A Howiesons Poort tradition of engraving ostrich eggshell containers dated to 60,000 years ago at Diepkloof Rock Shelter, South Africa

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Ongoing debates about the emergence of modern human behavior, however defined, regularly incorporate observations from the later part of the southern African Middle Stone Age and emphasize the early appearance of artifacts thought to reflect symbolic practice. Here we report a large sample of 270 fragments of intentionally marked ostrich eggshell from the Howiesons Poort at Diepkloof Rock Shelter, Western Cape, South Africa. Dating from ≈60,000 years ago, these pieces attest to an engraving tradition that is the earliest reliable evidence of what is a widespread modern practice. These abstract linear depictions were made on functional items (eggshell containers), which were curated and involved in daily hunter-gatherer life. The standardized production of repetitive patterns, including a hatched band motif, suggests a system of symbolic representation in which collective identities and individual expressions are clearly communicated, suggesting social, cultural, and cognitive underpinnings that overlap with those of modern people.

cultural modernity | Middle Stone Age | anatomically modern humans | symbolic expression

Symbolically mediated behavior has emerged as one of the few universally accepted markers of behavioral modernity (1–4). Symbolic practices are defined by socially constructed conventions (5) and may take various archaeological forms, varying in the nature of the material used or the kind of transformation performed. In all cases these practices require adherence to collective rules. Repetitiveness and patterning of practices are key elements for the emergence of a tradition mediating behavior through the involvement of artifacts.

The question of where, when, and in what form such symbolic traditions appear in human evolution constitutes a critical as well as a theoretical issue (1, 6–13). Currently, the southern African Middle Stone Age (MSA) presents suggestive evidence for early innovative technology and symbolic behaviors, predating the dispersal of anatomically modern humans throughout Eurasia some 50,000 years ago (14–22). The earliest symbolic practices documented in southern Africa consist of the perforation of shells, intended to be personal ornaments, as well as the engraving of mobile items such as ochre, bone, and ostrich eggshell (14–19, 23, 24). Whether specific markings always reflect representational intent is a matter of debate (2, 25). Because archaeological collections are limited to very small samples of stratigraphically contemporaneous pieces, the range of variability of the patterns remains poorly documented and interpreted. Moreover, engraved pieces are characterized by a noticeable diversity of patterns, of raw materials selected for marking, and of chronocultural contexts. Rather than considering engraving practices as a single and homogeneous phenomenon, it now is important to focus on their differences and to evaluate their implications in terms of the appearance and evolution of modes of symbolic expression.

Among the few sites displaying engraved mobile items in southern Africa, Diepkloof Rock Shelter provides an exceptional collection of intentionally marked ostrich eggshell. In the last few years, excavators have unearthed a rich collection of engraved ostrich eggshell (EOES) fragments (Fig. 1). These findings, added to the previously excavated sample of EOES from this site (16), expand the collection of fragments to 270 pieces. The large sample size of EOES documents a small range of geometric motifs that introduces the notion of group identification (adherence to rules) and individual expressions (stylistic latitude). The manipulation of a small range of motifs and the diachronic changes in motifs are persuasive evidence for symbolic expression. The large sample size of the EOES, its well-documented context, and the unequivocal nature of the markings offer a unique opportunity to study what constitutes the most reliable collection of an early graphic tradition.

Context of the Engraved Ostrich Eggshells from Diepkloof Rock Shelter

Diepkloof Rock Shelter, Western Cape, South Africa, is a large quartzitic sandstone shelter overlooking the Verlorenvlei River about 17 km from the present Atlantic shoreline. The excavation trench extends 16 m across the site including a section 3.6 m in depth. The main section exposes one of the most complete and continuous later MSA sequences in southern Africa (Fig. 2), dating from before 130 ka to about 45 ka and encompassing pre-Stillbay, Stillbay, Howiesons Poort, and post-Howiesons Poort occupations (17, 26). Although ostrich eggshell fragments are documented throughout the sequence, EOES are associated only with several layers within the Howiesons Poort complex. The majority of the recently recovered pieces of EOES (Fig. 1) were collected from two distinct stratigraphic units (*Frank* and *Darryl*), but the overall stratigraphic distribution is slightly broader, encompassing 18 stratigraphic units from *Governor* to *Dennis* (Fig. 2).

