



KEYWORDS: *Anthropogenic pattern – Pleistocene – Ammoglyph – Sand art – Palaeoart*

MODERN ANTHROPOGENIC PATTERNS IN PLEISTOCENE DEPOSITS ON SOUTH AFRICA'S CAPE COAST

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Abstract. Modern anthropogenic patterns in aeolianites and cemented foreshore deposits on South Africa's Cape coast have the potential to be confused with ancient patterns of 'sand art' created on dune and beach surfaces during the Middle Stone Age (ammoglyphs), and with Pleistocene fossil tracks and traces. Ancient patterns of sand art are of substantial geo-heritage importance. Therefore, it is of considerable relevance to reliably distinguish modern patterns from ancient patterns. Previous studies have approached this from the perspective of (ancient) ammoglyphs, whereas herein, for the first time, the challenge is addressed from the perspective of modern anthropogenic patterns. Ten sites (nine certain and one equivocal) are presented that illustrate salient features of modern anthropogenic patterns. Appreciating these attributes allows for the discussion of the essential principles that enable resulting distinctions, particularly between modern anthropogenic patterns and ancient sand art. A cautious approach is recommended, in which only compelling evidence is used to make the relevant distinctions, and equivocal cases are acknowledged as such.

Introduction

Anthropogenic patterns found on the surfaces of Pleistocene aeolianites (cemented dunes) and cemented foreshore deposits (the remains of ancient beaches) on the Cape coast can conveniently be divided into two categories: ancient and modern/recent. Ancient patterns, inferred to have been created during the Middle Stone Age (MSA) when the surfaces comprised unconsolidated sand, are referred to as 'ammoglyphs' and often form 'sand art', a form of palaeoart (Helm et al. 2019a, 2021a, 2024a, 2024b). They have substantial scientific and geoheritage significance. Modern patterns can be created directly by humans using hand tools in the creation of graffiti, for utilitarian purposes, or indirectly as a result of industrial activity. In addition to the potential confusion between modern anthropogenic patterns and ancient ammoglyphs, modern patterns can also be confused with Pleistocene vertebrate trackways and other traces. Where correctly identified, the latter have obvious palaeontological significance. In both cases, but in particular, with respect to palaeoart, the importance of developing a method of distinguishing modern from ancient patterns is considerable.

Optically stimulated luminescence (OSL) dating of associated deposits at sites inferred to host ammoglyphs suggests an age range spanning 139 ± 10 through 71 ± 5 ka (Helm et al. 2023a), and thus creation

during the MSA. Some of the inferred ammoglyph sites appear to represent a newly recognised form of palaeoart, constituting some of the oldest reported examples of art created by *Homo sapiens* (Helm et al. 2019a, 2021a, 2024a, 2024b). The notion that sand could have formed the canvas for some of the earliest art is not new. Prescient observers (Hodgson and Helvenston 2007) suggested this prior to the identification of ammoglyphs—patterns can be created in sand with a finger or a stick with relative ease. The purported identification of even older engravings by another species (*Homo naledi*) from southern Africa (Berger et al. 2023) adds to the potential importance of this field of study but also highlights the associated interpretative challenges (Martín-Torres et al. 2024).

To date, the five studies considering ammoglyphs have addressed their identification in general (Helm et al. 2019a, 2021a, 2024a, 2024b, 2024c). Implicit in developing such criteria is that ammoglyph 'signatures' are not modern. Indeed, some criteria allow an inferred Pleistocene origin with relative certainty. However, there may be cases when the evidence is not strong enough to reliably evaluate whether a pattern on a rock surface is ancient or recent in origin, partly because these deposits are not always well cemented. The timing of weathering that has occurred can be challenging to ascertain.

The geoheritage value (Helm et al. 2024d) of such

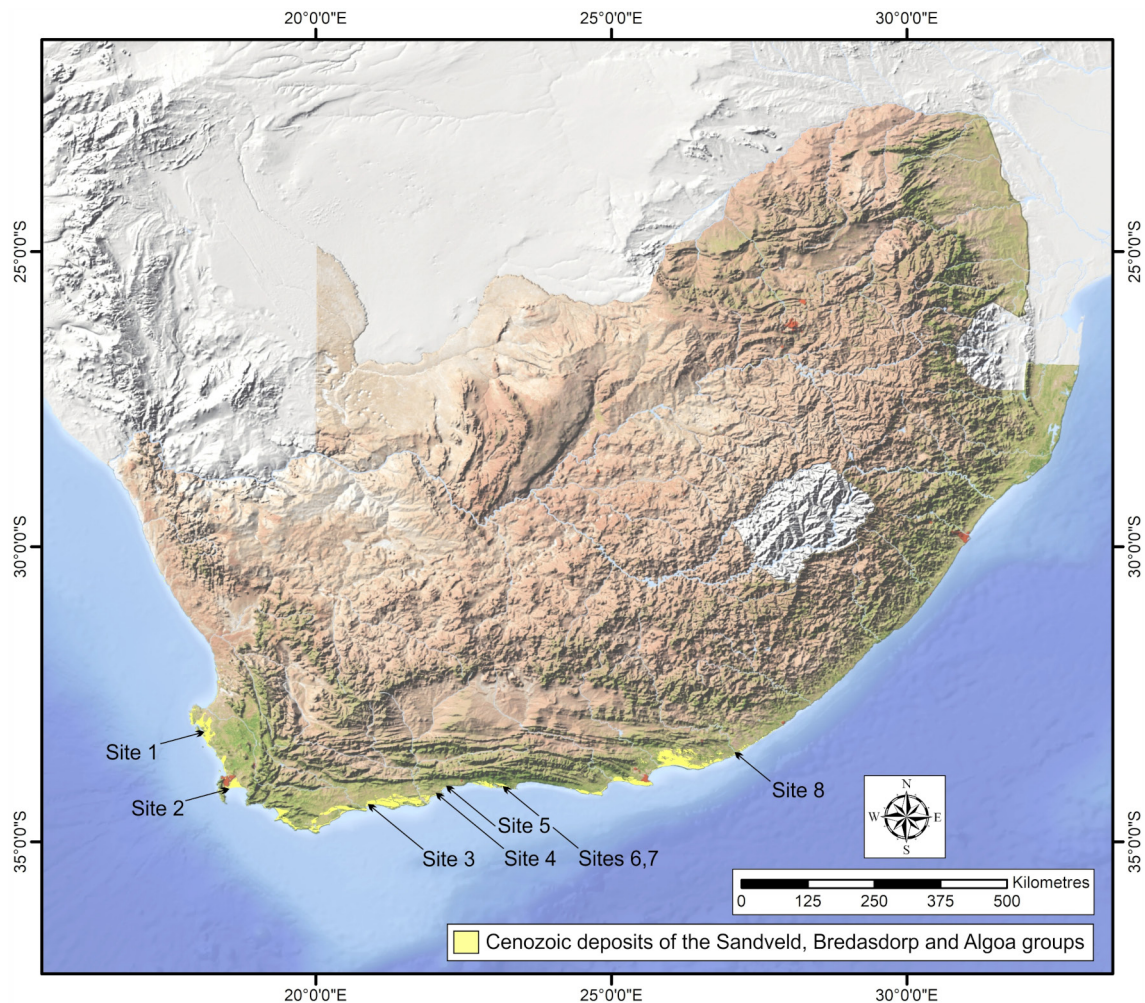


Figure 1. Map of the South African coast, showing the extent of Cenozoic deposits on the Cape coast and sites mentioned in the text.

