

Special Issue: Personal Ornaments in Early Prehistory

A Review of Shells as Personal Ornamentation during the African Middle Stone Age

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ABSTRACT

A number of Middle Stone Age (MSA) assemblages in northern Africa, as well as a few in South Africa and the eastern Mediterranean, preserve small mollusk shells, most notably estuarine and marine members of the sub-family Nassariinae (e.g., *Nassarius kraussianus*, *N. circumcinctus*, and *Tritia gibbosula*). In most of these instances, these small shells have additional holes, which were made by natural processes or humans. These holes have led some researchers to interpret these shells as having been used as beads or ornaments. Studies of traces from wear and ocher residues on these shells have supported this interpretation, but most lack traces of manufacturing. The antiquity of such shells in the archaeological record extends back to the early Late Pleistocene, and as such, these shells may provide the earliest consistent and geographically widespread evidence for human personal ornamentation in the world. Here we review what is known about each of these assemblages and their contexts—their species designations, relative abundances, context, antiquity, taphonomy, association with other aquatic resources, and analytical history. In doing so, we highlight similarities and differences between these assemblages. In particular, we highlight the abundance and antiquity of these shells in northwestern Africa, and we compare them to similar shells from South Africa and Israel. We find that there are discrepancies in how these shells are described from different sites, and that this limits comparisons. We present some suggested criteria to be included in analyses of these shells, with the goal of improving comparative studies between assemblages. Personal ornaments are frequently identified in assemblages attributed to modern human arrival in western Asia and Europe. As such, the study of the antiquity and distribution of early personal ornament use in the African MSA has implications for our understanding of the expansion of modern humans out of Africa.

This special issue is guest-edited by Daniella E. Bar-Yosef Mayer (Steinhardt Museum of Natural History and Institute of Archaeology, Tel Aviv University) and Marjolein D. Bosch (McDonald Institute for Archaeological Research, University of Cambridge). This is article #2 of 12.

INTRODUCTION

When discussing the evolution of “modern” human behavior, conversation generally comes back to symbolic signaling. One of the most widely agreed upon markers of symbolism that can preserve in the archaeological record is personal ornamentation. Therefore, much attention has been paid to tracking the earliest, best supported evidence for personal ornaments, generally beads. Beads have commonly been made from bone, teeth, ivory, stone, metal, glass, eggshell, and mollusks. In the African record,

directly relevant to the evolution and expansion of the earliest modern humans, two classes of artifacts have received the most attention—mollusk shell beads and ostrich eggshell beads. This review focuses on the former.

Hominin fossils and genetics indicate that the primary lineage of modern humans evolved in Africa during the Middle and Late Pleistocene (781 to 126 ka and 126 to 11.7 ka [ka=thousands of years ago])¹. In Africa, this puts the archaeological record of the Middle Stone Age (MSA; ~315 to at least ~45 ka) at the center of the discussion about

evolving modern human behavior, and whether symbolic signaling evolved during the MSA or appeared along with the subsequent Later Stone Age (LSA). Therefore, it is critical to track the appearance of complex behaviors, such as personal ornamentation. To most reliably do so, we must individually assess the quality of the available data.

With this goal, here we compile and review what is known about each of the available African MSA “perforated” small mollusk assemblages and their contexts—their species designations, relative abundances, context, antiquity, taphonomy, surface modifications, analytical history, and finally the relationship or association with other marine remains found in the same context where these shells are documented. We also consider other similar assemblages of similar antiquity also associated with early modern humans (namely Middle Paleolithic assemblages from Israel). We address many questions about these assemblages and highlight the abundance and antiquity of these finds in northern Africa, particularly northwestern Africa, compared to the better-documented and discussed South African record. Our review also highlights the inconsistencies in the current research and record and suggests ways of moving forward.

THE CURRENT SAMPLES AND ANALYSES

Some marine shells with holes from ancient contexts have long been recognized from Middle Paleolithic (contemporaneous with the MSA) assemblages that are associated with hominin skeletons that are approaching modern human morphology in the Levant (Israel) (Bar-Yosef Mayer 2005; Garrod and Bate 1937; Taborin 2003). However, the announcement of 41 perforated tick shells from Blombos Cave, South Africa, amplified the attention paid to these types of remains (Henshilwood et al. 2004), and the Blombos assemblage remains the best-studied and published sample of what are argued to be early personal ornaments. However, a total of 13 samples from Middle Stone Age contexts, which include multiple species, have now been recovered (Table 1; Figure 1). Most of these derive from northern Africa, but two samples from the eastern Mediterranean and associated with early modern humans also have been documented (Figure 2). These samples and their contexts have been analyzed and presented in varying detail, which we summarize and discuss (Table 2).

Throughout the text, we use “hole” and “perforation” interchangeably; these are secondary openings in the shells produced by natural or human causes. We prefer “hole” because it does not suggest an agent, while “perforation” might because of its association with the verb “to perforate.” However, many of the cited manuscripts use “perforation” so we retain this usage. Holes may result from humans intentionally perforating a shell with a tool, in which case manufacturing traces should be present, or from natural causes, such as decalcification and/or abrasion by marine water, waves, sand suspended in water, and beach sand. Predators may make holes, such as with the pincer of a crab or the beak of a bird. “Bioerosion pits,” which may penetrate the shell as distinctive small and very

symmetrical holes, are often drilled by predators, such as Porifera (Sponges), Anelida (*Polydora* sp.) or Gastropoda (Naticidae and Muricidae families) (Claassen 1998: Figure 11). “Bioerosion pits” also form after a mollusk dies, when small organisms continue to bore into shells to obtain calcium; this activity is visible as on the surface of dead shells (Claassen 1998: Figure 11 and our Figure 4B below). We use “aperture” to strictly indicate the natural opening of the shell through which the living gastropod emerges. For the parts of the mollusks, we follow the terminology used in Claassen (1998), provide definitions when needed, and also include the terminology employed by the original authors.

BLOMBOS CAVE, SOUTH AFRICA

Blombos Cave is currently situated about 100m from the Indian Ocean along the southern coast of South Africa. Excavations began at the site in 1991 (Henshilwood 2008) and have continued periodically since then. Three MSA accumulation phases (with numerous stratigraphic layers within each) have been identified, starting with M3 (BBC 3), then M2 (BBC 2), which contains bifacial points signaling the Still Bay industry, followed by M1 (BBC1), in which bifacial points are abundant and clearly indicate a Still Bay industry; sterile beach sands cap most of this sequence, which terminates with a late Holocene LSA (Henshilwood et al. 2001). During the 1992–2000 seasons, 41 *Nassarius kraussianus* tick shells were recovered (d’Errico et al. 2005), primarily from the MSA M1 layers, which accumulated approximately 74.9±4.3 to 72.5±4.6 ka (Jacobs et al. 2013) (Figure 3). Thirty-nine of the shells come from throughout the six M1 layers, and the remaining two derive from the upper-most M2 layer, allowing for possibility that they derive from the upper material (d’Errico et al. 2005; Henshilwood et al. 2004). More than 1,000 *N. kraussianus* were recovered from within the overlying late Holocene LSA deposits (d’Errico et al. 2005). These tick shells were found in association with faunal assemblages that strongly show consistent reliance on resources from the nearby coast. Alikreukel or turban shells (*Turbo sarmaticus*), brown mussels (*Perna perna*), and limpets (Patellidae) were frequently harvested from the intertidal zone of rocky shores, along with smaller numbers of a diversity of marine mollusks (Henshilwood et al. 2001; Langejans et al. 2012). Cape fur seal bones are quite common among the mammals, and some fish bones have been identified (Dusseldorp and Langejans 2013; Henshilwood et al. 2001; Thompson and Henshilwood 2011). Based on reconstructions of fluctuating sea levels, during the deposition of M1, the coast was somewhere between 2.3–43.78km or 7.65–49.42km from Blombos; the reconstruction of the distance from the coast depends on the specific antiquity of the deposits (Dusseldorp and Langejans 2013). The high abundance of marine remains indicate that the Blombos occupants had regular access to the marine coast. Therefore, the distance to the coast was likely on the shorter end of the reconstructions, because foragers generally do not transport large amounts of marine resources over long distances (Bigalke 1973; Erlandson 2001; Higgs and Vita-Finzi 1972). However, *N. kraussianus* lives in estuaries, and there-

TABLE 1. BACKGROUND INFORMATION ON THE SITES AND STRATIGRAPHIC LAYERS THAT PRESERVE MOLLUSK ASSEMBLAGES THAT HAVE BEEN INVESTIGATED FOR THEIR POTENTIAL USE AS EARLY ORNAMENTS.

Site	Country	Coast	Distance from Modern Coast	Archaeological Layer: Antiquity	Archaeological Layer: Associated Industry	References
Blombos	South Africa	Indian Ocean	adjacent; however, <i>Nassarius kraussianus</i> is an estuarine species, and today the closest estuaries are 20km away	M1 and M2 upper: ca. 78–72 ka	M1: Still Bay M2 upper: Still Bay	d'Errico et al. (2005); d'Errico et al. (2015); Henshilwood et al. (2004); Vanhaeren et al. (2013)
Sibudu	South Africa	Indian Ocean	15km	RGS: 70.5±2.4 ka, 69.5±3.0 ka	RGS: Still Bay RGS 2: Still Bay	d'Errico et al. (2008); Jacobs and Roberts (2017); Jacobs et al. (2008a); Plug (2006)
Border Cave	South Africa	Indian Ocean	82km	1 RGS: 74±4 ka	1 RGS: Howiesons Poort	d'Errico and Backwell (2016); Grün et al. (2003)
Bizmoune	Morocco	Atlantic Ocean	12km	Marine Isotope Stage (MIS) 5	Aterian	Bouzouggar and Barton (2012); Bouzouggar et al. (2017); Kuhn et al. (2015)
Contrebandiers (La Grotte des Contrebandiers; Smugglers' Cave)	Morocco	Atlantic Ocean	adjacent	IV-2: 96±4 ka CEA-4: 107±4 ka V-1a&1b: 113±7 ka CEA-5c&d: 115±3 ka	IV-2: Aterian CEA-4: Aterian V-1a&b: Aterian CEA-5c&d: Maghrebian Mousterian	Aldéias et al. (2014); d'Errico et al. (2009); Dibble et al. (2012); Jacobs et al. (2011)
El Mnasra	Morocco	Atlantic Ocean	adjacent	5: 107.5±6.6–106.5±6.5 ka 6: 111.6±7.3–107.4±5.8 ka 7: 108.8±6.6 ka	5: Aterian 6: Aterian 7: Aterian	Campmas et al. (2015); Part 3 of El Hajraoui et al. (2012a); Jacobs et al. (2012); Stoetzel et al. (2014)
El Harhoura 2	Morocco	Atlantic Ocean	adjacent	116±7–100±6 ka 6: 116±6.6 ka 8: 106.7±6.6 ka	6: Aterian (but without tanged pieces) 8: Aterian (but without tanged pieces)	Campmas et al. (2015); Part 2 of El Hajraoui et al. (2012a); Jacobs et al. (2012); Stoetzel et al. (2014)
Dar es-Soltan I	Morocco	Atlantic Ocean	adjacent	C² equivalent: 61.2±4.0–52.7±3.1 ka	C²: Aterian	Barton et al. (2009); Ruhlmann (1951)

TABLE 1. BACKGROUND INFORMATION ON THE SITES AND STRATIGRAPHIC LAYERS THAT PRESERVE MOLLUSK ASSEMBLAGES THAT HAVE BEEN INVESTIGATED FOR THEIR POTENTIAL USE AS EARLY ORNAMENTS (continued).