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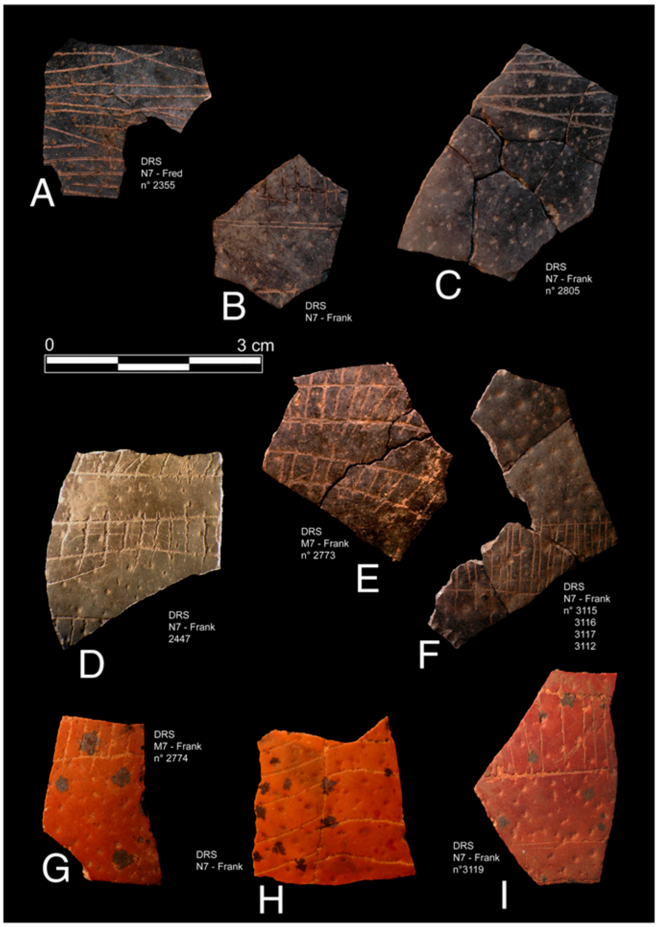

Fig. 1. Fragments of engraved ostrich eggshells found in the Howiesons Poort of Diepkloof Rock Shelter (Western Cape, South Africa). Except for *A*, all the pieces belong to the same stratigraphic unit (layer *Frank*). *A* and *C* show a series of deeply engraved, straight, subparallel lines. *B*, *D–G*, and *I* show a hatched band motif. *B* and *E* have evidence of two separate hatched bands, and fragment *D* has evidence of three separate hatched bands. Fragment *H* shows slightly curved lines crossing a central line.

The depositional sequence at Diepkloof consists primarily of beds and laminations of anthropogenic material, including burnt and nonburnt organic residues and ash associated with detrital sands and diagenetic components. The upper portion of the sequence, roughly corresponding to the Howiesons Poort and post-Howiesons Poort occupations, is composed of beds and laminations of black charcoal and white ash. Micromorphological analysis of these layers demonstrates that these laminations are anthropogenic and represent several types of deposits, including intact hearths, ash dumps and rake-outs, and burnt bedding (27).

The *Frank* layer has produced one of the most abundant assemblages of EOES. At the profile K6-M6/K7-M7 (Fig. 2), *Frank* consists of two layers including a lower layer of calcareous ash and an upper layer of charcoal. The calcareous ash has been locally phosphatized. Unlike other layers within the sequence, *Frank* exhibits an open and noncompact structure, suggesting that, at least locally, *Frank* was not extensively trampled. This interpretation is supported by the preservation of numerous calcitic plant pseudomorphs produced during combustion. The loose structure of *Frank* and the inclusion of noncombusted material (notably clay aggregates) suggest that this layer does not represent an in situ hearth but rather an ash dump or hearth rake-out.

