82,000-year-old shell beads from North Africa and implications for the origins of modern human behavior

Abdeljalil Bouzouggar[a], Nick Barton[b,c], Marian Vanhaeren[d,e], Francesco d'Errico[f,g], Simon Collcutt[h], Tom Higham[i], Edward Hodge[j], Simon Parfitt[k,l], Edward Rhodes[m], Jean-Luc Schwenninger[i], Chris Stringer[k], Elaine Turner[n], Steven Ward[o], Abdelkrim Moutmir[p], and Abdelhamid Stambouli[p]

[a]Institut National des Sciences de l'Archéologie et du Patrimoine, 10001 Rabat, Morocco; [b]Institute of Archaeology, University of Oxford, Oxford OX1 2PG, United Kingdom; [d]Ethnologie Préhistorique, Centre National de la Recherche Scientifique, Unité Mixte de Recherche 7041 ArScAn, F-92023 Nanterre, France; [e]Centre for the Evolution of Cultural Diversity, University College London, London WC1H 0PY, United Kingdom; [f]Institut de Préhistoire et de Géologie du Quaternaire, Centre National de la Recherche Scientifique, Unité Mixte de Recherche 5199, PACEA, F-33405 Talence, France; [g]Department of Anthropology, George Washington University, Washington, DC 20052; [h]Oxford Archaeological Associates Ltd., Oxford OX4 1LH, United Kingdom; [i]Research Laboratory for Archaeology and the History of Art, University of Oxford, Oxford OX1 3QY, United Kingdom; [j]School of Geographical Sciences, University of Bristol, Bristol BS8 1SS, United Kingdom; [k]Natural History Museum, London SW7 5BD, United Kingdom; [l]Institute of Archaeology, University College London, London WC1H 0PY, United Kingdom; [m]Research Schools of Earth Sciences and of Pacific and Asian Studies, Australian National University, Canberra 0200 ACT, Australia; [n]Römisch-Germanisches Zentralmuseum Mainz (RGZM), Forschungsbereich Altsteinzeit, 56567 Neuwied, Germany; [o]Centre for the Environment, University of Oxford, Oxford OX1 3QY, United Kingdom; and [p]Laboratoire des Recherches d'Analyses Techniques et Scientifiques de la Gendarmerie Royale, 10001 Rabat, Morocco

Communicated by Erik Trinkaus, Washington University, St. Louis, MO, April 28, 2007 (received for review March 23, 2007)

The first appearance of explicitly symbolic objects in the archaeological record marks a fundamental stage in the emergence of modern social behavior in *Homo*. Ornaments such as shell beads represent some of the earliest objects of this kind. We report on examples of perforated *Nassarius gibbosulus* shell beads from Grotte des Pigeons (Taforalt, Morocco), North Africa. These marine shells come from archaeological levels dated by luminescence and uranium-series techniques to ≈82,000 years ago. They confirm evidence of similar ornaments from other less well dated sites in North Africa and adjacent areas of southwest Asia. The shells are of the same genus as shell beads from slightly younger levels at Blombos Cave in South Africa. Wear patterns on the shells imply that some of them were suspended, and, as at Blombos, they were covered in red ochre. These findings imply an early distribution of bead-making in Africa and southwest Asia at least 40 millennia before the appearance of similar cultural manifestations in Europe.

anatomically modern humans | *Nassarius* shells | modern behavior | Middle Palaeolithic | optically stimulated luminescence

Although major interest in human evolutionary studies surrounds the appearance and dispersal of anatomically modern humans, an equally far-reaching but more contentious issue concerns the origins of culturally modern behavior (1, 2). Despite growing evidence that humans of anatomically modern form originated in Africa >150,000 years ago (3–5), there still is considerable controversy over precisely when and how humans attained physical and cultural modernity (6) and how such concepts can be diagnosed (3, 7–9). Regardless of whether behavioral changes were abrupt or accumulated gradually (5, 6), a common proxy for this process is the occurrence of personal ornaments, considered by many authors as tangible signs of symbolic material cultures (1–2, 7–10). Establishing when and where such items first appeared in the archaeological record is therefore of great interest. Of course the presence of ornaments in the archaeological record does not necessarily reflect when the capacity for that behavior first evolved. However, it does signify when the capacity for such behavior became embodied in long-lasting material culture and arguably was transmitted from generation to generation.

Until recently, the oldest worked shell beads were those reported from Blombos, South Africa (2, 10), but further examples now have been described for Oued Djebbana, Algeria, and Skhul, Israel, raising the possibility of even earlier occurrences in southwest Asia and North Africa (11). In addition, unresolved evidence for bead use comes from the ≈100-ka Mousterian levels at Qafzeh Cave in Israel where four water-worn *Glycymeris* spp. shells with natural perforations are interpreted as beads, or alternatively, pigment containers (12).

