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New Blombos Cave evidence supports a multistep evolutionary scenario for the culturalization of the human body

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ABSTRACT

The emergence of technologies to culturally modify the appearance of the human body is a debated issue, with earliest evidence consisting of perforated marine shells dated between 140 and 60 ka at archaeological sites from Africa and western Asia. In this study, we submit unpublished marine and estuarine gastropods from Blombos Cave Middle Stone Age layers to taxonomic, taphonomic, technological, and use-wear analyses. We show that unperforated and naturally perforated eye-catching shells belonging to the species *Semicassis zeylanica*, *Conus tinianus*, and another *Conus* species, possibly *Conus algoensis*, were brought to the cave between 100 and 73 ka. At ca. 70 ka, a previously unrecorded marine gastropod, belonging to the species *Tritia ovulata*, was perforated by pecking and was worn as an ornamental object, isolated or in association with numerous intentionally perforated shells of the species *Nassarius kraussianus*. Fluctuations in sea level and consequent variations in the site-to-shoreline distances and landscape modifications during the Middle Stone Age have affected the availability of marine shells involved in symbolic practices. During the M3 and M2 Lower phases, with a sea level 50 m lower, the site was approximately 3.5 km away from the coast. In the later M2 Upper and M1 phases, with a sea level at −60 m, the distance increased to about 5.7 km. By the end of the M1 phase, when the site was abandoned, Blombos Cave was situated 18–30 km from the shoreline. We use the new Blombos evidence and a review of the latest findings from Africa and Eurasia to propose a testable ten-step evolutionary scenario for the culturalization of the human body with roots in the deep past.

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1. Introduction

1.1. Background

The culturalization of the human body refers to the process by which cultural beliefs, norms, and practices shape and influence the physical body. It involves the ways in which societies and cultures impose specific meanings, values, and behaviors onto the body, thereby transforming it into a symbol and a site of cultural expression. This process encompasses various aspects, such as body modifications, adornments, grooming practices, clothing choices, and bodily rituals, which serve to communicate social identities, affiliations, and cultural meanings (see Joyce, 2005; Nowell and Cooke, 2021 for comparable definitions). The culturalization of the human body highlights the dynamic relationship between culture and the body, illustrating how cultural forces shape and mold individuals' physical appearance, behavior, and perception of self. There is a large body of theory on the cultural construction of bodies in anthropology, but it is only in the last few decades that the body has become one of the central theoretical topics of current sociological, philosophical, and anthropological debate (see Lock, 1993; Joyce, 2005; Borić and Robb, 2014 for seminal ideas and syntheses). Paleolithic archeology, partly because only some of the behaviors involved in the culturalization of the body leave traces in the archaeological record, has only incorporated some of the perspectives opened up by these theoretical reflections. The question of the origins of the phenomenon has played a prominent, albeit not exclusive, role as ochre, and beads have been traditionally seen

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as signaling, in one way or another, the emergence of symbolically mediated cultures and typically human cognition (e.g., McBrearty and Brooks, 2000; d'Errico et al., 2003; Wadley, 2003; Kuhn and Stiner, 2007; Henshilwood and Dubreuil, 2011; Stiner, 2014; Bar-Yosef Mayer et al., 2017; Bar-Yosef Mayer and Bosch, 2019; Steele et al., 2019). Our understanding of the origin and evolution of technologies for culturalizing our body has been remarkably refined over the past three decades. However, key questions, that we attempt to answer here, remain unresolved. Evidence suggesting ancient use of ochre in Africa and Europe indicates that body painting, clothing decoration, and tattooing may date back to more than 300 ka (De Lumley et al., 2016; Roebroeks et al., 2012; Watts et al., 2016; Brooks et al., 2018), possibly 500 ka (Dapschauskas et al., 2022). However, due to its attested or supposed use in utilitarian activities (Wadley et al., 2004; Rifkin, 2011; Soriano et al., 2015), ochre is seen by many authors as an ambiguous element of the archaeological record, which cannot be interpreted by, and in itself, without additional compelling evidence as proof that a culturalization of the body had occurred at times when ochre is first recorded in the archaeological record. The recent synthesis by Dapschauskas et al. (2022) identifies three phases of ochre use in the African Middle Stone Age (MSA), an initial phase from 500 to 330 ka, an 'emergent' phase from 330 to 160 ka, and an 'habitual' phase from 160 to 40 ka. These authors interpret the latter phase, when a third of archaeological sites contain ochre as the material manifestation of intensifying ritual activity in early populations of *Homo sapiens*.

Personal ornaments are generally seen as a more robust proxy for the emergence of the culturalized body and, by extension, a reflection of cultures comparable to those known ethnographically (e.g., Ambrose, 1998; Kuhn et al., 2001; Henshilwood et al., 2004; Vanhaeren and d'Errico, 2006; Bouzouggar et al., 2007; Bar-Yosef Mayer et al., 2009; d'Errico et al., 2009; d'Errico and Backwell, 2016; Conard, 2010). Their production and use entail the choice of distinct raw materials, the elaboration of technologies enabling them to be displayed on the physical body, the modification or coating of them to change their appearance and color, and the production of detectable use-wear traces attesting to their use for ornamental purposes. These suites of choices allow us to better characterize the degree of technological and cognitive complexity involved in the implementation of this practice.

This view, however, is not universally shared, and some authors do not consider personal ornaments as reliable indicator of complex human cognition (Coolidge and Wynn, 2005; Garofoli, 2015).

The discovery, almost two decades ago, of marine shells used as beads at the southern African MSA site of Blombos Cave, in layers dated to ca. 73 ka (Henshilwood et al., 2004; d'Errico et al., 2005; Vanhaeren et al., 2013) was the first to challenge the longstanding view that ornaments were first displayed on the human body in Europe, and not earlier than 40 ka. Additional marine shell beads dated to between ca 142 and 50 ka were identified in subsequent years at many sites from North Africa, South Africa, East Africa, and the Mediterranean Levant (Supplementary Online Material [SOM] Table S1).

In North Africa, the earliest known beads come from Moroccan sites. The oldest are thirty-two perforated *Tritia gibbosula* and a gastropod not figured in the publication, reported as a *Columbella rustica*, recently found at Bizmoune Cave, in 142 ka old Aterian layers (Sehasseh et al., 2021). Twenty perforated *T. gibbosula* and three perforated possible *Nassarius circumcinctus* shells come from the Grotte des Pigeons in layers attributed to the Aterian and dated to ~82.5 ka (Bouzouggar et al., 2007; d'Errico et al., 2009). Excavations at Contrebandiers Cave have identified 151 *T. gibbosula* in Aterian and Mousterian layers spanning from 115 to 95 ka (d'Errico et al., 2009; Jacobs et al., 2011; Dibble et al., 2012). At El Mnasra Cave, 221 *Tritia* sp. and 15 possible *N. circumcinctus* shells, 177 of them perforated, were retrieved from three Aterian layers spanning from ~115 to ~44 ka (El Hajraoui et al., 2012; Jacobs et al., 2012; Janati-Idrissi et al., 2012; Stoetzel et al., 2014; Campmas et al., 2015, 2016; Ben Arous et al., 2022). Single perforated specimens of *T. gibbosula* and *C. rustica* were found at Ifri n'Ammar, in an Aterian layer dated to 83 ka (d'Errico et al., 2009; Richter et al., 2010; Eiwanger et al., 2012). Five perforated *Tritia* sp. were recovered in atypical Aterian layers of El Harhoura 2, dated between 116 and 106 ka (El Hajraoui et al., 2012; Janati-Idrissi et al., 2012; Stoetzel et al., 2014). Three perforated *T. gibbosula*, one *N. circumcinctus*, and one *C. rustica* were collected from Aterian layers of Rhafas, probably dated to between 85 and 76 ka (d'Errico et al., 2009; Doerschner et al., 2016). The single perforated *T. gibbosula* shell found at Oued Djebbana, Bir-el-Ater, the eponymous site of the Aterian, located in Algeria close to the Tunisian border, comes from a layer for which we only have a minimum chronological estimate of <30 ka (Morel, 1974a, 1974b; Vanhaeren et al., 2006).

Several sites from the Levant have yielded shell ornaments. Two perforated *T. gibbosula* beads were recovered at the Skhul Cave, in layers dating to 100 or 135 ka (Vanhaeren et al., 2006). At Qafzeh Cave, layers dating to ca. 100 ka yielded *Glycymeris insubrica* shells with natural perforations (Bar-Yosef Mayer et al., 2009; Bar-Yosef Mayer et al., 2020). Notches on the natural perforations present on the umbos of these specimens, initially interpreted as due to use wear produced by suspension of the shells as ornaments, have been reinterpreted as resulting from natural wear (Cabral and Martins, 2016). Naturally perforated but still undescribed *Glycymeris* sp. shells in Mousterian contexts are also present at Ras el Kelb Cave on the Lebanese coast (Reece, 1998) and in Layer C of Sefunim rock shelter in Israel (Lamdan, 1984).

In southern Africa, Blombos Cave has yielded 68 perforated *Nassarius kraussianus* in Still Bay layers dated at ca. 73 ka (Henshilwood et al., 2004; d'Errico et al., 2005; Vanhaeren et al., 2013). Sibudu rock shelter, Kwa-Zulu Natal, located 18 km from the coast, has yielded twenty-three marine gastropods, nine of which are perforated. A cluster of perforated *Afrolittorina africana* shells, a perforated *Mancinella capensis*, and some unperforated shells of both *A. africana* and *M. capensis* are found in 70.5 ± 2.0 ka Still Bay layers. In a Howiesons Poort layer, 64.7 ± 1.9 ka, there is a single perforated *A. africana* shell interpreted as dislodged by rock fall from the underlying Still Bay layers. Two *N. kraussianus* shells, one of them perforated and bearing traces of utilization as a bead, were found in a late MSA layer dated at 46.6 ka (d'Errico et al., 2008; Vanhaeren et al., 2019). At Border Cave, Kwa-Zulu Natal, a whole perforated *Conus ebraeus* was found in a pit in which the body of an infant was deposited (d'Errico and Backwell, 2016). Stratigraphic correlations indicate the pit was excavated in layer 1RGBS, recently dated to 80–67 ka (Tribolo et al., 2022). A larger perforated shell belonging to the same species and bearing a similar perforation, found on a stratigraphic section, is also tentatively attributed to the same layer (d'Errico and Backwell, 2016). Two perforated *N. kraussianus* shells were found in more recent layers, dated at ca. 43 ka.

In East Africa, the recently published record of Panga Ya Saidi, Kenya (Shipton et al., 2018; d'Errico et al., 2020) identifies the use of naturally perforated and worn *Conus* shell spires as beads, possibly as early as ca. 67 ka, and certainly after 48 ka. At Porc Epic Cave, Dire Dawa, Ethiopia, 419 naturally perforated land snail opercula of the species *Revoilia guillainopsis*, recovered in MSA layers dated at ca. 44 ka, have been interpreted as possible beads (Assefa et al., 2008).

The MSA-to-Later-Stone-Age (LSA) transition in Africa is apparently marked by a decreased interest in marine shell ornaments and the appearance of disk beads, mostly made from ostrich eggshells (OESs). Eastern Africa has yielded the earliest occurrences

of these beads, with specimens directly dated to ca. 52 ka at Mumba Rock shelter in Tanzania (Gliganic et al., 2012), >50 ka at Magubike Rock shelter in southern Tanzania (Miller and Willoughby, 2014), 40.6 ka at Kisese II in central Tanzania (Tryon et al., 2018), 39.9 ka at Enkapune ya Muto in southern Kenya (Ambrose, 1998), and 33 ka at Panga Ya Saidi on the Kenyan coast (d'Errico et al., 2020). Border Cave has yielded amongst the earliest evidence of OES bead use in southern Africa, directly dated to 43–42 ka (d'Errico et al., 2012). It has been recently proposed that commonalities in OES bead dimensions between eastern and southern Africa broke down approximately 33 ka, with populations developing separate OES traditions until herders entered southern Africa after 2 ka (Miller and Wang, 2022).