The Howiesons Poort layers at Diepkloof Rock Shelter contain a substantial lithic component, including a noticeable portion of products less than 2 cm in size. The lithic collection consists of rocks of different geographical origins. Quartzite and quartz are both available in the vicinity of the site (<10 km); other raw materials (hornfels and silcrete) have a nonlocal provenance (from 10 km to more than 40 km distant) (28). The Howiesons Poort lithic collection from Diepkloof is dominated by fine-grained nonlocal silcretes, underlining the intentional acquisition and transport of these raw materials. In the layer *Frank*, for example, silcrete is about 60% of the total raw material. Two main *chaînes opératoires* characterize the Howiesons Poort from Diepkloof, one oriented toward the production of blades and bladelets and the other oriented toward the production of flakes. The typological corpus is dominated by classical truncated and backed tools, some with adhesive remains; notched and denticulate pieces are represented as well. The Howiesons Poort lithic assemblages from Diepkloof Rock Shelter nonetheless demonstrate some variability in the proportions of raw materials as well as in the typological corpus.

Throughout the sequence, the quality of organic preservation is exceptional, including the presence of various vegetal remains (wood, grass, seeds, fruits), which currently are under intensive study using field emission scanning electron microscopy. The Howiesons Poort botanical remains already have yielded much evidence for thicket or shrubland vegetation typical of kloofs (e.g., *Diospyros* spp., *Cassine* cf *peragua*, *Maytenus* spp., *Rhus* spp., *Hartogiella schinoides*). Also present are Afromontane forest taxa

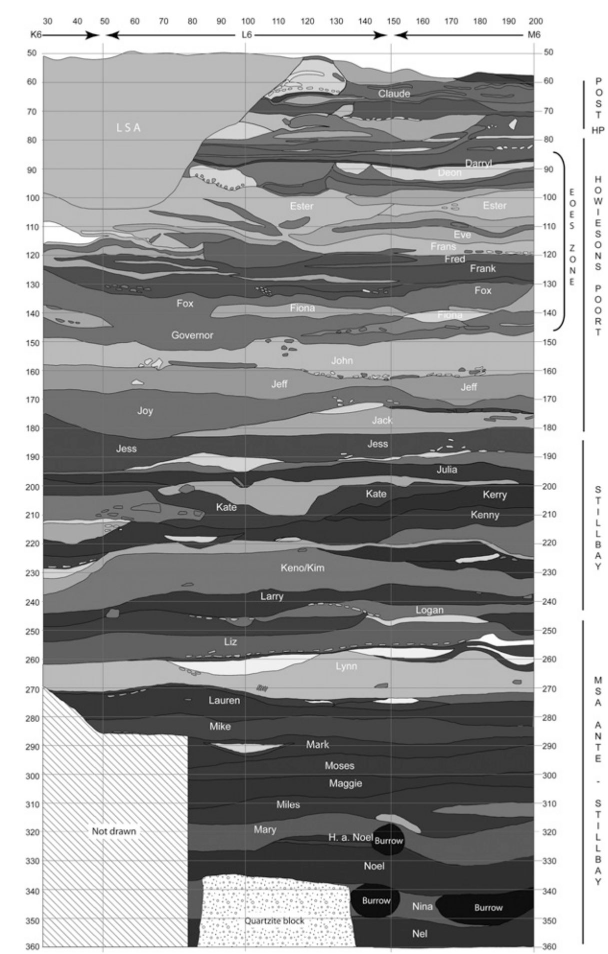

Fig. 2. Stratigraphic sequence at Diepkloof Rock Shelter (Western Cape, South Africa) and the main chronocultural attributions. The profile is at the section K6-M6/K7-M7. Only the main layers are shown.

including *Kiggelaria africana*, *Podocarpus elongatus*, and *Celtis africana*, which now are seldom found in the region of Diepkloof Rock Shelter. The presence of *Ficus* sp. indicates a much more diversely wooded riverine community fringing the paleo-river that forms the present-day Verlorenvlei.

