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## The Ndotu cranium and the origin of *Homo sapiens*

The reconstruction and anatomy of a crushed hominid cranium excavated from an Acheulean horizon at Lake Ndotu, Tanzania, is here described. It is assigned to archaic *Homo sapiens* on the basis of its expanded parietal and occipital regions of the brain. Archaic *H. sapiens* apparently evolved from an African species usually classified as *Homo erectus* but here argued to be a separate species, *Homo leakeyi*. It is further argued that *Homo leakeyi* evolved from *Homo habilis* about 1.5 million years ago and continued the Acheulean handaxe tradition that began with *H. habilis*. It is suggested that *Homo erectus* was a species that originated in Asia east of Bangladesh, possibly from a *Homo habilis* population isolated in that part of the world. Indications are that *H. erectus* was confined to that region, was not cognisant with Acheulean handaxe technology, and was not ancestral to modern man.

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### Introduction

During September and October 1973, Amini Mturi, Director of Antiquities for Tanzania, was excavating an archaeological site along the margins of Lake Ndotu in the Serengeti (3°0'S, 35°0'E) when he uncovered a fossilised hominid cranium (Mturi, 1976). Lake Ndotu is a seasonal soda lake at the western end of the Olduvai main gorge. During the dry seasons the western margins of the lake are littered with early Stone Age artifacts and fossil fragments. It was in order to locate the stratigraphic origin of this material that Mturi conducted his excavation. He found that there were two *in situ* archaeological horizons within a greenish sandy clay unit that ranged in thickness from 15 to 45 cm. The cranium occurred together with faunal fragments in the higher of the two archaeological horizons within the sandy clay and was resting on a silty clay sub-unit. The second archaeological horizon rested within the silty clay sub-unit on the channelled surface of an underlying sand-free green clay unit 60 cm in thickness. The sandy clay unit is overlain to the north of the site by a re-worked tuff that Hay (see Rightmire, 1983) considers to have mineralogical similarities to the Norkilili Member of the Upper Masek beds of Olduvai Gorge. This might date the Ndotu cranium at around 400,000 years (Leakey & Hay, 1982). However, the mineralogical analysis cannot clearly distinguish between the tuffs of the Upper Masek and those of the overlying Ndotu Beds. Thus the Ndotu cranium could be from the age bracket of 200,000 to 400,000 years B.P.

The artifacts associated with the Ndotu cranium were originally found by Mturi (1976) to be of indeterminate industry consisting of spheroids, hammerstones, flakes and cores. Subsequently, however, the lake rose, covering the site from 1977 to 1982. Mturi informed me that he visited the site when the lake level had dropped in October 1982 and found the site re-exposed with eight handaxes, mostly of quartzite, on the surface. He was confident that the handaxes could only have been eroded out of the sandy clay that contained the Ndotu cranium and were therefore contemporary with the cranium. He considered the handaxes to be typologically like those from the Masek Beds of Olduvai Gorge, i.e., Upper Acheulean, and that as such they could date between 300,000 and 500,000 years ago. The Ndotu cranium is far from unusual in being assigned to such a broad age span but it is

fortunate that there are at least some geological and cultural data permitting even such a rough estimate of its age.

### Cleaning and reconstruction

When the Ndotu cranium was handed to me for treatment in Nairobi in February 1974, the back portion comprising the occipital, parietals and temporals was broken and distorted but the pieces were held in correct anatomical relationship to each other by the matrix of sand and clay (Figures 1, 2, 3). Most of the frontal and the anterior part of the parietals were missing, leaving a large hole through which parts of the internal anatomy could be seen. The face was badly broken and the fragments were embedded in the sandy clay matrix. No teeth were preserved. The cranium and its sandy clay matrix had been impregnated at the time of excavation with a consolidant, Bedacryl. Firstly, I separated the broken fragments a little at a time by dissolving the consolidant with thinner applied by brush and by cleaning away the matrix with a dental probe. The occipital bone was reconstructed with relative ease after each fragment had been cleaned, consolidated with Bedacryl, and joined to its neighbouring fragments with a nitrocellulose adhesive. The left temporal, adjoined to a fragment of sphenoid, was reasonably complete externally but the petrous portion was fragmentary and separated. The mastoid and squamous portions of the right temporal were recovered and these were in reasonably sound condition. The parietals presented a problem as they were very badly fragmented to the extent that, in some areas, only the outer table remained and, in other places, only the inner table was present. In some areas, the inner and outer tables were separated from the diploë by a sandy matrix such that the parietal had an exaggerated thickness. Fortunately, enough of the parietal was preserved intact to allow for the reconstruction of the missing and badly damaged areas. It was possible to remove the displaced surface bone, clean out the sand and replace the inner or outer table fragments against the diploë. Where diploë was missing, plaster of Paris was used as a backing for the surface bone. The anterior third of the left parietal and the anteromedial portion of the right parietal were completely missing. Despite the damage to the parietals, enough of the surface was either intact or confidently reconstructed to show the original contours and they clearly had a degree of parietal bossing. The boss as reconstructed on the right is obviously exaggerated due to deformation either of the anterolateral parietal fragment relative to the posterior portion or vice versa. It was, however, necessary to reconstruct the area of the boss with plaster in order to strengthen what remained of the parietal. The extreme damage suffered by the parietals was a consequence of the repeated solution and crystallisation of salt within the diploë during wet and dry periods of the lake shore. The salt was in solution in the bone whilst it was wet and well buried. When the lake level dropped, the bone dried and the salt crystallised. The crystals pushed apart the inner and outer tables and during the next wet phase permitted sand to enter the gap so formed. The same kind of saline damage has been reported by Mehlman (1987: 144) on bones from Lake Eyasi. Only a small portion of the frontal bone, attached to the right parietal, was preserved. The face was very fragmentary and encased in sandy clay together with the anterior portion of the left palate. It was possible to reconstruct the posterior part of the roof of the right orbit and to relate it to part of the medial wall of that orbit which was attached to the nose and circumnasal region of the face. Although the facial portion did not join the posterior part of the cranium, I was able to place them in their correct relationship to each other and to join them with plaster of

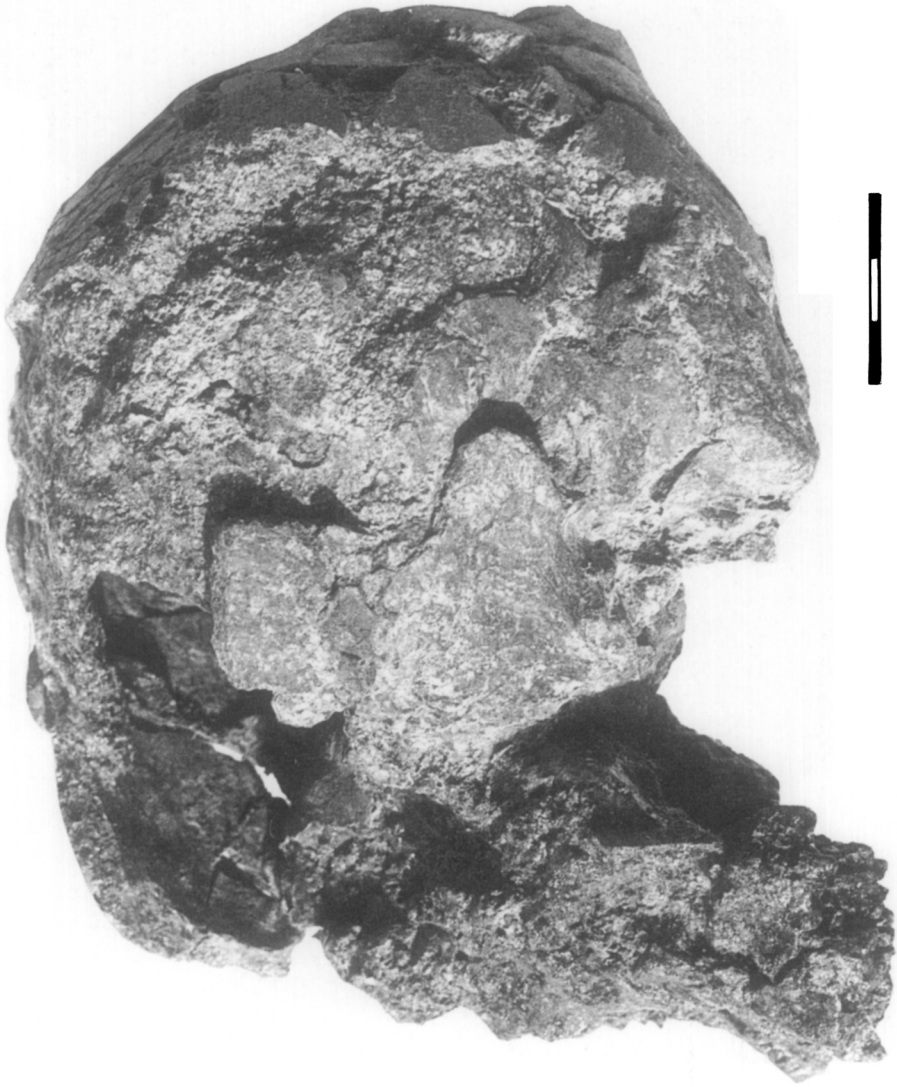


Figure 1. Left lateral view of Ndutu cranium before reconstruction. Scale in cm.

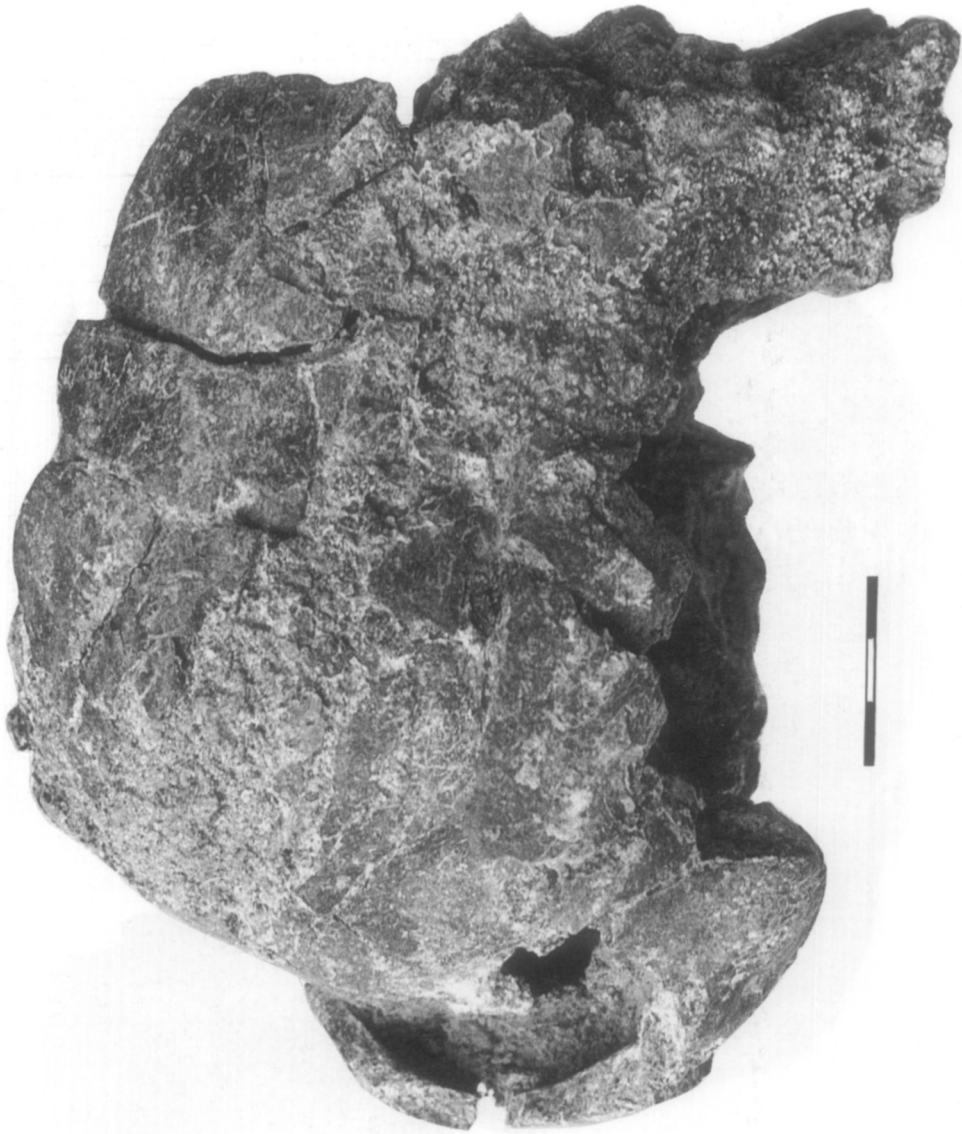


Figure 2. Right lateral view of Ndtutu cranium before reconstruction. Scale in cm.