Specialized studies of the earliest marine shell beads have provided information on how they were acquired, modified, and used. Taphonomic analysis and experimental reproduction of the modifications recorded on the shells have shown that *N. kraussianus* from Blombos Cave were collected alive and perforated through the aperture with the help of pointed tools, probably bone awls found in the same layers. *T. gibbosula* and *Glycymeris* sp., found in North Africa and the Levant, were instead gathered dead on the shores, already bearing natural perforations that were rarely enlarged with stone tools (d'Errico et al., 2009). Ochre residues are almost ubiquitous at North African and South African sites, and their presence on the whole shell surface on some specimens from Taforalt is interpreted as evidence that at least in some instances the shells were coated with ochre while being worn (d'Errico et al., 2009). Experimental data and chemical analyses indicate that *N. kraussianus* shell beads from Blombos Cave were heated in a reductive environment, probably to change their color (d'Errico et al., 2015). *T. gibbosula* that appear to have been blackened by heating also occur at North African sites and on one specimen from Grotte des Pigeons, traces of use-wear develop on cracks produced by heating, suggesting the latter took place before the use of the shell as bead (d'Errico et al., 2009). Use-wear is recorded on most of the earliest shell beads from Africa and the Levant (Steele et al., 2019). Experimental reproduction of use-wear recorded on *N. kraussianus* shell beads from Blombos Cave has suggested that a change in the way beads were strung and the visual appearance of the resulting beadwork occurred at this site between lower and upper Still Bay layers (Vanhaeren et al., 2013). The study also shows that these changes were coincident with environmental shift and the way the space inside the cave was used. A comparable approach was used to infer the attachment mode of shells belonging to the same species but from Holocene layers at Bushman rock shelter (Dayet et al., 2017). A peculiar use wear pattern, not recorded at Blombos Cave, has been identified on the *N. kraussianus* found at Border Cave in 43–42 ka layers (d'Errico et al., 2012). A new study of the Blombos Cave use-wear pattern on *N. kraussianus*, based on data published by Vanhaeren et al. (2013) but using a quantitative approach to compare experimental and archaeological wear, confirms that changes in use-wear patterns correspond to a shift in stringing methods but proposes a different link between wear and the way beads were attached (Hatton et al., 2020). This proposition, however, has not been tested experimentally.

The choice of targeted species, the transport to sites far from the coast, the prolonged use of the objects, their probable deliberate coloring with ochre or through heat treatment of shells in reductive environments (d'Errico et al., 2015), and the similarity of these practices with those observed in traditional societies are among the reasons given to argue in favor of a symbolic dimension of these ancient ornamental objects (e.g., Ambrose, 1998; Bouzouggar et al., 2007; Bar-Yosef Mayer et al., 2009; Kuhn et al., 2001; Henshilwood et al., 2004; Vanhaeren and d'Errico, 2006; d'Errico et al., 2009; d'Errico and Backwell, 2016; Conard, 2010).

The use of marine shells as ornaments between ca. 140 and 60 ka at sites in North Africa, South Africa and the Mediterranean Levant, and the production of OES beads from around 55 ka in different regions of Africa appear now as established facts. This is especially true considering that the oldest known ornaments are apparently the result of practices that were already relatively codified, as demonstrated by the almost exclusive use of a single species over vast territories, a constant mode of acquisition, linked to the collection of either dead or live shells, the almost systematic presence of ochre on the objects, and the practice of controlled heating of certain pieces to change their color. But this framework still leaves essential questions unanswered. How did we move from a world without durable ornaments to one in which ornaments were already fairly standardized? A recent work proposes, based on evidence from Misliya Cave, Mediterranean Levant, that the emergence of the first ornaments would have been preceded by targeted collection and transport to sites of shells that were not perforated (Bar-Yosef Mayer et al., 2020). Previous work has also noted the presence of unmodified eye-catching marine shells at Pinnacle Point, South Africa, in ca.110 ka and more recent layers, of water-worn, unperforated *Glycymeris connollyi* and *Phalium labiatum*, interpreted as deliberately collected for esthetic reasons, possibly foreshadowing the emergence of shell ornaments (Jerardino and Marean, 2010). Naturally perforated *Acanthocardia* and *Glycemeris*, together with other unperforated marine shells, one of which bearing traces of ochre, come from the 115 ka site of Los Aviones, and one unperforated, ochered *Pecten* from ca. 50 ka levels of Cueva Anton, Spain. In addition, at the Grotte des Pigeons, Morocco, a site that has yielded a large collection of naturally perforated shells used as ornaments, found in layers dated to around 80 ka, several specimens are unperforated (d'Errico et al., 2009). This indicates, considering the distance of the site from the sea, that in periods in which shells with natural perforations were used as personal ornaments, non-perforated shells of the same species were also collected and transported over distances of more than 50 km. Unperforated shells are however present in these assemblages in small proportions, which opens up the possibility that they were collected by accident or with the intention of perforating them at a later stage.

The evidence from the Levant, North Africa and South Africa raises the question of the motivations behind a collection of shells not intended for visual display on the physical body. Are these practices those from which the earliest bead traditions stemmed? Another unanswered question is when the production of ornaments incorporated technologies such as deliberate coloring with ochre or controlled heating that allowed a change of their natural appearance. These techniques, which increase the complexity of the information that can be conveyed by the ornaments, seem to have been incorporated into the North and South African shell ornaments traditions since they first appeared.

One way to complexify or vary the information conveyed by objects of adornment, while using the same types of objects, is to change the number on display, attach them to each other in different ways, or vary their location on the body. The limited number of studies conducted so far in this field and the small number of shells on which the wear is well preserved are an obstacle to reconstructing the attachment modes of these ancient ornaments and to understand how they evolved. Another way to complexify information conveyed by ornaments is to incorporate different types of objects in a beadwork. When did the first instances of this cultural practice occur? Did this change occur at the beginning of the Upper Paleolithic of Eurasia as is currently assumed, or are the prolegomena of this change to be found in earlier periods?

In this article, we build on the analysis of an extended collection of marine shells from Blombos Cave to address, and contribute to answer, the questions raised earlier.

We show that eye-catching unperforated marine shells with no nutritional value were brought to the site between 100 and 77 ka, well before Blombos inhabitants engaged in the production of standardized shell beads and that species other than *N. kraussianus* were used as beads at the site, at ca. 73 ka, and possibly already at 100 ka. In addition, the discovery of new *N. kraussianus* shell beads from Still Bay horizons reveal previously unrecorded use wear patterns, possibly reflecting additional unidentified modes of stringing. We propose, based on these and other findings, a multistep evolutionary scenario for the culturalization of the human body with roots in the deep past.

1.2. Archaeological context

Blombos Cave (Fig. 1) is situated approximately 300 km east of Cape Town, west of the village of Still Bay (34°25′S, 21°13′E). Bounded by the Duiwenhoks River to the west and the Goukou River to the east, the site lies within the Blombosfontein Nature Reserve, ca. 100 m from the Indian Ocean rocky shoreline and 34.5 m above the sea level. The cave opening faces south and was formed by wave action cutting into the calcified sediments of the Mio-Pliocene Wankoe Formation (Henshilwood et al., 2001a, 2001b). Initial investigation of the site was undertaken by one of us (C.S.H.) between 1991 and 1992 and is ongoing since 1997. Excavation has, from the beginning, followed the natural stratigraphy of the deposits and is done quadrant by quadrant with stratigraphic units identified by color and texture, defined by their thickness and content, and subsequently labeled as units or subunits. Layer thickness varies between 2 and 30 cm. Identified layers are given alphabetically ordered names (CA, CB, CD, CC) starting from the top. Layers with contextual similarities are attributed a third letter (e.g., CFA, CFB, CFD). All cultural remains are three-dimensionally plotted with a total station, and sediment is dry sieved with meshes of 3 mm and 1.5 mm.

The site records a relatively short LSA occupation, radiocarbon dated to 2000–290 BP, and a long MSA sequence with good organic preservation. The site's cultural succession is already published extensively elsewhere (d'Errico and Henshilwood, 2007; Villa et al., 2009; Mourre et al., 2010; Vanhaeren et al., 2013; Douze et al., 2015; Soriano et al., 2015; Henshilwood et al., 2018; Haaland et al., 2021). A culturally sterile layer of undisturbed sand (DUN) overlies the MSA sequence and separates it from the LSA deposits. The MSA sequence, from which the artefacts described in this paper come, consists of four phases. The upper two, BBC M1 (layers CA–CD) and BBC M2 Upper (layers CDB-CFD), are associated with the Still Bay techno-complex. These phases contain bifacial foliate points, a number of which were heated prior to the final shaping by pressure flaking (Mourre et al., 2010). The Still Bay assemblages from these layers also include bone awls and spear points (Henshilwood et al., 2001a; d'Errico and Henshilwood, 2007), possible engravings of parallel and joining lines on bone (d'Errico et al., 2001), 68 beads made from *N. kraussianus* shells (Henshilwood et al., 2004; d'Errico et al., 2005; Vanhaeren et al., 2013), eight pieces of ochre engraved with geometric patterns, two of which display distinct cross-hatched designs (Henshilwood et al., 2002, 2009), and a criss-cross pattern drawn with an ochre pencil on a small silcrete flake (Henshilwood et al., 2018).

The M2 Lower phase (CGAA-GCAC) is a low-intensity occupational horizon with no Still Bay–type artefacts or engraved ochre (Haaland et al., 2021). The M3 phase (layers CH–CPA) has yielded abundant unmodified and utilized ochre (Henshilwood et al., 2009; Watts, 2009), as well as a minimum of sixteen pieces of ochre engraved with geometric designs (Henshilwood et al., 2009). Two toolkits consisting of abalone shells containing a pigmented compound, found in close spatial association with modified ochre, seal bone, and ochre-processing tools, were recovered from this phase (Henshilwood et al., 2011). All Blombos Cave layers are primarily composed of sand, with lenses rich in shells, organic matter, ash, and recognizable combustion features. The last investigations on the chronology of Blombos Cave deposits (Jacobs et al., 2020) show that the sand at the base of the current excavation, conducted in what is provisionally called the pre-M3 phase, started to accumulate 107.8 + 10.3/−12.1 ka ago. Transition to the first human occupation of the site occurred at 97.7 + 4.9/−7.6 ka, followed by M2 lower at 82.5 + 3.8/−6.2 ka, M2 upper at 76.0 + 3.3/−5.6 ka, and M1 at 73.7 + 2.6/−5.2 ka. The MSA deposits ceased to accumulate at

