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## IMAGES ON STONE IN SHARJAH EMIRATE AND REVERSE ENGINEERING TECHNOLOGIES

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**Abstract.** This paper presents a preview of the research being carried out in the framework of a doctoral thesis. It presents the methods employed for the documentation and recording of the petroglyphs at the archaeological site of Khatm Al Melaha, located in Kalba (Emirate of Sharjah) on the east coast of the United Arab Emirates, during successive campaigns in 2015, 2016, 2018 and 2019. Due to their characteristics, these petroglyphs have been dated to successive late pre-History periods, and it is proposed that they were made for specific ritual purposes in a natural monument which is undoubtedly significant in terms of its landscape, description and scenery. The study has been carried out respecting the conservation of the petroglyphs, without direct intervention on them, using available technologies (aerial, terrestrial and digital photogrammetry of close-range objects) and applying the theoretical perspective of landscape archaeology to rock art research.

### Introduction

This paper presents the work carried out, and the partial results obtained, on the petroglyphs of the archaeological site of Khatm Al Melaha in Kalba on the eastern coast of the Emirate of Sharjah (UAE) on

the Gulf of Oman. It reports successive campaigns in 2015, 2016, 2018 and 2019 under a collaborative agreement between the Universidad Politécnica de Madrid (Spain), with the leadership of Dr Mercedes Farjas, and the Sharjah Archaeology Authority of the Emirate of

Sharjah, directed by Dr Sabah Jasim.

The 2019 campaign focused on the petroglyph panels located at the Archaeological Site of Wadi Al Helo, 15 km as the crow flies west of Kalba. The site is a dry riverbed that carries a quite considerable flow during the rainy season and contains representations that mainly depict 'riding scenes' and 'weapons', which are quite different from those found in Khatm Al Melaha.

In the present study, which is concerned with the topic of rock art, there can be no doubt that 'the

