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Preliminary study of the stratigraphy and mammalian palaeontology of Neogene sites in the Manonga Valley, northern Tanzania

By

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With 5 figures and 2 tables in the text

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Abstract: Preliminary geological and palaeontological research in the Manonga Valley of northern Tanzania has provided the basis for a new lithostratigraphic and biostratigraphic framework. The fossils were recovered from a series of fine-grained sediments that were deposited in a shallow lake basin in the Manonga depression. Comparisons of the fauna indicate that the fossil localities range in age from late Miocene to late Pliocene. The studies have served to identify the Manonga Valley as a productive new region in eastern Africa for future palaeontological and palaeoanthroppological research.

Zusammenfassung: Vorläufige geologische und paläontologische Nachforschungen im Manongatal im nördlichen Tansania haben eine Basis für neue lithostratigraphische und biostratigraphische Strukturen geschaffen. Die Fossilien wurden in einer Reihe feinkörniger Ablagerungen in einem flachen Seebecken des Manongatals entdeckt. Vergleiche der Fauna weisen darauf hin, daß sich die Lokalitäten der Fossilien in einem Zeitraum vom späten Miozän bis ins späte Pliozän bewegen. Die Studien erwiesen, daß das Manongatal eine neue produktive Region in Ostafrika für zukünftige paläontologische und paläoanthropologische Nachforschungen ist.

I. Introduction

In 1990, the Wembere-Manonga Palaeontological Expedition (WMPE) of New York University initiated a long-term programme of geological and palaeontological investigations in the Manonga Valley of northern Tanzania. The geographical location of the research area is illustrated in Figures 1 and 2. The 1990 expedition focused its attention on a relatively limited area (covering about 2500 km^2) of the Manonga Valley, in the vicinity of the villages of Igurubi

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and Kiloleli, where fossil localities have been recorded previously. The main objective of the expedition was to investigate the potential of the fossil localities in the region for further palaeontological research, especially that pertaining to the early origins of humans. More specifically, the aims of the field season were threefold: (1) to assess the nature of the geological context of the fossil localities, and to carry out geological mapping at both the regional and local levels; (2) to collect fossils from the surface exposures in order to improve understanding of the faunas at the various sites, as well as to provide a firmer basis for biostratigraphical correlation; and (3) to assess the potential of the sites for further detailed palaeontological and taphonomic studies. This paper provides a preliminary account of the geological and paleontological findings of the expedition.

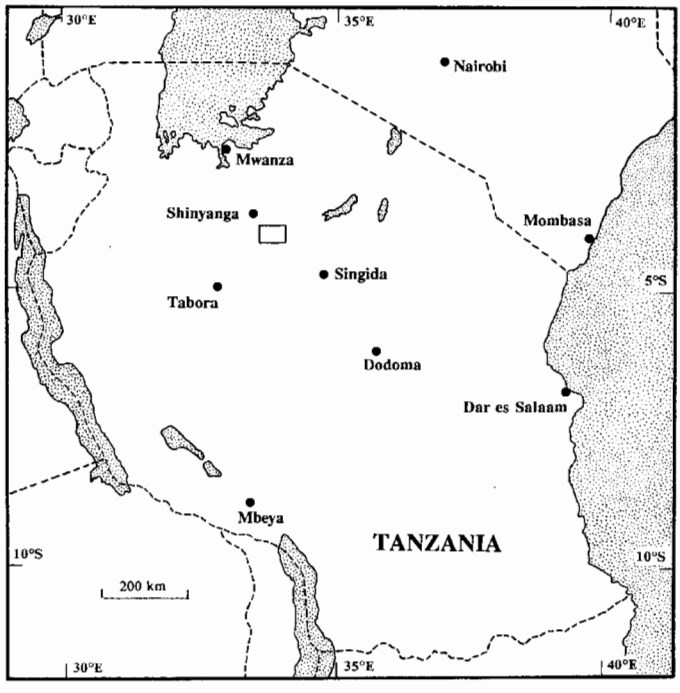

Fig. 1. Map of Tanzania showing location of the research area to the SE of Shinyanga (see Fig. 2 for details of inset).

