

HUMAN ROOTS
AFRICA AND ASIA IN THE
MIDDLE PLEISTOCENE

Edited by

Lawrence Barham and Kate Robson-Brown

Published for the Centre for Human Evolutionary Research at the University of Bristol, CHERUB,
by the Western Academic & Specialist Press Limited, Bristol, England

8 Northwestern African Middle Pleistocene hominids and their bearing on the emergence of *Homo sapiens*

Jean-Jacques Hublin

INTRODUCTION

Northwestern Africa represents an area of major interest for the understanding of Middle Pleistocene hominid evolution and specifically for analysing the process of emergence of *Homo sapiens*. This area belongs to the vast continental mass which represented for most of the Pliocene and the Pleistocene the demographic and evolutionary core of hominids. Human evolution there is rather well documented, partly by reason of favourable geological conditions, and also because of the development of almost continuous archaeological and palaeontological research since the 1930s. Besides the Rift Valley area in eastern Africa and South Africa, northwestern Africa is the only African region where a significant hominid fossil record is known for this period.

Another peculiar aspect of this area is its proximity to Europe. During most of the Pleistocene, western Eurasia represented a marginal domain far from the inter-tropical areas where hominids evolved in a quite distinctive way, giving rise to the Neanderthals during the second half of the Middle Pleistocene. Although Africa is impressively visible to anyone standing on the Rock of Gibraltar, the pattern of human evolution in north Africa and Europe displays very contrasting features. The Straits of Gibraltar could have been significantly reduced during low sea-level periods but it never disappeared during the Pleistocene. Possible biological exchanges and cultural interactions between the Pleistocene populations living on both sides of this potential filter have been a matter of long-term debate. To a lesser extent, relationships through a Siculo-Tunisian 'isthmus' have been also envisioned (Alimen 1975), but this possibility is much more debatable (Villa in press). The Levant in the east represented a permanent land connection between north Africa and Eurasia, and although it probably mainly played the role of a biogeographical barrier (or at least a filter) (Tchernov 1998) and was geographically distant from the Maghreb, it regularly offered similar ecological conditions.

Finally, the Maghreb also represents a singular domain by reason of its location between the main African

desert, the Sahara, and the Mediterranean. Periodic extensions of the Sahara, alternating with reductions and even disappearances, are likely to have played a major role in the possible exchanges between local populations and groups located further to the south and east. Interaction between the Levant and with western Eurasia may have been dependant on this environmental pulse. And it could have also resulted in strong demographic fluctuations as well as in peculiar pressures of selection.

GEOLOGICAL AND CHRONOLOGICAL FRAMEWORK

The richness of the palaeoanthropological record in northwestern Africa is partly related to the nature of the Pleistocene deposits along the Atlantic coast of Morocco. The exploitation of large quarries around Rabat, and even more around Casablanca, allowed a detailed analysis of the marine and continental deposits interstratified in this area. The thickness and continuity of these Pleistocene deposits enabled the establishment of a local chronostratigraphy that provided the framework for most of the geological studies in the western Maghreb before the development of the isotopic chronology.

Indeed the building by Sultan Moulay Abdelaziz of a modern harbour in Casablanca and its enlargement during the First World War played a major role in the development of Moroccan prehistorical studies. Vast quarries at the periphery of the town were then used. Amongst them was the quarry of Sidi Abderrahmane, which was the first to yield abundant lithic artefacts. The relationship between the scientists and the quarrymen was not always good and an unknown quantity of treasures ended up under the waves of the Atlantic Ocean. However, the discovery and the study of several karstic cavities allowed the publication of major contributions to the understanding of Pleistocene chronology. A first synthesis was written by Neuville and Rulhman (1941), and many other works followed, stimulated by the discoveries in the Rabat area.

The Atlantic coast of Morocco has been compared to a gigantic stairway rising from the seashore (Lefèvre

et al 1999). The slow vertical movement of the Meseta resulted in the exceptional preservation of all these deposits. Each step is an ancient shore covered by dunes, and the ages of these steps increase when one moves inland. Although the absolute altitude of a specific deposit can vary from one area to another, several major episodes were identified (Gigout & Raynal 1957), and this series was used by Biberson (1961) to establish a local succession of Quaternary marine and continental stages (figure 8.1). Above deposits at +2 m, related to the Flandrian, four major Pleistocene shorelines were interpreted as marine stages: Ouljian (5–8 m), Anfatian (25–30 m) Maarifian (55–60 m) and Messaoudian (80–100 m). Between these marine stages, continental deposits mostly made of cemented dunes were assigned to stages defined as Soltanian, Tensiftian, Amirian, Saletian, etc. Intertidal deposits, alteration facies (karsts and palaeosols) and reworked deposits are associated

with these regressive episodes. The Middle Pleistocene starts with the long Amirian continental cycle which yielded the first handaxe industries. This framework has been successfully used for at least 30 years. The chronology of faunas, fossil hominids and lithic industries discovered in Morocco as well as in other parts of the Maghreb explicitly refer to it.

However, Biberson (1961) identified several transgressive episodes (G0, G1, G2, etc) within the Anfatian, especially in Sidi Abderrahmane. With the rise of the isotopic chronology and the complexity of the Quaternary timetables, the classical Moroccan chronology has been more and more challenged. Stearns (1978) demonstrated that the ancient shorelines of the Atlantic coast cannot be assigned to only 5 or 6 cycles and made a first attempt to correlate the different deposits with the chronology based on the succession of oxygen isotopic stages. Jaeger (1981) followed, and proposed to relate the G2 Anfatian transgression to OIS 7. This major transgressive episode, which marks the end of the Amirian in the Biberson chronology is associated with warm malacofaunas and corresponds to a major interglacial stage. However, several indices suggest that G2 might be much older, bracketed between 530 and 330 ka BP (Lietz & Schmincke 1975). During the last two decades a series of works (Debenath et al 1982; Geraads 1980; Geraads et al 1980; Geraads & Amani 1997; Geraads et al 1986; Occhiotti et al 1993; Raynal & Texier 1989; Raynal et al 1986, 1993, 1995; Texier et al 1985, 1994) have provided evidence for an even more complex picture of the Moroccan chronostratigraphy. Figure 8.2 presents a simplified version of the table established by Raynal et al (2001) for the Pleistocene of the Casablanca area, in which the geochronology has been reorganised and the classical denominations abandoned.

EVOLUTION OF THE ENVIRONMENT

Aridity, especially marked at a distance from the coastline, is the main feature of the Maghrebian landscape during most of the Pleistocene. In northwestern Africa, an increase of this aridity is documented at least since the Pliocene but the phenomenon is very noticeable during the second half of the Middle Pleistocene and even more so during the late Upper Pleistocene. On faunal grounds (Arambourg 1960; Jaeger 1975c), the existence of two biogeographic provinces has been suggested: an internal province characterised by an open environment more xerophytic than the littoral province that would have been more forested. The border between the two domains might have moved toward the littoral during the Pleistocene. However, this assumption is based on a limited number of sites for each period.

Periodic extensions of the Sahara were driven by global climatic changes, but there is no simple correspondence between the oxygen isotope curves, the

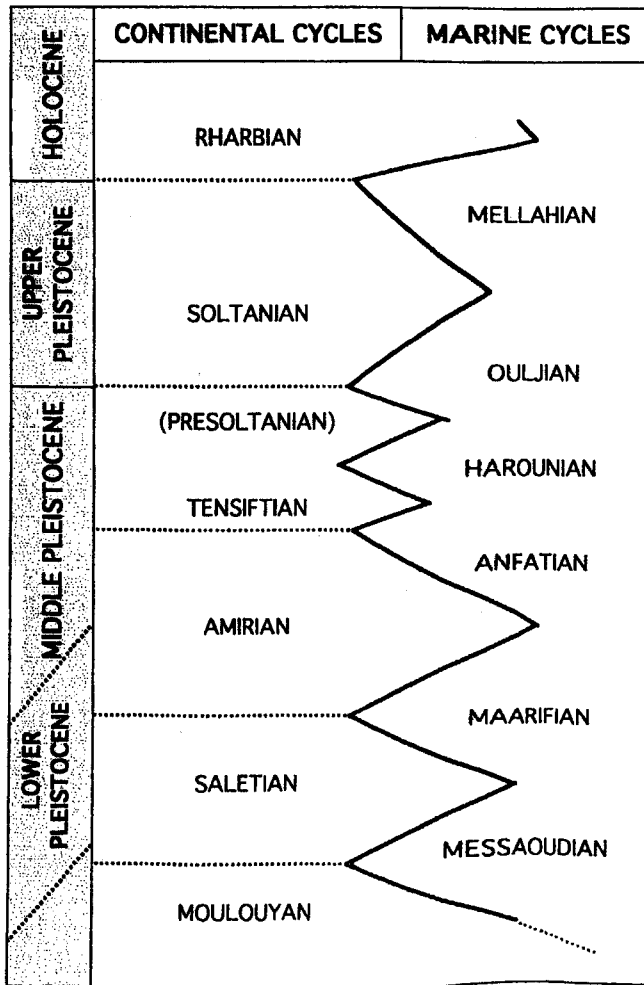


Figure 8.1 Chronology of the main marine and continental cycles on the Atlantic coast of Morocco (modified from Jaeger 1981).

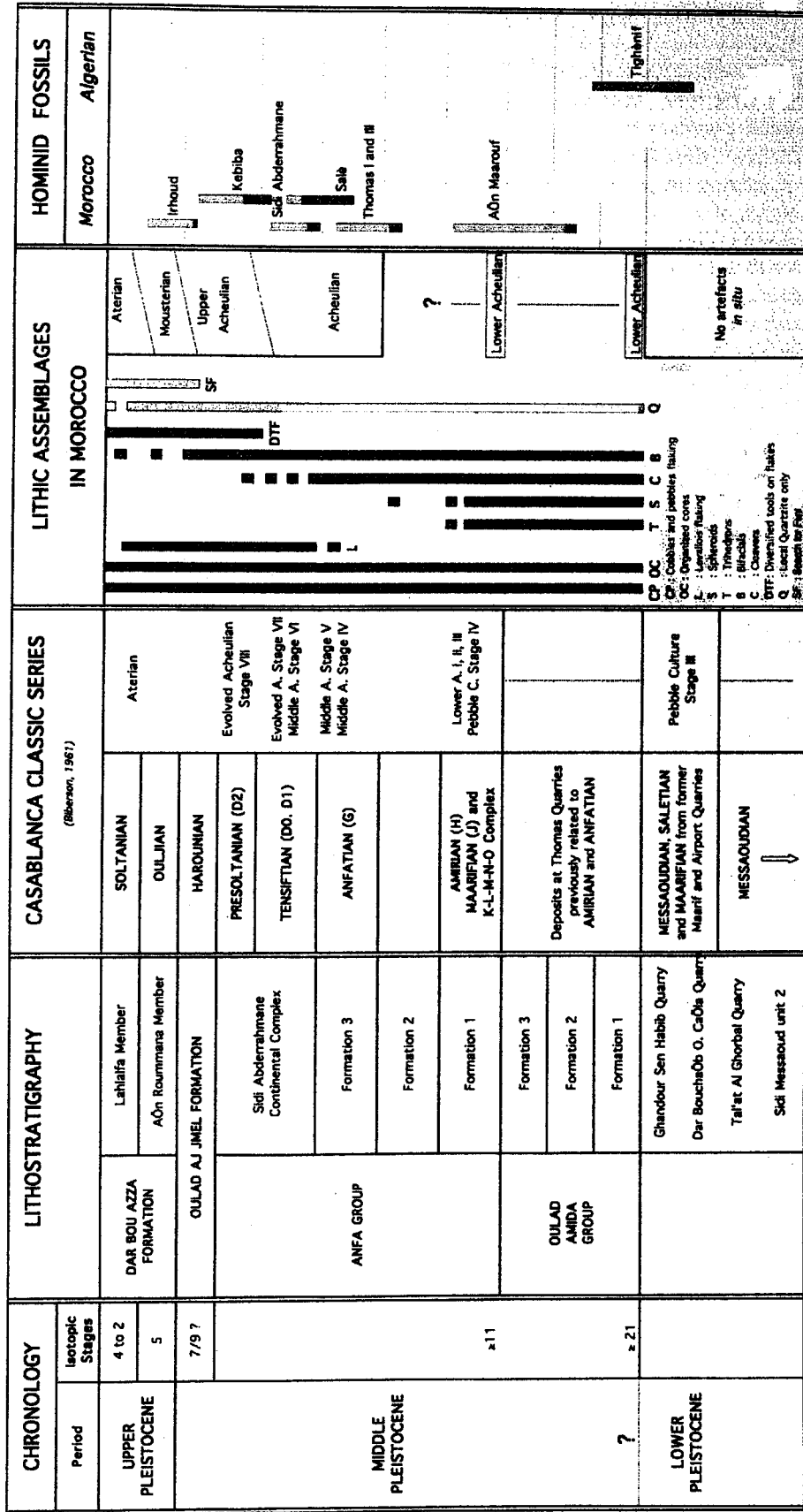


Figure 8.2 Middle Pleistocene lithic assemblages of Morocco and northwestern African hominids in their chronostratigraphical context (modified from Raynal et al 2001).

alternation of glacial and interglacial stages in Europe and the variation of size of the African deserts. In the lower latitudes, the periodical extensions of the African deserts seem mainly driven by a cycle which corresponds to that of equinoxial precession, modulated by eccentricity (Rognon 1996). In the Upper Pleistocene a near disappearance of the Saharan desert occurred during OIS 3 (Rognon 1996). While, in contrast, a fauna of dry savanna is observed during OIS 4 at Doukkalla II (Morocco) (Laquay & Cheddadi 1986) and, during OIS 2, at El Haroura cave (Morocco) (Beckouche, quoted by Raynal et al 1986; Geraads pers comm). Within OIS 5 a period of 23,000 years separates successive rainy periods separated by major extensions of the Sahara during OIS 5b and OIS 5d.