The finds from Blombos consist of 41 *Nassarius kraussianus* marine tick shells that had been perforated intentionally, bear traces of use, and come from Middle Stone Age (MSA) phase M1 of the sedimentary sequence that has been dated by optically stimulated luminescence (OSL) and thermoluminescence (TL) to ≈75,000 years (13, 14). Sediments of phase M1 also contain two pieces of engraved red ochre (13), elaborated bone tools (15), and 400 bifacially flaked points of the Still Bay industry (14).

The three shells from Skhul and Oued Djebbana belong to *Nassarius gibbosulus* and display, as in the Blombos beads, a central perforation that is found only rarely in naturally occurring shells (11). Although apparently well related to archaeological deposits, there still is uncertainty over their dating and interpretation. Concerns over Skhul findings arise from the observation that the stratigraphic positions of the two *Nassarius* shells never were explicitly recorded in the original excavations (16). However, it has been inferred from the chemical composition of sediments adhering to the *Nassarius* shells that they come from the same context (layer B) as the one that yielded remains of anatomically modern humans (17) with age determinations ranging from 100,000 to 135,000 years (18). The stratigraphic position of the single *Nassarius* shell from Oued Djebbana is even more ambiguous because it comes from a 0.80- to 1.0-m thick archaeological layer in an open-air location that was excavated in the 1940s (19). The finds consisted of a Middle Paleolithic Levallois industry with Aterian pedunculate points but also Upper Paleolithic forms (19). Nevertheless, the site

---

Author contributions: A.B., N.B., M.V., F.d., S.C., and C.S. designed research; A.B., N.B., M.V., F.d., S.C., T.H., E.H., S.P., E.R., J.-L.S., C.S., E.T., S.W., A.M., and A.S. performed research; A.B., N.B., M.V., F.d., S.C., T.H., E.H., S.P., E.R., J.-L.S., C.S., E.T., S.W., A.M., and A.S. analyzed data; and A.B., N.B., M.V., F.d., S.C., E.H., S.P., E.R., J.-L.S., C.S., E.T., and S.W. wrote the paper.

The authors declare no conflict of interest.

Abbreviations: MSA, Middle Stone Age; OSL, optically stimulated luminescence; TL, thermoluminescence.

[c]To whom correspondence should be addressed. E-mail: nick.barton@arch.ox.ac.uk.

This article contains supporting information online at www.pnas.org/cgi/content/full/0703877104/DC1.

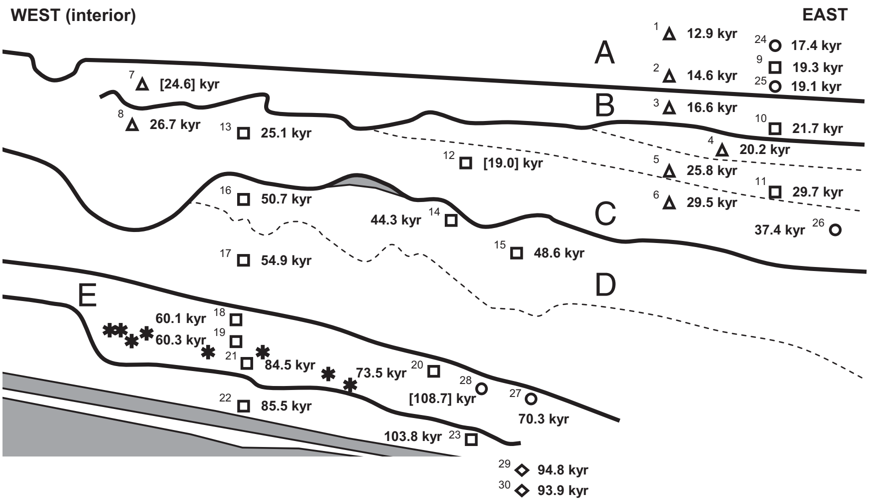


Fig. 1. Schematic stratigraphy with the position of *N. gibbosulus* marine shell beads and dates. Bold lines indicate erosive unconformities at sediment group boundaries. Dashed lines indicate selected in-group bedding planes. Gray fill indicates principal floor speleothems. (*A*) Gray series including anthropogenic cut features (ashy stony beds). (*B* and *C*) Upper Laminated group including Yellow series (finely and continuously laminated silty to fine sandy loams and finest scree with some finer partings, *cf.* Raynal Niveaux 1–11), upper and lower subgroups. (*D*) Pink group (stony, patchily cemented loams, traces only of lamination but some scour structures, minor speleothem at summit, *cf.* Raynal Niveaux 12–15). (*E*) Lower Laminated group (coarsely laminated often ashy silty to sandy loams, *cf.* Raynal Niveaux 16–23). (*F*) Calcareous group (interstratified floor speleothem and clayey to sandy loams, *cf.* Raynal Niveaux 24–32?). Full dating details and superscripted serial numbers are given in SI Table 2. Numbers in brackets indicate that the values are problematical (see text). △, C^{14}; □, OSL; ○, TL; ◇, uranium-series; ∗, *Nassarius* shells.

apparently was sealed beneath 3.9 m of sterile alluvial sediments, and the faunal components in the archaeological layer included large mammals indicative of more humid, and possibly savannah-like, conditions than at present (19). Landsnails from the layer provided an infinite radiocarbon date of >35,000 years (20).

