines L2, L6, L9, L11, L16, L17, L27, L30 and L31 (Figure 16). While the existing lines may have been created in older etchings, or been created over multiple interactions, the final etchings of the lines based on which lines overlap can be interpreted as follows: horizontal Lines 11 & 25 were created after vertical Line 2. Vertical Line 6 was created after L11. Vertical Line 18 was created after horizontal Line 17. Line 30 was created after horizontal Line 25, but before horizontal Line 31.

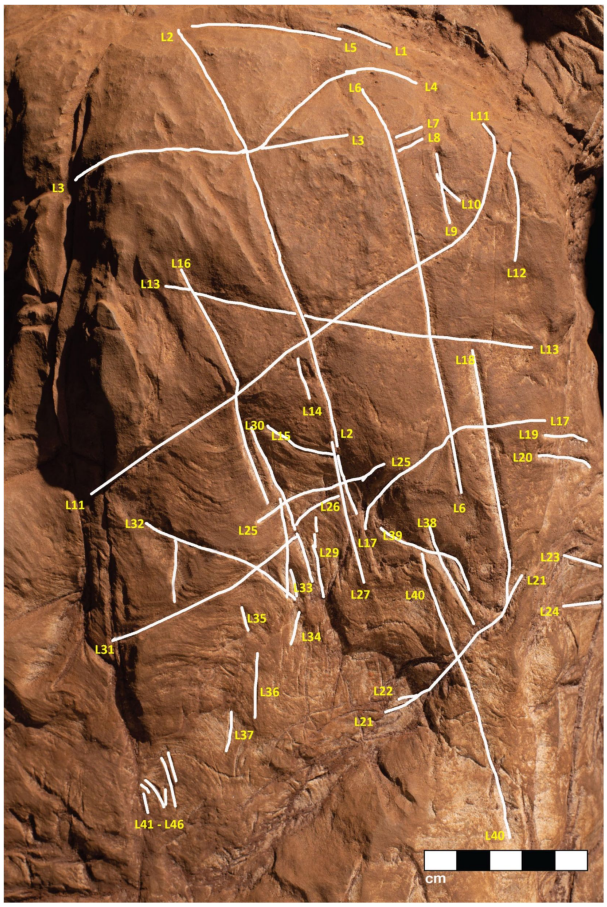


Figure 16

A conservative map of non-natural engravings observed on Panel A. Non-natural engravings are traced in white lines and given yellow numbers references in the text.

Evidence of hominin manufacture of engravings on Panel A

Dolomite is known for a pattern of natural weathering that results in patterns of recessed linear features on its surface. Artificial markings can be distinguished from this natural weathering pattern in several ways. Natural fissures and erosional features in weathered dolomite surfaces are characteristically deeper than several millimeters and they follow natural fracture planes within the rock. Artificial lines are limited in depth and extent due to the natural hardness of dolomite. This hardness means that any substantial artificial marking requires multiple parallel incisions with a hard tool. Natural erosional features in dolomite may have variable cross-sections, ranging from bevelled to U-shaped to rectangular in cross section, but do not have multiple parallel striations visible within them. Where artificial engraved markings intersect, they often exhibit an ordering in which one was completed before the other; this kind of feature is not typical of natural weathering. In

previous work, researchers have noted the limited depth of artificial lines, their composition from multiple parallel striations, and their association into a clear arrangement or pattern as evidence of hominin manufacture (Fernandez-Jalvo et al. 2014).

The engraved lines in Panel A have each of these features. They can clearly be distinguished from natural weathering of the surrounding dolomite walls, which can be seen adjacent to the panel within 20 cm of the nearest artificial marks (Figure 18). The features produced by natural weathering are deeper than 10 mm, in particular deep relative to the feature width, they maintain a consistency of size and depth across substantially undulating or rugged surfaces, they expand from natural cracks and fissures. In contrast, even the widest of the engraved lines that constitute Panel A have a relatively shallow depth. High-resolution macro-photography shows micro-striations constituting several of these engraved lines, in which roughly parallel incisions sometimes overlap with each other (See Figures 6, 13, 14, 15 and 17). Many of the lines also fall out of the direction of natural fracture features in the country rock, although it should be recognised that there are multiple places on this panel where natural lines and features of the rock may have been enhanced by artificial engraving. Figures 13, 14, and 15 show examples of ordering where engraved lines intersect, one having been completed clearly before the other.

Figure 17

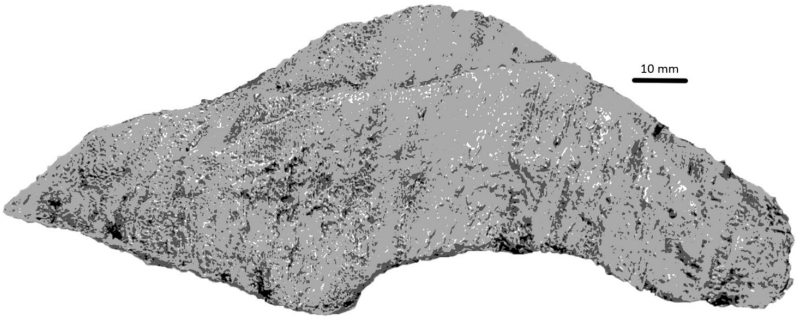
Magnified images of etchings 41 through 46 numbered from left to right. Scale in millimeters.

Figure 18

Image of dolomite above and right of Panel A. The top of the crosshatched etchings can be seen in the lower left of the image. Note the smoothing and alteration of the Panel's surface compared to natural, non-altered dolomitic surfaces above and right of the Panel typical of unaltered surfaces throughout the system.

In addition to the engraving depth, composition, and ordering, there are two additional aspects of Panel A engraved lines that distinguish them from natural weathering. The dolomitic bedrock of the Malmani Formation includes fossil stromatolites, which manifest as curving linear banded striations visible in the rock. Panel A includes these layered stromatolitic bands, and all engraved lines that pass below the bottom of Line 14 cross over this fossil feature (See Figures 13 and 15). Where engraved lines cross over this feature, they retain direction and in some cases the multiple striations slightly diverge, suggesting that maintaining a linear engraving over this irregular surface may have been challenging. Second, the engraved markings are, in places, covered wholly or partially in sediment or some other substance. This coating on the walls of the cave does not occur in other areas of the chambers where there are no engravings. Thus it does not appear this covering sediment can be explained by geological or other non-organic processes.

The means of manufacture of these engraved lines would have required an implement of equal or greater hardness as the native dolomitic limestone. At present, only one possible lithic artifact has been recovered in direct association with *H. naledi* remains (Berger et al. 2023a). This tool-shaped rock does resemble tools from other contexts of more recent age in southern Africa, such as a silcrete tool with abstract ochre designs on it that was recovered from Blombos Cave (Henshilwood et al. 2018) (Figure 19). Dolomite rocks of appropriate size and morphology to mark the cave walls have been recovered from surface contexts within the Dinaledi Subsystem, as have many chert fragments.



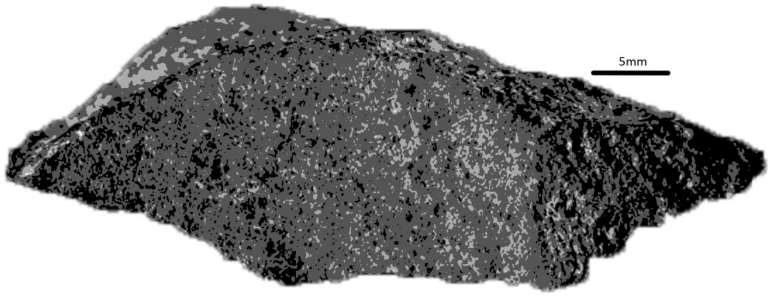


Figure 19

The tool-shaped artefact described in Berger et al, 2023a (top) recovered from the Hill Antechamber burial immediately below Panels B and C compared to the artefact from Blombos cave, South Africa attributed by Henshilwood et al 2009 as having symbolic markings in ochre made by *Homo sapiens* circa 78k years ago.