The Diepkloof faunal collection includes a rich sample of mammal bones, tortoise elements, and intertidal marine shell. Despite the numerous fragments of ostrich eggshell, ostrich bones are absent. The mammal bones throughout tend to be highly fragmented, and teeth are rare, reflecting unusual postdepositional geochemistry. Extreme fragmentation, combined with substantial postdepositional staining, complicates a search for anthropogenic alteration. The sample is dominated by rock hyrax (*Procavia capensis*), hares (*Lepus* spp.), dune mole rats (*Bathyergus suillus*), and small bovids (mainly steenbok or grysbok (*Raphicerus* spp.). The hyrax, klipspringer (*Oreotragus oreotragus*), and vaalribbok (*Pelea capreolus*) reflect the rocky, topographically variable environs of the site, whereas zebras (*Equus capensis* and *E. zebra aut quagga*) and alcelaphine antelopes—wildebeest (*Connochaetes*) or hartebeest (*Alcelaphus*)—indicate grass cover. Hippopotamus (*Hippopotamus amphibius*) and southern reedbuck (*Redunca arundinum*) suggest the persistence of the neighboring vlei, but shell fragments from black mussel (*Choromytilus meridionalis*) and limpets (primarily granite limpet, *Cymbula granatina*), which are especially numerous in the Howiesons Poort unit with EOES, suggest the coastline had moved up the vlei. Two bones of Cape fur seal (*Arctocephalus pusillus*) in the Howiesons Poort EOES levels also reflect occasional human visits to the coast. The Diepkloof tortoise bones come overwhelmingly from the angulate tortoise (*Chersina angulata*), which still is common nearby. Like angulate tortoises from other regional MSA sites, the Diepkloof specimens tended to be remarkably large compared with their Late Stone Age counterparts, suggesting different intensities of predation between MSA and Late Stone Age populations (29, 30).

The absolute chronology of the Howiesons Poort at Diepkloof is now well established. The layers *Darryl* and *Frank* occur below the *Buddy-Becky* complex (square E6) which has a ^{14}C age of >55 ka (GifA 102381) (26). Thermoluminescence measurements and Bayesian adjustments suggest an age of 61 ± 4 ka (26) for the transition between the set of layers including *Darryl* and *Frank* and layer *John*, located just below the limit of the EOES distribution. Optically stimulated luminescence dates (31) for the Howiesons Poort layers at Diepkloof range from 58.1 ± 1.9 ka to 63.3 ± 2.2 ka (layer *John*) and are consistent with the thermoluminescence estimates. Therefore, the production of EOES at Diepkloof can be placed securely between 55 and 65 ka. Because the EOES at Diepkloof Rock Shelter appear in 18 sequential stratigraphic levels, the fragments are likely to represent a tradition that lasted for several thousand years.

The Engraved Ostrich Eggshell Collection

As the result of a combination of various postdepositional effects (trampling, burning, salt infiltration), fragments of ostrich eggshells found at Diepkloof Rock Shelter are limited to 20–30 mm in maximum dimension. In some cases, it has been possible to refit several of the pieces into larger fragments (80 × 40 mm) of the original engraved eggshells.

The current sample of EOES exhibits a set of four repetitive linear motifs in the form of a hatched band motif, a parallel to subparallel line motif, an intersecting line motif, and a cross-hatching motif. All these patterns share a common geometric concept. Because EOES pieces are fragmentary, it is possible that some of the geometric patterns were part of more complex motifs, although to date, only one pattern or motif has been found per fragment.

The most common engraved motif consists of two long parallel lines intersected at roughly right angles by shorter, regularly spaced lines, forming a hatched band. The engraving of the motif appears to have been standardized in that the maker began by engraving the long, parallel lines and then carefully engraving the shorter, subperpendicular cross lines, usually starting outside the defined band and crossing over the long parallel lines (Figs. 3 *A*–*F* and 4). Despite the standardization of the engraving sequence, there is substantial variability in the width of the band (4–20 mm), the spacing of the hatched lines (1–5 mm), and the angle of intersection (90–140°) (Table S1). Some fragments have only one hatched band, whereas others have evidence of two (Fig. 1 *B* and *E*) or three (Fig. 1*C*) bands. In one piece (Fig. 1*E*), the curvature of the band suggests that the band was oriented latitudinally rather than longitudinally.

Fragments with a hatched band motif are found only in the lower part of the Howiesons Poort sequence with EOES, encompassing 12 stratigraphic units, *Governor* to *Ester*. They are most commonly associated with the layer *Frank*, which has produced more than 50% (n = 36) of the EOES fragments with a hatched band motif (Table S1). In that layer, the variability of the hatched band motif suggests the presence of at least four or five distinct engraved eggshells. A diachronic trend exists within the occurrence of the hatched band motif as well. Ostrich eggshell fragments engraved with two or three hatched bands are documented in only three stratigraphic units (successively, *Franck* to *Frans*) and are more closely associated with the stratigraphic unit *Franck* (Table S1).