The *Glycymeris* shells from Qafzeh bear a perforation on the umbo and were found in the layers that have yielded burials attributed to anatomically modern humans. The shells do not seem directly associated with the burials, but they probably were brought to the site, which is some 40 km from the sea. Analysis conducted by Walter (21) has detected the presence of ochre inside one specimen and manganese oxide, probably postdepositional in origin, both inside and outside two other specimens. The absence of any such traces on the perforations indicates that the shells may have been perforated deliberately. However, no comparative study of modern or fossil thanatocoenoses were conducted to characterize the morphology and quantify the occurrence of perforations on the umbo in the natural assemblages. Given the ambiguous nature of the Qafzeh evidence, the overall scarcity of *Nassarius* shell beads elsewhere, and lingering doubts over the stratigraphic integrity and dating of the finds at most of these sites, it is imperative to address the question of the potential antiquity of such ornaments through new excavation, the development of well established stratigraphies, the use of multiple dating methods, and the application of integrated methods of analysis involving taphonomic, morphometric, and microscopic analysis of archaeological and reference collections. The finds reported here from the site of Grotte des Pigeons in eastern Morocco fulfil each of these criteria and provide indisputable evidence for the use of personal ornaments in North Africa by ≈82,000 years ago.

Grotte des Pigeons (Taforalt, Morocco)

Grotte des Pigeons is situated in eastern Morocco (34°48′38″ N, 2°24′30″ W), near the village of Taforalt. The bedrock in this area comprises steeply folded Permo-Triassic dolomitic limestones, with the cave itself having formed by rekarstification in a zone of earlier travertines and fluvial conglomerates, constituting a more ancient deep karstic fill. The currently accessible cave, with a large entrance opening to the northeast, has a floor area within the drip line of >400 m^2. Today the site lies ≈40 km from the Mediterranean coast and at an altitude of 720 m above sea level. It currently is within the "thermo-Mediterranean" biozone (22) and has a local vegetation cover dominated by *Tetraclinis articulata* and *Pinus halepensis*, together with evergreen oak.

The cave, discovered in 1908, was the subject of major excavations in 1944–1947, 1950–1955, and 1969–1977 (23, 24). During the latter campaigns, an ≈10-m-thick sequence of archaeological deposits was described, containing typical Iberomaurusian (Upper Paleolithic) and Aterian (Middle Paleolithic) artifacts (23, 25). In addition, >180 Iberomaurusian human individuals were found in two burial zones (24, 26).

The current investigations began in 2003 with the aim of obtaining fresh dating as well as paleoenvironmental evidence and to explore more fully the extent of the Middle and Upper Paleolithic deposits. Our excavations deliberately were placed adjacent to the earlier trenches and next to a central type section that still survives. Cross-references to the original bed nomenclature proposed by Raynal (27) therefore are given, wherever possible, to aid comparison. The lithostratigraphy of relevance here can be divided into five main composite units (groups A, B + C, D, E, and F), bounded by clear and laterally persistent unconformities, each of which is bracketed by a significant shift in sediment type. The relevant geometrical relationships are reported in simplified form in Fig. 1. The sediments shown spanning groups B–F are ≈2.5 m thick.

Stratigraphic and Archeological Context

Within the Taforalt sequence, Middle Paleolithic occupation horizons have been recorded in each of the groups C–F. Finds of the Upper Paleolithic type also have been made near the top of group C, but these are yet to be described fully (28). Group E is characterized by Middle Paleolithic tools such as side scrapers and small radial Levallois cores, and, in this group (in the equivalent of Raynal's bed 21), a few thin, bifacially worked foliate points also were recovered [supporting information (SI) Fig. 6]. This finding is one of several components known from the Aterian facies of the Middle Paleolithic (29, 30). More typical

Table 1. Contextual and descriptive data on *N. gibbosulus* shells from the Middle Paleolithic layers of the Grotte des Pigeons (Taforalt)

Fig. 3 no.	Layer	Square	Inv. no.	Context	Length, mm	Width, mm	PST
1	18	L13	157	*In situ*	16.92	11.99	5.99
2	19	M13	5,348	*In situ*	NA	10.30	3.84
3	21	L13	278	*In situ*	NA	11.13	3.94
4	21	L14	1,965	*In situ*	14.47	10.72	4.27
5	21	L15	1,964	*In situ*	NA	10.73	4.57
6	21	M13	2,087	*In situ*	NA	10.85	5.33
7	21	M14	2,022	*In situ*	NA	11.80	4.38
8	21	M14	5,406	*In situ*	17.41	13.91	5.77
9	21	M17	2,047	*In situ*	15.35	11.48	4.28
10	Beneath 21	N13	3,367	Burrow	16.28	11.49	4.60
11	Beneath 21	N13	3,368	Burrow	15.85	11.75	4.12
12	Group E	P13	3,720	Burrow	NA	12.69	5.39
13	Group E	NA	5,305	Sieving	NA	13.30	5.15

NA, not applicable; Inv., inventory; PST, parietal shield thickness.