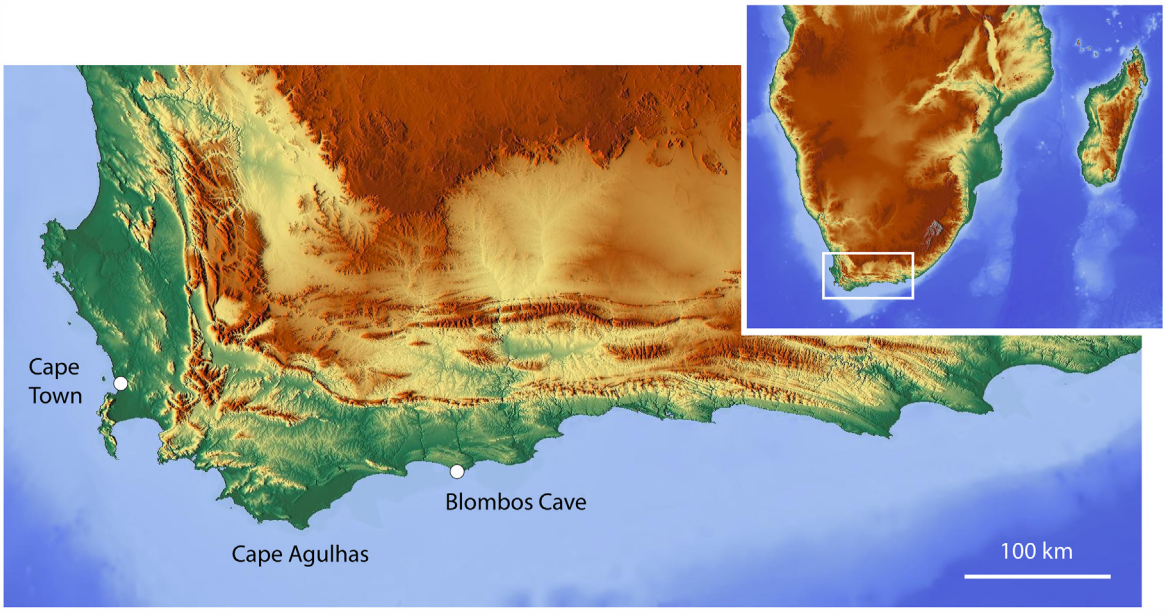


Figure 1. Map of Southern Africa with the location of Blombos Cave (modified from www.maps-for-free.com by Hans Braxmeier). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

71.0 + 3.8/−5.7 ka, after which a dune (DUN) sealed the cave until the late Holocene. This updated chronology indicates that sediment deposition occurred from MIS 5e through to MIS 4, with human occupation restricted to MIS 5d–5a and the very beginning of MIS 4.

The numerous paleoenvironmental studies carried out at Blombos Cave (Henshilwood et al., 2001b; Hillestad Nel, 2007; Thompson and Henshilwood, 2011, 2014; Langejans et al., 2012a, 2012b, 2013; Badenhorst et al., 2014, 2016; Discamps and Henshilwood, 2015; Roberts et al., 2016; Nel and Henshilwood, 2016, 2021; Reynard and Henshilwood, 2017, 2019) have produced an integrated vision of the evolution of the coastal ecosystems to which the MSA populations have adapted. Such a multiproxy approach highlights relatively stable environmental conditions during phase M3, contemporaneous with the end of MIS 5c, MIS 5b, and the beginning of MIS 5a. Gradual changes are recorded toward the end of M3 and through M2, the latter corresponding to the end of MIS 5a. Phase M1, contemporaneous with the beginning of the MIS 4, represents a period of marked change: large ungulates become more dominant in this phase, suggesting a shift to more open grassland (Henshilwood et al., 2001b; Thompson and Henshilwood, 2011; Discamps and Henshilwood, 2015). Shifts in the micromammal communities support the same interpretation (Nel and Henshilwood, 2016).

1.3. Availability of estuarine resources through time

Fluctuations in sea level and consequent variations in the site-to-shoreline distances and landscape modifications during MSA have affected the availability of habitable land and marine resources, including marine shells involved in symbolic practices. Over this period, relative sea-level fluctuated between about −18 m and −76 m below the present day sea level (Waelbroeck et al., 2002), exposing approximately 2.3–32.5 km of the now-submerged Agulhas Bank (Fisher et al., 2010). Sea floor mapping, seismic transects, and geophysical surveys of the coast in front of BBC (Cawthra et al., 2020; Jacobs et al., 2020) have allowed a fairly precise reconstruction of the evolution of the coastline and associated landscapes during the main phases of Blombos Cave occupation (Fig. 2).

With a sea level 50 m lower than the present (Fig. 2a), which is representative of the lowest sea level during the M3 and M2 Lower, dated from 96 to 76 ka, Blombos Cave is, with some fluctuation, 3.5 km away from the coast. The site is separated from the closest shore by ca 2.5 km of Lower Cretaceous bedrock substrate composed of silty mudstone and siltstone and 1 km of calcareous coastal dunes. To the east, the estuary of the Goukou River keeps the same distance from Blombos Cave. To the west, the Duivenhoks River bends to the east, runs almost parallel to the present coastline, and flows into the ocean only 10 km from the site, leaving a large band of floodplain sediment on its east bank. When the sea level was at −60 m (Fig. 2b), the situation occurring during the M2 Upper and M1 phase dated from c 76–71 ka, the coast lay ~5.7 km from Blombos Cave. The only substantial change in the geomorphological setting of the site occurring at this time is the even closer location of the Duivenhoks River estuary and its muddy riverbanks. With a sea level at −72 m (Fig. 2c), which occurred at the very end of the M1 phase, at the time the site was abandoned, Blombos Cave was situated 18–30 km from the shoreline. At this moment, the advance of the Duivenhoks and Goukou rivers into the plain created a funnel of land in front of the site, closed off at its end by a narrow strip of dunes and pebble beaches. The closest access to the coast as the crow flies, situated in a south-westerly direction, was made difficult by the streams of the Breede and Duivenhoks rivers. On the eastern side, access to the seashore was prevented by the estuary of the Goukou River advancing southwards. The distance of the site from the estuaries during the accumulation of M1 phase, the one in which the shell beads were found, as well as the very negligible amount of flesh they contain, their anthropogenic perforation and distinct use wear patterns (d'Errico et al., 2005), are among the arguments demonstrating that the shells were not collected for dietary reasons.

2. Materials and methods

Blombos marine gastropods were identified at genus and, where possible, species level using criteria proposed by Branch and Branch (1981), Kilburn and Rippey (1982), Marais and Seccombe (2010), Herbert et al. (2018). The taxonomic status of each species was checked using the WoRMS Editorial Board (Horton et al., 2023).

Identification of traces of manufacture, use-wear, and heating relied on experimental criteria established by d'Errico et al. (2005, 2015, 2008), Fernandez (2006), Vanhaeren et al. (2013), Gurova et al. (2013), Tátá et al. (2014), d'Errico and Backwell (2016), Langley et al. (2016), Bar-Yosef Mayer et al. (2020) and Gravel-Miguel et al. (2022). Some of these criteria were specifically developed for *N. kraussianus* (d'Errico et al., 2005; d'Errico et al., 2015; Vanhaeren et al., 2013), the more commonly used species to make personal ornaments at Blombos Cave during the MSA. We also paid close attention to recently developed criteria to identify use wear on shell bead based on the examination of ethnographic collections of personal ornaments (Falci et al., 2019) and proposed new methods to detect residues on shell beads (Collins et al., 2020). The use-wear categorization proposed by Hatton et al. (2020), based on Vanhaeren et al. (2013), was also considered when examining use-wear patterns on *N. kraussianus*. Identification of taphonomic damage took into account criteria proposed by Claassen (1998), Stiner (1999), d'Errico et al. (2005, 2015, 2008), and Vanhaeren et al. (2019). When necessary for the analysis, archaeological specimens were cleaned under the microscope with a wet wooden toothpick and a soft brush. The apertural, abapertural and, when relevant, apical view of each shell was photographed with a Canon PowerShot 67X. Small specimens were photographed with a motorized Leica M125 equipped with PLANAPO objective, a DFC295 digital camera, and a Leica Application Suite v. 4.5 software (Leica, Wetzlar), including the Multifocus module. The Multifocus module combines multiple digital images taken at different Z-positions into one single sharp, fully on-focus composite image. Photos taken with the camera and the microscope served as a base to produce drawings of the various aspects of each shell with Adobe Illustrator v. 16.0.0 (Adobe Inc., San Jose). Surface modifications on the shells and perforation edges (perforations made by predators, damage inflicted by bioeroders, marine encrustations, use-wear, tool marks, changes of shade and cracks due to heating, postdepositional damage), and pigment residues were photographed and marked on the drawings. We measured the height and width of the shells and of the perforations and recorded, when pertinent, the perforation type following the typology proposed by Vanhaeren et al. (2013). Measurements were taken with a digital caliper with jaws covered with thin transparent tape to prevent damage to the shells. The stratigraphic and spatial provenance of the shells were also checked to establish whether they could be included in groups of beads found in the same or neighboring quadrants and interpreted in previous work as possibly belonging to the same beadwork (Vanhaeren et al., 2013).

3. Results

3.1. Taxonomic and age class identification

Eighteen new marine gastropods that were used or had the potential to be used for symbolic purposes were recovered in the Pleistocene layers of Blombos Cave (Table 1; Fig. 3). They belong to

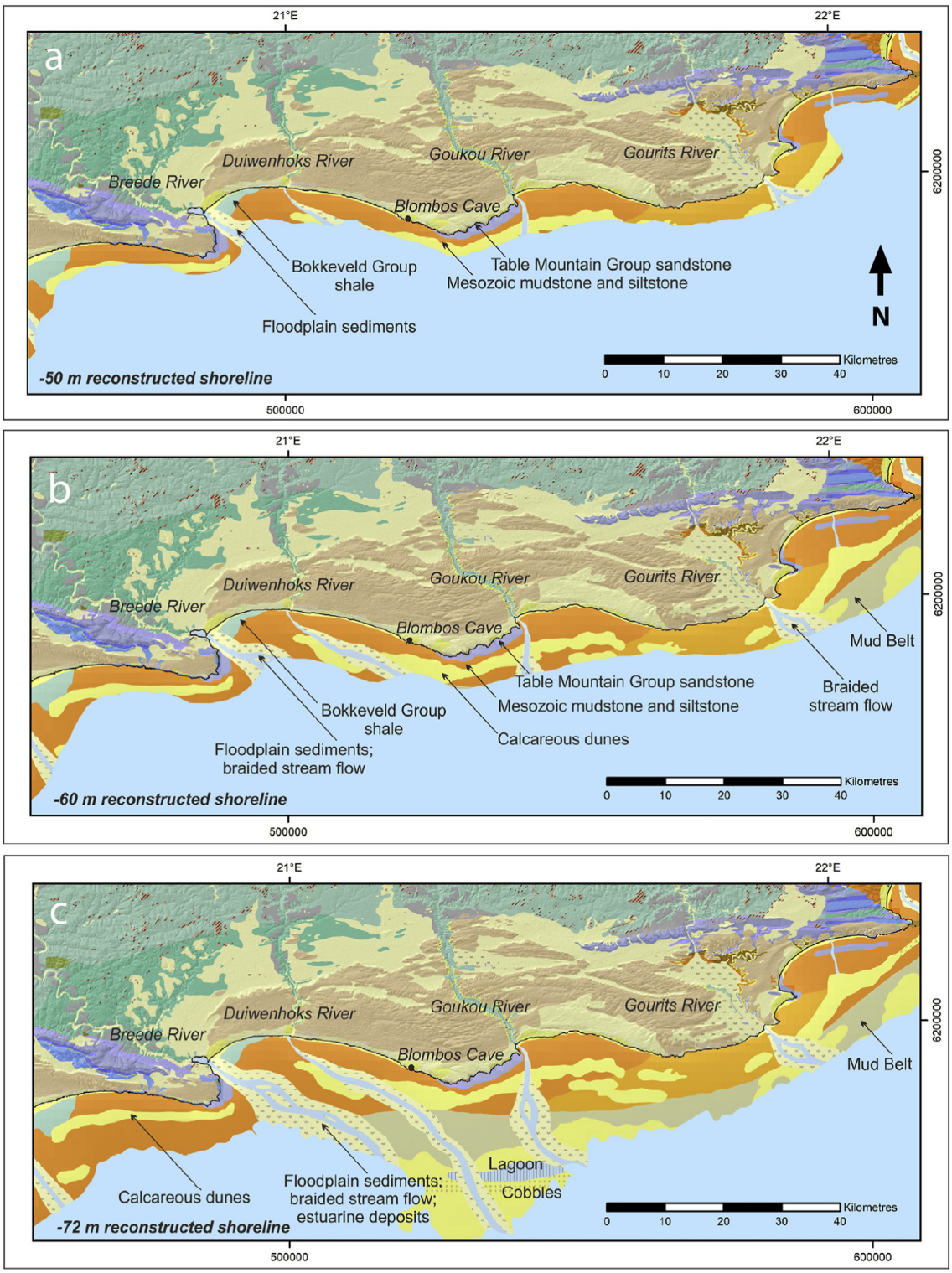


Figure 2. Evolution of the coastline in front of Blombos Cave. (a) −50 m reconstructed shoreline; (b) −60 m reconstructed shoreline; (c) −72 m reconstructed shoreline. Modified after Jacobs et al. (2020). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

