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Geological Interpretation of Two Pleistocene Hominid Sites in the Lower Omo Basin*

THE fossil hominids described in the following article by Dr Day were recovered from sedimentary units defined as the Kibish Formation[1-3], which has five major subdivisions. The first three, Members I, II and III, consist of delta-plain, delta-fringe and prodeltaic sediments represented by a total of twenty-one stratigraphically significant beds, with a cumulative thickness of at least 108 m. Accumulation of each member was followed by major dissection. There are littoral deposits in Members IV*a* (at least 13·5 m) and IV*b* (at least 5 m). The upper part of Member III appears to lie just beyond the range of ^{14}C dating: an *Etheria* bank from the penultimate bed gave "greater than 37,000 yr" (*L*-1203-*A*), while *Unio* shell from a stratigraphically uncertain bed gave "26,600 yr or greater" (*L*-1203-*F*) (refs. 1–3). Member IV*a* can be dated about 9700–7700 BP by ^{14}C, Member IV*b* about 5900–5350 BP. The interval of non-deposition or erosion between Members III and IV*a* can be tentatively dated *circa* 35,000(?)–9700 BP, that between IV*a* and IV*b* about 7700–5900 BP.

The geology of the Kibish Formation type areas was mapped in 1968 at a scale of 1 : 11,000, using air photographs taken in 1967 by R. I. M. Campbell. A simplified and reduced extract of the area of the sites is given in Fig. 1. Wherever exposed, Member I rests disconformably on the cemented and dissected surface of the Late Pliocene Nkalabong Formation. The terminal units, which consist of consolidated lacustrine clays, silts and tuffs, are quite unlike those of the Kibish beds in terms of sediment properties and compaction.

The earliest deposits of Member I consist of 7·5 m of light grey, silty clay and appear to be prodeltaic (colours follow the *Munsell Soil Color Charts* for fresh sediment facies (dry state); all textures were determined by the hydrometer method[4]). They are covered by 1·5 m of light grey, laminated or ripple-bedded tuff of silt loam texture. This tuff is restricted in area, representing distributary channel or mouth-bars that are locally prominent because of their resistance to erosion. The tuff was followed by a variable series of up to 7 m of conglomerates, gravelly loams, and light grey, silt loams. Near Kenya Camp (Fig. 1) the gravel sequence increases in size and degree of rounding from base to top, culminating in a well rounded, coarse-grade conglomerate, transported primarily by sliding motions[5] in a river channel of higher competence than the modern Omo River. The basal units are rich in weathered rhyolite pebbles, but weathered pebbles are absent in the higher units while basalt almost completely replaces rhyolite as the primary pebble constituent. It seems that residual gravels of more local origin mark the first true fluvial beds while gravels transported over greater distances constitute the later beds.

Whereas the conglomerates were deposited in flood-plain or delta channels, the second half of Member I is constituted largely of clays or loams of prodeltaic or delta-fringe origin. Exception to this are some distributary channel-beds that overlie a minor disconformity, representing a period of temporary emergence. The general stratigraphy of Member I can be summarized: (1) (base) 7·5 m; light grey, silty clay; (2) 1·6 m; light grey, laminated or ripple-marked tuff; (3) 6·5 m; intercalated conglomerates and light grey silt loams; (4) 0·5 m; white silt loam; (5) 11·5 m; very pale brown to pale brown, silty clay, silt loam and silty clay loam, with horizons of calcareous concretions or ferruginization; (6) 2·4 m; pale brown, current-bedded or ripple-marked, silty clay loam with limonitic staining; (7) (top) 1·0m; light yellowish brown, silty clay with secondary carbonate impregnation of dehydration cracks.

* Contribution No. 8, University of Chicago Group, Omo Research Expedition.

