same erosional disconformity is present here some 3 m below the characteristic tuff that marks the base of Member II. Because the sedimentary sequence is quite analogous, there seems little reason to question the assignment of the hominid Omo II at *PHS* to the same level as that of Omo I at *KHS*.

The stratigraphy and interpretation of the hominid sites have indicated that Members I, II and most or all of III antedate 35,000 BP, that is to say, the effective dating range of ^{14}C. The tuffs of these earlier units are too young for accurate dating by potassium–argon. Similarly, the faunal materials found *in situ* within the Kibish Formation cannot be dated precisely. Consequently, no firm date can be given for the hominid level.

In conclusion, the sites of Omo I and II both come from the same level, a minor disconformity in the upper third of Member I, Kibish Formation. The palaeo-environmental setting of both sites was within the former Omo delta fringe near the shores of a greatly expanded Lake Rudolf, approximately 65 m above modern lake level (370 m); the site *KHS* was possibly situated on a shallow levée. Members I and II predate the range of radiocarbon dating, while Member III probably terminated about 35,000 BP. This would indicate that the hominid level is no younger than mid-Upper Pleistocene but that it may be as old as late Middle Pleistocene.

The site of Omo III was not seen by myself, but seems to be related to Member III of the Kibish Formation (R. Leakey, personal communication).

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Omo Human Skeletal Remains

REMAINS of three adult individuals were recovered in large quantity by the Kenya group of the 1967 expedition and have been designated Omo I, Omo II and Omo III. All the material is very mineralized and, for the most part, undistorted and lacking in pathology. It has been difficult preparing the material for examination because of the hardness of adherent matrix and the degree of comminution of one skull and several of the long bones. A complete list of the material is given in Table 1.

Omo II (Site PHS)

This is the best calvaria of the three, the cranial vault being intact except for the right supraorbital region and a few small deficiencies in the parietal and occipital bones. The face is missing, as is a substantial part of the skull base including the basilar part of the occipital bone and the body of the sphenoid. Fortunately, both temporal bones and the nuchal portion of the occipital bone are preserved. The foramen magnum can be determined by its posterior and left lateral margins allowing identification of the opisthion.

The principal sutures are completely closed, although the ectocranial marks of the coronal, sagittal and lamboid sutures are still recognizable; thus it is possible to define the bregma, the lambda and the asterion of each side; it is less easy to define the pterion, but the sutural pattern here appears to be of the "human" type. If the state of sutural synostosis can fairly be compared with that of modern man, then the skull would appear to belong to an individual of advanced years. The cranium is heavily built with stout parietes and rugged muscle impressions. The maximum thickness of the parieto-mastoid region (on the angular torus of the parietal bone near the asterion) is 13 mm on the right and 13·5 mm on the left, and the maximum thickness in the region of the bregma is 9 mm.

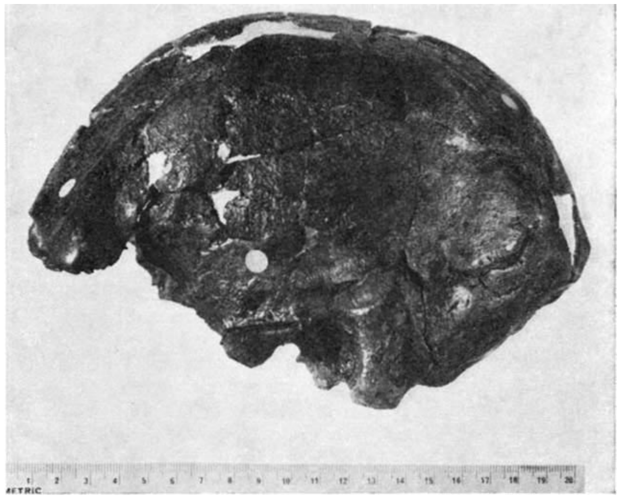

Fig. 3. Omo II calvaria, left lateral view.