discoveries requires a method of identification that is as reliable as possible. Notably, there should be the capacity to exclude false positives of recent anthropogenic origin or other pattern-generating origins. Clearly, a cautious approach is essential in which equivocal cases are acknowledged as such. Previous methods have approached this challenge from the perspective of ammoglyphs—there are certain features which, if identified, ‘rule in’ an ancient origin (Helm et al. 2019a, 2021a). Another way of approaching this challenge, employed here for the first time, is to consider the problem from the perspective of anthropogenic patterns that are indeed modern and then to consider the attributes that allow their identification with varying degrees of confidence. Overcoming this challenge will allow researchers to distinguish between ancient sand art and modern anthropogenic patterns.

The purpose of this article is to describe examples of modern anthropogenic patterns and to elaborate on how they can be distinguished from ancient patterns, such as ammoglyphs (including sand art) and Pleistocene tracks and traces. Ten illustrative cases of patterns in rock surfaces from the Cape coast of South Africa are presented and discussed, in order from west to east.

Geological context

The Cape south coast (Fig. 1) is richly endowed with Pleistocene vertebrate ichnosites (Helm 2023), with more than 350 sites having been identified along a 350 km stretch of coastline. The majority are encountered on aeolianite (cemented dune) surfaces of the Waenhuiskrans Formation (Malan 1989), and a minority are found on cemented foreshore deposits of the Klein Brak Formation (Malan 1991). The two formations form part of the Cenozoic Bredasdorp Group and are both Pleistocene in age (Malan 1990). Pleistocene sea-level fluctuations led to substantial variations in the position of the shoreline, with the vast Palaeo-Agulhas Plain being exposed for much of the Middle Stone Age (Fisher et al. 2010; Marean et al. 2014, 2020). The Cape south coast ichnosites are situated at what would have been the northern margin of this plain.

Studies to the west and east of the Cape south coast have confirmed that vertebrate tracks and traces are found on similar substrates and surfaces in those regions (Helm et al. 2022, 2024e). On the Cape west coast, Pleistocene aeolianites are assigned to the Langebaan Formation of the Sandveld Group (Roberts et al. 2006). In contrast, on the Cape east coast, equivalent aeolian-

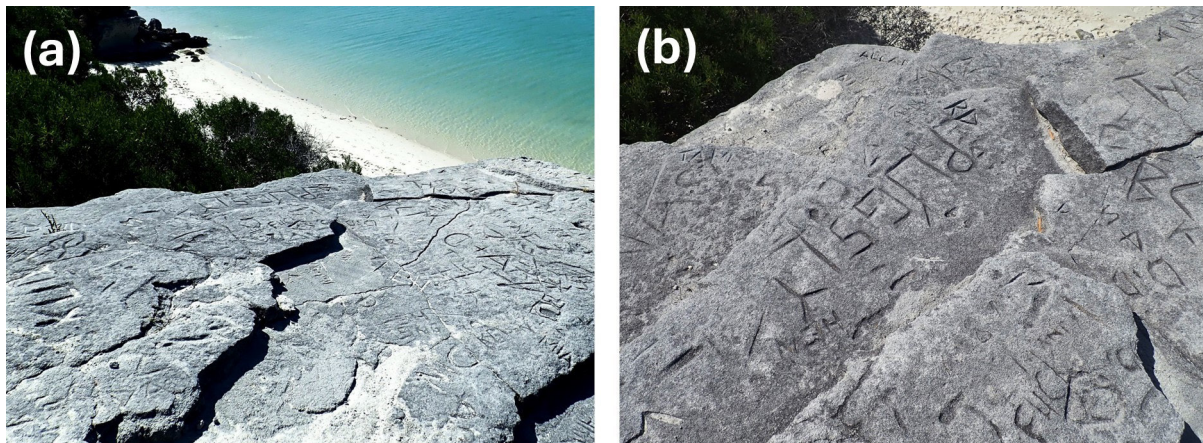


Figure 2. (a) and (b): Engraved graffiti on aeolianite surfaces beside the Langebaan Lagoon at Site 1; note the lower density of engravings towards the edges of the surfaces.

ites form the Nahoon Formation (Le Roux 1989) and cemented foreshore deposits form part of the Salnova Formation—the two formations comprise part of the Algoa Group (Le Roux 1990). The oldest ichnosites thus far identified are from MIS 11 aeolianites (Helm 2023), dated through OSL at ~400 ka (Roberts et al. 2012), and the youngest aeolianites are from MIS 3 at ~35 ka (Carr et al. 2019). The great majority of Cape south coast aeolianites date to MIS 6 and MIS 5, from ~153–70 ka (e.g. Roberts et al. 2008; Bateman et al. 2011; Cawthra et al. 2018; Helm et al. 2023a).

Pleistocene aeolianites and cemented foreshore deposits cleave along bedding planes and often come to lie as loose blocks and slabs below their sites of origin in the cliffs above. The surfaces exposed by these erosive processes may contain fossilised trackways and other traces and sometimes form sites for graffiti artists. Fossil tracks and traces (and modern graffiti) are then subjected to erosion by wind, rain, high tides and storm surges. Under such circumstances, depending on the degree of consolidation and cementation, the inevitable deterioration in the quality of traces may occur over a period ranging from a few weeks to years. New sites are exposed through cliff-collapse events, and known sites are eroded, slump into the ocean, or are covered by shoreline sand deposition (Helm 2023). Freshly exposed Pleistocene aeolianite surfaces are generally recognisable by their lighter yellowish colour, whereas surfaces that have been exposed for longer weather to darker grey and convex surfaces sometimes become covered by a dark layer of biofilm (Helm et al. 2017).