Panels B and C

Panels B and C are located on the northern wall within two meters of the Hill Antechamber burial feature described in Berger et al. (2023). Panel B is situated lower and to the right (West) of Panel C. Both panels appear to have been prepared in a similar way to Panel A, with possible use of cave sediment applied to the surface, giving the surfaces of these panels an obvious textural difference to adjacent walls of the chambers (Figures 2c & b and Figure 5) A number of obvious etchings and engravings can be seen, some in the form of geometric figures, crosses, X's and one possible non-linear geometric figure (Figure 5). It appears, in softer visible light, that a foreign substance has been applied to part of the panel. As was noted the purpose of this paper is not to describe these complex panels and the many etchings and engravings on them, but to simply note their presence in the Hill Antechamber. Future work in this difficult space is planned to sample the possible residues and map the non-natural etchings, attempt to date the etchings and we will conduct experimental work on native dolomite in controlled experiments.

Discussion and Conclusions

The attribution of engraved or painted markings to Neandertals, *Homo erectus*, or other hominin groups has generally attracted debate. Critics have emphasized the need to establish clearly the intentionality of possible markings in contrast to natural processes. Skepticism has also frequently surrounded methods to establish the geological age of

engraved or painted markings (*e.g.*,Pons-Branchu et al. 2020; White et al. 2020). Some have emphasized that while singular occurrences may indicate intentionality, only repeated evidence from multiple sites can provide evidence of possible symbolic or representational intent (Davidson 2020).

Geochronological evidence can be extremely difficult to obtain for markings on natural rock surfaces. The engraved panels in the Dinaledi subsystem are not overlain by sediments, and we have not identified any calcite formation overlapping the engraved features. This makes it challenging to assess whether the engravings are contemporary with the *Homo naledi* burial evidence from only a few meters away (Berger et al. 2023). At present we have no evidence limiting the time period across which *H. naledi* was active in the cave system. The maximum age constraint reported by Dirks et al. (2017) on *H. naledi* skeletal material (335 kyr BP) in Dinaledi is the highest 95% confidence limit of a direct ESR-US date on *H. naledi* teeth; while the minimum age constraint (241 kyr BP) is based on U-Th on a flowstone that formed in part around a bone fragment (Wiersma et al. 2020). These dates do not necessarily pertain to skeletal material from other parts of the cave system, nor do they exclude earlier or later access to the cave system by *H. naledi* individuals. The duration of *H. naledi* cultural activity within the cave system is therefore not presently known.

It is unlikely that any other hominin population made these engravings. No physical or cultural evidence of any other hominin population occurs within this part of the cave system, and there is no evidence that recent humans or earlier hominins ever entered any adjacent area of the cave until surveys by human cave explorers during the last 40 years. The number of modern cavers and archaeologists who have entered the Dinaledi subsystem is extremely limited (Table 1). There is no evidence of modern cavers altering cave walls in such a manner in the Dinaledi subsystem, or elsewhere in Rising Star system. The evidence that these engravings were created in multiple events over time further makes it unlikely that historic humans were involved in their creation. The available evidence is most compatible with the extinct species *Homo naledi* as the creator of these markings.

Table 1

Known humans who have entered the Dinaledi System

(IN APPROXIMATE ORDER OF ENTRY)

Neil Ringdahl

Rick Hunter

Steven Tucker

John Dickie

Selena Dickie

Bruce Dickie

Matthew Dickie

Matthew Berger

Megan Berger

Marina Elliott

Becca Peixotto

Lindsay Eaves Hunter

Hannah Morris

Elen Feuerriegel

Alia Gurtov

Christo Saayman

Pieter Theron

Andre Doussy

Allen Herweg

Michael Herweg

Rupert Stander

Lindin Mazilis

Dirk van Rooyen

Ashley Kruger

Zoë Rosen

Garrreth Bird

Eric Roberts

Maropeng Ramalepa

Elliott Ross

Tebogo Makhubela

Mathabela Tsikoane

Riaan Hugo

Corey Jaskolski

Kenny Broad

Juan Luis Arsuaga

Ignacio Martínez Mendizábal

Carlos Lorenzo Merino

Rolf Quam

Keneiloe Molopyane

Kerryn Warren

Angharad Brewer-Gillham

Raymond Messitar-Tooze

Zubiar Jinnah

Samuel Nkwe

Warren Smart

Lee Berger

Ginika Ramsawak

Sarah Johnson

The evidence of burials and associated mortuary practices by *H. naledi* near the engravings reinforces that assertion this species carried out repeated complex patterns of behaviour in this deep cave setting (Berger et al. 2023a, Fuentes et al. 2023). The engravings are located in a distinctive position, on the left-hand wall as seen when entering the system from the North, and interior left hand pillar that forms the entrance archway to the tunnel linking the Hill Antechamber burial area with the larger Dinaledi Chamber burial area. This is the only place engravings have been discovered so far within the Dinaledi subsystem. The evidence that Panel A was marked in multiple episodes, possibly separated by substantial time, suggests that the selection of this location was not random, and that an individual or individuals returned to this location to carry out a similar pattern of activity on multiple occasions.

The main engravings on Panel A appear similar to other engravings found in the later Pleistocene. The shapes of the engravings on panels A,B and C also appear to include the following geometric forms identified by Von Petzinger (2017): crosshatch, cruciform, line, flabellifrom, scalariform, open angle and oval. However, further analytic and comparative work must be conducted to confirm exactly how much similarity and overlap there is between the Dinaledi engravings and the engravings at other Pleistocene sites where such

designs are found. As a specific observation however, the engravings in panel A give the impression of overlapping crosses and lines and are remarkably similar in appearance to the engraving from Gorham's Cave, Gibraltar (Rodriguez-Vidal et al. 2014). This engraving was dated to greater than 39 kyr cal BP and has been attributed to Neandertals. Other geometric patterns made with lines occur in several contexts are reported for some later Pleistocene sites in southern Africa and elsewhere (e.g. Von Petzinger, 2017). These include ochre lines, engraved bones, and engraved ochre chunks from Blombos Cave (d'Errico et al. 2001; Henshilwood et al. 2002; Henshilwood et al. 2018), engravings from Wonderwerk Cave (Thackeray et al. 1981) and lines impressed within sand features that were later lithified into aeolianites (Helm et al. 2021). There are also a few other engravings from sites in Europe at similar time depth (Von Petzinger, 2017; Kissel and Fuentes 2017, 2018), as well as geometric lines on a freshwater mussel shell from Trinil Java, attributed geochronologically to *H. erectus* (Joordens et al. 2015). The engravings from the Dinaledi Subsystem share similarities with many of these geometric expressions from other sites and geographic regions. The Blombos artifacts also include some surfaces that appear to have been prepared or smoothed prior to engraving possibly similar to the processes involved in the smoothing of Dinaledi Panel A.

Many of these examples of engraved lines from later Pleistocene sites appear to be nonrandomly placed on an object or surface. Henshilwood and Dubreuil (2011) have suggested that one should be less focused on the specifics of the designs and rather concentrate on the underlying cause of their creation. Those and other authors suggest symbolic implications for such engravings and associated them with the emergence of contemporary *Homo sapiens*. However, the recent identification of engravings and other forms of material meaning making in a range of other-than-*Homo sapiens* hominins over the latter portions of the Pleistocene (Kissel and Fuentes 2018, 2021) suggests that such activity, be it "symbolic" or not, is not exclusive to *Homo sapiens*. With the engravings reported here we add to this growing dataset by providing additional evidence of later Pleistocene engravings associated with a non-*Homo sapiens* hominin. We also add to the complexity involved in examining and understanding the implications of such engravings by reporting that the most likely creator of these engravings was the small-brained *Homo naledi*. This has implications for the evolution of biological intelligence among hominins and the association with encephalization with cognitive complexity.

