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THE DATING OF EUROPEAN MIDDLE PLEISTOCENE HOMINIDS AND THE EXISTENCE OF HOMO ERECTUS IN EUROPE

INTRODUCTION

Because the first discoveries of specimens now attributed to the species *Homo erectus* were made in Asia, and that continent has provided the main samples of fossils generally classified within this species, our model of the morphology of *H. erectus* is inevitably derived from the Javanese and Chinese material originally described by, amongst others, Dubois (1896) and Weidenreich (1936, 1937, 1941, 1943, 1951). More recent accounts of discoveries and interpretations of the Asian *Homo erectus* material can be found in Jacob (1975), Sartono (1975), Oakley, Campbell and Molleson (1975) and Day (1977). African fossil material attributable to this species is now recognised from Ternifine (Arambourg and Hoffstetter 1963), Olduvai (Rightmire 1979), Koobi Fora (Walker and Leakey 1978) and elsewhere (Day 1977; Oakley, Campbell and Molleson 1977; Rightmire, in press), although there has been no satisfactory comparative study of the relevant material from the two continents. Fossils such as those from Mauer, Vértesszöllös, Arago, Petralona and Bilzingsleben have been attributed to *Homo erectus* (Wolpoff 1975, 1977; Vlček 1978; de Lumley et al. 1979) while others have argued that this sample of middle Pleistocene European material represents an early form of *Homo sapiens* and can be distinguished, where the material is complete enough for comparison, from Asian forms of *Homo erectus* (Stringer 1974a, 1978, 1980; Stringer, Howell and Melentis 1979; Wolpoff, 1980). A review of much of this material and a discussion of its evolutionary significance is given by Howells (in press).

The Petralona specimen assumes special importance in any discussion about the existence of *Homo erectus* in Europe. It is the most complete and well preserved "pre-Neanderthal" hominid cranium yet discovered and studies of its morphology and dating are increasingly convergent in indicating that it represents a sample from a population which, in the simplest terms, is morphologically and chronologically intermediate between early Pleistocene samples of *Homo erectus* and late Pleistocene samples of *Homo sapiens*. It has recently been the subject of a detailed morphological, metrical and radiographic study (Stringer, Howell and Melentis 1979; Stringer 1980) but even since that work was completed, important new evidence for the dating of European hominids attributed to *Homo erectus* has been published, and further studies of relevant material have become available. This brief paper is intended as a review of the sometimes confusing and contradictory statements in the literature about the fossil material and its possible antiquity, and it is hoped that a more detailed review paper on this subject will be published in the future (Stringer, Harmon and Currant, in preparation).

RELATIVE AND ABSOLUTE DATING OF THE FOSSIL HOMINIDS OF EUROPE

The treatment of Pleistocene stratigraphic terms in some recent anthropological publications suggests that many anthropologists are ignorant of, or have failed to comprehend, the revolution which has occurred in our concepts of the stratigraphic framework of glacials and interglacials by which European fossil hominids are most commonly dated. The extent of the collapse of the old system of relative dating has been expressed most succintly by Kukla (1977, p. 307): "The terraces representing the four Alpine 'glacial' stages ... correspond to both glacial and interglacial climates ... the Alpine 'interglacial' stages do not represent episodes of interglacial climate but probably intervals of accelerated crustal movements ... the physical evidence on which the north European classical subdivision is based accounts for only about 15 % of the time represented. This has led to serious miscorrelations." Furthermore he states (op. cit. p. 367) "There is no doubt whatsoever that after decades of misinterpreted usage of the Alpine and the north European subdivisions, neither can be saved ... The sooner the classical terminology is abandoned in interregional correlations, the better."

Kukla's proposal may sound drastic but there is ample justification for his views. But with what are we to fill the vacuum left by the collapse of the old stratigraphic framework? Kukla (1977) and others (e.g. Bowen 1979) are certainly correct in suggesting that oxygen isotope stratigraphy derived from deep sea cores should ultimately become the basis of future interregional correlations but until the fragmentary terrestrial sequences can be so correlated, some interim guidelines must be found which are based on available absolute dates and geomorphological, faunal and floral comparisons.

The International Geological Correlation Programme project 24 is much concerned with the establishment of better terrestrial correlations and in Britain, for example, a subsidiary working group is considering the problem of post-Hoxnian interglacials (Sutcliffe 1979). Discussion on aspects of middle Pleistocene stratigraphic problems in Britain and Germany has been provided by workers such as Gladfelter (1975) and Brunnacker (1975), and the uses of floral and faunal successions in Europe were reviewed by Turner (1975), Kahlke (1975), Maglio (1975) and Jánossy (1975). However certain important European sites which have produced fossil hominid specimens were not discussed or were dealt with only briefly and some pertinent information for these sites is provided below.