On unconsolidated dune and beach surfaces, substrate conditions and grain size are important for optimal track preservation and anatomical fidelity: moisture content that is neither too high nor too low, a surface that is neither too firm nor too soft, with sand of finer grain size yielding the best definition of traces (Helm 2023). However, from the perspective of anyone wishing to create divots or engravings in aeolianites today, the degree of consolidation and cementation of the rock surface is especially relevant. Consolidation

and cementation of aeolianites on the Cape coast vary substantially, often over short distances and without obvious links to regional/local environmental conditions (e.g. McLaren and Gardner 2004). For example, in the Rooikrans area east of Still Bay, deposits dated to 123 ± 8 ka are poorly cemented, such that a sample for dating could be easily obtained by pushing a pipe into the sediment and obtaining a tube core (Helm 2023). By contrast, at Robberg, near Plettenberg Bay, great difficulty was experienced in obtaining a block sample using geological hammers due to the hardness of the rock, yet these deposits were dated to 44 ± 4 ka (Helm et al. 2023b). There is a ‘sweet spot’ on the hardness spectrum between these extremes, where the rock is soft enough to yield to a tool like a chisel or knife but firm enough to maintain its consistency for at least weeks and months afterwards.

The case study series below highlights features that suggest or indicate a modern anthropogenic origin. A suite of principles is then presented to assist in separating ancient patterns, including sand art, from modern anthropogenic patterns.

Methods

Surfaces containing modern anthropogenic patterns were documented when they were encountered as part of the Cape south coast ichnology project. The rock type and location within the local stratigraphy were noted in all cases. The patterns’ dimensions and those of the host rock surface were measured. Photographs were taken, and where feasible, photogrammetric analysis (Falkingham 2012; Matthews et al. 2016) was performed. 3D models were generated with Agisoft MetaShape Professional (v. 1.5.2) using an Olympus TG-6 camera (focal length 4.5 mm; resolution 4000×3000 ; pixel size $1.56 \times 1.56 \mu\text{m}$). The final images were rendered using CloudCompare (v.2.10-beta). Where appropriate, a DJI Air 2 S drone with a built-in DJI camera/video was used to obtain further photographs, with images taken in camera mode.



Figure 3. Hominin footprint engraving on a Palaeozoic rock surface above Kalk Bay at Site 2; horizontal scale bar = 10 cm (photo credit: Carin Lichtenstein).

Results

Site 1

Aeolianite outcrops in the Langebaan area on the Cape west coast (Fig. 1) have been severely defaced by engraved graffiti, and in places almost every accessible and exposed surface (Langebaan Formation, Sandveld Group) is festooned with it (Fig. 2). Characteristically, the graffiti seldom reaches the margins of the surface, unless part of the surface has broken off subsequent to the engraving of the graffiti.

Site 2

A pattern of a human footprint in rock (Fig. 3) was reported by citizen scientist Carin Lichtenstein in 2020 from beside a hiking trail in Echo Valley, above Kalk Bay in the Cape Peninsula (Fig. 1). The shallow depression in the rock exhibited features of a

well-defined medial longitudinal arch and a prominent hallux impression and four lesser digit impressions. 'Footprint' length of 14 cm and width of 6.5 cm were recorded. The depression occurred on a rock surface of the Palaeozoic (Ordovician) Peninsula Formation, Table Mountain Group, Cape Supergroup. Further examination of the surrounding area revealed engraved images of a giraffe and a fish. As at Site 1, the engraving is located toward the centre of a suitable surface.

Site 3

In the Walker Bay Nature Reserve (Fig. 1), a four-wheel-drive track leads through dunes and intermittently crosses an aeolianite surface. Repeated use of the same route has resulted in a set of two parallel ruts separated by a raised area. A slightly pedestalled elephant track is evident in the middle of this raised area, ~35 cm in diameter. As occurs in many such tracks, it exhibits approximately concentric ring features. However, in the right portion of the track (as viewed in Fig. 4a), three parallel linear groove features are evident, ~7 cm in maximum length and less than 1 cm apart. Three metres to the south, also in the raised area between the ruts, a variety of large linear grooves are apparent (Fig. 4b), including grooves similar in size and alignment to those that occur on the elephant track.

Site 4

East of Still Bay on the Cape south coast (Fig. 1), a rugged 6 km stretch of coastline is characterised by aeolianite cliffs of the Waenhuiskrans Formation, reaching up to 30 m in height. The area is rich in vertebrate ichnosites, and its remoteness makes it attractive for coastal angling.

The coast can only be traversed at low tide, often by scrambling over blocks and slabs that have fallen from the cliffs above. Where these are grouped together and stacked, they present barriers for those traversing the coastline.

At one such site, four depressions were noted on the surface of

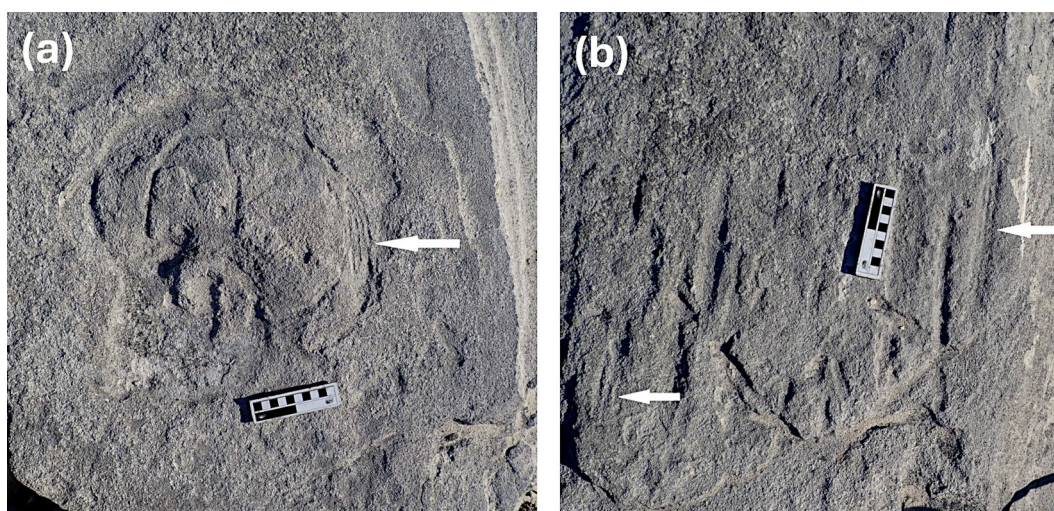


Figure 4. (a) Arrow indicates linear grooves on an elephant track at Site 3; (b) a variety of linear grooves made by 4WD vehicles at Site 3; arrows indicate those that resemble the grooves shown in (a). Scale bars = 10 cm.

a steeply sloping, loose slab that measured approximately 180 cm in maximum length and 170 cm in maximum width. The dimensions of the depressions were as much as 36 cm in length and 20 cm in width (Fig. 5). They were each characterised by longitudinal, parallel grooves or furrows in their bases, particularly in their distal walls, as viewed in Figure 5. They formed a 'staircase' that facilitated scrambling up and over the promontory. Bedding planes observed within this loose rock were not aligned parallel to the surface containing the depressions. The exposed surface, therefore, did not appear suitable for the registration and preservation of tracks, and the depressed features did not appear at all consistent with infaunal burrow traces.