Further back in time the geological resolution is weaker but one can assume similar patterns of climatic oscillations. In the Pliocene, there is a contrast between the fauna of Lac Ichkeul near the Algerian coast, revealing a landscape of gallery forests surrounded by open spaces (Arambourg 1969–1970; Jaeger 1981) and the fauna of Aïn Brimba in the south of Tunisia which included species related to arid environments (*Ctenodactylidae*, *Gerbillidae*, etc) (Jaeger 1975d). In the Lower Pleistocene an open environment is already developed as demonstrated by the faunas of Aïn Boucherit and Aïn Hanech in Algeria (Arambourg 1979; Geraads 1981). The evolution of the rodent faunas (Jaeger 1975c) as well as sedimentological data (Coque 1962; Coque & Jauzein 1965; Maurer 1968; Beaudet 1969) indicate a global increase of aridity during this period although there are some significant fluctuations.

At the limit between the Lower and Middle Pleistocene, the fauna of Tighénif (Algeria) yielded a faunal assemblage dominated by species associated with open environments. *Alcelaphinae* and *Gazella* represent 93 per cent of the bovids collected during our 1982–83 excavation, and *Gerbillidae* 84 per cent of the rodents (Geraads et al 1986). This is confirmed by the occurrence of aeolian sands in the deposit, suggesting a nearby steppe or dry savanna. In the course of the Middle Pleistocene a cooling (or several cooling episodes) occurred, indicated by the spread of rodents such as *Ellobius* and *Meriones*, while thermophile species disappeared from the northern and central areas (Jaeger 1969, 1975b, 1975c). It is likely during the same period(s) that Atlasic basins witnessed cold and arid phases (Maurer 1968). In the Moulouya basin, marked freezes were demonstrated above 1300 m of altitude (Rayal 1961, 1965; Couvreur 1981; Dutour 1983). In the marine deposits, the G1 Anfatian horizon yields *Littorina littorea* and also marks the most remarkable cooling for the Maghreb Middle Pleistocene.

The end of this cooler period is underlined by the development of the Middle Anfatian (G2) warm malacofauna with *Patella safiana* and *Thais haemastoma*.

On the Atlantic coast, the environment might have been more humid than inland, especially during the biostatic periods ('pluvials') (Raynal et al 1986). However, between these phases there are long rehexistatic periods when aeolian deposits are dominant. Indeed, the development of karsts and stalagmitic deposits at the beginning of the Tensiftian indicate a certain level of humidity, but one finds remains of *Alcelaphinae*, *Gazella*, *Gerbillidae* and *Ellobius* in the dissolution cavities of the Thomas quarries (Geraads 1980).

During the late Middle Pleistocene, hyper arid phases are indicated by the development of calcareous and gypsum crusts (Raynal et al 1986) and OIS 6 is marked by a climatic crisis leading to the extinction of the rodent genera *Ellobius*, *Arvicanthis* and *Praomys* (Jaeger 1975c, 1981).

The possibilities of biological exchanges between the Maghreb and the surrounding areas are mainly related to the changes in the level of aridity and the periodic extensions of the Sahara. The remarkable Pliocene fauna from Ahl al Oughlam (near Tit Mellil, Morocco), which makes it by far the best reference locality for the north African Plio-Pleistocene, is very similar to that of contemporary eastern African sites (Geraads 1995, 1996, 1997). This suggests that the Sahara did not then represent a continuous palaeogeographical barrier between northern and eastern Africa, which displayed comparable environments and mammal assemblages. According to Geraads (1982) this situation seems to prevail during the Lower Pleistocene. It is only during the Middle Pleistocene that the Maghrebian faunas start to display some Palaearctic characteristics. While the large mammals faunas are still very similar to those of eastern Africa, the occurrence of *Ursus* and later on of *Bos primigenius* and *Lynx thomasi* of Eurasian origin indicates likely exchanges via Gibraltar. It should be noted that, contrasting with the large faunas, the rodent faunas show a high degree of endemism and were even said to display 'insular' features in the Maghreb (Jaeger 1975d; Lavocat 1978). During the Upper Pleistocene, the appearance of *Dicerhorinus hemitoechus*, *Sus scrofa* and cervids emphasised the Eurasian connection, although one cannot exclude the possibility that they arrived from the Middle East.

CULTURAL BACKGROUND

With the exception of the site at Aïn Hanech (Algeria), most of the recent excavations on the Lower and Middle Palaeolithic in north Africa have been based in Morocco and I shall mainly concentrate on the data provided by this area. Biberson (1961) assigned pebble tools discovered in the Casablanca area to the Lower Pleistocene and even to the Pliocene. Further examination of the sites seems to indicate that there is no demonstrable ancient pebble culture on the Atlantic coast of Morocco (Raynal et al 1995). Presumed pebble tools assigned

to layers formerly attributed to the Maarifain, the Moulouyan or the Salctian (old Biberson collections from the Dépéz quarry) can be interpreted as geofacts generated in high energy littoral facies or as recent artefacts collected from superficial colluvial deposits. However, as mentioned above, ecogeographical connections between the Maghreb and eastern Africa remained intact until the Middle Pleistocene and one should remark that so far, contrasting with some Pliocene or Middle Pleistocene localities, the Lower Pleistocene formations of the Casablanca area are not very rich and have yielded only scarce palaeontological evidence.

In northeastern Algeria, the site of Aïn Hanech ('the spring of the snake') near Setif is certainly of Lower Pleistocene age. It yields 'Villafranchian' species such as *Sivatherium maurusium* and *Kolpochoerus phacochoeroides* (Arambourg 1979). According to D Geraads (pers comm) it could be between 1.2 and 1.4 Ma. But an older Lower Pleistocene age (*c* 1.7–1.8 Ma) has also been envisaged for the site (Sahnouni & de Heinzelin 1998) mainly on palaeomagnetic evidence. The locality was discovered in 1947 by the French palaeontologist Camille Arambourg. The first artefacts yielded by these layers were primarily polyhedrons and spheroids. In 1992 and 1993, archaeological excavations were carried out at Aïn Hanech and in the nearby locality of El-Kherba in layers of normal polarity separated by several metres from underlying layers of reverse polarity (Sahnouni & de Heinzelin 1998). More than 2600 stone artefacts made of flint and limestone were recovered, suggesting an *in situ* debitage (85 per cent of fragments and debitage <2 cm) and carcass processing. Flaked cobbles and cores, retouched pieces and whole flakes represent the remaining 15 per cent. The assemblage is comparable to the Mode I technology artefact assemblages from Olduvai Bed I and Lower Bed II and Koobi Fora.

Acheulian industries are known in northern Africa near the Lower to Middle Pleistocene transition. In Morocco, the first clear evidence for human activity is found in the late Lower Pleistocene. In the Casablanca sequence, the unit L of Thomas 1 quarry, *c* 1 Ma, yielded Acheulian artefacts made of quartzite and rarely of flint (Raynal & Texier 1989). The assemblage is composed of chopping tools, polyhedrons, trihedrons, bifaces (often only partial) and some cleavers. Flakes were produced from discoidal cores and polyhedrons (Raynal et al 2001).

The Tighénif (Mascara, Algeria) assemblage might be close in time although somewhat younger. Some measurements indicate a normal magnetic polarity of the sediments (Geraads et al 1986), but palaeontological data may agree with an early Middle or with a late Lower Pleistocene age. The industry has been compared to the Early Acheulian I and II defined by Biberson in the Sidi Abderrahman series (Balout et al 1967).

The evolution of the Acheulian is best documented in the Casablanca series. In the early Middle Pleistocene, the 'Rhino cave' of the Oulad Hamida 1 quarry yielded spectacular Acheulian assemblages (Raynal et al 1993). A large series of artefacts is associated with abundant white rhinoceros remains, suggesting specialised hunting and/or scavenging by hominids. When compared with earlier Acheulian assemblages, this series demonstrates an increase of flake production from discoidal cores, but tools on flakes remain rare (3.5 per cent of the assemblage). They are mainly represented by notches and denticulates. The bifaces become larger. They are characterised by convex and/or concave edges creating a pointed extremity (Raynal et al 2001). Near the Rhino cave, a karstic cavity known as 'Thomas 1 quarry cave' yielded a human mandible in 1969 together with faunal remains and a series of artefacts. The human fossil likely comes from the 'pink breccia' at the bottom of the deposits. The collections from this site have been recently enlarged by a 65 m² excavation led by JP Raynal. The lithic assemblage is dominated by flaked pebbles and is reminiscent of that from the upper unit of the Rhino cave. The faunal association is similar to that of the Rhino cave but dominated by carnivores (bears, hyaenas and *Canis*) (Bernoussi 1997). Similarities between the Thomas 1 and Rhino cave faunas and the Tighénif suite in Algeria suggest a greater antiquity than the previously estimated. A middle Middle Pleistocene age *c* 0.4 Ma should be considered as a minimum. More likely the two sites are *c* 0.6 Ma (Raynal et al 2001).

More recent stages of the Acheulian are represented in the 'Bears cave', Sidi Abderrahmane-Extension and Cap Chatelier (Raynal et al 2001). In Sidi Abderrahmane-Extension, flakes are produced mainly from discoidal cores while polyhedral forms are quite rare. Predetermined flakes are present. A change in the bifacial forms occurs with cleavers now rare while hand-axes generally made on flakes tend toward ovate forms. A final Acheulian was discovered in Cap Chatelier in levels dated by optically stimulated luminescence (OSL) in excess of 200 ka. The assemblage is characterised by the development of Levallois debitage and the variety of tools on flakes. Bifaces are small and thin, cleavers very few.

Additional Acheulian sites were explored in Morocco (Tit Mellil, Aïn Fritissa) and, during the colonial period, in Algeria (Lac Karar, Aboukir, El-Ma el Abiod, Ouzidane, etc) and Tunisia (Sidi-Zin, Gafsa, etc) (Balout 1955) but they have not been re-studied recently. Apart from Lac Karar and Aboukir most of them are related to the late or final stages of Acheulian.

Contrasting with the sub-Saharan zone, north Africa has yielded genuine Mousterian industries reminiscent of the European assemblages. However, sites are not very abundant and few of them have been analysed in detail. Significantly, the impressive review by Balout of

the *Préhistoire de l'Afrique du Nord* (1955) passes directly from a chapter on the chronology of the Lower Palaeolithic to a chapter on the Aterian problem. In Morocco, as demonstrated by the final stages of the Casablanca series, the Mousterian industries seem technologically rooted in the local final Acheulian. At Akka, in southern Morocco, a transitional final Acheulian/early Mousterian industry has been discovered in an altered palaeosol and fine-grained alluvial sediments. The assemblage is reported to be a 'typical Mousterian of Levallois facies' but includes Acheulian-type cleavers (Rodrigue 1987) and could represent a final Acheulian stage transitional to the Mousterian.

The Mousterian is probably represented already in the uppermost part of the Middle Pleistocene. The Moroccan Mousterian is best known by the series of Djebel Irhoud, near Safi. Various palaeontological arguments (Biberson 1964; Thomas 1981; Amani & Geraads 1993) support an age older than the Soltanian for the Djebel Irhoud layers. The faunal assemblage, including abundant *Gerbillidae*, indicates quite dry conditions that could match the maximum extension of the Sahara of the OIS 5e or some arid episodes of OIS 6. Attempts to estimate the age of the deposit by electron spin resonance (ESR) indicated early uptake (EU) age estimates between 90 and 125 ka and linear uptake (LU) estimates between 105 and 190 ka (Grün & Stringer 1991). The assemblage studied by J Tixier (Hublin et al 1987) is reminiscent of the La Ferrassie type Mousterian of southwestern France. It is made on local flint (54 per cent) and quartzite (36 per cent) and characterised by the use of the Levallois technique (lineal and recurrent) and by facettage for making a quarter of the tools. Tools are made on flakes and the laminar index is very low. There is no Quina retouch and rare bifacial retouch. The group of side-scrapers is dominant with a peculiar type of little canted scrapers. Unretouched Levallois tools, notches and denticulates are well represented. There are no end-scrapers and no tanged pieces.

Mousterian sites are rare in Algeria. The Mousterian is mainly evident at Retaïmia (in the Chelif valley) but might be present also at the Grotte du Phare (Cap Ténès). In Tunisia, Mousterian assemblages are noted at Oued Akarit (Gabès), El Guettar (Gafsa), Ain Meterchem, Ain Mhrotta (Kairouan) and Sidi-Zin, over the Acheulian layers. These assemblages are characterised by their Levallois debitage and richness in side-scrapers. In Ain Meterchem, as well as in El Guettar, one tanged point of Aterian type was found in the Mousterian series. One should also mention a mysterious pile of spherical stones discovered near the spring of El Guettar (Gruet 1955).

Late Mousterian sites have been recently excavated in Morocco near the Algerian border (area of Ouargla

(Wengler 1986). Interestingly, at Rhafas, as in the Grotte des Pigeons at Taforalt (Roche 1952) and Temara (Debenath et al 1986), Mousterian and Aterian industries are observed in the same stratigraphical series and the two assemblages seem to evolve one from the other without any discontinuity. At Rhafas and Temara, a clear typological transition is observed. At the Rhafas cave, where a 'proto-Aterian' lies between the final Mousterian and the Aterian *sensu stricto*, the series displays a regular evolution with a development of tanged artefacts and end-scrapers and a reduction in frequency of side-scrapers. The same strategies in raw materials procurement and debitage techniques were adopted in both the Mousterian and Aterian emphasising their cultural likeness (Wengler 1990). In the eastern Maghreb it has been suggested that the Mousterian and Aterian may even widely overlap (Wendorf et al 1990; White 1995).