four species (*N. kraussianus*, *Triviella ovulata*, *Semicassis zeylanica*, *Conus tinianus*). An additional Conus, which could be tentatively attributed to the species *Conus algoensis*, is too worn for species identification. *N. kraussianus* is a scavenging gastropod adapted to estuarine environments (Branch et al., 1994). It can be found at present all along the southern African and Mozambican coast, from the estuary of the Orange River up to that of the Ruvama River, at the boundary between Mozambique and Tanzania. The size and morphology of the thirteen new complete specimens indicate they are all adults. The incomplete specimen can also be attributed to an adult considering its width and thick parietal shield (d'Errico et al., 2005).

Table 1
Taxonomic, contextual, and descriptive data on the new marine gastropod shells found in the Middle Stone Age layers of Blombos Cave.

Number in Figure 4	Date of excavation	MSA phase	Level	Square quadrant	Species	Height (mm)	Width (mm)	Perf height (mm)	Perf width (mm)	Perf type[a]	Use-wear location[b]	New use-wear	Ochre	Heating
69	14/11/2011	M1	CA	H6d	*Nassarius kraussianus*	9.17	7.14	2.85	2.31	6	P, L, W, N	yes	–	–
70	08/12/2011	M1	CB	F6c	*Nassarius kraussianus*	8.66	7.04	6.74	6.30	8	P, L, W, C	no	–	–
71	04/02/2019	M1	CB	H7d	*Nassarius kraussianus*	10.18	8.40	3.74	5.70	8	P, L, W, N	no	–	–
72	31/03/2010	M1	CB	G6d	*Nassarius kraussianus*	9.24	7.22	3.64	5.47	8	P, L, W, N	no	–	–
73	07/12/2011	M1	CB	F7b	*Triviella ovulata*	15.57	12.20	5.78	5.77	–	P, N, N, N	–	–	–
74	30/11/2011	M1	CC	G7b	*Nassarius kraussianus*	8.41	7.84	4.82	6.66	8	P, L, W, N	no	–	–
75	06/02/2019	M1	CC	G7d	*Nassarius kraussianus*	8.27	7.39	3.38	5.51	8	P, L, W, N	yes	–	–
76[c]	15/11/2011	M1	CC	H6d	*Nassarius kraussianus*	9.48	8.20	3.69	7.48	8	P, L, W, N	no	–	[d]
77	30/11/2011	M1	CC	H7a	*Nassarius kraussianus*	9.50	7.03	5.11	6.75	8	P, na, W, N	no	–	[d]
78	07/12/2011	M1	CC	H7b	*Nassarius kraussianus*	10.37	8.07	5.49	7.08	8	P, L, W, N	no	–	–
79	06/04/2010	M1	CCC	G6d	*Nassarius kraussianus*	4.07	7.87	3.81	8.08	8	P, L, W, N	no	[d]	–
80	06/04/2010	M1	CCC	G6d	*Nassarius kraussianus*	9.52	7.80	4.16	6.94	8	P, L, W, N	no	–	–
81	06/04/2010	M1	CCC	G6d	*Nassarius kraussianus*	9.68	8.13	3.92	7.33	8	P, L, W, N	no	[d]	–
82	06/04/2010	M1	CCC	H6c	*Nassarius kraussianus*	8.00	6.28	3.52	2.90	6	P, L, W, N	no	–	–
83	15/04/2010	M1	CD	F6d	*Nassarius kraussianus*	8.79	5.88	3.24	6.30	8	P, L, W, C	no	–	–
84	17/11/2011	M2	CFA	H6d	*Semicassis zeylanica*	43.00	39.62	24.64	26.22	–	N	–	–	–
85	22/11/2011	M3	CIBh2	F6d	*Conus tinianus*	24.89	12.04	–	–	–	N	–	–	–
86	30/11/2011	M3	CN/CO	F6d	*Conus* sp.	28.52	16.05	1.82	1.69	–	N, L, N, N	–	–	–

Abbreviations: Perf = perforation; MSA = Middle Stone Age; P = perforation edge; L = lip; W = parietal wall; C = columella; no = none; na = not applicable; New use wear = use wear type unrecorded in previous publications.
[a] Perforation types correspond to those defined in d'Errico et al. (2005): Type 6 = unique medium size perforation located near the lip; Type 7 = Type 6 plus small perforations due to post-depositional damage; Type 8 = large perforation extending from the lip towards the right edge; Type 9 = Type 8 plus small perforations due to post-depositional damage.
[b] Location of use-wear on P, L, W, and C respectively.
[c] This specimen belongs to group 7.
[d] Presence of ochre or heating.

Triviella ovulata, commonly called smooth pearl cowries or 'baby's toes', is known around the South African coast from the Cape Peninsula to the Mozambique border in depths of 8–35 m. *Triviella ovulata* has a rounded, white to pink shell. When alive, the shell is covered by a white mantle with black spots. The species lives in colonies of marine invertebrates on which it feeds. Adults have a mean height of 20 mm and only exceptionally reach 40 mm. The size of the single specimen found at Blombos Cave (15.57 mm) indicates a subadult stage of development.

S. zeylanica, also known as helmet shell, is as the other members of this family a large gastropod-shaped as a bonnet, which occurs from the intertidal zone to a depth of 100 m. Its present distribution extends from the Cape of Good Hope to the Mozambique border. Members of this large family prey on sea urchins by making a hole through the combined action of an acid secretion and by rasping the urchin wall with their radula. The smooth form found at Blombos Cave occurs in rocky areas in the intertidal zone. This species can reach a height of ca. 80 mm. The width of the incomplete specimen found at Blombos Cave points to a young adult.

Conus tinianus (see revision of the taxon in Puillandre et al., 2015), or variable conus, is a morphologically elongated member of this vast genus. It occurs at present off the east coast of South Africa, from Cape Agulhas to the Mozambique border. The size of the shell varies between 20 mm and 60 mm. The small size of the specimen identified at Blombos Cave is characteristic of a juvenile to subadult individual.

3.2. Stratigraphic and spatial distribution

The specimens were recovered in M1, M2 Upper, and M3 phases (Table 1). The fourteen *N. kraussianus* and the single *Tr. ovulata* come from the M1 phase and the *S. zeylanica* from the M2 Upper phase. The two Conus, one identified as *Co. tinianus* and the other as *Conus* sp. or, possibly, *Co. algoensis*, come from the M3 phase. The *Tr. ovulata* was found in layer CB, a thin stratigraphic unit situated at the top of phase M1, separated from the LSA layers by layer CA and the thick sterile sand layer called DUN. The attribution of the *Tr. ovulata* to the MSA and particularly to the Still Bay technocomplex is however stratigraphically certain due to the absence of overlying LSA layers in the area of the cave in which this object was found. It is also supported by the fact that shell beads made of this species and, more in general, of Triviidae and Cypraeidae are absent among the personal ornaments recovered in the LSA layers of the site (Vibe, 2007). Apart from 290 OES beads and a few bone rings, the LSA layers have yielded *N. kraussianus* beads, a few perforated *G. connollyi*, *Bullia digitalis*, *Conus* sp., and pendants made from *Turbo sarmaticus*.

The discovery of *N. kraussianus* in virtually all layers composing the M1 phase (CA, CB, CC, CCC, CD) confirms the use and accidental loss of these shell beads by MSA inhabitants throughout the time span covering the accumulation of this phase (Vanhaeren et al., 2013), dated at present between ca. 74 and 71 ka (Jacobs et al., 2020). The reasons why the *N. kraussianus* discovered in the MSA levels of Blombos Cave cannot be interpreted as the result of stratigraphic mixing with the LSA layers overlying the DUN aeolian sand deposit have already been explained elsewhere (d'Errico et al., 2005; Henshilwood, 2005; Vanhaeren et al., 2013; Haaland et al., 2021). They relate to differences in the color and size of the shells, the type of perforation and use-wear, the shells' spatial distribution, and relationship with other remains identified in the M1 phase. The new *N. kraussianus* exhibit the same features observed in the shells of the same species from the M1 phase described in previous studies (see below). Fifty-six of the 68 *N. kraussianus* shells from the Blombos Cave MSA layers were found in seven groups of two to 24 beads, each recovered in different layers and in a single square (1 × 1 m) or in two adjacent

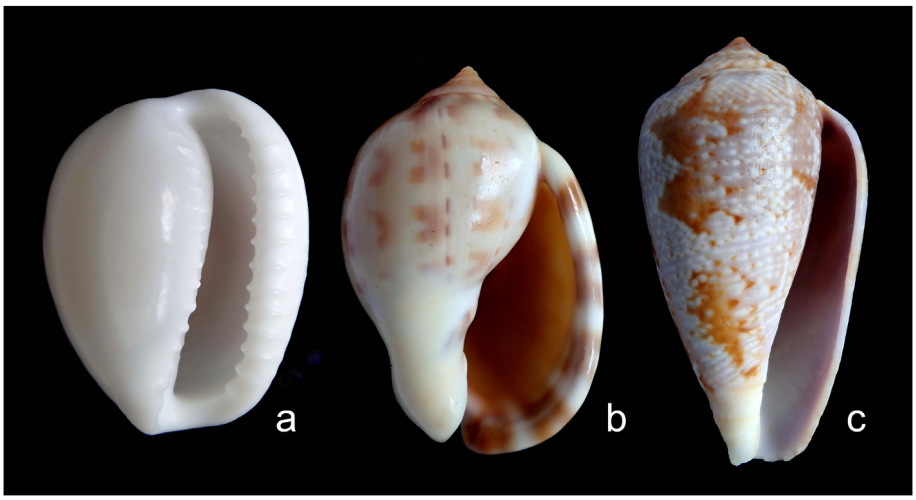


Figure 3. Modern specimens of the novel marine shell species identified in the Middle Stone Age layers of Blombos Cave. (a) *Triviella ovulata* (height = 18.4 mm); (b) *Semicassis zeylanica* (height: 39.3 mm); (c) *Conus tinianus* (height: 35.7 mm). Photos courtesy of Marcus Lussi. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

subsquares (50 × 50 cm) during the same excavation day. The finding that these clusters are associated with changes through time in the arrangement of the living space within the cave and differences in the size of the perforations and the location of use wear traces led the authors to propose that shells from each cluster group may have originally belonged to a single beadwork item, lost, or disposed during a single event. Three *N. kraussianus* from the enlarged collection described here may represent a new group (specimens 79–81; Table 1 and Fig. 4). They all originate from layer CCC, from the same subsquare and were recovered during the same excavation day. The *S. zeylanica* comes from a layer (CFA) situated at the top of the M2 phase, dated at ca. 74 ka. The *Co. tinianus* and *Conus* sp. were recovered from layers CIBh2 and CN/CO, located at the middle and the bottom of the M3 phase. Although these layers were not directly dated by optically stimulated luminescence (OSL), the age of layer CIBh2 can accurately be gauged as lying between