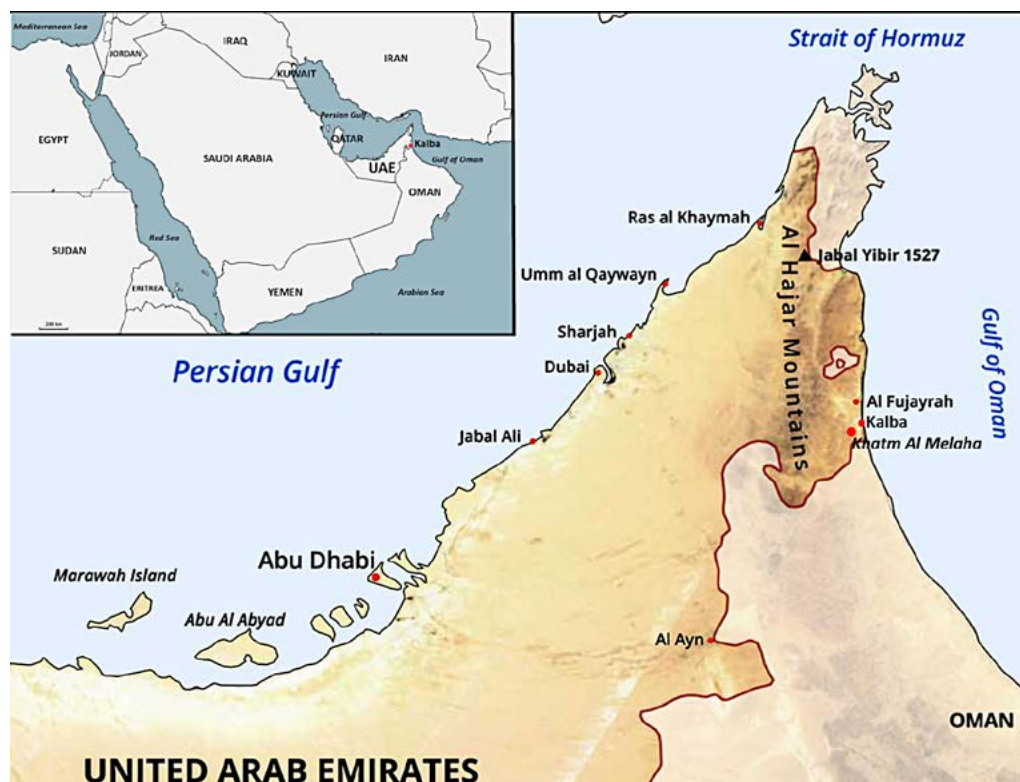


Figure 1. Location map of Kalba on the east coast of the Emirate of Sharjah (UAE),



Figure 2. View of the hill of Khatm Al Melaha from the east, with the two shell middens at the foot, an old coastline.

location of the petroglyphs is determined by regular patterns of location and relationship with the environment linked to the use and exploitation of these spaces' (Criado-Boado et al. 2013: 16). Taking the principle of the systematic relationship between archaeological sites and landscape as a starting point, an attempt shall be made to define the pattern that governs the location and distribution of the rock art found at Khatm Al Melaha.

#### General characteristics of the rock art of Khatm Al Melaha, Kalba

Khatm Al Melaha is an archaeological site located in Kalba, in the Emirate of Sharjah, on the east coast of the United Arab Emirates (Fig. 1). It is located on a small conical hill, a *jebel* in Arabic language (Fig. 2), between the Hajar Mountains and the coastline which barely rises 65 metres above sea level. However, the location of this hill in the terrain and its solitary position at the mouth of a wadi makes it a unique place, the most notable physical characteristic of which is its indisputable visibility and its prominent presence in the landscape, geographical feature very similar to the four *jebels* with petroglyphs beside the paleolake of Jubba, in northern Saudi Arabia (Bednarik and Khan 2005; Jennings et al. 2013). This makes it a landmark in the area, and it constitutes a place full of symbolism,



Figure 3. *Anadara uropigimelana* and *Terebralia palustris* shells from the two shell middens of Khatm Al Melaha.

containing numerous archaeological elements, among which its rock art stands out. In short, it is a natural monument, or what Felipe Criado-Boado terms a 'wild monument' (Criado-Boado 1993a). As Richard Bradley points out (Bradley 2000), it is common to associate certain natural places with supernatural powers (Betencourt et al. 2017).

In addition to the percussion petroglyphs, the presence of two shell middens at the foot of the hill is worthy of note. Their oldest radiocarbon datings, on shells of the *Anadara uropigimelana* and *Terebralia palustris* species (Fig. 3), date back to  $5038 \pm 38$  cal BCE ( $7013 \pm 69$  cal BP). Along with other evidence of culinary uses, these shell middens bear witness to the continued use of this site over a long period, at least until the Middle Bronze Age, and to the proximity of the sea, which, at that time, reached the very base of the hill (Lindauer et al. 2018).

The Khatm al Melaha petroglyphs were pounded into the surface of serpentinite blocks belonging to the Semail Ophiolite Complex, which was formed during the Cretaceous Period. The western limit of the ophiolite is defined onshore by the Semail thrust, while the eastern limit extends several kilometres offshore (Ali et al. 2020). The original colour of the serpentine rock is greenish (Fig. 4). However, due to the extreme temperatures and erosion caused by wind and water,



Figure 4. Original serpentinite rock fragment without the dark patina.



Figure 5. The total number by typology of motifs of Khatm Al Melaha panels.

its surface, which was originally rough, has become smooth and dark. The patina thus generated oscillates, depending on the degree of erosion and the insolation of the surface, between greyish tones to dark browns.

When the petroglyphs were made, the rocks had already been fragmented and heavily eroded, and their surface smoothed. The degree of conservation of the petroglyphs is generally quite good, despite exposure to the remarkably high summer temperatures and the heavy torrential rains occasionally affecting this area. Some of the panels have been displaced or turned, but they seem to have retained their original position in most cases.

