The rate of mass loss for the whole star is

$$-\dot{M} = 4\pi \ \rho_a \, a \, r_a^2 = 2 \times 10^{14} \text{ g s}^{-1} = 3 \times 10^{-12} M_{\odot} \text{ yr}^{-1} \quad (14)$$

Over a reasonable period the evolution of the star cannot be seriously affected by so low a rate of loss of mass.

I can also estimate how much additional energy is carried up through the corona by the succession of shock waves during the disturbed period after a flare. Let each shock front be followed by a region of enhanced density which extends downstream for a distance l, and let the shocks themselves come at distance L one after the other. Then energy is carried past a given level in the corona at a mean rate of the order of $\rho \mathcal{M}^3 a^3 l/L$ per unit area. With ρ typically equal to 4×10^{-15} g cm^{-3}, with $\mathcal{M} = 2$ and $a = 2 \times 10^7$ cm s^{-1}, this mechanical energy flux is $2{\cdot}6 \times 10^8 \, l/L$ erg cm^{-2} s^{-1} in the mean. Integrated over a sphere the radius of which is $2{\cdot}5 \times 10^{10}$ cm, the total rate of outflow of mechanical energy becomes $2 \times 10^{30} \, l/L$ erg s^{-1} for the star as a whole. Lovell states that the radio emission continues for some 3·5 h, say 10^4 s. During this period the shocks carry away energy equal to $2 \times 10^{34} \, l/L$ erg. But Kunkel ascribes a total energy of 10^{34} erg to the optical output of the flare. If this is adopted as a measure of the energy released by the flare event, then l/L must be rather less than unity. The interpretation is that, seen from a fixed point in the corona, the region of enhanced gas density behind the shock must tail off and must be followed by a longer quiescent period before the next shock comes up. Finally, Lovell states that the radio emission releases some $2{\cdot}8 \times 10^{29}$ erg during a flare. This estimate is clearly compatible both with a small value for l/L and a very modest efficiency factor for the conversion of hydrodynamic energy into electromagnetic radiation at radio frequencies. It seems therefore that this model fits and is worth investigating further.

I thank Sir Bernard Lovell for telling me, in advance of publication, about his latest observations of this interesting star.

Received March 27, 1969.

[1] Parker, E. N., *Interplanetary Dynamical Processes* (Interscience, New York, 1963).

Early *Homo sapiens* Remains from the Omo River Region of South-west Ethiopia

Among the finds of the Kenya group (led by Mr Richard Leakey) of the 1967 International Palaeontological Research Expedition to the Omo River were three skulls and some skeletal material belonging to very early representatives of *Homo sapiens*. The sites of the two oldest skulls are no younger than mid-Upper Pleistocene and may be as old as late Middle Pleistocene. After a short account by Mr Leakey of some of the other fossils found by the expedition, and a description of the geology of the hominid sites by Professor Karl Butzer (a member of the US group), this article ends with a preliminary description of the human remains by Dr Michael H. Day.

Faunal Remains from the Omo Valley

THE 1967 International Palaeontological Research Expedition to the Omo Valley was made possible through the interest and assistance of the Emperor of Ethiopia and his government. The expedition included three teams from Kenya, France and the United States. The fossils found by the Kenya team were recovered from a series of sediments known as the Kibish Formation. The human remains were found at the two sites, Site 1 (*KHS*) and Site 2 (*PHS*) marked on Fig. 1.

The Kibish deposits are not very fossiliferous and the specimens were recovered from a very large area. Unfortunately, the faunal assemblage is of little diagnostic value from a stratigraphic viewpoint.

A complete buffalo skeleton was collected *in situ* from the horizon in which the human skeleton Omo I was found. This buffalo differs slightly from *Syncerus caffer* and it may merit specific separation although it appears to have no characteristics that would preclude its being a direct ancestor to the living *Syncerus caffer* (personal communication from A. W. Gentry). Another bovid is represented by dental fragments the morphology of which recalls that of the *Syncerus/Homoicerus* stock; the occlusal features of these teeth being too advanced to fit *Pelorovis*. The Reduncini (reedbuck) are represented by a number of fragments, but there is insufficient material for positive identification.

Both *Ceratotherium simum* and *Diceros bicornis* are represented by individual teeth, the former being the more common. A primitive *Elephas loxodonta* occurs in Member I of the deposits and the occurrence of a very advanced *Elephas recki* has also been reported by the United States team (personal communication from F. H. Brown).

Primate material is scarce and the only two specimens collected are deeply embedded in a hard matrix and have yet to be fully examined. The specimens appear to be cercopithecoid; one could be a representative of the genus *Colobus* although it is larger than the representatives of either of the living species.

Very few stone tools were collected, all of which were surface finds with the exception of flake debris from the *KHS* excavation.

Omo I skeleton alone was associated with a small number of stone artefacts and some animal bone debris. Excavation of site *KHS* yielded some material *in situ* and established the provenance of the Omo 1 skeleton in terms of the stratigraphy of the Kibish deposits.

Above Member III of the deposits, sub-fossil mammal remains were noted in various localities. In the upper parts of the Kibish beds (Member IV*a*), several bone harpoon heads were found, usually associated with concentrations of *Etheria* and *Unio*.

All of the foregoing fossils are in process of further evaluation and it is hoped that these studies will result in more environmental information at a later date.

The Kenya team was supported by a grant from the Committee for Research and Exploration of the National Geographic Society, Washington DC.

R. E. F. LEAKEY

Kenya National Museum,
Nairobi, Kenya.

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.

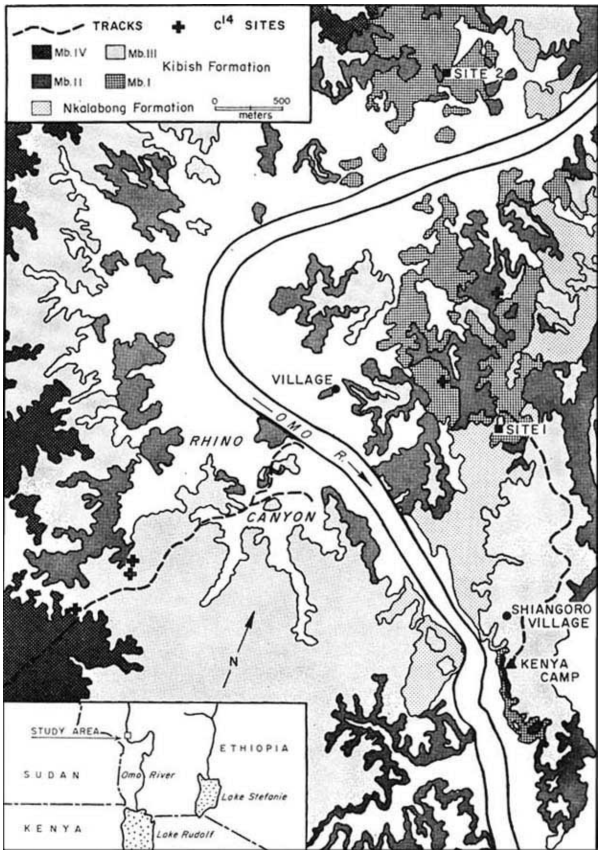

Fig. 1. Pleistocene stratigraphic units of the Kenya Camp-Rhino Canyon area (very generalized). Several small exposures of Members III and IV of the Kibish Formation have been omitted.

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