



# Early human expansions into Eurasia: The Atapuerca evidence

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## Abstract

The first humans to have migrated out of Africa were the ancestors of the Pithecanthropines — *Homo erectus* — of Java. Different sources point to ca. 1.9 Ma as the date of their exodus. Although the demographic success of early species of genus *Homo* preceded the 1.9 Ma date, a period of severe environmental crises ensued. A second dispersal was that of the Dmanisi population — *H. ergaster*, or *H. sp. cf. Ergaster* — these hominids came out of Africa most probably around 1.7 (earlier than 1.6 Ma BP), a time of continental uplift, aridification, the radiation of the Paranthropines, and the evolution of humans, all of which preceded the development of Paleolithic Mode 2 industries. The third movement of humans from Africa is attested to by the finds of Ubeidiya, with an Acheulean (Mode 2) artifactual assemblage, and a combination of faunal elements from East Africa and Eurasia that indicates an age of no more than 1.4 and barely less than 1.3 Ma. That interval is characterized by warm and humid climatic conditions, and vegetation improvement. The migration of mammals to the north may coincide with an inflection in environmental conditions dated to 1.3 Ma, or later. The record of fossil humans in Africa declines markedly at around 1.3 Ma BP, and recovers only slightly half a million years later, with a few localities between 800 and 600 ka BP. The evaluation of effects on human populations is impeded by physiographic changes globally adverse to sedimentary conditions for fossilization and the preservation of occupation floors. Archaeological and paleoanthropological sites in Eurasia, particularly the Atapuerca-Gran Dolina site, with findings in the “Aurora” Bed, testify to the successful expansion of a deme with modern asiatic traits, descendants of an ancient, not a new out-of-Africa exodus (that is, related neither to Geshar Benot Ya’aqov nor to Ubeidiya). More recent movements, at about 0.6 Ma, may correspond to the African origins of the European preneandertals — *H. heidelbergensis* — and Neandertals, as can be inferred from studies of the large fossil human sample of the Atapuerca-Sima de los Huesos site. Evidence points to several population movements between Africa and Eurasia in the past, and to a complex origin of modern mankind — *Homo sapiens*. © 2001 Elsevier Science Ltd and INQUA. All rights reserved.

## 1. First Out-of-Africa dispersal: Java

Evidence for an early exit out-of-Africa can be found in the Pithecanthropines — *Homo erectus sensu stricto* — of Indonesia. In these hominids, plesiomorphic traits of Australopithecines or of *H. habilis* are seen, and apomorphic, modern trends appearing in *H. ergaster* are absent. Consequently, it is most likely that the ancestors of Indonesian *H. erectus* departed from Africa no later than the time of the adaptive success of *H. ergaster* (i.e., at about 1.8, and not much before 1.9 Ma BP). These dates are consistent with both the chronometric ages assigned to the oldest Pithecanthropines of Sangiran [ca. 1.1 Ma (Hyodo et al., 1993), and ca. 1.8 Ma (Swisher et al., 1994)]; with the period of the creation of the Sunda Sea, in the later Olduvai magnetic subzone (Watanabe and Kadar,

1985; Sémah, 1997); and also with the dates of the earliest land mammal faunas of Java, near the end of the Olduvai (Leinders et al., 1985).

Just before 2 Ma, and between 2 and 1.9 Ma BP, hominid expansion, high mean sea level (MSL), lacustrine environments (Feibel et al., 1991; Feibel, 1999), a temperate and humid climate — forest, mosaic vegetal cover, vegetable resources even in high zones (O’Brien and Petters, 1999) — and increased mammal diversity (Behrensmeyer and Bobe, 1999) are recorded. At about or soon after 1.9 Ma, a change to colder and more arid conditions, globally compressive tectonics, lowered MSL, isthmuses in Bering and Sundaland, new faunal exchanges across Panama, faunal turnover mostly among the Bovids (Vrba in Vrba et al. (1996)), cooler vegetation at the end of Tiglian sequences (Zagwijn, 1992), and a generally coarser sedimentary regime are all described. The deterioration of the environment (climate, and vegetation), mammal extinctions, and an increasing number of herbivores are repeated from right before