Site	Country	Coast	Distance from Modern Coast	Archaeological Layer: Antiquity	Archaeological Layer: Associated Industry	References
Ifri n' Ammar	Morocco	Western Mediterranean Sea	59km	Upper OS (MP-A): 83.3±5.6 ka	Upper OS (MP-A): Aterian	d'Errico et al. (2009); Eiwanger et al. (2012); Richter et al. (2010)
Taforalt (Grotte des Pigeons)	Morocco	Western Mediterranean Sea	40km	Group E: ca. 82.5 ka (91.5-73.4 ka)	Group E: Aterian	Bouzouggar et al. (2007); d'Errico et al. (2009)
Rhafas	Morocco	Western Mediterranean Sea	50km	3a: 85.4±4.5/98.5±19.8 ka 76±8-60±5 ka	3a: Aterian	d'Errico et al. (2009); Doerschner et al. (2016); Mercier et al. (2007)
Oued Djebbana	Algeria	Mediterranean Sea	200km	>35 ka	Aterian	Morel (1974b, 1974a); Vanhaeren et al. (2006)
Porc-Epic	Ethiopia	Gulf of Aden	250km	160-170 cm: 33.700±0.3 ka 180-190 cm: 35.6±0.35 ka 270-280 cm: >43.2 ka Obsidian hydration: 61,202±958, 61,640±1,083, 77,565±1,575	Middle Stone Age	Assefa et al. (2008); Clark and Williamson (1984); Michels and Marean (1984)
Skhul	Israel	Eastern Mediterranean Sea	3.5km	Layer B (burials/B2): 135-100 ka 119±18 ka	Layer B: Levantine Mousterian	Bar-Yosef Mayer (2005); Garrod and Bate (1937); Grün et al. (2005); Mercier et al. (1993); Vanhaeren et al. (2006)
Qafzeh	Israel	Eastern Mediterranean Sea	40km	XXIII-XXVII: 92±5ka (109±9.9 to 82.4±7.7 ka) XXI: 143.0-89.1 (LU) or 118.0-73.7 (EU) ka	XXIV-XVII: Middle Paleolithic - radial/centripetal Levallois	Bar-Yosef Mayer (2005); Bar-Yosef Mayer et al. (2009); Schwarcz et al. (1988); Taborin (2003); Valladas et al. (1988); Walter (2003)

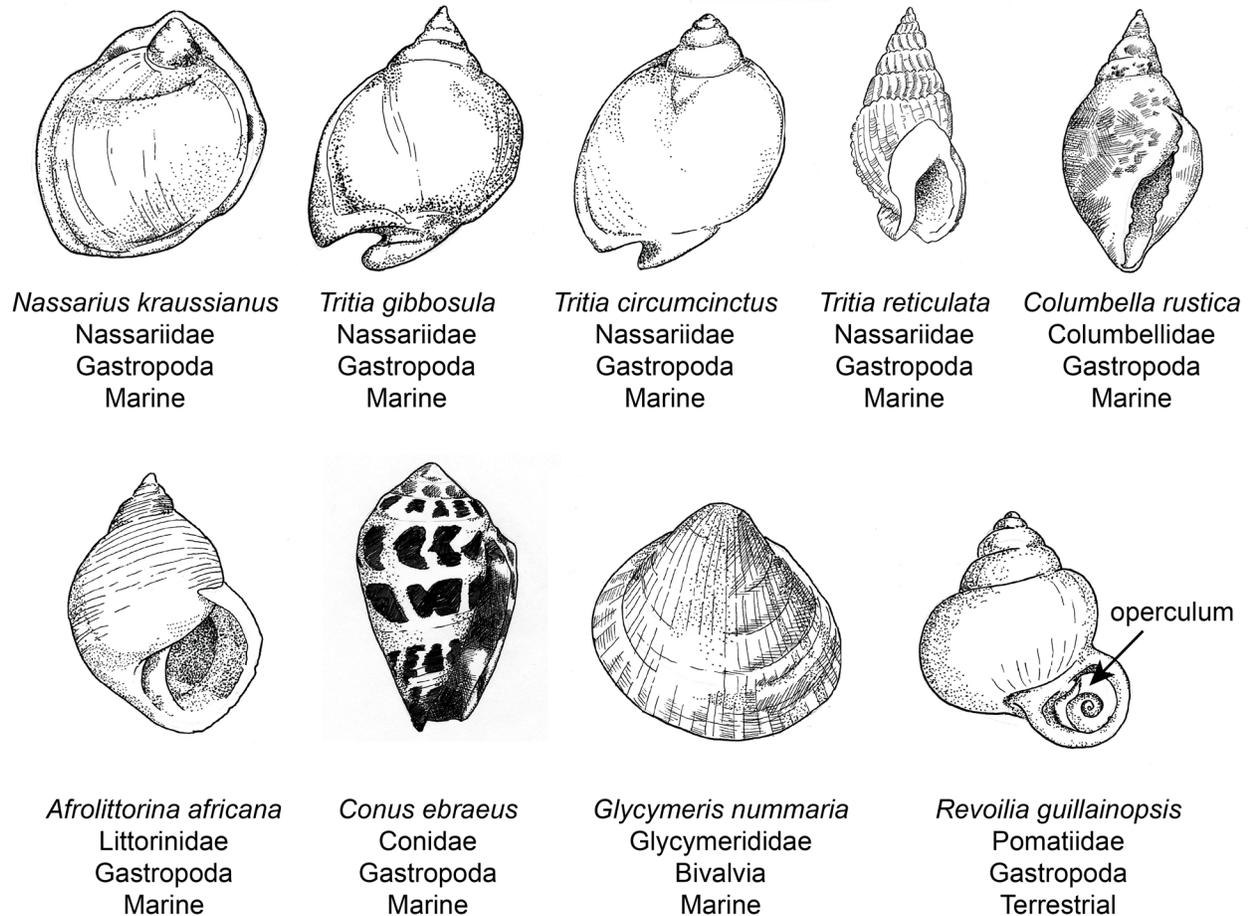


Figure 1. Illustrations of the mollusks discussed in the text and in Table 2 (drawings are by Anna Goldfield).

fore their local distribution would have been different from the rocky coast taxa and their habitats may have extended further inland. Today, the closest estuaries to Blombos are 20km west and east of the cave, and reconstructions based on topography indicate that they were unlikely to have been closer when Blombos was occupied (d’Errico et al, 2005).

d’Errico et al. (2005) present a detailed analysis of these 41 tick shells, and this analysis provided an initial standard for all subsequent analyses of similar assemblages. In their analysis, d’Errico et al. (2005) compare the MSA *N. kraussianus* shells with the large LSA assemblage, with three modern death assemblages (thanatocenoses), and with one modern assemblage gathered from a living population (biocenosis). They investigate the assemblages using morphometric, taphonomic, and microscopic analyses. In particular, they examined shell length, age class, hole (“perforation”) type and location, presence of holes drilled by carnivorous predator mollusks (identifiable by their small size and symmetry as in Figure 11 of Claassen [1998]), and state of preservation of the lip (d’Errico et al. 2005: 10–11). Their arguments for why the shells represent beads or ornaments can be summarized as follows:

- humans were most likely responsible for selecting,

- transporting, and accumulating the shells, because the tick shells could not have originated from the cave bedrock;
- the shells are not rounded as would be expected if they were transported by wave action, and the cave mouth is 34.5m above sea level;
- the mollusks are too small to have been useful as a food resource;
- age class data indicates that only the largest adult shells were brought into the site, indicating human preference, not accidental transport, which might have been possible if estuarine grass was brought into the site for bedding;
- perforation types observed on MSA specimens (Type 6=63.4%) are absent in living samples and rare (1.9%, 1.6, and 4%) in death assemblages (d’Errico et al. 2005: Table 2);
- while decalcification of specimens in the death assemblages produced natural perforations starting in the thinnest, weakest region of the shell, the MSA perforations are most commonly where the shell is thick and well-protected from abrasion;
- the surfaces of most of the MSA shells are well preserved, showing little evidence of decalcification

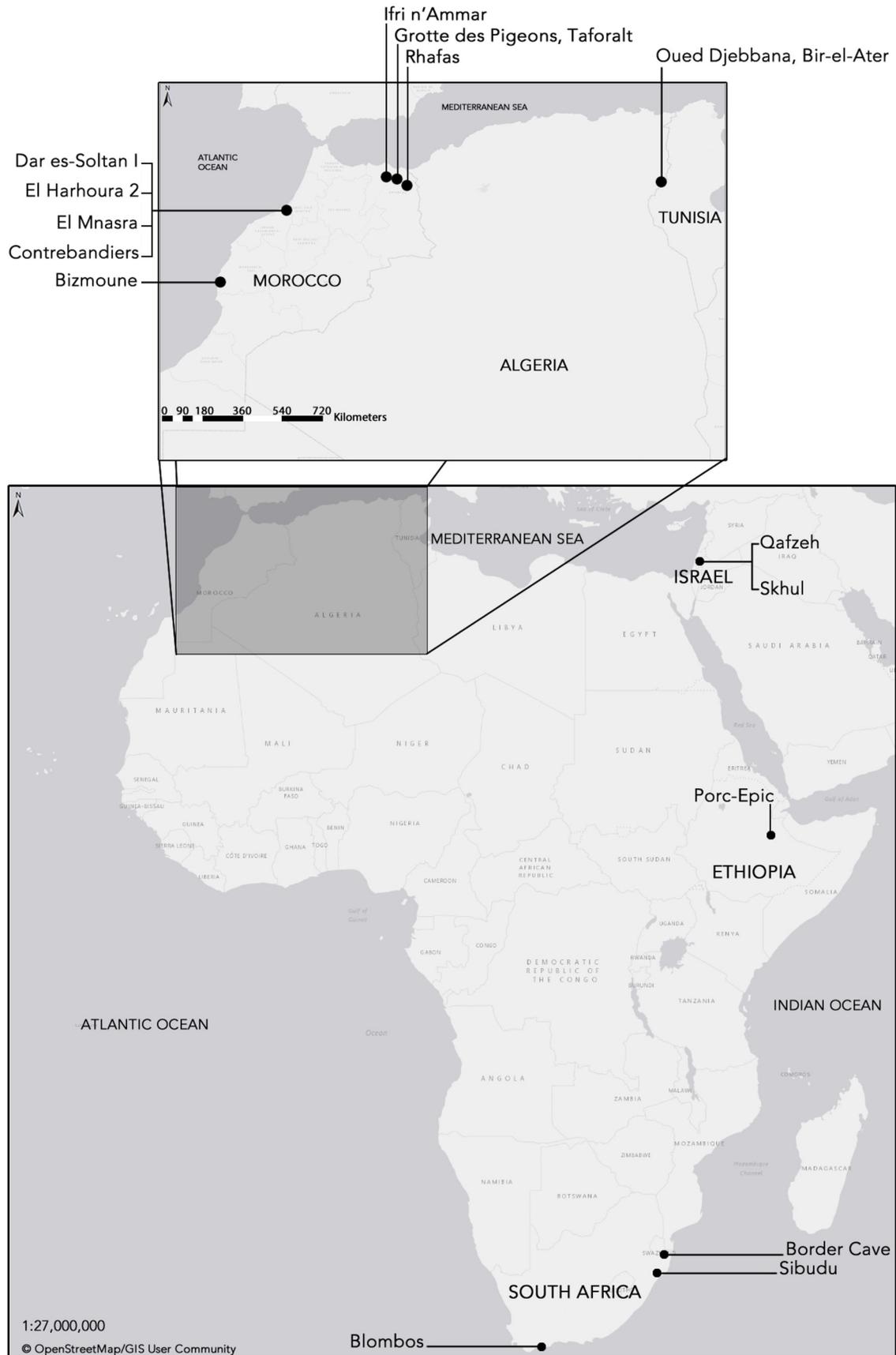


Figure 2. A map of the sites presented in Table 1.

TABLE 2. DETAILS ABOUT THE ANALYSES CONDUCTED ON ASSEMBLAGES THAT MAY REPRESENT EARLY ORNAMENTS.¹

Sample	Reference	Species	Sample Size (n=total, then by Layer)	With Holes?	Manufacturing Traces?	Wear Traces?	Red Staining or Ocher?	Blackened or Heated?	Other Mollusks Present? Taphonomically Analyzed?
Blombos	Henshilwood et al. (2004) d'Errico et al. (2005)	<i>Nassarius kraussianus</i>	n=41 M1: 39 M2: 2-may be intrusive?	Y: n=41 all dorsally perforated near the lip or over a larger area	Y: micro-chipping of the outer prismatic layer - piercing from the inside n=at least five based on d'Errico et al. (2005: Fig. 5), who state that "most" MSA shells have chipping (pg. 13)	Y: perforation edge, outer lip, parietal wall of aperture n=32	Y: n=4	Y: some dark orange or black	Y: food-resource mollusks presented separately; Subsample of unknown size studied for other traces, color variation, and evidence for heating
	Vanhaeren et al. (2013) d'Errico et al. (2015)		n=68 M1: n=66 -CA: 7 -CB: 7 -CC: 30 -CD: 1 Unattributed: 21 M2: n=2-may be intrusive? Inclusive of the d'Errico et al. (2005) sample	Y: n= 67 M1 CA-CAA: type 6 (n=7) M1 CC: type 8 & 9 (n=30)	Not presented	Y: n=62 M1 CA-CAA: perforation and/or outer lip (n=6) M1 CC: perforation edge, outer lip, parietal wall of aperture, some on columella (n=30)	Not presented	Discolored? n=55 (not "beige" or "light beige") Burnt? n=25	
Sibudu	d'Errico et al. (2008)	<i>Afrolittorina africana</i>	n=6 PGS: 1-may be intrusive? RGS: 3 RGS 2: 2	Y: n=3	Y: n=2, maybe 3 Micro-chipping on the external surface of the hole	N	Y: n=1	Y: n=3	Y but no taphonomic analysis presented
Border Cave	d'Errico and Backwell (2016)	<i>Conus ebraeus</i>	n=2 Burial pit equivalent to 1 RGBS: 1 Probably 1 RGBS: 1	Y: n=2	Y: n=1 maybe: "microfractures smoothed by intense wear"	Y: n=1; perforation edge, spine, outer lip (notches), inner lip	Y: n=2 Conus 2 analyzed: high in iron	N	N