PETRALONA

The age of the Petralona cranium can now be established with much greater certainty as middle Pleistocene. But its exact age, or even with which faunal assemblage at the site it should be associated, is still unclear. Poulianos (1980) believes that the fossil is associated with bed 11 of the separate excavated stratigraphy reported by him. Even if this association can be demonstrated and the record of a palaeomagnetic reversal claimed for this bed can be confirmed, it is by no means certain that the cranium is about 700,000 years old as claimed. A single polarity change in a stratigraphic sequence of unknown age and duration must be treated with caution before a decision can be made about which polarity epochs or events are recorded. Bucha (1980) observed that possible ages for layer 11 were 220,000 or 630,000 years bp and faunal and absolute dating for this stratigraphic sequence cannot, at present, resolve this problem. Kurtén (personal communication) reports that there are marked similarities between the Petralona fauna and that of the Czechoslovakian site of Stránská skála which is believed to be of late Matuyama age (Kočí and Sibrava, 1976). However British sites of broadly comparable faunal age such as the Cromer Forest Bed Series and Westbury-sub-Mendip have not so far produced evidence of reversed polarity (Montfrans 1971; Stringer, Andrews and Currant 1979) as is also the case for another significant site, Mauer (quoted by Brunnacker 1975a), although the earliest deposits at Westbury-sub-Mendip may record a reversal (Tarling, in litt.). Thus the latter sites, which also have faunal similarities to the Petralona cave, may belong to the Brunhes epoch.

Kurtén and Poulianos (1977) report that the carnivore fauna of beds 7—13 may be Cromerian *sensu stricto* which would give a true Cromerian/Biharian age for the Petralona cranium if Poulianos' (1980) claimed association is correct. However some post-Cromerian *s.s.* mammals have also been reported such as *Arvicola* (from bed 13 upwards — Kretzoi 1977, but apparently identified only from an upper incisor) and *Dicerorhinus hemitoechus* (from bed 13 upwards — Fortelius and Poulianos, 1979) which indicated that relative dating of the site by fauna will not be a straightforward process.

Equally, absolute dates for travertines from the Petralona cave have been ambiguous. Bed 10 may be between 140,000—350,000 years old depending on uranium series, thermoluminescence, or electron spin resonance dating determination (Schwarcz, Liritzis and Dixon 1980; Ikeya 1980; Liritzis 1980; Hennig, Bangert, Herr and Poulianos 1980). However although their determinations suggest that superficial travertines continued to accumulate in the cave until perhaps 70,000 years ago, these same authors agree that some of those from the 'mausoleum' area, from where the cranium was actually recovered, are among the oldest sampled from the cave and may date from more than 350,000 years bp.

I believe that this latter determination is the best present estimate of the age of the Petralona cranium, and such as age is also consistent with a recent preliminary uranium series date obtained from travertines associated with a Cromerian *s.l.* fauna at Westbury-sub-Mendip (Schwarcz, *in litt.*). If a late Biharian/Cromerian *s.l.* age is most likely for the Petralona cranium then this fossil is of the same order of antiquity as the Mauer and Vértesszöllös remains (see below). Significantly, it is also close in age to the majority of the Choukoutien lower cave *Homo erectus* fossils (Kurtén and Vasari 1960; Kahlke and Chow 1961).

BILZINGSLEBEN AND THE AGE OF LATER MIDDLE PLEISTOCENE SITES

The recent uranium series age determinations on travertines associated with fossil hominid remains from Bilzingsleben (Harmon, Glazek and Nowak 1980) are timely and, if accurate have given us a valuable datum point by which to relatively date some other European fossil hominids. On faunal, floral and geomorphological grounds, the Bilzingsleben site had been regarded as Holsteinian in age (Mania 1974) but the uranium series determination of about 228,000 years bp demonstrated that the interglacial represented at the site apparently correlated with "stage 7" of the marine oxygen isotope record rather than with "stage 9" (beginning at perhaps 330,000 years bp — Kukla 1977) or "stage 11" (beginning at perhaps 400,000 years bp — Kukla op. cit.), which have recently been regarded as the likely marine correlates of the terrestrial Holsteinian interglacial. Equally, other sites presently regarded as Holsteinian in age may not correlate with the true Holsteinian or with each other. Furthermore since the marine isotope record in some cores suggests that "stage 7" itself actually consisted of at least two separate interglacial events which were nevertheless close to each other in time, the potential for miscorrelation is clearly enormous.