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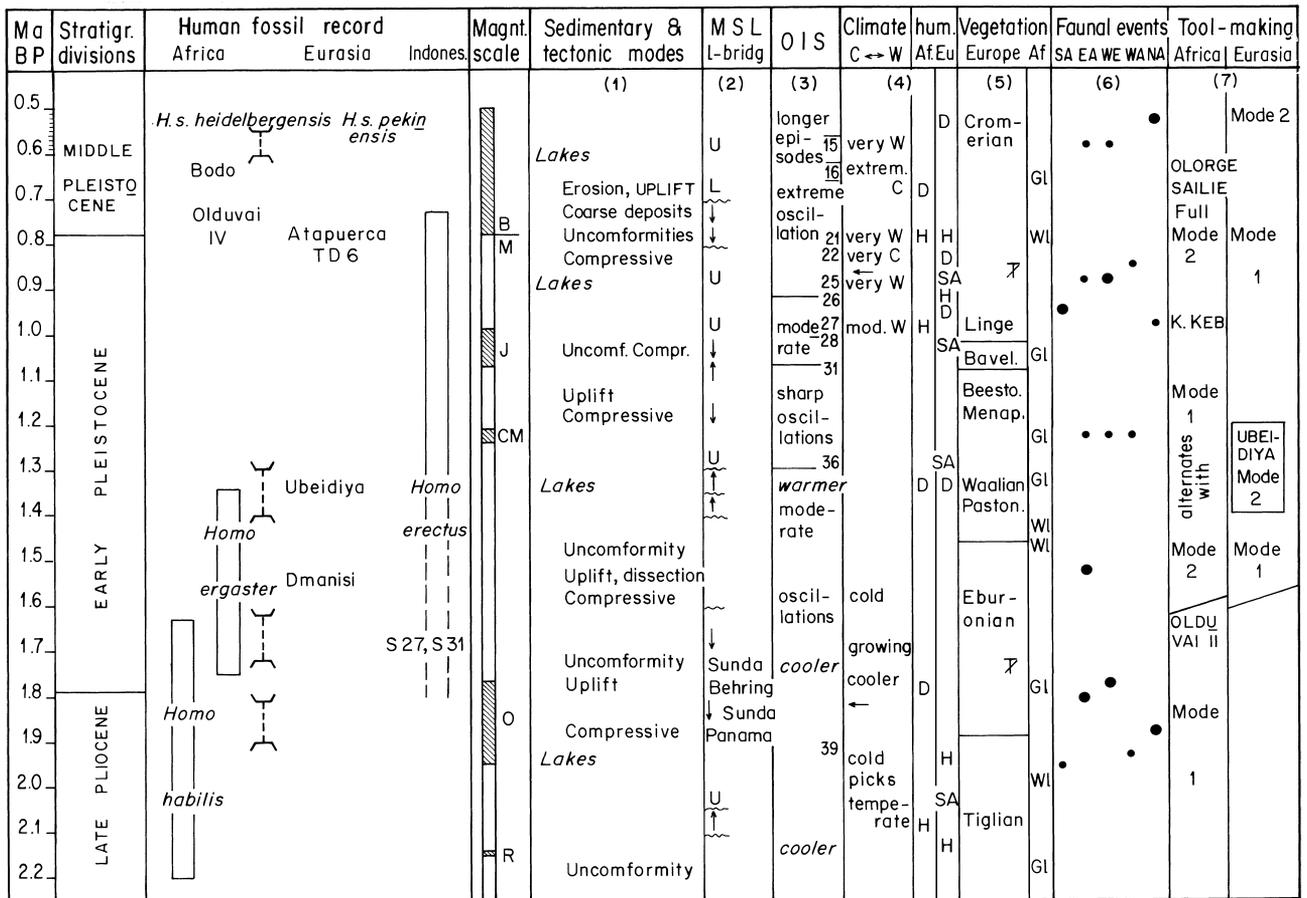