TABLE 2. DETAILS ABOUT THE ANALYSES CONDUCTED ON ASSEMBLAGES THAT MAY REPRESENT EARLY ORNAMENTS
(continued).¹

Sample	Reference	Species	Sample Size (n=total, then by Layer)	With Holes?	Manufacturing Traces?	Wear Traces?	Red Staining or Ocher?	Blackened or Heated?	Other Mollusks Present? Taphonomically Analyzed?
Bizmoune	Bouzouggar and Barton (2012); Kuhn et al. (2015)	<i>Tritia</i>	Not presented	Presumably yes, because described as “ornaments”	Not presented	Not presented	Not presented	Not presented	Y but no taphonomic analysis presented
Contrebandiers	Dibble et al. (2012)	<i>T. gibbosula</i> and <i>N. circumcinctus</i> primarily	n=151; analysis in progress	Y: majority but not all; analysis in progress	N	Y: shining	Y	Y	Y; quantification and taphonomic analysis in progress
El Mnasta	El Hajraoui et al. (2012b)	<i>Tritia</i> sp.: 5: 51 6: 125 7: 45 Uncertain context: 10	n=246 5: 55 6: 132 7: 49 Uncertain context: 10 (15 shells are included that are not <i>Tritia</i>)	Y: <i>Tritia</i> only: 5: 37 6: 85 7: 38 Uncertain context: 5	Not presented	Not presented	Not presented	Not presented	Y but no quantification or taphonomic analysis presented
El Haroura 2	El Hajraoui et al. (2012b); Stoetzel et al. (2014)	<i>Tritia</i>	n=5 6: 1 8: 4	n=5 6: 1 8: 4	Not presented	Not presented	Not presented	Not presented	Y but no quantification or taphonomic analysis presented (Nouet et al., 2015)
Dar es-Soltan I	Ruhlmann (1951)	<i>Tritia reticulata</i>	Present	Not presented	Not presented	Not presented	Not presented	Not presented	Y: presence/absence list; No taphonomic analysis
Ifri n'Ammar	d'Errico et al. (2009); Eiwanger et al. (2012)	<i>Tritia gibbosula</i> = 1; <i>Columbella rustica</i> = 1	n=2	Y: n=2* Type f (n=1)	Not presented	Y: n=1	Y: n=1 analyzed: high iron oxide content=hematite (ocher)	Y: n=1	Not presented

TABLE 2. DETAILS ABOUT THE ANALYSES CONDUCTED ON ASSEMBLAGES THAT MAY REPRESENT EARLY ORNAMENTS (continued).¹

Sample	Reference	Species	Sample Size (n=total, then by Layer)	With Holes?	Manufacturing Traces?	Wear Traces?	Red Staining or Other?	Blackened or Heated?	Other Mollusks Present? Taphonomically Analyzed?
Taforalt	Bouzouggar et al. (2007)	<i>Tritia gibbosula</i> primarily; N.	Group E: n=13 -18: 1 -19: 1 -21: 7 Beneath 21: 2 Group E, no specific layer: 2	Y: n=11 Type f (n=9) Type c (n=2) Type i (n=2) two without have gravel blocking their apertures	Some indications but agent inconclusive	n=10 Intense shine on edges and perforation on spots of the ventral and lateral side; pattern is different than on comparative samples	n=10 One unperforated and 9 perforated n=1 analyzed: high iron oxide content=hematite (other)	Not presented	Not presented
	d'Errico et al. (2009)	<i>circumcinctus</i> ? = 3	Group E: n=23 Context less clear but closely associated with Group E: 9 Inclusive of the Bouzouggar et al. (2007) sample	Y: n=27** Type h (n=15) Type g, j, k (n=3 each) Type c (n=2) Type b (n=1) two without have gravel blocking their apertures	n=2 One perforated, one not Striations produced by a lithic on the external, dorsal surfaces	n=18	n=23	n=5	Y: presented separately terrestrial mollusks only (Taylor et al., 2011); No taphonomic analysis
Rhafas	d'Errico et al. (2009)	<i>Tritia gibbosula</i> = 3; T. <i>circumcinctus</i> ? = 1 <i>Columbella rustica</i> = 1	n=5 3a: 1 Context less clear: 4	Y: n=5* Type k (n=2) Type j (n=1)	Not presented	n=5	n=3	n=2	Terrestrial mollusks; N
Oued Djebbana	Morel (1974b); Vanhaeren et al. (2006) d'Errico et al. (2009)	<i>Tritia gibbosula</i>	n=1	Y: n=1 Type f (n=1)	Not presented	Not presented	Not presented	Not presented	Terrestrial mollusks; N

TABLE 2. DETAILS ABOUT THE ANALYSES CONDUCTED ON ASSEMBLAGES THAT MAY REPRESENT EARLY ORNAMENTS (continued).¹

Sample	Reference	Species	Sample Size (n=total, then by Layer)	With Holes?	Manufacturing Traces?	Wear Traces?	Red Staining or Other?	Blackened or Heated?	Other Mollusks Present? Taphonomically Analyzed?
Porc-Epic	Assefa et al. (2008)	<i>Revoilia guillainopsis</i>	n=419 complete plus fragments From 50-290 cm below datum; mainly from 140-190 cm	n=419 complete plus fragments	N	Y	N	Y? variation in color, as a result of "carbonization"	N
Skhul	d'Errico et al. (2009)	<i>Tritia gibbosula</i>	Layer B - exact provenience uncertain: 2	Y: n=2 Type f (n=2)	Not presented	Not presented	Not presented	Not presented but absent based on our observation of the photos	Very small sample; No
Qafzeh	Bar-Yosef Mayer et al. (2009)	<i>Glycymeris nummaria</i>	n=10 XXI: 5 XXII: 1 XXIII: 1 XXIV: 3	Y: n=7 XXI: 4 XXII: 1 XXIV: 2	N	Y: n=4 XXI: 2 XXII: 1 XXIV: 1	Y: n=3 XXII: 1 red XXIV: 1 red & yellow 1 red: analyzed: high iron oxide content=hematite (ocher)	N	N

¹"n" is the sample size, "Y" indicates that the analysis has been conducted and the attribute is present, "N" indicates that the analysis has been conducted and the attribute was not identified, and "Not presented" indicates that the authors did not present the information, and so we are unable to determine if the attributes are present or not.

*Perforation types only presented for *T. gibbosula* and *N. circumcinctus*.

**Note that the type list employed in d'Errico et al. (2009) is expanded from that in Bouzouggar et al. (2007). Two additional types were inserted in the middle of the sequence such that types "g" onward in d'Errico et al. (2009) are not comparable to "g" onwards in Bouzouggar et al. (2007).

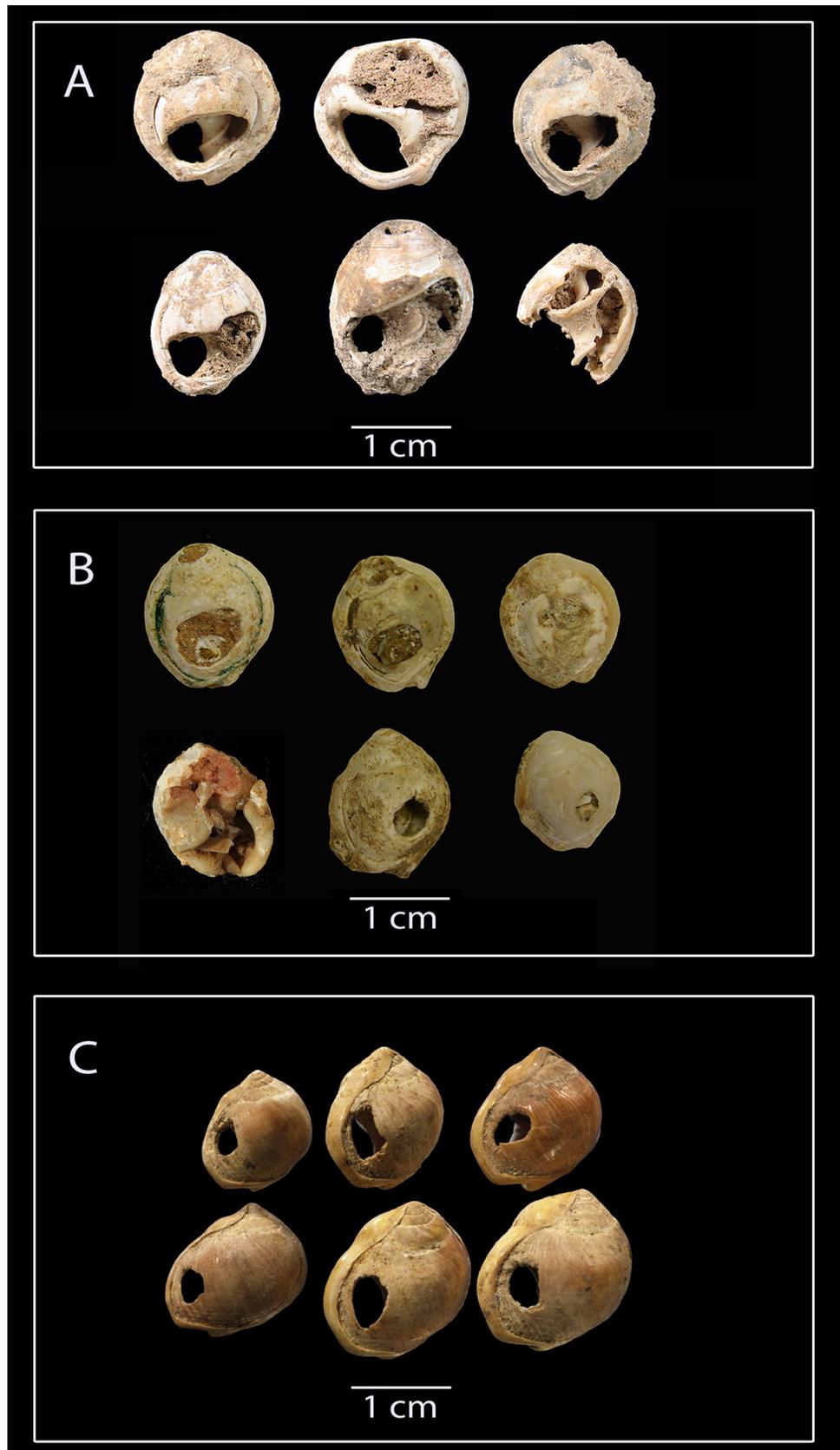


Figure 3. A comparison of a few examples of the shells discussed in the text. The specimens are from A) Contrebandiers Cave, Morocco, B) a fossil beach outcrop in Temara, Morocco (Chahid et al. 2016; Chakroun et al. 2017), and C) Blombos Cave, South Africa. Images A and B are courtesy of the Contrebandiers Project (from Dibble et al. 2012) and C is courtesy of Christopher Henshilwood, Francesco d'Errico, and Marian Vanhaeren (from Henshilwood et al. 2004).

or abrasion, particularly compared to the death assemblages;

- at least five shells show micro-chipping of the outer prismatic layer of some of the MSA specimens, indicating that the hole was made by piercing from the inside through the aperture of the shell (d’Errico et al. 2005: Figure 5);
- use-wear traces and wear facets were microscopically identified along the perforations in 78% of the specimens (d’Errico et al. 2005: Table 1, Figures. 5, 8–10); and,
- the MSA assemblage is distinct from the LSA assemblage, and therefore the MSA assemblage is not mixed in from the LSA deposits. The MSA shells are significantly larger (see also Teske et al. 2007), always perforated, primarily have a different perforation and use-wear types, have intact lips, are dark orange or black, and excavation clusters share distinctive features.

Continuing work at Blombos Cave subsequently yielded an additional 27 perforated *N. kraussianus* shells, 24 of which were clustered as if they originally belonged to the same beadwork item; this total sample of 68 shells provides the opportunity to explore how bead manufacturing and use may have changed through time (Vanhaeren et al. 2013). Expanding their original database, the authors continued to record the perforation type, location of use-wear, shell height and width, and perforation height and width. In addition, they experientially strung perforated *N. kraussianus* shells multiple ways, simulated use, and then examined the wear traces using the same protocols as applied to the archaeological specimens. Their analysis of the archaeological specimens showed differences in perforation size and locations and use-wear locations between the lower M1 CC layers and the upper M1 CA-CAA layers. Comparing the use-wear locations between these samples and the actualistic specimens suggested that the specimens from the upper layers, derived from at least five clusters (or bead-work pieces), may have been strung as “floating pairs of dorsally joining shells” (Vanhaeren et al. 2013:512) while the lower specimens, derived from at least five to six clusters (or bead-work pieces), could have been strung continuously with alternate orientation. Shells exhibiting similar patterns were clustered within the deposits, suggesting that they were used together on one item of beadwork; the largest cluster preserved 24 beads. Vanhaeren et al. (2013) argue that the persistence of the tick shell beads through multiple layers of the deposits, spanning an environmental change (as indicated by changing *Nassarius* size) indicates an enduring tradition of ornamentation. They also argue that the differing pattern of manufacturing and use indicates changes through time in how beads were strung and arranged, which may reflect changing styles or norms in symbolically mediated behavior, similar to those seen in recent human populations.