Aterian products such as pedunculate points have been noted elsewhere in the cave (31), but their absence in our samples may be attributable to the restricted nature of the newly examined area or to functional and spatial variation in the distribution of such artifacts across the site.

So far, 13 *N. gibbosulus* shells have been recovered (see Fig. 3), all from the group E deposits and the majority (13) from contiguous squares covering a maximum area of 6 m^2 (Table 1). Seven shells are in the equivalent of Raynal's bed 21, a set of lightly cemented, ashy lenses (on average 12 cm thick) with abundant evidence of human presence, including archaeological finds and hearth spreads. Two beads were from no more than 10 cm higher in overlying bed equivalents 18 and 19; because these beds also have a strong anthropogenic component and are relatively soft, the most parsimonious explanation is that the slight reworking of these objects was attributable to human activity. An additional four examples were found, in each case demonstrably lying in the fill of burrows that intersect with bed equivalent 21. In this part of the cave, bioturbation structures are discrete, and the matrix through almost the whole sequence is finely laminated (interpreted as attributable to repeated low-energy surface wash), whether in persistent units or more localized lenses giving excellent, often millimetric, stratigraphic integrity.

Environmental Data

Proxies for environmental conditions during the phases of cave occupation are available from both wood charcoal and small mammal evidence. A feature of considerable interest in the charcoal record concerns the fluctuating presence of cedar in the C–F sequence. *Cedrus* currently grows in Morocco only from ≈1,300–2,600 m in the Rif, the Middle Atlas, and Eastern High Atlas (32), and its presence throughout the Taforalt record highlights a significant vegetation shift since the Holocene. In particular, group E is dominated by *Cedrus atlantica* and deciduous *Quercus*, with the latter declining at the expense of *Cedrus* from bed equivalents 21 to 16. This finding suggests an increasing "montane" influence, perhaps reflecting environmental cooling and/or drying, which would be consistent with the proposed age of this subsequence.

Semiarid conditions are confirmed by the notable presence of *Ctenodactylus* spp. (gundi), which now occurs well to the south of Taforalt in Mediterranean steppe and rock outcrops along the northern margin of the Sahara. Other mammals from group E include *Equus* sp. (equid), *Lepus capensis* (hare), and abundant micromammals such as *Crocidura* spp. (white-toothed shrew), *Elephantulus rozeti* (North African elephant-shrew), bat, *Gerbillus* sp. (gerbil), *Meriones* sp. (jird), *Mus spretus* (Algerian mouse), and *Eliomys* sp. (garden dormouse). These taxa indicate that the shell bead occupation layer was closely associated with a largely open and sparsely vegetated environment with some locally wooded habitat.

Dating

Four different dating techniques were used. Radiocarbon accelerator mass spectrometry determinations on eight pretreated samples of charcoal provided a coherent set of dates for the upper part of the archaeological sequence. These results at 2σ ranges are shown in Fig. 1 and SI Table 2. Optical dating of 15 sediment samples using the OSL signal of quartz and TL determinations on five burnt flint artifacts gave a series of internally consistent dates that provided age estimates for, and bracketing, the bead-bearing deposits. Three samples bracketing the bead-bearing deposits also were measured by using single-grain OSL, providing consistent results with the multiple-grain OSL determinations. Uranium-series isotopic measurements were made on two subsamples from the uppermost part of a horizontal flowstone layer underlying the archaeological layer with beads. The dating series as a whole has good integrity, with only two objects (a charcoal fragment and a burned stone tool) seeming to have been reworked into secondary contexts. A small systematic offset between radiocarbon and other methods is observed in the upper parts of the stratigraphy. The pierced *Nassarius* shells are contained within the lower part of group E, which is marked by asterisks in Fig. 1. We have constructed a Bayesian age model (Fig. 2) incorporating 13 uranium-series, TL, and OSL age estimates from groups D, E, and F (33, 34). The age model constrains the main horizon containing the pierced *Nassarius* shells to between 73,400 and 91,500 years ago at 2σ, with a most likely date of ≈82,500 years (see SI Tables 3–5).

The Bead Evidence

The shells (Fig. 3, Table 1) belong to the species *N. gibbosulus* living today only in the eastern Mediterranean. The few known Pleistocene specimens are bigger than the modern representatives and show a thicker parietal shield (11, 35). Size distribution of the Taforalt specimens (Fig. 4) is significantly different ($P <$ 0.0001) from that of a modern biocoenosis (see *SI Text*).

