

five neutrons to produce the desired product. They have identified one decay chain attributable to $^{273}\text{110}$, but are still analysing their data.

All of these developments have caused much optimistic activity centring around the prospects of producing still heavier elements and longer-lived isotopes of currently known elements. Nuclear chemists hope that some of the new isotopes may live long enough to permit chemical studies which can now be conducted on the timescale of seconds. An international group is preparing to do such studies on element 106 at GSI in the next year.

Plans for newer, still more efficient instrumentation for the detection of elements 112, 113 and 114 are proceeding apace. Such 'superheavy' elements have long been sought. Originally the term was reserved for the cluster of relatively stable elements predicted to exist around the spherical shells at 114 protons and 184 neutrons — the 'island of stability'. Investigators are now establishing the existence of a 'rock of stability' at much lower

neutron numbers. The isotopes $^{271}\text{110}$ and $^{272}\text{111}$, as well as some of the longer-lived isotopes of elements 106 and 108, may be stabilized by their proximity to the deformed shells at 162 neutrons and 108 protons, and it has been proposed that these qualify as 'superheavy' elements. But detection of 'true' island elements requires creation of nuclides with neutron numbers near 184 — some 20 neutrons more than the most neutron-rich isotope known to date. Nevertheless, the current rock will be a stepping stone to allow us to reach element 114 even before reaching the spherical closed shell at 184 neutrons.

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1. Hofmann, S. *et al.* *GSI-94-82 Preprint* (November 1994); *Z. Phys. A* (submitted).
2. Hofmann, S. *et al.* *Z. Phys. A* (submitted).
3. Sobczewski, A. *Phys. Particles Nuclei* **25**, 295 (1993).

PALAEOANTHROPOLOGY

Homo at the gates of Europe

David Dean and Eric Delson

ALL current evidence points to Africa as the place that the human lineage originated¹. But the questions of when humans first left the continent and where in Eurasia they went are highly controversial². On page 509 of this issue³, Gabunia and Vekua add grist to the mill by describing a fossil mandible from Dmanisi, Georgia, attributed to *Homo erectus*. The mandible has been dated by three independent methods to about 1.8 million years old (Myr), making it comparable in age to the most ancient specimens from two sites in Java⁴; but although the dates provided by Swisher *et al.*⁴ are technically excellent, whether or not they apply to the human fossils at both sites is still questionable^{5,6}.

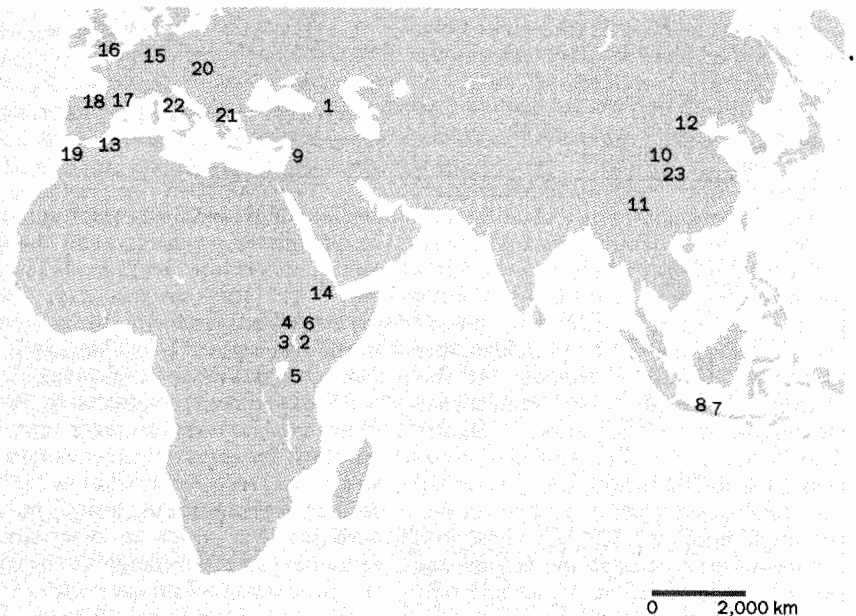
Until a year ago, most researchers would have accepted a date of about 1.25 Myr as a maximum for the first appearance of *Homo erectus* in Eurasia, either in China (Lantian Gongwangling or Yuanmou) or Java (Sangiran or Mojokerto). Older ages had been proposed, but they were mainly discounted, and even the 1.25 Myr Rubicon was questioned as possibly too old. In Africa, the first appearance of this species, there sometimes termed *Homo ergaster*, was dated to about 1.8–1.9 Myr⁷. The earliest human fossils in western Eurasia were dated to 0.5 Myr or less, and most palaeoanthropologists identified these as representing not *H. erectus* but early populations of *H. sapiens* or perhaps a distinct intermediate