Noting the high frequency of *Nassarius* shells that were discolored to dark orange or black, d’Errico et al. (2015) conducted further analyses to investigate if the discolor-

ing was intentional or incidental. In addition to studying the archaeological sample, they collected and heated two modern samples of *Nassarius*. In the first study, they heated specimens in a furnace, one set with the shells tucked between leaves and humic soil (creating a reducing atmosphere) in a crucible and the other set with the shells alone (in an oxidizing atmosphere) in a crucible. These samples were heated from 100°C to 1000°C in 10° intervals, with a sample of each set removed at each interval. In the second study, they heated the *Nassarius* in the soil under an open fireplace in three sets, with a set placed inside sour figs, wrapped in leaves, buried in the soil. Selections of these altered, unaltered, and archaeological samples were analyzed for structural composition and modification and elemental characterization (see d’Errico et al. 2015 for a detailed description of their methods). These analyses revealed that in a modern, dead shell, particles of pyrite (iron sulphide) could migrate through the more porous dorsal surface of a shell and stain it black. However, pyrite and iron sulphide were not found on the MSA shells that were examined this way. The heating of modern shells produced a wide variety of colors and shades, patterned relative to temperature and atmosphere (oxidizing or reducing). A reducing atmosphere created dark grey and black colors, because the shells became enriched in carbon. The color of many of the MSA shells is consistent with heating in a reductive atmosphere to 300°C to 500°C, and heat cracks confirm that they have been heated. Unlike the mollusks that had been collected as food (limpets, mussels, and others), which also demonstrate evidence of heating, the *Nassarius* were not heated to charring or calcining, which occurs with high temperatures in oxidizing environments. At Blombos, there is no clear spatial relationship between heated and unheated *Nassarius* and hearths. d’Errico et al. (2015) are confident that their data indicate that the MSA *Nassarius* from Blombos were heated. However, they are unable to determine if this heating was intentional to produce blackened shells or if it was incidental, because food-resource shells were also heated and in proportions similar to the *Nassarius*. However, more of the food shells were calcined compared to the *Nassarius* (none were calcined), which is suggestive of intentional blackening of the *Nassarius*. A higher-resolution spatial analysis would be needed to further investigate the issue.

ELSEWHERE IN SOUTH AFRICA

The assemblage from Blombos is intriguing, for all that it contains, but also for its uniqueness. Currently no other MSA *Nassarius* assemblages from southern Africa have been reported. Archaeological tick shells are not restricted to coastal contexts (see below), but at least ten MSA sites from coastal South Africa with marine shells in their deposits are known (Avery et al. 2008; Will et al. 2016); no others preserve perforated *Nassarius*. However, these sites do not preserve Still Bay materials either. *Nassarius* may not be expected if the employment of *Nassarius* as beads was a feature of coastal Still Bay producing populations. A few additional Still Bay assemblages from cave contexts

that preserve fauna are known, e.g., Apollo 11 (Vogelsang et al. 2010), Diepkloof (Steele and Klein 2013), and Sibudu (Plug 2006), but they do not preserve any *Nassarius* either. d'Errico et al. (2008: 2682) report that there is a "single, unperforated specimen [of *N. kraussianus*] in the late MSA layers of Sibudu", but we have been unable to verify this within the cited reference (Wadley 2006) or other potential sources of information (Plug 2006). In fact, Plug (2006: 297) states "Although there are some worked shell fragments at Sibudu, these do not include *N. kraussianus*."

Sibudu does preserve six sea snails (*Afrolittorina africana*), three of which have holes in them; five of them clearly derive from the Still Bay layers, and the sixth likely originates from there, too (d'Errico et al. 2008). Sibudu is 15km from the modern Indian Ocean coast and contains MSA deposits that were extensively excavated from 1998 to 2011 (Wadley and Jacobs 2006), and the excavations are still continuing (e.g., Conard and Will 2015; Will et al. 2014; Will and Conard 2018). The MSA deposits have been dated using single grain optically stimulated luminescence (OSL) (Jacobs et al. 2008b; Wadley and Jacobs 2006). *Afrolittorina* snails live in colonies on rocks in the intertidal zone along this coast. Human transport provides the most likely explanation of how these shells arrived in the shelter, but their small size and low numbers suggests that they were not likely a human food resource. Highlighting regular foraging at the coast, the MSA deposits from Sibudu, including the Still Bay, do preserve a persistent sample of marine resources, especially brown mussel (*P. perna*) shells (Still Bay: minimum number of individuals=15), despite being 15km from the modern coast (distance to the coast during occupation has not been reconstructed) (Plug 2006). A similar situation is seen at Diepkloof Rock Shelter, on the West Coast of South Africa where consumable marine mollusks were transported for at least 14km (Steele and Klein 2013). However, such instances are rare, and these taxa of mollusks are rarely transported more than a few kilometers (Bigalke 1973; Erlandson 2001; Higgs and Vita-Finzi 1972).

d'Errico et al. (2008) provide a macroscopic, microscopic, metric, and experimental analysis to investigate if the perforated shells could have been used as ornaments. Three of the shells are blackened from heating. Two of them were perforated and found within a hearth; however, it is still not possible to determine if the shells were incidentally burnt after discard or if perforated shells were intentionally placed in the hearth to darken them after manufacture. The unperforated blackened shell suggests that the burning may be incidental after discard. One perforated, blackened shell also has remnants of a "red pigment" all over its surface; however, this red coloring was not subject to elemental and mineralogical analysis. The margins of two of the holes exhibit micro-chipping of their outer prismatic layers. d'Errico et al. (2008) state that the outer surface of the third perforated specimen is poorly preserved; however, in their Table 2 they indicate that micro-chipping is present on this specimen, too. To further investigate, d'Errico et al. (2008) conducted an actualistic study to examine the patterns of damage associated with perforating modern *Afrolittorina*

using thin and robust wooden awls, thin and robust bone awls, a crab claw, and a lithic point (all applying pressure from the inside) and a lithic point and pebble (applying pressure from the outside)—only five shells received each treatment. They found that the patterns of micro-chipping and the holes' location, orientation, morphology, and size are consistent with a pointed tool (which includes all the items that were successful in punching from the inside as listed above). Micro-chipping occurs on the surface opposite of the pressure, and therefore, they conclude that the three shells were perforated by force originating from inside the shells. d'Errico et al. (2008: 2682) conclude that the "more parsimonious" explanation for the holes in the three Sibudu *Afrolittorina* is that humans made them, although they agree that a larger sample size is needed to confirm.

Further northeast, **Border Cave** preserves two perforated *Conus* shells, which may be uniquely associated with the Howiesons Poort and a human infant burial. As described by d'Errico and Backwell (2016), the site has been subjected to numerous excavation campaigns, starting with Dart in 1934. In 1940, the discovery of archaeological materials during guano extraction immediately brought about two seasons of controlled excavations, conducted by professionals. The burial and *Conus* shells were uncovered during these campaigns. The site continued to be excavated in the 1970s and 1980s by Beaumont and colleagues. The complete sequence preserves MSA, Howiesons Poort, post-Howiesons Poort, and early LSA assemblages, followed by a thick sterile layer and Iron Age layer. Following its discovery, there has been much discussion about the archaeological association and antiquity of the infant skeleton and the numerous other hominin fossils found at Border Cave. d'Errico and Backwell (2016) review this literature and the archives from the excavation, and they argue that the infant burial accumulated with 1 RGSB, a Howieson Poort deposit and that the burial is most recently estimated to be 74±4 ka old (Grün et al. 2003), which is older than other estimates for the Howiesons Poort elsewhere in southern Africa (Jacobs and Roberts 2017).

d'Errico and Backwell (2016) provide a detailed examination of the two *Conus* shells and their context. One *Conus* shell (*Conus* 1) was found in the pit with the infant and the excavators did not indicate that other items were found in association (d'Errico and Backwell 2016: 97). The other shell (*Conus* 2) was found in a remaining section during subsequent excavations and has been tentatively attributed to 1 RGSB; d'Errico and Backwell (2016) further argue that the preservation (including amino acid racemization tests) and the uniqueness of the shells suggests that the two were deposited contemporaneously. d'Errico and Backwell (2016) compared the Border Cave shells with modern living and death assemblages and concluded that the archaeological *Conus* were collected already dead from the beach. However, both *Conus* have holes in their apices, which the authors indicate is rare in modern death assemblages of these robust shells. Therefore, d'Errico and Backwell (2016) conclude that the holes were produced by humans, even though no manufacturing traces are present. *Conus* 2, the

better-preserved shell, does exhibit use-wear traces in multiple locations, which suggests that it had been strung. In addition, *Conus* 2 is covered with fine, randomly oriented micro-striations, which are not found on modern living or dead specimens; the analysts argue that these micro-striations are evidence that *Conus* 2 was used as an ornament for a prolonged period. Both *Conus* shells preserve red residues, and elemental analysis of a sample from *Conus* 2 suggests that it is rich in iron oxide, consistent with red pigments.

No other marine mollusks have been documented from Border Cave, with the exception of two (Villa et al. 2012: 13209), three (d'Errico and Backwell 2016: 95), or maybe even four (d'Errico and Backwell 2016: 102) *N. kraussianus* from early Later Stone Age layers (1 WA and 1 BS Lower B+C) dated to 44 to 42 ka (d'Errico et al. 2012). These *Nassarius* were found alongside 14 ostrich eggshell beads (d'Errico et al. 2012; Villa et al. 2012). Investigations into the vertebrate assemblages have not reported coastal components, but they focused only on the mammalian fauna (Avery 1992; Klein 1977). The site is 83km from the modern coast and would have been further during times of lowered sea-levels. This distance is much further than consumed marine resources are usually transported.

NORTHERN AFRICA

Isolated examples of *Tritia* sp. (previously known as *Arcularia*, *Nassa*, or *Nassarius*) have been known from MSA (Aterian) contexts in northwestern Africa for some time (Morrel 1974b; Ruhlmann 1951; Vanhaeren et al. 2006), but the samples from this region gained much more attention after the publication of the Blombos sample and the subsequent discovery of a similar assemblage from Grotte des Pigeons/Taforalt, Morocco.

Bouzouggar et al. (2007) provide the first publication of the **Taforalt (Grotte des Pigeons)** *Tritia* sample, which consisted of 13 specimens, all from a constrained horizontal zone of stratigraphic Group E, which is associated with the Aterian lithic industry and most likely accumulated about 82.5 ka. Bouzouggar et al. (2007) describe the site as having been originally excavated from 1944–1947, from 1950–1955, and then from 1969–1977. The recent excavations at Taforalt began in 2003, and the deposits have since been dated using OSL, thermoluminescence (TL), accelerator mass spectrometry (AMS) radiocarbon, and uranium-series (Bouzouggar et al. 2007). The site is 40km from the current shore, and unfortunately reconstructions of past estimates are unavailable. The authors argue that human transport is the best explanation for how the shells arrived to the site because the shells could not derive from the bedrock of the cave, the shore was at least 40km away, which is too far for animals or storms to have transported the shells, and they do not represent a random selection of naturally dead shells. The shells appear to have been collected already dead from the beach, because encrustations, tiny shells, and sea-worn gravel are embedded in the opening of a number of them; however, the authors argue for intentional selection by humans of already dead shells with an appropriate perfora-

tion, not a random or complete collection. For now, no other coastal elements, neither molluscan nor vertebrate, have been reported from Taforalt. Eleven of the 13 *Tritia* shells have holes; gravels are blocking the apertures of the two that do not have holes. For the 11 specimens, the source of the perforation is not clearly apparent. Diagnostic microfractures are absent and the smoothness (or lack thereof) of the perforation edges can be the result of multiple types of agents; however, their dorsal side perforation type is only rarely observed in their naturally dead comparative sample (n=285). Furthermore, 10 specimens preserve polish or sheen (characterized by Bouzouggar et al. (2007: 9967) as “an intense shine”) on their perforation edges and on spots on the shells’ ventral and lateral sides; these locations are different from the modern death assemblage and could be consistent with use-wear polish as a result of stringing. Ten of the shells (including one unperforated) have red staining; elemental and mineralogical analysis of the residues on one of the shells indicates that it is iron oxide with a very high proportion of iron, which is consistent with hematite (ocher). The unique perforations, the shining on the margin of many of the perforations, and the red staining combined led the authors to conclude that the *Tritia* from Taforalt were used as personal items. However, this conclusion did not go unchallenged, because the shells were collected already dead on the beach (abraded and with beach sediments), they were not deliberately shaped by humans, and their archaeological context was poorly defined (Klein 2008).

