J World Prehist (2005) 19:119–132
DOI 10.1007/s10963-006-9002-z

ORIGINAL PAPER

Getting "Out of Africa": Sea Crossings, Land Crossings and Culture in the Hominin Migrations

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Published online: 7 July 2006

Abstract Palaeoanthropologists and archaeologists have advanced a wide range of explanatory narratives for the various movements of *Homo erectus*/*Homo ergaster*, and the first modern *Homo sapiens*, "Out of Africa"—or even back again. The application of Occam's razor—a parsimonious approach to causes—gives a more cautious approach. There is nothing in the available evidence that would require the ability for a human water crossing from Africa before the later Pleistocene, whether across the Strait of Gibraltar, the Sicilian Channel or the southern Red Sea (Bab el-Mandab). A parsimonious narrative is consistent with movements across the Sinai peninsula. The continuous arid zone from northern Africa to western Asia allowed both occupation and transit during wet phases of the Pleistocene; there is no requirement for a "sponge" model of absorption followed by expulsion of human groups. The Nile Valley as a possible transit route from East Africa has a geological chronology that could fit well much current evidence for the timing of human migration. The limited spatial and temporal opportunities for movements "Out of Africa," or back again, also puts particular difficulties in the way of the gene flow required for the multiregional hypothesis of the development of modern *Homo sapiens*.

Keywords Out of Africa · Hominin migrations · *Homo erectus* · *Homo sapiens* · Sinai · Nile Valley

Archaeologists and palaeoanthropologists rightly dismiss unnecessarily complex explanations and hypotheses from laypersons for the phenomena investigated and analyzed by their sciences. But within the range of scientific interpretation and explanation, there is a wide range of "might-have-beens" advanced to explain links between identified finds. There is possibly no wider range of diverse interpretations than in the modeling of human origins.

Both palaeoanthropology and the archaeology of early humans operate in a framework where the science is not experimental, data are sparse and hypotheses are not easily refutable

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and replicable. There are few other sciences where an isolated piece of evidence can support or change a broad scale interpretative model without itself being readily testable.

In this framework, personality plays an important role—the conservative thinker or the innovator, the dogmatist or the sceptic, the taxonomic splitter or the lumper. Arguably, our safest touchstone remains the philosophical principle of Occam's Razor, that "Plurality should not be posited without necessity," that the simplest of options should be preferred to the more complex, and a parsimonious approach adopted to interpretation.

Central to the narrative of human evolution is the movements of hominins and their culture "out of Africa," at different temporal phases. A recent article even challenges the "out of Africa" model itself (Dennell and Roebroeks, 2005). This paper argues that the application of Occam's Razor in the framework of present evidence (which can of course change in a day) narrows both the geographical and the temporal options for explanation in the hominin story.

Questions of movement by land and water

Much of the popular (and scientific) debate is in terms of a geographical "Africa" and this stimulates the concept "Out of Africa." Arguably this is a fallacy. The distribution of the early hominins—variously classified as *Australopithecus* spp., *Paranthropus* spp., *Homo habilis* and *Homo rudolfensis*—is not "Africa" but is restricted to the grasslands and relatively open woodlands within Africa, limited by the coastal waters in the east, by the dense equatorial rainforest in the west and by the desert habitats to south–west and especially north, with no *Australopithecus* or *H. habilis* known north of the Sahara belt. The most northerly *Australopithecus*, that from Koro Toro in Chad, is from a mixed woodland-savannah context (Brunet *et al*., 1995). The relatives of the new species *Homo ergaster* who were the *H. erectus* of Asia and the *H. georgicus* of Dmanisi undertook the major hominin migration by moving north into and through what is today the arid zone contiguous from the Atlantic seaboard of Africa through to central Asia, without any water barrier to separate the political unit of "Africa" from "Asia" or "Eurasia." So in one sense there was not an "Africa" to get out of.

Homo ergaster emerged between 2.0 Mya (million years ago) and 1.7 Mya, replacing *H. habilis* in sub-Saharan Africa, and occupied more arid open environments than *H. habilis*—indeed, physically it seems better adapted to heat (Klein, 1999, pp. 249–250). Coexisting with robust Australopithecines and *H. habilis* (though only in sub-Saharan Africa) for the first part of this period, its descendants spread throughout Africa and into Eurasia. Its spread is one of the most interesting issues in palaeoanthropology and archaeology, matched by our interest in the spread of *H. sapiens* and its relationship to the *H. erectus* gene pools of Africa and other regions.