Fig. 1. Tentative correlation chart between various geodynamic and ecological events and situations, human fossil record, presumed out-of-Africa movements, and stone-tool making modes, between 2.2 and 0.5 Ma BP. (1) According to Bardaji et al. (1997); Benda (1995) (L. Eissman; Fetzer et al.; Stephan; Unger and Kahlke); Chavaillon (1982); Hay (1967); Leakey and Hay (1982); Mörner (1994); Ruiz Bustos (1999); Sastry (1997); Zhang (1997). (2) See Tonni and Fidalgo (1982); Haq et al. (1988); Zazo (1999); Zazo et al. (1997); Zubakov (1988). (3) Shackleton et al. (1990) (4) Hoyos and Aguirre (1995); Vrba et al. (1996). (5) Behrensmeyer and Bobe (1999); DeMenocal (1995); García-Antón (1995); Cattani et al. (1994); Grichuk (1997); West (1996); Zagwijn (1992). (6) Aguirre et al. (1997); Alberdi et al. (1997); Behrensmeyer and Bobe (1999); Bonifay (1996); Klein (1984); Qi (1989); Repenning (1987); Sastry (1997); Zhang (1997); Tchernov (1992); Turner and Wood (1993). Gladilin and Sitlivi (1991); Bosinski (1995); Díaz del Olmo and Baena (1997); Giles et al. (1996); Lumley et al. (1988); Ranov (1991); Ranov et al. (1995); Schick et al. (1991); Valoch (1995). Approximation to bracketing probable time of successive out-of-Africa human population movements. Abbreviations: J = Jaramillo; CM = Cob Mountain; O = Olduvai; R = reunion; U = high mean sea level (MSL); L = low MSL; OIS = oxygen isotopic stage; C = cold; W = warm; Af = Africa; Eu = Europe; H = humid; M = moist; D = dry; SA = semiarid; F = lost of thermophilous taxa from the Neogene; Gl = grassland; Wl = woodland; SAF = South Africa; EA = East Africa; WE = West-Europe; WA = West-Asia; NA = North America; • = faunal change; ● = major "faunal turnover"; K.keb = Kesem-Kebena.

1.8 Ma to 1.7 Ma. A maximum of human diversity is also recorded between 2.0 and 1.9 Ma, with the First Appearance Date (FAD) of *H. habilis*, whose Last Appearance Date (LAD) occurred at around 1.7 Ma. The FAD of *H. ergaster* occurs between approximately 1.8 and 1.7 Ma BP. Little doubt can remain concerning the basic connection of these critical events to the exodus of *H. erectus* between just after 1.9 and just before 1.8 Ma (Fig. 1).

## 2. Second Out-of-Africa dispersal: Dmanisi

The Dmanisi humans, or their parents, came out of Africa later than the Indonesian *H. erectus* ancestors.

The Dmanisi mandible is similar to mandibles of African *H. ergaster* in terms of morphological as well as biometric traits, so the Dmanisi humans are well classified as *Homo* sp. cf. *ergaster*, or simply as *H. ergaster*. Not seen in *H. erectus* mandibles from Java are such progressive "modern" traits as decreasing size in molar series, anterior flattening of the mandibular body, and incipient *trigonum mentale*, present, among others, in Dmanisi, as well as in ER 992, ER 730, and WT 15000 (Aguirre et al., 1980; Rosas and Bermúdez de Castro, 1998).

The most likely date therefore for the exodus of the Dmanisi population is during the time of the evolution of *H. ergaster*, more than 1.6, but not much more than

1.7 Ma BP. On the other hand, these dates are in accordance with the age assigned to the Dmanisi beds, including the fossil humans: less than 1.8 Ma but not less than 1.5 Ma BP. Continental uplift, compressive tectonics, low MSL, and dissection prevalent over sedimentation in wide areas are mentioned between slightly later than 1.7 and around 1.6 Ma. Open vegetation and increasing aridity are recorded in Africa in the same interval.

