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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

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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*.

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).

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

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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).

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.

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.

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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.

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 Figure s13 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-

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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.

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.

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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.

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.

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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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Figure legends

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.

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

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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

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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.

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.

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.

Figure 17

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

Figure 18

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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.

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.

Competing interest declaration

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

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Figures

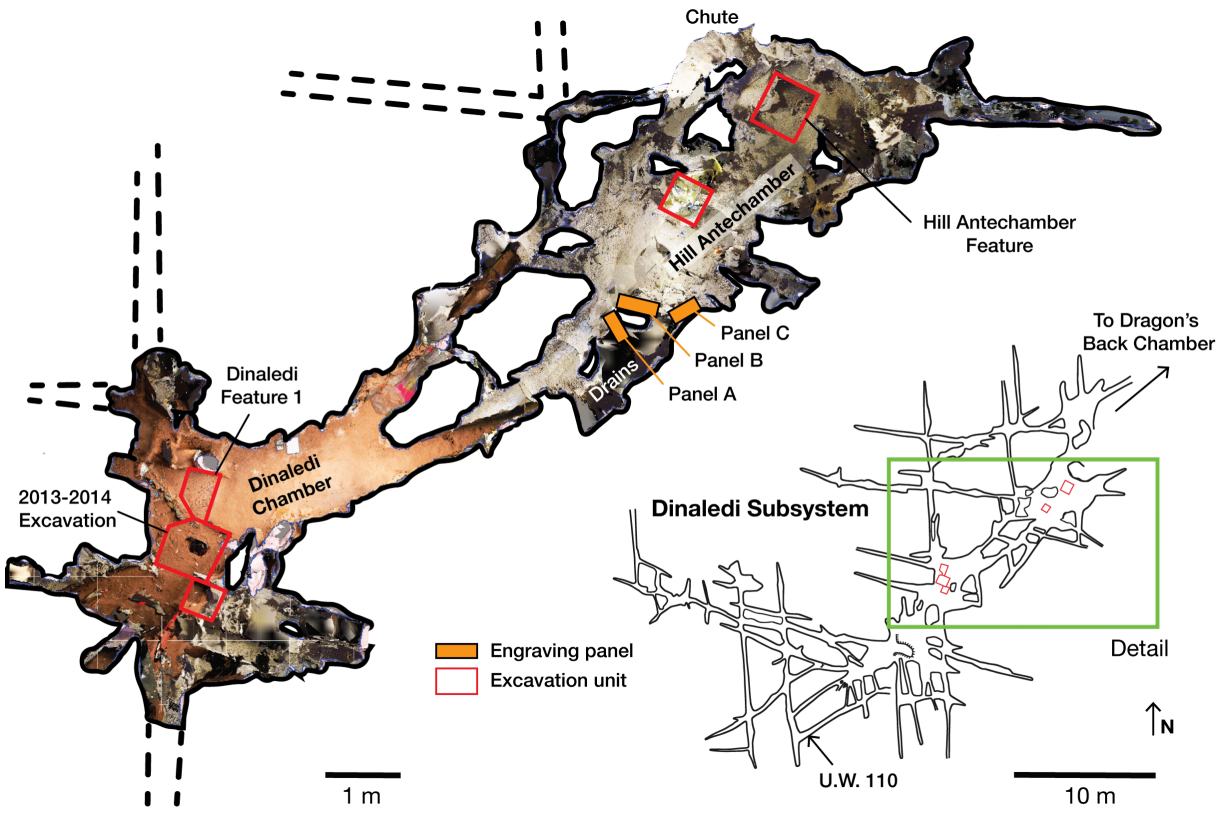

Figure 1

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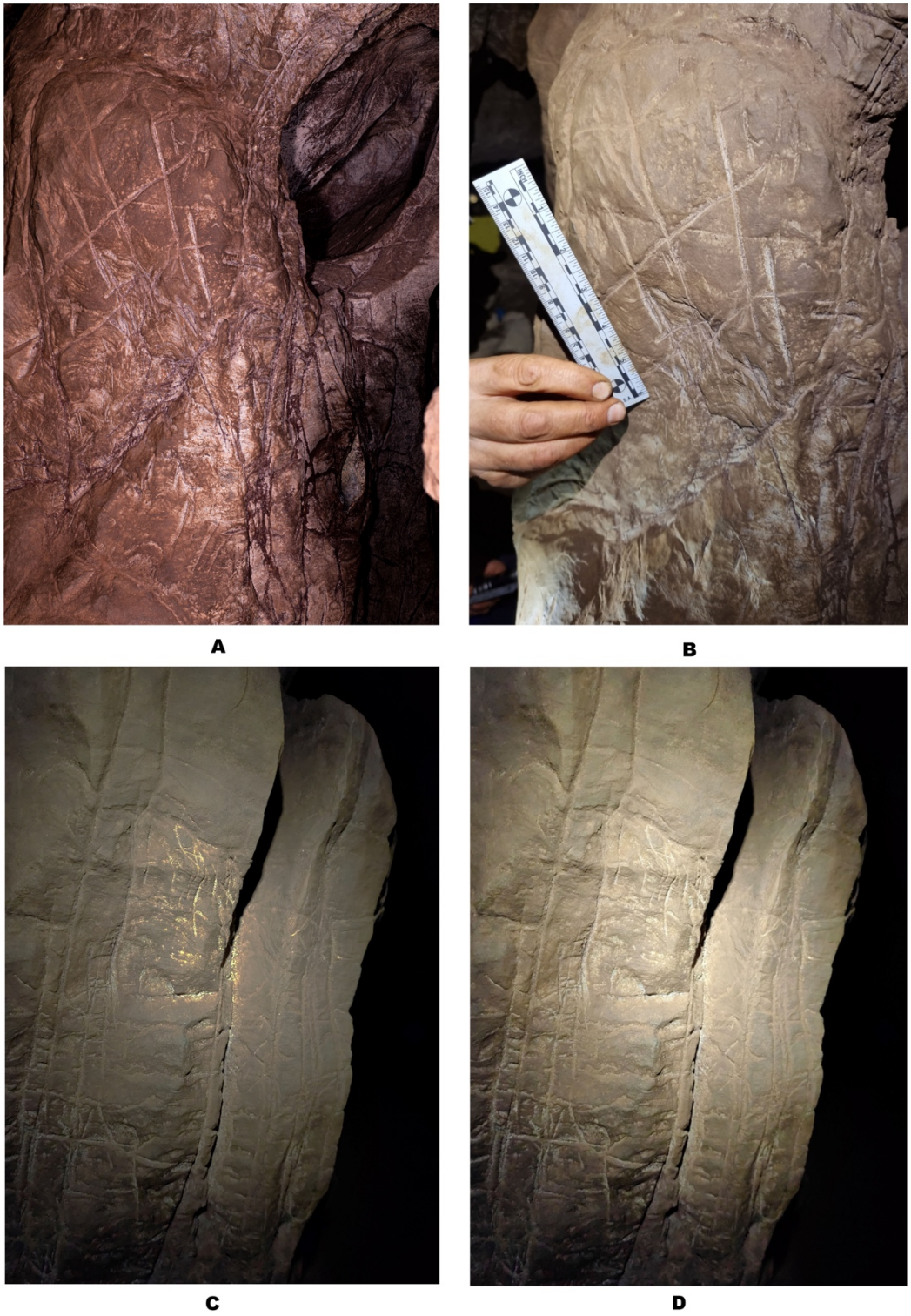