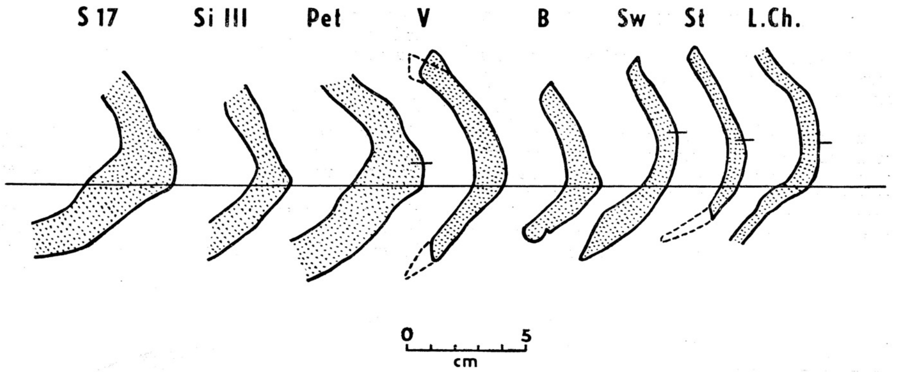

FIGURE 1. *Comparison of medio-sagittal sections of occipital bones of two Asian* Homo erectus *specimens (Sangiran 17,* "Sinanthropus" *III) and six European Pleistocene specimens (Petralona, Vértesszöllös, Bilzingsleben, Swanscombe, Steinheim and La Chapelle). Modified from Vlček (1978).*

The British Hoxnian interglacial has often been correlated with the Holsteinian interglacial of northern Europe (Turner 1975). For some British "Hoxnian" sites this correlation is likely to be correct, but for sites such as Swanscombe, only part of the stratigraphic sequence may be genuinely Hoxnian, and faunal and floral data may well be inadequate for meaningful correlations at present. Geomorphological and other evidence can be brought forward to suggest that the middle gravels at Swanscombe are, in fact, post-Hoxnian in age (Kerney 1971; Gladfelter 1975; Bridgland 1980). There are good reasons for not assigning the Swanscombe middle gravels an age as late as the early upper Pleistocene (i.e. the equivalent of marine oxygen isotope "stage 5"), but the possibility exists that the Swanscombe "skull" is close in age to the Bilzingsleben fossil hominid remains and could also belong to a terrestrial correlate of part of marine oxygen isotope "stage 7" at about 220,000 years bp.

The undoubted resemblances between the Swanscombe "skull" and the Biache fossil from France, which has been dated to a "pre-Weichselian interstadial" (Chaline et al. 1977; Vandermeersch 1978) suggest that these specimens are sampled from comparable populations of the late middle Pleistocene. The Steinheim cranium has for many years been recognised as a possible counterpart of the Swanscombe "skull" (Howell 1960; Weiner and Campbell 1964; Stringer 1974b, Wolpoff 1980). The Steinheim cranium apparently dates from the later middle Pleistocene but an exact age correlation between the Steinheim and Swanscombe hominids on faunal grounds (Howell 1960; Sutcliffe 1964) is no longer secure. Brunnacker (1975a) discusses the possibility that a localised palaeosol in the Steinheim sequence could exclude the Steinheim "forest phase" deposits from a penultimate interglacial age, but such a "count from the top" stratigraphic approach can be misleading particularly in view of the possibility that marine oxygen isotope "stage 7" itself consisted of two warm stages, and that the last interglacial was a complex of warm and cold stages (see, for example, Woillard 1978).

Additionally, however we may date the main Steinheim stratigraphic sequence and faunas, Brunnacker (1975b) claims that the fossil hominid site is uncertainly related to the main site at Steinheim.

The Ehringsdorf fossil hominids have been variously dated to the last interglacial or to some part of the "Saale" or "Riss" complexes (Oakley, Campbell and Molleson 1971; Kahlke 1975). The main hominid finds are associated with the lower travertine fauna which contains typical later Pleistocene interglacial mammals such as *Palaeoloxodon antiquus, Dicerorhinus hemitoechus* and *kirchbergensis, Cervus elaphus, Capreolus capreolus* and *Sus scrofa.* The lower travertines were dated as upper Pleistocene by an early Pa 231/U-Th 230 determination (Rosholt and Antal 1963) but more recent uranium series determinations by various workers suggest an age of about 200,000—220,000 years bp, although the uranium and thorium yields may be low (Harmon, Glazek and Nowak 1980; Schwarcz 1980). However if these latter determinations are accepted they would date the Ehringsdorf hominid remains within "stage 7" of the marine oxygen isotope record together with the Bilzingsleben fossils, a correlation which seems possible on faunal grounds.

ARAGO, MAUER AND VÉRTESSZÖLLÖS

Originally regarded as belonging to the "Riss" complex, and thus postdating the Mindel-Riss, Holsteinian and Hoxnian interglacials (de Lumley 1975), the Arago site is now considered to date from parts of the "Mindel" complex. The main hominid finds are from relatively high in the stratigraphic sequence excavated at Arago but have recently been assigned an absolute age of 450,000 years bp by amino acid racemisation (de Lumley et al., 1979). It is clear that the Arago faunas span a wide time-range, containing Cromerian *s.s.* and *s.l.* elements such as *Cervus elaphus acoronatus, Equus* cf. *mosbachensis, Premegaceros* sp., *Ursus deningeri, Praeovibos priscus* (Crégut and Guérin, 1979) and *Pliomys lenki,* as well as later middle Pleistocene and upper Pleistocene elements such as *Dicerorhinus hemitoechus* and *kirchbergensis,* and *Arvicola.* Crégut is quoted in Svoboda (1980) as dating the site as "late Mindel or early Mindel-Riss" but nevertheless it is likely on faunal grounds that the site and the associated fossil hominid specimens are older than the later middle Pleistocene fossil hominids from supposed Holsteinian/Hoxnian and "Riss" contexts such as Steinheim, Swanscombe, Bilzingsleben and Biache. Thus it is possible that the Arago material may group more readily chronologically with the Mauer, Vértesszöllös and Petralona fossils. However in terms of absolute age the quoted date of 450,000 years bp cannot yet be regarded as a final determination, particularly as admittedly later travertines at the site have been dated as considerably younger than this age (Turekian and Nelson 1976; Schwarcz 1980) and previous amino acid calibration suggested an age of about 330,000 years bp for the Arago 21 specimen (de Lumley et al., 1977).