A second pattern identified on several fragments consists of a series of deeply engraved, straight, subparallel lines (Fig. 1 *A* and *C*); other fragments show engraved lines converging or intersecting at a low acute angle. Because fragments are limited to only a portion of the complete motif, the variability and the distribution of the pattern on the egg remain unclear. However, when the individual and refitted EOES fragments are considered, it is likely that subparallel lines were widely distributed around the eggshell. This motif is found mostly within the upper portion of the Howiesons Poort complex, where the hatched band motif has not been found. This observation suggests diachronic change in the dominance of the hatched band motif and the subparallel line motif throughout the Howiesons Poort sequence with EOES.

A further geometric pattern, identified on a single fragment (Fig. 3*G*), consists of slightly curved lines that cross a central line. The curvature of the subperpendicular lines is reversed on either side of the central line, suggesting that the maker rotated the egg 180° during production. There is, in addition, one clear example of cross-hatching. These pieces introduce some variability and confirm the existence of geometric rules for engraving. In accordance with these rules, the two main patterns created at Diepkloof Rock Shelter were a hatched band motif and a subparallel lines motif.

Ostrich Eggshells as a Medium for Engraving

Ostrich eggshell is a biomaterial composed of 96% crystalline calcite and 4% organic material (mostly proteins). Ostrich eggshells are on average 160 mm long and 130 mm wide with an average volume of 1 L. The eggshell is comprised of three different layers that vary in structure and in thickness (32), affecting the morphology of the incisions. The examination of EOES fragments at low-power magnification and with a scanning electron microscope shows that the superficial incisions are limited to the external layer and exhibit a transversal V profile, whereas the deepest grooves extend into the upper part of the intermediate layer and mostly exhibit a transversal U profile (Fig. 4, *Bottom*). The heterogeneity of calcite crystallite orientation in the ostrich eggshell (33, 34) and the tool used for engraving can also influence the incision morphology.

Ostrich eggshell fragments vary in preservation as well as coloration. Although modern ostrich eggshell displays a milky-white color, several EOES fragments found at Diepkloof Rock Shelter exhibit a red external color (Fig. 3 *A, D, E,* and *G*). Such an observation might suggest that ochre was a potential colorant. A scanning electron microscopy chemical analysis (MEB-JEOL JSM 6460LV and Spectrometer EDXS Oxford INCA 300, 10 Pa mode,