A total of 161 panels were located, registered and inventoried, with 438 motifs, of which 225 are representations of different quadrupeds (51.37% of the total), 18.5% are 'signs', 11.87% are anthropomorphs, another almost 12% have been classified as indeterminate, 2.74% sun-like, 2.05% vulva-like and 1.6% footprints (Fig. 5). Among the quadrupeds, the following, which are characteristic of the area, stand out: equidae, 'oryx', 'ibex' and other ungulates, both with solitary individuals ('males or females') and in groups composed, above all, of 'females with young' in apparently relaxed attitudes.

In addition, the pounding technique finished with soft abrasion was used to create schematic representations of sinuous shapes, figures of individual concentric circles, human representations, a remarkable number of 'solar' and 'vulvar' representations, and 'rectangles with rounded corners and segmented inside by horizontal and vertical diameters' (Santos-Estévez 2007).

Regarding the chronology of the archaeological sites, references are available from varied sources, such as the study by Eddisford and Phillips (2009),



Figure 7. Time graphic by phases and periods of the petroglyphs of Khatm Al Melaha.



Figure 6. Interior of Hafit period tomb at top of Khatm Al Melaha hill.

who excavated the tomb in Khatm al Melaha known as K1A. These authors report that the only material they found consisted of 'a few bone fragments'. In comparison, the burial sites excavated in Jebel Hafit (Abu Dhabi, UAE) and Jebel Buhais (Sharjah, UAE) did, indeed, contain abundant material remains and have the same stylistic and constructive characteristics. The conclusion can, thus, be drawn that they date from the Hafit Period, which ranged from 3200 to 2700 BCE.

An ascending path leads to the Hafit-style tombs located on the upper part of the hill (Fig. 6) and is accompanied to the left and the right by panels with petroglyphs. Furthermore, a 'riding scene' depicted on one of these panels indicates that it cannot be dated before 900 BCE (Drews 2004; Anthony and Brown 2007).

After carrying out an extremely detailed and comparative study of the stylistic and technical resources employed, the conclusion can be drawn that the Khatm Al Melaha petroglyphs could have been made during successive periods of late pre-History and proto-History, employing various techniques and motifs over thousands of years, ranging from approximately the 3rd millennium BCE until the end of the Iron Age. In the United Arab Emirates, these periods would include the stages of the Bronze Age, which are divided into three phases: Hafit (3200–2700 BCE), Umm an Nar (2700–2000 BCE) and Wadi Suq (2000–1300 BCE), and a further three phases of the Iron Age: Period I (1300–1000 BCE), Period II (1000–500 BCE) and Period III (500–300 BCE) (Fig. 7).

In making the petroglyphs, various techniques were used to remove the rock surface, sometimes combined. Although, for the most part, the petroglyphs merely depict the contour of the figures, in other cases, all or part of the image is infilled with percussion or abrasion.

#### Methodology and data collection

The methodological approaches employed to research the rock art



Figure 8. Targets on a panel of Khatm Al Melaha for photogrammetry and orthophoto made in 2015.

of Khatm Al Melaha are, on the one hand, the theoretical and methodological principles of landscape archaeology along the lines of previous studies by Criado-Boado and Santos-Estévez (Criado-Boado 1993b, 2012; Criado-Boado and Santos-Estévez 2002). On the other hand, at a technical level, and based on the premise of 'non-invasive intervention' on the petroglyphs in order to prevent their deterioration, the decision was taken to resort to the use of digital photogrammetry and laser scanning as the optimal resource for recording, documenting, processing and the subsequent dissemination of the results (Farjas et al. 2010).

Digital aerial photogrammetry and digital surface modelling (DSM), which are currently being applied in the majority of archaeological sites under investigation, have, in recent years, become fundamental tools in the development of archaeological documentation work. This is due to the precision and quality of the information obtained and the perspective it offers in interpreting the study area via Landscape Archaeology (Farjas et al. 2014). In order to carry out research on the Khatm Al Melaha petroglyphs with non-invasive methods and to obtain the highest quality and greatest quantity of information possible, photogrammetric techniques were used, which made it possible to carry out all the processes with excellent economy, both in terms of time and resources (Rodríguez 2014), without any physical intervention on the surface of the petroglyphs.