Figure 2

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Figure 5

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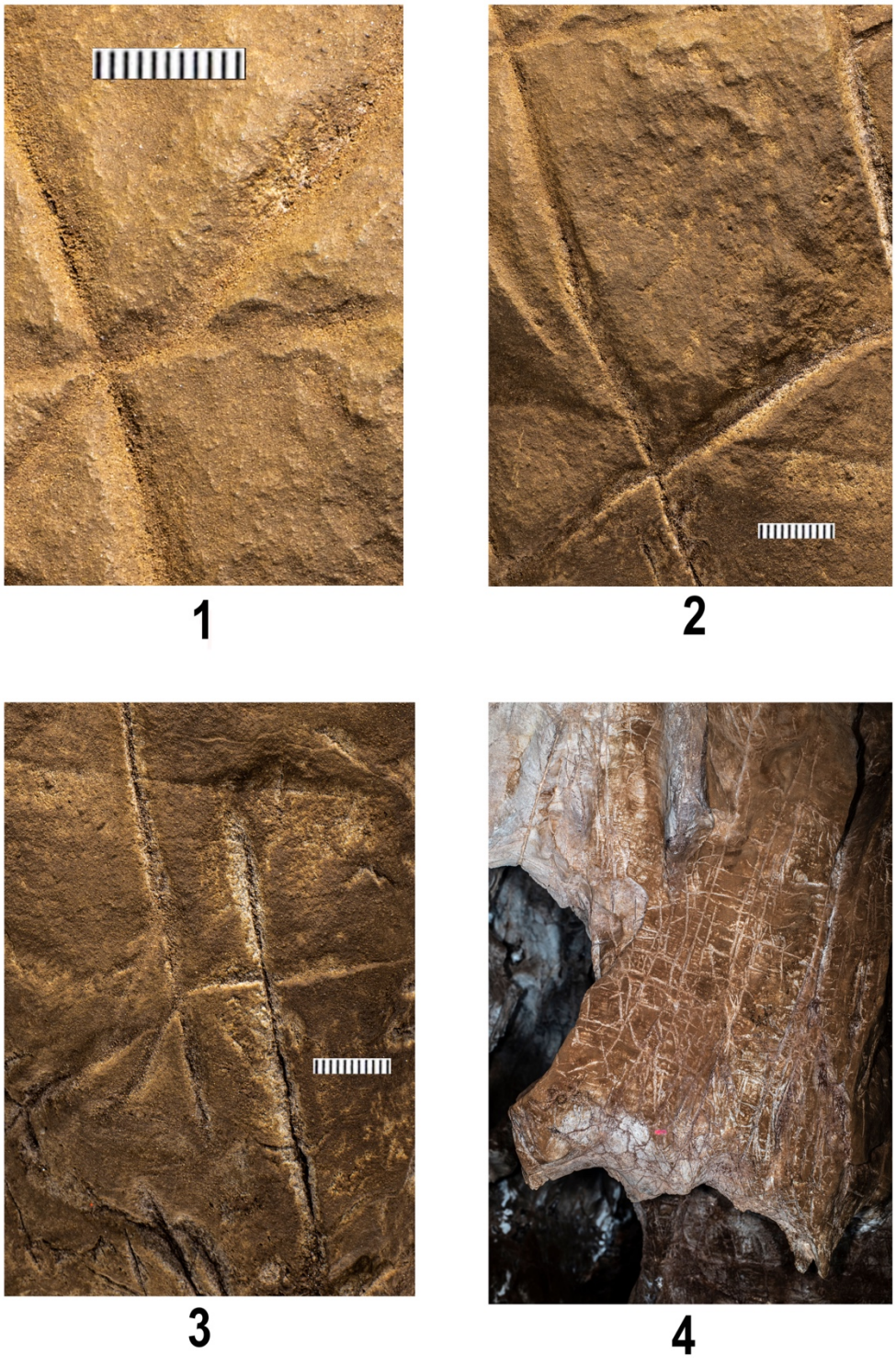

Figure 6

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Figure 7

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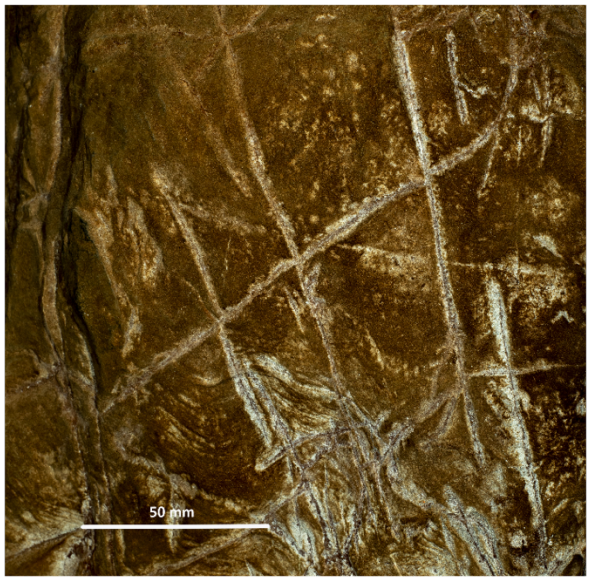