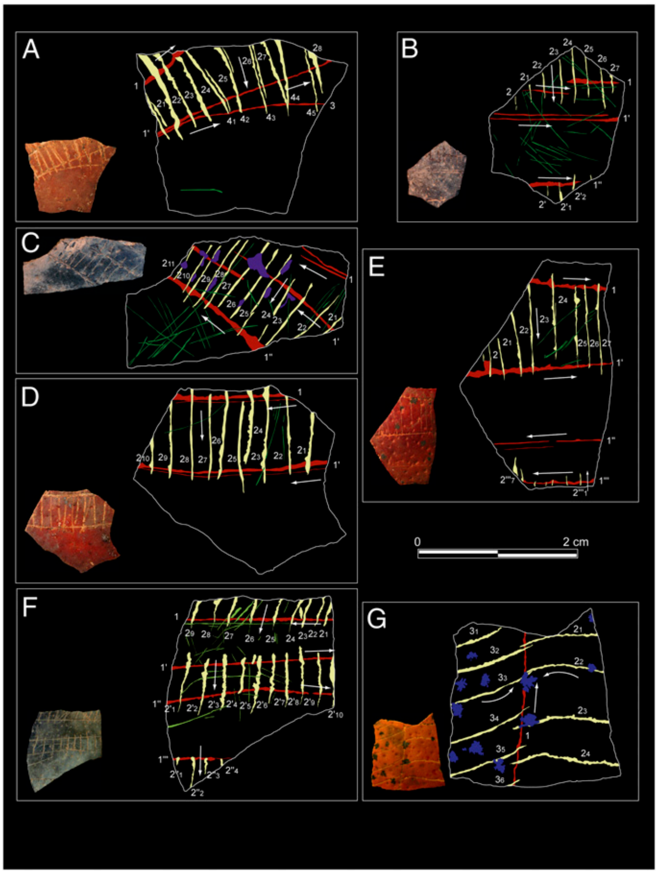

Fig. 3. Engraving sequences of ostrich eggshells at Diepkloof Rock Shelter (Howiesons Poort, Western Cape, South Africa). Numbers indicate the relative chronology of the patterns; arrows show the direction of the incisions. The engraving sequence of the hatched band motif (*A*–*F*) is standardized in that the hatched lines always postdate the band (horizontal lines). Motif G consists of slightly curved lines that cross a central line. The curvature of the sub-perpendicular lines is reversed on either side of the central line.

20 KeV, 10 mm) coupled with a detailed X-ray diffractometry study (D8 ADVANCE Brüker, Cu anticathode) was performed to assess this hypothesis. The absence of iron disproves the hypothesis that the eggs were intentionally colored with ochre. Some refits of ostrich eggshell fragments exhibiting differential coloration further corroborate this conclusion. Preliminary thermal experiments of fresh ostrich eggshell show that the range of ostrich eggshell color (orange, red, black, or gray) is caused exclusively by the accidental effects of fire. Consequently, it is clear that color changes of the ostrich eggshell postdate both engravings and breakage of the eggshell.

Ethnographic Parallels and Archaeological Evidence for Use of Ostrich Eggshells as Containers

Ostrich eggs were collected by recent Kalahari hunter-gathers as a source of protein and also for use of the shells as beads and water containers (35–38). Hunter-gatherers typically puncture a hole in the top of the egg, using one or multiple techniques (drilling, punching, grinding, or hammering) (38, 39). The ostrich eggshell then is used as a flask to store and transport various fluids, usually water. Ostrich eggshell flask engraving occurs in some Later Stone Age and historical contexts (40, 41). Engravings have been ethnographically documented as signifiers of ownership or content (36).

An EOES from Diepkloof exhibits evidence of a punctured opening, with an estimated diameter of 12 mm and with deeply engraved lines diverging from the aperture (Fig. 5*A*). The curvature of the perforated fragment suggests that the position of the hole is on the apical part of the egg rather than on the egg's equatorial zone. Two other fragments, with openings suggestive of a punching technique, show no engraving around the hole (Fig. 5*B*) but come from stratigraphic levels where EOES have been found. It is likely that most of the engraved fragments of ostrich eggshell discovered at Diepkloof represent intentionally marked ostrich eggshell containers. We consider the presence of an intentional perforation as a proxy for the use and curation of the eggshell as a container. Although ostrich eggshell occurs throughout the sequence at Diepkloof, evidence of intentional perforation is documented only in contexts where engravings occur as well.

Conclusion

Engraved abstract patterns are widely accepted as evidence for the presence of symbolic thought (1–11). The number of EOES at Diepkloof is exceptional ($n = 270$) and has no equivalent in the current archaeological record. According to the stratigraphic distribution of the EOES throughout 18 stratigraphic units (*Governor* to *Dennis*), and considering both the diversity of the motifs and the stylistic variability of each piece, it is possible to propose a minimum number of 25 EOES containers.

This unique collection demonstrates not merely the engraving of a single geometric pattern but the development of a graphic tradition (24) and the complex use of symbols to mediate social interactions. The large number of marked pieces shows that there were rules for composing designs but room within the rules to allow for individual and/or group preferences. In effect there were a number, albeit a limited number, of alternative patterns that could be transferred to ostrich eggs, transforming them from ordinary items into specifically and uniquely marked ostrich eggshells.

Engraved pieces from Diepkloof Rock Shelter differ from those currently documented in other contexts on other materials, including ochre and bone (19, 23, 24), and are more equivocal. Engravings on ostrich eggshells, unlike those on other media, have no technical purpose. A few incised pieces of ochre occur in the MSA of Diepkloof, but none seem to demonstrate a clear representational intent. Ostrich eggshells are objects that can be oriented and are uniform in shape and dimensions. The deliberate choice of ostrich eggshell as a medium for decoration is a significant element in the emergence and development of a graphic tradition. Engravings at Diepkloof were standardized and systematized with respect to uniform objects (ostrich eggshells), favoring the development of specific geometric rules.