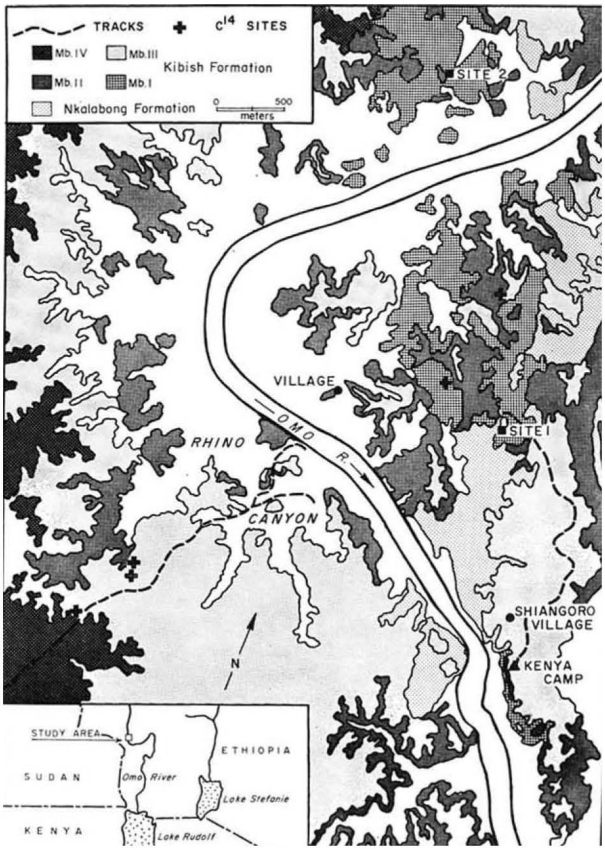

Fig. 1. Pleistocene stratigraphic units of the Kenya Camp-Rhino Canyon area (very generalized). Several small exposures of Members III and IV of the Kibish Formation have been omitted.

The major hominid site, *KHS*, is located 1·8 km north-west of Kenya Camp at 5° 24′ N, 35° 57′ E at 435 m (Fig. 1). The Leakey's trench, cut into the southern flank of a conical hill, records the upper part of Member I and the base of Member II (Fig. 2). Rapid denudation and a very incomplete vegetation mat has locally impeded the development of a mature soil and an incipient 10 cm (*A*)-horizon is frequently replaced by a 10 to 20 cm horizon of re-worked organic soil. Gradual leaching and surface transfer of primary salts from several of the strata, combined with capillary concentrations in the subsoil, have produced a pedogenic horizon of diffuse sodium salts with a thickness of 30 to 50 cm.

From bottom to top the strata are as follows (with reference to Fig. 2): (*a*) Over 3·00 m. Well stratified, very pale brown, silty clay; *p*H 7·6. Slightly hard with blocky structure. Terminated by clear, wavy boundary (consistence (dry), structure, horizon boundaries, and colour patterns are described according to the US Soil Survey terminology[4]). (Member I, bed 5.) (*b*) 0·15 m. Well stratified, light yellowish brown, silt loam with distinct, horizontal, reddish yellow limonitic staining; *p*H 8·3. Embed weakly to strongly cemented ferruginous–calcareous concretions of various sizes. Soft, with blocky structure and traces of diffuse, primary sodium salts. Clear, wavy boundary. (Member I, bed 5.) (*c*) 0·30 m. Well stratified, pale brown, silty clay; *p*H 8·0. Slightly