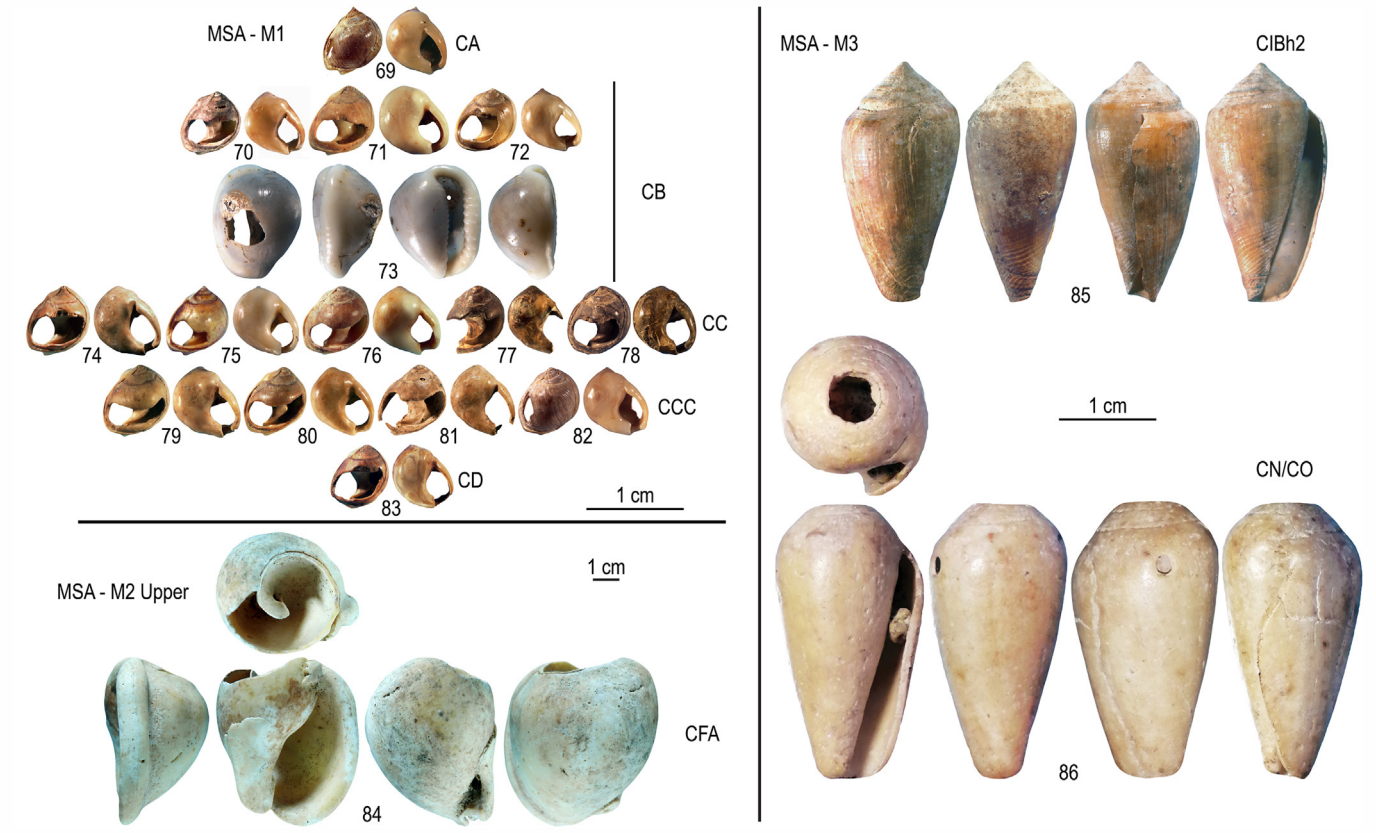


Figure 4. Marine shells from Blombos Cave Middle Stone Age layers with indication of the phase and layer of provenance. Specimens: 69–72, 74–83 = *Nassarius kraussianus*; 73 = *Triviella ovulata*; 84 = *Semicassis zeylanica*; 85 = *Conus tinianus*; 86 = *Conus* sp. Scale bar = 1 cm. See Table 1 for additional contextual and descriptive information. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

the age of the overlying layer CIBh1 (83 ka), and the underlying layer CJ (93.2 ka). Layer CN/CO would be close to ca. 94.9 ka, the age of layer CO.

3.3. Taphonomic, technological, and use-wear analysis

The state of preservation of the new *N. kraussianus* from M1 (Fig. 4) does not differ substantially from that observed on the other *N. kraussianus* recovered from the same phase. All the shells are perforated on the dorsal side. Most of them have a light–dark brown color, typical of the *N. kraussianus* beads from the Blombos Cave MSA layers and different from the bright yellowish-white color of those found in the LSA layers. Two are dark brown, and one has micro-fractures and flaking of the nacre on the ventral side (Fig. 5) indicating prolonged heating in a reductive environment (d'Errico et al., 2015). The unburnt specimens have well-preserved surfaces with only two showing a small, elongated perforation on the spire (specimens 70 and 81; Table 1; Fig. 4). None display predator perforations on their ventral sides, a feature common in estuarine thanatocoenoses of this species, or porous surface textures produced by gradual degradation of the shell in these environments (d'Errico et al., 2005). Dead *N. kraussianus* from estuaries with perforations on the dorsal side tend to be heavily etched and fragile, which is not the case with those found at Blombos Cave. The archaeological specimens also do not display the features recently identified on *N. kraussianus* shells washed up on beaches and modified by wave action, which are heavily rounded over all surfaces and display microimpacts (Vanhaeren et al., 2019). Naturally perforated *N. kraussianus* found on beaches display an advanced stage of rounding obliterating all outer anatomical features. They often also have small gravel pieces stuck in the shell aperture. All these features are absent from the Blombos Cave MSA *N. kraussianus*. The aforementioned evidence confirms, as previously demonstrated, that at Blombos Cave, the *N. kraussianus* were collected alive and were later deliberately perforated (d'Errico et al., 2005).

The *Tr. ovulata* from the M1 phase is well preserved apart from a large perforation on the dorsal side and a spot of decalcification producing a 200-μm elongated hole next to the perforation (Fig. 6a). It was almost certainly collected dead on or close to the shore, considering the depth at which this species lives (8–35 m; Branch and Branch, 1981).

The *S. zeylanica* from the M2 Upper phase is missing the spire (specimen 84; Fig. 4). Its surface has a matt appearance reminiscent of shells washed on the shore. The presence of perforations caused by bioeroders inside the shell confirms it was collected dead.

The *Co. tinianus* from the M3 phase shows differential preservation from the apex to the anterior canal (Fig. 7). The spire is heavily eroded and is covered by micro perforations produced by bio-eroders, while the remainder of the shell surface is well preserved. Although the heavy erosion of the spire may suggest collection of a dead animal, living *Conus* may occasionally have eroded spires. The irregular outline of the lip, due to numerous microflake scars, is likely due to the lip of this species being thin and fragile, thus prone to natural breakage from wave action on the shore or trampling at the cave.

The *Conus* sp (which might be *Co. algoensis*) from the M3 phase is homogenously smoothed by wave action (specimen 86; Fig. 4). The apex is missing, leaving a large circular perforation at the center of the spire cap (Fig. 8a, b). A second, smaller perforation on the body whorl is likely due to drilling by a predator and subsequent erosion (Fig. 8c). A round piece of beach gravel is stuck in the shell aperture (specimen 86; Fig. 4). Overall, these features support the collection of a dead shell.

3.4. Modification

The perforations on the dorsal side of the new *N. kraussianus* shells fall in types 6 and 8 perforation types identified in natural modern and archaeological collections (Figs. 4 and 9), i.e., a small perforation close to the lip and a large elliptical perforation removing a large portion of the dorsal side, respectively (d'Errico et al., 2005). It has been shown that these types are rare in estuarine and shore thanatocoenoses and when present are associated with advanced alteration and decoloration of the shell's dorsal side. In contrast, types 6 and 8 account for almost 90% of the perforations



Figure 5. Dark brown *Nassarius kraussianus* from Blombos Cave M1 phase, layer CC, displaying on its ventral face cracks and flaking of the nacre interpreted as evidence of prolonged heating in a reductive environment. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

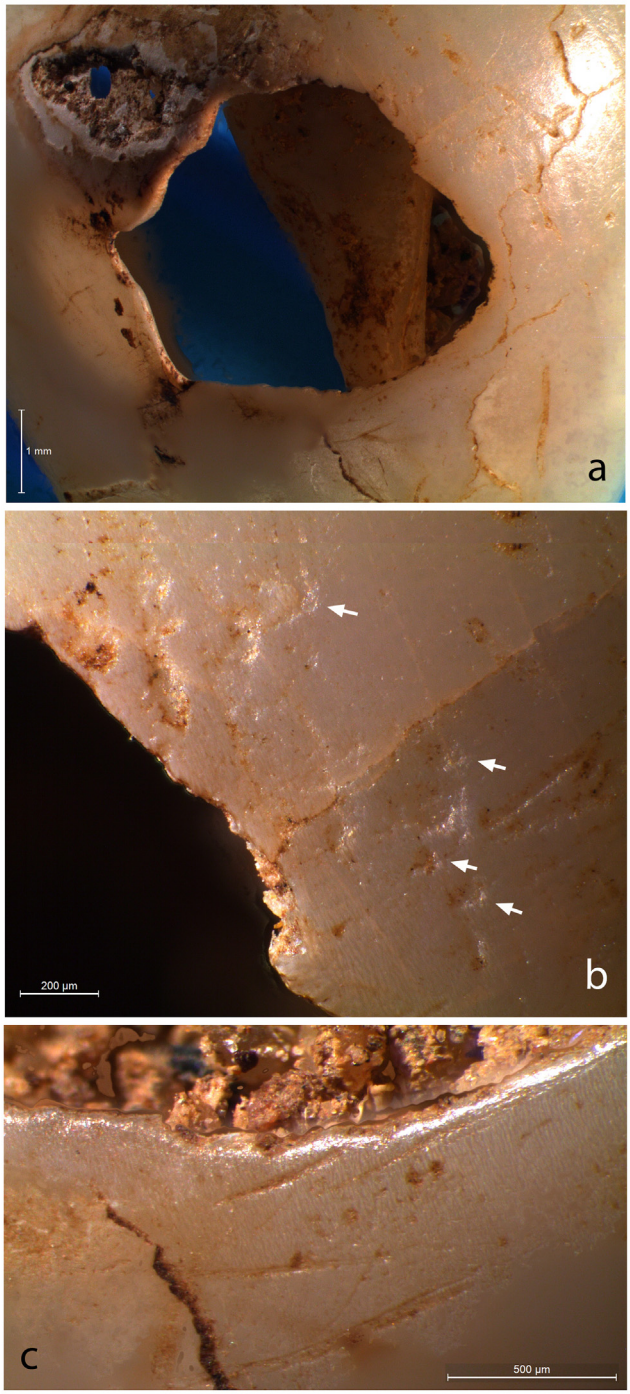


Figure 6. Close-up views of the *Triviella ovalata* from M1 phase, layer CB. (a) perforation displaying smoothed crenulated edge on the right side and sinuous smooth edge with a notch on the left side. Notice a spot of decalcification close to the top left edge of the perforation associated with a small hole; (b) top right edge of the perforation showing numerous pits produced by pecking the shell surface. Arrows indicate pits of same morphology and orientation produced by the same tool; (c) striations close to the bottom of the perforation edge produced by a lithic tool, possibly to regularize the edge after its perforation and enlargement by pecking. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

on the *N. kraussianus* from the Blombos Cave MSA layers (Vanhaeren et al., 2013), which leads to the interpretation of this modification as resulting from human agency, a hypothesis supported by experimental piercing of the shells with a pointed bone tool through the aperture, the otherwise good state of preservation of the archaeological shells and the presence of use wear patterns being absent on shells from natural thanatocoenoses (see below). As in some specimens described in previous studies, ochre residues were detected in two of the new *N. kraussianus* beads analyzed in this study (Table 1).