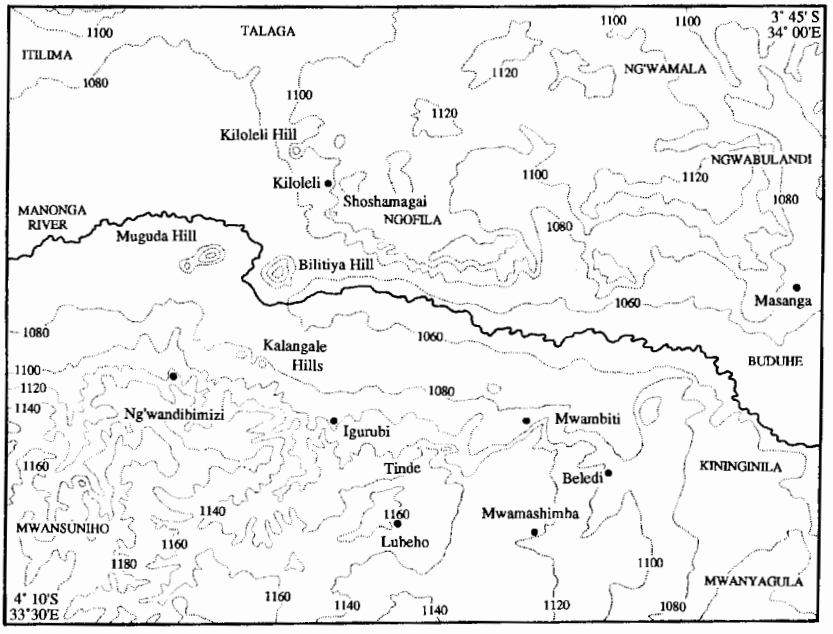

Fig. 2. Topographic map of the research area showing major geographical features discussed in the text.

II. Previous research in the Manonga Valley

Fossil vertebrates were first recovered in the Manonga Valley during the late 1920s at the site of Tinde (Stockley 1929; Grace & Stockley 1930). A brief note describing the fossil mammals from the site was published by Hopwood (1931). Based on a jaw fragment of a primitive elephantid from the site, Hopwood (1931) estimated an age equivalent to that of the Kaiso Formation in Uganda (i. e., Pliocene). A similar assemblage of fossils was later reported as having been recovered from a locality near the village of Kiloleli (Williams & Eades 1938; Quennell et al. 1956). However, apart from brief reconnaissance work conducted in the region by Kleindienst & Haldemann in 1959 and Leakey & Monahan in 1976, no further palaeontological exploration has been undertaken over the last 50 years.

III. Regional geology

The basement complex in the Manonga Valley is part of the Nyanzian System of Precambrian age. It can be subdivided into two main events, separated

by a minor unconformity. The lower division consists of pelitic and psammitic sediments with intercalated volcanic rocks, primarily including siliceous sandstones, silicified amygdaloid, epidiorites and greenstones. These beds were later disrupted by the intrusion of doleritic dykes. The upper division consists of a comparable series of beds with quartzites, banded ironstones, metamorphosed shales and acidic volcanics. The intrusion of large granitic masses in the upper division was accompanied by episodes of contact metamorphism and steep isoclinal folding (GRACE & STOCKLEY 1930; WILLIAMS & EADES 1938; QUENNELL et al. 1956).

During the Tertiary, the basement complex covering most of the area to the west of Singida was subject to peneplanation. This resulted in the accumulation in shallow depressions of extensive deposits of terrestrial sands and gravels (EADES & REEVE 1938; WILLIAMS & EADES, 1938). The erosional cycle continued to mature throughout the Tertiary, eventually resulting in a terrain of relatively uniform topography. The major elevated features on the Tertiary peneplain were low, rounded and isolated monadnocks that were formed from the more resistant Precambrian outcrops. The combination of relatively arid conditions and low elevations resulted in broad, shallow valleys that became choked with coarse, poorly-sorted granitic and metamorphic detritus of local origin. The sediments are generally not bedded, but are cemented together by a calcareous or ferruginous clay matrix. The included particles are predominantly angular, although rounded facies may occur locally (WILLIAMS, 1939).

By the close of the Miocene, crustal instability, associated with the initiation of regional rifting, led to warping of the basement complex. This produced a shallow, but extensive lake basin in the Manonga and Wembere depressions, probably covering an area in excess of 10,000 km^2 (STOCKLEY, 1929; WILLIAMS & EADES, 1938). This paleolake has been given a variety of different names in the literature (e. g., GRANTHAM et al., 1945; BARTH 1989), but the Manonga-Wembere Lake, proposed by WILLIAMS & EADES (1938), has priority. The Precambrian hillocks of the Tertiary peneplain remained sufficiently elevated to form a complex of small, low-lying islands on the lake. During the late Miocene and Pliocene, fine calcareous lake sediments were deposited towards the centre of the basin, while coarser sandy and pebbly littoral facies were produced along the gently-graded shorelines (EADES 1936; WILLIAMS & EADES 1938; WILLIAMS 1939). These Mio-Pliocene lake deposits preserve abundant remains of fossil vertebrates.