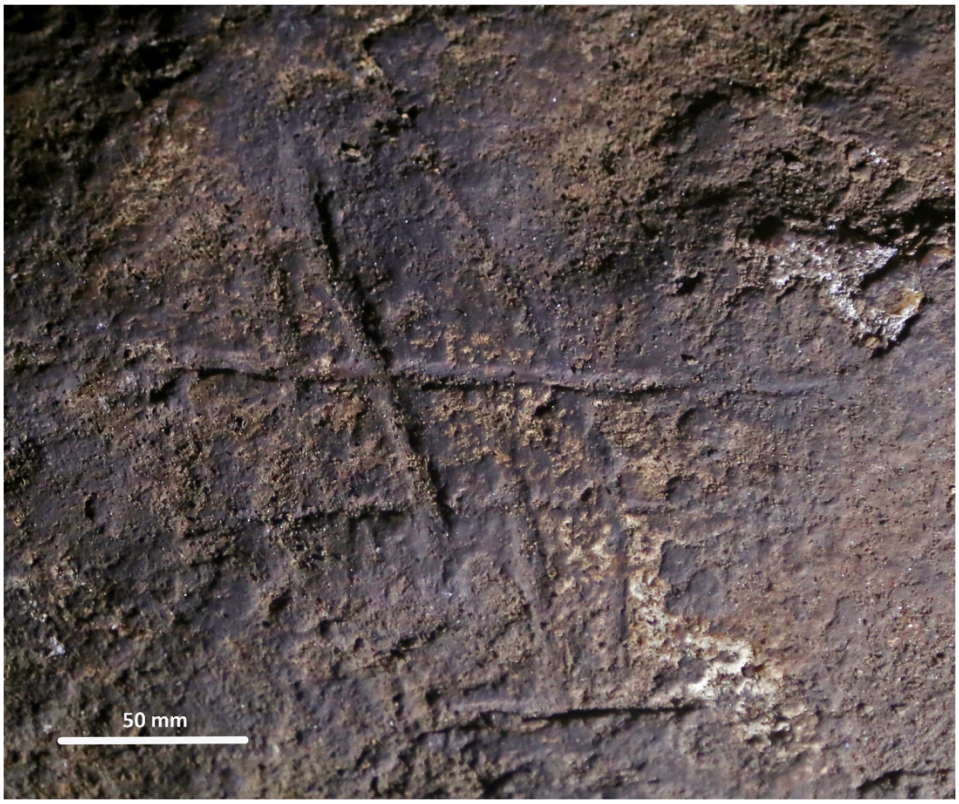

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Figure 8

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Figure 9

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Figure 12

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Figure 13

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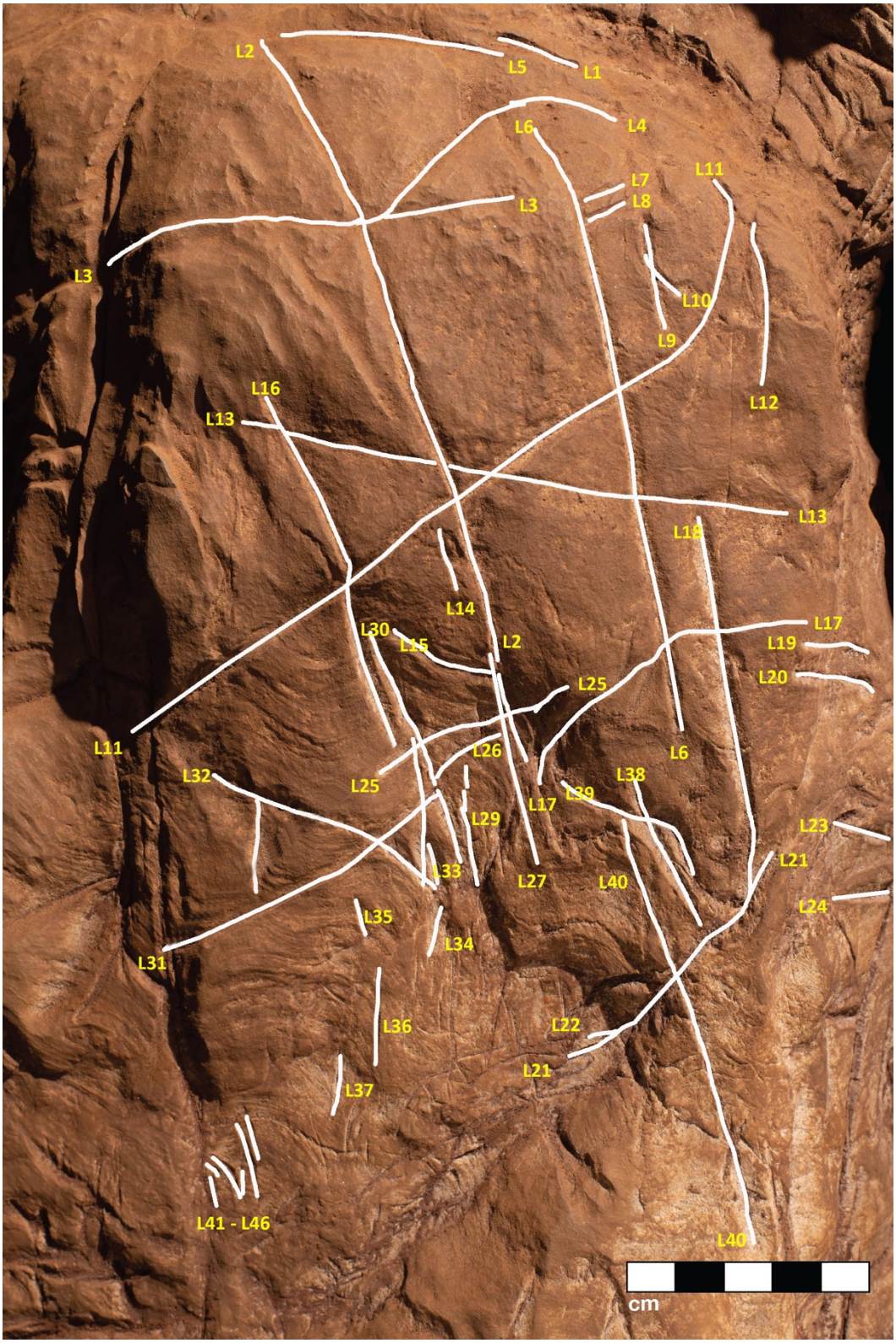

Figure 16

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Figure 17