Methods

The etchings and engraving markings were examined using high resolution photography and magnification of lines and markings. Polarizing filters were also used to enhance relief and this is indicated when used.

Cross-polarisation was employed for control of specular highlights/reflections in order to limit artefacts when generating the 3D-depth map for photogrammetry purposes. A circular polariser was used on the camera lens in conjunction with a linear polarising gel placed over the two speed lights (electronic flash heads) used as the light source. The different minerals/material on the dolomite are reflecting/absorbing the cross-polarised light emphasising the "bright" striations visible in images.

Images were shot with a 50mm (Polariser fitted) at f/11 unless otherwise stated.

The light source used (twin speed lights with polarised gel attached) were placed as close to the Lens axis as possible so that the angles of incidence approximate the reflected angles limiting shadow. This assisted us in building the 3D mesh for photogrammetry purposes. The cross-polarisation also removed specular highlights that create artefacts.

We used Metashape 1.8.1 (Agisoft, Inc.) to generate three-dimensional models of panels A and B based on photographs taken with the parameters reported above. Generation of cross-sections and measurements from these models were performed with MeshLab 2021.20. Resolution of the three-dimensional surface is estimated to be accurate to 0.2 mm.

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Competing interest declaration

The authors declare that they have no competing interests with the production or publication of this research.

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Reviewer #1 (Public Review):

I think it is important to note up front that I recognize that the goal of this paper was to announce the discovery of what appear to be intentionally-made marks in Rising Star cave in South Africa. This was not meant to be an in-depth analysis or a declaration of definitive results. With this in mind, I appreciate that the authors did not try to overstate this new discovery, but instead simply reported what had been observed, provided a little bit of background on the current state of the field in regards to the evolution of hominin visual mark-making, made a few tentative identifications, but then clearly acknowledged that a lot more documentation, sampling, and study would be needed before we could understand the full scope and potential importance of this find.

This is a big claim. If it proves to be true, it has the potential to be paradigm-shifting as the identification of intentional engraved marks, made by a small-brained distant human cousin 200,000+ years ago in South Africa, would completely change our understanding of where, when and who made the first graphic marks. Twenty years ago, this claim would probably have been dismissed out of hand as being too far-fetched to be taken seriously, but there have been some major shifts in the field in recent years, in regard to the age of the art and the identity of the artists, that means this is a claim that should be approached with a

scientifically cautious, but open mind. There is now mounting evidence for Neanderthals, and potentially other closely related species as well, to have been engaging in similar art-making practices to our own Homo sapiens ancestors. What makes this particular claim so extraordinary is that these marks are some of the oldest in the world and that *Homo naledi* is a more distant relation with a smaller brain. This is also what makes the further study of this discovery such a fascinating exercise in scientific inquiry.

From a technical and methodological perspective, there is an excellent range of tools and technologies that can be used to study these engravings, so I have no doubt that further studies will help answer some of the "nuts and bolts" questions. Then there is also the opportunity created by this discovery to really open a broader dialogue in the field about who were the first artists and at what point does the hominin brain become "primed" for making visual marks. I look forward to all sorts of lively debates in the future and to seeing the results of further in-depth studies.

Reviewer #2 (Public Review):

Patterns scored into or painted on durable media have long been considered important markers of the cognitive capabilities of hominins. More specifically, the association of such markers with *Homo sapiens* has been used to argue that our evolutionary success was in part shaped by our unique ability to code, store and convey information through abstract conventions.

That singularity of association has been cast into doubt in the last decade with finds of designs apparently painted or carved by Neanderthals, and potentially by even earlier hominins. Even allowing for these developments, however, extending the capability to generate putatively abstract designs to a relatively small-brained hominin like *Homo naledi* is contentious. The evidential bar for such claims is necessarily high, and I don't believe that it has been cleared here.

The central issue is that the engravings themselves are not dated. As the authors themselves note, the minimum age constraint provided by U/Th on flowstone does not necessarily relate to the last occupation of the Dinaledi cave system, as the earlier ESR age on teeth does not necessarily document first use of the cave. The authors state that "At present we have no evidence limiting the time period across which *H. naledi* was active in the cave system". On those grounds though, assigning the age range of presently dated material within the cave system to the engravings - as the current title unambiguously does - is not justifiable.

Because we don't know when they were made, the association between the engravings and *Homo naledi* rests on the assertion that no humans entered and made alterations to the cave system between its last occupation by *Homo naledi*, and its recent scientific recording. This is argued on page 6 with the statement that "No physical or cultural evidence of any other hominin population occurs within this part of the cave system".

There is an important contrast between the quotes I have referred to in the last two paragraphs. In the earlier quote, the absence of evidence for *Homo naledi* in the cave system >335 ka and <241 ka is not considered evidence for their absence before or after these ages. Just because we have no evidence that *Homo naledi* was in the cave at 200 ka doesn't mean they weren't there, which is an argument I think most archaeologists would accept. When it comes to other kinds of humans, though - per the latter quote - the opposite approach is taken. Specifically, the present lack of physical evidence of more recent humans in the cave is considered evidence that no such humans visited the cave until its exploration by cavers 40 years ago. I don't think many archaeologists would consider that argument compelling. I can see why the authors would be drawn to make that assertion, but an absence of evidence

cannot be used to argue in one way for use of the cave by *Homo naledi* and in another way for use of the cave by all other humans.