The *Tr. ovulata* bears on its dorsal aspect a large irregular perforation located in the middle of the body whorl. Diagnostic traces of modification occur around the top right and the lower margin of the perforation. In the first area, they take the form of numerous micro pits produced by repeatedly pecking the shell surface with a pointed lithic tool (Fig. 6b). Several pits show the same morphology and orientation, indicating that the pecking was executed with rapidly repeated gestures using the same tool (Fig. 6b). Pecking was probably the technique used to perforate the shell. The crenulated morphology of the perforation's right edge and the presence of pecking pits relatively far from the edge indicate that this technique was certainly used to enlarge the perforation. The reason for perforating the body whorl by pecking instead of by puncturing it through the aperture, the technique used for perforating the *N. kraussianus*, is certainly related to the aperture narrowness and the robustness of the body whorl of this species, which makes puncturing through the aperture challenging. In the second area, traces of modifications consist of several rectilinear or slightly curved striations parallel to the perforation outline, left by a lithic point (Fig. 6c). These striations probably result from the attempt to regularize to some extent the irregular perforation edge left by pecking.

No apparent traces of anthropogenic modifications were recorded on the *S. zeylanica* and *Co. tinianus* apart from the presence of two microscopic spots of ochre on the spire of the latter, which can be due to accidental contact with ochre pieces or ochre containing sediment in a layer rich in this material (Fig. 7b). The lip of the *Conus* sp. bears an elongated facet that removes the very edge of it, exposing the inner aragonitic layers. This facet may have been produced by longitudinally scraping the lip with a robust lithic edge. Superficial striations left by this action are barely visible on the inner lip surface (Fig. 8d, e).

3.5. Use-wear

Use-wear on the *N. kraussianus* shells from Blombos Cave is recorded around the perforation on the dorsal aspect in the form of smoothing and polish, and on the lip, parietal whorl and the columella in the form of facets (Table 1; Figs. 9 and 10). This use-wear is not always present at all these locations and does not always extend over their entire surface. Most of the wear patterns identified on the new *N. kraussianus* are the same recorded on Blombos Cave MSA shell beads previously and confirm recorded differences between layers such as the noticeable tendency of almost all *N. kraussianus* from lower levels CC, CCC, and CD to bear larger perforations and more invasive facets on the lip and parietal whorl (Fig. 9). However, two specimens (specimens 69 and 75; Figs. 9 and 11; Table 1) from layers CA and CC show previously unrecorded wear patterns from those layers.

The first displays two adjacent facets on the parietal whorl, not found on any of the shells from CA. The second displays an elongated wear facet on the left side of the body whorl, on the shell's ventral side. The perforation edge of the *Tr. ovulata* specimen is heavily smoothed by use-wear, certainly produced by a thread, except for a portion of the top right edge, displaying a fracture that has removed a thin band of the worn edge (Fig. 6a). The bottom right edge displays use wear that is slightly less developed than that present on the left edge, suggesting the latter was the outline portion on which friction from a stringing thread was exerting more intense attrition. The edge of the



Figure 7. a) *Conus tinianus* from the Blombos M3 phase showing differential preservation from the apex to the anterior canal. (b) Close-up view showing erosion and micro perforations produced by bio-eroders as well as a spot of ochre (arrow). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

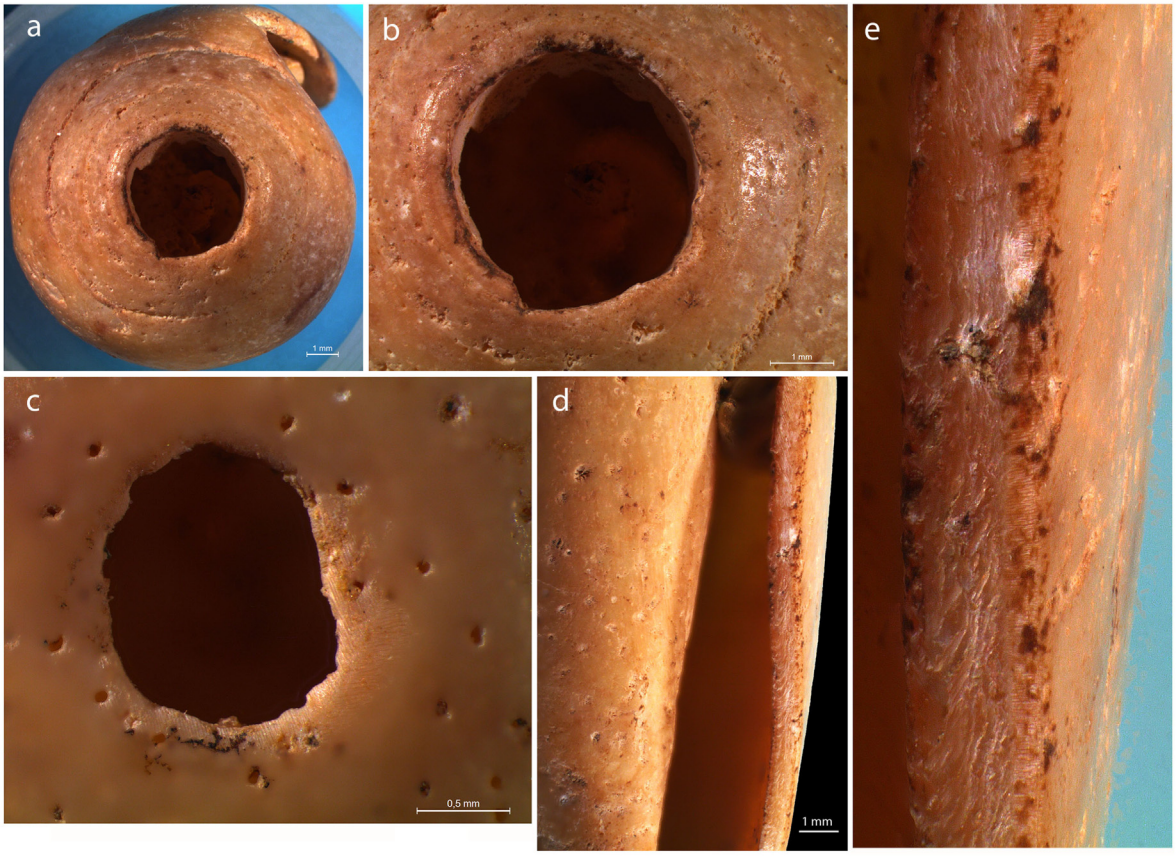


Figure 8. *Conus* sp. from Blombos M3 phase. (a), (b) Natural hole with smoothed edge at the centre of the spire cap produced by erosion of the apex; (c) Small perforation on the body whorl interpreted as due to a predator and subsequent erosion; (d), (e) Facet flattening the lip and exposing inner aragonitic layers, possibly produced by scraping the lip. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

perforation on the apex of the *Conus* sp. is heavily worn and is possibly smoother than the surrounding surface of the spire (Fig. 8b). It is difficult to establish whether this use wear should be attributed to beach abrasion, transport, and curation, wear produced by a thread, post depositional processes or a combination of these causes.

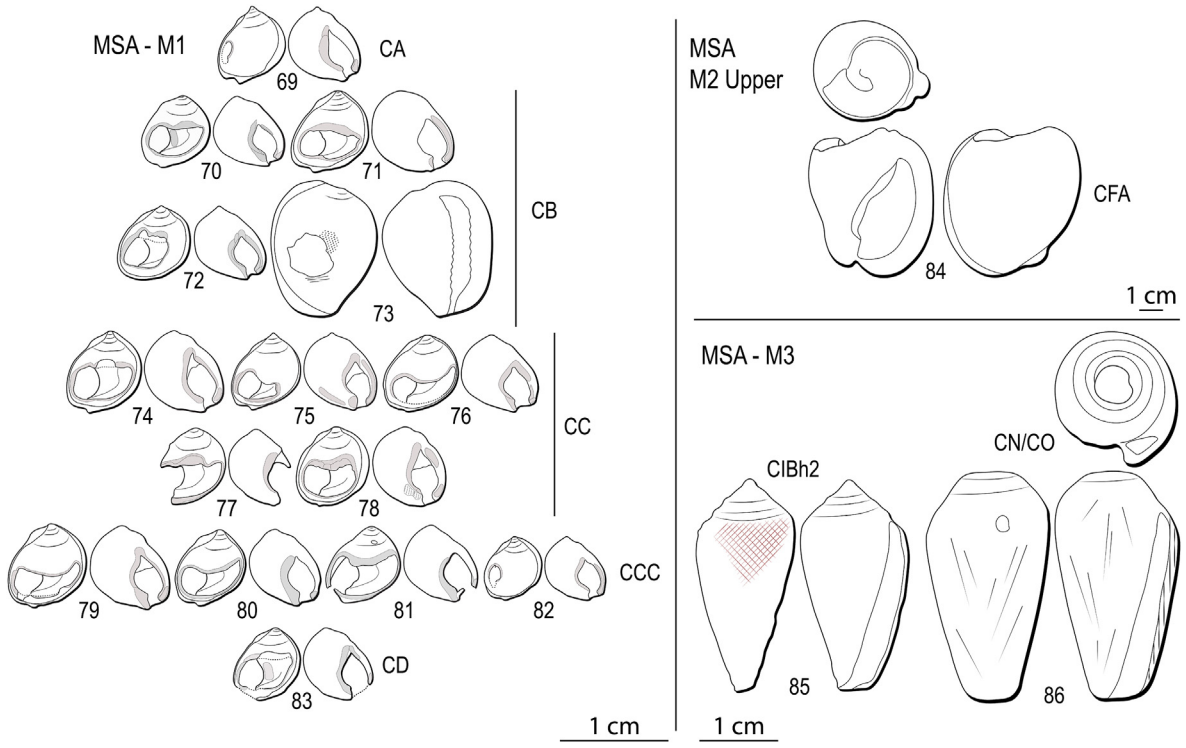


Figure 9. Drawings of marine shells from Blombos Cave Middle Stone Age layers with indication of the phase and layer of provenance. Use-wear areas are highlighted in gray. Dots and subparallel horizontal lines in specimen 73 identify the location of pecking and incising respectively; criss-cross red pattern in specimen 85 identifies red staining and spots of ochre; parallel striations on the outer lip of specimen 86 circumscribes possible scraping marks. See Table 1 for additional contextual and descriptive information.