Subsequently, additional MSA specimens of *Tritia* from four sites were published (d'Errico et al. 2009). The assemblages included an enlarged sample from Group E at Taforalt (19 additional specimens for a new total of 32) and small samples from Rhafas Cave (n=5), Ifri n' Ammar (n=2), and Contrebandiers (n=1). When context is secure, all are associated with Aterian industries (see Table 1). This increased sample size further supported the conclusions already put forth in the original publication on the Taforalt specimens:

- The specimens are overwhelmingly *T. gibbosula* plus four possible examples of very similarly shaped *N. circumcinctus* (three from Taforalt, one from Rhafas). In addition, Rhafas and Ifri n' Ammar preserved one each of *Columbella rustica*.
- All were collected from the beach already dead and, with the exception of the Contrebandiers specimen, were transported 40–60km inland. Humans are the only apparent agent of transport.
- The vast majority of *Tritia* specimens are perforated, along with the *C. rustica*. Furthermore, the location and size of the holes are different from those found in modern and fossil death assemblages. In these comparative assemblages, dorsal perforations are present (75%, 54%, and 14% for each sample) but are quite small, reflecting types d and e: (d'Errico et al. 2009: Figure 3).
- From Taforalt, one perforated and one unperforated shell show striations on their external, dorsal

surfaces consistent with hole manufacturing traces (or attempt at manufacturing), employing a stone artifact (d'Errico et al. 2009: Figure S4).

- Three types of use-wear are visible on many of the specimens, which are not visible on the modern and fossil comparative material (d'Errico et al. 2009: Table S1):
 - Shine on all prominent, well-preserved surfaces, which is the result of many micro-striations randomly distributed across the shells' surfaces (n=26, count of use-wear "a"). The authors propose that these were "produced by sorted abrasive particles scratching the shell surface in a situation in which the shell was relatively free to move" (d'Errico et al. 2009: 16054).
 - The perforation edge and spiral whorl (central column or spiral; columella) of some of the shells preserve intense smoothing (n=25, count of use-wear "b" and "c") (d'Errico et al. 2009: Fig. S6).
 - The outer lip of the aperture, parietal wall (inner lip/edge of the aperture), and the perforation edges preserve wear facets (n=13, count of use-wear "d", "e", and "f").
- A subset of specimens (see Table 2) are blackened, apparently because of heating from a fire. In addition to the dark color, which could be the result of natural staining, the shells have exfoliations and microcracks, which are consistent with burning. The challenge is to identify if this was intentional discoloration before the perforated shells were used by humans or if this was accidental proximity to a fire after discard. One shell from Taforalt provides a clue—microcracks that were the result of heating were subsequently overlain by use-wear traces, indicating that the shell was heated before being used (d'Errico et al. 2009: Figure S7).
- Many of the shells preserve traces of red staining (see Table 2), sometimes in the groove between the outer lip of the aperture (labrum) and the external surface of the body whorl, sometimes in the bio-erosion pits, other small depressions, and microcracks, and sometimes along the central column or spiral (columella) (d'Errico et al. 2009: 16055 and Figure S8). One specimen was completely covered in ochre. Two of these stains have been subjected to elemental and mineralogical analysis. In both cases the red residues have high iron oxide content and therefore appear to be hematite (ochre).

Rhafas Cave, is also in eastern Morocco, near Taforalt but further inland, being approximately 50km from the modern coast, and again no reconstructions of past estimates are available. The initial work at the site (1979–1986; 1995–1998) revealed a long sequence—4.5m of archaeological and sterile deposits, the deepest of which contain MSA/Maghrebian Mousterian (without tanged pieces), followed by Aterian, and capped by Neolithic (Mercier et al. 2007;

Wengler 2001). In more recent work (2007–2010), in addition to continuing the previous main excavation area, the terrace was explored and revealed LSA materials (Doerschner et al. 2016). Rhafas has provided a small sample of *Tritia* (n=4) and *C. rustica* (n=1), but only one, a *T. gibbosula*, was found in a secure context, which was Layer 3a, attributed to the Aterian (d'Errico et al. 2009). Analysis of these shells was included in d'Errico et al. (2009)'s analyses of the expanded Taforalt sample. Like the Taforalt sample, the Rhafas shells were collected already dead on the beach. d'Errico et al. (2009) found that four of the shells exhibit shine on the outer surface of the shell and that the holes of all five are smoothed on the edge. However, they did not identify any wear facets. In addition, two of the shells were interpreted to have been heated (d'Errico et al. 2009: Figure S7) and three preserved red residues. On at least one of the shells, the red residues are in the pits left behind by bioeroders (d'Errico et al. 2009: Figure S3).

d'Errico et al. (2009) were only able to study the **Ifri n'Ammar** sample from photographs. The original description of this sample was in press (Eiwanger et al. 2012) when d'Errico et al. (2009) published on the photographs presented there. One specimen is *T. gibbosula* and the other appears to likely be *C. rustica* (d'Errico et al. 2009). Eiwanger et al. (2012) describe the specimens as having perforations on their dorsal surfaces and as preserving use-wear traces along their margins. The *Tritia* is blackened as if it was exposed to fire and it is quite shiny; the authors argue that this shininess indicates prolonged use, but microscopic photos of the surfaces are not provided. Traces of red are found inside the *Tritia*; spectrometry analysis indicates that the red is hematite. In addition, ochre fragments were found near the specimen during excavation. Terrestrial snails are present in the Ifri n'Ammar deposits, but no other marine mollusks have been recorded (Klasen et al. 2017; Nami and Moser 2010), which is expected given the site's distance from the modern coast (59km). Ifri n'Ammar was excavated between 1997 and 2005 and preserved Aterian (with and without tanged pieces) and Iberomaurusian deposits; the Aterian accumulated in two components, OS and OI, each with Upper and Lower designations (d'Errico et al. 2009; Eiwanger et al. 2012; Richter et al. 2010). The mollusks of interest originate from the Upper OS, which has been dated to 83.3 ± 5.6 ka (Eiwanger et al. 2012; Richter et al. 2010). Work at the site is continuing, working from new profiles (Klasen et al. 2017).

The one specimen from **Contrebandiers Cave (Smugglers' Cave)** included in d'Errico et al. (2009) was uncovered in 2005 when the site's dormant sections were prepared for OSL and environmental sampling, and therefore its context is not secure. The site had been excavated extensively by Roche and then Roche and Texier from 1955 to 1957 and 1967 to 1975, with two other limited campaigns by others subsequently; modern excavations extended from 2007–2011 (Dibble et al. 2012). The current Contrebandiers sequence begins with MIS 5e beach sands at the base, followed by Maghrebian Mousterian, and then Aterian with limited Iberomaurusian (Later Stone Age) assemblages

at the top of the anterior of the cave; Roche completely removed the capping Neolithic materials (Aldeias et al. 2014; Dibble et al. 2012). During the recent excavations, *Tritia* shells (n=151) were found within the MSA (Maghrebian Mousterian and Aterian: Dibble et al. (2013) discuss if these should even be considered distinct industries and conclude that they should not be) (see Figure 3). The Maghrebian Mousterian layers that preserved *Tritia* specimens, based on their geological context and OSL analyses, accumulated about 115 ± 3 ka (Jacobs et al. 2011), making the Contrebandiers perforated *Tritia* specimens the oldest known (see Table 1). Consistent with their identification in other fossil beach deposits (Brébion 1983; Chahid et al. 2016; Chakroun et al. 2017; Ruhlmann 1951) (see Figure 3), a few (n=5) specimens were also found in the archaeologically sterile basal beach sands of Contrebandiers. Five additional specimens were found in the Iberomaurusian deposits. These small shells were found in association with rich assemblages of marine mollusks that were exploited for food. Preliminary analyses have shown that mussels (primarily *Mytilus* sp. but also *Perna perna*) and limpets (primarily *Patella vulgata* but other Patellidae, too) dominate the assemblages, along with top snails (*Phorcus lineatus*) and predatory snails (*Stramonita haemastoma*); interestingly, a few large (~10cm) shells of predatory triton sea snails (*Charonia lampas*) were collected already dead on the beach, like the *Tritia* were (Dibble et al., 2012; Steele and Álvarez-Fernández 2011). Aside from the mollusks, evidence of the exploitation of coastal resources is limited but consistent: marine birds are present (MSA: n=105), large marine fish remains exist (MSA: n=32), alongside some crab and sea urchin fragments; seal bones are absent (Hallett-Desguez and Marean 2015; Steele et al. 2016a). The site is adjacent to the modern coast. Past reconstructions of changing coastlines and therefore the distance to the ancient coast are not available yet, but the abundance of marine resources throughout the deposits indicates that Contrebandiers was likely consistently within 10km during occupation (Bigalke 1973; Erlandson 2001; Higgs and Vita-Finzi 1972).

The full analyses of the Contrebandiers assemblage is forth-coming, but Dibble et al. (2012) present preliminary results (Figure 4). In addition to *T. gibbosula* and *N. circumcinctus*, many specimens of primarily *N. corniculatus*, but also *T. incrassata*, *T. reticulata*, *Trivia* sp., *C. rustica*, and *Littorina obtusata* were also found. Like the other North African examples, the Contrebandiers specimens were collected already dead from the shore—their margins are muted from abrasion, pits created by bioeroders are present, and one specimen is blackened from burial in anaerobic beach sands. While examples of *Tritia* were transported into the cave in the sandy matrix forming the basal beach sand layer, the lack of a clear beach component in the anthropogenic layers indicates other agents transported *Tritia* into those layers. The majority of the specimens have a hole, typically located on the outer edge of the aperture (the labrum) near the central column or spiral (columella). At the time of publication, only about one-quarter of the Contrebandiers sample had been studied microscopically. Within

this smaller sample, most of the specimens had holes, but the specimens preserved no traces that would indicate that humans produced the holes. Shining—which is interpreted as resulting from human activity—is visible along the edges of the holes of some specimens, and red residues are also visible on many.

El Mnasra Cave is a few kilometers northeast of Contrebandiers, along the Atlantic coast of Morocco towards Rabat. Following its discovery in the 1960s by Roche and excavations during the 1990s by El Hajraoui (El Hajraoui 1993, 2004), excavations at El Mnasra Cave were re-opened in 2005 by Nespoulet and El Hajraoui (Campmas et al. 2015; El Hajraoui et al. 2012a: Part 3; Stoetzel et al. 2014). A large sample of *Tritia* shells (n=231 out of 246 similarly sized shells) was recovered from these excavations (see Table 2). Mostly these shells were found scattered throughout the three main Aterian layers (Layers 7, 6 and 5, although Layers 11 through 4 contain Aterian materials), but one cluster of five was discovered together in Aterian Layer 6. El Hajraoui et al. (2012b) provide macroscopic examination of the sample, where they recorded the perforations' number, location, orientation, shape, contour, and size. Like the other North African samples, the perforations are predominantly singular, located in the central part of the shells' dorsal surfaces, and oval or circular shaped. Their edges vary in their contours. The authors argue that the consistency of the placement of the perforations indicates that the holes were made by humans. Furthermore, the presence of unperforated shells suggests that they were transported to the site and then most of them were then perforated by humans once there. However, it is unclear how the humans perforated the shells. There are no traces of abrasion and the holes are off-set from the spot that would be accessible if they were pierced from the inside. The authors wonder if the broken pieces were accidental, due to prolonged or improper use. The authors also highlight the similarity between the El Mnasra sample and the one from Contrebandiers. El Mnasra has quantified mollusk remains from Aterian Layer 8 that include limpets (Patellidae), mussels (Mytilidae), sea snails (Trochidae and/or Littorinidae), and predatory sea snails (Muricidae), along with unidentifiable shells (Campmas et al. 2016). Campmas et al. (2015) observed that the quantities of shellfish were higher in Aterian Layers 7-5. Some small bird remains were identified at El Mnasra, although it is unknown if these are marine birds (Amani et al. 2012).