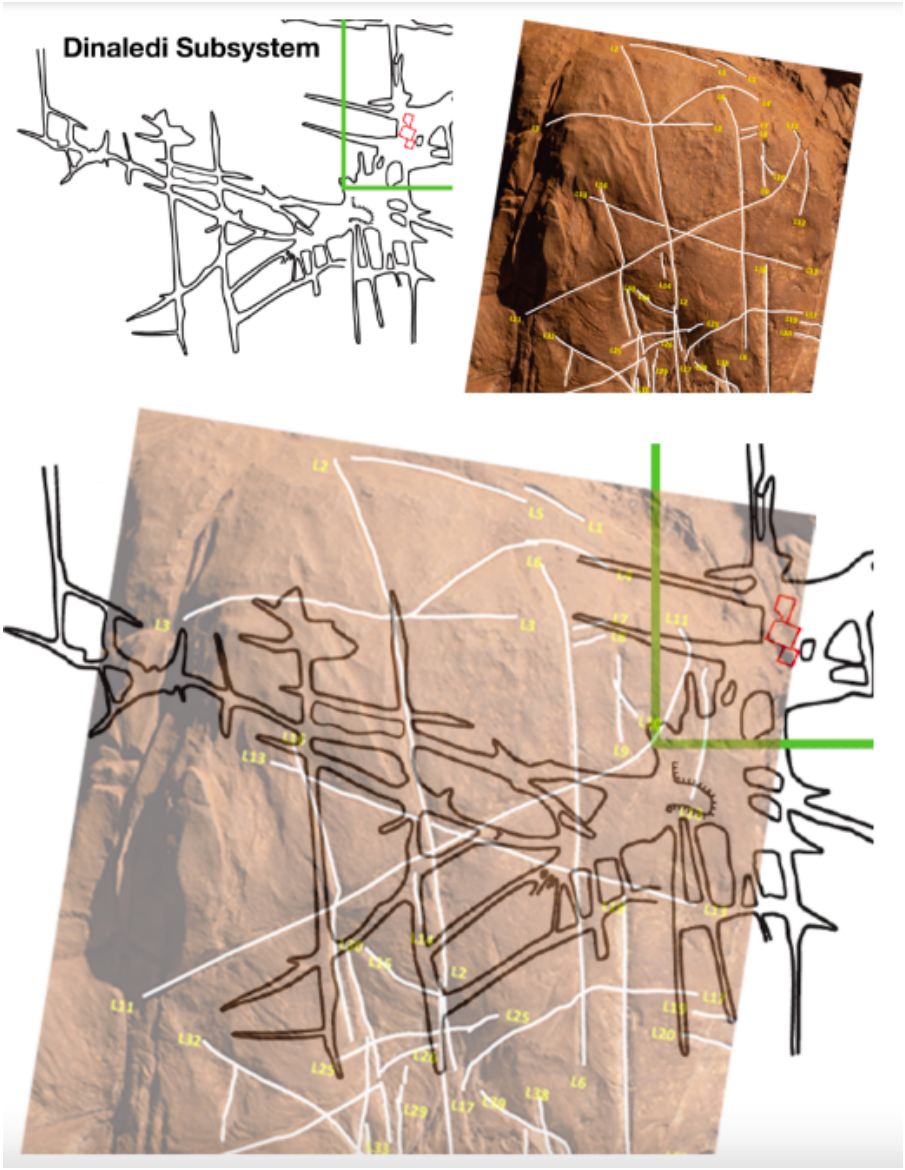
A second problem is with what *Homo naledi* might have made engravings. The authors state that "The lines appear to have been made by repeatedly and carefully passing a pointed or sharp lithic fragment or tool into the grooves". The authors then describe one rock with superficial similarities to a flake from the more recent site of Blombos to suggest that sharp-edge stones with which to make the engravings were available to *Homo naledi*. Blombos is considered relevant here presumably because it has evidence for Middle Stone Age engravings. The authors do not, however, demonstrate any usewear on that stone object such as might be expected if it was used to carve dolomite. Given that it is presented as the only such find in the cave system so far, this seems important.

My greater concern is that the authors did not compare the profile morphology of the Dinaledi engravings with the extensive literature on the morphology of scored lines caused by sharp-edge stone implements (e.g., Braun et al. 2016, Pante et al. 2017). I appreciate that the research group is reticent to undertake any invasive work until necessary, but non-destructive techniques could have been used to produce profiles with which to test the proposition that the engravings were made with a sharp edge stone.

One thing I noticed in this respect is that the engravings seem very wide, both in absolute terms and relative to their depth. The data I collected from the Middle Stone Age engraved ochre from Klein Kliphuis suggested average line widths typically around 0.1-0.2 mm (Mackay and Welz 2008). The engraved lines at Dinaledi appear to be much wider, perhaps 2-5 mm. This doesn't discount the possibility that the engravings in the Dinaledi system were carved with a sharp edge stone - the range of outcomes for such engravings in soft rock can be quite variable (Hodgskiss 2010) - only that detailed analysis should precede rather than follow any assertion about their mode of formation.

None of this is to say that the arguments mounted here are wrong. It should be considered possible that *Homo naledi* made the engravings in the Dinaledi cave system. The problem is that other explanations are not precluded.

As an example, the western end of the Dinaledi subsystem has a particular geometry to the intersection of its passages, with three dominant orientations, one vertical (which is to say, north-south), and two diagonal (Figure 1). The major lines on Panel A have one repeated vertical orientation and two repeated diagonal orientations (Figure 16), particularly in the upper area not impacted by stromatolites. The lines in both the cave system and engravings in Panel A appear to intersect at similar angles. Several of the cave features appear, superficially at least, to be replicated. In fact, scaled, rotated, and super-imposed, Figure 16 is a plausible 'mud map' of the western end of the Dinaledi system carved incrementally by people exploring the caves. A figure showing this is included here:



Of course, there are problems with this suggestion. The choice of the upper part of Panel A is selective, the similarity is superficial, and the scales are not necessarily comparable. (Note, btw, that all of those caveats hold equally well for the comparison the authors make between the unmodified rock from Dinaledi and the flake from Blombos in Figure 19). However, the point is that such a 'mud map hypothesis' is, as with the arguments mounted in this paper, both plausible and hard to prove.

Having read this paper a few times, I am intrigued by the engravings in the Dinaledi system and look forward to learning more about them as this research unfolds. Based on the evidence presently available, however, I feel that we have no robust grounds for asserting when these engravings were made, by whom they were made, or for what reason they were made.

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Reviewer #3 (Public Review):

Lee Berger and colleagues argue here that markings they have found in a dark isolated space in the Rising Star Cave system are likely over a quarter of a million years old and were made intentionally by *Homo naledi*, whose remains nearby they have previously reported. As in a European and much later case they reference ('Neanderthal engraved 'art' from the Pyrenees'), the entangled issues of demonstrable intentionality, persuasive age and likely authorship will generate much debate among the academic community of rock art specialists. The title of the paper and the reference to 'intentional designs', however, leave no room for doubt as to where the authors stand, despite avoidance of the word art, entering a very disputed terrain. Iain Davidson's (2020) 'Marks, pictures and art: their contributions to revolutions in communication', also referenced here, forms a useful and clearly articulated evolutionary framework for this debate. The key questions are: 'are the markings artefactual or natural?', 'how old are they?' and 'who made them?, questions often intertwined and here, as in the Pyrenees, completely inseparable. I do not think that these questions are definitively answered in this paper and I guess from the language used by the authors (may, might, seem etc) that they do not think so either.

First, a few referencing issues: the key reference quoted for distinguishing natural from artefactual markings (Fernandez-Jalvo et al. 2014), whilst mentioned in the text, is not included in the references. In the acknowledgements, the claim that "permits to conduct research in the Rising Star Cave system are provided by the South African National Research Foundation" should perhaps refer rather to SAHRA? In the primary description of their own markings from Rising Star and their presumed significance, there are, oddly, several unacknowledged quotes from the abstract of one of the most significant European references (Rodriguez-Vidal et al. 2014). These need attention.

Before considering the specific arguments of the authors to justify the claims of the title, we should recognise the shift in the academic climate of those concerned with 'ancient markings' that has taken place over the past two or three decades. Before those changes, most specialists would probably have expected all early intentional markings to have been made by *Homo sapiens* after the African diaspora as part of the explosion of innovative behaviours thought to characterise the 'origins of modern humans'. Now, claims for earlier manifestations of such innovations from a wider geographic range are more favourably received, albeit often fiercely challenged as the case for Pyrenean Neanderthal 'art' shows (White et al. 2020). This change in intellectual thinking does not, however, alter the strict requirements for a successful assertion of earlier intentionality by non-sapiens species. We should also note that stone, despite its ubiquity in early human evolutionary contexts, is a recalcitrant material not easily directly dated whether in the form of walling, artefact manufacture or potentially meaningful markings. The stakes are high but the demands are no less so.

Why are the markings not natural? Berger and co-authors seem to find support for the artefactual nature of the markings in their location along a passage connecting chambers in the underground Rising Star Cave system. The presumption is that the hominins passed by the marked panel frequently. I recognise the thinking but the argument is weak. More confidently they note that "In previous work researchers have noted the limited depth of artificial lines, their manufacture from multiple parallel striations, and their association into clear arrangement or pattern as evidence of hominin manufacture (Fernandez-Jalvo et al. 2014)". The markings in the Rising Star Cave are said to be shallow, made by repeated grooving with a pointed stone tool that has left striations within the grooves and to form designs that are "geometric expressions" including crosshatching and cruciform shapes. "Composition and ordering" are said to be detectable in the set of grooved markings. Readers of this and their texts will no doubt have various opinions about these matters, mostly related to rather poorly defined or quantified terminology. I reserve judgement, but would draw little comfort from the similarities among equally unconvincing examples of early, especially very early, 'designs'. Two or even three half-convincing arguments do not add up to one convincing one.