4. Discussion

4.1. Expanding the Blombos Cave personal ornament record

Although the sample size from which we have derived our inferences is still small, the analysis of the new marine shells discovered at Blombos Cave sheds new light on the origins of practices aimed at the culturalization of the human body. Our study reveals that between 100 and 77 ka, visually striking marine gastropods belonging to the genus *Conus*, one of which bears a natural perforation, were collected on the coast, which at that time was between 2 and 3 km away, and brought to the site. The perforated *Conus* with the potentially modified lip may have been hung and used as an ornamental object. Between 77 and 73 ka when the site was ca. 10 km from the coast, a *Semicassis* shell was brought to the site. The state of preservation of this object makes it difficult to know whether the spire was naturally perforated when the object was collected or was intentionally modified for use as an ornamental object. It was not until approximately 73 ka, when the site was between 20 and 30 km from the sea, and access to the coast was made difficult by several rivers and estuaries, that the inhabitants of Blombos Cave developed ornamental items using numerous specimens, collected live, of one species, *N. kraussianus*, which was available in marshy estuaries between 20 and 40 km from the site. These shells were defleshed, systematically perforated, deliberately or accidently colored with ochre, sometimes heated to change their color, and attached to one another creating designs that changed over time. New wear patterns identified in the framework of this study and work conducted at other sites (Dayet et al., 2017) indicate that further experimentation would contribute to a better understanding of the evolution of these designs.

Contrary to what was previously considered as definitively established, i.e., that the Still Bay inhabitants of Blombos Cave used only one species of estuarine shell to assemble their ornaments, our study shows that toward the end of the Still Bay occupation at least one other, but in this case a marine gastropod, *Tr. ovulata*, was also used as an ornamental object. To collect this dead shell from a beach, the Blombos Cave inhabitants had to walk ca. 40 km, or cross two now-submerged rivers, which would have shortened their trip by about 10 km. In either case, it is a species that was more difficult to acquire than *N. kraussianus*. We cannot gauge whether the object was worn alone, as a pendant, or was integrated into an ornamental device in which it was associated with *N. kraussianus*. In the latter case, it is likely, considering its rarity in relation to the number of *N. kraussianus* found so far in the upper layers of the M1 phase, that this object would have had a prominent and visible position in the adornment.

4.2. A multistep evolutionary scenario

The new data presented here, and the wealth of information accumulated over the last decade on the first practices aimed at the culturalization of the body clearly indicate that, contrary to what was believed until a couple of decades ago, these practices did not suddenly manifest themselves with the complexity that we recognize today in many human cultures. Instead, they seem to have developed in stages whose significance and implications we are only now beginning to grasp.

Two new types of evidence from Blombos Cave contribute to the identification of these stages. The discovery of unmodified and naturally perforated shells from 100 to 73 ka confirm previous scant evidence that marine shells were collected, taken to the site and, in some cases, perhaps worn as personal ornaments before a stage in which shells belonging to selected species were systematically, and intentionally perforated with suitable techniques and associated to create composite beadworks. The new evidence from this site also highlights that at the end of a stage during which a

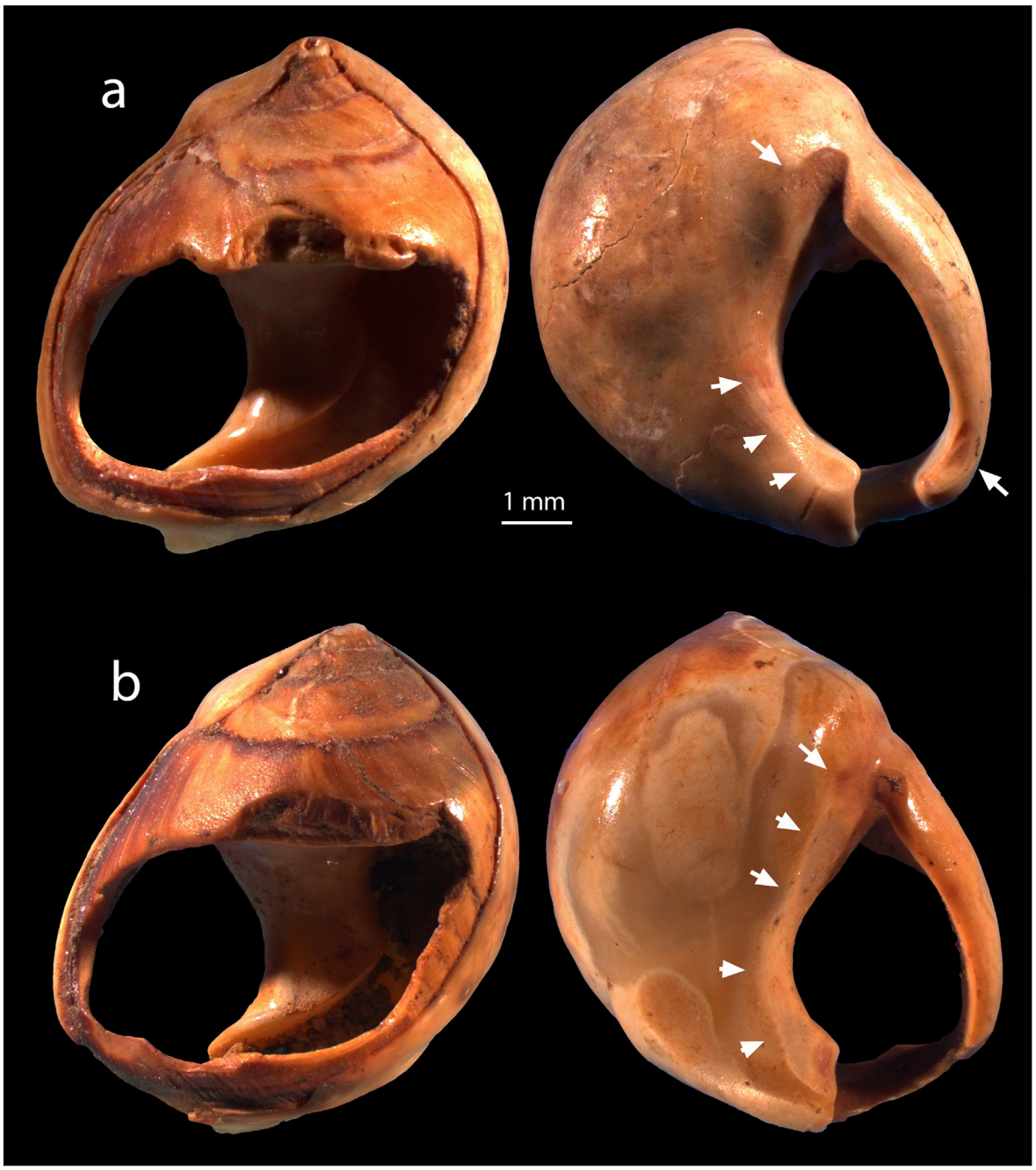


Figure 10. *Nassarius kraussianus* beads from layers CC (a) and CD (b) of Blombos M1 Phase showing enlargement and intense smoothing of the perforation on the dorsal side and invasive use-wear facets on the parietal whorl (arrows). (a) Specimen 74; (b) specimen 83. See also Figures 4 and 9 and Table 1. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

single species is perforated and worn as ornaments, a new species was introduced, arguably leading to the complexification of the beadworks and the symbolic code associated with them. This new information is precious considering the relatively low number of well-dated sites that record variation in shell use between 140 and 50 ka. These practices tell us about the technological evolution of populations in the past but, above all, about the growing role they must have assumed in increasingly complex social interactions (Joyce, 2005; Moro Abadía and Nowell, 2015; Nowell and Cooke, 2021). Any major change in these practices is likely to reflect changes in these interactions, both within and across human groups. Currently, we observe at least ten stages in the evolution of these practices (Fig. 12). These stages should not be seen as a unilinear and inevitable process. Independent invention and cultural transfer have undoubtedly been mechanisms for skipping some of these stages, and in some cases, we can even envisage a reversal of this process. In proposing these stages, we have confined ourselves to considering technologies for the culturalization of the body that leave archaeological traces of themselves. This choice enables us to rely on robust and dated data, but it is probable that these practices were complemented, probably very early on, by a panoply of other practices expressed through gestures, dance, mutilation, scarification, tattooing, and clothing, which have left until recently only circumstantial, ambiguous, or episodic evidence of themselves

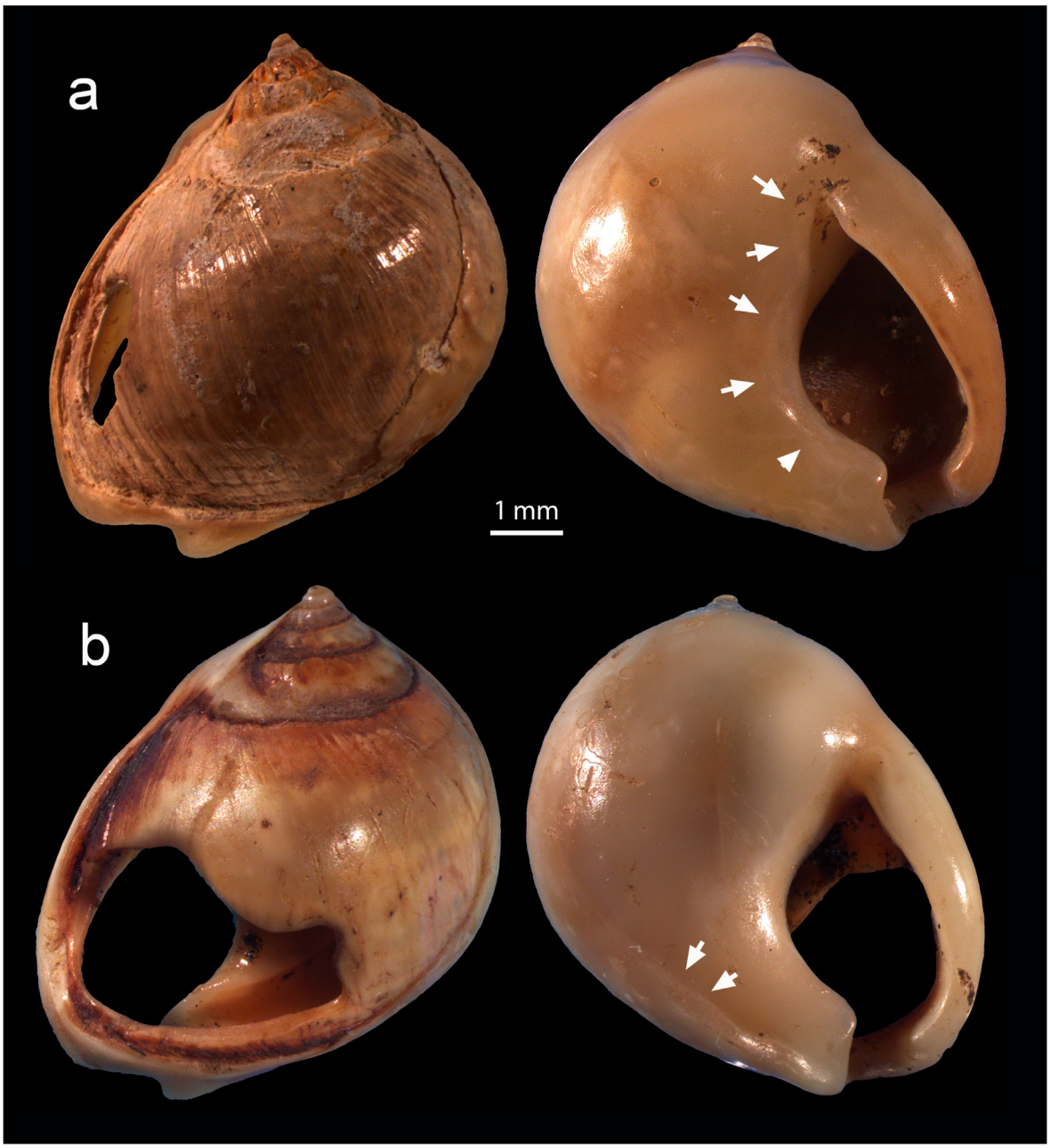


Figure 11. *Nassarius kraussianus* beads from layer CA (a) and CB (b) of Blombos M1 Phase showing (arrows) a wear pattern previously unrecorded in layer CA (a) and in the M1 phase (b). (a) Specimen 69; (b) specimen 75. See also Figures 2 and 7 and Table 1. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

(d'Errico et al., 2018; Garfinkel, 2018; Nowell and Cooke, 2021; Doyon et al., 2023). Also, these ten steps should be seen as an interpretive framework to be tested against future discoveries.