In the November 2015 campaign, a tool was employed that made it possible to measure and create a 3D model in real-time, using stereoscopic photogrammetry and optical triangulation scanning. In this way, orthophotographs and 3D models were obtained from 22 panels, selected due to the interest of both the elements represented and the techniques used (Fig. 8). This method consisted of the use of a tablet called EyesMap, a device designed and manufactured by e-Capture Research and Development, a technology company based in Cáceres, Spain. Because it was both light and highly versatile, this tool was perfectly adapted for use with the complicated orographic characteristics of the hill.

During the November 2016 campaign, a visual survey of the upper area of the hill was carried out. This area has two sections, both topped by burial sites. However, extensive survey work did not reveal any rock art in this area.

As previously mentioned, these burial sites had been dated to the Hafit Period, at the end of the 4th millennium BCE or the beginning of the 3rd millennium BCE. They are part of a group from the same period located all along the side of the Al Hajar Range, which can be seen to the south of the hill and forms the border with the Sultanate of Oman. In this area of the Arabian Peninsula, numerous such tombs are located on the tops of the mountains along prominent and highly visible ridges (Dood and Dueñas 2014).

Also, during the 2016 campaign, in order to make

it easier to identify non-visible reliefs and marks, Jon Harman's DStretch application was employed (Harman 2006), the operating principle of which consists of intensifying the contrast of the chromatic variables present in a graphic file, thus making it possible to observe details that cannot be seen with the naked eye. This tool is available for several operating platforms (Martínez et al. 2010).

DStretch was applied for both the observation and registration of new petroglyphs, as well as for the documentation of those that had already been inventoried in previous campaigns (Fig. 9). The results derived from the application of this technology ensued in the detection of new petroglyphs, which had previously gone unnoticed. Through the application of different colour filters in the photographs taken (with both a digital camera and a smartphone), details that could not be appreciated in previous shots became visible, even in those images which had not been taken in the best possible conditions for photography.

In the same campaign (November 2016), a digital map of the study area was drawn up. This was achieved thanks to the use of the *Sensefly eBee*, an ultralight fixed-wing drone, which captures RGB images that are then processed by the operating system itself, from which orthophotos and 3D maps can be obtained (Angás 2012, 2019).

The different colours of the digital surface map reveal significant aspects concerning the conditions of the terrain and the relief of the study area (Fig. 10). The area with the darkest blue tone can be considered to be particularly interesting, as a significant degree of soil moisture was notable at the time the image was taken, making it difficult to walk or move a vehicle. According to both the previously mentioned publications of Lindauer et al. (2017, 2018), which were based on the samples obtained in Kalba, and the paper published by Berger et al. (2013) on the dynamics of the mangroves of the coast of Oman, this moisture would correspond to the former line of the coast. During the Neolithic period, it was situated at the base of the hill, although it is located much further away today.

To the gradual retreat of the coastline, pointed out by Lindauer and Berger, would be added the successive natural accumulations of deposition of the materials carried by the



Figure 9. KLB-034 panel with hominid and colour filter of the DStretch application.

waters in periods of heavy rains of the different wadis that converge at this point and by the intentional and voluminous landfills that have been created in recent years, due to the large-scale construction, maritime and strategic activity of Kalba.

During the November 2018 campaign, a full coverage survey was conducted at Khatm Al Melaha, in which a total of 161 panels were located, photographed, georeferenced and inventoried. Once all the stones with petroglyphs had been georeferenced, a map was obtained showing the distribution of all the panels on the hill, and a distribution pattern was thus defined (Fig. 11).