The authors draw our attention to one very interesting issue: given the extensive grooving into the dolomite bedrock by sharp stone objects, where are these objects? Only one potential 'lithic artefact' is reported, a "tool-shaped rock [that] does resemble tools from other contexts of more recent age in southern Africa, such as a silcrete tool with abstract ochre designs on it that was recovered from Blombos Cave (Henshilwood et al. 2018)", also figured by Berger and colleagues. A number of problems derive from this comparison. First, 'tool-shaped rock' is surely a meaningless term: in a modern toolshed 'tool-shaped' would surely need to be refined into 'saw-shaped', 'hammer-shaped' or 'chisel-shaped' to convey meaning? The authors here seem to mean that the Rising Star Cave object is shaped like the Blombos painted stone fragment. But the latter is a painted fragment, not a tool and so any formal similarity is surely superficial and offers no support to the 'tool-ness' of the Rising Star Cave object. Does this mean that Homo naledi took (several?) pointed stone tools down the dark passageways, used them extensively and, whether worn out or still usable, took them all out again when they left? Not impossible, of course. And the lighting?

The authors rightly note that the circumstance of the markings "makes it challenging to assess whether the engravings are contemporary with the *Homo naledi* burial evidence from only a few metres away" and more pertinently, whether the hominins did the markings. Despite this honest admission, they are prepared to hypothesise that the hominin marked, without, it seems, any convincing evidence. If archaeologists took juxtaposition to demonstrate authorship, there would be any number of unlikely claims for the authorship of rock paintings or even stone tools. The idea that there were no entries into this Cave system between the Homo naledi individuals and the last two decades is an assertion, not an observation, and the relationship between hominins and designs no less so. In fact, the only 'evidence' for the age of the markings is given by the age of the *Homo naledi* remains, as no attempt at the, admittedly very difficult, perhaps impossible, task of geochronological assessment, has been made.

The claims relating to artificiality, age and authorship made here seem entangled, premature and speculative. Whilst there is no evidence to refute them, there isn't convincing evidence to confirm them.

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- White, Randall et al. 2020. Still no archaeological evidence that Neanderthals created Iberian cave art.

Reviewer #4 (Public Review):

This is potentially a landmark study with far-reaching consequences for archaeology, palaeoanthropology, and more widely. The antiquity of intentional human mark marking is a hot topic but this study – understood as initial – has as yet incomplete sources of evidence and methods; and it will be interesting to follow how the study develops in subsequent studies.

Strengths and points to build on:

* Heuristic potential: As knowledge advances it poses a risk to accepted knowledge – and we should accept that one such risk is moving on from long-held disciplinary tenets. In this case, there has been a growing quantum of evidence – all hotly debated – for the deep antiquity of mark-making and even symbolism by species other than ourselves. Most researchers now accept Neanderthal symbolic capacity actualised in burials, intentional mark-making and the like. The evidence here presented is not unequivocal but is very suggestive and an ideal test case for applying multi-disciplinary techniques of analysis and interpretation beyond the expertise of the listed authors *see comments in 'weaknesses'). This work by itself may be equivocal but when taken together with other such work, points to a 'human' sensu lato past that is as complex as it is long. This work then helps all researchers to at least be alive to the possibility of things like anthropic marks and residues in a context not normally thought to have it.

* Decentering speciesism: As per the above comment, I appreciate empirical studies that erode speciesism – in particular studies that open up our minds to the possibility that multiple members of the Genus *Homo* were capable of intentional mark-making and even 'symbolic' behaviour, though this latter term is not well understood or uniformly used. This is probably because of continuous unconscious bias on our part as currently the only exemplar of our genus living - in contrast to most of the past in which different species and genera co-existed - if not on the same landscape and/or at exactly the same time, then with enough overlap that people would have realised 'others' were about either by sight and/or by encountering their physical remains and artefacts.

* Problematising 'firsts' and deep time: A strength – but which needs to be developed in this manuscript – is our understanding of time and change. We have a plethora of dating techniques but relatively few substantive monographs, articles, and think tanks on time – and especially on how change comes about and what causes it. This leads us to privilege 'firsts' and the 'oldest' finds in 'deep' time above those that are more recent and in 'shallow' time. I would suggest in addition to the claims for the oldest of the reported marks, the authors develop nascent remarks on the possibility the suite of marks may have been made over time. This will help counter criticism that these marks – if established to be anthropic – were not just a singularity, but part of patterned behaviour, which would move it towards the realm of 'symbolic' cognitive behaviour. And indeed, it would be good to hear more about why in this place, these marks were made to establish a replicable model for identifying early anthropic marks.

Ultimately, this manuscript presents evidence that those who are pro the deep antiquity of intentional mark-making by *Homo* (and possibly even other genera) will find enough evidence to support; while those sceptical of such claims will find enough methodological flaws and evidential limits to refute those claims. The next decade of work will likely be definitive and this article makes a key contribution to the debate.

Weaknesses and points to attend to:

* Definitions: The term 'rock engraving' is used rather uncritically and also the term 'etching' – and it would be useful to have a short definition of how the authors understand the term. Rock art scholars regularly debate these terms and whether they are or are not 'rock art' with its overwhelmingly visual bias; which this discovery may usefully help overthrow and advance.

* Dating: There is no evidence provided for dating the marks found in the cave system. They could, for example, have been made more recently than the dates claimed – and by another species (if we accept their anthropogenic authorship). This is a perennial problem of much rock art research – especially when it comes to understanding the wider archaeological/palaeoanthropological context. More crucially, accurate dating allows a more reliable understanding of authorship and who/what was responsible for a particular artefact or feature. This has not been demonstrated in this case, though we do have fossil evidence of Homo naledi in the cave system. The article title is this incorrect / and unsupported claim as the marks, if they are anthropic, have not been dated and are of unknown age. The authors allow that there may have been multiple episodes, but not that the marks can belong to a time other than they posit – either earlier, later, or distributed over a long period as the authors allow for in their concluding remarks.

* Authorship: The study does not utilise either a geoscientist as one of the authorial team, or a rock art specialist. These are key oversights as the former would help better contextualise the dating of the marks reported on, as well as explore alternative non-anthropogenic agents that may have created the marks reported on. For example, the marks and 'pitting' etc may be the result of water bringing abrasive agents during times of flooding, hitting prominent rock features in the cave system. Some explanation is given from lines 114-124, but are uncited. The overlying 'sediment' may be similar to the mondmilch found in cave systems and which is of natural origin. It may be that these non-anthropogenic causes are easy to discount; but the arguments do need to be made. Or, that the polishing was made by *Homo naledi* brushing against the surfaces as they moved in the cave system, independent of any mark-making. A Table showing the pros and cons of intentional anthropic versus natural authorship would be very effective - as well as showing some of the natural linear marks in the cave system to avoid any confirmation or similar bias. FTIR analysis of the panel A-C would be more than useful to determine whether an additional layer of material has been added. This is mentioned for future work, but this seems a rather post-hoc research programme.

* Use-wear analysis: If the marks are anthropic in origin; they are likely to have been made by a stone tool, which would leave characteristic marks, directionality and sequencing, distinct from natural causes. It is vital this work – such as was done on the Blombos engraved ochre – is done here – for example, linking to the chert and other tools described on lines 152-158. Note Figure 19, of such a tool, is very hard to make out. The Blombos – and Klasies River Mouth engraved ochres (curiously not referenced) – have very similar geometric markings and there is a real opportunity to compare these in securely dated contexts of 70-120 kya –which could support the argument made here for *Homo naledi's* cognitive capacity. On figure 16 it would be good to know on what basis some marks were

selected as anthropic – and why others were not; this would help demonstrate the methodology and ability to distinguish between the two kinds of marks.