The relative thickness and homogeneity of the beds indicate that the lake basin was a low-energy depositional environment in which sediments were rapidly accumulated. However, the occurrence of extensive red lateritic soils throughout the sequence, especially in the lower part, as well as the associated occurrence of polygonal surface cracking with crystalline calcite infilling at the interface between beds, suggests that the lake underwent periods of regression, during which the lake floor emerged subaerially.

During the Pleistocene, the Lake Eyasi graben and the Wembere graben to the east of the Manonga depression were initiated by continued tectonic activity of the Gregory Rift. As a consequence, Lake Manonga-Wembere drained towards the northeast into the deeper Eyasi trough (WILLIAMS & EADES 1938; WILLIAMS 1939; GRANTHAM et al. 1945). The rifting process also apparently produced a slight downwarping of the Pliocene lake beds. This served to direct the course of the Manonga River eastwards through the centre of the depression towards Lake Kitingiri and Lake Eyasi, thus initiating the development of the present-day Wembere-Manonga drainage system.

Since the Pleistocene, erosion of the underlying Neogene sediments has been active. A broad, shallow valley about 10-20 km wide, and bordered by low cliffs up to 20 m in height, has been cut in an east-west direction through the Manonga depression. The valley has a low topography, ranging in elevation from 1000 m to 1200 m above sea level. The presence of a number of low hills, formed by persistent remnants of the Precambrian basement, has created a slightly undulating surface to the general area. Formation of the valley was initiated by the action of the ephemeral Manonga River, but its retreat is due to continued erosion of the cliffs by heavy seasonal rainfall. These actively eroding cliff faces provide the main exposures of the Neogene lake sediments in the Manonga Valley today, and are associated with the most productive fossil localities. The Neogene sediments are overlain in places by quite thick layers of undifferentiated alluvial sands and mbuga clays of Recent origin.

Today the Manonga Valley is sparsely populated by the Wasukuma people, who live principally by cattle and goat herding, and by small-scale cultivation. The local vegetation consists mainly of patchy grasslands, interspersed with stunted trees and acacia thickets. There are distinct vegetational differences between the valley floor, which has a very impoverished flora, and the cliff plateau, where the vegetation is more diverse, and where active cultivation is concentrated. Overgrazing by livestock, and the destruction of mature trees for firewood and charcoal production, has led to widescale denudation of vegetation and active surface erosion in most areas.

IV. Local geology

Detailed geological work was confined to a limited area in the vicinity of Igurubi and Kiloleli, which is located close to the centre of the Manonga Valley. Seven different structural units were identified in the area (Figs. 3 and 4). The units have been differentiated by one or more of the following criteria: (1) the presence of Neogene or Precambrian lithologies, or the occurrence of both together; (2) the orientation of the Neogene sediments exposed at cliff faces; and (3) the location of fault lines. The units are delimited as follows: Units A - Mwamakona-Kininginila block; Unit B - Igurubi-Mwansuniho area; Unit C - Ng'wandibimizi strip; Unit D - Central Manonga Valley; Unit E_1 - Kiloleli-Shoshamagai-Ngofila area; Unit E_2 - Nhuliku-Masanga block; and Unit E_3 - Ng'wabulandi-Ng'wamala area (Figs. 3 and 4).

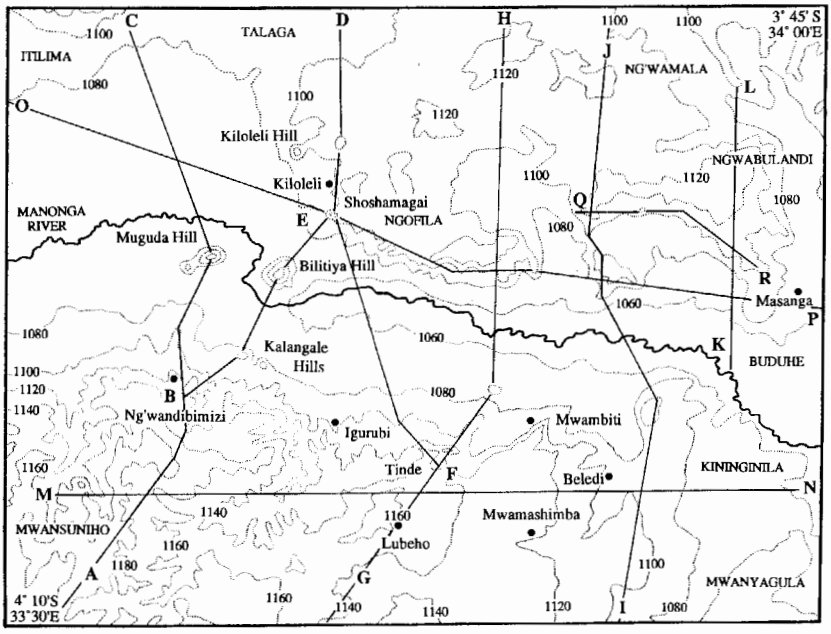

Fig. 3. Topographic map of the research area showing survey transects (see text for further details).