In these debates, we have seen much interest in the question of possible water crossings from the African continent for *H. ergaster*/*H. erectus* and, of course, for early *H. sapiens*. In the literature, this discussion has, too often, been the province of the biologists, the physical anthropologists. But for a terrestrial hominin, viable breeding populations do not cross water on the wind or the waves. It is not biology that allows the crossing of water, it is culture, and that is the province of the archaeologist. Water is crossed by technology and technology is created by culture as reflected by social organization, social need and language (or at least, complex communication). The question of water crossings is inextricably linked to cultural capability.

The earliest confirmed maritime crossings by modern *H. sapiens* remain those from the Indonesian/Malaysian archipelago to Sahul (New Guinea and Australia) in excess of 40 kya

(thousand years ago), as a culmination of a major expansion of modern humans from Africa by ca. 60 kya (Forster, 2004), and very possibly earlier.

In reviewing the evidence we can find no requirement, in the application of Occam's razor, for hominins to have left the African continent by water until the later Pleistocene; nothing is inconsistent with movements limited to land during wet periods in what is now the continuous arid zone that extends across Africa and Asia.

In fact the occupation of Africa's offshore islands, the only sure test of sea-crossings, is a very late phenomenon with even indirect evidence supporting only Holocene dates for the first contact with offshore islands (Mitchell, 2004; Erlandson, 2001) as with most Mediterranean islands (Gamble, 1994, p. 239).

Leaving the African continent

We need to explain and interpret several key stages in hominin dispersals from Africa. At least five stages or episodes have been proposed in more recent literature.

1. The first is the apparent migration of *H. ergaster*/*H. erectus* with a core-chopper technology into areas of North Africa, the Middle East, Georgia (Dmanisi) and east Asia (Zhu *et al*., 2004) around 1.8 Mya or a little earlier, around the Pliocene/Pleistocene boundary. This is close in time to vegetational change in the south Mediterranean region (Bertoldi, Rio, and Thunell, 1989), and is a period of other mammalian migrations (Turner, 1999, p. 567). Dennell (2003, p. 435) argues convincingly for this to be episodic and discontinuous rather than "colonization."
2. The probable further spread by *H. erectus* with handaxe culture is suggested in the Lower Pleistocene, around 1.4 Mya (Bar-Yosef and Belfer-Cohen, 2001) (the Acheulian being considered to have African origins ca. 1.7–1.6 Mya). The Lower Pleistocene saw relatively little dispersal out of Africa of other species, compared to the late Pliocene (Turner, 1999).
3. Sometimes called "Out of Africa 1" is the assumed wide spread into Asia around the start of the Middle Pleistocene, after 800 kya, of hominins, still most commonly classified as *H. erectus,* with fully formed Acheulian technology. The earliest isolated hominin evidence in Europe has a more basic core technology (Roebroeks, 2001, pp. 441–2).

Did the evolution of these hominins into *H. heidelbergensis, H. antecessor* and other archaic predecessors of modern *H. sapiens* involve further migrations from Africa (Klein, 1995, p. 178)? Lahr and Foley (1998) have argued that the major dispersals out of Africa—a one-way movement—took place in the Middle Pleistocene interglacial episodes of OIS 11 (oxygen isotope stage) (i.e., 430–350 kya) then in OIS 5 (i.e., ca. 130–80 kya) and that the common ancestor of modern *H. sapiens* and *H. neanderthalensis* emerged between these episodes at 350–250 kya. But the debate continues.

4. Of key importance is what was originally named "Out of Africa 2": the movement of the first modern *H. sapiens* out of Africa in the early Late Pleistocene—according to some placed ca. 100 or 120 kya (Cameron and Groves, 2004, pp 229–241); with the alternate multiregional hypothesis of a widespread gene exchange within an evolving pre-modern *Homo* population. This would be significantly later than the first emergence of anatomically modern *Homo* for which new dates back to ca. 195 kya in southern Ethiopia have been advanced (McDougall, Brown, and Fleagle, 2005).
5. All these precede the major expansion of modern *H. sapiens* into Eurasia, especially the proposed southern dispersal route (e.g. Stringer, 2000) whose African origins have been