Figure 3. Facial view of Ndotu cranium before reconstruction. Scale in cm.

Paris (Clarke, 1976). From the estimated position of the glabella relative to a change in curvature of the frontal squama, I concluded that there must originally have been a supra-orbital torus and I reconstructed the cranium with that in mind (Figures 4 and 6). The facial portion had to be attached to the calvaria with plaster of Paris. A brief description was published (Clarke, 1976) in which I noted that the reconstruction was preliminary and that slight adjustments might be made. Accordingly in August 1978 I visited Dar es Salaam to reposition the facial portion of the cranium and to make a detailed study of the specimen. Three more fragments of the cranium had been discovered during sorting of



Figure 4. Left lateral view of Ndutu cranium after first reconstruction in 1974. Scale in cm.



Figure 5. Left lateral view of Ndutu cranium after modification and addition of brow ridge and other fragments in 1978. Scale in cm.

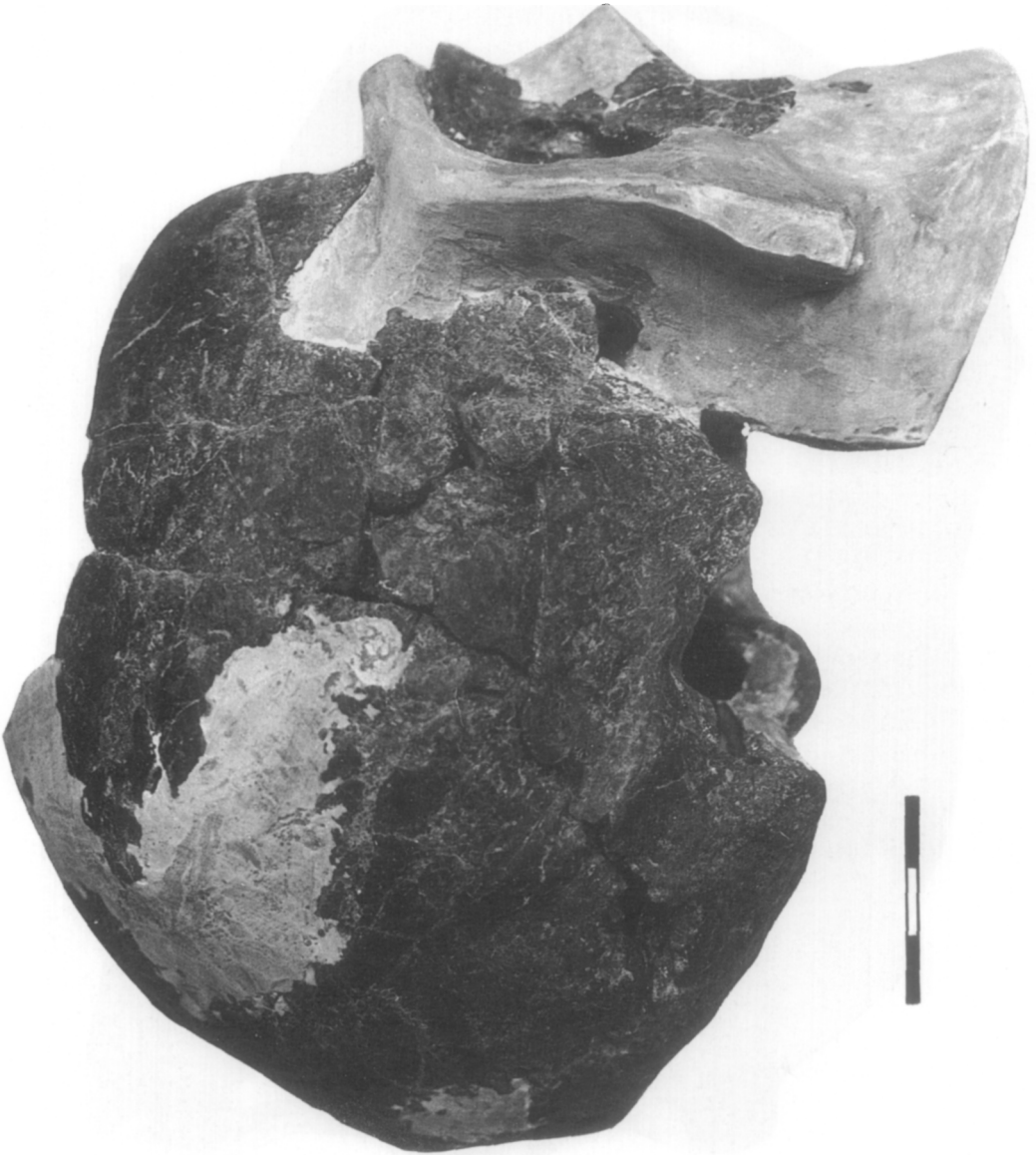


Figure 6. Right lateral view of Nduvu cranium after first reconstruction in 1974. Scale in cm.



faunal material after the 1974 reconstruction of the cranium. These fragments are: (1) the left lateral supra-orbital portion of the frontal bone with, as predicted, a supra-orbital torus; (2) a left fronto-parietal fragment that joined onto the existing inferior fragment of left parietal, and (3) a weathered parietal fragment that does not attach to the cranium.

Although the face was repositioned relative to the calvaria, it must be stressed that the position is based only upon relative association of orbital parts and cribriform plate parts and should thus be regarded only as a reasonable approximation of position. Similarly, the left supra-orbital fragment was positioned with plaster of Paris in an estimate of its probable position based on curvature of the left and right portions of frontal squamae and curvature of the right temporal fossa.

## Description

### *The cranium as a whole*

Measurements of the reconstructed cranium compared with those of some other relevant fossils are given in Tables 1–4. Views of the reconstructed cranium are shown in Figures 4–11 and sections through the cranium are shown in Figures 12–19. It can be seen from the sections that in general shape and proportions, the Ndotu cranium is similar to that from Steinheim. Many of the measurements are estimated due to the reconstructed nature of the cranium.

### *The face*

Only the central portion of the face is preserved and even that is fragmentary. Glabella is missing but the superior end of the nasal bones is virtually intact and thus nasion can be located with reasonable accuracy.

The superior part of the right lacrimal and lacrimal groove is present and dacryon can be located, although on the left it is missing. A superior fragment of both nasal bones is preserved and the left nasal bone is preserved for about 20 mm of its probable original length (along the naso-maxillary suture) of about 30 mm. This is known because the left nasomaxillary suture is preserved in its entirety, thus giving the lateral extent of the nasal bones. The breadth of the left nasal bone at its broken inferior edge is 9 mm and its original greatest breadth inferiorly would have been about 12 mm. From the preserved parts it is clear that the nasal bones were widest inferiorly and then narrowed superiorly to 13 mm at a position about 10 mm below nasion. The nasal bones then broadened again to 11.7 mm at 3.5 mm below nasion. The frontal processes to the maxilla and the nasal bones face antero-laterally, forming a prominent nasal bridge, and the preserved portion of the nasal bones shows that at least for two-thirds of their length superiorly they formed an angle of about 90° to each other superiorly and 100° inferiorly. In left profile view, the sagittal mid-line can be seen descending inferiorly and slightly posteriorly for 10 mm below nasion and then turning sharply antero-inferiorly. The angle thus formed between the upper third and lower two-thirds of the nasal bridge is 124°. The anterior, lateral margins of the piriform aperture are thin and sharp-edged and the breadth of the nasal aperture can be measured as 27.4 mm.

Unfortunately, little is preserved of the inferior nasal margin. A sufficient part of the anterior nasal floor is preserved on the right to enable an estimate to be made of the position of nasospinale. The estimated height of the nasal aperture is 33 mm and an estimate of nasion to nariale is 57 mm. Only the medial margins of the orbits and the

**Table 1** Length and height measurements (in mm) of Ndutu and some other hominids

	Ndutu	Steinheim	Salé	Pithecanthropus		<i>Homo erectus</i>				
				I	II	Sinanthropus				
						II	III	X	XI	XII
Maximum cranial length (glabella-opisthocranion)	(184)	185	>168	(183)	176.5?	194?	188	199	192	195.5
Nasion-opisthocranion	(179)	177					184	194	185	192
Nasion-inion	(174)						184	194	185	192
Glabella-inion	(80)									
Nasion-basion	(108)								105.5?	
Nasion-opisthion	(141)				134?		144?		145	147
Glabella-lambda	(171)	(172-174)			159?	183?				
Nasion-lambda	(169)	(167-169)				180	170	184	166	175
Basal-bregmatic height	(115-120)	(110-112)		(105)	105?				115?	

Values for Steinheim are from Weichert (1936). Those for Salé are from Jaeger (1975) and for *Homo erectus* from Weidenreich (1943). Figures in brackets are estimates.

**Table 2** Breadth measurements (in mm) of Ndutu and some other hominids

	<i>Homo erectus</i>												
	Ndutu	Steinheim	Salé	Pithecanthropus			Sinanthropus						
				I	II	II	III	X	XI	XII			
Pteryon-ptyeron	(100)												
Average maximum breadth (euryon-euryon)	(135)		134	(130?)	135		137.2		143		139.8		141
Least frontal	(90)	102	77	85	79		81.5		89		84		91
Postorbital	(78)	102	83	(91)	83?		88		98		93		95
Greatest frontal (coronale-coronale)	108	(118-119)		92?	102?		101.5		110?		106		108
Biporial	125				114		122.6		124?		120		128?
Biastrionomic	117.2	(106-108)	116	(92?)	120?		117		111?		113		115
Bimastoid (maximum)	129		101		102		106?				103?		
Bimastoid (minimum, tip-tip)	113	(93-94)											
Lateral interglenoidal	(134)				117		131?				126?		130?
Medial interglenoidal	(74)				71?		82?				84		92?
Stylomastoid-stylomastoid	(87)						91.4		100?		88		92?
Distance between temporal lines (greatest)	(110)				67		90		94		86		104?
Distance between temporal lines (least)	(92)												
Biparietal tuberosity	(125)		122										
Bisupramastoid crest	138												
Bi-infratemporal crest	92												
Dacryon-dacryon	(23)												
Maxillofrontale-maxillofrontale	(32)												

References as in Table 1. Figures in brackets are estimates.

posterior portion of the roof of the right orbit are preserved. From their most medial position, the orbit margins slope markedly infero-laterally and then, as seen on the right side, begin to level to the horizontal just above the infra-orbital foramen. The estimated antero-posterior length of the right orbit from the antero-inferior margin to the optic foramen is circa 56 mm. The supero-medial portion of the right infra-orbital foramen is preserved and the infero-medial portion of a slight hollowing below the position of the foramen can be seen on the left. Also on the left is the medial portion of an infra-malar notch. Medial to the infra-orbital foramen on the right are two smaller foramina.

Only a left anterior portion of the palate is preserved and this is relatively deep. The incisor region is missing. Of the teeth, only the roots of the left canine, P<sup>3</sup>, P<sup>4</sup> and M<sup>1</sup> are present. P<sup>3</sup> and P<sup>4</sup> appear each to have two root canals and M<sup>1</sup> is three-rooted. The mesiobuccal root socket of M<sup>2</sup> is present. The infra-malar notch is situated above M<sup>1</sup>.

#### *The frontal*

The left supra-orbital torus is about 14 mm thick medially and is divided into a superciliary and supra-orbital portion by a slight groove that ends laterally in a 2.5 mm broad foramen about 12 mm lateral to the supra-orbital notch. Although the complete notch is not preserved, its apparent lateral margin is present. From the torus laterally, there is a well-marked temporal crest running postero-medially from the zygomaticofrontal suture. About 22 mm of this is preserved. This crest divides the supra-orbital portion of the frontal from the temporal surface of the frontal, with which it forms an angle of about 90°.