Moving a few kilometers farther northeast along the Moroccan coast from El Mnasra, El Hajraoui et al. (2012b) note the discovery of a few perforated *Tritia* shells at **El Harhoura 2 Cave**. Four were found in Layer 8 and one in Layer 6, with both layers attributed to the Aterian; furthermore, a perforated "pendant" made on marine shell was found in the low-density deposits of Layer 3, which is the uppermost of the MSA deposits (Stoetzel et al. 2014). El Harhoura 2 has limpet (*Patella* sp.) remains in Aterian Layer 8 (Nouet et al. 2015) and there are fewer mollusk shells in the upper layers (Campmas et al. 2015). Fish remains are present in Aterian Layers 7, 5, 4, and 3 (although their size and spe-

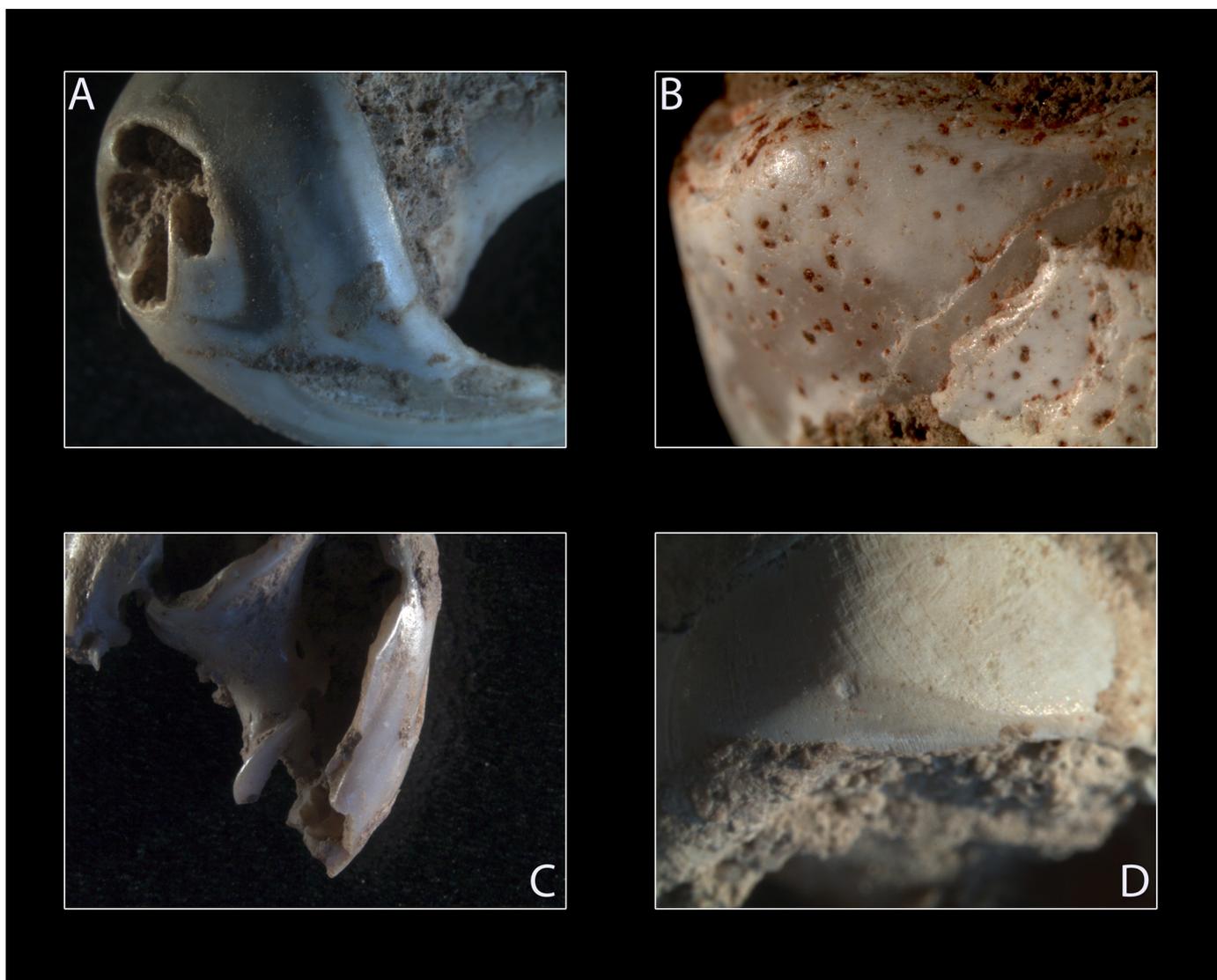


Figure 4. Examples of some of the taphonomic attributes identified on the Contrebandiers Aterian (Layer CEA-4) sample, illustrating A) shining or polish (I15-371; 10x magnification), B) red staining in pits created by bioeroders (I15-367; 12.5x magnification), C) shining or polish and breakage along the worn area of the shell (I14-198; 8x magnification), and D) abrasion (I15-324; 16x magnification). Images are courtesy of the Contrebandiers Project and A, B and D are from Dibble et al. (2012).

cies are not yet documented) and bird remains were found in Aterian Layers 8–3, although it is unknown if these are marine birds (Stoetzel et al. 2010).

Continuing northeast along the Moroccan Atlantic coast is **Dar es-Soltan I**. Ruhlmann (1951) excavated the site in 1937 and 1938, uncovering a 7.3m sequence extending from beach sands at the base to Bronze Age materials at the top. Ruhlmann (1951) identified Aterian materials in Layers I and C². His report also provides a list of molluscan species present for three prominent layers—the basal beach sands (Layer M), the Aterian (Layer C²) and the Neolithic (Layer B); *T. reticulata* were recorded as simply present in Layers M and C². This netted dog-whelk has also been recovered from Contrebandiers. *N. circumcinctus* was recovered in abundance from the basal beach sands but not from the archaeological layers; it is absent along the Moroccan

Atlantic coast today. No discussion is provided about if any of these shells, or any others, have any suspicious holes. Recent re-assessment of Dar es-Soltan I's sequence has estimated that the C² deposits likely accumulated between 61.2 ± 4.0 and 52.7 ± 3.1 ka (Barton et al. 2009).

Much farther south along the Moroccan Atlantic coast near Essaouira, the Aterian layers of **Bizmoune Cave** are reported to have preserved perforated *Tritia* shells, but their quantities have not yet been published; the site is 12km inland from the modern Atlantic coastline; marine mollusks that would have been used for food, such as mussels (*Mytilus* sp.), are also found there, but no other coastal components have been reported (Bouzouggar et al. 2017; Kuhn et al. 2015). Bizmoune Cave was discovered only in 2004, excavations began only more recently in 2014 (Bouzouggar et al. 2017). Future work should reveal much more about

this site and assemblage.

Outside of Morocco, only one additional MSA assemblage from the Maghreb has yielded *Tritia*, **Oued Djebbana, Bir el-Ater**, in Algeria, the type site for the Aterian Industry (Morel 1974b). The site is an open-air site, which provides challenges for assessing the chronology (Morel 1974a), but only Aterian materials have been identified. Importantly, though, this site is almost 200km from the modern Mediterranean Coast, providing a reliable data point for transportation distances during the MSA. Only one *Tritia* specimen was found in the assemblage, and it has a perforation; no other marine components have been documented from the assemblage (Morel 1974b). Vanhaeren et al. (2006) examined the specimen in more detail. They argue that the location of the single perforation is rare in modern death assemblages, which indicates that a rare shell was deliberately collected or that humans perforated the shell. The transportation distance of the shell along with the rarity of its perforation type lead the authors to argue that the *Tritia* from Oued Djebbana was used as a bead.

EASTERN AFRICA

The only site in eastern Africa that has contributed to the discussions of early and potential ornaments made of mollusk shells is **Porc-Epic Cave** in east-central Ethiopia. The site was originally excavated in 1933, and more modern excavations were conducted in 1974 and from 1975–1976 (Clark and Williamson 1984; Pleurdeau 2006). Obsidian hydration dating of unprovenanced MSA artifacts from the early excavations gave minimum ages of $77,565 \pm 1,575$, $61,640 \pm 1,083$, and $61,202 \pm 958$ years ago (Clark and Williamson 1984). Subsequent direct dating the remains of interest yielded radiocarbon ages that got younger as depth decreased: >43.2 , 35.6 ± 0.35 , and 33.7 ± 0.3 ka (Assefa et al. 2008). The MSA occupants of Porc-Epic used a variety of techniques to produce mostly flakes, but also blades, bladelets, and points, with retouched points, scrapers, and notched tools dominating the tool types (Pleurdeau 2006). The deposits preserved a large faunal assemblage. Not surprisingly given the site's distance from the coasts of the Red Sea, Gulf of Aden, or Arabian Sea, there are no marine elements; however, freshwater aquatic resources, such as fish or mollusks derived from rivers or lakes, also have not been reported (Assefa 2006). At least two species of *Nassarius* (*N. arcularia plicatus* and *N. coronatus*) currently live along east African shores (Lindner 2000), but even if these were of interest, Porc-Epic is even further inland than recorded elsewhere (such as at Oued Djebbana) for transport during the MSA.

The MSA deposits of Porc-Epic preserve hundreds of opercula (the "little lid" or trap door that closes a terrestrial or marine snail's shell; see Figure 1) of the terrestrial gastropod (*Revoilia guillainopsis*), and Assefa et al. (2008) provide a detailed analysis. While they are dispersed throughout the sequence, the majority originate from the middle deposits, 140–190 cm below datum, where faunal remains are also most abundant (Assefa 2006; Assefa et al. 2008). The assemblage includes 419 complete opercula, and every speci-

men has a central hole; all the fragmented opercula have holes near their centers, too. Although Assefa et al. (2008) do not provide images or details of modern opercula of this species, modern *Revoilia guillainopsis* opercula appear to be unperforated ($n=4$; <http://www.femorale.com>²). Although the holes occur in the thinnest part of the opercula, Assefa et al. (2008: 749) argue that the holes are unlikely due to processes such as sediment compaction, decalcification, acid dissolution, and predation. To examine the specimens in more detail, 38 were scanned using a scanning electron microscopy (SEM), which showed variation in the margins of the holes, with some having additional tiny perforations and others often having thin, jagged pieces remaining, which can be consistent with acid dissolution and decalcification. However, none of the holes showed clear evidence of human modifications or manufacturing traces; no signs of polish are apparent along the margins of the holes. The raised, spiral ridges on the dorsal surfaces of most of the opercula preserved polish. Only a few have polish on their ventral surfaces, no signs of polish are apparent along the outer edges of the opercula. Assefa et al. (2008: 749) argue that if the polish was the result of abrasion in the sediments of the site, these outer edges should exhibit polish, too. However, they concur that without modern comparative data, they cannot conclude that the polish unequivocally reflects use as an ornament.

Very little shell was found within the Porc-Epic deposits (Assefa et al. 2008). If complete gastropods had been brought into the site, for example, for consumption by humans or other predators, or if *Revoilia* lived naturally in the site, the authors argue that more shell fragments should be preserved (however, they do not provide the employed screen sizes). However, Assefa et al. (2008) found no ethnographic records of humans eating *Revoilia* or other members of their family. In addition, no opercula without holes were found, although no convincing manufacturing traces were found either. Assefa et al. (2008) argue that the unnatural presence of *Revoilia* opercula in the deposits, the lack of *Revoilia* shells, and the universality of the holes in every operculum indicates that humans collected, transported, and accumulated the opercula for non-subsistence reasons, possibly for symbolic reasons. Detailed taphonomic work on recent specimens must be undertaken to provide support for these claims. For example, Stiner et al. (2013: Figure 6) illustrate an example of a *Pomatias elegans* terrestrial snail shell plus operculum from the Epipaleolithic deposits at Üçağızlı, Turkey; the operculum has a hole, which they argue was likely made by a predator. While presented on a different genus of snail, this hole looks remarkably similar to the holes observed on the Porc-Epic opercula.

EASTERN MEDITERRANEAN

Just outside of Africa, a few small samples of shells were found in the Middle Paleolithic deposits of the sites of Skhul and Qafzeh, Israel. These deposits have also yielded early anatomically modern human fossils. More recently, researchers have investigated if these shells could have been employed as ornaments.

Excavated during the landmark 1929–1934 campaigns at Mount Carmel, **Skhul Cave** has provided one of the most important assemblages of early anatomically modern human fossils known (McCown and Keith 1939). The sequence starts with Layer C at the base, excavated over only a small area and yielding only a small sample; Layers B1 and B2 form the majority of deposits and contain Levallois-Mousterian (Middle Paleolithic) lithic assemblages; at the top of the sequence (Layer A), small amounts of Natufian (late hunter-gatherers) and Aurignacian (early Upper Paleolithic) materials were preserved and mixed with underlying Levallois-Mousterian items (Garrod and Bate 1937). Most of the human remains were found in Layer B2. These human fossil bearing deposits are thought to have accumulated around 135–100 ka (Grün et al. 2005; Mercier et al. 1993). In addition to abundant stone artifacts and animal bones, *Cardium (Acanthocardia) ?deshayesii* and *Laevicardium crassum* (both cockles, elsewhere both as *Cardium* sp. [(Bar-Yosef Mayer 2005)]), *Nassarius? gibbosulus* (now *T. gibbosula*), and *Pecten jacobaeus* (Mediterranean scallops) were listed as having been found within the deposits (D.M.A. Bate in Garrod and Bate 1937: 224 [Part 2]). Detailed provenience information is not provided, but presumably the shells derived from Layer B (because the table only indicates “Skhul” while the Tabun materials are divided by layers). Terrestrial snails were also found, along with turtle and crocodile bones, but no marine components are listed. Today, the site is only 3.5km from the coast, so more marine materials might be expected. However, the lack of precise dating makes reconstructions of past distances to the Mediterranean difficult. It is worth noting that four recent (Holocene) beads were also uncovered in “Layer B” (H. Beck in Garrod and Bate 1937: 125 [Appendix 1]).