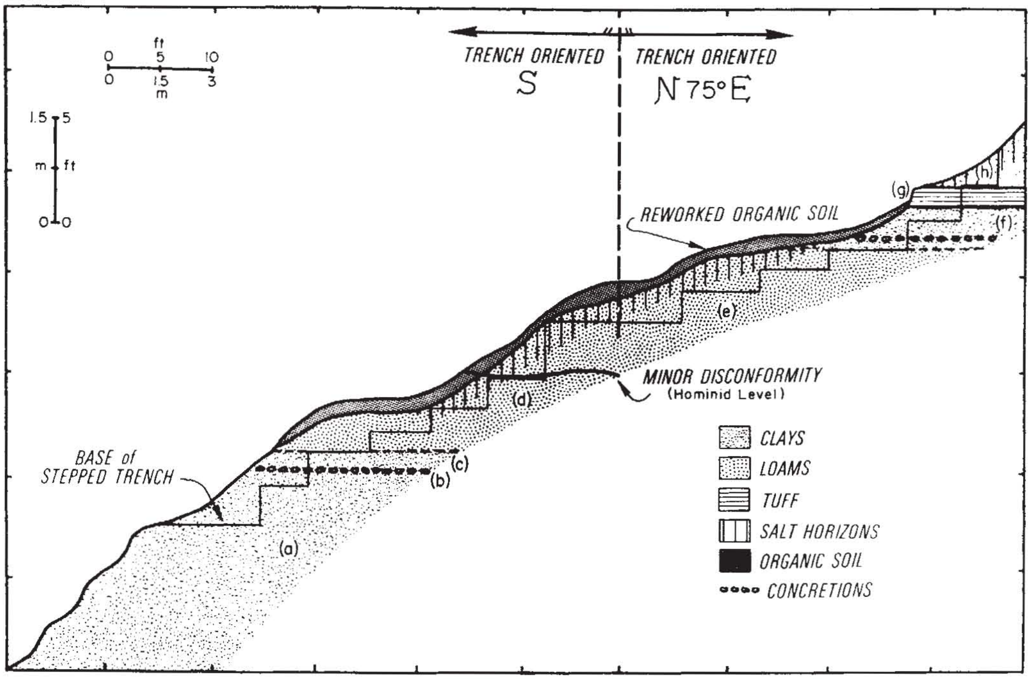

Fig. 2. Stratigraphy of the hominid site, *KHS*. Vertical exaggeration 2 : 1.

hard; blocky peds with pyrolusite staining. Clear, wavy boundary. (Member I, bed 5.) (*d*) 1·05 m. Well stratified, very pale brown, silty clay loam; *p*H 7·8. With a few fine but distinct, reddish yellow mottles and weakly cemented ferruginous microconcretions in sand grade. Biotite present among sands. Slightly hard and blocky; abrupt, wavy boundary suggests erosional truncation. (Member I, bed 5.) (*e*) 1·80 m. Well stratified, in part current or ripple-bedded, pale brown, silty clay loam with abundant and prominent, reddish yellow limonitic staining in form of subcontinuous horizons and fine mottles; *p*H 7·1. Slightly hard, blocky. Biotite, muscovite, amphiboles and pyroxenes among sand fraction, with wafery quartz grains of tuff origin. Truncated by abrupt, wavy boundary. (Member I, bed 6.) (*f*) 0·60 m. Laminated, light yellowish brown, clay with primary halite, and strongly cemented calcareous concretions with sodium salts (40 per cent $CaCO_3$; *p*H 7·8) that form subcontinuous horizons (up to 2 cm thick) or fill minor, vertical earch networks. The clay itself is non-calcareous, hard and has conchoidal structure; *p*H 6·9. Truncated by abrupt, smooth boundary. (Member I, bed 7.) (*g*) 0·30 m. Laminated, light grey tuff, primarily in 10–50 micron grade (silt loam) with some biotite in sand fraction; *p*H 7·0. Slightly hard with blocky to platy structure. Truncated by abrupt, wavy boundary. (Member II, bed 1.) (*h*) Over 1·00 m. Well stratified, pale brown, clay with primary sodium salts and gypsum; *p*H 7·3. Slightly hard with conchoidal structure. Grades up into some 20 m of alternating clays and silts, rich in salts, and with ferruginous horizons. (Member II, bed 2.)