There is a large flake of surface bone missing from the supero-medial part of the torus and this has removed the ophryonic groove as well as the superior part of the torus above the middle of the orbit. A small fragment of frontal squama is attached to the left parietal and a larger fragment is attached to the right parietal. Neither fragment shows any defined temporal line. On the left, the coronal suture can be detected as a slight ridge, and on the

**Table 3** Thickness (in mm) of cranial bones in Ndotu and some other hominids

	Ndotu	<i>Homo erectus</i>						
		Pithecanthropus		Sinanthropus				
		I	II	II	III	X	XI	XII
<i>Thickness of frontal</i>								
Torus supraorbitalis: lateral	10.0							
Torus supraorbitalis: medial	>13.5			14.2	13.5	12.6	14.0	17.0
Facies temporalis	8.5	4.0	3.5	6.5	4.8	(5.8)	4.6	5.5
<i>Thickness of parietal</i>								
Near coronal suture	6.5							
Tuberosity	(11.0)	9.0	12.5	11.0	11.0	12.5	16.0	9.0
Angularis mastoidea	13.0		14.0	13.5	17.2	14.0	13.5	14.5
<i>Thickness of occipital</i>								
Centre of planum (superior)	9.0		13.0	(10.7)	10.0	10.0	9.0	9.0
Centre of occipital torus	14.0		20.4		20.4	15.0	12.0	15.0
Fossa cerebellaris	1.5		5.0		6.8	(5.0)	2.8	2.5
<i>Temporal thickness</i>								
Centre of squama	8.5(R), 9.0(R)		8.0	10.0	9.3	(5.2)	6.0	7.0
At asterion	13.0							
Sutura parietomastoidea	12.0(R)							

Values for *Homo erectus* from Weidenreich (1943). Figures in brackets are estimates.

**Table 4 Occipital arc and chord measurements (in mm) of Ndutu and some other hominids**

	Ndutu	Pithecanthropus		<i>Homo erectus</i> Sinanthropus				
		I	II	II	III	X	XI	XII
Lambda-opisthion								
Arc	112	(103)	101?		106?		118	118
Chord	87	(78)	75		80?		86	86
Lambda-asterion								
Arc, right	92		98	90?	90	93	99?	92
Arc, left	85		99	90?	88	88	85?	100
Chord, right	85		85	83?	81	85	84?	87
Chord, left	81		83	83?	77	78	77?	87
Lambda-inion								
Arc	70		47		49	51	50	55
Chord	64	(43)	45		47	49	48	52.5

Values for *Homo erectus* from Weidenreich (1943). Figures in brackets are estimates.

right, the coronal suture is clearly visible. Internally can be seen the sagittal portions of the floor and lower medial wall of a left and right frontal sinus that would originally have been of large capacity.

#### *The sphenoid and ethmoid*

On both sides are preserved small areas of the temporal surface of the sphenoid. On the left, an inferior fragment is present from the zygomaticosphenoid suture to the temperosphenoid suture. The temporal surface forms a 90° angle with the infra-temporal surface and a slight infra-temporal crest is present. Internally on the right, a small portion of the lesser wing of the sphenoid lacking the clinoid processes is joined to the posterior portion of the orbital plate of the frontal which is preserved medially to form the margin of the cribriform plate. A very small fragment of the corresponding area is preserved on the left around the cribriform plate only. The plate itself is not preserved but the crista galli of the ethmoid is present.

#### *The temporals*

The best preserved is the left temporal. From the infra-temporal surface of the sphenoid, the flat infra-temporal surface extends posteriorly onto the temporal until it curves sharply into a clearly defined articular eminence, which is marked medially by a slight, downturned entoglenoid process and posteriorly with a slight undercut by the glenoid fossa. The articular eminence is at an angle of 120° to the preglenoid planum and separated from it by a faint ridge. The lateral part of the eminence is missing but the central portion is formed into a convex tubercle. Behind this tubercle the glenoid fossa is antero-posteriorly narrow, deeply impressed and defined posteriorly by a small postglenoid process. This region is impressed 4 mm above the surface of the tubercle and is about 30 mm broad and 5.9 mm long. The length of the mandibular fossa from the anterior margin of the articular eminence to the postglenoid process is 18 mm.

The tympanic plate is 23.5 mm in depth and 18 mm from its posterolateral margin to the vagina of the styloid process. There is a well-ossified styloid process that is broken off. The lateral margin of the tympanic plate is formed into a triangular elongated process inferior

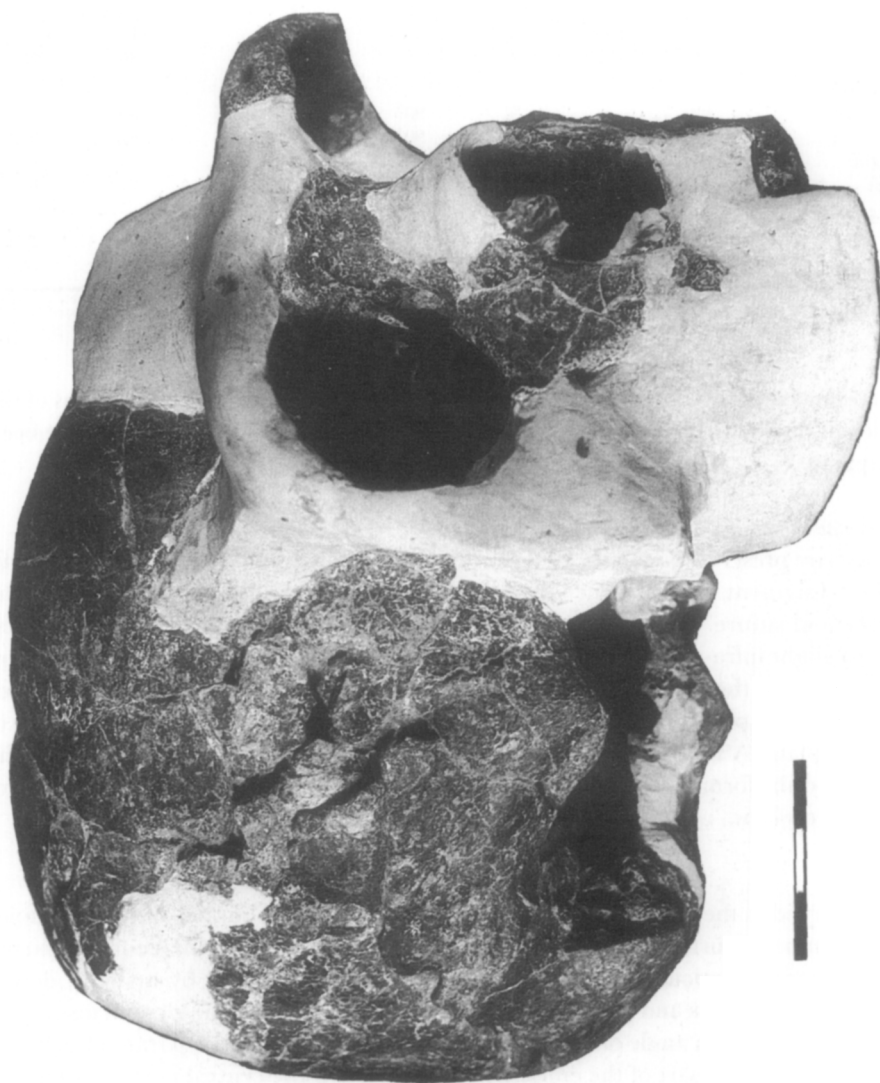


Figure 7. Right facial view of Ndotu cranium after modification and addition of left brow ridge in 1978. Scale in cm.

to the floor of the acoustic meatus. This process measures 12.5 mm in vertical length. The posterolateral margin of the tympanic plate is situated anterior to the mastoid process. The inferior tip of the triangular process of the tympanic plate is directly anterior to the stylomastoid foramen. From the stylomastoid foramen, a 4.5 mm, narrow, but well-defined, digastric groove runs posteriorly for 20.3 mm. Medial to this groove is a crest (the paramastoid process) which separates the digastric groove from a very narrow groove (0.6 mm) that is probably for the occipital artery. This medial groove is best seen on the right temporal where its medial wall forms, with the adjacent area of the occipital, a slight occipitomastoid crest.

Of the right temporal all that is preserved is most of the temporal squama, the supramastoid crest, porion, the lateral fragment of the roof of the acoustic meatus, the mastoid process, the digastric notch and a fine groove medial to the mastoid notch which is probably for the occipital artery. There is also an isolated fragment with the root of the styloid process (Figure 11).

The occipitomastoid crest on both temporals is marked by a slight rounded ridge and is at an inferior level to the tips of the mastoid and to the paramastoid crest that divides the

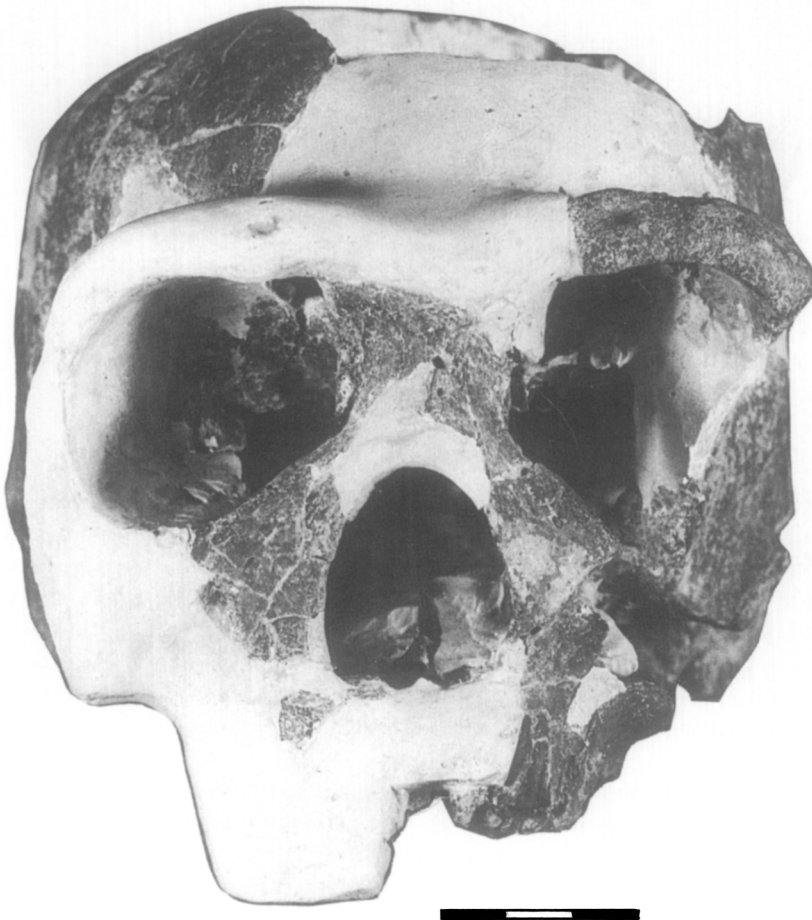


Figure 8. Facial view of Ndotu cranium after 1978 modification. Scale in cm.



Figure 9. Posterior view of Ndotu cranium (1978). Scale in cm.

digastric groove from the groove for the occipital artery. The mastoid processes are small and triangular in transverse cross-section. The flat posterior part of the mastoid forms a continuous plane with the nuchal surface of the occipital. The mastoids resemble those of OH 9 and OH 12. From the tip of each mastoid two rugose, flat ridges run posteriorly across the posterior surface, one along the lateral margin and the other in the centre. On the left are two mastoid foramina. One measures 1.7 mm in diameter. The other is situated on the occipitomastoid suture and only half is preserved. On the right are three mastoid foramina measuring 4.5 mm, 1.7 mm and, on the occipitomastoid suture, 2.3 mm diameter.

On both temporals above the mastoid process is a 13 mm broad depression running postero-superiorly from the acoustic meatus. Superior to this depression is a well-defined supra-mastoid crest that begins at porion and runs postero-superiorly for 53 mm before it fades into the parietal squame. This is only preserved in its entirety on the left. About 26 mm of this length is on the parietal.