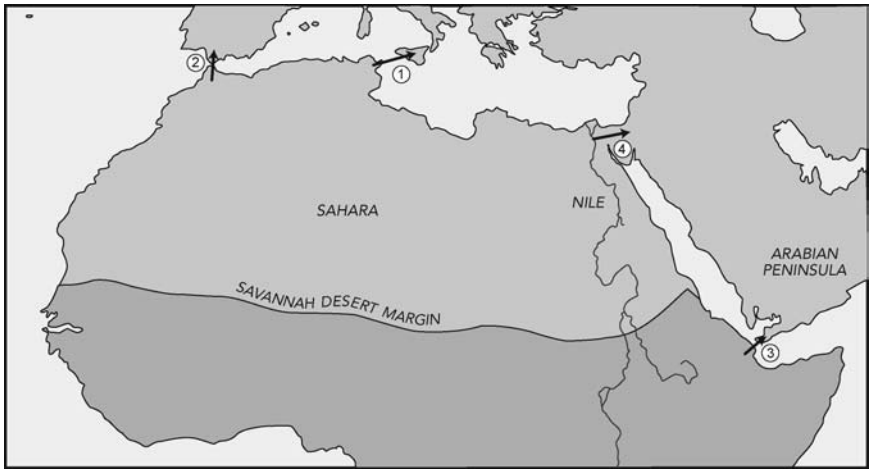

Fig. 1 Northern Africa and possible migration routes. 1 Sicilian Channel. 2 Strait of Gibraltar. 3 Bab el-Mandab. 4 Sinai Peninsula

dated on genetic evidence some time between 85 and 55 kya (Forster and Matsumura, 2005) and which did include maritime crossings, at least in southeast Asia, into New Guinea and Australia, so possibly also across the Red Sea.

Dennell and Roebroeks (2005) have suggested the "lack of evidence" leaves room for alternative models, including Australopithecine migrations to Asia, the evolution of *Homo ergaster* within Asia, and dispersals back into Africa. Such hypotheses put even greater stress on considering the actual possible paths taken in space and time.

Four routes have been suggested for hominins—whether *H. ergaster*/*H. erectus* or early *H. sapiens*—to have left the African continent. One of these—the Sinai peninsula—is a land route and three water crossings have entered the debates: the Sicilian Channel, the Strait of Gibraltar, and the Bab el-Mandab in the southern Red Sea (Fig. 1).

Tunisia to Sicily

The furthest stretch proposed for an early water crossing is the 145 km across the Sicilian Channel between Tunisia and Sicily (which was linked to the Italian mainland by land during Pleistocene glaciations).

In a comprehensive review of the cultural material, Villa (2001) has shown that Middle Pleistocene settlement of Italy came from the north, not via Sicily. There is no cultural material that requires the explanation of a Mediterranean crossing of people carrying Acheulian cultural traditions.

Strait of Gibraltar

Africa is separated from Europe by the Strait of Gibraltar, where the Mediterranean has been open to the Atlantic since the end Miocene around 5.3 Mya. Today the Strait is 14 km wide at its narrowest between Point Marroqui (Spain) and Point Cires (Morocco). Even variable Pliocene and Pleistocene sea levels would not have affected the central channel, 5 km wide, and now 300 m deep, through which most of the sea water exchange passes, with a 2-knot

surface current flowing eastwards. This represents a significant barrier to human migration without sturdy watercraft, though a few modern athletes have swum it in as little as six hours. The most bullish bid for a possible crossing by an earlier hominin species (Arribas and Palmqvist, 1999) claims a sea-level fall of 200 m during the Aullan event (1.8–1.6 Mya) would result in the narrowing of this passage up to 6.5 km approximately, but even with a greater sea level fall there is a significant cross current as barrier.

While assemblages classified on morphological grounds as Oldowan have been found in the Maghreb as well as the upland Central Sahara (Aumassip, 2004, pp. 47–49), absolute dating to confirm these as a pre-Acheulian sequence is virtually absent. The significance and dating of finds at Ain Hanech in Algeria, commonly dated at 1.8 Mya, or of other settlement earlier than 1.2 Mya, is still under debate (Sahnouni *et al*., 2002; Geraads, Raynal, and Eisenmann, 2002). The earliest site in the well researched Casablanca sequence is of Acheulian ca. 1 Mya and the probable *H. erectus* from Ternifine with Middle Acheulian is dated ca. 650 kya (Aumassip, 2004, pp. 40–46). This uncertainly further reduces the Strait as a candidate for such very early hominin migrations, though Aumassip (2004, p. 64) considers Middle Acheulian links from Morocco to Spain existed. While the debate will no doubt continue, the Palaeolithic traditions of Iberia seem to require neither direct origins from, or links with, users of Acheulian traditions in north Africa.

Most researchers acknowledge that this distance, and this water current, was sufficient to inhibit the movement of *H. neanderthalensis* into North Africa from their well attested occupation of southern Spain. Indeed the Neanderthals may, under pressure from modern humans, have had southern Spain (including Gibraltar itself) as a late area of refuge, but still did not have the cultural equipment to expand their territory into the Maghreb.