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Figure 18

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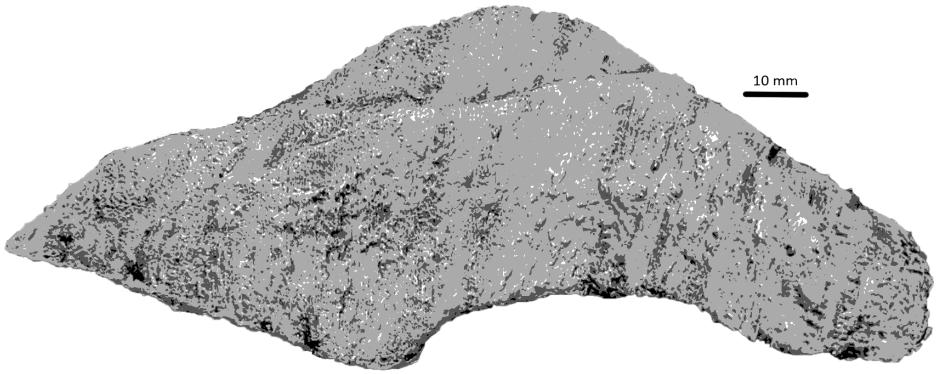

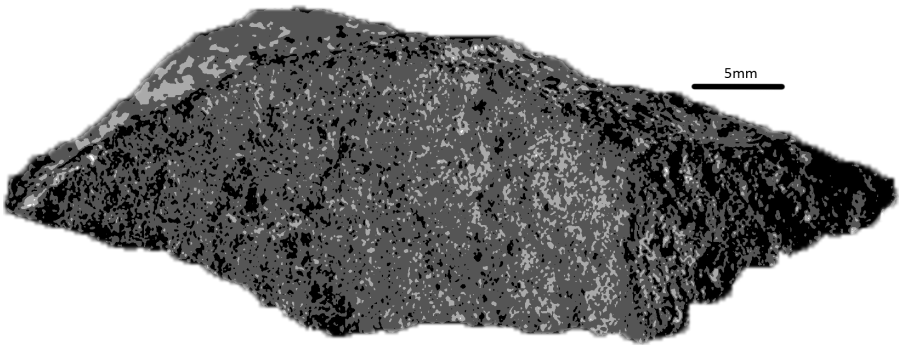

555 Figure 19

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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

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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