THE FOSSIL EVIDENCE

Tighénif (Mascara, Algeria)

The oldest human remains discovered in north Africa come from a sand pit near Tighénif (formerly Ternifine) 20 km east of Mascara (Algeria). The site has been known since the nineteenth century but the main excavation was conducted only between 1954 and 1956 by C Arambourg and R Hofstetter. Faunal association suggests an age close to the transition from Lower to Middle Pleistocene (Geraads et al 1986). The human remains series includes three mandibles (Tighénif 1, 2 and 3), one isolated parietal (Tighénif 4) and several isolated teeth that may have belonged to the same juvenile individual aged between 8 and 10 years old by modern standards (Tillier 1980). For the first time, human remains reminiscent of Asian *Homo erectus* were identified in Africa, and Arambourg (1954) described them under the denomination *Atlantropus mauritanicus*.

Tighénif 1 is characterised by very large dimensions and, in this respect, can be compared to Sangiran 5 and Olduvai H51 (Rightmire 1990). The specimens display primitive features. The lateral side has a constant height and bears pronounced profiles. The *torus marginalis inferior* is remarkably strong and develops a *tuberculum marginale anterius* and *posterius*. A *torus lateralis superior* ends in the *prominentia lateralis*. The mental foramina are simple and located under P4. The symphysis is remarkable by its thickness (19mm) corresponding to the *planum alveolare* and *torus transversus*. The morphology of the chin area has been much debated (Arambourg 1963; Rightmire 1990; Schwartz & Tattersall 2000) and it seems there is an incipient *tuber symphyseos*, a condition much more marked in Tighénif 2 and 3. Laterally, one does not observe a *torus mandibularis* as described by Weidenreich in the Asian *erectus* at Zhoukoudian (Weidenreich

1936). There is a spectacular *sulcus extramolaris* lateral to M2 and M3.

Tighénif 2 is an hemimandible of smaller size than Tighénif 1 and 3. On the lateral side of the body the bone morphology is similar to that observed in Tighénif 1 but less marked. The symphysis remains thick (18 mm) but displays a pattern different from Tighénif 1. On the anterior side there is a clear *tuber symphyseos*. According to Arambourg (1963) and Schwartz & Tattersall (2000) the morphology of this area can be interpreted as a *trigonum mentale*¹ (figure 8.3). There is no *incurvatio mandibulae*. The *trigonum basale* is prominent in the middle of the *incisura submentale*. There is a *planum alveolare* longer than in Tighénif 1, but below the inferior edge of the mandible it is not so thick and does not develop a genuine *torus transversus*. The insertions of the digastric muscles are oriented downward and posteriorly. The ramus is low, wide and slightly inclined.

Tighénif 3 is the most complete specimen yielded by the site and the largest specimen. The bi-condylar width can be estimated at 143 mm and the total length is 125 mm. Its comparison with T2 indicates a strong sexual dimorphism and/or an individual variability. At the level of M1, the thickness is 20 mm for a height of 37 mm which sets Tighénif 3 near the maximum observed in *Homo erectus sensu lato*. Profiles are similar to those of Tighénif 1 but mental foramina are multiple and located below the mid-level of the body. The symphysis is reminiscent of that from Tighénif 2: receding but with a *tuber symphyseos*, or even possibly a *trigonum mentale* on its anterior side. But there is no *incurvatio mandibulae* or any other element of a bony chin. Insertions of the digastric muscles are large (23×9 mm) and inferiorly oriented. On the posterior side of the symphysis, below the *torus transversus superior*, there is a deep *fossa genioglossa* that one does not find on the other specimens from Tighénif. The ramus is very strong, high and weakly inclined posteriorly. The sigmoid notch is deep



Figure 8.3 Tighénif 2 mandible, chin area in anterior view (after Arambourg 1963).

and the coronoid process higher than the condyle. Again, laterally to the M3, one observes a spectacular *sulcus extramolaris* 8 mm wide. There is also a genuine retromolar space.

Dentition of the Tighénif series is characterised by macrodonty especially evident in the molars. Molar robusticity is greater than the Zhoukoudian means. Incisors and canines are poorly preserved. The P3, especially on T1 and T2, displays a predominance of the vestibular cusp. The lingual cusp is smaller and distally displaced. There is a *fovea anterior* and a *fovea posterior*, a mesial and distal cingulum. The P4 is more symmetrical. It displays a ridging of enamel on T2. The *fovea posterior* is especially developed. There is a faint distal and mesial cingulum. There is a reduction of the M3 and the molar sizes are ordered M2>M1>M3. The molars displayed a dryopithecine pattern (Y5 or +5) with a predominant metaconid. The *tuberculum sextum* is observed on M2 and M3 in Tighénif 2. Traces of cingulum can be observed. Four isolated teeth are deciduous upper molars likely to be from the same individual aged between 8 and 10 years old (Tillier 1980).

The isolated left parietal bone of Tighénif 4 is well preserved. According to Arambourg (1963), it belonged to a young individual because of the opening of the suture and the relative thinness of the bone when compared to Asian *erectus*. However, the thickness reaches 9 mm near the centre of the squama and it could be the regular feature of a young adult. The specimen displays numerous primitive features including a temporal edge longer (105 mm) than the sagittal edge (95 mm). The parietal arc is among the shorter recorded in *Homo erectus sensu lato*, close to KMN ER 3883 and Sangiran 2. The temporal edge is poorly arched indicating a triangular temporal squama. In all directions the curvature of the bone is weak and there is no differentiated parietal bossing (see figure 8.5). The external morphology suggests the development of sagittal keeling but there is no angular torus. The internal surface displays a primitive pattern of the meningeal vessels with a predominance of the temporal branch on the fronto-parietal branch and few anastomoses.

Aïn Maarouf (El Hajeb, Morocco)

A human femoral diaphysis was identified in 1989 by D Geraads in a series of fossil remains coming from the site of Aïn Maarouf, 12 km west of El Hajeb on the south edge of the Meknès plateau. Mammal bones were collected between 1950 and 1951 with Acheulian artefacts. The faunal assemblage includes *Parmularius ambiguous*, only known in Tighénif, and *Rabaticeras arambourgi* represented in the Thomas quarries and in the upper beds of Olduvai. It suggests an early Middle Pleistocene age (Geraads et al 1992). The morphological analysis of the specimen (Hublin 1992) indicates an

individual of short size with a bicondylar length (M2) estimated to be 390 mm by regression on a modern sample. The diaphysis shows a strong curvature contrasting with the Olduvai and Zhoukoudian specimens but reminiscent of the Neanderthals and some modern series. Transversal and sagittal diameters are within the modern variation but the diaphysis displays primitive features such as the lack of pilaster, a convex popliteal surface, a rounded diaphysis with a low pilastric index (98.12), again close to the Neanderthal mean, a medio-lateral widening and a strong development of the cortical thickness.

Thomas Quarries (Casablanca, Morocco)

The Thomas quarries are located a few hundred metres from the ancient Sidi Abderrahmane quarry and numbered I, II, III from the road. During their exploitation, artefacts, fossil mammals and humans remains were collected from fissures and caves by P Beriro in Thomas quarry I and II. A mandible was found in 1969 in Thomas I in a cave deposit with a 'very archaic facies of Middle Acheulian' (Roche in Geraads et al 1980). Initially, the geological and palaeontological data pointed to an 'upper Amirian' (Sausse 1975; Jaeger 1981) or to an 'Early Tensiftian' age (Geraads 1980; Geraads et al 1980). More recent works tend to assign the site an early Middle Pleistocene age (Raynal et al 2001) *c* 600 ka BP.

The human mandible was first mentioned by Ennouchi (1969a, 1970) before being described by Sausse (1975). Only the left body and a part of the left ramus are preserved. The symphyseal part is missing as well as the coronoid process and the condyle. The series P₄-M₃ is still preserved, but one can observe the alveolus of P₃ and part of that of C. Compared to the Tighénif specimens the bone is gracile, reinforcing the notion of strong sexual dimorphism and/or individual variation. The thickness and height of the body are near the minimal values observed in the Zhoukoudian series (H1). There is a *torus marginalis* but the *tuberculum marginale anterior* located under the P₄-M₁ contact and the *tuberculum marginale posterior* located below the M₂ are poorly marked. The mental foramen opens at the mid-height of the body under the distal part of the P₄. The morphology of the lingual side of the body near the symphysis indicates the occurrence of a *planum alveolare* but it is impossible to estimate its development. The digastric insertion is oriented downward but slightly extends on the lingual side. The alveolar edge does not display a *torus mandibularis*.

The ramus is low, wide and slightly inclined backward. The anterior edge is damaged but there was no retromolar space. Again, there is a *sulcus extramolaris*, about 5 mm wide. On the lingual side, as on the Tighénif specimens, one finds a very marked *crista pharyngea* continuing backward into a *torus triangularis* to which a

crista endocoronoidea and a *crista endocondyloidea* converge. Below and behind the mylohyoid sulcus, strong asperities correspond to the insertion of the *m pterygoideus medialis*.

The impressive size of the dentition strongly contrasts with the relative gracility of the bone. The P₄ is symmetrical with a predominance of the vestibular cusp. The *fovea anterior* is reduced while the *fovea posterior* is very developed distally. There is a weak cingulum on the lingual side. The molars, as the P₄, are strongly worn. They display a dryopithecian pattern (Y5) and strong development of the metaconid. Only the M₃ displays a *tuberculum sextum* and the trace of a cingulum on the vestibular and mesial sides. Their size range decreases in a series M₂>M₁>M₃. The robusticity of the M₂ even exceeds the size observed in Tighénif. M₁ is comparable to that of Tighénif 2 and only the M₃ is smaller than in the Tighénif specimens.

Human remains were recovered in Thomas quarry III by P Beriro at the end of March 1972. They come from a little cave created by the dissolution of the 'Amirian' aeolianites. The filling was blanketed by a deposit of calcite indicating a humid phase of the early 'Tensiftian I' (Texier et al 1985). However, an Inter Amirian-Tensiftian age was not excluded.

Ennouchi (1972, 1976) described cranio-facial fragments including a left portion of the frontal squama, the infraorbital area, and a part of the nasal and lacrymal bones on the left side. The specimen is poorly preserved and the external table is strongly eroded. It is difficult to assess the morphology of the torus. Its anterior wall is partly destroyed, exposing the frontal sinus.

Sidi Abderrahmane (Casablanca, Morocco)

Human remains were collected in 1954 by P Biberson at the 'Grotte des Littorines' at the southwest end of the 'cunette', a large trench open at the north of the ancient Sidi Abderrahmane quarry. They were embedded in a sandstone lens (level F) belonging to the filling of a karstic cavity open in the 'Anfatian' deposit (maximum transgressive G₂ of Biberson). These deposits were assigned to the early Tensiftian *sensu stricto* (Tensiftian I of Texier et al 1985). In the chronology of Raynal et al (2001) they are assigned to the middle part of the 'Anfa group' (bottom of the Continental complex of Sidi Abderrahmane in the middle of the Middle Pleistocene). They were found in association with a Middle Acheulian assemblage.

A description of the human remains was provided by Arambourg & Biberson (1955, 1956). The fragments allowed the reconstruction of two portions of the same mandible. The biggest corresponds to the posterior right body with three molars, the second to the left anterior body broken at the level of the I₂ alveolus, but this tooth and the canine are missing. The poorly preserved

surface of the bone does not allow much morphological description. On the right body the alveolar edge is parallel to the basal edge. Thickness and height at the level of M2 are close to those observed on Tighénif 2. Below M2 a *proeminentia lateralis* is developed, but at the bottom of the body there is no clear *torus marginalis*. P3 is strongly worn. It bears a single root but with a longitudinal groove on the distal side. The crown is asymmetrical, the buccal cusp being larger than the lingual one which is slightly shifted in a distal direction. The *fovea anterior* is small while the *fovea posterior* is well developed. These features are reminiscent of those described in Tighénif. The molars range by size in this order: M2>M1>M3. M3 is less worn than M1 and on M2 one can observe that the enamel is wrinkled in its unworn distal portion. M1 is sub-rectangular and displays a dryopithecian pattern (Y5) with a strong metaconid in contact with the hypoconid and a defined *fovea anterior*. M2 is more elongated and elliptical. The pattern of the cusps is similar to that of M1 but there is also a *tuberculum sextum* between the hypoconid and the entoconid. There is a vestigial cingulum at the bottom of the crown on the buccal side. M3 is smaller and displays at least five cusps. The protoconid and the metaconid are the most developed. Regarding robusticity, P3 and M2 belong to the range of variation observed in Tighénif, but M1 and particularly M3 are significantly smaller.

Salé (Morocco)

The specimen was discovered in 1971 in a sandstone quarry located 5 km northeast of Salé on the Atlantic coast of Morocco. It was embedded in a fossil dune deposited 1.5 km from the present shoreline. This aeolianite yielded some large mammals (*Ceratherium* cf *simum*, *Conochaetes* sp and *Canidae* indet) and the overlying palaeosol a microfauna of 'Presolatian' age. The specimen was assigned to the bottom of the Tensiftian (Jaeger 1975a, 1981). It would be then contemporary with the Sidi Abderrahmane specimens and somewhat younger than the Thomas quarries specimens. Jaeger (1981) assigned this group of specimens and the G2 maximum Anfatian transgression to OIS 7, c 220 ka BP. But this transgression is now more likely correlated to OIS 13. Two preliminary ESR dates obtained in 1987 by R Grün, then at McMaster University (Canada), from bovid enamel from the same layer at 389 ka BP and 455 ka BP (linear U-uptake) may confirm this age.