The whole issue has been usefully reviewed with much of the supporting data by Straus (2001). He concludes not only that Neanderthals did not cross the strait of Gibraltar into North Africa, but also that their sanctuary in southern Spain was safe because the anatomically and culturally more advanced contemporaries in mid-Upper Pleistocene north Africa did not cross into Spain. The cultural contrasts across the Strait remain through the Aterian of the Maghreb Middle Palaeolithic. Straus's findings are that "for the upper Pleistocene, it is only in the terminal Palaeolithic that. . .a credible case can be made for trans-Gibraltar human contact" (Straus, 2001, p. 91). But arguably the limits on cultural contact across the Strait remained at least into the Upper Palaeolithic (Close, in press).

Ironically, Straus accepts that a passage of *H. erectus* across the Strait remains plausible, noting the linear distance to early hominin finds in Europe. However, the linear distance between European and African sites is insufficient to make this a necessary explanation. The Levantine route from north Africa to Spain is still less than from north Africa to Indonesia where *H. erectus* is early attested.

There is therefore no reason—if other explanations for European settlement exist—to suggest that any human species prior to modern *H. sapiens* had the cultural basis to cross from Africa into Europe across the Strait, and no evidence that *H. neanderthalensis* did. The fact that, on a modern map, the land masses are "close" does not mean that to early hominins they were closer than a land link through the Levant to southern Europe.

There are and will remain local enthusiasms to make the Strait a pioneering crossing point for early hominins. In a curious line of argument, in support of early dispersals through Gibraltar and possibly the Sicilian strait, Arribas and Palmqvist (1999) state, "(1) the Levantine corridor requires longer distance movements to reach Western Europe, crossing large rivers and mountainous chains . . .". This has the logical error that early hominins were somehow "trying to reach" Europe by the most convenient route. Arribas and Palmqvist continue, ". . . and (2) a simultaneous colonization of Europe through Gibraltar, perhaps

Sicily, and the Eastern Mediterranean helps to explain the presence [in Europe] of certain African species of large mammals." This creates a strange mental image evocative of the animals sailing on the raft in Yann Martel's novel *Life of Pi*. Turner has noted the Later Pliocene migrations were followed by fewer mammalian migrations in the Lower Pleistocene (Turner, 1999).

Bab el-Mandab

The Bab el-Mandab has similar status in hominin origins, in appearing, on our modern maps, to bring Africa close to Asia (the Arabian peninsula), yet having a firm water barrier to migration. The Bab el-Mandab is the strait that connects the Red Sea with the Gulf of Aden. The surface inflow is to the north. Although about 32 km wide, it is broken by Perim Island (13 km^2 with today a population of one thousand) which is 26 km from the African coast and 3 km from the Arabian coast. No early cultural or human physical remains have been recovered from Perim Island and the whole distance is over double that of the Strait of Gibraltar.

The palaeoanthropologists' assumptions of a possible early Bab el-Mandab crossing are not supported by evidence of a land bridge, despite the periodic lowering of the water level in the Red Sea (Petraglia, 2003, p. 169).

In ecological terms the destination area—the southwest of the Arabian peninsula—is not the most inviting territory for hominin expansion. Nevertheless, the model of migration via the Bab el-Mandab gives a direct route from sub-Saharan Africa which is the hominin homeland.

The spread of Lower Palaeolithic material in the Arabian peninsula includes the southwest, near the Bab el-Mandab (Petraglia, 2003). This was an arid region, in the late Pliocene and early Pleistocene, as it is today. While there are unstratified finds of Oldowan appearance, they may be significantly younger (Petraglia, 2003, p. 148). Artefacts classified on formal grounds as Acheulian have been found in the Arabian peninsula, without absolute dating, and there is as yet no firm evidence of early *Homo* or of Lower Pleistocene cultural material.

However, if it is accepted that early *Homo* did reach north Africa across the Sahara, the Bab el-Mandab is not a requirement to explain human expansion into Asia and the Arabian peninsula, only a possibility.

Research is under way to examine the Red Sea area for early settlement and movement. A preliminary note (Flemming *et al*., 2003) argues that the Bab el-Mandab may have been only 5 km wide at the glacial maxima and emphasises the prehistoric evidence in the Arabian peninsula. However, access to the Arabian peninsula via Sinai is no harder than to the Caucasus and other occupied regions. There is no cultural, fossil hominin, ecological or chronological evidence at present that precludes the human settlement of the Arabian peninsula entirely via the land routes to the north.