The medial part of the left tympanic plate is down-turned at 31 mm from its infero-



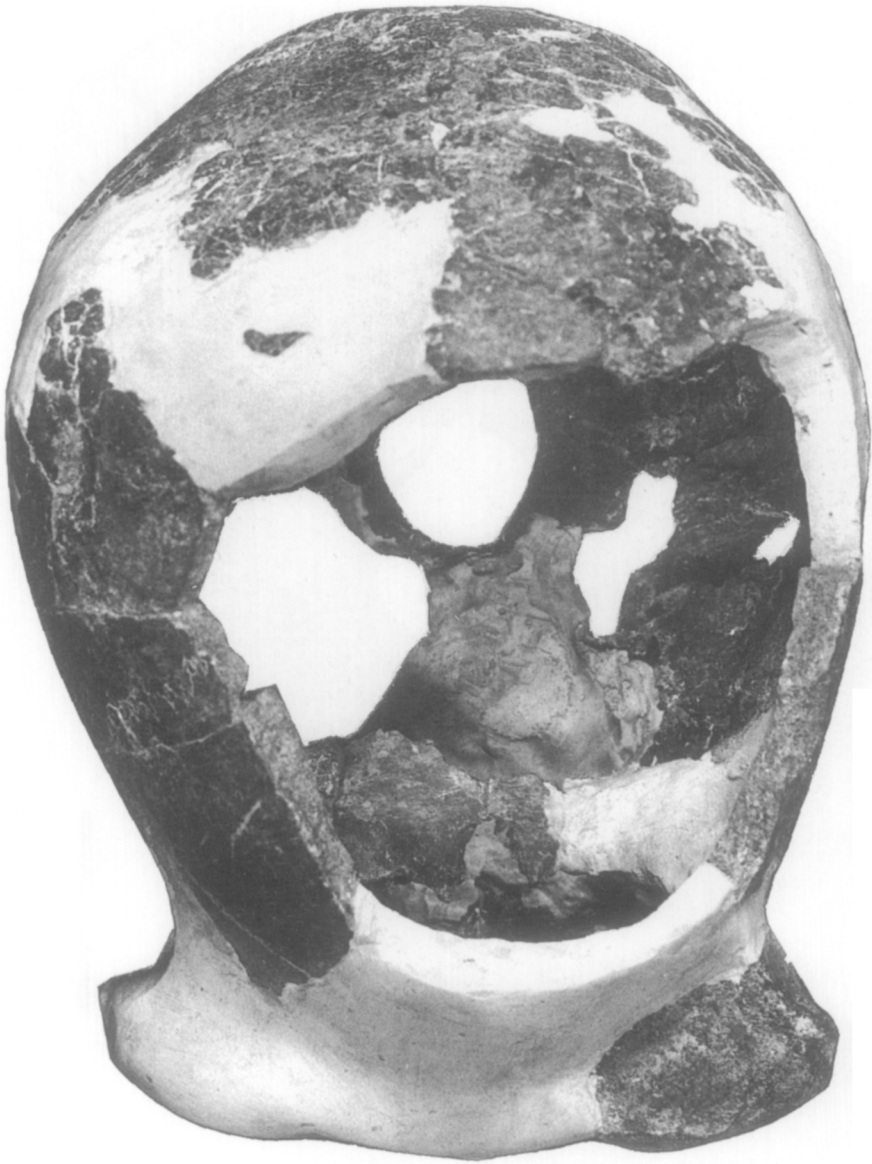


Figure 10. Superior view of Ndotu cranium (1978). Scale in cm.



Figure 11. Basal view of Nduutu cranium (1978). Inset: enlargement of isolated right temporal fragment to show ossified root of styloid process. Scales in cm.

lateral margin but is then broken away so it cannot be determined whether it formed a tubercle as in *Homo erectus pekinensis*. The sagittal plane of the temporal wall of the cranium is situated above the middle of the glenoid fossa and the articular eminence (the lateral part of which is broken away), as in *H.e. pekinensis* and unlike modern man where the glenoid fossa and articular eminence are situated medial of the temporal wall of the cranium (Weidenreich, 1943: 50, Figure 116).

Internally on the right is preserved the lateral portion of the petrous pyramid with a vertical posterior surface, undercut by the sigmoid sulcus. The whole of the posterior surface, as well as part of the superior surface, is preserved but has not been glued into position as the join is so small.

At asterion on the right side are two small ossicles adjacent to each other and at asterion on the left is one small ossicle. The larger of those on the right is missing and they are not symmetrical.

*The parietals*

Both parietals are in very poor condition. The right parietal is the more complete but lacks a large portion of the anteromedial corner and large areas of inner and outer table in its centre. Much of the remaining surface is cracked and fragmented. There is, however, a solid undistorted region extending along the lambdoid suture from lambda to asterion and then approximately half way along the squamous suture. The left parietal is represented by only the posterior two-thirds and of this the medial half consists mainly of the outer table and the lateral portion consists mainly of the inner table. Both of these surfaces are cracked and fragmented except for a small region extending from half way along the lambdoid suture to half way along the squamous suture. Despite the shattered and distorted nature of

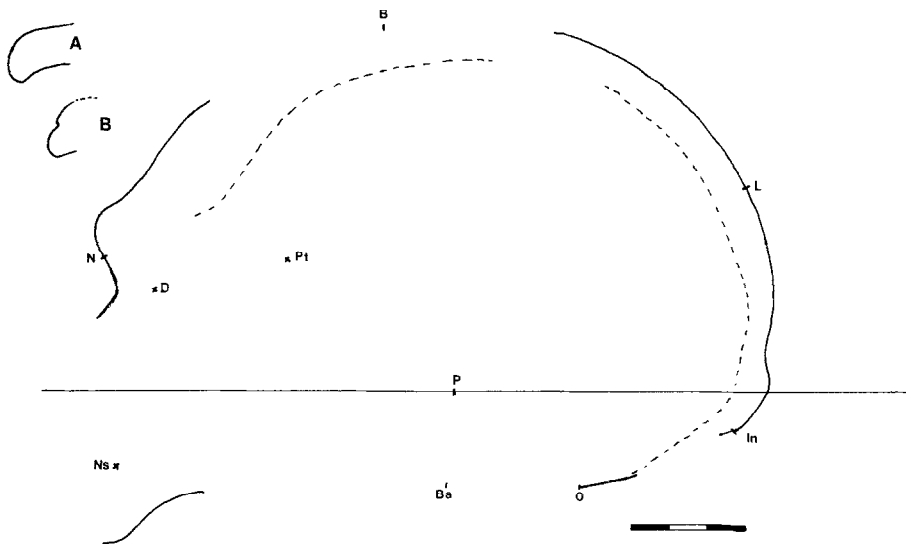


Figure 12. Mid-sagittal craniogram (solid line) and mid-orbital craniogram (dotted line) of Ndotu cranium. Large A is a section through lateral part of left supra-orbital margin and large B is a section through medial part of left supra-orbital margin. Letters on craniograms as follows: N, nasion; Ns, nasospinale; D, dacryon; Pt, pteryon; B, bregma; P, porion; Ba, basion; O, opisthion; In, inion; L, lambda. Horizontal line is Frankfort plane. Scale in cm.

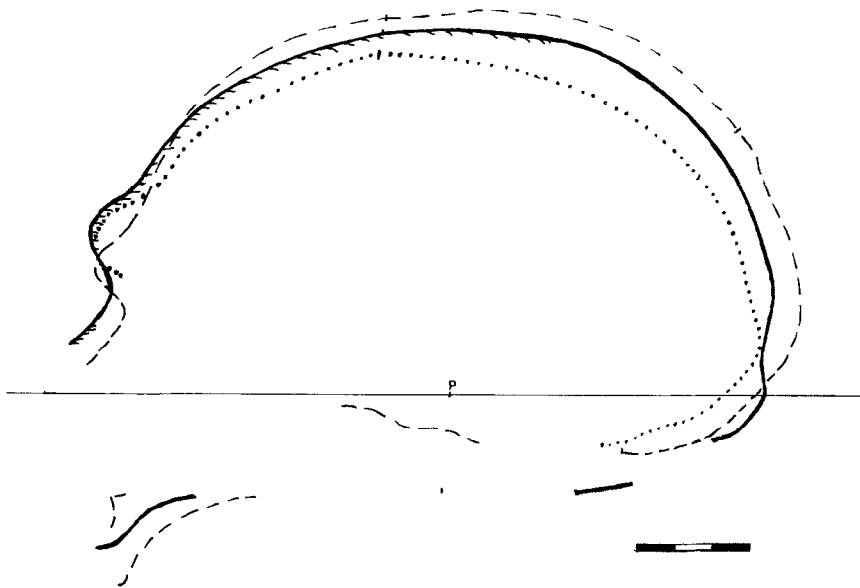


Figure 13. Mid-sagittal craniograms of Ndutu (solid line), Steinheim (dashed line, after Weinert, 1936), and Pithecanthropus II (dotted line, after Weidenreich, 1943). Hatched areas are reconstructed. P = porion. Scale in cm.

some areas of the parietals it is possible from a close examination of the small well-preserved areas to appreciate something of the original contours of the parietal including the fact that there were parietal bosses. On the right the anterior portion of parietal adjoining the coronal suture appears to be distorted upward slightly at its posterior end relative to the nearby surface of the rest of the parietal. That surface in this central parietal region is shattered and possibly distorted downward relative to the anterior portion. Whichever is distorted it is clear from the general conformation of the parietal surface and from comparison with the contour of the left parietal that there must have been parietal bosses. Although that on the right has been reconstructed with plaster for reasons of strength and is exaggerated by the distortion just mentioned, the reconstructed area of the boss on the left is probably close to the original conformation. With the exception of the exaggerated boss on the right, the left and right parietal curvatures match each other well. Near the lambda end of the sagittal suture there is also slight distortion of the surface of both parietals but to the front of the preserved portion of left parietal along the sagittal suture there is no distortion and there is no sign whatsoever of a sagittal keel. The superior temporal line is lightly indicated on the anterior portion of the right parietal. On the well preserved posterior portion of the right parietal there is a slight ridge marking a continuation upward and backward of the supramastoid crest of the temporal. From the ridge, the parietal surface extending back to within 1 cm of asterion and the lambdoid suture is slightly concave. Internally on both parietals can be seen small portions of the grooves for the middle meningeal vessels. Thickness of the parietals can be measured accurately at a few undistorted points. Near the coronal suture it is 6.5 mm. At the mastoid angle it is 13 mm and an estimate at the right parietal tuberosity is 11 mm.

*The occipital*

The occipital bone is almost complete, lacking only the basilar process, the anterior half of the left condyle, the jugular processes, a small portion of the right cerebellar fossa, a small triangular fragment along the right parietal suture, a 20 mm by 25 mm area of surface along the sagittal midline inferior to inion and a few small chips of surface bone. Externally there is a large sutural bone asymmetrically situated at the apex. It measures 30 mm along the left parietal suture and 15 mm along the right. To the right of this is another sutural bone extending 42 mm along the right parietal suture and with an antero-posterior diameter of 14 mm. A large portion of the right side of this ossicle is missing but its original presence is shown by the sutural pattern. A third small sutural bone measuring 7 mm by 10 mm is situated at the right asterion adjacent to the gap from a missing sutural bone of the temporal.