It is likely that the skull was initially complete. However, it was recovered by quarrymen and some parts are missing, especially the face. Nonetheless, some anatomical areas, such as the palate, are known by their natural mould in the sandstone. The specimen is mainly represented by the braincase behind the supratoral area

(figure 8.4). The basicranium is preserved and a portion of the maxilla holding the right M3 is still attached to it. A separate fragment of the left maxilla is preserved holding the series I², C, P³, P⁴, M¹, M¹. It has been possible to complete the specimen with fragments extracted from the natural endocast, in the area of the *fossa hypophysialis*, *ala minor* and *ala major* of the sphenoid and the *crista frontalis* (Hublin 1991) and a 3D virtual reconstruction of a composite specimen combining the fragments of Thomas quarry III and Salé has been proposed (Kalvin et al 1992). It is a rather small specimen particularly with regard to the braincase and might be considered as a female. Considering the pattern of wear of the molars it was probably a young adult at the time of death.

A detailed description of the specimen has been provided elsewhere (Hublin 1991). However, it is important to emphasise some aspects of the Salé skull. As already mentioned (Hublin 1985, 1991), this individual displayed pathological conditions probably resulting from a congenital torticollis. It resulted mainly in an atrophy of some nuchal muscles and in a reduction of their surfaces of insertion which are strongly asymmetrical. A moderate facial asymmetry was also likely present. As a result, features of the rear skull should be interpreted with caution in taxonomic and phylogenetic terms. Specifically some 'advanced features' emphasised by Wolpoff (1980), Jaeger (1981) and Bräuer (1984) more likely result from the congenital distortion of the individual.

The cranial capacity of the specimen is a very small in contrast to the powerful masticatory system. It has been estimated c 930 cl, below the average values met in *Homo erectus sensu lato*. As a whole, the specimen displays many plesiomorphic retentions reminiscent of this group:

- maximum breadth of the skull at the level of the *crista supramastoidea*
- low convexity of the sagittal edge of the parietal
- reduced minimal width of the frontal
- sagittal keeling of the frontal
- bregmatic eminence
- occipital torus (but wide and poorly projected)
- small size of the *fossa occipitalis inferior* relatively to the *fossa occipitalis superior*
- simple pattern of the middle meningeal vessels
- lack of marked *crista infratemporalis*
- strong development of the *crista supramastoidea*
- pattern of the *incisura mastoidea*
- angulation between the axis of the *pars tympanica* and *pars petrosa* of the temporal
- reduction of the *foramen lacerum*
- lateral closure of the *fissura orbitalis superior*
- thickness of the cranial walls
- robusticity of the masticatory system.

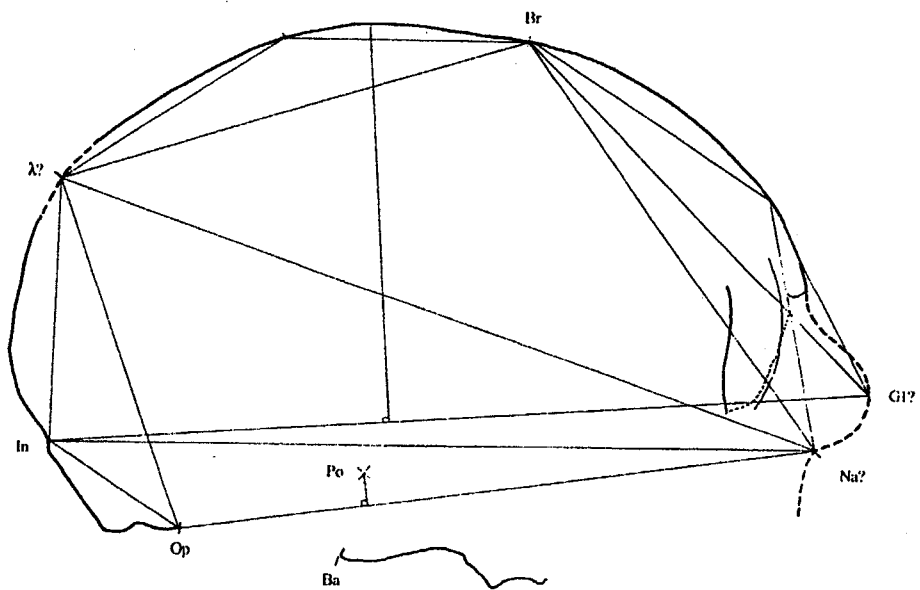


Figure 8.4 The Salé skull, lateral view and median profile. In=Inion, Op=Opisthocranium, Ba=Basion, Po=Porion, Na=Nasion, Gl=Glabella, Br=Bregma, λ=Lambda.

However, some metrical features, such as the length of the parietal arc, the height of the temporal squama or the relative height of the braincase, are at the upper limit of the *Homo erectus sensu lato* and are reminiscent of later Middle Pleistocene specimens. Furthermore, Salé displays clear synapomorphies with *Homo sapiens*:

- convexity and orientation of the frontal inferred from the remaining *crista frontalis* (figure 8.4)
- rounded outline of the temporal squama
- development of the *tuber parietale* (figure 8.5)
- vertical orientation of the lateral walls of the skull
- degree of basicranial flexion (?)
- preponderance of the *ramus frontoparietalis* on the *ramus temporalis* of the middle meningeal vessels
- well-marked *tuberculum pharyngeum*
- occurrence of a *spina ossis sphenoidalis*
- orientation of the pterglenoidian plane.

This mosaic of features, especially when one considers the shape of the braincase, is reminiscent of that observed on roughly contemporary African specimens which have been traditionally assigned to 'archaic *Homo sapiens*'

(Rightmire 1983; Brauer 1984; Clarke 1990) or, more recently, to the species '*Homo heidelbergensis*' by some authors (Stringer 1994; Rightmire 1996, 1998; Tattersall 2000). They mainly include Bodo (Ethiopia), Ndotu (Tanzania), Kabwe (Broken Hill, Zambia), and Hopefield (South Africa). This group displays highly variable degrees of robusticity, probably expressing a marked sexual dimorphism. The most gracile specimen of this group, ie, Ndotu, is certainly the one morphologically closer to Salé. However, it is worth noting the contrast observed in Salé between the primitive size of the endocranium, often considered as an important feature separating '*Homo heidelbergensis*' from earlier species of hominids, and the quite derived shape of the braincase. In this respect it is interesting to compare the morphology of the Salé specimen with the Tighénif parietal (figure 8.5) which displays much more primitive conditions.

Kebibat (Rabat, Morocco)

The Kebibat specimen was recovered in 1933 by J Marçais at a quarry in the suburb of Rabat and it was the first Middle Pleistocene fossil hominid ever found in

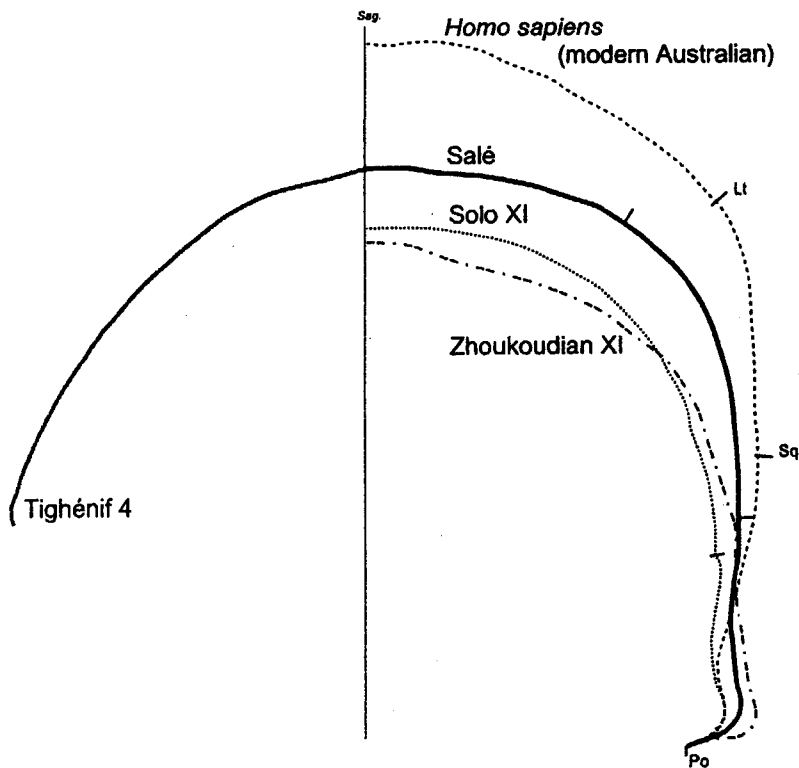


Figure 8.5 Transversal profiles of the vaults of Salé, Zhoukoudian XI, Solo XI, a modern Australian and the Tighénif 4 parietal. The profiles run from one porion to the middle of the parietal arc. All individuals are resized on the same bi-porion diameter. Salé is its natural size. Orientation of Tighénif 4 is estimated and the specimen is resized on Zhoukoudian XI.

north Africa. The most unusual conditions of this discovery (the skull was blasted by dynamite and then reburied by quarrymen) explains its fragmentary state. The specimen is composed of 23 cranial fragments from which it has been possible to rebuild some portions of both parietals and the central portion of the occipital, a fragment of the left maxilla with the series I^2 to M^2 associated with a natural mould of the palate, and a large portion of the mandible excluding the portion behind the left M_1 and behind the right M_3 . The dental series I_1 – M_1 is preserved on the left side. On the right side, I_1 , P_3 , P_4 and M_3 are preserved as well as the roots of M^1 and M^2 . The stratigraphic origin of the fossil has been much debated. Its layer overlaid the Anfatian deposits and it is generally assigned to the middle Tensiftian (Tensiftian *sensu stricto*, Tensiftian I of Texier et al 1985). However, according to Jaeger (1975b, 1981) it might also belong to the 'regressive Harounian–Rabatian', ie, the Tensiftian II of Texier et al (1985). The Kebibat specimen could then be either close in age to the Sidi Abderrahmane hominid or slightly later in age *c* 250–350 ka BP.

Several publications have described the mandibular morphology (Vallois 1945, 1959) (Saban 1975), the dentition (Vallois 1945, 1959) (Thoma & Vallois 1977), and the braincase (Saban 1975, 1976, 1977).

The body of the mandible is thick (18 mm at the *foramen mentale*) but moderately high, which produces a robusticity comparable to those of the Zhoukoudian series or to those of the most robust Neanderthals. On the lateral side of the body, one finds a *torus lateralis superior* and a *tuberculum marginale anterior*, but the *torus marginalis* is hardly indicated. The *sulcus extramolaris* is narrow. The anterior edge of the ramus hides the M_3 in lateral view. The mental foramina are double and in a rather low position. The symphysis is receding but displays a *tuber symphyseos* and is reminiscent of Tighénif 2. On its posterior side, a *planum alveolare* is developed, extending into a *torus transversus superior* over a *fossa genioglossa*. There is no real *torus transversus inferior*. The digastic insertions face downward.

The dentition was described in detail by Thoma & Vallois (1977). It indicates an individual age of 14 to 15 years by modern standards. It displays primitive retentions such as the persistence of a cingulum on I^2 and C on the maxilla, C, M_1 and M_3 on the mandible. The upper incisors show a moderate shovelling. The lower C is semi-incisiform. Premolars are strongly molarised. The P_3 displays the same asymmetrical pattern one observes in Tighénif. On the maxilla $M^1 > M^2$. On the mandible, M_1 still has a Y5 pattern and M_3 a +6 pattern with a ridged enamel. Dimensions are large, especially for C and P_3 which are bigger than on Tighénif 2.

The cranial bone is rather thin, similar to that of Tighénif 4, but this might be explained by the young age

of the individual. The occipital is remarkable for its rounded profile and the lack of *torus occipitalis transversus* is reminiscent of the weakness of this structure in Salé.

Djebel Irhoud (Morocco)

The Djebel Irhoud cave is located 55 km south east of Safi (Morocco). It was opened in 1960 during the exploitation of a barytine mine. The incidental discovery of a cranium (Irhoud 1) occurred in 1961. Then, an excavation undertaken by E Ennouchi yielded an adult calvaria (Irhoud 2) at the bottom of the sequence ('ashy level C' in Ennouchi 1963). In 1968 a juvenile mandible (Irhoud 3) was unearthed 0.6 m lower than Irhoud 2 (Ennouchi 1969b). During an excavation by J Tixier and de Bayles des Hermens in 1969, a juvenile humeral diaphysis (Irhoud 4) was discovered in the lowermost part of the archaeological deposits in level 18 (Hublin et al 1987). More recently I have identified a fragmentary pelvis of an adolescent in a sample of breccia collected by J Tixier.

Palaeontological evidence (Biberson 1964; Thomas 1981; Amani 1991; Amani & Geraads 1993) suggests an age older than the Soltanian. The faunal list established by Amani (1991) includes *Gerbillus grandis*, a species which was described in the Thomas quarry (Tong 1989) and an *Alcelaphinae* bearing a primitive dentition (*Rabaticeras?*). These two elements give the fauna a more archaic character than the fauna of 'Soltanian' sites such as Doukala (Morocco). The assemblage indicates quite dry conditions that could match the maximum extension of the Sahara of the OIS 5e or some arid episodes of the OIS 6. Attempts to estimate the age of the deposit by ESR were also conducted by R Grün with 3 horse teeth and a block of matrix I provided from the Tixier excavation. Five ESR dates were obtained ranging between 90 and 125 ka (early U-uptake) and between 105 and 190 ka (linear U-uptake) and published by Grün & Stringer (1991). These authors conclude that the site had a long depositional history covering at least OIS 5 and 6 and favour an age within OIS 6 (130–190 ka) for the hominids, assuming that they were low in the stratigraphic sequence. However, the close stratigraphic origin of the three samples, in the bottom of the stratigraphic sequence, seems inconsistent with the very wide range of ages determined.