In general form the skull is dolichocephalic. Its greatest length (glabella/opisthocranion, minimally reconstructed) is 215 mm; its greatest breadth (bimastoid) 145 mm. The Cranial Index is 67·5.

In lateral view (Fig. 3) the skull has several striking features, the most outstanding of which are the recession of the forehead, the size of the occipital torus and the flatness of the nuchal plane. The outline of the vault slopes almost directly backwards from the region of the glabella, the curve smoothly increasing to the bregma which appears to coincide with the vertex when the skull is orientated in the Frankfurt plane. Behind the bregma, the outline proceeds gently at first then dips evenly to the bulge of the external occipital protuberance by traversing a slight supratoral depression. The inion and the opisthocranion coincide. The occipital torus blends laterally with a marked supramastoid crest which in turn surmounts a prominent downturn mastoid process. The crest is continuous with the base of the zygomatic process of the temporal bone, and passes above the external auditory meatus as a low ridge. Above and behind the meatus on the left side there is a short linear depression in the region of the suprameatal triangle. The tympanic bone is extremely robust posteriorly and it encloses an elliptical meatus the principal axis of which is inclined forwards.

The supraorbital torus runs laterally to a thickened zygomatic process; this in turn gives rise to a prominent temporal ridge that sweeps posteriorly almost parallel with the vault outline, to rejoin the supramastoid crest. Surface erosion precludes its exact delineation throughout.

The frontal view of the Omo II skull reveals the lowness of the vault, the recession of the frontal region, the lateral bulging of the supramastoid crests and the presence on the vault of a sessile sagittal torus or keel (itself the subject of a shallow sagittal groove along part of its inter-parietal course) flanked by shallow parasagittal depressions. The glabella is broken away to reveal an endocast of the left frontal sinus. This sinus extends laterally into the orbital roof and backwards between the tables of the skull.

In occipital view the frontal outline is confirmed, and the supramastoid bulge is accentuated by the inturned direction of the mastoid processes. The most remarkable feature of this view, however, is the massive size of the occipital torus which spans the skull and divides the squamous part of the occipital bone into an upper, curved, occipital portion and a lower, flat, nuchal portion. The lower border of the torus overlaps the nuchal plane as a thick rolled edge that culminates medially in a triangular prominence the apex of which leads down to an external occipital crest that terminates at the foramen magnum. The impresses for the nuchal muscles are considerable and testify to the size of the nuchal muscle mass. The nuchal plane is separated from each mastoid process by a deeply incised digastric groove that is bounded medially by a prominent occipitomastoid crest. There are sutural and exsutural mastoid foramina on both sides, but there is no external evidence of parietal foramina.

The basal view of the skull is characterized by the size of the zygomatic processes of the temporal bones, the depth and extent of the artitular fossae and the stoutness of the left supraorbital ridge. The base of each temporal bone is of particular interest because the robust tympanic bone appears to abut directly on the squamous portion of the temporal at the squamotympanic fissure with no intervention of a tegmen tympani, while the vaginal portion of the tympanic plate surrounds a distinct styloid groove leading to the stylomastoid foramen. The styloid process is absent. Much of the foramen magnum is missing, including the occipital condyles; none the less, its postero-lateral quadrant is preserved on the left side and is thickened by a postcondylar tuberosity. As far as can be judged, the plane of the postcondylar part of the foramen faces downwards and forwards when the skull is orientated in the Frankfurt plane.

Internally, the skull is marked by a well defined frontal crest which leads back to a median sagittal ridge that, further posteriorly, develops a groove to house the superior sagittal sinus. The internal occipital protuberance is low and widely separated from the external occipital protuberance. Provisional estimates of the cranial capacity show a mean value of 1,435 cc $\pm$ 20 cc.

Omo I (Site KHS)

The skull of Omo I consists of an incomplete vault that includes parts of the occipital bone, both parietal bones and most of the frontal bone. Much of the right temporal bone, the right zygomatic bone, and three maxillary fragments are present. The mandible is represented by the symphysial region, part of the left side of the body, the right ramus, and the condylar process. Two tooth crowns belong to the right upper canine and the left lower first molar.