There is a prominent occipital torus measuring 20 mm in height in the midsagittal plane but tapering laterally until it fades away about 16 mm medial of asterion. The inferior margin of this torus is sharply defined by the superior nuchal lines that meet at inion in the form of a linear tubercle. This constitutes inion as defined by Martin (1928). Weidenreich (1943: 98) chose the centre of the occipital torus as inion. The superior margin of the torus is also well defined but has a smooth rather than a sharp margin. It is marked in the sagittal midline by an external occipital protuberance that projects posteriorly about 1 mm beyond the somewhat flat surface of the torus. The protuberance is about 30 mm in breadth and 10 mm along the sagittal midline. The shape is that of a flattened ellipse with tapered ends. The inferior margin of the torus forms the division between the superior or upper scale of the occipital and the nuchal area or lower scale of the occipital. The angle formed between the lambda-inion chord and the inion-opisthion chord, i.e., the occipital curvature (no. 33(4) of Martin, 1928), is 110. The lower scale is slightly convex from side to side as well as

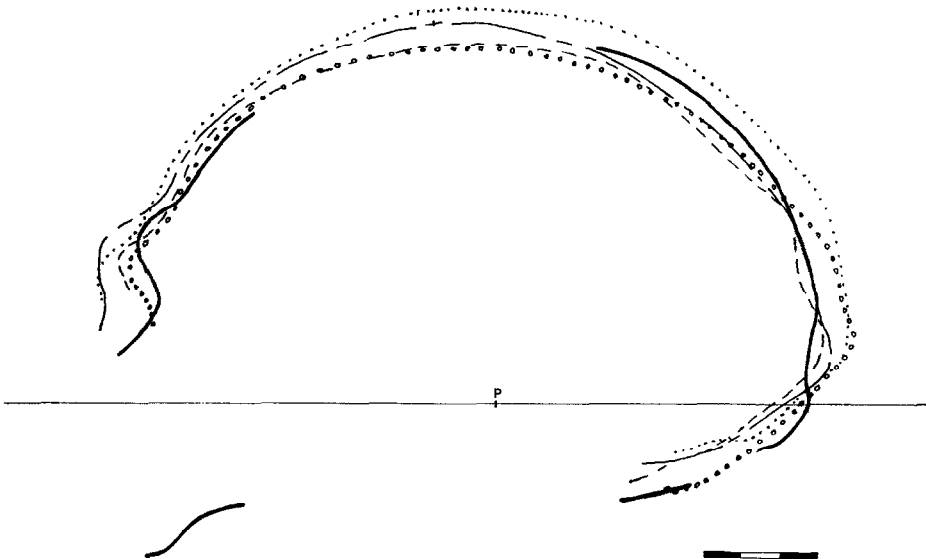


Figure 14. Mid-sagittal craniograms of Ndotu (thick, solid line) and four *H. sapiens* skulls after Weidenreich (1943). Skull III (short-dashed line), Skull X (dotted line), Skull XI (beaded line), and Skull XII (thin, broken line). P = porion for all skulls. Scale in cm.

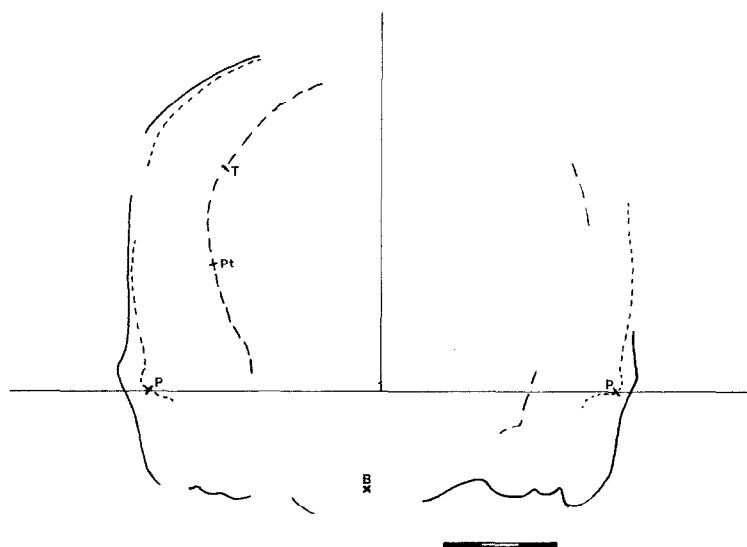


Figure 15. Three coronal craniograms of Ndotu as viewed from the front. Mid-mastoid (solid line), mid-porion (short dashes) and mid-pteryon (long dashes). T, temporal line; Pt, pteryon; P, porion; B, basion. Scale in cm.

antero-posteriorly on each side but in sagittal midline much of the surface is missing except for an area extending about 16 mm behind opisthion. This portion displays an external occipital crest. The nuchal surface also shows well defined muscle markings and the inferior nuchal line appears as a thin, comb-like band. The foramen magnum is of ovoid shape, measuring 37.5 mm long by 28.2 mm broad. The thickness of the occipital bone ranges from 14 mm in the centre of the external occipital torus to 1.5 mm in the fossa cerebellaris.

The internal surface of the occipital is well preserved and displays the cruciate eminence with an internal occipital protuberance. The centre of the latter is 28 mm from opisthion, i.e., much closer than the external occipital protuberance which is 51 mm from opisthion. The line marking the attachment of the tentorium cerebelli extends across the lower portion of the internal protuberance, dividing it from the short (15 mm) inferior arm of the cruciate eminence which is represented by a single ridge. The 9 mm wide left lateral arm of the cruciate eminence and the enclosed flat sulcus for the transverse sinus are weakly defined at the lateral margin and slightly more prominent medially where they curve into the superior arm and the flat sulcus for the superior sagittal sinus. The left hand margin of the latter fades into the cerebral fossa about 10 mm above the protuberance then reappears higher up as a very indistinct rugose line. The right hand margin is similarly ill-defined in the upper portion but well-defined lower down and where it curves laterally into the superior margin of the right lateral arm of the cruciate eminence. The margins of the arm are indistinct laterally and the sulcus is flat for its entire length. The sulcus for the sigmoid sinus is clearly defined, deeply impressed and 6.5 mm wide on the left where it can be seen descending into the jugular notch. On the right the sigmoid sulcus is preserved against the posterior surface of the petrous temporal and would have encroached on the occipital only at the jugular notch which is not preserved. Anteromedial to the left jugular notch is a

prominent jugular tubercle, behind and beneath which is the hypoglossal canal. Only the inferomedial portion of that canal is present on the right.

The left and right cerebellar fossae are deeply impressed and occupy an area slightly smaller than that of the cerebral fossae. The right cerebral fossa is very deeply impressed at its inferomedial corner, contrasting with the more shallow left cerebral fossa.

### Comparisons with other crania

When I first assessed the Ndotu cranium (Clarke, 1976), I concluded that it had a strong resemblance to *Homo erectus pekinensis* in the form and contour of the occipital with its thickened nuchal torus, the form of the mastoid region, the almost vertical forehead, the inferred supra-orbital torus, the great thickness of the vault and the outline in norma verticalis. I did not make clear, however, that the features I listed did not all differentiate the Ndotu cranium from other subspecies of *Homo erectus* or indeed from early *Homo sapiens* but should have said that the character complex seemed most similar to that of *H.e. pekinensis*.

I listed other features in which the Ndotu cranium differs from *H.e. pekinensis* and resembles *H. sapiens*. These are the presence of pronounced parietal bosses, more vertical sides to the vault, the presence of an ossified styloid process, apparent absence of sagittal torus and that the supramastoid crest does not extend over the external acoustic meatus. My conclusion was that the Ndotu cranium represented an evolutionary link between *H.e. pekinensis* and *Homo sapiens* but that it could not be classified as *Homo sapiens* and that it may have to be placed in a new subspecies of *H. erectus*.

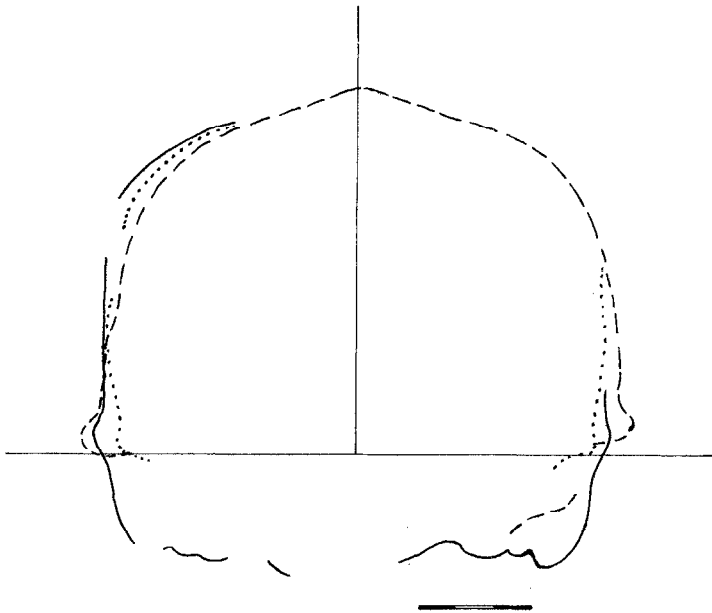


Figure 16. Mid-mastoid (solid line) and mid-porior (dotted line) coronal craniograms of Ndotu compared to mid-porior coronal craniogram of *H.e. pekinensis* Skull XI (dashed line, after Weidenreich, 1943). Note more vertical sides and parietal bosses in Ndotu. Note wider supramastoid region of *H. erectus*. Scale in cm.

### *Comparison with Salé*

Coincidentally, unknown to me at the time, the back of a cranium similar in many respects to Ndotu had been discovered at Salé in Morocco in 1971 and Jaeger (1975) also found that the Salé fossil had characters common both to *Homo erectus* and to modern man and concluded that it should be attributed to an evolved *Homo erectus*. The features he listed as being like those of *H. erectus* were platycephaly, general dimensions, the maximum transverse diameter basally situated, low cranial capacity (930–960 cc), frontal morphology characterised by a sagittal keel and a strong postorbital constriction, and the tooth measurements. The characters he noted as being like modern man were the transverse curve of the parietals and the development of parietal bosses, the modern form of the occipital with a rounded contour and inion situated lower than opisthocranium and the development of the mastoid process.

Hublin (1985) gave an age for the Salé specimen at probably around 400,000 years and agreed that it is like *Homo erectus*. Although he considered the occipital bone to be abnormal and therefore not reliable as a taxonomic indicator, he did agree that there were some *H. sapiens*-like features “such as the proportions of the basisphenoid and basioccipital, the relative gracility of the temporal bone and above all the development of the parietal bosses”. When I examined the Salé cranium in 1984, I found it had strong similarities to Ndotu in size, outline from above (i.e., broad parietals, narrow frontal), in outline from behind (parietal bosses) and in the morphology of the supramastoid region. Salé is similar to Ndotu also in having a deep antero-posteriorly narrow glenoid fossa and apparently an ossified styloid process. Salé, like Ndotu, does not have a sagittal keel on the parietals but does have a slight metopic keel and a swelling around bregma. The corresponding region is missing in Ndotu so it is unknown if it was similar.

Thus in Ndotu and Salé we have two similar crania perhaps of similar geological age (i.e., ca. 400,000 years) but from widely separated areas of Africa that both have a mosaic of characters seeming to link them to both *Homo erectus* and *Homo sapiens*.

### *Comparison with Homo erectus*

In mid-sagittal profile (Figure 14), the Ndotu cranium seems at first glance to fall within the range of variation of *H. erectus pekinensis*. It does differ though in appearing to have less of an angle between upper and lower occipital scale and in the position of its occipital torus which is situated at a lower level than it is in *H.e. pekinensis* or in *H.e. erectus* (Figure 13). Although the occipital curvature of Ndotu is only 110°, i.e., not much more than the maximum of 106° for *H.e. pekinensis*, the occipital appears less angled because the nuchal plane is facing more inferiorly than it is in *H.e. pekinensis*, *H.e. erectus* or Olduvai H. 9. The profile of *H. erectus erectus* is much flatter in supero-inferior dimension than either *H.e. pekinensis* or Ndotu. When the same profile of Ndotu is compared with that of an early *Homo sapiens*, the 250,000 year old Steinheim cranium, there is a size and shape similarity except for the occipital torus of Ndotu which is absent in Steinheim. The coronal craniograms through the mastoid (Figure 16) show that Ndotu contrasts with *H.e. pekinensis* in having more vertical sides to the vault and a much reduced supramastoid crest. Although the latter feature may not be significant, the vertical sides are of relevance in that they are an indication of the expansion of the parietal area of the brain. In this profile, Ndotu is closer to the early *H. sapiens* from Steinheim than it is to *H. erectus* (Figure 17).