The Irhoud specimens have been repeatedly allocated to the Neanderthals or designated as bearing Neanderthal features (eg, Ennouchi 1963, 1969; Clark Howell 1978; Bräuer 1984). This interpretation has been contested by Ferembach (1972), Howells (1975), Stringer (1974, 1978), Hublin (1978a), Santa Luca (1978), Hublin & Tillier (1981), Hublin et al (1987) and Hublin (1991). Detailed descriptions of Irhoud 1, 2, 3 and 4 are to be found in Hublin et al (1987) and Hublin (1991).

Irhoud 1 (figure 8.6) is a large skull, long and wide but already with an anteriorly positioned maximum width. The vault is low, in the common range of variation of the Neanderthals and the first modern humans. The sagittal profile is elevated in its anterior part, but after the bregma it forms a long and moderately convex arc. Thus, the bregmatic index (height of bregma above

the glabella-inion line/glabella-inion length) is of 51.35, well above the range of variation of the European Neanderthals (36.5–43.1) and near the values of Skhul 5 (47.8) or Qafzeh 9 (50.2). In posterior view it displays a pentagonal profile flattened at the top; the lateral sides are nearly parallel. The *tuber parietale* are high and well defined. The frontal bone is wide like the Neanderthals,



Figure 8.6 Irhoud 1, facial and lateral views.

and also like the Skhul-Qafzeh group or the Omo 2 or Eliye Springs material, but less so than the extremely wide Florisbad frontal. The convexity of the frontal is near the modern condition. A moderately pneumatized supraorbital torus is present. It thins laterally. The parietal arc is long absolutely and relatively to the temporal border of the parietal, but the sagittal convexity remains weak. The squamosal has a rounded and absolutely high outline but it is elongated antero-posteriorly. The root of the zygomatic process is set above the external acoustic meatus. The glenoid fossa is deep and well delimited, with a raised *tuberculum articulare*. The mastoid process is rather small but well defined and projecting downward below the juxta-mastoid eminence. The occipital displays low proportions and a flat *planum occipitale* without protruding

occipital torus. The endocranial capacity has been estimated to be 1480 cc by Anthony (1966) and 1305 cc by Holloway (1981). The face is wide and low. The prognathism does not exceed the modern condition. The alveolar prognathism is strong but there is no indication of mid-facial prognathism. The orbits are voluminous, rectangular, with axes oriented slightly downward laterally. The nasal cavity is wide in its lower part, but narrow upward, and it is very short. The medial part of the zygomatic bone as well as its *facies lateralis* are oriented frontally. The maxilla is of the 'inflexion' type, with an obliquely oriented and moderately wide frontal process. The alveolar arcade is very robust.

Irhoud 2 (figure 8.7) is very similar to Irhoud 1, but the former is metopic, which might explain some difference between the two specimens, including its wider



Figure 8.7 Irhoud 2, facial and lateral views.

proportions and its more convex frontal bone. This more modern aspect of the frontal is associated with a higher differentiation of the supraorbital elements. Nevertheless, the specimen has no genuine *trigonum supraorbitale*. The cranial bones are thinner than in Irhoud 1 and not far from the modern values. Some other aspects including the higher proportions of the temporal, a more convex parietal arc and the occurrence of an infra-temporal crest are more advanced than in Irhoud 1. In contrast, some other features are more primitive (length of the temporal edge of the parietal, lower proportion of the occipital). This variation seems compatible with that observed in series such as Qafzeh, Skhul or Shanidar (1939, 1981, 1983). Despite the stratigraphical uncertainty, Irhoud 1 and 2 probably belonged to the same population.

The Irhoud 3 (figure 8.8) mandible belonged to an individual approximately eight years old. It is more robust than a present-day mandible of an individual of the same age, with some primitive aspects on the posterior side of the symphysis which bears a *planum alveolare* and a *fossa genioglossa*. However, it does not display any clear Neanderthal apomorphy. The anterior teeth are not in alignment. The condyle is not expanded laterally. It can be extrapolated that the retromolar space would have been reduced in the adult. In contrast, modern traits such as the small size of the condyle, the height of the corpus decreasing posteriorly, the orientation of the digastric fossae, and the association of the four components of a bony chin (*tuber symphyseos*, *tuber lateralia*, *fossae mentales* and *incurvatio mandibulae*) are observed. One of the most striking features is the size of the teeth, especially the cheek teeth (Hublin & Tillier 1981). This macrodonty associated with a modern-like chin area and with the persistence of some archaic features on the posterior side of the symphysis evokes the conditions observed in the Skhul-Qafzeh series from the Near East.

The Irhoud 4 humeral diaphysis is flattened medio-laterally. The lateral supracondylar crest is projecting and the distal epiphysis would have been wide. The deltoid tuberosity is positioned high on the humerus and is frontally oriented. The cresting in the deltoid area forms a very narrow V. The *facies anterior medialis* is flattened and the lateral side of the shaft does not display a *sulcus nervi radialis* but a faint convexity. The cortical part of the bone is thickened relative to the medullary cavity. None of these features, however, need be considered as exclusively Neanderthal but express a great robusticity. The high position of the deltoid tuberosity, the flattening of the diaphysis and the reduction of the medullary cavity are more likely plesiomorphic conditions which should have been common in pre-modern *Homo*.

The features observed on Irhoud 1 and 2 are consistent with those seen on Irhoud 3 and 4. No Neanderthal apomorphies are observed. The skulls especially lack:

- a round profile ('bun') in *norma occipitalis*
- a flattening of the mastoid process on the petrous part of the temporal
- a *tuberculum mastoideum anterius* (Hublin 1978b)
- a projecting juxtamastoid eminence
- the bilateral protrusion of the occipital torus associated with a developed suprainiac fossa
- a strong convexity of the *planum occipitale* (figure 8.9)
- high and rounded orbits
- mid-facial prognathism and related features:
 - flattening of the antero-lateral part of the maxilla, with no frontal, sagittal or horizontal concavity
 - a broad and sagittally oriented frontal process of the maxilla
 - a receding zygomatic
 - a low subspinal angle (SSA of Howells 1973)
 - a large difference between M1 alveolus and zygomaxillare radii (AVR and ZMR of Howells 1973).

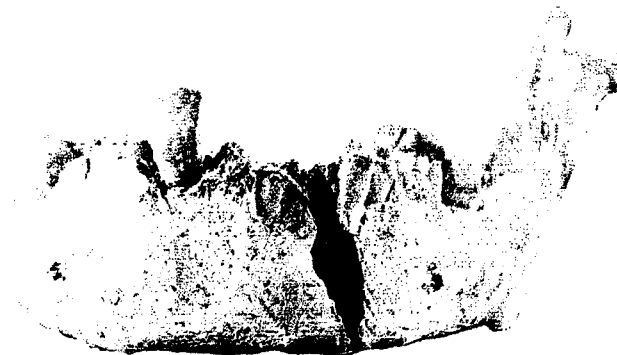


Figure 8.8 Irhoud 3, anterior view.

The only features shared with the Neanderthals are primitive retentions, such as the general robusticity of the skull and of the mandible, some degree of platycephaly (already reduced), and related features (weak convexity of the parietal, low proportions of the occipital squama, elongated temporal).

The Irhoud hominids are, therefore, clearly to be excluded from the Neanderthal clade. Moreover, they display clear affinities with the early modern humans of the Skhul-Qafzeh group, combining modern apomorphies (especially the development of a bony chin on the mandible, the convexity and orientation of the frontal squama, the dissociation of the supraorbital elements in Irhoud 2) and some plesiomorphies (general robusticity, macrodonty, strong supraorbital profiles, a wide, low and flattened face), which suggest an ancestor-descendant relationship with Upper Pleistocene modern humans.

When compared with the Skhul-Qafzeh group, the Irhoud specimens are only slightly more primitive. The

cranial vaults of Irhoud 1 and 2 are lower than Skhul 5 (figure 8.9), mainly in their posterior parts. The postero-inferior shifting of the occipital is less advanced, with a series of consequences such as moderate sagittal convexity of the parietal, a still rather elongated temporal, and the low proportions of the occipital squama. In some morphological aspects, for example the supra-orbital morphology, Irhoud 1 and 2 are similar to the most primitive specimens from Skhul and Qafzeh. When comparing Irhoud with the Aterian specimens, the latter display a more advanced morphology. Nevertheless, no anatomical argument would demonstrate any evolutionary discontinuity between the two groups, a statement already emphasised by Ferembach (1976) and which is consistent with the archaeological record. Furthermore, as with Irhoud, the Aterian hominids display a comparable combination of modern features in association with the same primitive retentions, ie, the supraorbital profile, the broad braincase and megadonty (Ferembach 1976; Hublin & Tillier 1981; Hublin 1991).

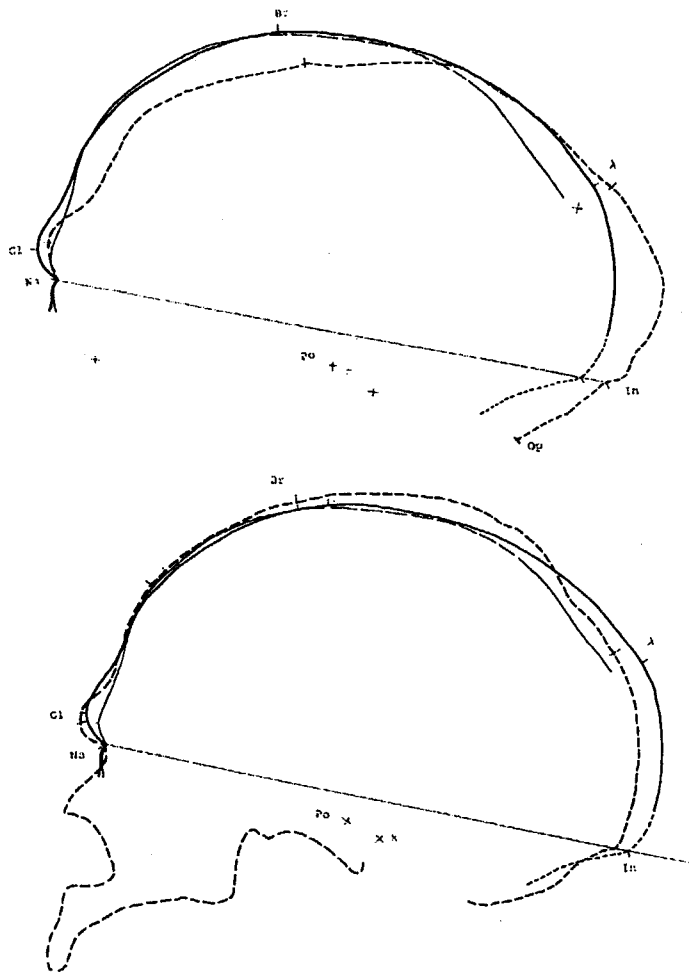


Figure 8.9 Irhoud 1 and 2 median profiles compared to La Chapelle-aux-Saints (top) and to Skhul 5 (bottom).

PHYLOGENETIC DISCUSSION

North Africa has provided a most significant series of Middle Pleistocene fossil hominids, of crucial importance for the understanding of modern human origins. It provides an exceptionally rich comparison for the European Middle Pleistocene record and allows us to discuss several issues concerning the taxonomic and phylogenetic interpretation of contemporary and later hominids. For most of the late Middle and Upper Pleistocene, the Mediterranean appears to represent a major barrier separating two biogeographic domains. At the western end of Eurasia, hominids evolved under relative geographical and genetic isolation. Located at the limit of the ecogeographical range of the hominids, this area witnessed the emergence of the Neanderthals. The evolution of the Neanderthal morphology results from an accretion process and from a shift in the frequency of derived features within the European populations from at least the middle of the Middle Pleistocene. This process started c 450,000 at least, probably in conjunction with environmental changes and their ecogeographical consequences (Hublin 1998), although genetic segregation may substantially predate the beginning of the phenetic distinction (Krings et al 1997). Emergence of the late ('classical') Neanderthals from Preneanderthals provides an example of rather gradual evolution within a hominid lineage, and although it has been possible to define stages along this process (Hublin 1988; Dean et al 1994), they are not clear-cut. From a taxonomic point of view and considering the importance of the phenetic differences between Neanderthals and contemporary groups of hominids, we favour the use of *Homo neanderthalensis*. Geographical separation between the two sides of the Mediterranean probably played a major role in the diverging evolution of this group relative to the lineage leading to *Homo sapiens*. The number of synapomorphies shared by extant humans and the Jebel Irhoud specimens demonstrates the existence of *Homo sapiens sensu stricto* ('early modern humans'), probably at least at the end of OIS 6 in north Africa.

The taxonomic assignment of the ancestral group of the two lineages and the possibility of other specific differentiations between them have been the matter of many discussions in past decades. For the authors who support the view that Neanderthals and modern humans both belong to the same species (*Homo sapiens*), their common ancestor has to be already a *Homo sapiens*. That is, the so-called 'archaic *Homo sapiens*' represented by specimens displaying derived features from *Homo erectus sensu lato* (a taxon which for most of these authors would be represented in Asia, Africa and possibly Europe), specifically in the size and shape of their braincase. This concept of 'archaic *Homo sapiens*' is very easy to use, but it is confusing as it encompasses the

Neanderthals and their ancestors as well as Asian specimens of uncertain affinities together with specimens which are probably directly ancestral to modern humans.