Vanhaeren et al. (2006) revisited the small Skhul mollusk assemblage, to directly examine the specimens and to reassess their context. They found two *Tritia* and one fragment each of *A. deshayesii*, *L. crassum*, a cypraeid (cowry), and an unidentifiable shell. Only the *Tritia* could have been used as ornaments: both have holes on their dorsal surfaces. Holes in this location are rare (3.5%) in modern death assemblages, and therefore the authors conclude that ancient humans either deliberately selected these rare specimens from a natural death assemblage or manufactured the holes. Through microscopic analyses, the authors also concluded that the specimens preserve indicators on the outer dorsal surface of their body whorls suggesting that the perforation was produced from that surface, but the perforating agent could not be determined.

Determining the context of these specimens is also important, because Garrod and Bate (1937) did not provide detailed provenience information for the materials. One *Tritia* from Skhul preserved an ancient piece of sediment still adhering to it. Vanhaeren et al. (2006) elementally and chemically compared this sediment to archival samples from the excavation. They conclude that the *Tritia* sample derived from Layer B, but they were unable to determine if it derived from the younger B1 phase or the older B2 phase, where the human fossils were uncovered.

Also in Israel, **Qafzeh Cave** has preserved remains of early anatomically modern humans and a small sample of interesting shells. The site was first excavated from 1933–1934, and more modern excavations continued from 1965–1979 (Bar-Yosef Mayer et al. 2009). The basal layers XXIV to XVII contain the highest density of material and are thought to have accumulated rapidly (Bar-Yosef Mayer et al. 2009; Hovers et al., 2003), about 100 ka (Schwarcz et al. 1988; Valladas et al. 1988). An abundance of human remains were found in Layer XVII, with an additional example in XXII (Vandermeersch 1981), and therefore these deposits have received the most attention. However, mollusk remains were derived from deposits preserved below the human remains; no other marine resources have been identified in the assemblages (Bar-Yosef Mayer et al. 2009). The site is 40km from the current coast and would have been further when Mediterranean Sea levels were lower in the past. However, like Skhul, the lack of precise dating of the deposits makes reconstructions difficult.

Taborin (2003) provides the first description of these mollusks. The assemblage was revisited by Bar-Yosef Mayer et al. (2009), who documented ten shells of *Glycymeris nummaria* (previously published as *G. insubrica*), a saltwater clam. Like the tick shells in Africa, four of the five measurable *Glycymeris* shells are large compared to their modern equivalents. Seven of the specimens preserve their umbos (or beak near the hinge of a bivalve), all of these umbos have holes, and all of these holes appear to have been naturally produced. This type of abraded hole is common (41.5%) in modern death assemblages of *Glycymeris*. (Sivan et al. 2006). However, microscopic study of the Qafzeh sample revealed traces suggesting that two of these natural holes were further enlarged and that four of the natural holes preserve smoothing or notching, which are interpreted as traces of use produced from stringing. Furthermore, red and yellow ochre stains are preserved. One shell (Layer XXII) has red on the outside, one (Layer XXIV) has red on the outside and yellow on the inside, and a third (Layer XXIV) has yellow on the edge of the hole (Bar-Yosef Mayer et al. 2009). Elemental analysis of one of the red stains confirmed that it is ochre (Walter 2003). Based on their locations, the staining on the shells is argued to be the result of human manipulation and use as ornaments—stains were found covering the entire concave surface as well as spots on the convex surface of one shell and stains were identified around the edge of the hole of another shell. At least 84 pieces of ochre were found in Layers XXIV to XVII, with most coming from XXI, XIX, and XVII; 71 of them were available for analysis, and four of them exhibited traces of use; eleven stone artifacts from those deposits were also preserved ochre stains, mainly on their edges and tips but also in the last flake scar of a large Levallois core (Hovers et al. 2003). In summary, Bar-Yosef Mayer et al. (2009) argue that the Qafzeh *Glycymeris* shells were used as ornaments because many of the holes in the umbos preserve use-wear traces and use-notches and because ochre is found in different locations on some of the shells; Bar-Yosef Mayer et al. (2009) argue against their use as ochre containers, because

if the *Glycymeris* were used as ocher containers, we would expect to find ocher on all the shells, to find ochre only on the concave surfaces of the shells, and we would not expect wear-traces in the umbos.

DISCUSSION

HOW WERE THEY TRANSPORTED ONTO THE SITES?

A consistent feature of all the assemblages discussed here is that humans are the most likely agent for transporting the mollusks onto the sites. Many of the studies discussed here explore a few alternative explanations for how the shells may have arrived, such as eroded out of the bedrock, washed in during high sea stands, accumulated by non-human predators such as birds or small carnivores, or transported unintentionally with other items of interest, such as mollusks used for food or estuarine grass used for bedding. In each case, the authors discount these alternative explanations as unlikely. With the samples of only a few specimens, transport is not discussed in as much detail; the authors assume that the distances involved limit the probability of non-human agents. However, intentional transport by humans is often not distinguished from accidental transport by humans. Accidental or incidental transport by humans is only explicitly considered for the Blombos sample, where the authors argue that it is possible, but unlikely, that the *Nassarius* were carried accidentally in grass for bedding (d'Errico et al. 2005). For the other samples, such as Taforalt, the authors argue for intentional transport because the perforation frequency, size, and locations do not reflect random sampling of natural death assemblages, and therefore, they reflect intentional selection by humans.

The small size of most of these shells precludes them from likely being used as food items themselves. Furthermore, many of the shell assemblages were transported over distances significantly longer than marine mollusks used for food are normally carried (using Sibudu and Diepkloof as maximum distances during the MSA, ~15km); the specimens from Taforalt, Rhafas, and Ifri n'Ammar were transported for at least 40–60 km and mostly significantly the one from Oued Djebbana travelled ~200km. Therefore, the very presence of these shells in their respective sites is interesting and worth investigating.

Other larger, non-food-resource shells have been found in MSA assemblages, too. These specimens have pits made by bioeroders on their surfaces, indicating that they were collected already dead and therefore certainly were not consumed as food. They are too large to have reasonably been used as ornaments, but they were transported onto sites nonetheless. Contrebandiers (Dibble et al. 2012) and Pinnacle Point Cave 13B in South Africa (Jerardino and Marean 2010) preserve such shells; however, many other coastal MSA assemblages do not (i.e., Avery et al. 2008). The meaning of these shells is not entirely clear, but early humans, including Neandertals, have been known to collect interesting objects (see Mellars [1996] for some examples).

WERE THEY INTENTIONALLY PERFORATED BY HUMANS?

Blombos is the primary assemblage that provides potential evidence of manufacturing traces around the shells' holes; micro-chipping of the outer layer of the external surfaces surrounding the holes has been used to argue that the shells were perforated through piercing from the inside (d'Errico et al. 2005). However, it is unclear what proportion of the assemblage of 68 shells demonstrates these traces. Photos of five shells exhibiting these traces are provided in d'Errico et al. (2005: Figure 5), but further quantification is not provided in d'Errico et al. (2005) or in subsequent publications (Vanhaeren et al. 2013). A similar argument is made for the three perforated snails from Sibudu, and microscopic photos of two of them are presented (d'Errico et al. 2008: Figure 5). Two shells of 32 in the Taforalt assemblage preserve striations on their external dorsal surfaces potentially consistent with attempts at perforation with a lithic (d'Errico et al. 2009: Figure S4). Otherwise, the remainder of the assemblages are either too poorly preserved to yield reliable traces, are well preserved and exhibit no manufacturing marks, or have not been examined microscopically for traces. For the vast majority of the North African specimens, it seems that ancient humans were using specimens that had been naturally perforated through beach and wave erosion; these specimens were not intentionally perforated, but shells with holes appear to have been intentionally collected. Other sources of natural perforations, such as predator made holes, are seen on the shells, but these holes do not appear to have been exploited by humans, i.e., these holes do not exhibit additional modifications, such as use-wear traces or key-holing.

In general, most of the studies lack detailed information about potential manufacturing traces. Quantification is rarely presented, particularly of the proportion of shells that are well preserved. Quantification is also rare when presenting the proportion that were examined microscopically, and the proportion that preserved indicative traces or not. Furthermore, most publications provide only a small subset of photos, if at all, of the documented surfaces. Rarely are there close-up photos providing details, especially of experimental and comparative living and death assemblages.

WERE THEY INTENTIONALLY BLACKENED?

A number of assemblages contain what appear to burnt shells, and these have usually been quantified (see Table 2). Two concerns are relevant here.

First, the challenge of reliably distinguishing burnt specimens from discolored specimens. Shells buried in anaerobic (no oxygen) conditions, such as can be found in deeper beach sands, will discolor and blacken. Such darkening may have already happened when *Tritia* (or other) shells were collected already dead. Therefore, it is important for researchers to carefully distinguish between discoloring and burning, describing their criteria for doing so. Experimental work heating *Nassarius* shells provides some guidelines—in a reductive atmosphere (in the presence of

organics) burnt shells will be dark grey to black to glossy black and will have microcracks (structural modifications) (d'Errico et al. 2015). Based on these results, it should be possible to reliably distinguish burnt from stained shells, based on color and microcracking. In most of the samples where data have been presented, burnt shells have been identified—Blombos 25/68 (37%), Sibudu 3/6 (50%), Ifri n'Amman 1/2 (50%), Taforalt 5/32 (16%), and Rhafas 2/5 (40%). No evidence of burning was found on the small Border Cave, Skhul, or Qafzeh samples.

Second, were the shells intentionally blackened to vary the color of ornaments or were they incidentally burnt after being discarded at the site? This question has been approached two ways—microscopic analysis and spatial analysis. On one Taforalt specimen, microscopic analysis revealed heat-induced cracking which was then smoothed by use-wear, indicating that the shell had been heated and then used as an ornament (d'Errico et al. 2009: Figure S7), suggesting intentional heating or selection of accidentally heated shells. To the best of our knowledge, this is the only example of where the sequence of heating and use is documented. For the Blombos assemblage, d'Errico et al. (2015) investigated the spatial relationship of the burnt and unburnt *Nassarius* relative to the hearths in the site. Unintentional burning would be easier to demonstrate than intentional burning; for unintentional burning we would expect burnt specimens to be associated only with hearths and unburnt specimens to be removed from the influence of hearths. However, at Blombos, no patterning was found, leaving the question unresolved. To the best of our knowledge, no other assemblage has been investigated (or at least published) in this spatial detail.

WERE THEY USED BY HUMANS?

Use-Wear

One of the most convincing lines of evidence that shells were actually used in the past is the presence of use-wear traces. These are generally identified when polish or shining is preserved on the shell's edges, margins, and surfaces. The largest and best-published samples, Blombos and Taforalt, have been microscopically and systematically examined for use-wear traces. The results, including the location on the shells of the traces when identified, are clearly tabulated in the publications (d'Errico et al. 2009: Table S1; Vanhaeren et al. 2013: Table 1). The small samples from Rhafas and Ifri n'Amman were included in the Taforalt analysis. The Qafzeh *Glycymeris* are presented in similar detail (Bar-Yosef Mayer et al. 2009: Table 1), and the two Border Cave *Conus* were studied microscopically and also presented in detail (d'Errico and Backwell 2016). Understandably, only a subset of 38 of the >400 *Revoilia* opercula from Porc-Epic was subjected to microscopic (SEM) analysis; polish marks were identified on “most” of the specimens, but a full quantification is not provided (Assefa et al. 2008: 750). The Sibudu *Afrolittorina* were studied microscopically, but no use-wear traces were identified (d'Errico et al. 2008). Use-wear analyses, data, and quantification have not yet been

presented for the remaining samples.

In the Blombos sample, of the 68 specimens, all had holes, three do not exhibit use-wear, and two others may but the surfaces are “affected by alteration” (poorly preserved?) (Vanhaeren et al. 2013: Table 4). Therefore, 93–96% of the specimens preserve use-wear, almost all of it visible on some combination of the perforation edge and shell lip. The Blombos assemblage appears to be the best-preserved sample under consideration here. One reason may be that the mollusks appear to have been collected while alive, instead of dead on the beach where bioeroders, abrasion, and demineralization may have already impacted the shells.

At Taforalt, 24 of the 32 (75%) specimens had holes on their dorsal surfaces, three (9%) had very small holes, and five (16%) were undiagnostic because they were fragmented (d'Errico et al. 2009: Figure 3). Of the 32 specimens, 26 (81%) exhibited shine on a prominent area, 25 (78%) smoothing, and 13 (41%) facets; three specimens did not exhibit use-wear traces and one was indicated as “not applicable”, presumably because of its poor state of preservation (Bouzouggar et al. 2007; d'Errico et al. 2009: Table S1). These percentages are lower than recorded in the Blombos sample, but only slightly. All five (100%) of the Rhafas specimens preserved use-wear (d'Errico et al. 2009: Table S1). Of the seven (out of ten) Qafzeh *Glycymeris* that preserve holes, four (57%) show smoothing or notching (Bar-Yosef Mayer et al. 2009: Table 1).