At the time I first reconstructed and briefly described the Ndotu cranium, the only reasonably complete cranial remains of *H. erectus* with which it could be compared were



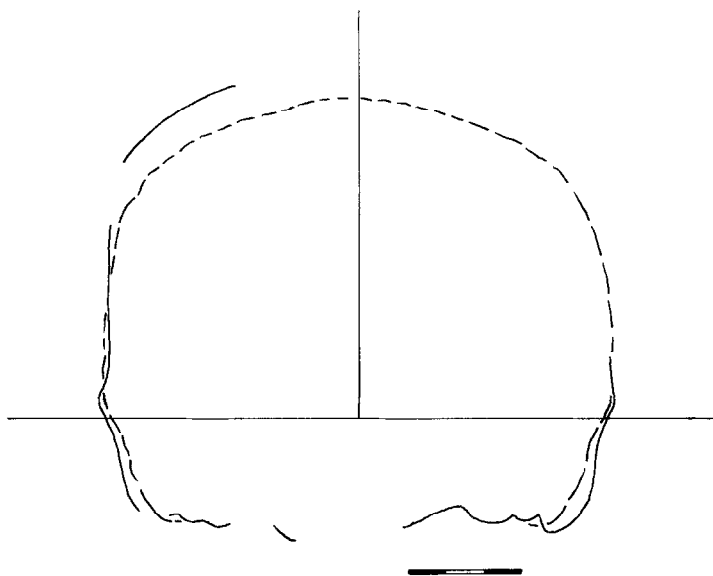


Figure 17. Mid-mastoid coronal craniogram of Ndotu (solid line) compared to coronal craniogram, at euryon, of Steinheim (dashed line, after Weinert, 1936). Note strong similarities between the two. Scale in cm.

those from Java and China and the OH 9 calvaria from Olduvai Gorge, Tanzania. Compared to all of these, the Ndotu cranium was more sapient-like in its expanded parietal region and the morphology of its temporal. Coincidentally, however, I was also at the time working on the analysis of the 1.5 million year old SK 847 cranium from Swartkrans and concluded (Clarke, 1977) that although the supra-orbital torus was lightly structured and the temporal was sapient-like, it might be considered as a more sapient-like member of a polytypic *Homo erectus*. This conclusion was strengthened by the discovery in 1976 of an early 1.5 million year old *Homo erectus*, almost identical to SK 847 from East Lake Turkana (R. Leakey & Walker, 1976). This specimen, KNM ER 3733, is reasonably complete and in the mid-sagittal profile it displays the sharply angled occipital with posterior facing nuchal surface characteristic of *H.e. erectus*, *H.e. pekinensis* and Olduvai Hominid 9. Also in coronal section through the mastoids the sides of the vault slope gently inward and upward from the supramastoid crest.

With this new insight into the existence of sapient-like morphology in early *Homo erectus*, I have looked again at what I had supposed to be sapient-like characters of the Ndotu cranium and find that of the characters I listed and others that I found subsequently, it is only the vertical sides of the vault with parietal bossing together with the vertical upper scale of the occipital that can be accepted as a sapient character complex that does not occur in *H.e. pekinensis*, *H.e. erectus*, OH 9 or KNM ER 3733. An ossified styloid process and a vertical posterior surface of the petrous pyramid with sigmoid sulcus undercutting are present in SK 847 and thus cannot be considered as apomorphic characters of *Homo sapiens*. The apparent absence of a sagittal torus or keel is not diagnostic because the early *H. erectus* KNM ER 3733 also does not have a sagittal torus on the parietals. It does have a frontal swelling near bregma but that region is not preserved in Ndotu and it might well have had such a swelling as does the similar cranium from Salé. The fact that the

supramastoid crest does not extend over the external acoustic meatus cannot be considered diagnostic of *Homo sapiens*. The crest in Ndotu certainly decreases in prominence over the external acoustic meatus and contrasts in this respect with *H.e. pekinensis*. The condition in Ndotu is, however, very similar to that of OH 9 and not so very different from KNM ER 3733.

Rightmire (1983) also listed features of the temporal and occipital of Ndotu that he considered pointed in the direction of *H. sapiens* and which persuaded him to assign the Ndotu cranium to that species. Apart from the vertical upper scale of the occipital, he also noted that the glenoid cavity is bounded anteriorly by a raised articular tubercle, that there is a strong post-glenoid process, that the inferior tympanic border is delicate in construction and that details of styloid morphology seem to match the human. The latter three features do not seem diagnostic of *H. sapiens*. An ossified styloid process occurs in the early *Homo erectus* SK 847 which also has a delicate construction to the inferior tympanic border. As to the strong postglenoid process, one has only to look at the Olduvai Hominid 9 *Homo erectus* cranium to see left and right postglenoid processes even more pronounced than that of Ndotu.

The raised articular tubercle in Ndotu could be considered as a sapient-like character not encountered in *H.e. pekinensis*, *H.e. erectus*, OH 9, SK 847, or KNM ER 3733. In those specimens the articular eminence grades more or less smoothly from the roof of the glenoid fossa onto the preglenoid planum. In Ndotu the tubercle forms a distinct entity largely due to the deep and antero-posteriorly narrow roof of the glenoid that slightly undercuts the posterior margin of the tubercle. Weidenreich (1943: 47) discussed the two factors influencing the development of the tubercle as demonstrated by Lubosch (1906) who also showed that there is great variability in the development of the tubercle in modern man. The two factors are the form and size of the glenoid fossa behind the tubercle and the degree of supero-anterior slope of the preglenoid planum in front of the tubercle. Although the depth and shape of the glenoid fossa varies greatly in modern man (Sullivan, 1917)

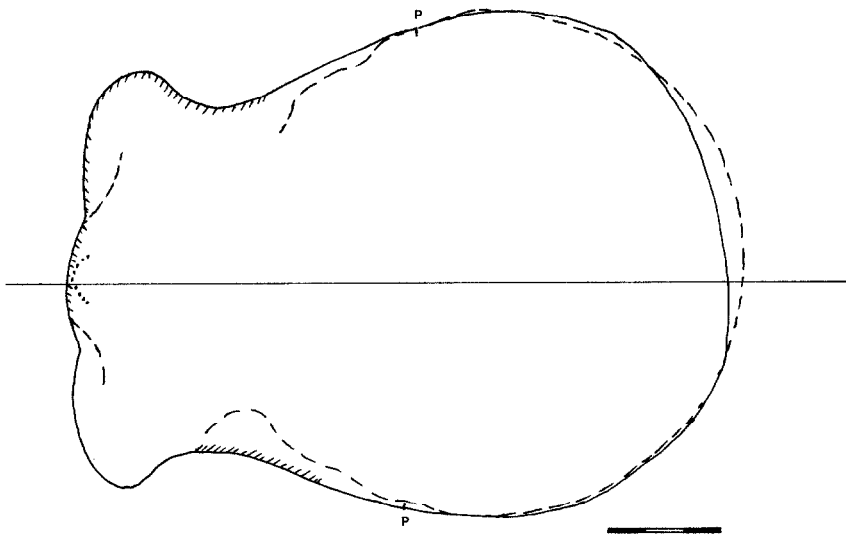


Figure 18. Horizontal craniograms of Ndotu. Mid-glabella (solid line), mid-porion (dashed line) and nasal bones (dotted line). P = porion. Scale in cm.

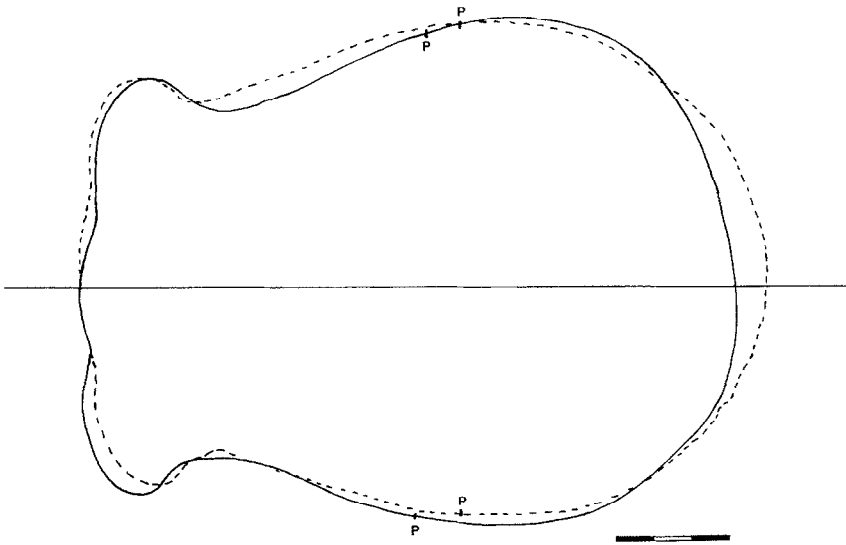


Figure 19. Mid-glabella horizontal craniograms of Ndotu (solid line) and *H. erectus pekinensis* Skull XII (dotted line, after Weidenreich, 1943). P marks relative position of porion in each skull. Scale in cm.

such variation that might influence the development of the tubercle has not been recorded for specimens classified as *Homo erectus*. Thus the presence in Ndotu of a well-defined tubercle should be considered a character which may prove to be significant in the taxonomic placing of Ndotu. Apart from this one feature and the complex of vertical parietal walls, parietal bosses and vertical upper occipital scale, all the other features considered by me and by Rightmire to be sapient-like are apparently undiagnostic of *H. sapiens* as they occur in specimens classified as *H. erectus*. It is of course possible in view of the damage to the Ndotu parietals to question, as Rightmire (1983) has done, the extent of parietal bossing as reconstructed by me. He did, however, agree that the sides of the parietal walls are more nearly vertical than would be expected in *H. erectus*. It is indeed this verticality of the parietal walls together with the verticality of the occipital upper scale and the contours of adjoining undistorted areas of parietal that contribute not only to the expansion of the brain case in that region but to the conclusion that there had to be some degree of parietal bossing in order for the contours to meet. It is known that the very similar cranium from Salé did have parietal bosses, so Ndotu would not be unusual in that respect.

The vertical upper scale of the Ndotu occipital is associated with a tilting downward of the nuchal surface and an occipital torus situated lower than is usual for *H. erectus*. Despite this, the internal occipital protuberance is situated much closer to opisthion than is the external occipital protuberance. As in *H. erectus pekinensis*, the transverse arms of the cruciate eminence are situated low in the occipital. Weidenreich (1943: 40) contrasted this condition to that in modern man in which the cerebellar fossae are much larger than the cerebral fossae. In *H.e. pekinensis* the situation is reversed with the cerebellar fossae occupying almost half the area of the cerebral fossae. Ndotu occupies an intermediate

position in that the cerebellar fossae are slightly smaller than the cerebral fossae. It thus has the *erectus* morphology, though not to such an extent.

### Affinities of the cranium

The Ndotu cranium seems to show no feature that would clearly distinguish it from *Homo erectus* (as presently constituted) except for the expansion of the parietal and occipital areas of the brain and that alone is surely significant. The cranial capacity of Ndotu has been estimated by Rightmire (1983) to be circa 1100 cc. It is a small capacity, falling well within the *H. erectus* range and comparable to the 1067 cc calculated by Holloway (1975) for OH 9. Yet in the verticality of its parietal walls and upper occipital profile and in the lowering of its nuchal plane, Ndotu has departed dramatically from the typically *erectus* morphology seen, for example, in *H.e. pekinensis* and has more in common with *Homo sapiens*. This might seem to indicate that the Ndotu cranium is a representative of a population that was evolving out of *Homo erectus* and into *Homo sapiens*. The problem is to decide into which species it should be placed if such an interpretation were accepted.

Rightmire (1983) concluded that on occipital characteristics, glenoid cavity morphology and anatomy of the tympanic plate, Ndotu should be classified in a sub-Saharan subspecies of *Homo sapiens* and suggested it might, for example, be referred to *H. sapiens rhodesiensis* together with the fossils from Broken Hill, Elandsfontein and probably Bodo. At the same time, he recognised and discussed the problems, particularly with poorly dated specimens, of classifying fossils, such as Ndotu, which exhibit characteristics common to two *Homo* taxa. He stated that it is difficult to decide whether such specimens should be seen as falling within expected limits of one taxon or "rather as representative of populations that are transitional in an actual phylogenetic sense". This problem was discussed also by Bräuer (1984a: 349). He opted to use the term "archaic *Homo sapiens*" for fossils which could not be clearly designated as either *Homo erectus* or as anatomically modern *Homo sapiens* though he stated that it is not possible to draw a temporal or morphological line between archaic *Homo sapiens* and developed *Homo erectus*. Following analysis of craniological features of a variety of such apparently transitional fossils from Africa, Bräuer (1984a: 387) classified them by a modification of the "grade" model of Stringer *et al.* (1979). Thus he placed Ndotu in "grade 1" as an "early archaic *Homo sapiens*" together with Bodo, Broken Hill, Hopefield, Eyasi, Cave of Hearths, Rabat, and possibly Salé, Sidi Abderrahman and Thomas. He considered that, compared to a *Homo erectus* such as Olduvai H. 9, these specimens are "considerably more evolved", that their cranial vaults are more expanded and that Ndotu exhibits an "especially pronounced" mosaic of archaic and anatomically modern traits. Thus both Rightmire and Brauer agree with my original assessment of Ndotu as a hominid having characteristics in common with both *Homo erectus* and *Homo sapiens*, but whereas I chose to classify it in the former taxon, they had reasons to classify it in the latter taxon. Where I would now differ with them is in their interpretation of certain traits as anatomically modern and consequently in their reasons but not their decision to place Ndotu as an archaic *Homo sapiens* rather than as a developed *Homo erectus*.