* Viewshed: The rock art specialist would have added essential expertise on how to study anthropic marks. For example, the images of the marks shown are all of individual or small collections of motifs rather than showing each panel as well as all panels together, to help understand the iconographic context as an ensemble – a 'feature' rather than isolated 'artefacts' or 'motifs'. Line 60 mentions being able to see these as a 'triptych' but the reader is not able to have this view in this manuscript. From the cave map, it is not clear whether all three 'panels' (an unfortunate art historical term that suggests a framed entity - better to use a term like 'cluster') can be viewed simultaneously or in sequence. The view shed in relation to the area where the bodies were recovered is vaguely stated as 'only a few metres away' and is worth developing. I understand 3D scans have been made so it would be useful to have a version showing the marks in relation to where the bodies were recovered and as a 3-cluster ensemble.

* Image enhancements: Also, in addition to polarised images, have colour enhancement tools like DStretch been tried to see if, for example, attempts at colouring with different coloured sands were made? Similarly, a 3D scan of the motif and panel – (Metashape is mentioned but not shown) – might assist in understanding how the marks and the rock they are on might relate to each other- as research in European upper Palaeolithic contexts has shown. Here, experimenting with different kinds of lighting - or in the absence of lighting, of tactility and how these marks and their rock support may have been experienced by those who may have made and interacted with them? As a note, it would be useful to have a scale in each image of the 'engravings' and it is a pity the one in situ photograph with the scale is not a standard rock art colour-corrected scale as is commonly used in rock art research.

Author Response:

We would like to thank the eLife reviewers for the considerable time and effort they have invested to review these manuscripts. We have also benefited from a previous round of review of the manuscript describing the proposed burial features, which underwent two rounds of revisions in a high-impact journal over a period of approximately 8 months during 2022 and early 2023. Both sets of reviews have reflected mixed responses to the evidence we have presented, with one reviewer recommending acceptance with minor editorial revisions, two recommending acceptance with minor revisions and the fourth recommending rejection based upon similar arguments to those reflected by some of the reviewers in this current round of reviews in eLife. Ultimately the managing editor of this first journal took the decision that the review process could not be completed in a timely manner and rejected the manuscript although the submission here reflected our consideration of these reviewers suggestions.

We have chosen in this initial response to the eLife reviews to include some references to the previous anonymous reviews in order to illustrate differences of opinion and differences in revision suggestions within the review process. Our goal is to offer maximal insight into our decision-making process and to acknowledge the considerable time and effort put into the assessment of these manuscripts by reviewers (for eLife and in the case of the earlier review process). We hope that this approach will assist the readers, and reviewers, of our manuscripts in understanding why we are proceeding with certain decisions during the revision process.

This is a new process for us and the reviewers, and one way in which it significantly differs from more traditional review is that both the reviews and our reply will be public well in advance of our revisions to the manuscript. Indeed, considering the scope of the reviews,

some of those revisions may take considerable time, although many can be accomplished fairly easily. Thus, we are not in a position to say that we have solved every issue raised by the reviewers. Instead, we will examine what appear to be the key critical issues raised regarding the data and the analyses and how we propose to address these as we revise the papers. We will also address several philosophical and ethical issues raised by the reviews and our proposal for dealing with these. More specific editorial and citational recommendations will be dealt with on a case-by-case basis, and we do not address these point-by-point in this reply. Please note, this response to the reviewers is not the revision of the manuscript and is only the initial opinion of the corresponding authors with some guidance from the larger group of authors of all three papers. Our final submitted revision will reflect the input of all authors included on those submissions.

We took the decision to submit three separate papers consciously. The two different categories of evidence, burials and engravings, involve different kinds of analysis and different (although overlapping) teams of researchers, and we recognized that each deserved their own presentation and assessment. Meanwhile, together they inform the context of *H. naledi* in a way that requires some synthetic discussion, in which both kinds of evidence are relevant, leading to a third paper. But the mutual relevance of these different kinds of evidence and their review by a common set of reviewers naturally raises cross-cutting issues, and the reviewers have cross-referenced the three articles. This has sometimes led to suggestions about one manuscript based on the contents of another. Considering the situation, we accepted the recommendation that it would be clearer to consider all three articles in a single reply. Thus, while each of the three papers will proceed separately during the revision process, it will be necessary to highlight across all three papers occasionally in our responses.

Scientific Issues:

In reading the reviews, we feel there are 9 critical points/assertions raised by one or more of the reviewers that present a problem for, or challenge to, our hypothesis that the observed evidence (bone accumulations and engravings) described in the Dinaledi subsystem are of intentional naledigenic origin. These are:

1. The evidence presented does not demonstrate a clear interruption of the floor sediments, thus failing to demonstrate excavated holes.

2. The sediments infilling the holes where the skeletal remains are found have not been demonstrated to originate from the disruption of the floor sediments and thus could be part of a natural geological process (e.g. water movement, slumping) or carnivore accumulations.

3. Previous geological interpretations by our research group have given alternative geological explanations for formation of the bony accumulations that contradict the present evidence presented here and result in alternative origins hypotheses.

4. Burial cannot be effectively assessed without complete excavation of the features and site.

5. The skeletal remains as presented do not conform clearly to typical body arrangement/positions associated with human (*Homo sapiens*) burials.

6. There is no evidence of grave goods or lithic scatters that are typically associated with human burials.

7. Humans may have been involved with the creation of either the *Homo naledi* bone accumulations, the engravings, or both.

8. Without a date of the engravings, the null hypothesis should be the engravings were created by *Homo sapiens*.

9. The null hypothesis for explanation of the skeletal remains in this situation should be "natural accumulation".

Our analysis of the Dinaledi Feature 1 leads us to accept that the laminated orange-red mudstone (LORM) sedimentary layer is interrupted, indicating a non-natural intervention, and that the hole created by the interruption was then filled by both a fleshed body (and perhaps parts of other bodies) which were then covered by sediment that originated from the hole that was dug. We recognize that the four eLife reviewers are not convinced that our presentation is sufficient to establish this. Interestingly, this was not the universal opinion of earlier reviewers of the initial manuscript several of whom felt we had adequately supported this hypothesis. The lack of clarity in this current version of the burial manuscript is our responsibility. In the upcoming revision of this paper to be submitted, we will take the reviewers' critiques to heart and add additional figures that illustrate better the disruption of the LORM and clarify the sedimentological data showing the material covering the skeletal remains in the hole are the disrupted sediments excavated from the same hole. We are proposing to isolate this most critical evidence for burial into a separate section in the revised submission based on the reviewers' comments. The fact that the LORM layer is disrupted, a fleshed body was placed in the hole created by this disruption, and the body (and perhaps parts of other bodies) was/were then covered by the same sediments from the hole is the central feature of our hypothesis that the bone accumulations observed reflect a burial and not a natural process.