Only with the later expansion of modern *H. sapiens* ca. 60 kya does a water crossing of the Red Sea fit more closely with the necessities of the genetic and archaeological evidence (Forster and Matsumura, 2005) and this cultural capacity is seen as part of the same cycle with the first settlement of Australia and New Guinea before ca. 40 kya.

Into Sinai

The only land route out of Africa is into Sinai and, more important, this has been the only land route throughout the Pliocene and Pleistocene.

The western boundary of Sinai is ecologically diverse as is Sinai itself. Routes into, and out of, Sinai are the limiting factors on human movement. The Sinai peninsula covers 61,000 sq. km and, being part of Egypt, is politically part of modern Africa. The completion of the Suez Canal in 1869 created a water boundary. Sinai—at a maximum 210 km from west to east—is ecologically an extension of the eastern desert of Egypt and its link to the Negev desert (and on the north to the Gaza Strip). The western land "boundary" of Sinai is across a range of different areas, from north to south:

- A possible strip of sandy dry land only accessible in glacial periods at low sea level of the Mediterranean (120–140 m below interglacial level)
- Marshy areas
- Dry land between the marshy areas and Lake Timsah (about 30 km long)
- Lake Timsah (which has been dry in modern times before the Suez canal opened)
- Dry land between Lake Timsah and the Great Bitter Lake (about 15 km long)
- Great and Little Bitter Lakes
- Dry land between Bitter Lakes and Gulf of Suez (about 25 km long)

To the south lies the Gulf of Suez, some 315 km long and 19–32 km wide, with a maximum depth today of 75–80 m and an average of 40–60 m. in many parts. Therefore, much of the floor of the Gulf would have been exposed during the drier stages of the Pleistocene, extending the access into the Sinai peninsula from the Eastern Desert, but remaining a flooded barrier during the wetter phases (Fig. 2).

Thus in climate like today's there is a potential for land crossing out of Africa across three zones totaling 70 km width, out of a total African coastline estimated variously from 30,500 km up to two and a half times that length. In the wetter periods of the Pleistocene the coastal strip would not have existed, the marshy areas and lakes would have been fuller, narrowing further the actual access routes between the Eastern Desert and Sinai. This is important in contrasting movements "out of Africa" with movements within Africa and within Eurasia.

Within and across Sinai, water is the limiting factor on human settlement so that most population past and present is on the northern fringe. The major trade route since

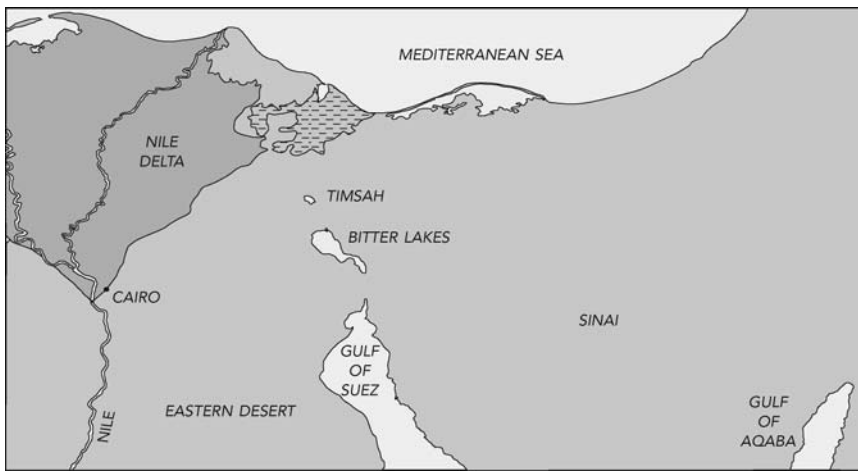

Fig. 2 Western Sinai and the eastern desert

predynastic times runs along the north of Sinai into Palestine; Oren (1973) notes the growth of contacts between Egypt and the Levant from the predynastic era. In a climate like that of the modern era, most routes are from these western land entries across the northern part of Sinai to the Levant. A route also exists parallel to the coast, avoiding the more arid interior.

The possibility exists of a wider coastal strip during the low sea levels that accompanied the cold phases when the desert was probably driest and the area least inhabited. This strip was mainly sand and sandy loam which was not attractive to human occupation (Ronen, 1983). However, Smith (1989) argues it was the coastal sands and salt marshes with at least an element of Mediterranean flora that was the main avenue of contact in later Holocene prehistory between north Africa and the Levant. During such drier periods of the Pleistocene, however, the Gulf of Suez would have been very much reduced and much of western Sinai more readily accessible from the Eastern Desert. Thus one could say that, environmentally, the Eastern Desert of Egypt and the Sinai Peninsula, being contiguous arid zones, can be regarded as one region. The greater economic and environmental barrier lies in entering and occupying the Eastern Desert; the extension into Sinai is not noticeable.