species⁸. Claims of more ancient human occupation were based upon supposed mode 1 (Oldowan-like) archaeological residues (see ref. 9), but these had been

questioned both as to the age and human origin of the purported artefacts².

Then Swisher *et al.*⁴ reported high-precision dates of 1.6–1.8 Myr for the oldest fossils at the two Indonesian sites, reopening the questions of whether these Asian populations indeed represented a different species from the African and whether mode 2 (Acheulean) archaeological industries had developed by the time hominids left Africa. The earliest African Acheulean is now dated at about 1.4 Myr in Ethiopia¹⁰, and similar assemblages are known from 'Ubeidiya, Israel, estimated to be of equivalent age (but unassociated with diagnostic human remains)¹¹.

Gabunia and Vekua³ now shift attention westwards again to Dmanisi, which was a major centre between the eighth and twelfth centuries. Excavations there revealed a number of deep pits for grain storage dug into the floors of now-collapsed buildings. In 1981, the walls of such a pit revealed animal bones *in situ* which were identified as belonging to species of Late Villafranchian (Late Pliocene to Early Pleistocene) age, according to the well-documented sequence of mammalian faunas of the Black Sea region. Further work resulted in the recovery of mode 1 artefacts and the development of a stratigraphic profile with normal geomagnetic polarity throughout and a basal basalt dated to about 1.8 Myr. Finally, in 1991, the team found a well preserved human mandible in one of the storage pits.



Fossil localities mentioned in the text and other important sites of early *Homo*. 1, Dmanisi; 2, Koobi Fora (East Turkana); 3, West Turkana (Nariokotome); 4, Omo Shungura; 5, Olduvai Gorge and Lake Ndutu; 6, Konso-Gardula; 7, Mojokerto; 8, Sangiran; 9, 'Ubeidiya; 10, Lantian (Gongwangling); 11, Yuanmou; 12, Zhoukoudian; 13, Tighenif (Ternifine); 14, Bodo; 15, Mauer (Heidelberg); 16, Boxgrove; 17, Arago; 18, Atapuerca; 19, Thomas Quarries; 20, Vértesszöllös; 21, Petralona; 22, Fontana Ranuccio; 23, Yunxian. Sites 1–8 and 10–12 have yielded *Homo erectus*; site 9 early artefacts and unidentified human bone fragments; sites 5 and 13–23 early 'archaic' *Homo sapiens*.

Features of the Dmanisi mandible

THE molar teeth of the jaw show a great size reduction from front to back, greater than that known for any Asian (or African) *H. erectus* fossil or sample, and similar in some ways to that seen in later 'archaic' specimens of *H. sapiens*, such as those from Atapuerca (Spain). The rami are broken away, but they would almost certainly have splayed out postero-inferiorly as in African and Chinese *H. erectus*; moreover, the rear of the tooth row is crowded, as evidenced by the reduced M_3 and lack of a retromolar space. As in all *H. erectus*, the symphysis in the Dmanisi mandible is rounded anteriorly, although it does not slope back as steeply as in some early African individuals (for example WT 15000; ref. 14). On the other hand, the Dmanisi jaw shows no sign of the lateral tubercles on either side of the symphysis which are responsible for the mental trigone in the earliest 'archaic' *H. sapiens*. These tubercles are probably the result of greater

'wishboning' stress due to increased brachycephaly and klinorhynchism in early *H. sapiens*. The angulation of the mental area is less important than this biomechanical shift, which should be the subject of renewed investigation.

All the mandibular differences may reflect evolution towards a wider cranial base and perhaps other 'gestalt' changes in earliest 'archaic' *H. sapiens* as compared to *H. erectus*. Increased brachycephaly would result in less prognathism and greater distance across the mandibular condyles, so that the gonial area need not splay out to provide proper position for the masseter muscle, and the symphysis, in effect, would 'migrate' back to the lateral tubercles as it widens. As the anterior dentition later becomes smaller, the intertubercular width decreases and the general gracility leads to the modern trigone and mental eminence.