The possibility of fluvial transport or involvement in the subsystem is a topic that we have addressed extensively in past work, and it is clear from these reviews that we must enhance our current manuscript to discuss this issue at greater length. Our previous work (Dirks et al. 2015; Dirks et al. 2017) emphasized that fluvial transport of whole bodies into the subsystem was precluded by several lines of sedimentological evidence. We excavated a rich accumulation of skeletal remains, including articulated limbs and other elements in subvertical orientations inconsistent with slow sedimentary infill, which were difficult to explain without positing either a large and dense pile of bodies and/or sediment movement. We encountered fractured chunks of laminated orange-red mudstone (LORM) in random orientations within our excavation area, within and among skeletal remains, which directly refuted that the remains were inundated with water at the time of burial, and this limited the possibility of fluvial transport. Water flow sufficient to displace bodies or complete skeletal evidence would also transport large and course sediment, which is absent from the subsystem, and would sort the commingled skeletal material that we found by size, which we do not observe. But our excavation only covered less than a square meter at very limited depth, and this was the limit to our knowledge of subsurface sediment. We thus were left with uncertainty that led us to suggest the possibility of sediment slumping or movement into subsurface drains, although these were not observed near our excavation. Our current work expands our knowledge of the subsurface and presents an alternative explanation for the disposition of skeletal remains from our earlier excavation. But we acknowledge that this new explanation is vulnerable to our own previous published proposals, and we must do a better job of explaining how the new information addresses our previous suggestions. By not clearly creating a section where we explained how these previous hypotheses were now nullified by new evidence, we clearly confused the reviewers with our own previous work. We will revise the manuscript by enhancing the review of the significant geological evidence demonstrating that there is no significant fluvial action in the system and making it clear how the burial hypothesis provides a clearer explanation for the situation of skeletal remains from our previous excavation work.

One of the central issues raised by reviewers has been a perceived need to excavate these features completely, totally exhuming all skeletal remains from them. Reviewers have written that it is necessary to identify every skeletal element that is present and account for any missing elements. On this point, we have both ethical and scientific differences from these reviewers. We express our ethical concerns first. Many of the best-preserved possible burials ever discovered by archaeologists were subjected to total excavation and exhumation. Cases like La Chapelle-aux-Saints, La Ferrassie, and Skhūl were fully excavated at a time when data recording and excavation methods did not include the range of spatial and geomorphological approaches that later became routine. The judgment of early investigators that these situations were intentional burials was challenged by later workers, and the kind of information that might enable better tests had been irrevocably lost (Gargett 1999; Dibble et al. 2015; Rendu et al. 2014).

Later, improved excavation standards have not sufficed to remove uncertainty or debate about possible burials. For example, it was long presumed that well-preserved remains of young children were by themselves diagnostic of intentional burial, such as those from Dederiyeh, Border Cave, or Roc de Marsal. Such cases were also fully excavated, with adequate documentation of the positioning of skeletal remains and their surrounding stratigraphic situation, but such cases were later challenged on several bases and the complete exhumation of material has confused or precluded testing of new hypotheses (e.g. Gargett 1999). The case of Roc de Marsal is one in which data from the initial excavation combined with data from the initial excavation combined with re-excavation and geoarchaeological analysis led to a naturalistic interpretation of the skeletal material (Sandgathe et al. 2011; Goldberg et al. 2017). But even in this case, the researchers erred in their interpretation of the skeleton's situation due to a lack of identification of parts of the infant's skeleton (Gómez-Olivencia and García-Martinez 2019). That is to say, it is not only the burial hypothesis but other hypotheses that suffer from complete excavation. Researchers concerned with preserving all possible information have sometimes taken extraordinary measures to remove and study possible burials at high-resolution in the laboratory. Such was the case of the Shanidar IV burial removed from the site and transported in plaster jacket by Solecki, which led to the disruption and loss of internal stratigraphic information (Pomeroy et al. 2020). Arguably, the current state of the art is full excavation with partial preparation, such as that undertaken at Panga ya Saidi (Martinón-Torres et al. 2021). But again, any future attempt to reinterpret or test the hypothesis of burial must rely on the adequacy of documentation as the original context has been removed.

In our decision to leave material in place as much as possible, we are expanding upon standard practice to leave witness sections and unexcavated areas for future research. The situation is novel, representing possible burials by a nonhuman species, and that makes it doubly important in our opinion to be conservative in not fully exhuming the skeletal material from its context. We anticipate that many other researchers, including future investigators, will suggest additional methods to further test the hypothesis of burial, something that would be impossible if we had excavated the features in their entirety prior to publishing a description of our work. We believe strongly that our ethical responsibility is to publish the work and the most likely interpretation while leaving as much evidence in place as possible to enable further testing and replication. We welcome the suggestions of additional methods/analyses to test the *H. naledi* burial hypothesis.

This being said, we also observe that total exhumation would not resolve the concerns raised by the reviewers. The recommendation of total exhumation is in pursuit of a full account of all skeletal material present and its preservation and spatial situation, in order to demonstrate that they conform to body positions comparable to human burials. As has been highlighted in forensic casework, the excavation of an inhumation feature does not necessarily provide an accurate spatial or anatomical manifest of the stratigraphical relationships between the body,

encapsulating matrix, and any cut present due to preservational, taphonomic and operational factors (Dirkmaat and Cabo, 2016; Hunter, 2014). In particular, in cases where skeletal elements are highly fragmented, friable, or degraded (such as through bioerosion) then complete excavation—even under controlled laboratory conditions—may destroy bone and severely limit skeletal identification (Henderson, 1997; Hochrein, 2002; Owsley and Compton, 1997), particularly in elements where the ratio of trabecular to cortical bone is high (Darwent and Lyman, 2002; Lyman, 1994). As such, non-invasive methods of 3D and 4D modelling (preservation *in situ*) are often considered preferable to complete necropsy or excavation (preservation by record) where appropriate (Bolliger and Thali, 2009; Dell'Unto and Landeschi, 2022; Randolph-Quinney *et al.,* 2018; Silver, 2016).

The test of burial is not primarily positional, but taphonomic and geological. The position and number of bones can elaborate on process-driven questions of decay and destruction in the burial environment, or post-mortem modification, but are not singularly indicative of whether the remains were intentionally buried – the post-mortem narrative of *all* the processes affecting the cadaveric island is required (Knüsel and Robb, 2016). In previous cases, researchers have disputed or accepted the hypothesis of intentional hominin burial based upon assumptions about how modern humans or Neandertals would have positioned bodies, with the idea that some positions reflect ritual intent while others do not. But applying such assumptions is unjustifiable, particularly for a species like *H. naledi*, whose culture may have differed fundamentally from our own. Our work acknowledges that the present evidence does not enable a full reconstruction of the burial positions, but it does show that fleshed remains were encased in sediment prior to decomposition of soft tissue, and that subsequent spatial changes can be most parsimoniously explained by natural decomposition within sedimentary matrix contained within a burial feature (after Green, 2022; Mickleburgh and Wescott, 2018; Mickleburgh et al., 2022). If the argument is that extraordinary claims require extraordinary evidence, we feel that the evidence documents excavation and interment (and will do so more clearly in the revision) and the fact of the remains do not match a "typical" human burial in body positioning is not in itself evidence that these are not *H. naledi* burials.

We feel that the reviewers (in keeping with many palaeoanthropologists) have a clear idea of what they "think" a burial should look like in an idealised sense, but this platonic ideal of burial form is not matched by the extensive literature in archaeothanatology, funerary archaeology and forensic science which indicates enormous variability in the activity, morphology and post-mortem system experienced by the human body in cases of interment and body disposal (e.g. Aspöck, 2008; Boulestin and Duday, 2005 and 2006; Connelly *et al.,* 2005; Channing and Randolph-Quinney, 2006; Cherryson, 2008; Donnelly *et al.,* 1995; Finley, 2000; Hunter, 2014; Parker Pearson, 1999; Randolph-Quinney, 2013). Decades of experience in the identification, recovery and interpretation of clandestine, deviant, and non-formal burials indicates the platonic ideal is rare, and in many contexts, the exception (Cherryson, 2008; Parker Pearson, 1999). This variability is particularly relevant to morphological traits in burial context, such as the informal nature of the grave cut in plan and section, shallow burial depth, and initial disposition of body (placement) during the early post-mortem period. These might run counter to the expectations of reviewers or others referencing the fossil hominin record, but are well accepted within the communities of researchers investigating Holocene archaeological sites and forensic contexts.