The *N. gibbosulus* shells certainly were brought to the site by humans. The local dolomitic bedrock is too old to be a source, predating the origin of the species (36). The distance from the site to the contemporary coast could not have been <40 km (37), too far for natural processes known to carry marine shells inland, such as animal predators or major storms (38). It also is clear that

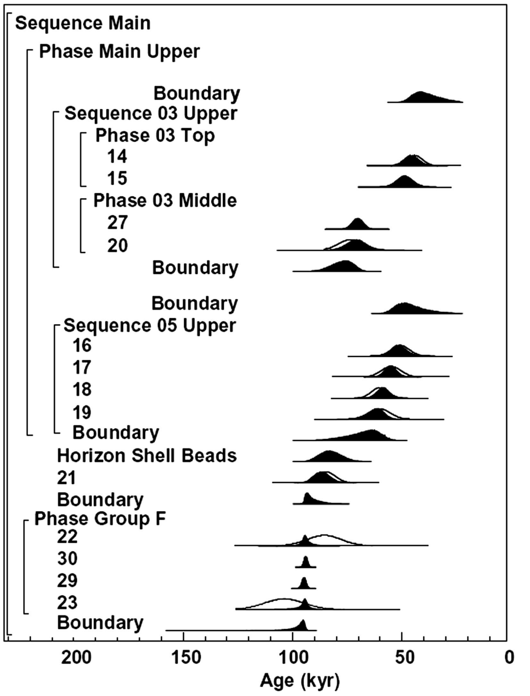


Fig. 2. Bayesian age model results of the 13 OSL, TL, and uranium-series samples used to constrain the age of pierced *Nassarius* shells; numbers refer to the serial number for each sample in SI Table 5. The raw age distribution from each sample is shown with an open symbol, and the Bayesian age model distributions are shown with filled symbols. Boundaries indicate the analysis structure; up to four hierarchical levels of sequences and phases are indicated by the vertical lines at the left of the plot. The best age estimate for the main group of shells is provided by the boundary titled ''Horizon Shell Beads.'' All ages are shown in thousand years (kyr) before present.

the *N. gibbosulus* were not intended for human consumption because all show features characteristic of dead shells accumulated on a shore. These features include encrustations produced by bryozoa, tiny shells, and sea-worn gravel embedded into the body whorl and perforations produced by a predator on the ventral side of the shell (SI Fig. 7). Comparison with the perforation pattern recorded on a modern thanatocoenosis of this species reveals that the Taforalt shells do not represent a random selection from a natural assemblage of dead shells (Fig. 5). None of the archaeological examples is undamaged, whereas almost half of those from the comparative sample are intact, and the perforation type most common on the archaeological specimens is rare in nature. This type, a single perforation on the dorsal side at the center of the last spiral whorl, is observed in only 3.5% of the comparative sample; the probability of randomly collecting a sample of shells like that from Taforalt is extremely low ($P < 0.0001$), which suggests that the shells with a perforation on the dorsal side were either deliberately collected or perforated by humans. Although the latter seems more probable, the agent responsible for the perforations cannot be firmly identified. Microscopic features diagnostic of human intervention in the production of the perforation are absent (39). Hole edges on the dorsal aspect are rounded and smoothed on four shells. The remainder have irregular outlines with chipping of the inner layer, indicating the agent responsible for the perforation punched the shells from the outer dorsal side. Holes with irregular edges may be obtained by punching the dorsal side with a lithic point (2, 11). Smoothed hole edges have been replicated by wearing strung modern shells (39). Both types of hole edges occur on shells used as beads in Upper Paleolithic sites (40). However, they are equally common on naturally perforated shells from a shore (38). Exclusive collection of naturally perforated shells, however, is contradicted at Taforalt by the presence of two unperforated shells in the excavated collection. The aperture of these specimens is obstructed by gravel, which might explain why they were never modified. It also suggests that some, if not all, of the shells from Taforalt had no perforations when they were collected and that they subsequently were perforated by humans. In contrast, the presence of sea gravel stuck in the broken apex of three shells (SI Fig. 7 and Fig. 3, nos. 2, 5, and 7) indicates that the breakage of the apex, also recorded on three other specimens (Fig. 3, nos. 3, 6, and 12), already was present when the shells were collected and is not the result of human agency.

Fig. 3. Five aspects of the *N. gibbosulus* shells (nos. 1–13) from the Middle Paleolithic layers of the Grotte des Pigeons, Morocco, and a modern specimen (no. 14) of the same species from Djerba, Tunisia. Contextual and analytical data are provided in Table 1.

Possible evidence for the stringing of the perforated shells as beads comes from the identification on ten specimens of a wear pattern different from that observed on both the modern reference collection and unperforated specimens from Taforalt. The wear in the latter case homogeneously affects the whole surface of the shells and consists of a microscopic dull smoothing associated with micropits and rare short, randomly oriented striations. The wear on the presumed strung examples is found on the perforation edge and on spots of the ventral and lateral side, and it is characterized by an intense shine associated with numerous random or consistently oriented striations (SI Fig. 8).