Pigments

In many of the analyses, presence of “ocher” (red pigments or staining) on the shells has provided important pieces of evidence in support of the argument that the shells were used as ornaments. The argument is that the shells became stained with ocher during use, likely when they were suspended on ocher-stained items or came into contact with ochre on people's skin or garments. Most of the assemblages that have been analyzed in detail exhibit evidence of red staining. Specimens in eight of the nine assemblages that have been studied in sufficient detail preserve red staining; only Porc-Epic exhibits none. However, there is a wide range of proportions of shells that preserve stains—Blombos 4/41 (10%), Sibudu 1/6 (17%), Border Cave 2/2 (100%), Ifri n'Amman 1/2 (50%), Taforalt 23/32 (72%), Rhafas 3/5 (60%), and Qafzeh 3/7 (43%). Of these 37 specimens with staining, however, only four (one each from Border Cave, Taforalt, Ifri n'Amman, and Qafzeh) of the red stains have been analyzed for their elemental compositions, verifying their origins. In these instances, the red has been high in iron or iron oxide, consistent with ocher (hematite) (Bouzouggar et al. 2007; d'Errico and Backwell 2016; Eiwanger et al. 2012; Walter 2003). However, red staining is also visible on the surfaces of *Tritia* from fossil beaches (see, for example, Figure 3B, 4th shell). Ochre is also variable in its presence in the associated deposits, from abundant in the Blombos (Henshilwood et al. 2002; 2009; 2011) and Qafzeh (Bar-Yosef Mayer et al. 2009; Hovers et al. 2003) assemblages, to absent in the Contrebandiers (Vera Aldeias, personal observation) and Taforalt (Bouzouggar et al. 2007) assem-

blages. Furthermore, very few of the studies state if they explicitly examined the surfaces of other artifact classes to observe if comparable staining was present, and if they mention it, no quantification of the sample is provided (e.g., d'Errico et al. 2005: 16).

WERE COMPARATIVE SAMPLES INCLUDED?

Most of the studies incorporated some sort of comparative sample and/or published comparative data. In most instances, these included living and/or death assemblages of the taxa of interest, with the purposes of collecting comparative data on shell size, hole location and size, and natural abrasion locations and extent (Bar-Yosef Mayer et al. 2009; Bouzouggar et al. 2007; d'Errico et al. 2005; d'Errico et al. 2009; d'Errico and Backwell 2016; Vanhaeren et al. 2006; Vanhaeren et al. 2013). Furthermore, many of these modern shells were used in attempts to replicate the mode of hole production and the location of wear (d'Errico et al. 2005; d'Errico et al. 2008; Vanhaeren et al. 2013). One modern sample was subjected to heating to document patterns of discoloration (d'Errico et al. 2015). However, in most instances, documentation of these samples is limited, the attributes of interest are not always quantified, and the processes and outcomes are sparsely documented with photographs. This limits our ability to compare the modern specimens with the archaeological ones and to apply the knowledge to the analysis of a different assemblage. Furthermore, there is the challenge that some of the comparative samples have been collected on beaches located far from where the shells were gathered in prehistory. This is particularly a problem when studying the ancient *Tritia* from Morocco, because the species of interest no longer exists on those coasts. Comparative specimens originate from Tunisia (Bouzouggar et al. 2007; d'Errico et al. 2009), and they have different sizes and shapes than the older specimens (d'Errico et al. 2009: Figure S2; see also Teske et al. 2007).

WHAT IS THEIR CONTEXT?

Aside from providing stratigraphic details, very few of the samples have been analyzed and presented within the full spatial context of the excavations and other artifact classes. The spatial distribution of the *Nassarius* assemblage was presented in detail for the Blombos sample, with the aim of examining if use-wear patterns, perforation types (reflecting size and location), or shell sizes were similar within clusters found within the site; the authors concluded that the data were spatially patterned, consistent with expectations if clusters of shells were derived from one beadwork item with similarly strung ornaments (Vanhaeren et al. 2013). Furthermore, the Blombos *Nassarius* sample was spatially examined for associations between burnt and unburnt *Nassarius*, burnt and unburnt food-resource shells, and the locations of hearths and ashes in the deposits (d'Errico et al. 2015). Otherwise, this very valuable thread of analyses has not yet been conducted for the samples considered here. Unfortunately, many of the samples are from under-documented contexts (Border Cave, Dar es-Soltan I, Rhafas,

Oued Djebbana, Porc-Epic, and Skhul) or the analyses are in progress (Bizmoune, Contrebandiers, El Mnasra, and El Harhoura 2).

The largest assemblages, El Mnasra (n=246), Contrebandiers (n=151) and Blombos (n=68) are found adjacent to the coast and associated with abundant marine mollusks that were consumed as food. The overall proportion of *Tritia* and *Nassarius* shells is low compared to the entire mollusk assemblage. The accumulators of these assemblages had regular access to beaches and were harvesting food from rocky shorelines. Detailed analyses of the Blombos and Contrebandiers assemblages have been presented, with additional information forthcoming for Contrebandiers. These analyses have presented relative species abundances by layer, and the taphonomic state of the food-resource shells, including burning and pigment staining, have been presented for comparison with the potentially ornamental shells.

WHAT IS THEIR DISTRIBUTION IN SPACE AND TIME?

More than half (9 of 15) of the assemblages considered here are from the northwestern region of Africa, and eight of those are from the Moroccan coast. Additionally, these assemblages are all similar because the shells are uniform in their species composition and because they were collected already dead and water-worn from beaches. Furthermore, some comparable examples are known from non-human accumulated contexts (e.g., Contrebandiers and Dar es-Soltan). Many of these northwestern African assemblages accumulated adjacent to the shore (5 of 9), based on their association with marine shells gathered as food. Specimens from three of these sites (3 of 9) were transported 40–60km. Of all the assemblages considered here, the Oued Djebbana specimen is remarkable for the unprecedented distance over which it was securely transported, 200km. Rarely were items transported over these distances during the MSA. Local use of materials is most common, although transportation distances of 40–60km are known from the MSA—marine mollusks traveling for at least 45km at Varsche Rivier 003, South Africa (Steele et al. 2016b) and obsidian regularly traveling for 25–50km (with one specimen from 95km away) at Olorgesailie, Kenya (Brooks et al. 2018). The only other reliable data on transport distances even approaching the *Tritia* at Oued Djebbana is the regular transport of obsidian for 166km at the MSA Sibilo School Road Site, Barino, Kenya (Blegen 2017).

The oldest assemblage considered here is from Layer CEA-5c&d at Contrebandiers Cave, with an antiquity of about 115 ± 3 ka (Jacobs et al. 2011). The assemblages from the very nearby sites of El Mnasra and El Harhoura 2 are comparably ancient (Jacobs et al. 2012). In North Africa, the *Tritia* assemblages cluster first in the early Late Pleistocene along the Morocco Atlantic coast; then there is another cluster in the eastern part of the country around 84 ka or so, although the ranges around the antiquity estimates are wide. This clustering in time and space may reflect regional patterns of variation or more likely the preservation and inves-

tigation of deposits, i.e., there are no comparably aged deposits from the two regions—the Atlantic coastal deposits are older than the inland, eastern Moroccan deposits. The *Tritia* samples appear to persist in the Aterian record until the Aterian also disappears from the landscape. The transition from the Aterian to early Upper Paleolithic and then the Iberomaurusian remains poorly resolved, although the Iberomaurusian (and subsequent Neolithic) does preserve beads made on *Tritia* at Contrebandiers. The Dar es-Soltan I sample remains as an outlier at ~60–50 ka, but we caution that the age estimates were taken on standing profiles of an ancient excavation and therefore the associations between the *Tritia* and the dating samples are not as well-defined as would be ideal; furthermore it is unknown if these shells have holes (Barton et al. 2009).

In contrast, the samples from South Africa vary widely in their geography and their species composition. Only the Blombos shells are *Nassarius*, which are very similar in their appearance to *Tritia* (Bar-Yosef Mayer 2015). Like the Atlantic Moroccan assemblages, the Blombos assemblage accumulated in a coastal environment because marine mollusks that were consumed as food are abundant. Unlike the North African *Tritia*, the Blombos *Nassarius* were collected alive. Spanning from ~80–70 ka, the South African samples are also just younger than the North African samples. Interestingly, despite the excavation and research focus on the late MSA (post-Still Bay) industry of the Howiesons Poort, no *Nassarius* are known from these deposits. The late and final MSA deposits also have not yielded perforated *Nassarius*. The Howiesons Poort at Border Cave has provided the two worn *Conus* shells, but the provenience of these remains and the associated human burial have been questioned and subsequently reconstructed (d’Errico and Backwell 2016). After Blombos, perforated *Nassarius* do not appear again until 44–43 ka in the early Later Stone Age at Border Cave (d’Errico et al. 2012; Villa et al. 2012). Interestingly, perforated *Tritia* (*Nassarius*) simultaneously appear within some of the earliest Upper Paleolithic assemblages known—~44–41 ka at Üçağlızlı, Turkey (Kuhn et al. 2001; Stiner et al. 2013) and Ksâr ‘Akil, Lebanon (Bosch et al. 2015a; Bosch et al. 2015b). Also, worth noting is that gap in shell bead employment discussed here may be filled by ostrich eggshell beads, which have been documented in Howiesons Poort and late MSA contexts (Miller and Willoughby 2014; Steele et al. 2016b).

WHAT ARE THE IMPLICATIONS OF THESE ASSEMBLAGES?

If at least some of these assemblages are composed of shells that were employed as ornaments, then they represent the earliest evidence of human personal ornamentation. But what do they imply about their users and wearers? These shells, especially *Tritia* and *Nassarius*, appear to have been deliberately selected multiple times across space and through time, demonstrating a great deal of intentionality in selection. There appears to be a strong preference for particular taxa which suggests something along the lines of an aesthetic and/or functional preference for shells that

confirm to that size, morphology, and coloration (Bar-Yosef Mayer 2015; d’Errico et al. 2015; Stiner 2014; Stiner et al. 2013). Remarkably, that preference spanned a wide geographic area (Morocco to Israel to South Africa), so wide that connections are hard to imagine. The distances argue more for independently developed or manifested preferences for these shell sizes, shapes, and colors. Furthermore, this preference expanded beyond those initial geographies and persisted through tens of thousands of years.

Beadwork represents a meaningful time investment—to gather materials, to manufacture the beads, and finally to string and or sew them. However, the earliest items employing marine shells discussed here reflect more minimal investments. The North African *Tritia* shells were collected already with holes from shorelines, and these shores were often visited for other reasons—for edible marine mollusks. No investment of manufacturing was needed, although stringing would have still required materials and time. These are “ready-to-use” beads, which are a common bead type (Bar-Yosef Mayer 2015). Even if their “production” costs were low, however, these shells would have been effective in communicating, as would be expected of an object used for signaling.

FUTURE DIRECTIONS?

While the argument for the employment of personal ornamentation has now been made for a number of MSA shell assemblages, there is still much to learn. These continuing investigations will be greatly facilitated by increasing the detail and standardization of the data presented. Fortunately, there are some good guidelines to follow (e.g., Stiner et al. 2013; Vanhaeren et al. 2013), but more can always be done.

Unfortunately, many analyses of the purported “personal ornament” assemblage are presented in isolation. They are rarely integrated with data on other artifact classes, such as the lithic, pigment, and faunal finds, including marine and terrestrial mollusks. Furthermore, suitable detailed comparative, taphonomic, and experimental data are lacking. In particular, it would be helpful to have information on: 1) densities and relative abundances of different artifact classes. Ideally this would be done in horizontal and vertical spatial contexts; 2) the taphonomy of other artifact classes, such as burning, water-wear, and ochre staining; 3) all aspects of the comparative samples, such as living, death, fossil, and experimental assemblages, that are consistent and comparable to the data presented on the “personal ornament” assemblage (this should include tabulation and photographic evidence of all specimens; this is feasible now that journals commonly provide archival space for supplementary on-line materials); and, 5) elemental and mineralogical composition of any pigments preserved in the deposits and on the “personal ornaments” and comparative samples under study (we appreciate here, however, the challenges of accessing the appropriate equipment or of obtaining export permits to transfer the specimens to places where suitable equipment exists). Such clear and consistent data presentation will greatly contrib-

ute to our knowledge of early personal ornament production and use.

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ENDNOTES

¹International chronostratigraphic chart v 2018/08: <http://www.stratigraphy.org/ICSchart/ChronostratChart2018-08.pdf>

²<http://www.femorale.com/shellphotos/detail.asp?species=Revoilia+guilainopsis+%28Bourguignat%2C+1882%29&url=%2Fshellphotos%2Fthumbnailpage%2Easp%3Ffamily%3Dpomatiasidae%26cod%3D5009>.

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