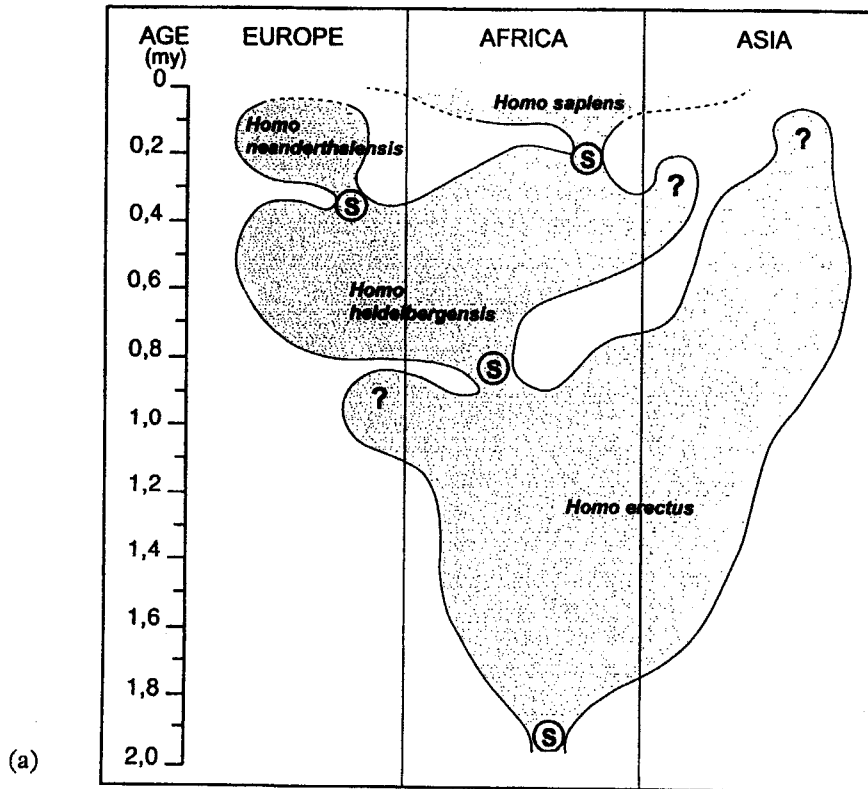
For those who separate *Homo sapiens* from *Homo neanderthalensis*, different solutions have been adopted to designate ancestral forms. One has been to call '*Homo heidelbergensis*' the common ancestor of the two lineages (Stringer 1994; Rightmire 1996, 1998; Tattersall 2000) (figure 8.10a). The hypodigm of this species would primarily include African (eg, Kabwe, Bodo, Ndutu, Hopefield, etc) and European fossils (eg, Mauer, Petralona, Arago, possibly Atapuerca SH, Swanscombe, Steinheim, etc). However, Asian specimens such as Dali have also been considered as possible eastern emigrants of the same species. In our view, under this meaning (*Homo heidelbergensis sensu lato*), *Homo heidelbergensis* is a root group which includes the representative of an ancestral lineage at the bottom of two daughter lineages. Such a grouping is rather common in vertebrate paleontology, when the roots of separated lineages are not identifiable through the derived features of their descendants. However, in this precise case, most of the European specimens included in *Homo heidelbergensis sensu lato* do display synapomorphies with Neanderthals and these synapomorphies are not observed in the African group. This is true for Swanscombe, Steinheim, Petralona, and Arago (see review in Hublin 1998 but also Maureille & Houët 1997 and Franciscus 1999 for Petralona). Furthermore, according to Antonio Rosas and José M Bermúdez de Castro (1998) it also is possibly true for the Mauer mandible itself. This fossil is the very specimen from which the species *Homo heidelbergensis* was created (1908), although interestingly no feature of this specimen type is actually ever used by the supporters of *Homo heidelbergensis sensu lato* to define the taxon. Even if the synapomorphies with *Homo neanderthalensis* emphasised by Rosas and Bermúdez de Castro (1998) (but see also Wolpoff 1982) are not considered sufficient, at least the Mauer specimen should be cautiously considered as an *incertae sedis*. An extended use of *Homo heidelbergensis* is therefore almost as confusing as the ancient notion of 'archaic *Homo sapiens*' as defined here above. It excludes the late Neanderthals under the denomination *Homo neanderthalensis*, but it mixes their identifiable ancestors with the African ancestors of *Homo sapiens*. A more restrictive use of *Homo heidelbergensis* (*Homo heidelbergensis sensu stricto*) is conceivable, as a grade encompassing only the most primitive section of the Neanderthal lineage (Petralona, Arago, Atapuerca SH, Swanscombe, Steinheim, etc). This is the position adopted by Rosas and Bermúdez de Castro (1988) and Arsuaga et al (1997). However, the mosaic nature of the evolution of the derived Neanderthal features may make the

definition of an effective diagnosis of this chronospecies quite difficult. It would be probably more consistent to include in *Homo neanderthalensis* all the specimens displaying Neanderthal-derived features, even incipient ones, than to vainly attempt to delineate a border between *Homo heidelbergensis* (*sensu lato* or *sensu stricto*) and *Homo neanderthalensis* among the Late Middle Pleistocene European specimens. Under what criteria should fossils such as those found at Swanscombe, Reinlingen or Biache be assigned to one or to the other?

A similar situation may occur in Africa when considering the relationship between the specimens currently included in *Homo heidelbergensis sensu lato* and *Homo sapiens*. Assuming that these specimens (Bodo, Kabwe, Ndutu, Hopefield, Salé) can be clearly separated from later representative of early *Homo sapiens* such as Irhoud, it would seem appropriate to use the term *Homo rhodesiensis* created by Woodward (1921) for the Kabwe specimen, which is the first fossil of this group that received a binominal denomination (figure 8.10b). However, the question remains whether the distinction between *Homo rhodesiensis* and *Homo sapiens* results from a speciation event or if once again we are dealing with grades. How gradual the change was from one to the other will determine whether we can continue to use this denomination in the future.

A partly distinct issue is that of the taxonomic assign-

ment of specimens further predating the split point between the Eurasian clade leading to the Neanderthals and the African clade leading to *Homo sapiens*. It is quite possible that no major evolutionary changes occurred in Africa when the Neanderthals apomorphies started to develop in Europe. In this situation, *Homo rhodesiensis* might be the sister group but also the ancestor of *Homo neanderthalensis*. Further discoveries will clarify this point. However, more primitive African and European specimens that do not display the derived conditions observed in *Homo rhodesiensis* have been described from the Lower Pleistocene to the early Middle Pleistocene. They have been assigned to *Homo erectus sensu lato* (Bräuer 1994; Ascenzi et al 1996) by authors who do not separate an eastern Asian clade from an African clade within Lower Pleistocene hominids assigned to this species (figure 8.10b). Alternatively, if differences are emphasised between Africa and Asia within this group (Andrews 1984; Stringer 1984; Wood 1984; Clarke 1990; Arsuaga et al 1999), the term *Homo erectus sensu stricto* is to be restricted to the Asian clade and denominations such as *Homo leakeyi* or *Homo antecessor* have been proposed (Clarke 1990; Arsuaga et al 1999). However, assuming that such a western taxon could be firmly established, it was certainly represented in the late Lower to Early Middle Pleistocene of Africa. *Homo mauritanicus* (Arambourg 1954) would have then priority on the other proposed denomination (figure



NORTHWESTERN AFRICAN MIDDLE PLEISTOCENE HOMINIDS

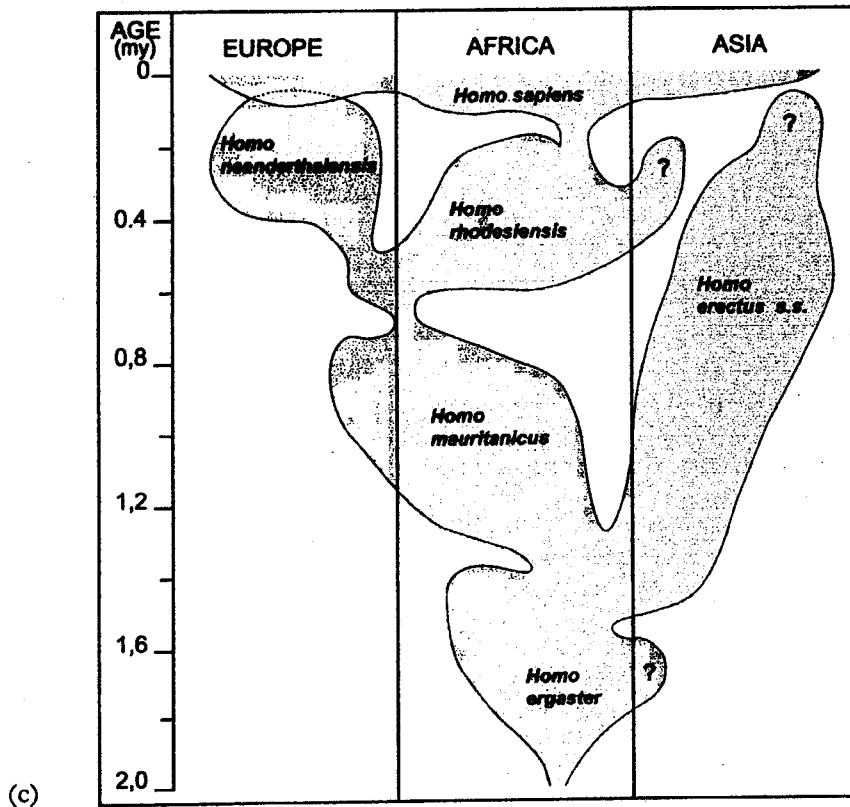
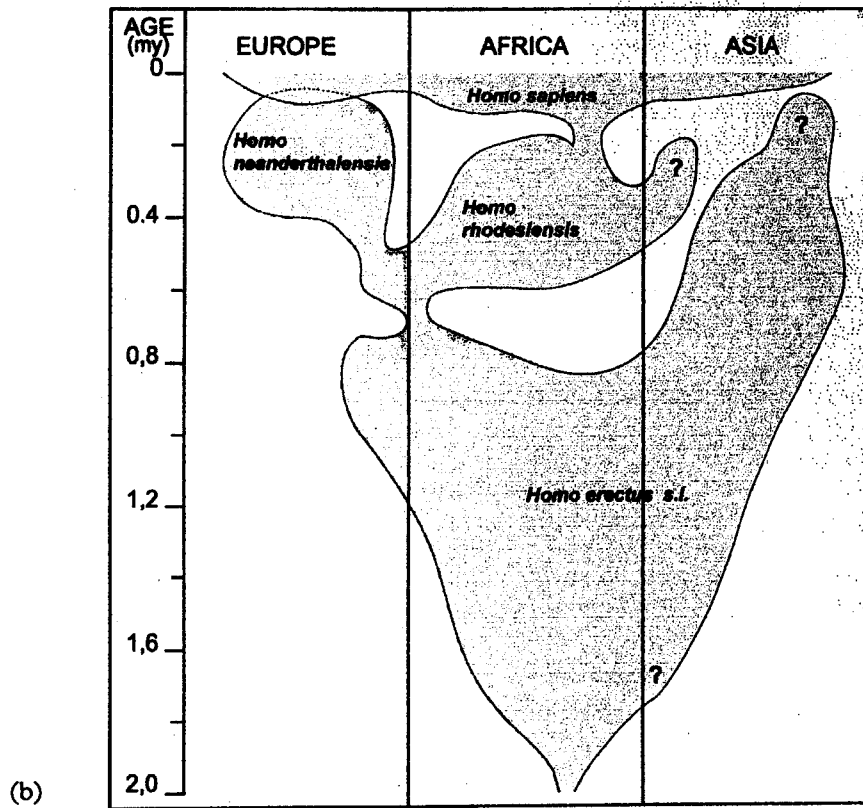


Figure 8.10 Three phylogenies of the Pleistocene representatives of the genus *Homo* (a is after Rightmire 1998). See comments in the text.

8.10c). In this perspective it should be remembered that although the material from Tighénif may display shared derived features with *Homo sapiens* (Schwartz & Tattersall 2000), it appears more primitive than the specimens assigned to *Homo rhodesiensis* when one considers the shape of the cranial vault. Figure 8.5 shows how the parietal transverse profile of the Salé specimen is far more advanced than the one exhibited by Tighénif 4. It is also worth noting that of the 15 dental features analysed by Bermúdez de Castro et al (1999) on the Gran Dolina material assigned to *Homo antecessor*, 14 are exhibited in the Middle Pleistocene African specimens primarily represented by the north African series. In the metrical analysis conducted by these authors, the first, second and third principal components of dental variables also demonstrate considerable similarity between the Gran Dolina and Tighénif samples.

FINAL REMARKS: ISOLATION AND CONNECTIONS

Cultural and biological evidence on both sides of the Mediterranean in the Middle Pleistocene provide contrasting pictures and shed some light on the nature of the exchanges between north Africa and adjacent areas. Although initially the main faunal similarities are observed between north and east Africa, eventually very limited exchanges of fauna occurred between Eurasia and northwestern Africa, maybe via the Levant, maybe also filtered by the Straits of Gibraltar. However, most of the mammalian taxa are not involved in these exchanges and some of them, such as the rodents, even display 'insular' features in the western Maghreb. As far as we know, when considering the hominids, the first half of the Middle Pleistocene seems marked by some degree of connection between western Eurasia and Africa underlined by similarities between the late Lower Pleistocene hominids of Gran Dolina (Atapuerca, Spain) and their African contemporaries. Later, the first Preneanderthals are still morphologically very close to the African *Homo rhodesiensis*. As already suggested (Lahr & Foley 1998), the spread of the Acheulian in Europe, which predates the emergence of the Neanderthal apomorphies may be related to the existence of these connections. The distribution of Acheulian assemblages in western Europe, with the possible existence of a 'Movius line' separating an eastern group of Lower Palaeolithic industries without handaxes from a western group, and the high frequency of cleavers in southwestern Europe suggests that Gibraltar was then an occasional path between north Africa and Europe (Alimen 1975; Otte 1996).