The Mauer and Vértesszöllös sites belong faunally to the late Biharian/Cromerian *s.l.* (Kahlke 1975) and are probably close in age to each other and to parts of the Petralona and Arago faunal sequences. As mentioned previously, the Mauer site appears to belong to the Brunhes polarity epoch but no absolute dates are yet available for it. "Ionium age" determinations of the ages of travertines at Vértesszöllös were carried out by Cherdyntsev, Kazachevsky and Kuz'mina at least fifteen years ago (reported by Isaac 1972). Absolute ages obtained ranged from 225,000—475,000 years bp. More sophisticated procedures for uranium series age determinations are now available (for example see Schwarcz, 1980) and it would be very valuable to have new determinations of absolute age attempted for the Vértesszöllös travertines. The Vértesszöllös fauna probably corresponds in age to von Koenigswald's (1973). "*Arvicola* fauna group 1" and can be approximately correlated with that of Mauer, and Westbury-sub-Mendip in England (Bishop 1974; Stringer, Andrews and Currant, 1979). The Arago fossil hominids may be somewhat younger than this faunal age but if we can accept the Bilzingsleben uranium series dates as accurate for the age of the late middle Pleistocene fauna, flora and hominid remains at that site, then the Arago hominids should date from before about 228,000 years bp while the Mauer, Vértesszöllös and Petralona hominids, at least, may be older than 350,000 years bp. The Steinheim, Bilzingsleben, Swanscombe, Biache and Ehringsdorf specimens should be younger than those from Arago, and the Swanscombe, Biache and Ehringsdorf specimens, at least, may more closely approximate the age of the Bilzingsleben site (i.e. perhaps about 228,000 years bp). Thus in the simplest terms the middle Pleistocene hominids of Europe may fall into two groups dating from (i) the middle part of the middle Pleistocene (Mauer, Vértesszöllös, Petralona and, perhaps, Arago), (ii) the later part of the middle Pleistocene (Steinheim, Bilzingsleben, Swanscombe, Biache and Ehringsdorf). Still younger hominids from the middle Pleistocene of Europe are known from sites such as La Chaise (Schwarcz and Debenath 1979). Having made this simple chronological division of the European middle Pleistocene fossil hominid material it is now of interest to examine the material(or at least some of the more complete cranial specimens which have been studied by the author) to ascertain whether differences between specimens may be derived from temporal, interpopulation or intrapopulation couses.

FIGURE 2. *Right oblique view of the Petralona occipital bone (right) and a cast of the Vértesszöllös occipital.*

FIGURE 3. *Occipital view of casts of the Broken Hill cranium (left) and Monte Circeo Neanderthal cranium (right) compared with the Petralona cranium.*

THE PETRALONA CRANIUM

As suggested in the introduction, the Petralona cranium is a key specimen in the interpretation of European middle Pleistocene fossil hominids. I have suggested elsewhere (Stringer, Howell and Melentis 1979; Stringer 1980) that it probably represents a primitive form of *H. sapiens* sharing some grade characteristics with specimes from outside Europe. such as the Bodo and Broken Hill crania *(Figure 3)* and other characteristics with European fossil hominids such as Vértesszöllös, Arago and Bilzingsleben *(Figures 1, 2, 5).* If we were to dismantle the Petralona cranium and study the occipital bone in isolation, its morphology would lead most anthropologists to classify the specimen as *H. erectus.* Its angulation (although not extreme), its great thickness, and its continuous torus resemble aspects of the typical *H. erectus* morphology present in specimens from China and Indonesia *(Figures 1—4 and 6).* Similarly, apart from the great pneumatisation and degree of supraglabellar depression, there are resemblances in supraorbital torus form between the Petralona specimen and *H. erectus* fossils, as well as between the Petralona specimen and European fossils such as Arago 21, Bilzingsleben and Steinheim *(Figure 5).* But I think it is unwise to attempt to classify fragmentary specimens such as those from Arago, Bilzingsleben and Vértszöllös, without first comparing them with more complete specimens of similar age and morphology. Other areas of the Petralona cranium which are not preserved in the Arago, Bilzingsleben and Vértesszöllös fossils, show features found in Neanderthal or anatomically modern forms of *H. sapiens,* rather than in *H. erectus* as known from Asia.