At around 1.5 Ma, the sea level rises, the climate warms, woodland improves in Africa, and lakes expand. The Eburonian cool climate vegetation interval is recorded in European mid-latitudes between around 1.8 and slightly later than 1.5 Ma.

During the interval between approximately 1.8 and 1.6 Ma, more *Paranthropus* than *Homo* fossils are recorded in East Africa. Changes in *Homo* representatives are cited from around 1.75 to 1.70 Ma, with the evolution of *H. ergaster* and disappearance of *H. habilis*. The invention of Paleolithic Mode 2 (Acheulean) technology came later, at around 1.6 Ma BP.

That a relationship between these human events and the above-mentioned environmental conditions exists cannot be avoided, and deserves more intensive study. The Dmanisi dispersal out of Africa was a part of the picture showing that turnover. It is to be hoped that the study of the newfound skulls will only increase our understanding of this event.

### 3. Third exodus: Ubeidiya

The Ubeidiya occupants represent a new — currently the third — out-of-Africa exodus. The Ubeidiya mammal assemblage includes faunal elements from Olduvai upper Bed II (therefore, no younger than 1.25 Ma), mixed with components from Eurasia. Among the latter, the rodent *Lagurodan arankae* is a good guide fossil, living between 1.4 and 1.1 Ma. The Ubeidiya fossiliferous level, with a few human remains and a Mode 2 type lithic assemblage, must be dated between 1.4 and 1.3 Ma BP (Tchernov, 1992; Bar-Yosef, 1994).

In that time span, tectonic activity is expansive, MSL continues to rise and is transgressive, and lakes develop in interior basins. Woodlands recover in Africa, and temperate, Waalian–Pastonian vegetation is found in Europe. A sharp change is recorded in many environmental components at about 1.3 Ma or slightly before. This includes changing sedimentary activity, with erosional unconformities and/or coarser deposits and other evidence of compressive tectonic activity and continental uplift in East-Africa, the Siwaliks in India, and the Baetics in Spain. Sharp climate oscillations are reflected in the Oxygen Isotope Stages (OIS) after the cold Episode 36. In addition, there is deterioration of vegetable cover with significant increase of grassland in Africa (DeMenocal, 1995), transition from Waalian to cooler

Menapian floral associations in Western Europe (Zagwijn, 1992), and the loss of more thermophilous taxa all over mid-latitudes of Eurasia (Grichuk, 1997).

The abundance of human fossils in such sequences as Middle Awash, East Turkana, Omo-Shungura, and Olduvai ceases abruptly. With rare exceptions, no human remains are found in these areas after Garba IV in Ethiopia, and the OH9 calvaria in Olduvai approximately dated to 1.3 Ma, nor above the L-Tuff in Shungura and above the Chari Tuff in East Turkana, until much younger deposits: Mb IV in Olduvai, Gomboré II in Ethiopia, and above the Silbo Tuff in East Turkana — all at about 0.8 Ma.

That scarcity of human fossil remains in Africa can be explained as an effect of a change to those sedimentary processes adverse to fossilization, due to altered physiographic conditions.

At least in part, the environmental deterioration may have influenced faunal displacements. This is not so far-fetched, given that the cold conditions began in the Southern Hemisphere at a time when humidity and vegetation were improving in the Near East, soon before the global deterioration at around 1.3 Ma. Humans may have been forced to migrate in that direction, either by overpopulation in parts of Africa after the invention of Mode 2 technologies, or simply following other mammals at the time of environmental turnover.

### 4. Blank slate at around 1 Ma. The Atapuerca evidence for Eurasian expansion and the limited exodus of Gesher Benot Ya'aqov

After a long gap, the human fossil record in the Old World restarts in the latest part of the Early Pleistocene and at the end of the Matuyama magnetic Epoch of reversed polarity, between 0.99 and 0.78 Ma BP. Human fossil sites for that interval are, in Africa, the lower part of Olduvai Bed IV; Gomboré IIB, with a frontal and a parietal associated in the deposits with mid-Acheulean tools just above the B-Tuff, 0.84 Ma BP (Chavaillon, 1982); and possibly Swartkrans Member 3, with the latest fossils of *Paranthropus* and an imprecise date between 0.75 and 0.9 Ma BP. Two mandibles from Kapthurin, Kenya, are dated at less than 780 ka; the three Ternifine (Algeria) mandibles at no less than 700 ka, and the Bodo (Ethiopia) skull is dated at approximately 600 ka (Geraads et al., 1986; Wood and van Noten, 1986; Clark et al., 1994).