In contrast, the second half of the Middle Pleistocene is marked by an increasing divergence of the populations north and south of the Mediterranean. This divergence culminates with the emergence of *Homo sapiens* in north

Africa, while *Homo neanderthalensis* is well documented in the Iberian peninsula and on the Rock of Gibraltar itself. Unless both groups were subjected to considerable pressures of selection, it is difficult to imagine that significant and regular exchanges of populations could take place between the two geographic domains. Theoretical computations demonstrate that such genetic exchanges would have rapidly led to the homogenisation of the two populations. In the meantime connections between northwestern and eastern Africa documented by the mammal faunas became weaker with the periodic establishment of a Saharan desert belt which became continuous in the Upper Pleistocene. However, isolation from the human populations in Europe, although more marked than in the previous period, could not have been total. The development of the 'Mode 3' industries in Europe and Africa during OIS 7 has been related to significant exchanges of populations between the two areas and even to the spread of a new species of hominid: *Homo helmei* (Lahr & Foley 1998 and this volume). But this does not seem to be supported by the palaeontological evidence which already indicates a high degree of endemism of the European populations. Conceivably the development of the Mousterian assemblages from the Acheulian assemblages may have occurred in a parallel way in different areas in relation to the development of hafting and the related reduction in the use of bifaces. The Levallois debitage itself has been sometimes considered as a natural development of the Acheulian 'chaînes opératoires' by transformation of bifaces into cores (Tuffreau 1995). Finally, the age of the very earliest Levallois products is also debated and according to Tuffreau (1995), these products are documented in the Somme valley during the OIS 12 and even OIS 14, which leads us back to a period when the endemism of the human population of Europe was not yet fully established. Alternatively, if the similarities between the rare Mousterian assemblages from north Africa and those from Europe (Tixier in Hublin et al 1987) result from some exchanges in the late Middle Pleistocene, it will then indicate that some level of technical diffusion could have occurred without significant biological admixture, a phenomenon which occurred in other instances between *Homo neanderthalensis* and *Homo sapiens*.

NOTE

1 Inappropriately called 'trigonum basale' by Schwartz & Tattersall (2000: 402).

REFERENCE

- Alimen, HM, 1975. Les 'isthmes' hispano-marocain et siculo-tunisien aux temps acheuléens. *L'Anthropologie* 79, 399-436.
 Amari, F, 1991. La faune du gisement à hominidés de Jebel Irhoud (Maroc). Thesis, Université de Rabat.

- Amani, F, & Geraads, D, 1993. Le gisement moustérien du Jebel Irhoud, Maroc: précisions sur la faune et la biochronologie, et description d'un nouveau reste humain. *Comptes Rendus de l'Académie des Sciences* 316:847-852.
- Andrews, P, 1984. An alternative interpretation of the characters used to define *Homo erectus*. *Courier Forschungsinstitut Senckenberg* 69:167-178.
- Anthony, J, 1966. Premières observations sur le moulage endocrânien des hommes fossiles du Jebel Irhoud (Maroc). *Comptes Rendus de l'Académie des Sciences Paris* 262:556-558.
- Arambourg, C, 1954. L'Homnien fossile de Ternifine (Algérie). *Comptes Rendus de l'Académie des Sciences de Paris* 239:893-895.
- Arambourg, C, 1960. Au sujet de *Elephas iolensis* Pomel. *Bulletin d'Archéologie Marocaine* 3:93-105.
- Arambourg, C, 1963. L' *Atlanthropus mauritanicus*. *Mémoires et Archives de l'Institut de Paléontologie Humaine* 32: 37-190.
- Arambourg, C, 1969-1970. Les vertèbres du pléistocène de l'Afrique du Nord. *Arch. Muséum Nat. Hist. Nat.* 10:1-126.
- Arambourg, C, 1979. Vertébrés villafranchiens d'Afrique du Nord. Paris: Fondation Singer-Polignac.
- Arambourg, C, & Biberson, P, 1955. Découverte de vestiges humains acheuléens dans la carrière Sidi Abd-er-rahman, près de Casablanca. *Comptes rendu de l'Académie de Sciences de Paris* 240:1661-1663.
- Arambourg, C, & Biberson, P, 1956. The fossil human remains from the Paleolithic site of Sidi Abderrahman (Morocco). *American Journal of Physical Anthropology* 13:191-202.
- Arsuaga, JL, Martinez, I, Lorenzo, C, Gracia, A, Munoz, A, Alonso, O, & Gallego, J, 1999. The human cranial remains from Gran Dolina Lower Pleistocene site (Sierra de Atapuerca, Spain). *Journal of Human Evolution* 37:431-457.
- Arsuaga, JL, Martinez, I, Gracia, A, & Lorenzo, C, 1997. The Sima de los Huesos crania (Sierra de Atapuerca, Spain). A comparative study. *Journal of Human Evolution* 33:219-281.
- Ascenzi, A, Biddutu, I, Cassoli, PF, Segre, AG, & Segre-Naldini, E, 1996. A calvarium of late *Homo erectus* from Ceprano, Italy. *Journal of Human Evolution* 31:409-423.
- Balout, L, 1955. Préhistoire de l'Afrique du Nord. Paris: Arts et Métiers Graphiques.
- Balout, L, Biberson, P, & Tixier, J, 1967. L'Acheuléen de Ternifine (Algérie): gisement de l'Atlanthrope. *L'Anthropologie* 71:217-238.
- Beudet, G, 1969. *Le plateau central marocain et ses bordures : étude géomorphologique*. Paris: Imprimeries françaises et marocaines.
- Bermudez de Castro, JM, Rosas, A, & Nicolas, ME, 1999. Dental remains from Atapuerca-TD6 (Gran Dolina site, Burgos, Spain). *Journal of Human Evolution* 37:523-566.
- Bernoussi, R, 1997. Contribution à l'étude paléontologique et observations archéozoologiques pour deux sites du Pléistocène moyen du Maroc atlantique: grotte à Hominidés de la carrière Thomas 1 et de la grotte des Rhinocéros de la carrière Oulad Hamida 1 (Casablanca, Maroc). Thesis, Université Bordeaux 1.
- Biberson, P, 1961. Le cadre paléogéographique de la Préhistoire du Maroc Atlantique. *Publ. Serv. Antiq. Maroc* 16:1-235.
- Biberson, P, 1964. La place des hommes du paléolithique marocain dans la chronologie du Pléistocène atlantique. *L'Anthropologie* 68:475-526.
- Bräuer, G, 1984. A craniological approach to the origin of anatomically modern *Homo sapiens* in Africa and implications for the appearance of modern Europeans. In Smith, FH & Spencer, F, *The origins of modern humans: a world survey of the fossil evidence*; 327-410. New York: Alan R. Liss.
- Bräuer, G, 1994. How different are Asian and African *Homo erectus*? *Courier Forschungsinstitut Senckenberg* 171:301-318.
- Clark Howell, F, 1978. *Hominidae*. In Maglio, VJ, & Cooke, HBS, *Evolution of African mammals*; 154-248. Cambridge: Harvard University Press.
- Clarke, RJ, 1990 The Ndutu cranium and the origin of *Homo sapiens*. *Journal of Human Evolution* 19:699-736.
- Coque, R, 1962. *La Tunisie présaharienne; étude géomorphologique*. Paris: Armand Colin.
- Coque, R, & Jauzein, A, 1965. Le quaternaire moyen de l'Afrique du Nord. *Bulletin de l'Association française pour l'Etude du Quaternaire* 2:117-132.
- Couvreux, G, 1981. *Essai sur l'évolution morphologique du Haut-Atlas central calcaire*. Thesis, Université de Lille.
- Dean, D, Hublin, J-J, Ziegler, R, & Holloway, R, 1995 On the phylogenetic position of the pre-Neandertal specimen from Reilingen, Germany. *Journal of Human Evolution* 34:485-508.
- Debenath, A, Raynal, JP, Roche, J, Texier, J-P, & Ferembach, D, 1986. Stratigraphie, habitat, typologie et devenir de l'atérien marocain : données récentes. *L'Anthropologie* 90:233-246.
- Debenath, A, Raynal, J-P, & Texier, J-P, 1982. Position stratigraphique des restes humains paléolithiques marocains sur la base des travaux récents. *Comptes-Rendus de l'Académie des Sciences* 294:1247-1250.
- Dutour, A, 1983. Etude géomorphologique de la partie occidentale de la Haute Moulouya (Maroc). Thesis, Université de Poitiers.
- Ennouchi, E, 1963. Les Néanderthaliens du Jebel Irhoud (Maroc). *Comptes Rendus de l'Académie des Sciences* 256:2459-2460.
- Ennouchi, E, 1969a. Découverte d'un Pithécantropien au Maroc. *Comptes Rendus de l'Académie des Sciences* 269:763-765.
- Ennouchi, E, 1969b. Présence d'un enfant néanderthalien au Jebel Irhoud (Maroc). *Annales de Paléontologie (Vertébrés)* LV[2]: 251-265.
- Ennouchi, E, 1970. Un nouvel archanthropien au Maroc. *Annales de Paléontologie (Vertébrés)* 56(1):95-107.
- Ennouchi, E, 1972. Nouvelle découverte d'un Archanthropien au Maroc. *Comptes Rendus de l'Académie des Sciences de Paris* 274D: 3088-3090.
- Ennouchi, E, 1976. Un deuxième Archanthropien à la Carrière Thomas III (Maroc). *Bulletins du Musée national d'Histoire naturelle* 397(3):273-296.
- Ferembach, D, 1972. L'ancêtre de l'homme du paléolithique supérieur était-il néandertalien? In Bordas, F, (ed) *Origine de l'Homme moderne*. 73-80. Paris: Unesco.
- Ferembach, D, 1976. Les restes humains de la grotte de Dar-es-Soltane 2 (Maroc), campagne 1975. *Bulletins et Mémoires de la Société d'Anthropologie de Paris* 3:183-193.
- Franciscus, RG, 1999. Unique vs. non-unique aspects of Neandertal upper respiratory anatomy. *Journal of Human Evolution* 36:A7.
- Geraads, D, 1980. La faune des sites à *Homo erectus* des carrières Thomas (Casablanca, Maroc). *Quaternaria* 22:65-94.
- Geraads, D, 1981. *Bovidae et Giraffidae (Artiodactyla, Mammalia) du Pléistocène de Ternifine (Algérie)*. *Bulletins du Musée national d'Histoire naturelle* 3:47-86.
- Geraads, D, 1982. Paléobiogéographie de l'Afrique du Nord depuis le Miocène terminal, d'après les grans mammifères. *Geobios (mem.spec.)* 6:473-481.
- Geraads, D, Beriro, P, & Roche, H, 1980. La faune et l'industrie des sites à *Homo erectus* des Carrières Thomas (Maroc). Précisions sur l'âge de ces Hominidés. *Comptes-Rendus de l'Académie des Sciences* 291:195-198.
- Geraads, D, 1995. Rongeurs et insectivores (*Mammalia*) du Pliocène final de Ahl Al Oughlam (Casablanca, Maroc). *Geobios* 1:99-115.
- Geraads, D, 1996. Le *Sivatherium (Giraffidae, Mammalia)* du Pliocène final d'Ahl al Oughlam (Casablanca, Maroc), et l'évolution du genre en Afrique. *Paläontologische Zeitschrift* 70:623-629.
- Geraads, D, 1997. Carnivores du Pliocène terminal de Ahl Al Oughlam (Casablanca, Maroc). *Geobios* 30(1):127-164.
- Geraads, D, & Amani, F, 1997. La faune du gisement à *Homo erectus* de l'Ain Maarouf, près de El Hajeb (Maroc). *L'Anthropologie* 101:522-530.
- Geraads, D, Amani, F, & Hublin, J-J, 1992. Le gisement pléistocène moyen de l'Ain Maarouf près de El Hajeb, Maroc: présence d'un hominidé. *Comptes Rendus de l'Académie des Sciences* 314:319-323.
- Geraads, D, Hublin, J-J, Jaeger, J-J, Tong, H, Sen, S, & Tourbeau, P, 1986. The Pleistocene hominid site of Ternifine, Algeria: new results on the environment, age, and human industries. *Quaternary Research* 25:380-386.
- Gigout, M, & Raynal, R, 1957. Corrélations des phénomènes marins et continentaux dans le quaternaire marin. *Comptes rendus de l'Académie des Sciences* 244:2528-2531.
- Gruet, M, 1955. Amoncellement pyramidal de sphères calcaires dans une source fossile moutérienne à el'Guettar (Sud Tunisien). Actes du II Congrès Pan-Africain de Préhistoire. 449-456.