Pigment Residues

Microscopic residues of red pigment were detected on one unperforated and nine perforated shells (SI Fig. 9). In the former, the residue is in the space between the parietal wall and sea gravel obstructing the aperture. In the latter, it consistently is trapped in the groove at the contact between the last body whorl and the parietal shield, on the hole edges, the columella, fissures in the parietal shield, and the syphonal canal. On one shell (Fig. 3, no. 9), pigment residue is sealed by calcite concre-

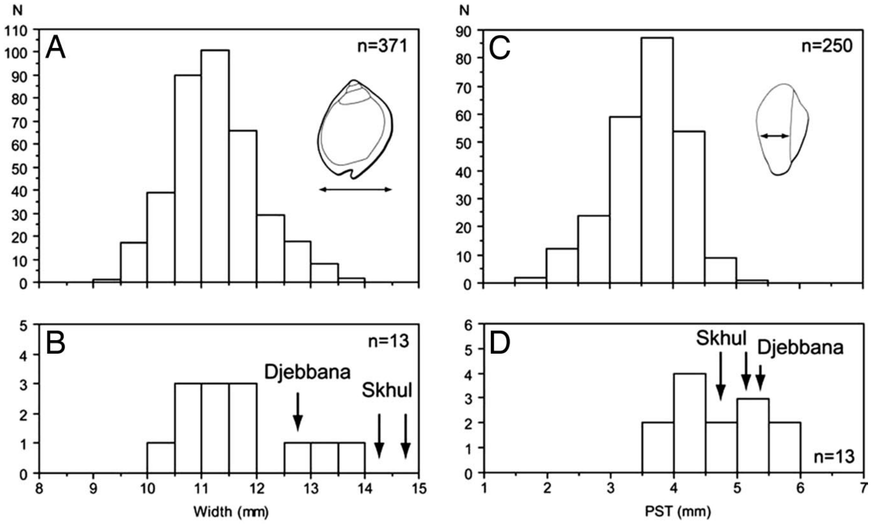


Fig. 4. Width and parietal shield thickness (PST) of *N. gibbosulus* shells collected from modern biocoenosis at Djerba Island, Tunisia (*A* and *C*) and Grotte des Pigeons (*B* and *D*). Arrows indicate the width and PST of the *N. gibbosulus* from Skhul and Oued Djebbana.

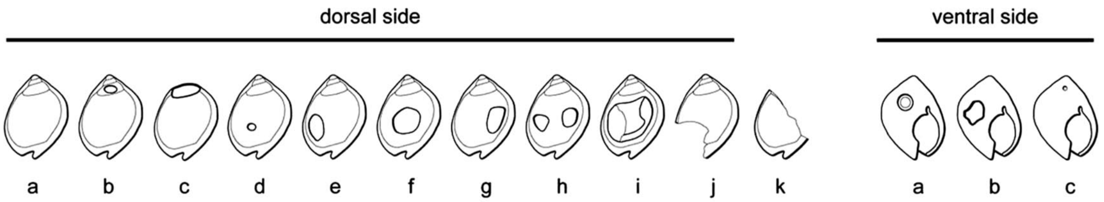
tion. Elemental and mineralogical analysis (see *SI Text*) of the residue on this shell identified the red pigment as iron oxide (currently in a ferric or haematitic state) with a very high proportion (>70%) of iron.

The most likely explanation for the presence of pigment on the shells is their rubbing against material embedded with ochre, such as hide, skin, thread, or other substance. We can rule out accidental causes because in two specimens colorant is stuck in microcracks that cross the worn area, indicating wear and coloring were intertwined processes. No other objects (e.g., artifacts or bones) from these deposits carry similar pigments, nor are there obvious particles of natural ochres/ores in the sediments. As for postdepositional effects, although more or less hydrated iron oxides have contributed a reddish color to the carbonate and phosphate concretions present in the sediment matrix and sometimes adhering to larger objects (especially bones), it is difficult to see how purer iron oxide could have been deposited on the shells at any point during the diagenesis of these cave sediments, let alone how such oxide then could have been so closely integrated with the wear patterns.

Conclusions

The discovery and dating of the perforated marine shells from Taforalt provide unequivocal evidence that dead marine shells were collected on North African shores ≈82,000 years ago. Shells were either perforated deliberately or, less probably, carefully selected on the beach for their large perforation, which is rare in nature, then used as personal items. At Taforalt, the possible stringing of the shell beads and the association with red pigment may have given them added visual value because these were the only items with colorant in the cave. In the MSA of southern Africa, the use of ochred shells also is recorded at Blombos (2).

The Taforalt finds have a much more precise stratigraphic and chronological control than those from Djebbana and Skhul, but together with Blombos, this suggests that soon after 100,000 years, and possibly even earlier (18), personal ornamentation became a widespread practice in Africa and adjacent areas of southwest Asia. This finding implies that, in each of these regions, material culture indicative of one aspect of behavioral modernity was present long before the Upper Paleolithic of Eurasia (41, 42). Although the roots and early spread of bead-making traditions still need to be elucidated, present evidence suggests some homogeneity in the early phases of this phenomenon. The same species of marine gastropod is used at Taforalt, Djebbana, and Skhul, and morphologically similar shells of the



		dorsal side N (%)											ventral side N (%)				
N. gibbosulus collection	N	a	b	c	d	e	f	g	h	i	j	k	a	b	c	d	na
Djerba thanatocoenosis	285	126 (44.2)	28 (9.8)	6 (2.1)	10 (3.5)	8 (2.8)	10 (3.5)	4 (1.4)	4 (1.4)	13 (4.6)	12 (4.2)	64 (22.5)	153 (53.7)	30 (10.5)	31 (10.9)	12 (4.2)	59 (20.7)
Skhul	2	-	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-
Oued Djebbana	1	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-
Taforalt	13	-	-	2	-	-	9	-	-	2	-	-	10	-	2	1	-