This new interpretation of the anterior mandible leads to a better understanding of

the value of this region in taxonomic evaluation of individual fossils — for example, the Tighenif (ex-Ternifine) mandibles appear to display lateral tubercles, which led one of us (D.D.) to transfer that population to *H. sapiens*¹⁸. In turn, given the estimated age of 0.6–0.7 Myr for Tighenif and the age of ~0.6 Myr for the Bodo (Ethiopia¹⁹) cranium of early *H. sapiens*, it is likely that, at the least, earliest 'archaic' *Homo sapiens* populations were present in the northern half of Africa before the earliest known anatomical evidence for their presence in Europe, ~0.5 Myr². Recent evidence from East Asia suggests that there was a late but long (0.3–0.15 Myr) period of overlap between 'archaic' *H. sapiens* and late-surviving *H. erectus*. This implies that the routes to East Asia might not have been open to 'archaic' *H. sapiens* until after Europe had been successfully inhabited.

D.D. & E.D.

Analytical details have not been published for either the date or the palaeomagnetic profile, but they are concordant with a correlation to the Olduvai normal geomagnetic subchron, currently dated between 1.77 and 1.95 Myr⁶; the base of the Pleistocene is defined as just younger than the end of this interval. This would fit closely with the estimated age of the faunal assemblage, which might date at between 2.1 and 1.4 Myr. If indeed the polarity is normal, no other option remains: the Réunion Subchron(s) date to 2 Myr or older¹², while the only younger normal subchrons are the newly revitalized Cobb Mountain at about 1.15–1.2 Myr¹³ and the Jaramillo spanning 1.0 Myr. The associated fossil mammals, including rodents of Pliocene affinity and no species of Biharian age, count as strong evidence against the younger dates. On the other hand, it is conceivable that the palaeomagnetic analysis did not involve sufficient (alternating field) demagnetization to remove later overprinting, in which case the fossils could be of somewhat younger age.

There is little doubt that the mandible itself can be attributed to *Homo erectus*. We do not consider that the African Pleistocene fossils sometimes termed *H. ergaster* represent a distinct biological species, given the known ranges of variation — ref. 7 supports the concept of *H. ergaster*, while refs 14 and 15 reject it (as we do). But several features of the Dmanisi jaw are quite distinctive, especially when taken in combination. The technical details and their implications are discussed in the boxed text.

As Gabunia and Vekua note, if the Dmanisi specimen indeed dates to 2.0–1.5 Myr, roughly 1 Myr passed between then and the first widespread occurrence of

humans farther west, in Europe proper. Was this time gap the result of climatic severity, such that pre-*sapiens* humans were unable to survive long in the periglacial environments of even southern Europe? Or was it related to their inability to cope with the large terrestrial carnivores, as hypothesized by Turner¹⁶? Further studies of the archaeological residues at Dmanisi, as well as determination of whether the fauna was human food refuse or the result of other taphonomic circumstances, should help to answer these questions. As Bar-Yosef¹⁷ points out, most of the mammalian fauna of Pleistocene southwest Asia is derived from farther east or perhaps Europe; little of it, other than *Homo*, comes from Africa. Whatever the sequence of sites, *H. erectus* must have traversed southwest Asia en route to Indonesia, China and the rest of Eurasia, but various attempts may have been made before one or more colonizations were successful¹⁷.

Perhaps the situation in the Early Pleistocene was analogous to that around 0.1 Myr, when (according to one view) early modern humans entered southwest Asia from Africa but did not move into Europe for over 50,000 years. It may be that

cultural adaptation, involving toolkit technology and perhaps broader social evolution, was at the root of both successful invasions of western Eurasia, by 'archaic' and anatomically modern *Homo sapiens*, respectively. Given our growing understanding of *Homo erectus* and 'archaic' *Homo sapiens* palaeodemography and migration patterns, it is becoming ever more clear that these two species form an ancestor-descendant pair in the Middle Pleistocene, with the latter replacing the former from west to east. We are now faced with the continued challenge of finding not only more evidence of these extinct populations, but also the palaeoclimatic and perhaps technological conditions which allowed or prevented them from occupying various regions of the Old World, including the cul-de-sac we know as Europe. □

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