The superior sagittal suture is closed and entirely obliterated internally, but the coronal and lambdoid sutures are open wherever they are preserved. It is not possible to define the bregma, the lambda or the asterion with absolute confidence, but the glabella and the opisthion are both intact. While the skull is clearly adult, it may belong to a younger individual than Omo II. Similarly, while the vault is robust by modern human standards, it seems to be more lightly built than the Omo II calvaria. The maximum length of the Omo I skull is 210 mm (glabella/opisthocranion), and the glabella/inion length a little less, 207 mm, the opisthocranion being about 10 mm above the inion. The maximum breadth can only be estimated by doubling the half breadth, as much of the left side of the vault is missing. A provisional estimate of the greatest breadth is 144 mm (biparietal) producing a provisional Cranial Index of 68·5.

In lateral view (Fig. 4), the outline of the skull differs markedly from that of Omo II particularly in the occipital region. From the prominent glabella the contour passes gently backwards through a shallow supratoral sulcus and rises evenly to the vertex. Behind this point the curve steepens in the mid-parietal zone and descends smoothly to the inion which forms part of a moderate occipital torus that is undercut by the nuchal attachments. The occipital torus fades laterally and almost disappears before reaching the temporal region. The mastoid process is prominent and downturned.

In frontal view the Omo I skull shows a higher vault than Omo II, a receding forehead and an expanded parietal region. The supraorbital torus is prominent and

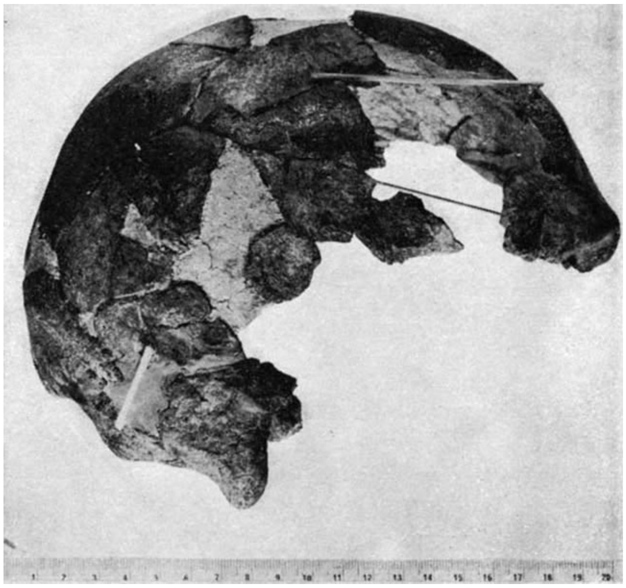

Fig. 4. Omo I calvaria, right lateral view.

Table 1. LIST OF THE OMO HUMAN SKELETAL MATERIAL

		Limb bones
OMO I	Skull Incomplete calvaria including frontal, parts of both parietals and occipital bone, and right temporal bone. Facial skeleton Right and left maxillary fragments, right zygomatic, symphysial region and part of the body of the mandible, right mandibular ramus and condyle. Teeth present include right upper canine crown and left lower first molar crown. Vertebral column Three cervical vertebrae and several cervical spinous processes. Three thoracic spinous processes, eight neural arch fragments and transverse processes. One lumbar neural arch and transverse process. Numerous rib fragments including nine rib heads.	Upper limb Complete left clavicle, two right clavicular fragments, both coracoid processes, almost complete left humerus, head and distal third right humerus, shaft of left radius, proximal end and part of shaft of right radius, proximal and distal ends of right ulna. (All of the following hand bones belong to the right side) Lunate, hook of hamate, ? head of first metacarpal, base and styloid process of third metacarpal, ? shaft fragment of fourth metacarpal, head of proximal phalanx, two bases of proximal phalanges, two intermediate phalanges, one base of a terminal phalanx. Lower limb Distal end of right femur, parts of the shafts of both tibiae, distal end of right tibia, distal end of right fibula. (All of the following foot bones belong to the right side) Navicular, medial cuneiform, intermediate cuneiform, cuboid, first metatarsal, second metatarsal base and shaft, fourth metatarsal base, first proximal phalanx, terminal phalangeal fragments.
OMO II	Skull Almost complete calvaria lacking face and part of the base.	—
OMO III	Skull Frontal fragment including the glabella, and a vault fragment.	—

In addition, there are 800 g of, as yet, unidentified fragments.