Fig. 5. Perforation types (*Upper*) recorded on the dorsal and the ventral sides of *N. gibbosulus* shells and their frequency (*Lower*) in a modern thanatocoenosis from Djerba, Tunisia, and the archaeological specimens from Taforalt.

same genus were used at Blombos, a site located in a region where the species used at the three Mediterranean sites did not exist. In contrast to the Upper Paleolithic of Europe in which >150 bead types are recorded for a single cultural entity (43), only one or possibly two types, if the bivalves from Qafzeh are accepted as personal ornaments, are found at these earlier sites, which indicates that the role beads played in African and southwest Asian Middle Paleolithic societies may have been different from the one personal ornaments had in the Upper Paleolithic of Europe. Is this an early manifestation of symbolic behavior, by which we mean the use of something that represents something else by convention (44), or is it simply a form of material expression requiring no established link between a meaning and a sign? First archaeological instances of modern behavior are notoriously ambiguous. However, results presented above and evidence from other sites (10, 11) indicate that the choice, transport, coloring, and long-term wearing of these items were part of a deliberate, shared, and transmitted nonutilitarian behavior. We argue that to be conveyed from one generation to another over a very wide geographic area, such behavior must have implied powerful conventions that could not have survived if they were not intended to record some form of meaning.

Furthermore, documented lithic raw-material procurement patterning in the African MSA and the Levantine Mousterian only exceptionally exceeds 100 km and generally is much lower (45–47). The transport of shells over distances up to 200 km (Oued Djebbana) and of >40 km, in the case of the shell beads from Taforalt, may suggest the existence, already at this early stage, of previously unrecorded interlinking exchange systems or of long-distance social networks. These networks apparently transgressed cultural boundaries defined by lithic technology, because at least three of the four sites where similar bead types were found can be attributed to a different technocomplex (Taforalt and Oued Djebbana: Aterian; Blombos: Stillbay; and Skhul: Levantine Mousterian).

We still lack the chronological resolution to draw definite conclusions on the time span during which *N. gibbosulus* shells were used for beads in North Africa and southwest Asia. However, it is clear that the practice of bead manufacture was geographically widespread and occurred in regions >5,000 km apart. The discoveries also challenge the notion that the transition to complex behaviors associated with recent humans was focused solely around the MSA–Late Stone Age (LSA) transition in Africa (6).

A.B. thanks the Moroccan Ministry of Culture, Institut National des Sciences de l'Archéologie et du Patrimoine (INSAP), and J. Benslimane for their support. N.B. acknowledges awards from Natural Environmental Research Council (NERC) (NER/T/S/2002/00700), the British Academy (LRG 39859), and Oxford University. F.d. and M.V. thank C. Barbera, B. Cahuzac, L. Charles, C. Claes, L. Ferranti, P. Lozouet, G. Mastronuzzi, H. Mienis, I. Nofroni, R. Sablon, J.-P. Tastet, M. Taviani, J. Todd, and J. Van Goethem for providing information on *N. gibbosulus*. This work was funded by the Origin of Man, Language and Languages program of the European Science Foundation (ESF); the French Ministry of Research; and postdoctoral grants from the Centre National de la Recherche Scientifique and the Fyssen Foundation. E.H. thanks D. Richards and P. Smart for their help and was funded by NERC Grant NER/S/A/2000/03194. S.P. is grateful to the Leverhulme Trust and G. Salter for processing samples. S. Pasty drew the artifacts.