In China, Qiyuanhekou (Yunxian) yielded two deformed skulls and several tools (Wu and Poirier, 1995) with dates > 581 ka by ESR and between 830 and 870 ka by means of paleomagnetic correlation. The two upper incisors of Yuanmou and the incomplete skull of Gongwangling, associated with lithic artefacts, provide contradictory dates of less than 0.8 and more than

1.1 Ma; the associated faunal assemblages may also be consistent with an early Brunhes or a pre-Brunhes magnetic age (Aguirre et al., 1997; Zhang, 1997). The Chenjawa (Lantian) mandible is approximately dated to either 650 or less than 600 ka. Two human femora from Geshen Benot Ya'aqov are dated to not much less than 780 ka (Bar-Yosef, 1994; Tchernov, 1999).

Tectonic compression is recorded globally between approximately 1.0 and 0.9 Ma, and again from 0.8 to 0.7 Ma, this time with low MSL, and coarse deposits or sedimentary hiatus inland (Bardaji et al., 1997) (also Eissman and Unger and Kahlke in Benda (1995)). At around 0.7 Ma, MSL raises again, and lacustrine deposits are found. Relating the fossil finds at Kapthurin, Ternifine, Bodo, Geshen Benot Ya'aqov, Chanjano, and possibly Ceprano to these changing environmental conditions also deserves consideration.

The "Aurora" Bed, in the upper TD6 unit of Atapuerca (Burgos, Spain), around 0.30 m thick, yielded 85 human remains, almost 200 stone artifacts, and more than one thousand vertebrate fossils in a test pit of less than 7 m<sup>2</sup> (Bermúdez de Castro et al., 1995). These have provided a reliable date of around 800 ka on paleomagnetic grounds (Parés and Pérez-González, 1995), and when the faunal assemblage of late Bihorian mammal age is taken into account (Aguirre et al., 1987; Sesé and Gil, 1987; Cuenca et al., 1999; Van der Made, 1999). Pollen samples (García-Antón, 1995) and the morpho-stratigraphical evidence (Hoyos and Aguirre, 1995) suggest the beginning of an interglacial, with improved temperature, rain, and vegetation following a severely cold steppe ("páramo"), such as those presently found in the highlands, 100–200 m above the summits of the Sierra de Atapuerca. This climatic change can be correlated to OIS 22 to 21, at around 830 ka BP, or to 20 to 19, at about 795 ka BP (Berggren et al., 1995). Other authors have assigned an age of 795 ka to the OIS 22–21 transition.

OIS 22 has been characterized as very cold and dry, and was followed by a major change to very warm and humid conditions, with woodland in East Africa. In China, the corresponding transition is from Loess L9 to Soil S8. This is probably the situation reflected in the AT-TD6 "Aurora" Bed. The humans recovered here have been described as a new species, *Homo antecessor*, and as the last common ancestor of Neandertals and modern humans (Bermúdez de Castro et al., 1997).

The study of *H. antecessor* teeth places this sample far from the Neandertal, Mauer, and Atapuerca-SH populations, and close to those of Ternifine, Zhoukoudian, Dmanisi, and in some aspects also to *H. ergaster* (ER 992, WT 15000) (Bermúdez de Castro et al., 1999b). The 45 post-cranial bones from the "Aurora" Bed resemble modern humans more than European Mid-Pleistocene fossils or Neandertals (Carretero et al. in Bermúdez de Castro et al., 1999b; Lorenzo et al. in Bermúdez de Castro et al., 1999b). The multivariate study of the mandibular

remains of *H. antecessor* demonstrates a closer similarity to Zhoukoudian and the Middle Pleistocene humans from Africa (Ternifine; OH 22), even to modern humans and to *H. ergaster*, than to the preneandertals (*H. heidelbergensis*) or the Neandertals (Rosas and Bermúdez de Castro in Bermúdez de Castro et al. (1999b)).