The 2019 campaign was mainly focused on collecting data from the rock art panels located in Wadi al Helo, which, at a distance of 15 km as the crow flies

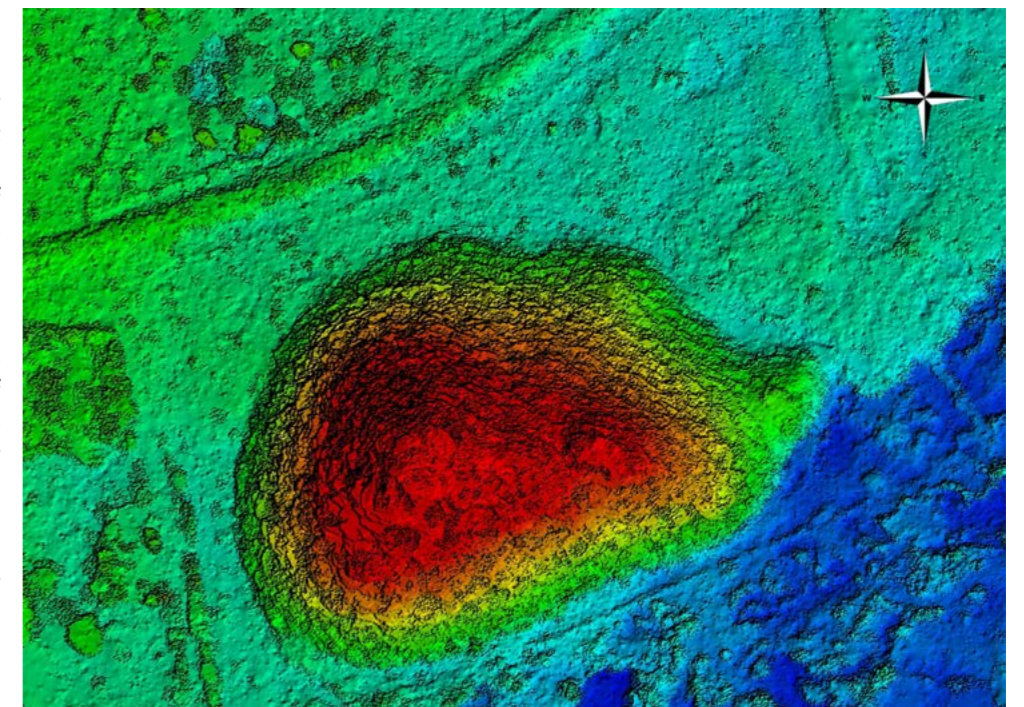


Figure 10. Digital surface map of Khatm Al Melaha, made by Jorge Angás in 2016.