1. Mellars P (2006) *Proc Natl Acad Sci USA* 103:9381–9386.
2. d'Errico F, Henshilwood C, Vanhaeren M, van Niekerk K (2005) *J Hum Evol* 48:3–24.
3. White TD, Asfaw B, DeGusta D, Gilbert H, Richards GD, Suwa G, Clark Howell F (2003) *Nature* 423:742–747.
4. McDougall I, Brown FH, Fleagle JG (2005) *Nature* 433:733–736.
5. McBrearty S, Brooks AS (2000) *J Hum Evol* 39:453–563.
6. Klein RG (2000) *Evol Anthropol* 9:17–36.
7. Bar-Yosef O (2002) *Ann Rev Anth* 31:363–393.
8. Wadley L (2001) *Camb Arch J* 11:201–221.
9. Henshilwood C, Marean CW (2003) *Curr Anthropol* 44:627–649.
10. Henshilwood CS, d'Errico F, Vanhaeren M, van Niekerk K, Jacobs Z (2004) *Science* 304:404.
11. Vanhaeren M, d'Errico F, Stringer C, James SL, Todd JA, Mienis HK (2006) *Science* 312:1785–1788.
12. Taborin Y (2003) in *Echanges et Diffusion dans la Préhistoire Méditerranéenne*, ed Vandermeersch B (Comité des Travaux Historiques et Scientifiques, Paris), pp 113–122.
13. Henshilwood CS, d'Errico F, Yates R, Jacobs Z, Tribolo C, Duller GAT, Mercier N, Sealy JC, Valladas H, Watts I, Wintle AG (2002) *Science* 295:1278–1280.
14. Jacobs Z, Duller GAT, Wintle AG, Henshilwood CS (2006) *J Hum Evol* 51:255–273.
15. Henshilwood CS, d'Errico F, Marean CW, Milo RG, Yates R (2001) *J Hum Evol* 41:631–678.
16. Garrod DA, Bate DMA, eds (1937) *The Stone Age of Mount Carmel: Volume I* (Clarendon Press, Oxford).
17. McCown TD, Keith A, eds (1939) *The Stone Age of Mount Carmel: Volume II* (Clarendon Press, Oxford).
18. Grün R, Stringer C, McDermott F, Nathan R, Porat N, Robertson S, Taylor L, Mortimer G, Eggins S, McCulloch M (2005) *J Hum Evol* 49:316–334.
19. Morel J (1974) *L'Anthropologie* 78:53–80.
20. Morel J (1974) *Bull Soc Préhist Française* 71:103–105.
21. Walter P (2003) in *Echanges et Diffusion dans la Préhistoire Méditerranéenne*, ed Vandermeersch B (Comité des Travaux Historiques et Scientifiques, Paris), p 122.
22. Blondel J, Aronson J (1999) *Biology and Wildlife of the Mediterranean Region* (Oxford Univ Press, Oxford).
23. Roche J (1963) *L'Epipaléolithique Marocain* (Fondation Calouste Gulbenkian, Lisbon).
24. Roche J (1976) *Actes du IXè Congrès de l'UISPP* (Union International des Sciences Préhistorique et Protohistorique, Nice, France), pp 153–167.
25. Roche J (1969) *Quaternaria* 11:89–100.
26. Ferembach D (1962) in *La Nécropole Epipaléolithique de Taforalt (Maroc Oriental)*, eds Ferembach D, Dastugue J, Poitrat-Targowla MJ (Edita Casablanca, Rabat, Morocco).
27. Raynal JP (1980) *Bull d'Archéol Maroc* 12:69–72.
28. Barton RNE, Bouzouggar A, Bronk Ramsey C, Collcutt SN, Higham TFG, Humphrey LT, Parfitt S, Rhodes EJ, Schwenninger JL, Stringer CB, *et al*., in *Rethinking the Human Revolution*, eds Mellars P, Bar-Yosef O, Stringer C, Boyle K (Macdonald Institute, Cambridge), in press.
29. Tixier J (1959) *Bull d'Archéol Maroc* 3:107–247.
30. Tixier J (1967) in *Background to Evolution in Africa*, eds Bishop W, Clark WJD (Univ of Chicago Press, Chicago), pp. 771–820.
31. Roche J (1956) *Quaternaria* XI:89–100.
32. Rivas-Martínez S (1997) *Bioclimatic Map of Europe* (Servicio Cartográfico, Univ de León, León, Spain).
33. Bronk Ramsey C (2000) *Radiocarbon* 42:199–202.
34. Rhodes EJ, Bronk-Ramsey C, Outram Z, Batt C, Willis L, Dockrill S, Bond J (2003) *Quat Sci Rev* 22:1231–1244.
35. Moshkovitz S (1968) PhD thesis (Hebrew Univ of Jerusalem, Jerusalem, Israel).
36. Gili C, Martinell J (2000) *Lethaia* 33:236–250.
37. Siddall M, Rohling EJ, Almogi-Labin A, Hemleben C, Meischner D, Schmelzer I, Smeed DA (2003) *Nature* 423:853–858.
38. Claassen C (1998) *Shells* (Cambridge Univ Press, Cambridge, UK).
39. d'Errico F, Jardon-Giner P, Soler P, Major B (1993) in *Traces et Fonction: les Gestes Retrouvés*, eds Anderson P, Beyries S, Otte M, Plisson H (Éditions ERAUL 50, Univ de Liège, Liège, Belgium), pp 243–254.
40. Taborin Y (1993) *La Parure en Coquillage au Paléolithique* (Centre National de la Recherche Scientifique, Paris).
41. Brantingham PJ, Kuhn SL, Kerry KW (2004) *The Early Upper Paleolithic beyond Western Europe* (Univ of California Press, Berkeley).
42. Mellars P (2006) *Evol Anthropol* 15:167–182.
43. Vanhaeren M, d'Errico F (2006) *J Archael Sci* 33:1105–1128.
44. Peirce CS (1935) *Collected Papers* (Harvard Univ Press, Cambridge, MA).
45. Ambrose SH (1998) *J Archael Sci* 25:377–392.
46. Hovers E, Kuhn SL, eds (2006) *Transitions Before the Transition* (Springer, New York).
47. Minichillo T (2006) *J Hum Evol* 50:359–364.