Beds (*a*) to (*f*) mark the terminal stratigraphic subunits of Member I, beds (*g*) and (*h*) the base of Member II, Kibish Formation. With the exception of the concretionary horizons and certain clayey lenses, such as bed (*c*), each unit has stratigraphic meaning over areas of many square kilometres. The Omo I skeleton was found at the minor disconformity separating beds (*d*) and (*e*).

Very probably beds (*a*), (*b*) and (*c*) were deposited in a pro-deltaic environment, with the textural contrasts as well as carbonates or ferruginous horizons reflecting differences of water depth or impeded circulation (interdistributary bays ?). The texture and other characteristics of bed (*d*) are reminiscent of overbank silts associated with distributary levées in the delta fringe. The mottles follow root structures of reed or sedge vegetation, probably contemporary with the final phase of deposition. Bed (*e*), with its bedding properties and heavy mineral concentrations, is probably typical of distributary-channel or mouth deposits in the delta fringe. This interpretation is supported by the radiocarbon-dated *Etheria* bank*, which comes from the base of (*e*). Subsequent emergence is indicated by the ferruginized root structures. A pro-deltaic environment is once more strongly suggested by bed (*f*), the solubles of which impregnated a strongly dehydrated sediment at a much later date.

The local development of the tuff, in part grading into a coarse detritus on slopes of 20° or more, in part highly saline on absolutely horizontal surfaces, indicates subaqueous deposition in waters of variable depth and circulation, standing within the irregular topographic outlines of an old, dissected delta plain. The subsequent, massive sequence of bed (*h*), constituting the remainder of Member II, is characteristically pro-deltaic.

On the basis of this detailed analysis of the sedimentary sequence, there can be little doubt that the *KHS* site was occupied by man during a period of temporary emergence. The over and underlying deposits indicate a setting on shallow levées of the delta fringe. The sporadic presence of partially articulated mammalian bones at this horizon also suggests that the Omo distributaries were near by.

The second site, *PHS*, is located on the westerly side of the Omo valley, 4·8 km north-west of Kenya Camp at 5° 25·5′ N, 35° 55·5′ E, and at about 435 m (Site 2, Fig. 1). Unlike site *KHS*, where some bone and artefactual material was found geologically sealed in place, the skeletal remains (Omo II) at *PHS* (Site 2) were found spread over the side of a small clay residual, just next to a hill representing the upper half of Member I and the lower third of Member II. Although it was therefore not possible to determine the stratigraphic position with complete certainty, it is not likely that the bones have been exposed for long, or that they have been "lowered" appreciably through erosion of the underlying sediments. Consequently, the vertical position of the hominid can be related to the stratigraphic sequence exposed a few metres away and it is very probable that it comes from the top of unit (5) or the base of unit (6), Member I. The

* Shell was submitted by R. E. Leakey to both Geochron and Isotopes Inc. for ^{14}C dating.

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

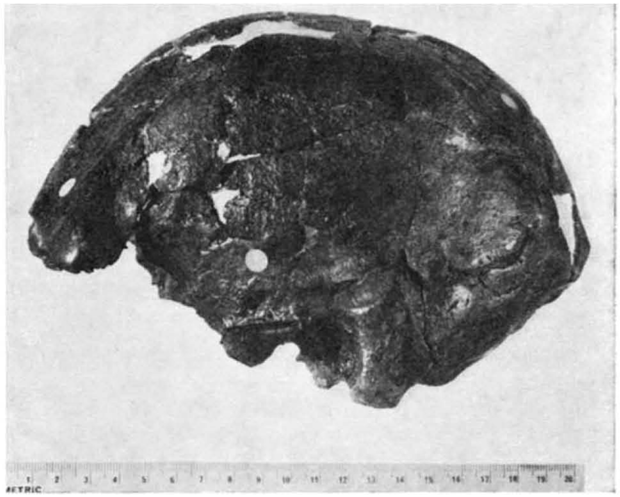

Fig. 3. Omo II calvaria, left lateral view.

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.

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