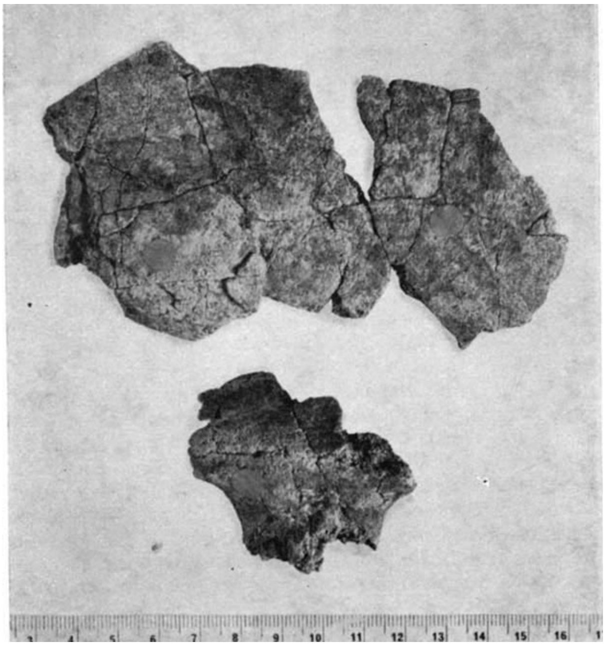

Fig. 5. Omo III skull fragments.

leads laterally to thickened zygomatic processes. On the right, the frontal bone is a little distorted making accurate reconstruction difficult. Both frontal sinuses are filled with hard matrix. The vault shows neither sagittal keel nor parasagittal flattenings, but it has a small depression of the outer table in the mid-frontal zone.

In occipital view the skull is well rounded and shows a restricted nuchal plane, modest nuchal markings and a lower inion than Omo II. The maximum breadth of the skull is low on the parietal bone. Paired parietal foramina are present, and an exsutural mastoid foramen on the right side.

The base of the skull is almost entirely missing, but the right temporal bone shows some interesting features. A fortunate break in the petrous temporal reveals a perfect endocast of the cochlea and exposes the semicircular canal system.

Much of the foramen magnum is missing, including both of the occipital condyles, but the opisthion and part of the left margin of the opening are present. This margin shows no post-condylar tuberosity. The plane of the post-condylar portion of the foramen magnum faces downwards and forwards when the skull is orientated in the Frankfurt plane.

Internally, the frontal crest is high and leads back for at least one third of the sagittal length of the frontal bone; beyond this the internal sagittal ridge is low and has a poorly defined groove. The internal occipital protuberance is set low and corresponds in position with the external occipital protuberance. The groove for the superior sagittal sinus is weak and joins the groove for the left transverse sinus. The cranial capacity of the Omo I skull can only be estimated from water displacement of an endocast of the fully restored and reconstructed cranium; however, at present there is no reason to believe that it will prove to be less than that of Omo II.

The facial bones are scanty and broken, but in general are of moderately robust structure; the maxillary fragments can be arranged in a U-shaped arcade to match the mandible. The symphysial portion of the mandible is of particular interest because it displays a well developed chin, posteriorly placed digastric impressions, single mental foramina and genial tubercles.

The canine tooth is heavily worn so that the incisive edge is flat with considerable exposure of the dentine. The labial surface is convex and the lingual surface, also worn, expanded towards the base. The crown of the tooth is robust by comparison with modern human teeth. (Crown dimensions—mesio-distal length 8·9 mm; bucco-lingual breadth 8·1 mm.)