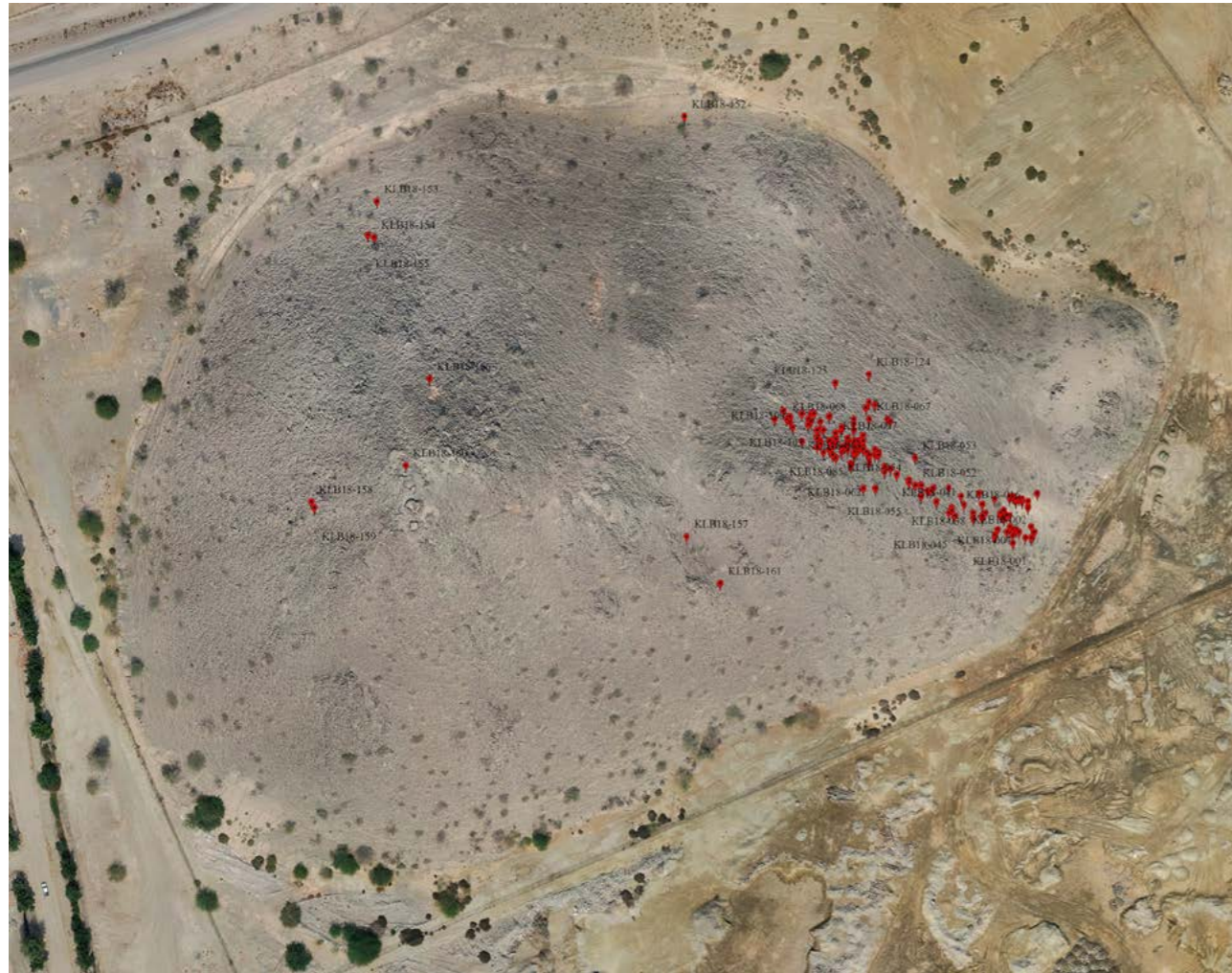


Figure 11. Mapping with petroglyphs georeferenced of the 2018 campaign.

from Khatm Al Melaha, shows a very different and differentiating iconographic model. The preponderance of 'riding scenes' and 'weapons' in the motifs of Wadi Al Helo speaks of a different ritual and mythical



Figure 12. 'Riding scenes' in panels of Wadi Al Helo that are not represented in the panels of Khatm Al Melaha.

meaning for this space (Fig. 12). Although there is a notable difference in iconography and motifs, the general characteristics of both sites are very similar to those recorded by Angelo E. Fossati in the petroglyphs of the Al Hajar Mountains of the Sultanate of Oman (Fossati 2017, 2018, 2019a, 2019b) and those recorded by Michele Ziolkowski in the Emirate of Fujairah (UAE) that are also located, for the most part, in the wadis of the Al Hajar Mountains (Ziolkowski 1998, 2007, 2013).

#### Contextualisation

The relationship of Khatm Al Melaha with the sea is of fundamental importance. The orientation of the petroglyphs towards the east made it possible for boat crews approaching the coast to see them. Kalba has been a busy trading port since Neolithic times, and this activity has continued up to the present day. In the last ten years, the research carried out on the evolution of the Neolithic period in the United Arab Emirates has examined the stability of the settlements of human groups on the coasts, favoured by

notable improvements in the management of marine resources, both in terms of fishing techniques and boat building (Mashkour et al. 2016).