I examined 21 characters of the Petralona cranium and found 6 of these were typical of Asian *H. erectus* crania (5 of them confined to the supraorbital torus or occipital bone), 8 were typical of Neanderthal or anatomically modern *H. sapiens*, while 7 were of an intermediate nature or were undiagnostic (Stringer 1980). Using an alternative and much quoted definition of *H. erectus* (modified by Campbell in Clark 1978), of 14 relevant characters, the Petralona specimen displays only 5 (marked platycephaly, little frontal convexity, massive supraorbital tori, pronounced post-orbital constriction and thick cranial wall). 3 characters are doubtfully expressed or are undiagnostic (cranial capacity about 1000 ml, sagittal ridge near vertex of cranium, and molars with well- differentiated cusps and occasionally with secondary wrinkling). The 6 remaining characters of *H. erectus* are not present in the Petralona specimen (opisthocranion coincident with inion, robust tympanic plate tending to horizontal disposition, broad and flat nasal bones, teeth large with basal cingula, canines sometimes projecting with upper diastema, and upper second molar often larger than first).

THE VÉRTESSZÖLLÖS, BILZINGSLEBEN AND ARAGO FOSSILS

Most of the areas discussed above are not preserved in the Vértesszöllös, Bilzingsleben and Arago specimens, but where they are preserved I believe that these fossils are comparable with the Petralona cranium rather than with fossils from outside Europe. If this is true, then these European specimens should not be classified as *H. erectus* unless it can be demonstrated that the Petralona specimen is also a *H. erectus.* In its preserved portions the Vértesszöllös fossil is morphologically similar to the Petralona specimen and, although damaged and eroded (Wolpoff 1977), appears to be larger, less angulated, less thick and to possess a less developed occipital torus than the Petralona occipital bone *(Figures 1, 2).* Therefore I find it strange that Wolpoff should wish to classify the Vértesszöllös occipital as *H. erectus* (Wolpoff 1977) and yet is prepared to accept the Petralona specimen as an early example of *H. sapiens* (Wolpoff, 1980).

It is interesting that Vlček (1978) should choose Olduvai hominid 9 (O.H.9) and *"Sinanthropus"* III as the closest matches for the occipital morphology of the Bilzingsleben specimen (he was not able to study the Petralona cranium). He was aware of differences the Bilzingsleben fossil exhibited from most other Asian *H. erectus* fossils and attributed these to expressions of geographical variability. However if we look more closely at the occipital morphology of O.H.9 and *"Sinanthropus"* III it is clear that they are not representative of *Homo erectus* in the form of the occipital torus either. Rightmire (1979) states that in comparison with Choukoutien *H. erectus* specimens, the occipital torus of O.H.9 is only moderately developed in the midline and is not present laterally. Weidenreich (1943) believed that *"Sinanthropus"* III (the locus E "adolescent") was in fact the skull of a male child of only 8 or 9 years of age. Despite its robusticity, Weidenreich stated that its occipital torus was "only faintly indicated" and was weaker than that of any other *"Sinanthropus"*, and the muscular markings of the nuchal plane were also faintly indicated. Even compared with *"Sinanthropus"* III I believe that the Bilzingsleben occipital bone (studied from a cast) displays a torus which is less sharply delineated, and the form of the torus is like a smaller version of that described for the Petralona occipital bone (Stringer, Howell and Melentis 1979) where there is an elevated triangular area with its apex in the midline above opisthocranion *(figure 3).* The supratoral sulcus is slightly marked in the Bilzingsleben specimen and parallels the shape of the occipital torus, dipping laterally, as in the Petralona cranium. The structure of the Vértesszöllös occipital torus also appears to be similar but is more comparable with that of the Petralona specimen in extent, especially vertically. Despite the differences discussed above there is no doubt that the Bilzingsleben occipital bone does show other metrical and morphological resemblances to those of *Homo erectus* fossils (Vlček 1978; Wolpoff, 1980) but there is certainly equal justification for grouping the Bilzingsleben fossils with European middle Pleistocene specimens rather than with those from Asia.

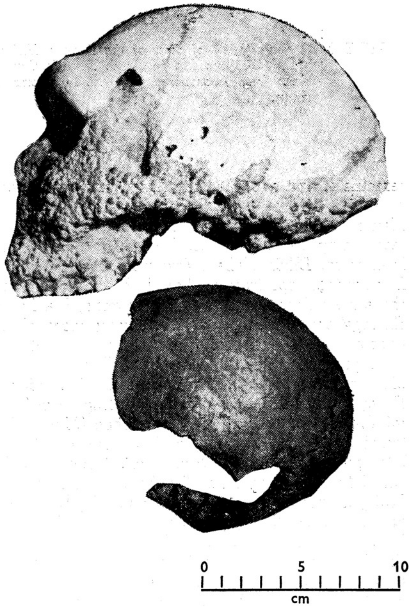

FIGURE 4. *Left lateral view of the Petralona cranium (top) and a cast of the Swanscombe "skull".*