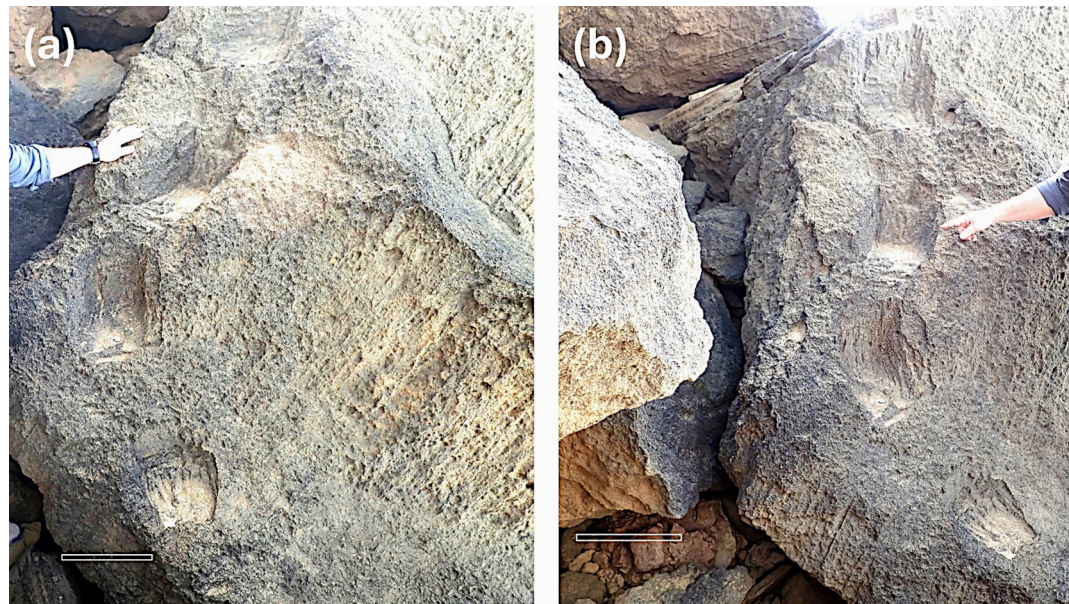


Figure 5. (a) and (b): A 'staircase' of four depressions in an aeolianite slab at Site 4; scale bars = 30 cm.

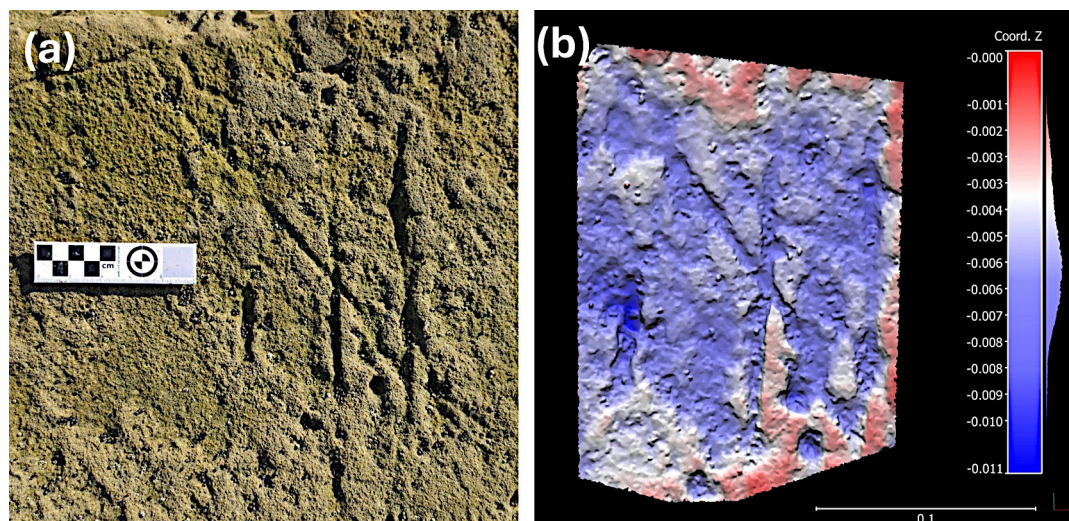


Figure 6. Site 5, in MIS 11 aeolianite deposits at Dana Bay; (a) the small possible 'hashtag' pattern; scale bar = 10 cm; (b) 3D photogrammetry model of the pattern shown in (a); horizontal and vertical scales are in metres.

Site 5

A pattern on an aeolianite surface at Dana Bay (Fig. 1) comprised three parallel linear grooves and a diagonal groove that transected the central groove (Fig. 6). The grooves varied in length from 5–12 cm, with a width of ~0.5 cm. No surrounding features suggested vertebrate tracks, but another linear groove was present nearby on the surface. The surface was located within deposits that have been dated through OSL to MIS 11 at ~400 ka (Roberts et al. 2012).

Site 6

The coastline at Tergniet (Fig. 1) comprises a five-km

stretch of cemented foreshore deposits of the Klein Brak Formation, whose surface has been eroded by twice-daily tides. Consequently, the area is devoid of fossil tracks. The rocks render ocean swimming difficult, and as a result, two concrete tidal pools were constructed decades ago: they are filled by the high tide and retain their water at low tide. Beside one of them, the cemented foreshore surface is indented by several series of regularly spaced depressions, ~20–30 cm in length and ~13 cm apart (Fig. 7). These were reported by Hendrik Graham, Aleck Birch and Ilona Birch. Some of these have a 'trident' or 'tridactyl' appearance and could, at first glance, be mistaken for giant armadillo (*Orycteropus afer*) tracks or a pattern inscribed by an ancestral hominin using a stick. However, the proximity to the tidal pool and the knowledge



Figure 7. The tidal pool at Tergniet at Site 6, where series of depressions have been created in the underlying rocks of the Klein Brak Formation. Scale bars = 10 cm.



Figure 8. A grader has made deep grooves in these cemented foreshore deposits at Site 7 at the Great Brak River mouth (photo credit: Melanie Harris).

of the activity that must have occurred there during its construction point to an anthropogenic origin.