Kalba was the port of exit to the sea for copper and other products from Wadi Al Helo. These products also went from east to west, crossing the Hajar Mountains on the natural route from Kalba to Mleiha, where archaeological sites date back to at least 125 000 BP in the Al-Faya Caves (Bretzke et al. 2014). This confirms that Mleiha has been a primary crossroads of routes from north to south and east coast to the west since pre-Historic times.

During the four campaigns of archaeological excavation in the ruins of an ancient fortress in Kalba (carried out between 2017 and 2020 thanks to a collaboration agreement between the Sharjah Archaeology Authority [SAA] and the Faculty of Social and Human Sciences [FCSH] of the Nova University Lisbon, through the Instituto de Arqueologia e Paleociências [Institute of Archaeology and Palaeosciences, IAP]), it was concluded that the important strategic maritime position of Kalba attracted Portuguese sailors during the rule of a famous local leader named Al-Qasimi (an ancestor of the current Emir of Sharjah). In March 1624, according to the contemporary text of Manuel Godinho de Erédia, the Portuguese established a fortified colony that controlled the traffic of maritime goods from the Arabian Gulf and the Indian Ocean, as well as the trade of the old caravan routes that crossed the Arabian Peninsula (Cárta et al. 2020).

In the present day, the port of Kalba maintains its great strategic relevance, not only due to its position adjacent to the Sultanate of Oman and its excellent communication by road through Wahi Al Helo to Mleiha and the rest of the Peninsula but also thanks to its proximity to the port of Fujairah. This is one of the most important ports in the Persian Gulf, which links the intense maritime traffic of Asia and the Mediterranean through the Suez Canal.

#### Analysis of the archaeological landscape.

The vast majority of the Khatm Al Melaha petroglyphs (specifically 93.83%) are located along a route that ascends from the very base of the hill to the top. The burial sites, however, are concentrated at the summit, except for two burial mounds located on the shell middens at the foot of the hill.

The configuration of the different groups of decorated rocks seems to be linked to the natural route that allows access from the base of the hill to the top. Quite possibly, one of the functions of the petroglyphs was to symbolically mark and signpost an ascending transit route, which would have extended from the coast to the funerary monuments on the summit.

Indeed, the way most of the panels are arranged makes it possible to refer to an 'ascending transit route' since the petroglyphs are arranged in such a way as to be seen by anybody making the ascent via this route



Figure 13. 'Weapons' in panels of Wadi Al Helo (resembling gold-plated lunate pommel dagger handle from the Royal Cemetery of Ur (PG755) dated to c. 2400 BCE).

because the engraved surfaces are oriented towards the observer climbing the hill. There may, therefore, be a vertically structured landscape in which the petroglyphs would function as a dynamic link between the lower and upper parts; or, in other words, between the coast and the top of the hill.

Khatm Al Melaha is not only a differential element in the terrestrial landscape but also in the maritime landscape. From the sea, the hill constituted a landmark for sailors along a busy sea route from the early days of coastal navigation. It is possible that this characteristic, as both a natural monument and a spatial point of reference, led to the site becoming a sacred place of great symbolic significance, accommodating funerary monuments at the top as points of reference in the landscape.

As far as the petroglyphs located in several places of the archaeological site of Wadi Al Helo are concerned, it can be said that the fundamental conceptual difference of the representations is related to the productive and symbolic use of this space, which differs significantly from the presumed mythical use of the Khatm Al Melaha site (Fig. 13). The HLO1 archaeological site, an important centre for metallurgical production related to the obtention and production of copper, is located close to the petroglyphs. Stratigraphic studies and extensive radiocarbon dating have provided a time frame for these copper production and processing activities in HLO1 from the end of the 4th millennium BCE to the Iron Age (Kutterer 2014) (Fig. 14).