In the form of the frontal bone I believe that the Bilzingsleben glabellar morphology is more comparable with that of Arago 21 than was indicated by Vlček (1978). The form of this area in the Petralona cranium is more distinctive, resembling some Neanderthal crania, but it is interesting that both the Bilzingsleben and Petralona specimens display a nasal notch in the shape of an inverted V. This type of nasal-frontal articulation is common in Neanderthal crania but is not apparent in *Homo erectus* specimens nor in the Broken Hill and Arago 21 fossils. It does, however, appear to be present in the Steinheim cranium. When the Bilzingsleben supraorbital torus is compared with those of other European middle Pleistocene fossils there are certainly differences due to its uninterrupted form and the lack of the supraglabellar depression found in the Petralona, Steinheim and Arago 21 fossils *(figure 5).* However the overall form of the frontal bone fragment in mediosagittal section is more like that of Arago 21 (and Steinheim) than Vlček's (1978) figure 2 would indicate. Placing incomplete specimens such as Arago 21 and Bilzingsleben in the glabello-inion plane is a hazardous procedure, but this can be achieved with certainty in the case of the Petralona cranium and my comparisons indicate a close correspondence between the frontal bones of the Bilzingsleben and Petralona specimens in mediosagittal section, where they can be compared.

EUROPEAN MIDDLE PLEISTOCENE HOMINIDS – SOURCES OF VARIATION, AND CLASSIFICATION

Turning now to the problem of the degree of morphological variation in the European middle Pleistocene sample, Wolpoff has recently proposed that sexual dimorphism is the most valid single explanation to account for observed variation in these fossils (Wolpoff, 1980). Furthermore he has suggested that the degree of observed variation is compounded by the fact that earlier specimens (Petralona, Vértesszöllös) are probably male while later specimens (Steinheim, Swanscombe, Biache and Arago 21) are probably female. Although he preferred not to classify these European specimens at all, he suggested a temporal division would be best whereby the fossil hominids dating from before the end of the Mindel glaciation would be arbitrarily referred to *H. erectus* and those dating from later would be classified as *H. sapiens.*

Considering this last proposal first, Wolpoff admits a problem with this system in that the Petralona cranium would belong to *H. erectus* if we accept the most ancient date claimed for it, or would belong to *H. sapiens* if we prefer a "post-Mindel" dating. This is certainly a serious weakness in such a scheme. As in a previous definition of Neanderthals (Brose and Wolpoff 1971), great reliance must be placed on accurate and definitive dating of the fossils. In the case of the Neanderthal definition of Brose and Wolpoff (1971), the end of the Riss was suggested as a worldwide datum point after which all hominids would be designated as "Neanderthals", until the time of the appearance of anatomically

FIGURE 5. *Facial view of casts of Arago 21 (centre) and Steinheim (right) fossils compared with the Petralona cranium.*

modern humans. Kukla's (1977) views on the complexity of European correlations were quoted earlier, and a further example can be given to show the impracticality of this kind of proposal. It used to be believed that the Eemian interglacial of northern Europe correlated directly with the Riss-Würm interglacial of the Alpine sequence. Thus in Brose and Wolpoff's (1971) scheme, the hominids of the Eemian would have been designated as "Neanderthals". However there is now evidence from Europe (Frenzel 1973; Woillard 1978) that the Eemian interglacial is actually older than the Riss glaciation, thus excluding Eemian fossil hominids from the "Neanderthal" group as defined by Brose and Wolpoff (1971)! Attempting to apply such a scheme globally could only lead to confusion in the absence of large numbers of reliable absolute dates or good correlations with some standard framework such as the marine oxygen isotope record. Equally serious problems would arise if we attempted to use a datum point like "the end of the Mindel glaciation (or its equivalents)" (Wolpoff, 1980) for the *H. erectus/H. sapiens* boundary, for even in Europe we simply do not know when the "Mindel" glaciation ended nor do we certainly know what are its equivalents. Furthermore even since Wolpoff completed his paper (Wolpoff, 1980) the Araga material has been redated from the "Riss" to the "Mindel", to use the terms of de Lumley (1975, 1979), so it would now become *H. erectus* rather than *H. sapiens* following Wolpoff's scheme.