The molar tooth is heavily worn and incomplete, lacking part of its distal half. Sufficient of the crown is retained, however, to identify five cusps and a Y-shaped fissure arrangement. There is no evidence of a buccal cingulum and none of secondary enamel wrinkling. (Crown dimensions—mesio-distal length, unobtainable; bucco-lingual breadth 11·5 mm.)

The post-cranial bones listed in Table 1 are parts of the skeleton of the upper limb girdle, the arm, the forearm and the right hand, as well as parts of the cervical, thoracic and lumbar portions of the vertebral column. The lower limb remains include parts of the right femur, both tibiae, the right fibula and the right foot. There are no recognizable parts of the pelvic girdle. The bones are fully adult, strongly built and carry commensurate muscular impressions. Anatomical examination has disclosed no features that can be said to be outside the range of normal variation of the post-cranial skeleton of modern man.

Omo III

The few remains of the third individual belong to the skull alone (Fig. 5). There is a left fronto-parietal frag-

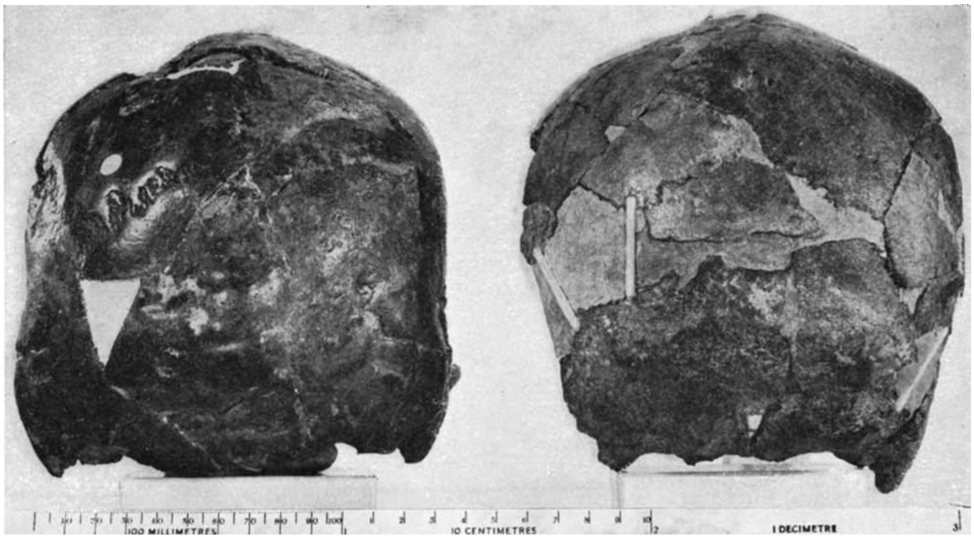

Fig. 6. Omo I (right) and Omo II (left) calvaria, compared in occipital view. Both skulls are orientated in the Frankfurt plane.

ment which includes the lower part of the fronto-parietal suture and the superior temporal line at its junction with the suture (the stephanion). The suture is closed, but it is still discernible on the ectocranial surface, suggesting that the individual was adult. The fragment is relatively thin, but this may be the result, at least in part, of weathering of the specimen. Internally, it is just possible to trace the larger meningeal vascular grooves.

The only other fragment consists of the glabellar region and includes part of the frontal bone, small parts of the frontal process of each maxilla and small parts of both nasal bones and the ethmoid bone. This fragment is heavily built, having a marked supraorbital torus divided by a weak glabellar depression; also, the receding forehead is separated from the torus by a shallow supratoral groove.

Assessment of the affinities of the Omo skeletal remains must depend eventually on intensive anatomical investigation coupled with wide comparative studies including multivariate statistical analysis. In particular, it is hoped to construct a discriminant function from cranial parameters that will assist in the grouping of these and other fossil skulls.