Towards the end of the 3rd millennium BCE, the societies of the Oman Peninsula had to adapt to significant environmental changes due to a process of aridification, which would have begun around 4500 BCE (Bortolini and Munoz 2015). These changes affected their food consumption strategies, with the development of date palm cultivation in the valleys and foothills and the intensification of coastal fishing, as well as technical innovations in the exploitation and



Figure 14. (a) Copper smelting site HLOI and (b) copper slag, Wadi Al Helo.

metallurgy of copper, the production of ceramics and stone architecture (Munoz 2019).

It can be supposed that the copper ore deposits located in the Hajar Mountains were a significant reason for the strong development of the Bronze Age in SE Arabia. Indeed, a cuneiform inscription of the Ur III period mentions the land of *Magan* as the origin of copper (Kutterer 2014). From the end of the 4th millennium BCE onwards, Mesopotamia and other Middle Eastern cultures desired copper from the Hajar Mountains, which lacked such resources (Giardino 2019).

Thus, Wadi Al Helo, with a watercourse that provided abundant plant and hunting resources, with a significant deposit of copper desired by other cultures such as Mesopotamia and a strategic position that served as a natural crossroads from east to west of the Hajar Mountains, was part of a complex network of trade routes linking different strategic sites of the SE Arabian Peninsula. Research carried out on the iconography of the petroglyphs related to the commercial exchanges of copper between Scandinavia and the Italian Alps from the second half of the 3rd millennium BC to the Iron Age has revealed certain specific symbolic

elements related to these commercial copper routes in these periods (Melheim and Sand-Eriksen 2020).

### Conclusions

The Khatm Al Melaha petroglyphs may have begun to be made in Holocene times and continued to be made in the same ritual site over thousands of years. To trace this temporality, it is necessary to rely, on the one hand, on the chronologies obtained by Lindauer et al. (2017, 2018) for the shell middens of Khatm al Melaha based on radiocarbon techniques applied to *A. uropigimelana* and *T. palustris* shells; and, on the other, on comparisons with petroglyphs of similar representations.

The petroglyphs were made for specific purposes in a 'natural monument' with an unquestionable visual and landscape significance, both from the land and from the sea. The use of this site as a ritual space, most likely associated with a mythical narrative, meant that it continued to serve this purpose for thousands of years.

Before the appearance of writing, mythical stories were communicated orally and represented graphically through rock art. Today, it is difficult to understand



Figure 15. (a) Footprints on KLB-058 panel of Khatm Al Melaha; and (b) their tracing.

their meaning or to try to interpret them because they are graphic representations made by people with cognitive approaches totally different from ours. Perhaps the true key lies in examining their material characteristics, uses and social contexts (Fig. 15).

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## The following articles will appear in forthcoming issues of *RAR*:

‘Seeing beyond pareidolia: implications for palaeoart’, by Derek Hodgson, including debate

‘Cupules of Cuba: a review’, by Yasmani Ceballos-Izquierdo, Johanset Orihuela, Luis Olmo Jas, Carlos R. Borges-Sellén, Alberto F. Arano-Ruiz, Jorge Garcell-Dominguez and Robert G. Bednarik

‘Interpretation and similarity recognition of typical graphic symbols in Damaidi rock art’, by Shu Xi-hong, Feng Yi-fei and Wang Yan

‘Future direction of rock art research: a conceptual pursuit of the epistemology of rock art study’, by Giriraj Kumar

‘Preminghana petroglyphs returned’, by Peter C. Sims

‘Cups used for painting ancient stone tablets in Peru’, by Jesus E. Cabrera

‘Preserving Australia’s cave art’, by Robert G. Bednarik

‘The pictograms of Poldokhtar (Takht Chan) of Lorestan province, Iran’, by Saeed Rahimi, Reza Rezalou and Sara Sadeghi

‘Multi-view 3D recording of Jiangjunya rock art’, by Yin Jie, Wu Shuang, Zhang Kaiyue and Wang Tao

‘Rock painting within southern Peru in the context of physicochemical analysis of pigments’, by Beata Miazga, Józef Szykalski and Jakub Wanot