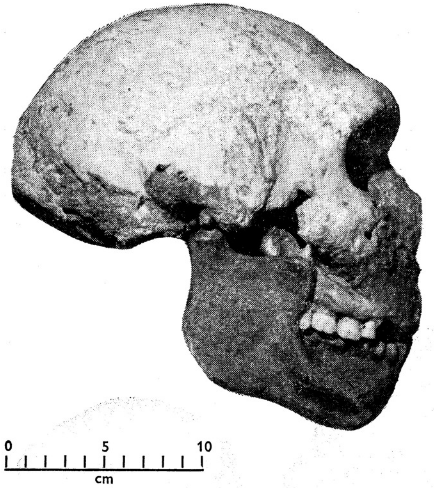

FIGURE 6. *Right lateral view of the Petralona cranium articulated with a cast of the Mauer (Heidelberg) mandible.*

Another equally serious problem which follows from a chronologically based system of classification is the assumption that hominid evolution operates through universal unilinear gradualism and that specimens of the same age should automatically be classified together. Thus the Broken Hill, Petralona and Ngandong fossils were considered on chronological grounds to be "Neanderthals" by Brose and Wolpoff (1971) — a classification which would be difficult to justify today. The morphology of the fossils rather than their supposed age must be the primary means of deciding their classification, whether traditional or cladistic methods of study are used, if there is to be any stability or consistency in taxonomic allocations. For example, the Bilzingsleben and Swanscombe hominids may both date to a terrestrial correlate of "stage 7" of the marine oxygen isotope stratigraphy. Nevertheless we must consider independently whether the morphological differences they display are sufficient to exclude them from belonging to the same taxon. If they are sufficient, then we might conclude that *H. erectus* and *H. sapiens* did indeed coexist in Europe at that time, as suggested by Vlček (1978). But an alternative is to re-examine our model of species variation, and Wolpoff's (1980) work is a valuable compilation and examination of data to test the proposal that these differing morphologies could be dimorphs or variants within a single highly variable lineage. In the case of the Bilzingsleben and Swanscombe specimens, this seems a possible explanation.

However when this proposal is extended to suggest that differences between the Petralona and Steinheim crania can be explained by sexual dimorphism, I cannot agree.

Wolpoff (1980) reported that the Steinheim cranium was more distorted than had been recognised previously (Howell 1960) and that some breadth measurements and estimations were liable to error. However he calculated an index of percentage dimorphism for particular measurements of the Petralona cranium compared to the Steinheim cranium, which purported to demonstrate that the degree of dimorphism involved was of the same order as, or only slightly larger than, comparisons between known or supposed Neanderthal male and female individuals. Thus metrical differences between the Petralona and Steinheim crania could predominantly be explained by sexual dimorphism rather than by evolutionary differences. Wolpoff has criticised some of my previous work as typifying the multivariate approach, even though the paper in question (Stringer 1978) made much use of the type of indices employed by Wolpoff (1980). The main criticism appeared to be that although many of my conclusions anticipated those of Wolpoff (1980), the overall results were "disparate" and did not provide clear-cut, simple conclusions. I believe the results may, in fact, reflect the course of human evolution more realistically than models which are based solely on universal unilinear gradualism. In 1974 I published multivariate studies of Pleistocene fossil hominid crania (Stringer 1974a, 1974b) which could more justifiably be criticised using Wolpoff's (1976) criteria. Nevertheless, valuable insights were achieved into patterns of variation between fossil crania and they, rather than multivariate distances alone, were the main basis of many of my conclusions. In my study of the Petralona and Steinheim crania (the latter studied only as a cast) the following variables, in order of importance, were the most important discriminators in an analysis of 25 variables: — biauricular breadth, biorbital breadth, palate breadth, nasal height and prosthion radius.

Even if we discount the palate breadth and prosthion radius values for Steinheim in deference to Wolpoff's comments on the degree of distortion of the specimen, a comparison between the Petralona and Steinheim crania can be achieved using a combination of data from Wolpoff (1980) and my own data(*table 1*). His values for bijugal breadth and frontomalare breadth are used as they correlate highly with biorbital breadth in recent crania (Howells 1973). Similarly I have compared the specimens in another important discriminating variable, that of basion-bregma height. In each case in *table 1* I have provided a comparison of the La Ferrassie 1 and Gibraltar 1 crania which gave a value of the index of sexual dimorphism which was generally greater than the Neanderthal average (Wolpoff, 1980), and where possible I have also provided data for the *Homo erectus* sample from Ngandong. However it should be noted that the Neanderthal comparisons may use specimens of different ages which are sampled from metrically and morphologically distinct populations, and therefore may not necessarily reflect the true level of dimorphism in any actual Neanderthal "population". Even so, as can be seen from *table 1*, the level of dimorphism which is exhibited if we treat the Petralona and Steinheim crania as dimorphs of a single population is extremely high compared with the Neanderthal and Ngandong samples.