I cannot now accept certain sapient-like features of the Ndotu temporal as diagnostic of *Homo sapiens* because the presence of such features in the early *Homo* SK 847 would indicate that they are plesiomorphic characters retained from that ancestral stock. The morphology of the Ndotu glenoid together with the slight prominence of the articular tubercle might be of diagnostic value but the most diagnostic of the Ndotu features that would suggest an

affinity with *Homo sapiens* is the complex associated with the expansion of the parietal area of the cerebrum. This is manifest in the vertical parietal walls, parietal bossing and vertical upper scale of the occipital. It is a complex which is not seen in any indisputable *Homo erectus* but which is characteristic of modern man. It can thus be considered an apomorphic character complex of *Homo sapiens* and it follows that it is taxonomically correct to classify Ndutu as a representative of archaic *Homo sapiens* probably belonging to the same subspecies as the very similar Salé and Steinheim crania.

The suggestion by Rightmire (1983) that Ndutu could be a female and Broken Hill a male of the subspecies *Homo sapiens rhodesiensis* deserves some consideration. If this were indeed the case, then Broken Hill, Bodo and Petralona would be males whilst Ndutu, Salé and Steinheim were females. Stringer (1985: 291) rejected this hypothesis on the ground that the range in size, robusticity and occipital morphology between, for example, Steinheim and Petralona is much greater than that in dimorphic samples of *H. erectus* and Neanderthals. He considered instead that they are population differences. Although the great differences in brow ridge size between the two groups might indicate subspecific differences, the suggestion of sexual dimorphism is not so remarkable if one considers the range of supra-orbital development seen in *Homo sapiens sapiens*. For example, there are relatively massive brow ridges in some modern Australian aborigines (Cunningham, 1909, Plates II and III) and in a recent American Indian (Bell & Hrdlička, 1935) and in ancient Brazilian skulls (Bryan, 1978). If such massive brow ridges occur, albeit infrequently, in the usually light browed modern man, then it would not be so remarkable to find very massive brow ridges in the males of a prehistoric species in which females had lighter but prominent brow ridges.

The relationship of Ndutu to its possible contemporaries or to more recent *Homo sapiens* skulls is difficult to assess because of the lack of accurate dating for many of these fossils, Ndutu included. Weidenreich (1943: 255) stated, "One of the greatest obstacles to a general agreement regarding the origin of '*Homo sapiens*' are difficulties which arise from geological dating". Forty-five years and many dating methods later we still suffer from the same problem. This, coupled with the scarcity and often fragmentary nature of *H. erectus* and early *H. sapiens* remains, means that only very general observations on possible relationships can be made, taking into account the possibly undiscovered or unfossilised variations on the theme through the ages. Here we may recall Weidenreich's (1943: 256) three assumptions: "(1) Human evolution was not limited to a certain geographical center but went on over a vast area comprising, possibly, the entire Old World. (2) There was always great variation with a tendency to racial differentiation. (3) This process of human evolution and racial differentiation went on over a long period of time starting in the middle Tertiary and ending in the upper Pleistocene interrupted for longer or shorter intervals possibly by changes in the environment".

Early *Homo sapiens* specimens can be loosely grouped into three main cranial morphotypes which do not necessarily imply taxonomic groups. The first, as represented by Ndutu and Steinheim, has a prominent but not massive supra-orbital torus separated from the rising frontal squama by a supra-toral sulcus. Although the supra-orbital region of Salé is not preserved, the morphology of the rest of the cranium shows that it also belongs to this group which lived possibly between 400,000 and 200,000 years ago.

The second morphotype is that of the massive-browed Broken Hill, Saldanha, Bodo, Petralona group, also existing during the period of possibly 400,000 to 200,000 years ago. Whether the differences between this cranial form and that of Ndutu/Steinheim are of sex,

race, subspecies or, as Stringer (1985) suggested, species, is unclear. The third and geologically younger morphotype is represented by Florisbad (Clarke, 1985*b*), Ngaloba (Magori & Day, 1983), and Omo 2 (Leakey, Butzer & Day, 1969). These crania have receding, low frontal squamae and a modest to quite prominent brow ridge development but without the marked supra-toral sulcus. This group covers a period of possibly 200,000 to 100,000 years ago. Similar neurocranial shape is seen in some fossil Australian skulls, modern Australian aborigines (e.g., Burkitt & Hunter, 1922) and even in modern acromegalics. None of the three morphotypes is limited to a particular geographic area and the differences between them might not seem so marked if we had much bigger samples from time and space.

### **Ancestry of the Ndotu hominid**

Upon completion of the anatomical study of the 1.5 million year old hominid SK 847 (Clarke, 1977), I was puzzled by the fact that although there were similarities to *Homo erectus*, SK 847 had a temporal morphology that was more like that of modern man. I could not envisage a situation whereby the more ape-like temporal morphology of *Australopithecus* would change to sapient-like and then back to ape-like in the classic *Homo erectus* of Java and Choukoutien. I concluded that 847 might be classified as an early subspecies of *Homo erectus* on the understanding that the taxon *Homo erectus* was far more variable than had hitherto been supposed. I decided, however, that pending the discovery of further cranial remains and definitely associated mandibles it was preferable to leave the SK 847, SK 27 and SK 2635 cranial fossils plus the SK 45 mandibular portion as *Homo* species indet. Subsequently, I was able to examine a cast of a then recently discovered early *Homo erectus* (KNM ER 3733) from East Lake Turkana and realised that SK 847 was so similar that it should be classified also as *Homo erectus* (Clarke, 1985*a*). With its lightly structured cranium and sapient-like temporal it can be considered as a member of an ancestral stock from which archaic *H. sapiens* populations as represented by Ndotu, Salé and Steinheim could have evolved without passing through the classic *H. erectus* morphotype displayed by *H. erectus erectus* and *H. erectus pekinensis*. This raises a very important question, i.e., do the African specimens assigned to early *H. erectus* really belong to that species or do they, as I originally suspected (Clarke, 1977), belong to a distinct species ancestral to *Homo sapiens*? This is discussed in the following section.

### **The relationship of Ndotu to *Homo erectus* of Asia**

In my original brief description of the Ndotu cranium (Clarke, 1976), I stated that it seemed to form an evolutionary link between *Homo erectus pekinensis* and *Homo sapiens*. My subsequent analysis of the early *Homo* SK 847 and of Ndotu has shown, I believe, that I was wrong. The Ndotu cranium exhibits the advanced sapient-like features of the temporal that are present in the early African *Homo* SK 847 but which are not seen in *H.e. pekinensis* or *H.e. erectus*. It therefore seems most probable that the early *erectus*-like *Homo* of Africa as represented by SK 847 and KNM ER 3733 developed into early *H. sapiens* as represented by Ndotu and that the Chinese and Javanese *H. erectus* had no close affinity to Ndotu or indeed to the preceding African *H. erectus*, including O.H. 9 and the Ternifine fossils known as *Atlanthropus*.

The inference from this suggestion is that the African specimens that have been assigned

to *Homo erectus* do not belong to that taxon but should be assigned to a separate species that was a direct ancestor to *Homo sapiens*. Such a concept was originated by Louis Leakey who did not accept that the Ternifine mandibles and parietal of *Atlantropus mauritanicus* were necessarily those of a *Pithecanthropus*, i.e., *H. erectus* (L. S. B. Leakey, 1959: 27) but thought that they could be more closely related to early *Homo sapiens*. He considered *Pithecanthropus* to be an over-specialised "side branch of the human stock". When he first announced the massive browed O.H. 9 calvaria from Olduvai he wrote (Leakey, 1961a), "It has a number of resemblances (although some of them are only superficial) to the Pithecanthropines". He found it resembled, in some characters, Steinheim, Broken Hill, and Saldanha and elsewhere (Leakey, 1961b) he considered it would rank as *Homo* rather than *Pithecanthropus* and that probably Steinheim and *Homo sapiens* could have sprung from such a stock.

Two years later he maintained this viewpoint, stating with reference to O.H. 9, "I do not believe it is a Pithecanthropine, in the accepted sense" (L. S. B. Leakey, 1963: 43). By 1969, however, he appeared to be in two minds about it, stating on one page (Leakey & Goodall, 1969: 172) that there can be no doubt that O.H. 9 should be referred to as *Homo erectus*, yet on page 184 of the same publication including it with Ternifine as a "supposed" *Homo erectus* type of Africa. Nevertheless, he still maintained his belief that *Homo erectus* was not the direct ancestor of *Homo sapiens*. This belief is clearly outlined in his (1963: 43) statement: "It is at least as likely that the Far Eastern *Pithecanthropus* genus represents the descendents of an early stock which shared a common ancestor with *Atlantropus* and with the new Chellean skull from Olduvai in the remote past, and that *Pithecanthropus* developed into an extinct branch, while the other continued to evolve towards *Homo*". By "*Homo*" he meant *Homo sapiens*.

Twenty-one years later, a similar expression of doubt concerning identification of *Homo erectus* in Africa was given by Andrews (1984). He demonstrated that numerous characters used to define *H. erectus* are in fact primitive retentions from a common ancestor of hominids or hominoids and he provisionally concluded that "the African skulls formerly attributed to *erectus* would have been close to the line leading to *sapiens* and that the Asian *erectus* was some way removed from this lineage". My studies of SK 847 and Ndotu provide support to Louis Leakey's belief and lead me to agree with him and with Andrews. Clarke (1977) showed that 1.5 million year old SK 847 has several sapient-like characters of the tympanic plate and petrous pyramid as follows:

- (1) The short distance from the vagina of the styloid to the lateral end of the tympanic plate;
- (2) The presence of a clearly defined and prominent ossified styloid process, ensheathed in a vaginal process;
- (3) The medial portion (apex) of the petrous pyramid is in a straight line with the tympanic plate;
- (4) The posterior surface of the petrous pyramid is vertical and partly undercut by the sigmoid sulcus;
- (5) The base of the petrous pyramid is rough-textured.

Other African *H. erectus* crania such as OH 9 and ER 3733 have similarities with SK 847 in those regions which are preserved and visible. In all of these features, however, the Chinese and Javan *H. erectus*, including the Ngangdong skulls, differ from SK 847 and have retained ape-like characters of tympanic and petrous pyramid (Weidenreich, 1943: 202–204, 206). This would seem to imply that the form of early *Homo* represented by SK 847 and

KNM ER 3733 had separated from the lineage leading to Chinese and Javan *erectus* prior to 1.5 million years ago.

### Archaeological clues to population relationships

A further indication of a probable early separation is provided by the dating and distribution of early stone tools found in Africa, Europe and Asia. From about 1.6 million years ago when early Acheulean handaxes and cleavers occur with *Homo habilis* at Sterkfontein (Clarke, 1985c), the handaxes and cleavers of the Acheulean became characteristic and prolific tool types firstly throughout Africa, then Europe, the Middle East and India. Significantly, they do not appear to have been found in China or Southeast Asia. Instead those areas are dominated by stone cores, flakes and choppers more akin to the Oldowan (Movius, 1948; Ikawa-Smith, 1978). Although there have been claims of a few handaxes and cleavers of Acheulean form from sites such as Dingcun in China (Yi & Clark, 1983), Chon Gok Ni, Korea (Yi & Clark, 1983) and Mongolia (Okladnikov, 1978), doubts have been expressed as to whether they really are Acheulean. Sohn (1983: 196) says that the bifaces from Chon Gok Ni are mostly not refined in shape and can be classified as flake cores. Shackley (1983: 196), referring to the Mongolian sites, says that bifacial core choppers are frequently misidentified as handaxes. To date, there have been numerous discoveries of *Homo erectus* in China and Java and yet no indisputable sign of an Acheulean industry (Pope, 1988: 65). If there had been gene flow between the hominids of Africa/Europe/India and those of Java/China, it is surely inconceivable that physical contact would not have brought cultural contact. It seems highly improbable that the Acheulean technology of the handaxe and cleaver which were such prolific and enduring tool types in Africa, Europe and India, would not have been adopted by the hominids of China and Southeast Asia. The conclusion to be drawn from this is that the hominids of China and Southeast Asia were apparently isolated from the Acheulean hominids of Europe and Africa. Butzer (1971: 452–453) discussed the distribution of the Acheulean and provided a useful map showing geographic barriers of mountains and rain forests. He noted, "In Asia, Acheulean industries have not yet been found north of the mountain barrier formed by the Caucasus, the Elburz, the Hindu Kush and the Himalayas" and that "typical Acheulean industries have not been found beyond the monsoon forests of East Pakistan and the Indian Burma border".