The Howiesons Poort EOES at Diepkloof Rock Shelter show a signature completely different from those associated with engraved or scratched ochre and bones. EOES from Diepkloof Rock Shelter demonstrate a clear standardization in the engraving and show repetitive patterns, made in accordance with a mental design shared by a group. Such a practice represents the earliest evidence of the existence of a graphic tradition among prehistoric hunter-gatherer populations.

Because their function and socioeconomic context can be determined, these EOES make it possible to assess the context of use of early engraved items. The Howiesons Poort graphic tradition at Diepkloof Rock Shelter is found on functional items: containers that probably were used to store liquids such as water. These objects were used daily, were curated, and were elements of a collective and complex social life. For these reasons, ostrich eggshell provided an ideal surface for informative marking, such as self or group identification.

EOES are documented only in the Howiesons Poort complex but do not occur in all layers from this complex. They are not present in the oldest Howiesons Poort stratigraphic units or in the latest ones. When they do occur, EOES are present without stratigraphic interruption. One other important observation is the existence of a diachronic trend within the engraving tradition seen

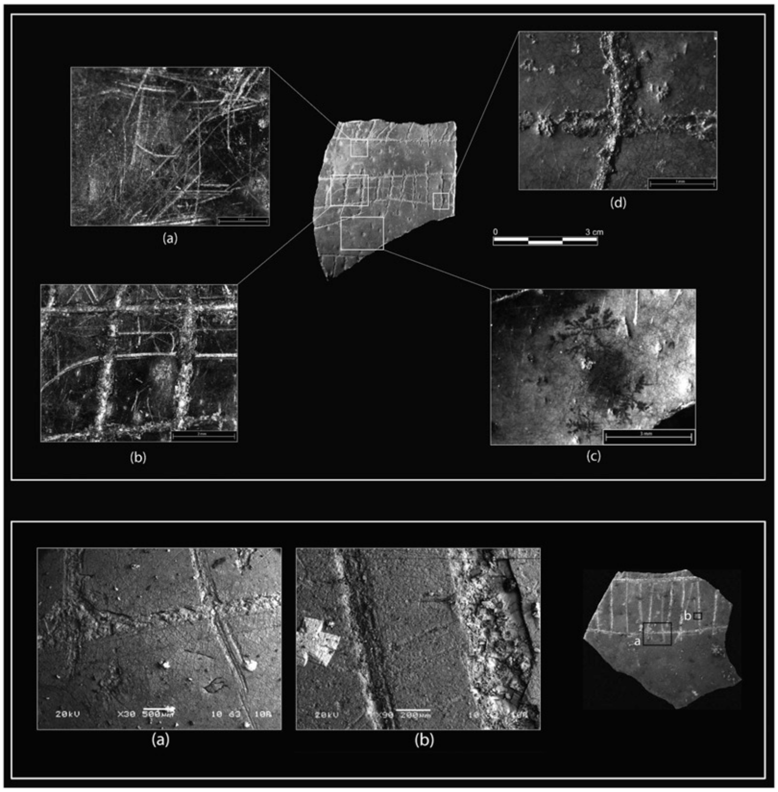

Fig. 4. Macro- and microscopic details on EOES fragments with a hatched band motif from Diepkloof Rock Shelter (Western Cape, South Africa). (*Top*) Macroscopic details on a fragment with three bands (*Middle*) from DRS-layer *Frank*, N7, #2447 (*A*) Detail of scratches. Scratches are superficial marks originating from a friction mechanism. Their origin could predate the acquisition of the egg or could be functional (use or storage) or postdepositional. (*B*) Detail of hatched lines. (*C*) Dendritic manganese spot. (*D*) Vertical hatched line postdates the horizontal line. (*Bottom*) (*A* and *B*) Microscopic details on a fragment with one band from DRS-layer *OB2*, O9, #638. (*A*) Detail of groove intersection within a hatched band motif. The vertical hatched lines postdate the horizontal line. (*B*) Two parallel grooves document different morphologies: a V-shaped morphology on the left and a U-shaped morphology on the right. The photograph on the far right shows the location on the fragment of the details in *A* and *B*.

in the disappearance of the hatched band motif from the latest Howiesons Poort sequence with EOES and the persistence of the subparallel lines motif. This diachronic change, as well as the synchronic variability in patterns between and within each motif, may document groups or individuals manipulating the same geometric rules in different ways. These stylistic attributes and the diachronic changes throughout the sequence of Diepkloof Rock Shelter provide compelling evidence for a cultural tradition of engraving and for symbolic communication.