Site 7

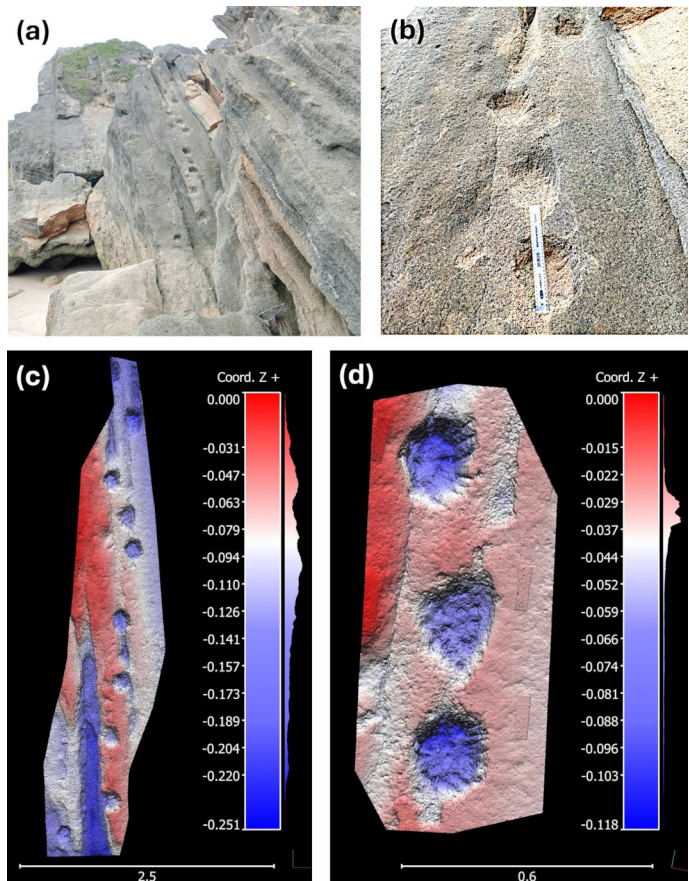
Five km east of Site 6, at the mouth of the Great

Brak River estuary on the Cape south coast (Fig. 1), cemented foreshore deposits of the Klein Brak Formation are typically covered by metres of sand but are occasionally exposed. Management of the estuary involves periodic use of large machinery (e.g. graders) to remove a sand berm and open the river mouth. Sometimes the graders strike the underlying rock, creating gouges and furrows in it, which may be in the form of linear or curvilinear grooves. Such grooves were reported by Melanie Harris (Fig. 8, and Helm et al. 2019a: Fig. 14f). Without knowledge of the preceding industrial activity, these features might be mistaken for unusual palaeo-ichnological traces.

Site 8

In the Goukamma Nature Reserve on the Cape south coast (Fig. 1), varying amounts of sand cover sometimes create extensive modern beaches, whereas at other times, in situ layers or loose slabs of the Waenhuiskrans Formation are exposed. Traversing this coastline around high tide can be problematic, especially where aeolianite promontories extend

Figure 9. (a) and (b): At Site 8 in the Goukamma Nature Reserve a sequence of depressions heads up a steep aeolianite slope beside a promontory; predominantly transverse grooves are evident in the walls of some of the depressions; length of ruler = 30 cm (photo credit: Douglas Euston-Brown; (c) and (d) 3D photogrammetry models of the features at Site 6—predominantly transverse grooves are evident in the walls of the top and bottom impressions in (d); horizontal and vertical scales are in metres.



seawards—hiking around the seaward end of such promontories is not always safe or feasible. For hikers and anglers, it may be safer to climb over them, but the surfaces are sometimes steep and smooth.

In one such case, reported by Douglas Euston-Brown, nine depressions in a pattern that might be mistaken for a vertebrate trackway were found on a steeply sloping aeolianite bedding plane in a track-rich area (Fig. 9). The depressions ranged in length from 17–22 cm and in width from 16–19 cm and were as much as 11 cm deep. Deep linear grooves, often perpendicular to the orientation of the ‘trackway’, were present in the walls of the depressions. Crossing over the promontory using these depressions as footholds and handholds facilitates passage.

Site 9

Further east in the Goukamma Nature Reserve on the Cape south coast (Fig. 1), a bizarre, unexpected pattern was noted on a loose aeolianite slab of the Waenhuiskrans Formation with dimensions of 60 cm × 42 cm (Fig. 10). The ‘mystery’ was solved by the presence of a broken plastic crab pot with an identical pattern wedged in the rocks close by; in each case the inner circle had a diameter of 18 cm. The inference is that during a high tide or storm surge event, this hard plastic object became lodged between two rocks and that it applied substantial pressure onto the softer aeolianite surface, creating the depressed pattern.

An example of how rapidly aeolianites can be carved or eroded following the application of consistent or repeated pressure by wave and current action within modern intertidal zones was noted in aeolianites at South Kaipara Head in New Zealand. Following recent (i.e. two years ago) heavy flooding and cliff collapse events, dislodged aeolianite slabs came to lie at the foot of sea cliffs along with flotsam of tree trunks and branches on the beach. The surfaces of some slabs exhibit deep curvilinear grooves and other depressions (as deep as 20 cm), which could be correlated with the shape and size of branches that had become wedged into the depressions. It is evident that the branches had repeatedly applied frictional force to

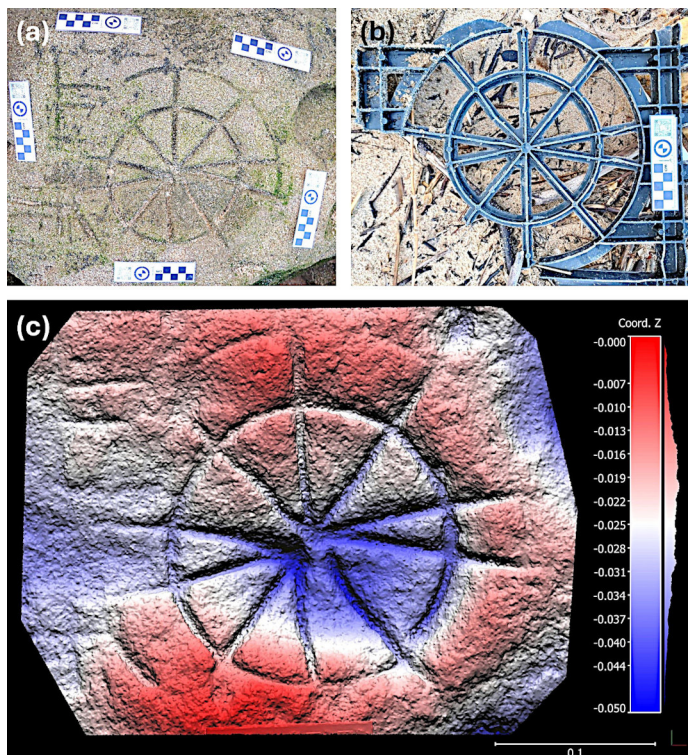


Figure 10. Site 9, in the Goukamma Nature Reserve; (a) the pattern of a crab pot on a loose aeolianite slab; scale bars = 10 cm; (b) the remains of the crab pot, found adjacent to the site; scale bar = 10 cm; (c) 3D photogrammetry model of the crab pot pattern in the rock; horizontal and vertical scales are in metres.