Both Eastern Desert and Sinai have been subject to archaeological survey though much more potential remains; most emphasis has been on historic remains or the rock art of nomadic herders or recent hunters.

A climatic framework

It can be seen that the region was able to support hunter-gatherer activity which fluctuated with wet and dry periods. In broad summary one can reconstruct an arid zone of the Eastern Desert and Sinai which in the emergence of wet periods of the Pleistocene and post-Pleistocene attracted occupation, but not intensive occupation, from nomadic hunter-gatherer groups within limits set by the availability of fresh water and the distribution of food resources which were also, of course, determined by fresh water. Mobility in such a situation would involve movement of small populations within and through the Eastern Desert/Sinai linked area. Groups moving to the more fertile edges of the region would be rewarded with richer environments. However, the onset of the dry periods of the Pleistocene would severely limit the resources for human groups in the region and significantly reduce both use and passage.

The model is not so much one of a sponge (absorbing populations then squeezing them out with the onset of arid periods) as of a region inviting for settlement and transit alike, then losing its attraction for both processes. This model would help identify the potential periods of settlement and movement into Eurasia. However, the definition of wet and dry periods in the region is still unsettled. In particular, there is a long history of debate and no universal agreement on how closely the wet and dry cycle of the Saharan region can be correlated with the warm and cold cycle of the northern glaciations (and the sea level changes that accompanied this).

Lambeck *et al*. (2002) have recently assessed that there is a complex relationship between the glacial/interglacial periods and the process of desertification in Africa and the Middle East; involving both time delays and feedback. In the less widely accepted hypothesis that some wet phases in Saharan Africa were correlated with cooler glacial episodes, lower sea levels could have opened up a wider migration zone from Africa to Eurasia along the Mediterranean coast and across a dry Gulf of Suez. which itself would have allowed greater population densities and higher population movements. But if the dry periods coincided with

the colder phases, as is more widely accepted, this lower sea level (and greatest access from the Eastern Desert to Sinai) would be when the region was least inhabited.

Vrba (1995, especially pp. 28–29) has used the warm/wet and cold/dry correlation to argue for an interesting "traffic light" model. This would allow mammalian migrations north from Africa to Eurasia in the short periods after the onset of each warm phase and the rise of sea levels to close land bridges. However, for the Pleistocene this clever concept is limited by the absence of such land bridges to be crossed, with the exception of the probable areas of the Gulf of Suez and the Mediterranean side of Sinai.

More convincing is the assessment by Bar-Yosef (1995). He supports the view that in the arid Sahara-Arabia region human populations did not survive during the northern glaciations. This would limit occupation and transit to the warm interglacials and the wetter conditions that accompanied them in today's desert region. The onset of an interglacial thus provides an opportunity to leave Africa/Sinai for Eurasia, and this opportunity is then blocked by the glacial onset. Bar-Yosef suggests movement to Eurasia would be at the onset of glacial/dry conditions, but as indicated above, there is no need to adopt a pull/push, squeezed sponge, model. The onset of a glacial dry may well have squeezed the last remaining human groups out of the arid zone (to the northeast and south) but they could just as easily have migrated across the zone throughout the interglacials.

Lambeck *et al*. (2002) argue that interglacials occurred for less than 10% of the Pleistocene. If these are even loosely correlated with the periods when the Sahara-Arabian region could have hominin occupation and transit, it gives us some neatly defined windows of time, as well as space, for Pleistocene migrations "Out of Africa."

The Late Pleistocene stages relevant to modern human migrations are those dated approximately 130–75 kya (OIS stage 5), and 60–25 kya (stage 3) as well of course as the present interglacial, from ca. 12 kya. The first of these correlates with the genetic record to give the most likely period for "Out of Africa 2." Seven Middle Pleistocene warm periods are identified in the sequence of oxygen isotope stages, from OIS 21 (after 900 kya) to OIS 7 (ca. 250–190 kya). The last of the Lower Pleistocene temperate phases may also provide such a window. This provides a framework in which to place any expansion of the range of archaic *H. sapiens*, as well as the major spread of early *Homo* with advanced Acheulian technology—"Out of Africa 1."