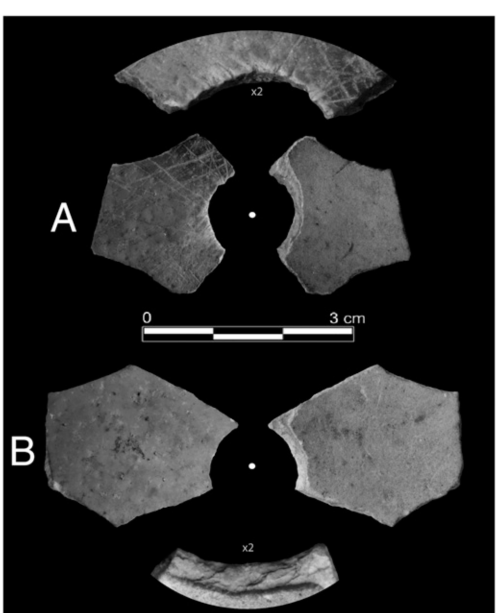

Fig. 5. Diepkloof Rock Shelter (Western Cape, South Africa). Two examples of intentionally perforated ostrich eggshells from the Howiesons Poort. *A* shows diverging grooves starting at the edge of the perforation. The aperture diameter is estimated to be 12 mm. *B* shows percussion marks characteristic of a punching technique. In both cases, the perforation is funnel-shaped with an internal diameter greater than the exterior diameter, suggesting a final percussive blow.

The EOES of Diepkloof Rock Shelter occur in contexts with other innovative elements, including new hunting technologies and strategies for long-distance procurement of raw material. They provide unequivocal evidence for the existence of symbolically mediated social behavior and the development of a behaviorally modern system by 60,000 years ago. Both the emergence and disappearance of this tradition require explanation and reference to socioeconomic theories.

Numerous southern Africa MSA sites contain ostrich eggshell, including many Howiesons Poort sites. To date, however, none present a tradition of ostrich eggshell engraving as documented at Diepkloof Rock Shelter, apart from the occurrence of two EOES fragments with linear engravings from the site of Apollo 11 in Namibia (39). The uniqueness of the Howiesons Poort ostrich eggshell engraving tradition at Diepkloof Rock Shelter distinguishes the site from other Howiesons Poort sites and underlines the existence of distinct regional traditions within the broad and technologically innovative Howiesons Poort complex. It places the Western Cape Province, in general, and Diepkloof, specifically, as one of the preeminent locations in Africa for investigating the behavioral evolution of anatomically modern humans.

Methods

All finds larger than 20 mm are plotted in three dimensions during excavation, the remainder being captured by 5 × 5-mm mesh sieving. Stratigraphic unit, square, and quadrant constitute the basic information assigned to any find. The layers identified during excavations are given proper names in alphabetical order rather than traditional numbers or letters. Stratigraphic correlations derive from a combination of field geological observations, micromorphology, and analyses of lithic find distributions.

EOES are plotted during excavation regardless of their size. Nonplotted ostrich eggshell fragments are sorted in the laboratory where they are examined and described under the naked eye and under magnification (10×

and 40×). Classification includes the size class, taphonomic damage (scratches, spots of manganese, salt crystals, thermal alterations), and color. The taphonomic data are used to assess the impact of postdepositional processes on the spatial and stratigraphic distribution of ostrich eggshell. The gradient of color of the ostrich eggshell (from 0 to 4) was defined according to preliminary results of ostrich eggshell-burning experiments.

EOES were observed and photographed using high-power microscopy to confirm the sequence of incisions and directions diagnosed at 10× to 70× magnification. Despite postdepositional effects, the chronology of the intersected lines and the direction of the groove usually are clearly identifiable, both at a macroscopic and microscopic scale (Fig. 4).

This study also encompasses observations of Later Stone Age collections of ostrich eggshell flasks curated at the University of Cape Town. Perforation and engraving were replicated using silcrete-backed tools to build a preliminary reference collection.

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