The preserved fragments of the facial skull from the AT-TD6 "Aurora" Bed have been studied and illustrated by Arsuaga et al. (Bermúdez de Castro et al., 1999b). These fossils show strong similarities to modern humans and with Zhoukoudian and other Mid-Pleistocene fossils from China in the maxillary region, with a "canine fossa" in front, a deep submalar recession of the maxillary bone, extremely opposed to the flat, hyperpneumatized maxillary bone of both the Neandertals and the preneandertals. The shortened face, short malar, arched zygomatic crest, and orbital infero-lateral edge of fragments ATD6-38, ATD6-58, and ATD6-69 plainly resemble modern and Mid-Pleistocene Chinese skulls.

The putative ancestral relationship of TD6 Man to the "*heidelbergensis-neanderthalensis*" lineage is based solely on the assumption that the evoked apomorphic traits of preneandertals and Neandertals originated in later times, and is the reason these are not found in "*antecessor*" (Arsuaga et al., 1999). Nevertheless, the shape and configuration characteristics of the maxillary region and the zygomatic arch of the European preneandertals are already found in the Bodo skull, and resemble those features in WT 15000.

The artifactual assemblage found in association with the human remains of Atapuerca-TD6 "Aurora" Bed is classified as Mode 1 (Carbonell et al. in Bermúdez de Castro et al. (1999b)), as in other Eurasian sites of similar age, with the exception of Geshen Benot Ya'aqov, which has a progressive, Mode 2 assemblage. This allows the inference of a fourth out-of-Africa exodus at that time, which did not extend farther to the north into Europe.

The evidence summarized above leads to several assertions, and poses new questions related to the evolution of early human demes:

1. There was an expansion and flourishing of human groups across Eurasia between approximately 1 Ma and later than 0.7 Ma, attested to not only by fossil humans, but also by artifactual assemblages in Korolevo VII–VIII, Kuldara, Donggutuo, Monte Poggiolo, early beds in Atapuerca-Gran Dolina ATD-4, Azykh 7-8 (Carbonell et al. in Bermúdez de Castro et al. (1995)), and at still higher latitudes in Diring-Yuriakh (Ranov, 1991).
2. The fossil humans preserved in the aforementioned sites in Eurasia show similarities and differences with contemporary or penecontemporary fossils from Africa, also with earlier African *H. ergaster*, and with younger humans from Asian Mid-Pleistocene and

fully “moderns”. Those fossil humans, and particularly the TD6 “Aurora” Bed population, represent a well-characterized deme that can be considered an early subspecies of *Homo sapiens*, namely *H. s. antecessor*, rather than a species, *H. antecessor*. The pattern of dental growth is definitely modern (Bermúdez de Castro et al., 1999a).

3. Those populations that lived in Eurasia in the late Early and early Middle Pleistocene were not descendants of the Ubeidiya occupants. They were at least occasionally meat consumers, who did not use Mode 2 heavy-duty bifaces or cleavers, already known by the Ubeidiyans. There is no explanation for the abandoning of those technical modes. Consequently, they must be considered descendants of populations that had arrived in earlier times and evolved in Eurasia at least since the times of Dmanisi.
4. The questions of appearance: extension or improvement, selection or disjunction of “modern” traits; and those of the “origin of *Homo sapiens*”, can only be answered taking into account the fact that the changes involved took place diachronically, over a period of more than one million years, and were dependent on more than one and perhaps several out-of-Africa displacements. Also, the possibility of one or more movements in the opposite direction, that is North to South, the way of Abraham, back to Africa, should be investigated, and not excluded a priori.
5. Ecological conditions that affected the above-traced scenarios should also be studied carefully. Climatic improvement during the Jaramillo Event may have favored the successful dispersal of groups through vast Eurasian mid-latitude regions. Less than 1 Ma ago, oscillations became more extreme after the very warm and humid OIS 25, with raised sea levels and inland lakes between 0.92 and 0.85 Ma. Mammalian faunas changed in that interval in East Africa (Vrba in Vrba et al. (1996)); from late Makapanian to Cornelian assemblages in South Africa (Klein, 1984); from stages E to F in SW Europe (Alberdi et al., 1997); from Tamanian to Tiraspolian in East and SE Europe; from lower to upper Irvingtonian in North America (Lindsay, 1997); and between Dongcun and Shangnabang faunas in China (Zhang, 1997).