A chronology of warmer, interglacial, phases within the Lower Pleistocene gives the framework in which we can set the earlier, sparser migrations, and we need such a framework from Quaternary geologists in which to bracket these archaeological events.

The arid zone

To reach Sinai from savannah Africa requires movement across the Sahara, or along the Nile Valley, or through the Eastern Desert which extends between the Nile and the Red Sea.

In the Eastern Sahara (i.e., west of the Nile Valley), Acheulian occupation predated 300 kya (Hill, 2001). A long and hyperarid period separated the wet period of the Late and Final Acheulian from the next wet period (Wendorf and Schild, 1980, pp. 225–228). The conclusion of the team working at Bir Tarfawi and Bir Sahara East was to bracket the Saharan Middle Palaeolithic within the period 230–260 kya (Wendorf, Schild, and Close, 1993, p. 558) (Haynes, 1997). The Middle Palaeolithic of the Sahara was a wet-phase phenomenon. Before this recent research, (Said, 1993, pp. 46–50) had linked the Egyptian Middle Palaeolithic to a Saharan wet period from ca. 200 kya with no later pluvial period to postdate the Mediterranean Mousterian, and the Aterian settlement of the Sahara.

Sodmein Cave in the Eastern Desert near the Red Sea shows the Middle Palaeolithic during wet phases and the cave was visited over a long period for short visits. There was a significant wet phase dated ca. 115 kya, which can be correlated to the warm OIS 5 (Mercier *et al*., 1999; Moeyersons, Vermeersch, and van Peer, 2002).

We can consider the Sahara climatic variations in part by looking at recent variations. The early Holocene of Africa is thought to have had a wetter stage with drier conditions from ca. 4500 B.P. Lake levels are thought to link with glacial changes, with lower lake levels (like low sea levels) correlating with glacial maxima—the cool/dry link (Hassan, 1997). In North Africa a warmer, wetter period from ca. 14000 B.P. was interrupted by arid intervals at 10550–9200 and 7000 B.P. and there is scattered evidence for other drought periods in the Holocene sequence.

An arid Pleistocene Sahara would not support human occupation or transit. A wet phase—tentatively linked to the warm stages—would permit modest populations to enter and occupy appropriate regions of the arid zone of the Eastern Sahara and the Eastern Desert, while equally allowing them to migrate on via Sinai, to Arabia, and to the more fertile regions of Eurasia. The existing desert evidence is consistent with such a pattern of wet phase use in the Acheulian and Middle Palaeolithic interrupted by periods without human occupation or transit. Van Peer (1998) dates only to the last interglacial an expansion to the desert of the Nubian complex of the Nile Valley Middle Palaeolithic.

Reaching Sinai via the Nile

A glance at an environmental map of Africa would suggest that one convenient way to reach Eurasia from savannah Africa was to follow the River Nile. The problem with this explanation is that for most of the Lower Pleistocene, there was no River Nile.

Vermeersch (2001) has noted this difficulty of reconstructing a movement from sub-Saharan Africa into the Levant. While the Nile Valley is the obvious route, he notes an arid period 2.0–1.8 Mya in which the Nile itself may have ceased to flow, and notes there are no Lower Pleistocene hominin remains in the Nile Valley. The Middle Pleistocene created the water flow of the Nile but the archaeological evidence of the Nile Valley is sparse. He puts more emphasis on the African links to the Levant in the Middle Palaeolithic (Mousterian) era. The paucity of archaeological material obscures the story.

In his authoritative overview of the geology of the Nile, Rushdi Said (1993, pp. 2–5) noted that the original Nile operated as a gulf from the Mediterranean and ceased to exist throughout the Lower Pleistocene from 1.8 Mya (when African forest zones also began to reduce) to ca. 800 kya. If the river were a transit route north, that would apply only to the earliest sporadic *H. ergaster*/*H. erectus* and no confirmed chopper-tool assemblages are known from the Nile Valley. With the creation of the drainage system of the modern Nile at the beginning of the Middle Pleistocene ca. 800–700 kya, it could have been a migration route for people with advanced Acheulian culture ("Out of Africa 1") and the more frequent Nile Valley Acheulian finds, although hard to date, would support this possibility. Said (1993, pp 40–41) recognized two short episodes of more frequent rain in the Lower Pleistocene; such episodes might mark periods when the first hand-axe makers moved north out of Africa. However, Said considers (Said, 1993, p. 178) that during at least the later wet phases of the region, the Nile Valley would have been less attractive for human occupation than the Sahara.