It is surely no coincidence that the division between the Acheulean industries and the chopper, core and flake industries corresponds with these geographic barriers. Yet somehow *Homo erectus* or his ancestors did enter China and Southeast Asia. All indications at present are that man originated in Africa and that stone tool manufacture began in Africa with *Homo habilis* just over 2 million years ago. The earliest tools were cores, flakes and choppers—just the kind of industries that are found in China and Southeast Asia. Thus one possible explanation for the early colonisation of those regions might be that populations of early *Homo habilis* with Oldowan culture could have spread over a period of perhaps thousands of years northeastward out of Africa and into Asia. Early man could only have reached Java by dry land from the Malay peninsula during a glacial sea level regression which exposed parts of the Sunda shelf presently beneath the sea. It could have been during such a sea level regression that *Homo habilis* populations were able to cross from India to Burma and thence the Malay peninsula via Bangladesh and the emerged coastal margins of Burma. Much later during an interglacial this route would have been largely



cut off by a high sea level and perhaps denser forest and inundation of Bangladesh. Such barriers apparently kept Acheulean man out of Southeast Asia. The effectiveness of such a barrier was just demonstrated by the 1988 flooding of Bangladesh.

The populations of *Homo habilis* that settled in Southeast Asia and China might then have evolved into classic *Homo erectus* while *Homo habilis* in Africa evolved into an *erectus*-like species with a more sapient-like temporal.

A second possibility is that at least two subspecies of *Homo erectus* could have evolved out of *Homo habilis* in Africa. One subspecies represented by SK 847 evolved a sapient-like temporal, possessed Acheulean technology and remained in Africa to perhaps evolve eventually into *Homo sapiens*. A second subspecies could have retained an ape-like temporal, possessed only an Oldowan culture and eventually spread into Southeast Asia and China where it either developed eventually into *Homo sapiens* or became extinct (see Simpson, 1953: 381 for mechanisms). Such an explanation would fit with the regional continuity hypothesis of Weidenreich (1943), Coon (1962), Thorne & Wolpoff (1981) who believe that *Homo erectus* evolved into *Homo sapiens* in separate areas of the Old World. Although I once favoured this hypothesis (Clarke, 1977), this was based on my erroneous impression that Ndutu had affinities with *H.e. pekinensis*. It now seems to me improbable that one or more subspecies of *Homo erectus* could have been sufficiently isolated during the Acheulean not to have adopted that technology and yet still to have maintained sufficient gene flow to ensure evolution into *H. sapiens*. Even the presence of supposed Asian *H. erectus* autapomorphies in some archaic *Homo sapiens* which gave Andrews (1984: 172) pause for thought cannot be used to support this hypothesis as I will now demonstrate.

Andrews listed the characters as: (1) frontal keel present; (2) thick cranial vault bones; (3) angular torus present, and (4)inion widely separated from endinion. He stated that these characters are shared by Petralona, Arago and Bodo. However, Stringer, Howell & Melentis (1979: 240) stated with reference to Petralona, "The frontal bone is relatively flat without sagittal keeling". The Arago cranium has only a very slight metopic ridge and only towards the front of the frontal. That region is missing in SK 847 and O.H. 9 but a sagittal keel is present in KNM ER 3733 (Rightmire, 1986) and thus appears to have been a feature of African "erectus". Thick cranial vault bones certainly do occur in the African "erectus" O.H. 9 so this is not an autapomorphy of Asian *Homo erectus*. The inion widely separated from endinion is a feature also of the Ndutu early *H. sapiens* but Andrews himself observes (1984: 174), "It is not known what condition is present on the African crania attributed to *erectus*". That dispenses with three of the four supposed Asian *erectus* autapomorphies. The fourth character, the presence of a torus angularis parietalis, may not be of diagnostic value. It certainly does not seem sufficient to demonstrate any relationship between Asian *H. erectus* and the early *H. sapiens* of Petralona, Arago and Bodo.

A third possible explanation for the early colonisation of China and Southeast Asia could be that *Homo erectus* of Java and China might have evolved independently from a local species of *Australopithecus*. If that were so, then they would not be *Homo* but *Pithecanthropus erectus*. So far, no specimens that can be certainly assigned to *Australopithecus* have been found in China or Java. There are, however, some teeth and mandibular fragments which have been considered as australopithecine by the following authors: (1) the teeth of *Hemantropus peii* from China (von Koenigswald, 1957); (2) similar teeth from Jianshi district, China (Gao Jian, 1975); (3) the *Meganthropus* mandibles from Java (Robinson, 1953a), and (4) the *Pithecanthropus dubius* mandibles from Java (von Koenigswald, 1968; Franzen, 1985a and b). An account of the relevant history, dating and proposed affinities of

these specimens is given by Franzen (1985*b*). The age of the *Hemantropus* teeth is unknown but that of the similar teeth from Jianshi district is possibly between 0·8 and 1·2 million years (Pope & Cronin, 1984). The oldest Sangiran hominids which include *Megantropus* and *Pithecanthropus dubius* are, according to Semah (1984), likely to be younger than 1·67 million years. If any or all of these specimens are australopithecine, then they would belong to a species that existed long after *A. africanus* of Africa had already evolved into *Homo habilis* but they would have been contemporary with *Paranthropus* of Africa.

At present the affinities of these specimens should remain a source of research and debate but they are inadequate to demonstrate that an evolution from *Australopithecus* to *Pithecanthropus* took place in Southeast Asia.

Of the three possible explanations for the origins of Asian *Homo erectus* it is the first which I favour, i.e., that possibly some *Homo habilis* populations with Oldowan industry spread into Southeast Asia, were then geographically isolated and evolved into *Homo erectus* which eventually became extinct. Meanwhile in Africa other *Homo habilis* populations developed the Acheulean industry and evolved into an *erectus*-like *Homo* of which SK 847, KNM ER 3733 and O.H. 9 are examples.

### Taxonomy

This *erectus*-like *Homo* was the evolutionary bridge between *Homo habilis* and *Homo sapiens* but cannot be classified into either of these species. African fossils that have in recent years been considered as belonging to the species *Homo erectus* have formerly and variously been classified as *Telanthropus capensis* (Broom & Robinson, 1949), *Atlanthropus mauritanicus* (Arambourg, 1954), *Homo leakeyi* (Heberer, 1963) and *Homo ergaster* (Groves & Mazak, 1975). As it now seems that these African hominids do not belong to *Homo erectus*, their former classifications should be re-examined for validity. The name *Telanthropus capensis* was given to the SK 15 mandible from Swartkrans, and later a maxillary fragment, SK 80 (now part of SK 847), and a mandible fragment, SK 45, were included in that species (Robinson, 1953*b*). Although the species name *capensis* should have priority, it is unfortunately already occupied in the genus *Homo* by the Boskop calvaria (Broom, 1917, 1918) and is thus not available.

The next name to have priority would be *mauritanicus*, the species designation given by Arambourg (1954, 1955*a*, 1955*b*, 1956, 1963) to three mandibles and a parietal from Ternifine, Algeria. These fossils are possibly between 0·6 and 1·0 million years old (Geraads, 1981; Jaeger, 1981) and are associated with an early Acheulean handaxe industry that Isaac (1967: 49) equated with that of Peninj. Regrettably, Arambourg (1954) did not list characters purporting to differentiate his specimens from *Homo erectus* of Asia although he considered certain details of the Ternifine mandibular corpus to suggest a "more progressive" stage. Later, he stressed their similarities (Arambourg, 1963: 144–145). Thus under Article 13 of the *International Code of Zoological Nomenclature* the species name *mauritanicus* seems not to be available for the genus *Homo*.

Next in priority is the name *Homo leakeyi* proposed by Heberer (1963) to accommodate the massive browed O.H. 9 calvaria found by Louis Leakey in upper Bed II at site LLK, Olduvai Gorge. The top of Bed II probably dates between 0·7 and 1 million years according to Hay (1971: 14). Heberer's proposed new species name does appear to be valid in that it satisfies the requirements of Article 13 of the *International Code of Zoological Nomenclature* by giving a brief description listing characters purported to differentiate the

taxon. Although purists may argue about the diagnostic value of some of the characters that Heberer listed, the point is that he did list characters purporting to differentiate the taxon. It is my belief, after recognition of other differentiating characters of the temporal, that he was justified in creating a new species. I propose, therefore, to accept the name *Homo leakeyi* for the *erectus*-like species of Africa.

If this name were not available then the next in priority would be *Homo ergaster* which was a new species name created by Groves & Mazák (1975) to accommodate early *Homo* specimens from East Lake Turkana which could not be classified as *Homo habilis*. The type specimen is a well-preserved mandible, KNM ER 992, and they also considered that the *Telanthropus* fossils from Swartkrans might belong to *Homo ergaster*. I would certainly agree that the Swartkrans *Homo* fossils SK 15, SK 847, SK 45, SK 27 and SK 2635 belong to the same taxon as KNM ER 992 and ER 730, which I would group with the crania KNM ER 3733 and 3883 as early representatives of the taxon *Homo leakeyi*.

### Conclusion

The Ndotu cranium, associated with handaxes of the Acheulean industry, has proved very significant to the interpretation of the origin of *Homo sapiens*. In its temporal morphology it can clearly be seen as a descendant of the early *erectus*-like *Homo* of Africa as represented by SK 847 and O.H. 9 and for which I propose to use the name *Homo leakeyi* (Heberer) 1963. This species has no direct relationship to *Homo erectus* of Asia. The Ndotu cranium, in its expanded parietal and occipital region of the cerebrum, is evolving toward later *Homo sapiens* of Africa and I now believe that the expansion of the brain in these regions places it definitely as an archaic *Homo sapiens*. An overall assessment of this hominid and its affinities in conjunction with the earlier study (Clarke, 1977) of the SK 847 cranium tends to support Louis Leakey's long-held contention that *Homo sapiens* evolved from an early African *Homo* and that *Homo erectus* of Asia had no part in this evolution. This theory has been expanded and refined by Bräuer (1982, 1984a, 1984b) in his Afro-European *sapiens* hypothesis and by Stringer & Andrews (1988). Whether or not this theory is correct can hopefully be demonstrated by future detailed anatomical studies of the crania that are available and by further discoveries of fossils and artifacts from the relevant time horizons.

It used to be common practice for every new and slightly different hominid specimen to be given at least a new species name and frequently a new generic name. The increasing tempo of palaeoanthropological research in the 1960s and 1970s, however, brought with it the censoring pen of the taxonomically-minded who frowned on the multiplicity of hominid taxa and encouraged the lumping of specimens into fewer species and even fewer genera. There is now, however, a recognition by some researchers that there were more species of *Homo* than just *habilis*, *erectus* and *sapiens* (e.g., Groves & Mazák, 1975; Andrews, 1984; Stringer, 1985). Indeed, why should there not have been more species? We are, after all, looking at a few, usually fragmentary specimens that represent only a few individuals out of the many millions who populated Africa, Asia and Europe during a period of 2 million years. We cannot know from our few specimens the ranges of individual and sexual variation within species or their geographic and temporal boundaries, but equally well we cannot know how many species of *Homo* existed at any one time. We accept the synchronic existence of many species of any animal genus except man. It is true that man differs from the animals in that he possesses culture, is self-domesticated and, as a single species, inhabits all parts of the globe. In the distant past, however, communication between widely

separated geographic areas may not have been so easy or so frequent and the chance of geographic isolation and speciation would have been greater.

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