##### 5. Out of Africa in the Mid-Pleistocene. The Atapuerca contribution

The first Acheulean (Mode 2) sites in Europe are dated to less than 0.6 Ma BP. They include Cagny in France; Boxgrove in England; Fontana Ranuccio and Notarchirico in Italy; Kärlich-E in Germany; and Laguna de Medina, Transfesa, Ambrona (lower unit), and Atapuerca-Galería (Beds TG 6-8, or GIIa) in Spain. The oldest of these sites are correlated with OIS 13

(515–470 ka BP). On the other hand, Belle-Roche (Belgium) and sites in the high terraces of the Guadalquivir Valley, which can be assigned to OIS 15 (615–565 ka), yield evolved Mode 1 artefacts (Díaz del Olmo and Baena, 1997).

The hypothesis of independent invention is not excluded. However, the alternative is more parsimonious and seems more probable, namely, the dispersal of a group “out-of-Africa” at a date referable either to OIS 14 (565–515 ka BP) or, less probably, to the end of the extremely cold OIS 16.

The populations bringing the Acheulean tradition to Europe can be identified. The resemblances between *H. heidelbergensis* from Europe and Mid-Pleistocene human fossils from Africa are more than random, or coincidental. The closest similarities to the Atapuerca SH sample — MNI = 32, dated to around 320 ka BP (Arsuaga et al., 1997) — and to Arago, France, are found in Olduvai hominids 22 and 23 for the mandibles (Aguirre et al., 1980), and in Bodo, Ndutu, and Kabwe for skulls (Rightmire, 1995). The shape and traits of the zygomatic arch and of the maxillary region — hyperpneumatized, prognathic, lacking a submalar constriction and a “post-canine fossa” — are very similar in the Bodo skull and in the skulls of Atapuerca-SH, Arago, Petralona, Saccopastore. The age of Bodo (approximately 600 ka) is consistent with the African scenario for the European origin of *H. heidelbergensis*, and the remote ancestorship of the Neandertals.

The climate was very warm in OIS 15, and there is a record of faunal events in various regions between 600 and 500 ka BP. Extreme cold and aridity are attested to in OIS 16, near its end at around 615 ka. Afterwards, tectonic behavior was tensional, lakes developed, and MSL rose.

Throughout the Old World, there are so many sites with fossil humans after the last-mentioned date of around 500 ka, and finding traces of human activity associated with fossil mammal sites becomes so common in the late Middle and Upper Pleistocene, that one can speak of a true demographic explosion, and the global ecological impact of the human species. The high number of sites may be due to better conditions of sedimentary preservation, but not completely.

Technological progress in Mode 2, with increased standardization and more frequent pre-forming of blanks, is observed in successive beds of Atapuerca-Galería Unit II, dated between around 400 and 300 ka (Carbonell et al., 1999).

Attention should be drawn to the fact that the fully evolved Acheulean is not found in Europe until some time later, while in Africa it is already present in Olorogailie, at about 600 ka. The questions that arise from this are whether populations were forced to leave Africa by demographic pressure, and whether these were the less developed, or marginal populations.

The possibility of more than one migration around 500/400 ka is therefore not excluded. The Gibraltar route, out of the question — we believe — for the earlier out-of-Africa dispersals, deserves investigation in connection with these mid-Middle Pleistocene movements. At this time, humans probably did not need land bridges in the place of straits to move from one land mass to another, but diverse human Acheulean groups may have reached Europe from the Maghreb and through the Middle East at various times.

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