The first stage probably involved the use of mineral pigments for body decoration. The exponential increase in the use of ochre during the MSA of southern Africa indicates that while ochre may have served primarily utilitarian needs during its first uses at the beginning of the MSA, around 500–300 ka, symbolic functions, including its use for body decoration, must have become predominant after 160 ka, as convincingly argued recently by Dapschauskas and colleagues (2022). This first stage is, for the moment, mainly attested in sub-Saharan Africa and to a lesser extent in Europe (Rosso, 2022). The transport and use of high-quality red ochre from distant sources is consistent with this view. Pigment use certainly continued in later periods, and it cannot be ruled out that objects, including adornments, made of perishable materials accompanied these early instances of body culturalization.

A second stage, so far attested in southern Africa, involved the collection and curation of marine shells and perhaps other natural objects without modifying them (Jerardino and Marean, 2010; Bar-Yosef Mayer et al., 2020; Hoffmann et al., 2018; this study). The fact that these are unique specimens and that some of them do not bear natural or anthropic perforations suggests that these objects may have been used initially as amulets or similar devices, not necessarily intended to be worn visibly. This phase may have coincided with or been followed by the use of shells or other objects with

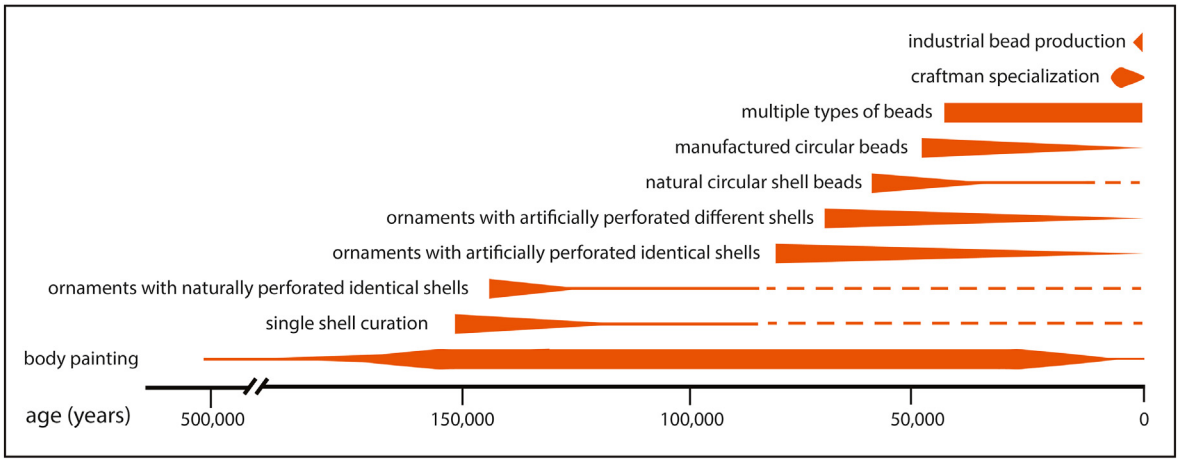


Figure 12. A tentative multistep evolutionary scenario for the culturalization of the human body. The scenario includes evidence from both Africa and Eurasia. Thicker lines indicate continuous and widespread use of the relevant body culturalization technology in large regions. The tapering from thick to thin lines indicates a gradual reduction in the practice. Thinner lines indicate continuous, less intensive use. Dashed lines indicate periods during which we may reasonably assume that the practice was implemented although the record has not been investigated in detail. See text and SOM Table S1 for supporting evidence. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

natural perforations or features allowing them to be attached. This practice was apparently used at sites such as Blombos Cave in southern Africa (this study), Qafzeh in the western Asia (Cabral and Martins, 2016; Bar-Yosef Mayer et al., 2020), or Cueva de los Aviones in Europe (Zilhão et al., 2010; Hoffmann et al., 2018) between 150 and 80 ka. These studies provide evidence that already in this phase, ochre was applied deliberately to the shells or was transferred accidently between ochered skin and the objects.

The third stage consisted of assembling several homologous objects with natural or slightly modified perforations, for example shells belonging to the same species or to species that are morphologically very close, into an ornamental device. According to the latest findings, this practice seems to have been present in north-western Africa since about 140 ka and to have continued in this region until 80 ka (Bouzouggar et al., 2007; d'Errico et al., 2009; Steele et al., 2019; Sehasseh et al., 2021). This practice appears to be associated with a more systematic use of ochre and dedicated heating techniques to modify the color of the shells. The exclusive or almost exclusive use of natural perforations limits the possibilities of varying the arrangement of the shells.

A next step entailed the implementation of perforation techniques that allowed for variations in the arrangement of homologous ornaments and more easily producing different ornamental items with the same shells. This practice is attested at Sibudu rock shelter from 80 ka and at Blombos Cave between 73 and 70 ka (Vanhaeren et al., 2013, 2019).

The fifth step entailed integrating a larger shell of another species into an ornamental item mostly composed of smaller shells or to present the two types of objects separately. This practice is attested at Blombos Cave at the end of Phase M1, dated to around 72 ka (this study), and at approximately the same time at Sibudu (Vanhaeren et al., 2019). A possible explanation for the scarcity of instances of this step in the archaeological record could be linked to the significantly lower occurrence of large shells in these ornamental devices than smaller shells. This discrepancy diminishes the likelihood of their discovery during excavation efforts.

A further step was the use of fragments of shells heavily modified and perforated by natural agents as ornaments. This stage is so far only known from Panga Ya Saidi, Kenya, where naturally perforated Conus spires were used as beads (d'Errico et al., 2020). The naturally perforated opercula from Porc Epic may represent an additional instance of this stage. This practice opened the way to the following, seventh, step in the evolution of body culturalization: the production from around 50 ka, probably first in East Africa, of fully manufactured circular beads made of OESs (d'Errico et al., 2012; Miller and Willoughby, 2014; Tryon et al., 2018). The latest research on these objects shows a regionalization, expressed by a difference in the size of the beads from 33 ka (Miller and Wang, 2022). A much greater diversification marks the next, eighth, evolutionary step from around 45 ka, which took the form, in large regions of Eurasia, of an explosion of ornament types in different raw materials, shapes, modes of production, and, no doubt, different modes of attachment to the body (Vanhaeren and d'Errico, 2006; Fernández and Joris, 2008; Langley et al., 2019; d'Errico et al., 2021; Rybin, 2015; Wolf, 2015). This wealth of ornament types is fully comparable in terms of types richness to the most elaborate ornament traditions known in more recent prehistoric and historical societies (Dubin, 2009; Rigaud et al., 2015; McAdam and Davidson, 2018). The geographic distribution of these highly diversified Paleolithic ornaments suggests their use as ethnic markers (Vanhaeren and d'Errico, 2006; d'Errico and Vanhaeren, 2015; Wolf, 2015). The use of exotic objects, obtained through long-distance trade, and their presence in quantity in some Paleolithic burials and not in others, suggests the use of ornaments, already in these societies, as markers of social inequality (Vanhaeren and d'Errico, 2005).

The use of ornaments, and other practices of body culturalization for this purpose, was exacerbated by the ninth step: the production by specialized craftsmen of ornaments intended for members of other social groups following the advent of production economies and accumulation of wealth (Tite et al., 2002; Dubin, 2009; Nicholson, 2012).

The final tenth step corresponds to the industrial production of ornaments, which allows to a large extent all members of a society to wear any kind of adornament, including beads to which special values were attributed in previous steps either because they were made of rare raw materials or because their production required special skills (Razazadeh, 1997; Dubin, 2009; Tomalin, 2016). This is achieved by the industrial production of beads made of synthetic gemstones, pearls, amber, and the like (Shigley, 2000).

The logic that seems to have governed this step-by-step process from the beginning is that of a gradual increase in the complexity of the technologies used to culturalize the body and in the time and effort invested in the acquisition and transformation of raw

materials. In the most recent phases, this effort led to the use of rare or exotic materials and the rise of artisans with specialized knowledge. This process led, on the one hand, to the development of increasingly complex visual codes together with the diversification of the ornament's functions and, on the other hand, to the transformation of ornaments into valuable goods to be kept, exchanged, or inherited. This required the creation, in each culture, of dedicated cognitive functions and neural circuits allowing the increasing complexity of the messages conveyed by ornaments to be deciphered and novel values to be attributed to these objects and their association on the body (Salagnon et al., 2023). It also required the creation of means to precisely quantify this wealth. This step-by-step process is also reflected by the increasing artificialization of ornament shapes: from unmodified natural items, humans moved to natural objects transformed by perforating, coloring, and arranging them in different ways. This was followed by a shift to entirely artificial geometric shapes and colors in the following periods and to a multiplication and standardization of these shapes and colors, without necessarily abandoning the natural objects used in previous stages. It is likely that the process we have just identified, although limited to personal ornaments and the use of ochre, also informs us about the evolution of other practices for culturalizing the body. We can anticipate that these practices, too, have progressed toward increased complexity in terms of techniques, symbolic codes, and the involvement of specialized individuals to ensure their continuity and, if needed, further elaborate development.

It is also clear that these practices have certainly co-evolved and been influenced in their development by other cultural innovations, not originally designed to be applied to the body. Although it is difficult to identify a single cause behind this process, it is tempting to interpret these evolutionary steps as reflecting both a long-term human niche construction (Kendal et al., 2011; Laland et al., 2016) and a form of self-domestication (Wrangham, 2019), which, by relying on increasingly sophisticated means of communication and strategies of cultural transmission, has led human societies to create environments in which the human body becomes the means of displaying oneself in the society, of constructing oneself as a person, and of reading these multiple identities in others.

5. Conclusion

In summary, our unique ability to culturalize our body has deep roots. The available archaeological evidence and the new data provided by the Blombos Cave material indicate that humans gradually complexified these practices and transformed them into tools for communication, storage of information, and creation of wealth that gradually but radically changed the way we look at ourselves and others, and the nature of our societies. We propose, for the first time, an evolutionary scenario for the culturalization of the human body that, although only relying on technologies that have left traces on the archaeological record, identify trends that probably shed light on the evolution of ephemeral practices. This scenario starts 500 ka and identifies major tipping points at 140 ka, 70 ka, and 45 ka, followed by an acceleration corresponding to the emergence of production economies. Future research should focus on better characterizing the early phases of this evolutionary process, the mechanisms that may have triggered tipping points, and their technological, social and cognitive implications for the societies involved.

Declaration of competing interest

None.

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Appendix A. Supplementary Online Material

Supplementary Online Material to this article can be found online at https://doi.org/10.1016/j.jhevol.2023.103438.

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