The anatomical evidence so far suggests that all the Omo specimens should be attributed to *Homo sapiens*, although all three skulls show a number of specialized features; also, the two major specimens show striking differences of skull form. The more complete calvaria, Omo II, has many features both in its general configuration and in its detailed anatomy, which is similar to the Solo skulls and, to a lesser extent, the Broken Hill skull, the Vertessöllös occipital, the Kanjero skulls, and even indeed *Homo erectus*. On the other hand, the Omo I skull, which is contemporaneous with Omo II, is more modern in its general form and can be reasonably compared with both the Swanscombe and Skuhl skulls. The presence of a chin, of relatively modern teeth, of a rounded occiput and of a considerable quantity of limb bones of modern human form supports this suggestion. The fragmentary remains of the later Omo III skull preclude any real assessment of its affinities at this time, but what resemblance it has lies with the more modern of the first two Omo skulls.

Thus we can say that, at this time in East Africa, there were early representatives of *Homo sapiens* whose range of normal variation, at least in terms of skull characters, was every bit as wide as that known for Upper Pleistocene sapients from other parts of the world. What is obscure at present, and what the full evaluation of these remains may illuminate, is, first, the relationship of the more rugged Omo form to other early sapients and to *Homo erectus*; and second, the relationship of all the Omo material to the origin of *Homo sapiens* in the Lower Middle Pleistocene or even the Lower Pleistocene periods.

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Some Late Cenozoic Sedimentary Formations of the Lower Omo Basin

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Geological and geomorphological studies in the lower Omo valley 1967–1968 have established a sedimentary sequence recording much of the late Cenozoic.

THE potential significance of the lower Omo valley for the palaeontology and stratigraphy of East Africa was first suspected by E. Suess in 1891 (ref. 1) on the basis of L. von Höhnel's observations. He placed the Omo Delta and Lake Rudolf within the Kenya Rift, emphasizing the palaeogeographic implications of the nilotic fauna. In 1896, the ill-fated Bottego Expedition explored the lower Omo valley and its geologist, M. Sacchi, recognized the widespread sedimentary series that cover the basin floor[2]. Sacchi's bouts with malaria hindered him from visiting the area of the fossiliferous Omo Beds, which were subsequently discovered by E. Brümpt in 1902 (ref. 3). This first fossil collection found its way to Paris and ultimately led to C. Arambourg's pioneer work during 1933 (ref. 4). He recognized the Omo Beds as lacustrine or fluviolacustrine deposits of apparent early Pleistocene age; they were unconformably overlain by late Pleistocene lacustrine beds. Detailed examination of the Omo Beds type area was begun by F. H. Brown in 1966 as a prelude to the systematic, multi-disciplinary studies of the international Omo Research Expedition to the Omo valley in 1967 (ref. 5) and 1968.

The expedition included teams from Kenya, France and the United States. Geological and geomorphological investigations were carried out by K. W. Butzer, F. H. Brown and J. de Heinzelin (Chicago group), and by J. Chavaillon (French group). This article outlines the stratigraphy and depositional history of those sedimentary formations studied by Butzer, including the late Pliocene Mursi and Nkalabong Formations, the late Pleistocene to mid-Holocene Kibish Formations, and the late Holocene Lobuni Beds. The radiocarbon dating of the Kibish is by Thurber.

Geological Setting

The lower Omo Basin is a tectonic depression, forming an extension of the Lake Rudolf trough (Fig. 1). The regional basement is formed by Pre-Cambrian metamorphics, primarily gneisses and amphibolites with intrusions of granite and pegmatite. In the Nkalabong Range, this basement complex is directly overlain by a thick sequence of extrusives, the lithological and stratigraphic details of which remain to be studied. Pending isotopic dates from Mt Nkalabong (F. H. Brown, in preparation; see also ref. 5), dating of the lavas of Turkana and the Ethiopian Plateau[6] suggests a Miocene to early Pliocene time range for the volcanics of the basin peripheries.

The essential topographic outlines of the lower Omo valley were formed by downwarping and downfaulting before deposition of the earliest known deltaic sediments,