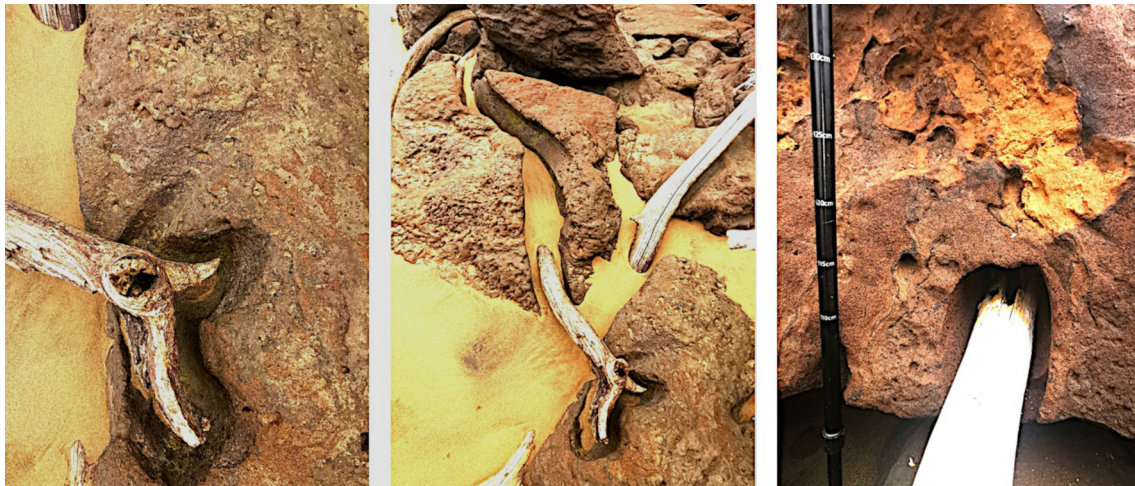


Figure 11. Examples from South Kaipara Head in New Zealand of aeolianite slabs being eroded by flotsam: (a) tridactyl-like impression; (b) a deep curvilinear groove was carved by a branch still wedged in position (partly covered by sand); (c) a hole is in the process of being 'drilled' by a straight branch.

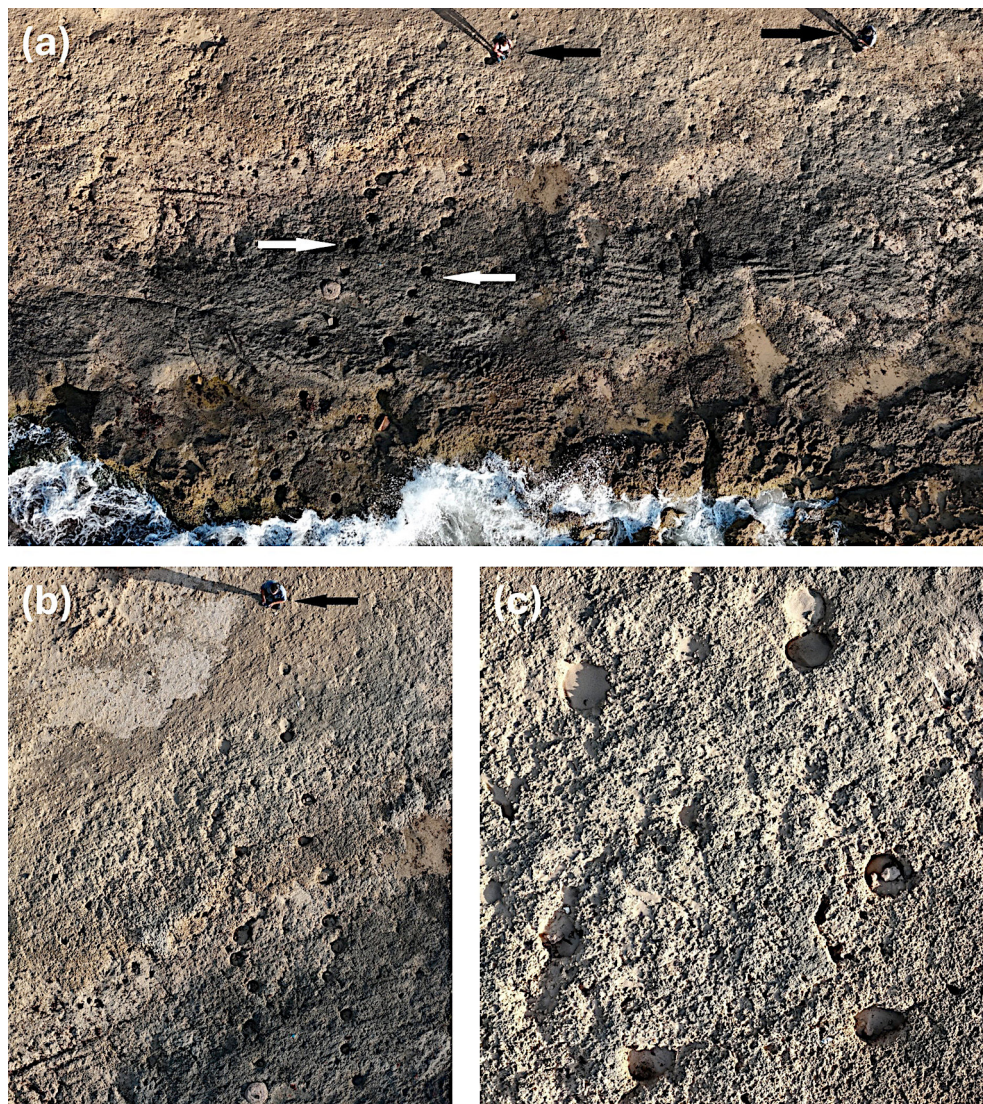


Figure 12. Drone images of patterns in the rock, resembling juvenile elephant trackways (indicated by white arrows) at Site 10 near Kenton-on-Sea, exhibit left-right symmetry; predominantly shore-parallel striations are also evident in (a). Adult human figures, indicated by black arrows in (a) and (b), provide scale.

portions of the surfaces as a result of tidal action (Fig. 11). In this case, had the context not been known (i.e. if the flotsam was no longer in place, as is the situation on other grooved sandstone slabs on the beach), burrow structures or even a tridactyl track might have been suspected. While these aeolianites may be less well-cemented than some of those of the Cape coast, the underlying principle is clear: aeolianites are easily eroded, and patterns displayed on their surfaces could be misinterpreted.