- Grün, R., & Stringer, CB, 1991. Electron spin resonance dating and the evolution of modern humans. *Archaeometry* 33:153-199.
- Holloway, RL, 1981. Volumetric and asymmetry determinations on recent hominid endocasts: Spy I ans II, Djebel Irhoud I and the Salé Homo erectus specimens, with some notes on Neandertal brain size. *American Journal of Physical Anthropology* 55:385-393.
- Howells, WW, 1973. Cranial variation in man: a study by multivariate analysis. *Peabody Museum Papers* 67:1-259.
- Howells, WW, 1975. Neanderthal Man: facts and figures. In Tuttle, Russell H, *Paleoanthropology, morphology and paleoecology*; 389-407. The Hague: Mouton.
- Hublin, J-J, 1978a. Le torus occipital transverse et les structures associées: évolution dans le genre *Homo*. Thesis, Université de Paris VI.
- Hublin, J-J, 1978b. Quelques caractères apomorphes du crâne néandertalien et leur interprétation phylogénétique. *Comptes Rendus à l'Académie des Sciences de Paris* 287D:923-926
- Hublin, J-J, 1985. Human fossils from the North African Middle Pleistocene and the origins of *Homo sapiens*. Delson, Eric. *Ancestors: the hard evidence*. 282-288. New York: Alan R. Liss.
- Hublin, J-J, 1988. Les plus anciens représentants de la lignée préneandertalienne. In Trinkaus, E., *L'homme de Neandertal 3: l'anatomie*; 30, 81-94. Liège: ERAUL.
- Hublin, J-J, 1991. L'émergence des *Homo sapiens* archaïques: Afrique du Nord-ouest et Europe occidentale. Thesis, Université Bordeaux I.
- Hublin, JJ, 1992. Le fémur humain pléistocène moyen de l'Ain Maarouf (El Hajeb, Maroc). *Comptes Rendus de l'Académie des Sciences* 314(Série II):975-980.
- Hublin, J-J, & Tillier, AM, 1981. The Mousterian juvenile mandible from Irhoud (Morocco): a phylogenetic interpretation. In Stringer, CB. (ed) *Aspects of human evolution*; 167-185. London: Taylor and Francis.
- Hublin, J-J, Tillier, AM, & Tixier, J, 1987. L'humerus d'enfant moustérien (Homo 4) du Jebel Irhoud (Maroc) dans son contexte archéologique. *Bulletins et Mémoires de la Société d'Anthropologie de Paris* 4:115-142.
- Hublin, J-J, 1998. Climatic changes, paleogeography, and the evolution of the Neandertals. In Akazawa, T, Aoki, K, & Bar-Yosef, O, (eds) *Neandertals and modern humans in Western Asia*; 295-310. New York: Plenum Press.
- Jaeger, JJ, 1969. Les rongeurs du Pléistocène moyen de Ternifine (Algérie). *Comptes Rendus de l'Académie des Sciences* 269:1492-1495.
- Jaeger, JJ, 1975a. Découverte d'un crâne d'hominidé dans le pléistocène moyen du Maroc. Problèmes actuels de paléontologie. Evolution des Vertébrés. 897-902. Paris: CNRS.
- Jaeger, J-J, 1975b. The mammalian faunas and hominid fossils of the Middle Pleistocene in the Maghreb. In Butzer, KW, & Isaac, GI., *After the australopithecines*; 375-397. The Hague: Mouton.
- Jaeger, J-J, 1975c. Evolution des Rongeurs du Miocène à l'actuel en Afrique nord-occidentale. Thesis, Université de Montpellier.
- Jaeger, J-J, 1981. Les hommes fossiles du Pléistocène moyen du Maghreb dans leur cadre géologique, chronologique et paléocécologique. In Sigmond, BA, & Cybulski, JS, *Homo erectus*. Papers in Honor of Davidson Black. 159-264. Toronto: University of Toronto Press.
- Kalvin, AD, Dean, D, Hublin, J-J, & Braun, M, 1992. Visualization in anthropology: reconstruction of human fossils from multiple pieces. *Computer Science*; 1-14.
- Krings, M, Stone, A, Schmitz, R., Krainitzki, H, Stoneking, M, & Paabo, S, 1997. Neandertal DNA sequences and the origin of modern humans. *Cell* 90:19-30.
- Lahr, MM, & Foley, RA, 1998. Towards a theory of modern human origins: geography, demography and diversity in recent human evolution. *Yearbook of Physical Anthropology* 41:137-176.
- Laquay, G, & Cheddadi, A, 1986. Nouvelles données sur la faune de vertébrés de la carrière Doukkala II (Rabat-Maroc). *Société Géologique de France*. 11th RST:106.
- Lavocat, R, 1978. *Rodentia and Lagomorpha*. In Maglio, VJ & Cooke, HBS, *Evolution of African mammals* 69-89. Cambridge: Harvard University Press.
- Lefèvre, D, Raynal, J-P, Texier, J-P, & El Graoui, M, 1999. Où l'océan rencontre le continent. In Raynal, JP, Sbihi-Alaoui, FZ, & El Hajraoui, A, *Maroc terre d'origines*; 15-17. Le Puy-en-Velay: CDERAD.
- Lietz, J, & Schmincke, HV, 1975. Miocene-Pliocene sea-level changes and volcanic phases on Gran Canaria (Canary islands) in the light of new K-Ar ages. *Paleogeography, Palaeoclimatology, Palaeoecology* 18:213-239.
- Maureille, B, & Houët, F, 1997. L'orientation spatiale des surfaces infra-orbitaires maxillo-zygomatiques chez *Homo sapiens*. Une clé de la compréhension de la face néandertalienne. *Biométrie Humaine et Anthropologie* 15:75-80.
- Maurer, G, 1968. Les montagnes du Rift central: étude géomorphologique. Travaux de l'Institut scientifique chérifien. [14]. Rabat: Sric géologique et géographique physique.
- Neuville, R, & Ruhlmann, A, 1941. La place du paléolithique ancien dans le Quaternaire marocain. *Hesperis VIII*.
- Occhiotti, S, Raynal, J-P, Pichet, P, & Texier, J-P, 1993. Aminostratigraphie du dernier cycle climatique au Maroc atlantique, de Casablanca à Tanger. *Comptes Rendus de l'Académie des Sciences*, 317:1625-1632.
- Otte Marcel, 1996. *Le Paléolithique inférieur et moyen en Europe*. Paris: Armand Colin.
- Raynal, J-P, Sbihi Alaoui, FZ, Geraads, D, Magoga, L, & Mohi, A, 2001. The earliest occupation of North Africa: the Moroccan perspective. *Quaternary International* 75:65-75.
- Raynal, J-P, Texier, JP, Lefevre, D, & Fedoroff, N, 1986. Quaternary paleoenvironments and palaeoclimates of Morocco. In *Quaternary climate in the Western Mediterranean*; 503-515. Proceedings of the Symposium on Climate Fluctuations during the Quaternary in the Western Mediterranean Regions.
- Raynal, J-P, Geraads, D, Magoga, L, El Hajraoui, A, Texier, J-P, Lefevre, D, & Sbihi-Alaoui, F-Z, 1993. La Grotte des Rhinocéros (Carrière Oulad Hamida I, anciennement Thomas III, Casablanca), nouveau site acheuléen du Maroc atlantique. *Comptes Rendus de l'Académie des Sciences* 316:1477-1483..
- Raynal, J-P, Magoga, L, Sbihi-Alaoui, F-Z, & Geraads, D, 1995. The earliest occupation of Atlantic Morocco: the Casablanca evidence. Roebroeks, W. and van Kolfschoten, T. *The earliest occupation of Europe*. [255-262]. Leiden: University of Leiden.
- Raynal, J-P, & Texier, J-P, 1989. Découverte d'Acheuléen ancien dans la carrière Thomas I à Casablanca et problème de l'ancienneté de la présence humaine au Maroc. *Comptes Rendus à l'Académie des Sciences* 308:1743-1749.
- Raynal, R, 1961. *Plaines et piedmonts du bassin de la Moulouya (Maroc oriental): étude géomorphologique*. Rabat: Imprimeries françaises et marocaines.
- Raynal, R, 1965. Sédimentation et évolution des processus géomorphologiques au cours des pluviaux quaternaires en Afrique du Nord. Congrès international d'Etudes Nord Africaines. Cagliari; 115-127
- Rightmire, GP, 1983. The Lake Ndutu cranium and early *Homo sapiens* in Africa. *American Journal of Physical Anthropology* 61:245-254.
- Rightmire, GP, 1990. *The evolution of Homo erectus: comparative anatomical studies of an extinct human species*. Cambridge: Cambridge University Press.
- Rightmire, GP, 1996. The human cranium from Bodo, Ethiopia: evidence for speciation in the Middle Pleistocene? *Journal of Human Evolution* 31:21-39.
- Rightmire, GP, 1998. Human evolution in the Middle Pleistocene: the role of *Homo heidelbergensis*. *Evolutionary Anthropology* 6:218-227.
- Roche, J, 1952. Note préliminaire sur la grotte de taforalt (Maroc oriental). *Hesperis* 40:89-116.
- Rodrigue, A, 1987. Nouveaux éléments sur le Moustérien du Maroc: la station d'Akka (Maroc Saharien). *L'Anthropologie* 91:483-496.
- Rognon, P, 1996. Climatic change in the African deserts between 130,000 and 10,000y bp. *Compte rendu de l'Académie des Sciences* 323:549-561.
- Rosas, Antonio & Bermúdez de Castro, José M, 1998. The Maur mandible and the evolutionary significance of *Homo Heidelbergensis*. *Geobios* 31:687-697.
- Saban, R, 1975. Les restes humains de Rabat (Kébitat). *Annales de Paléontologie (Vertébrés)* 61:153-207.

- Saban, R, 1976. A propos des traces vasculaires endocrâniennes chez l'homme de Rabat. IXth congrès UISSP Nice. Les plus anciens hominidés; 430-444
- Saban, R, 1977. The place of Rabat man (Kébitat, Morocco) in human evolution. *Current Anthropology* 18:518-523.
- Sahnouni, M, & de Heinzelin, J, 1998. The site of Ain Hanech revisited: new investigations at this Lower Pleistocene site in northern Algeria. *Journal of Archaeological Science* 25:1083-1100.
- Santa Luca, AP, 1978. A re-examination of presumed Neandertal-like fossils. *Journal of Human Evolution* 7:619-636.
- Sausse, F, 1975. La mandibule atlanthropienne de la carrière Thomas I (Casablanca). *L'Anthropologie* 79(1):81-112.
- Schoetensack, O, 1908. *Der Unterkiefer des Homo heidelbergensis aus sanden Mauer bei Heidelberg*. Leipzig: Wilhelm Engelmann.
- Schwartz, JH, & Tattersall, I, 2000. The human chin revisited: what is it and who has it? *Journal of Human Evolution* 38:367-409.
- Stearns, CE, 1978. Plio-pleistocene emergence of the Morocco Meseta. *Geological Society of America Bulletin* 89:1630-1644.
- Stringer, CB, 1974. Population relationships of later Pleistocene hominids: a multivariate study of available. *Journal of Archaeological Science* 1:317-342
- Stringer, CB, 1978. Some problems in middle and upper Pleistocene hominid relationship. In Chivers, DJ, & Joysey, KA, *Recent advances in primatology. 3: Evolution*; 395-418. London: Academic Press.
- Stringer, CB, 1984. The definition of *Homo erectus* and the existence of the species in Africa and Europe. *Cour. Forsch. Inst. Senckenberg* 69:131-143.
- Stringer, CB, 1994. Out of Africa. A personal history. In Nitecki, MH, & Nitecki, DV, *Origins of Anatomically modern humans*; 149-172. New York: Plenum Press.
- Tattersall, I, 2000. Palaeoanthropology: the last half-century. *Evolutionary Anthropology* 7, 2-16.
- Tchernov, E, 1998. The faunal sequence of the Southwest Asian Middle Paleolithic in relation to hominid dispersal events. In Akazawa, T, Aoki, K, & Bar-Yosef, O, *Neanderthals and modern humans in Western Asia*. 77-90. New York: Plenum Press.
- Texier, JP, Lefèvre, D, & Raynal, JP, 1994. Contribution pour un nouveau cadre stratigraphique des formations littorales quaternaires de la région de Casablanca. *Comptes rendus de l'Académie des Sciences* 318:1247-1253.
- Texier, J-P, Raynal, J-P, & Lefevre, D, 1985. Nouvelles propositions pour un cadre chronologique raisonné du Quaternaire marocain. *Comptes Rendus de l'Académie des Sciences* 301:183-188.
- Thoma, A, & Vallois, H-V, 1977. Les dents de l'homme de Rabat. *Bulletins et Mémoires de la Société d'Anthropologie de Paris* 4:31-58.
- Thomas, H, 1981. La faune de la grotte à néandertaliens du Jebel Irhoud (Maroc). *Quaternaria* 23:191-217.
- Tillier, AM, 1980. Les dents d'enfant de Ternifine (Pleistocène moyen d'Algérie). *L'Anthropologie* 84:413-421.
- Tong, H, 1989. Origine et Evolution de Gerbillidés (*Mammalia, Rodentia*) en Afrique du Nord. *Mém. Soc. Géol. de France* 155.
- Tuffreau, A, 1995. The variability of Levallois technology in northern France and neighbouring areas. In Dibble, HL, & Bar-Yosef, O, *The definition and interpretation of Levallois technology. Monographs in World Archaeology*, 23:413-427.
- Vallois, HV, 1959. L'Homme de Rabat. *Bull. Archéologie marocaine* 3:87-91.
- Vallois, HV, 1945. L'homme fossile de Rabat. *Comptes Rendus à l'Académie des Sciences* 221:669-671.
- Villa, P, in press. Early Italy and the colonization of Western Europe. *Quaternary International*.
- Weidenreich, Franz, 1936. The mandibles of *Sinanthropus pekinensis*: a comparative study. *Palaeontologia Sinica Series D*, 7(3):1-162.
- Wendorf, F, Close, AE, Schild, R, Gautier, A, Schwarcz, HP, Miller, G, Kowalski, K, Królik, H, Bluszcz, A, Róbins, D, & Grün, R, 1990. Le dernier interglaciaire dans le Sahara oriental. *L'Anthropologie* 94:361-391.
- Wengler, L, 1986. Position géochronologique et modalités du passage Moustérien-Atérien en Afrique du Nord. L'exemple de la grotte du Rhafas au Maroc oriental. *Comptes Rendus à l'Académie des Sciences* 303:1153-1156.
- Wengler, L, 1990. économie des matières premières et territoire dans le moustérien et l'atérien maghrébins exemples du Maroc oriental. *L'Anthropologie* 94:335-360.
- White, TD, 1995. African omnivores: global climatic change and Plio-Pleistocene hominids and suids. In Vrba, ES, Denton, GH, Partridge, TC, & Burckle, LH, *Paleoclimate and evolution with emphasis on human origins*; 369-384. New Haven: Yale University Press.
- Wolpoff, MH, 1982. The Arago dental sample in the context of Hominid dental evolution. In *L'Homo erectus et la place de l'homme de Tautavel parmi les hominidés*; 389-410. Nice: CNRS.
- Wolpoff, M, 1980. *H. Paleanthropology*. New York: Alfred A. Knopf.
- Wood, BA, 1984. The origins of *Homo erectus*. *Courier Forschungsinstitut Senckenberg* 69:99-112.
- Woodward, AS, 1921. A new cave man from Rhodesia, South Africa. *Nature* 108:371-372.