If we were to accept the Nile as the means of reaching Eurasia from savannah Africa, then the geological and archaeological history still allows a parsimonious explanation for early hominin migrations, although we must be careful of too dogmatic acceptance of such

a simple approach. The Nile which existed before ca 1.8 Mya is consistent with the time of the first, sparse, movements of early *Homo* out of Africa through Sinai and with Turner's argument (Turner, 1999) for late Pliocene rather than early Pleistocene migrations. Given the possibility of very brief periods of rain in the Nile Valley record, these could be consistent with the further movements of early *H. erectus* with early Acheulian culture. The creation of the modern Nile at the beginning of the Middle Pleistocene ca. 800 kya coincides with what is sometimes called "Out of Africa 1" and is the most parsimonious explanation for the significant spread of a fully developed Acheulian culture.

The relationship between the Nile Valley Middle Palaeolithic, which begins earlier than OIS 5, and that of adjacent desert areas sets a framework within which to discuss the dating of "Out of Africa 2" (van Peer, 1998, p. S117). The increased flow of the Nile at certain time is emphasized by the age of Mediterranean sediments, sapropels dated to 124, 102, and 81 kya (McDougall, Brown, and Fleagle, 2005; Lourens *et al*., 1996).

And back again . . .?

This paper suggests that movement out of Africa was very tightly bounded by time and space. It was limited by those periods when rainfall was sufficient to allow sparse populations to enter, survive and pass through zones which today (in a dry stage of the Pleistocene) are inhospitable. In those phases it was probably limited by narrow necks of land, a few kilometres wide, that separated water and marsh in the area where the Eastern Desert meets western Sinai. This does give a pattern consistent with the "Out of Africa" model for the emergence of modern humans.

In such a framework of time and space, the amount of genetic transmission back across the Sinai/Eastern desert link could never be substantial, despite the enthusiasm of Dennell and Roebroeks (2005) for "two-way traffic." We can envisage at most a small breeding population of hominins with links to the south and west into Africa, and links north and east into Eurasia. Such an image seems inconsistent with the hypothesis that modern *H. sapiens* developed across a vast region from a single genetic pool. That pattern presumes a significant amount of genetic exchange across those few kilometers of uninviting land that mark the point where the African continent meets Sinai and the links to Eurasia. It is therefore hard, using the principles of simplicity and Occam's razor, to accommodate the significant global gene flow, across the limited area between Sinai and the Eastern Desert, which would be required to support the multiregional hypothesis for modern human origins, to the real time and space constraints.

Models for movement

The application of Occam's Razor—the preference for the simplest solutions consistent with current evidence—helps narrow the options in space and time for early human movement out of Africa. However, it should be noted that new discoveries in the archaeological record could change any of these assumptions.

Without such a parsimonious approach to interpretation, the potential for an explanatory framework broadens to the untestable. Dennell and Roebroeks (2005) argue the possibility that *H. ergaster* (and thus *H. erectus*) originated in Asia, noting "we cannot show the absence of hominins from areas in Asia at a time before the little evidence we have indicates their

presence." The application of such an approach more broadly to world prehistory would be substantial.

A parsimonious approach to explanation leads to several conclusions.

1. Water crossings: nothing in the archaeological record requires crossing of water boundaries rather than the Sinai land bridge before at least the late Pleistocene (the movements now dated some time after 85 kya).
2. There is no reason to suppose that today's arid regions operated like a sponge, retaining human populations in wet periods and only expelling them into Eurasia with the onset of the dry conditions.
3. Rather, there is ecological continuity of today's desert regions across north Africa, Sinai, Arabia and southwest Asia. Hunter-gatherer populations could both occupy and cross these arid regions to more fertile zones throughout the wet periods which are, today, thought broadly to be correlated to the warm interglacials.
4. An alternate route from savannah Africa to Sinai lies in the Nile Valley, and such a route is consistent with the apparent interrupted stages of migration; the first migrations of early *Homo* and the major Acheulian "Out of Africa 1" bracket the period when the Nile ceased to flow.
5. The wet period equivalent to interglacial OIS 5 (ca. 130–75 kya) coincides with the period acknowledged to mark "Out of Africa 2" and is consistent with movement through today's arid region. The geographical and climatic limitations on movement between Africa and Eurasia seem insufficient to support the level of gene flow required by the multiregional hypothesis for the emergence of modern humans.

Acknowledgements Thanks for assistance or comments to colleagues including Geoff Bailey, Angela Close, Iain Davidson, Robin Dennell, Donald Denoon, Colin Groves, David Phillipson, and an anonymous reviewer, none of whom are implicated in my conclusions, errors or omissions.

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