Site 10

Two parallel sequences of round depressions, each with a diameter of ~23 cm, were noted on a level Pleistocene aeolianite surface of the Nahoon Formation, Algoa Group, near the community of Kenton-on-Sea (Fig. 1) and hence in an inhabited area. They exhibited dimensions and 'step-lengths' (~80–115 cm) consistent with juvenile elephant tracks, and two parallel elephant trackways extending perpendicular to the modern coastline were initially considered. It was then noted, however, that the two 'trackways', when examined together, exhibited precise mirror-image symmetry (Fig. 12), a phenomenon inconsistent with elephant trackways. Furthermore, parallel, regularly spaced groove features or striations, mostly with a shore-parallel orientation, were evident close by. Enquiries at the local municipal office confirmed that a pier structure had been constructed in the area in the past that was in accordance with the observed findings.

Discussion

Review of sites 1–10

Site 1 illustrates the scourge of graffiti and the attractive canvases that aeolianite surfaces provide for graffiti artists equipped with tools such as hammers and chisels. The subject of graffiti on aeolianite surfaces has been addressed (Helm et al. 2021b), along with egregious examples that have affected hominin ichnosites (Helm et al. 2024f: Fig. 3; Roberts 2008).

Fortunately, the Cape south coast and east coast aeolianite exposures have not been plagued with graffiti to the same extent as in the Langebaan area, but nonetheless, it appears to be on the rise. Graffiti is easy to recognise when it takes the form of letters or heart symbols, but abstract forms may be more difficult to identify with confidence. However, things are not always what they first appear to be, and a note of caution relates to a recently described example of rock art from the Cape south coast: what appeared to be geometric patterns resembling letters of the alphabet was interpreted as a realistic rock art depiction of flotsam from a shipwreck (Paterson 2023). Eroded graffiti that is decades old may also lose the sharp corners and outlines that would help to distinguish it from ancient patterns. Likewise, recent graffiti exhibits a colour contrast between the engraved surface and the host rock surface (the former is usually lighter in colour),

but this colour contrast becomes progressively less obvious with the passage of time. Therefore, despite these useful points of distinction, in some cases it may not be possible to determine with confidence whether a pattern is ancient or modern.

Site 2 illustrates the importance of determining the age and type of the host rock. Hominin footprints are clearly impossible in Palaeozoic rocks. However, if the age and type of rock are not known with certainty, as may still occur in remoter parts of southern Africa, confusion may arise, as in the case of 'Queen Nzinga's footprints' at Pungo Andongo in Angola (Helm et al. 2019b). While most authors regarded them as recent engravings (Rudner and Rudner 1970), some did not exclude the possibility of a genuine ancient age (Lategan and Van Wyk 2016). One further clue in such cases lies in the perfection of the footprints, which appear 'too good to be true'. The relatively coarse grain size of cemented dune and foreshore surfaces precludes the anatomical fidelity exhibited at Site 2 and the Angolan example. Furthermore, it would be substantially easier to etch a 'trackway' into an aeolianite surface than into Palaeozoic bedrock, and the possibility of such 'fake' trackway phenomena needs to be borne in mind when assessing tracks and trackways in aeolianites and cemented foreshore deposits.

Site 3 presents a case of anthropogenic mechanical activity that has disfigured a genuine vertebrate track. Linear parallel grooved features are not characteristic of elephant tracks. Furthermore, the site, being on a raised area between two vehicle ruts, and containing similar linear grooves located a few metres distant, provides a ready explanation: part of the undercarriage of a 4WD vehicle, lacking adequate clearance, scraped against the aeolianite surface and left its impression on the elephant track. There is thus no need to consider how an elephant track might potentially exhibit linear groove features.

Site 4 is unlikely to present confusion for a discerning ichnologist, as the surface on which the depressions occur is not aligned with bedding planes, and the depressions do not appear to be consistent with burrow traces. However, from a distance, they resemble a vertebrate trackway. A more plausible explanation is that anglers incised depressions in a sloping surface to create footholds and handholds and thus facilitate their passage along the coastline. This appears, therefore, to be a utilitarian reason for incising depressions on an aeolianite surface.

At first glance, the pattern at Site 5 resembles a small 'hashtag' pattern, a palaeoart phenomenon recorded elsewhere on the Cape south coast during the Middle Pleistocene (Henshilwood et al. 2002, 2009, 2018). However, distinguishing features such as displacement rims are absent, the grooves appear unusually narrow, and adjacent tracks and traces that might suggest an ancient origin are absent. An ancient anthropogenic origin seems unlikely or at least impossible to argue for convincingly. More likely expla-

nations include a random orientation of linear traces (perhaps representing an arrangement of stick casts) that happen to form a pattern resembling a 'hashtag', or else a recent engraving of a 'hashtag' pattern with a sharp object. This conclusion is buttressed by the age of the rock surface of ~400 ka. There is no evidence that ancestral hominins on the Cape south coast at that time had the capacity to register such patterns in the sand, and any evidence for such behaviour would need to be unequivocal and compelling.

Sites 6 and 7 indicate the value of local knowledge of activities that have occurred in the region. Without an awareness that machinery had been operating in the area and may have inadvertently 'graded' the underlying cemented foreshore deposits, the features might have seemed enigmatic. They might even have prompted speculation about ancient sand art, vertebrate traces on palaeo-beach surfaces, crocodilian tail drag impressions (not yet recorded on the Cape coast), or giant aardvark tracks.

In contrast to Site 4, where the gouged depressions do not occur on a palaeosurface, at Site 8, the line of depressions, which from a distance resemble a vertebrate trackway, do occur on an aeolianite bedding plane that represents a palaeodune surface. Again, however, the depressions are deeper than expected (as much as 10 cm), and their walls are festooned with linear grooves, which often appear in a transverse alignment that is ichnologically inconsistent with features such as claw scratch marks. The location of the line of depressions on a promontory that poses problems for hikers or anglers at high tide is likely not coincidental. In this case, however, we suggest that whoever created this 'staircase' may have used and deepened an existing trackway. Site 8 thus represents another example of a utilitarian motive for creating depressions in aeolianites.