Furthermore if we compare the Petralona cranium with the Steinheim and Swanscombe specimens in values of cranial thickness, considerable differences are again apparent. *Figure 1* displays mediosagittal views of the occipital bones of these specimens, and *table 2* provides comparative data on cranial thickness at bregma and inion. Differences manifested between the specimens are beyond any which can be obtained from comparisons within the Neanderthal and Choukoutien samples except for the Petralona/Swanscombe comparison at bregma. I believe the metrical contrasts between the Petralona and Steinheim crania are so much greater than those obtained in any biologically meaningful middle or upper Pleistocene hominid "population" that they reflect real evolutionary differences which should be recognised by some degree of taxonomic separation even if this is only at the subspecific or "grade" level (Stringer, Howell and Melentis 1979). Wolpoff (1980) and I agree that the variation manifest in the middle Pleistocene European hominids probably has both temporal (phyletic) and in-

TABLE 1. *Index of percentage sexual dimorphism in cranial measurements of middle and upper Pleistocene hominids. Measurements from Wolpoff, (1980) W; Stringer S; Santa Luca (1977) Sa; Weidenreich (1951) We.*

Measurement	Petralona/ Steinheim	La Ferrassie 1/ Gibraltar 1	Maximum ratio Ngandong adults
Biauricular breadth (W, S, Sa)	136	114	108
Bijugal breadth (W, S)	126	107	—
Frontomalare temporal breadth (W, We)	123	106	107
Biorbital breadth (S)	124	106	—
Nasal height (S)	135	110	—
Basion-bregma height (W, S, We)	122	111 (estimate)	107

TABLE 2. *Index of percentage sexual dimorphism in cranial thickness for middle and upper Pleistocene hominids (data from author and Wolpoff, 1980).*

	Petralona/ Steinheim	Petralona/ Swanscombe	Maximum Neanderthal ratio	Maximum Choukoutien ratio
Thickness at inion	278	225	140	170
Thickness at bregma	167	137	117	139

trapopulation causes. We also agree on many other details of interpretation, and the main difference between our viewpoints lies in Wolpoff's emphasis on the role of individual variation and sexual dimorphism, and my emphasis on differences which may reflect temporal or evolutionary factors. We both recognise that the European sample contains specimens which more closely resemble *H. erectus* and others which more closely resemble Neanderthal or anatomically modern forms of *H. sapiens*. I have favoured an interpretation where the differences are related to time, since the most *erectus*-like fossils seem to be dated earlier than the specimens which share more derived characters with upper Pleistocene hominids. However if the Bilzingsleben fossils (which I group morphologically with the Petralona and Vértesszöllös specimens) date from the later part of the middle Pleistocene then either some populations retained an "archaic" morphology longer than others, or the degree of morphological and metrical variation present within the populations of the middle Pleistocene has been underestimated by many workers, including myself. One other problem raised by Wolpoff (1980) concerns the sex of the Arago 21 specimen. I do not believe it is possible to sex this specimen reliably but if it were from a female individual, as Wolpoff considers likely, it would certainly be more acceptable on metrical and chronological grounds as a female for the Petralona specimen, than is the Steinheim cranium *(figure 5)*.

One other point concerns the relationship between the cranial material of the middle Pleistocene already discussed, and the Mauer (Heidelberg) mandible. This has been attributed to *H. erectus* by various authors but this seems to have been done mainly on the basis of its age and its robusticity rather than a study of characters shared with known *H. erectus* mandibles. The Mauer mandible does not articulate well with the Petralona cranium *(figure 6)* since the M_1 of the mandible "occludes" with the P^4 of the cranium when they are articulated at the temporomandibular joint. Furthermore the bicondylar breadth of the Mauer specimen is insufficient for an anatomically correct relationship, while there is actual contact between the anterior edge of the wide Mauer ascending ramus and the wide maxilla of the Petralona cranium. An interesting, if entirely hypothetical, basicranium, model of an upper jaw and brasicranium for the Mauer mandible was made by J. H. McGregor in 1917. The biauricular breadth of this model is about 10 mm less than that of the Petralona cranium, while the hypothetical upper dentition is very similar to that of the Petralona specimen in size, but not in the shape of the arcade.

There is considerable size and shape variation in middle Pleistocene mandibles, and those from Europe display a number of characters in common including a few shared with the Choukoutien sample, but a greater number shared with the north African material (Aguirre and de Lumley 1977). Thus it seems feasible at present to group the Mauer mandible with the Arago sample, and thus, indirectly, on morphological and chronological grounds, with the Petralona cranium. However until associated mandibular and cranial material is recovered there will always be difficulty in assessing relationships between these disparate specimens.

CONCLUDING REMARKS

I do not accept as yet proven than *H. erectus* existed in Europe during the middle and later parts of the middle Pleistocene since the most complete cranium known from that period differs in overall Morphology from the "type" morphology of *H. erectus* from Asia. That the European middle Pleistocene hominids evolved from a geographic variant of what is presently called the species *H. erectus* seems probable, but the time and place of origin of the primitive forms of *H. sapiens* present in Europe are completely unknown. As I have stated elsewhere (Stringer, Howell and Melentis 1979; Stringer 1980) I believe that African middle Pleistocene hominids may be more closely related to those of Europe, and in this context it will be interesting to know whether suggestions of a close similarity between new material of *H. erectus* from Koobi Fora, Kenya and *H. erectus* from Choukoutien (Leakey and Walker 1976) are confirmed by further study. The latter fossils are probably close in age to the earliest known European Pleistocene hominids and this suggests that even if *H. erectus* and *H. sapiens* did not co-exist in Europe, they may have co-existed in different continents or parts of continents.

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