It is encouraging to see reviewers beginning to incorporate the extensive (often experimentally derived) literature from archaeothanatology and forensic taphonomy in their deliberations, and we will be taking these comments on board going forward. In particular, we acknowledge reviewers' comments and the need to construct a more detailed post-mortem narrative, accounting for joint disarticulation (labile versus persistent joints etc), displacement, and final disposition of elements within the burial space. As such we will incorporate the hierarchy of decomposition (rank order disarticulation), associations between

regions of anatomical association, areas of disassociation, and the voids produced during decomposition (after Mickleburgh and Wescott, 2018; Mickleburgh et al., 2022) into our narrative. In doing so we acknowledge the tensions between the inductive archaeolothanatological narrative-driven approach (e.g. Duday, 2005 & 2009) versus robust decomposition data derived from human forensic taphonomic experimentation recently articulated by Schotsmans and colleagues (2022) - noting that we will highlight comparative data based on forensic experimental casework and actualistic modelling over inductive intuitive approaches which come with significant evidential shortcomings (Bristow *et al.* 2011).

Finally, from a taphonomic perspective it is worth pointing out to reviewers that we have already addressed the issue of lack of taphonomic evidence for carnivore involvement in the formation of the Dinaledi assemblage (Dirks, *et al.,* 2016). Absence of any carnivore-induced bone surface modifications, patterns of skeletal part representation, and a total absence of any carnivore remains found within the Dinaledi chamber (following Kuhn and colleagues, 2010) lead us to reject carnivores as possible vectors of body accumulation within the Dinaledi Chamber and Hill Antechamber.

Reviewers suggest that without a date derived from geochronological methods, the engravings cannot be associated with *H. naledi,* and that it is possible (or probable) that the engravings were done in the recent past by *H. sapiens*. This suggestion neglects the context of the site. We have previously documented the structure and extremely limited accessibility of the Dinaledi subsystem. This subsystem was not recorded on maps of the documented Rising Star Cave system prior to our work and its discovery by our teams. Furthermore, there is no evidence of prehistoric human activity in the areas of the cave related to possible subterranean entrances There is no evidence that humans in the past typically ventured into such extreme spaces like those of Rising Star. It is clear from the presence of the remains of many individuals that *H. naledi* ventured into these spaces again and again. It is likely that *H. naledi* moved through these spaces more easily than humans do based on their physique. We show that the engravings overlay each other suggesting multiple engraving events. These engravings took time and effort and the only evidence for use of the Dinaledi subsystem by any hominin is by *H. naledi*. The context leads to the null hypothesis that *H. naledi* made the marks. In our revision, we will elaborate on this argument to clarify the evidence for our stance on this hypothesis. Several reviewers took issue with the title of the engraving paper as we did not insert a qualifier in front of the suggested date range for the engravings. We deliberately left out qualifying language so that the title took the form of a testable hypothesis rather than a weak assertation. Should future work find the engravings were not produced within this time range, then we will restate this hypothesis.

Finally, with regards to the engravings we have chosen to report them because they exist. Not reporting the presence of engraved marks on the walls of a cave above hypothesized burials would be tantamount to leaving relevant evidence out of the description of an archeological context. We recognize and state in our manuscript that these markings require substantial further study, including attempts at geochronological dating. But the current evidence is clearly relevant to the archaeological context of the subsystem. We take a similar stance with reporting the presence of the tool shaped artefact near the hand of the *H. naledi* skeleton in the Hill Antechamber. It is evident that this object requires further study, as we stated in our manuscript, but again omitting it from our study would be leaving out relevant evidence.

Some have suggested that the null hypothesis should be that all of these observed circumstances are of natural origin. Our team took this approach in our early investigation of the Dinaledi subsystem (Dirks et al. 2015). We adopted the null hypothesis that the geological processes involved in the accumulation of *H. naledi* skeletal remains were “natural” (e.g., non-naledigenic involvement), and we were able to reject many alternative explanations for the assemblage, including carnivore accumulation, “death trap” accumulation, and fluvial transport of bodies or bones (Dirks et al. 2015). This led us to the hypothesis that *H. naledi*

were involved in bringing the bodies into the spaces where they were found. But we did not hypothesize their involvement in the formation of the deposit itself beyond bringing the bodies to the location.

This approach seems conservative. It followed the traditional view that small-brained hominins do not engage in cultural practices. But we recognize in hindsight that this null hypothesis approach did harm to our analyses. It impeded us from recognizing within our initial excavations of the puzzle box area and other excavations between 2014 – 2017 that we might be encountering remains that were intrusive in the sedimentary floor of the chamber. If we had approached the accumulation of a large number of hominins from the perspective of the null hypothesis being that the situation was likely cultural, we perhaps would have collected evidence in a slightly different manner. We certainly note that if the Dinaledi system had been full of the remains of modern humans, there would have been little doubt that the null hypothesis would have been that this was a cultural space and not a "natural space". We therefore respectfully disagree with the reviewers who continue to support the idea that we should approach hominin excavations with the null hypothesis that they will be natural (specifically non-cultural) in origins. If excavations continue with this mindset we believe that potential cultural evidence is almost certain to be lost.

There has been a gradient across paleoanthropological excavations, archaeological work, and forensic investigation, with increasing precision of context. The reality is that the recording precision and frame of approach is typically different in most paleontological excavations than in those related to contemporary human remains. If anything comes from the present discussion of whether the Dinaledi system is a burial site for *H. naledi* or not, we hope that by taking seriously the possibility of deep cultural dynamics of hominins, we will encourage other teams to meet the highest standards of excavation in order to preserve potential cultural evidence. Given *H. naledi*'s cranial capacity we suggest that even very early hominin skeletal assemblages should be re-examined, if there is sufficient evidence or records available. These would include examples such as the A.L. 333 *Au. afarensis* site (the so called First Family site in Hadar Ethiopia), the Dikika infant skeleton, WT 15000 (Turkana Boy) and even A.L. 288 (Lucy) as such unusual taphonomic situations where skeletons are preserved cannot be simply explained away as "natural" in origin, based solely on the cranial capacity and assumed lack of cognitive and cultural complexity of the hominins as emphasized by us in Fuentes et al. (2023). We are not the first to observe that some very early hominin situations may represent early mortuary activity (Pettitt 2013), but we would advocate a step further. We suggest it may be damaging to take "natural accumulation" as the standard null hypothesis for hominin paleoanthropology, and that it is more conservative in practice to engage remains with the null hypothesis of possible cultural formation.

We are deeply grateful for the time and effort all of the 8 reviewers (across three reviews) have taken with this work. We also acknowledge the anonymous reviewers from previous submissions who's opinions and comments will have made the final iterations of these manuscripts better for their efforts. As this process is rather public and includes commentary outside of the *eLife* forum, we ask that the efforts of all 37 authors and 8 reviewers involved be respected and that the discourse remain professional in all venues as we study this fascinating and quite complex occurrence. We appreciate also the efforts of members of the public who have engaged with this relatively new process where preprints are posted prior to the reviews allowing comments and interactions from colleagues and the public who are normally not part of the internal peer review process. We believe these interactions will make for better final papers. We feel we have met the standards of demonstrating burials in *H. naledi* and that the engraving are most likely associated with *H. naledi.* However, given the reviews we see many areas where our clarity and context, and analyses, were less strong than they can be. With the clarifications and additions taken on board through these review processes the final papers will be stronger and clearer. We, recognize that this is an ongoing

process of scientific investigation and further work will allow continued, and possibly better, evaluation of these hypothesis and others.

Lee R Berger, Agustín Fuentes, John Hawks, Tebogo Makhubela

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