Site 9 can be regarded as an unusual case in which a plastic feature was wedged between two rocks for long enough to enable its distinctive pattern to be imprinted deeply on one of the surfaces. It illustrates the capacity of aeolianites to be indented by persistent pressure. Rare and unlikely as such an event may be, it serves as a warning to consider this mechanism in enigmatic or unexplained cases, in which there may be a danger of reaching an unwarranted conclusion about ancient abstract sand art. Again, the pattern appears 'too good to be true', which should raise concerns about a recent anthropogenic cause. In this case, the 'culprit' was still located nearby, providing a straightforward explanation. Had this not been the case, a matching pattern would have to be sought to explain the findings. Once again, if the rock surface had only been identified after erosive forces had had time to act on it, the identification of a recent anthropogenic origin might not have been as simple, and ancient causes might have had to be considered. The examples from New Zealand present an even more extreme illustration of the capacity of aeolianites to

be eroded by persistent pressure.

As in the case of Site 6 and Site 7, the value of knowing or investigating local history at Site 10 proved crucial in identifying the recent anthropogenic origin of what, at first sight, resembled a pair of Pleistocene juvenile elephant trackways. As with sites 1, 2, 6 and 7, proximity to a peri-urban, highly frequented area would serve as a 'red flag' for a non-ancient origin of the observed features. Even without this knowledge, however, careful scrutiny using drone aerial photography would have revealed the likelihood of a modern origin given the precise, mirror-image symmetry between the two 'trackways' and the adjacent parallel striations. While symmetry does not fall within the exclusive domain of hominin creations, it always requires an explanation, and in this case, a recent anthropogenic (industrial) origin is by far the likeliest.

In summary, Sites 1 and 2 were created through direct human action as graffiti (Site 1) and as what some may consider modern art (Site 2). Site 4 and Site 8 provide examples of utilitarian motives in creating features resembling trackways, presumably also using hand tools. In contrast, Sites 3, 6, 7, 9 and 10 provide examples of patterns created through mechanical activity. Site 4 is an equivocal case, in which an ancient anthropogenic origin can be excluded and a modern anthropogenic origin is plausible.

Principles

The ten cases presented here offer a variety of features that permit the development of sixteen general principles which may aid in identifying or excluding a modern anthropogenic origin of patterns seen in rocks of Pleistocene age on the Cape coast (or indeed in similar deposits elsewhere) and distinguishing this origin from ancient patterns, which include ammoglyphs and sand art.

- 1) Patterns occurring close to populated areas or hiking trails have a higher likelihood of a recent anthropogenic origin.
- 2) Patterns in truly inaccessible areas of cliffs are less likely to have a recent origin.
- 3) A plausible rationale for the creation of depressions in rock surfaces, such as ease of travel over a challenging promontory, favours a recent anthropogenic origin.
- 4) Recently created patterns tend to be situated towards the centre of exposed surfaces unless the surface was fractured during or after the creation of the pattern; ancient patterns do not exhibit such bias.
- 5) Graffiti, when recognised through obvious letters and contemporary symbols, is easily identifiable as modern, but eroded cases that have lost their initial sharp delineation may be more challenging to identify.
- 6) A colour contrast between the host surface (darker) and the feature in question (lighter) indicates a recent phenomenon, but over months to years,

this distinction will fade.

- 7) Patterns in the surfaces of in situ rocks older than the Middle Pleistocene were almost certainly not made by ancestral humans. Consequently, if they are of anthropogenic origin, they are recent. While Site 2 takes this principle to the extreme, Site 4 presents a more ambiguous case: potential anthropogenic patterns found in MIS 11 deposits are best regarded as modern in origin unless there is highly compelling evidence to the contrary.
- 8) Patterns that appear 'too good to be true' should be viewed with great suspicion.
- 9) Patterns that do not conform to ichnological principles (e.g. linear grooves in an elephant track at Site 3, transverse linear grooves within the walls of depressions at Site 8) have probably been formed recently.
- 10) Patterns (other than infaunal burrow traces) on rock surfaces that are not aligned with bedding planes can safely be interpreted as modern.
- 11) Explanations for seemingly inexplicable features, such as the use of heavy machinery or the former presence of man-made structures, may be obtained through an accurate history of local events of the past decades.
- 12) In the case of clear and unusual patterns that suggest a hominin signature, a 'perfect match' should be sought, in case the pattern represents a rare phenomenon such as at Site 9; ammoglyphs are rare, but recently created patterned moulds in rock are also rare.
- 13) Wherever examples of symmetry or parallel groove features or striations are encountered, an explanation should be sought.

In addition, previously established criteria, including the following, can help to 'rule in' an ancient origin (Helm et al. 2019a, 2021a).

- 14) It is virtually impossible for a graffiti artist to create raised rims around inscribed symbols—raised rims, when evident, are sediment displacement features that fall within the domain of ancient patterns.
- 15) If a pattern or depression can be shown to extend underneath and beyond an overlying layer, it was created when the surface comprised unconsolidated sand.
- 16) If the pressure from creating a pattern in unconsolidated sand creates recognisable distortions in underlying layers (e.g. Helm et al. 2021a), a modern or recent origin can be excluded; this can be regarded as similar to the phenomenon of 'transmitted tracks' (Thulborn 1990, 2012).

If such features can be identified, a modern origin is excluded. However, they are not necessarily present in all ancient examples, and their absence is therefore not of diagnostic value. Finally, in patterns determined to be ancient, proximity to hominin footprints (e.g. Helm et al. 2019a: Fig. 5) increases the likelihood of

the pattern being an ammoglyph.

Conclusions

A plethora of potential patterns is evident in Pleistocene surfaces on the Cape coast, which can be attributed to various causes. Identifying a 'hominin signature' as an origin of such patterns is of great importance, given the implications of ammoglyphs and palaeoart as examples of cognitive complexity. Being able to distinguish between ancient and modern origins of such a signature thus becomes critical. Moreover, the possibility of a modern origin for tracks and traces on Pleistocene surfaces needs to be considered and excluded when possible.

The examples provided here and the resulting principles that have been developed add to an approach that involves ruling out or ruling in ancient or modern patterns. Nonetheless, cases may still be identified in which the distinction cannot readily be made. Given the geoheritage value of these sites, accurate identification is of paramount importance. A necessarily cautious approach requires that equivocal cases not be regarded as ammoglyphs, ancient sand art or Pleistocene ichnosites unless compelling evidence becomes available. In many cases, though, the principles provided here may aid in the accurate distinction between ancient and modern hominin patterns and assist in accurately identifying Pleistocene ammoglyphs, including sand art.

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