Unit A - Mwamakona-Kininginila block

Sections G-H, I-J and M-N show that this area is a monoclinal block of Neogene sediments with a 0.5° dip to the ESE. In section M-N the Neogene beds of Unit A overlie the Precambrian rocks of Unit B (Igurubi-Mwansuniho area) to the west. It has not yet been determined how this area is delimited to the north. Section I-J and G-H clearly demonstrate that the Neogene beds dip towards the Manonga River, which may indicate that the river is following a line of faulting. A parallel east-west alignment could also indicate the presence of a minor fault between Ibole and N'goholyambiti Hill, but no evidence to support this inference was discovered in the field. The paleontological localities of Tinde and Mwambiti are located within Unit A.

Unit B - Igurubi-Mwansuniho area

Based on preliminary field observations, and supported by evidence from aerial photographs, this area can be distinguished by the presence of extensive Precambrian outcrops. It is the most elevated feature in the immediate area, being up to 1200 m above sea level. It is covered by wooded vegetation, and is heavily dissected by small, ephemeral streams. To the east, the Precambrian is overlain by Neogene sediments, and to the north it is limited by a fault. Section

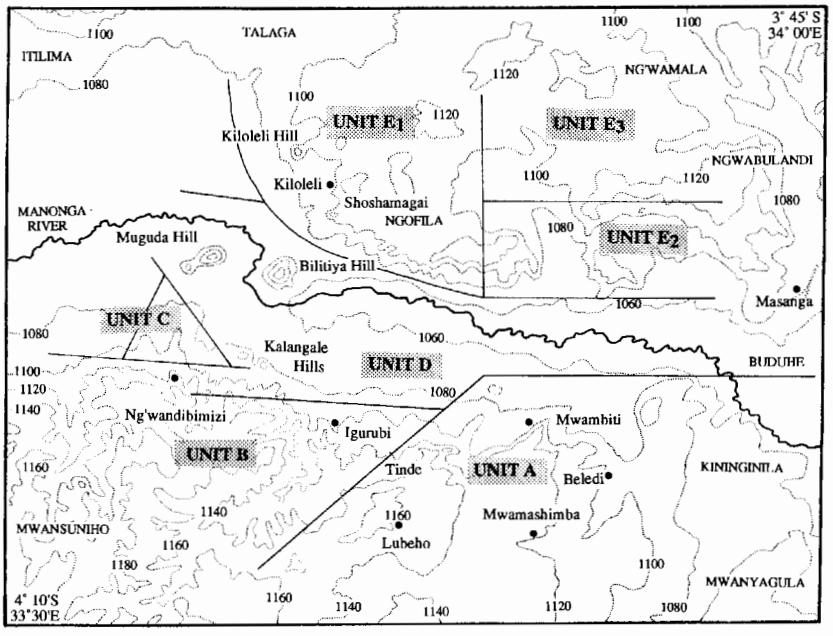

Fig. 4. Topographic map of the research area showing the main structural units (see text for further details).

A-B shows that the base of the Neogene sediments in Unit B, located at an elevation of 1130 m, is about 100 m higher than the projected base of the Neogene beds in the Mwamakona-Kininginila block. This implies that there may be an east-west fault between the two units, with a significant downthrow in Unit A.

Unit C - Ng'wandibimizi strip

Three mesa-like features appear in the Ng'wandibimizi area. These form a descending south-north series, in which the crown of each mesa is approximately 20 m lower than that of its predecessor. This may be due to a series of minor stepfaults.

Unit D - Central Manonga Valley

This area represents the floor of the Manonga Valley, bordered to the north and south by a subparallel series of low cliffs. The predominant exposures consist of an extensive series of red lateritic layers (comprising the Ibole Formation), located at the base of the Neogene lake sequence. In most cases, the laterite layers have been partially covered by degraded sediments from the

overlying Neogene beds, as well as by Recent mbuga clays. The valley is only sparsely vegetated, and active erosion has produced extensive badlands. Deep subparallel gullies with vertical wall have been cut into the superficial layers by runoff from heavy seasonal rainfall. Terrestrial sediments (comprising the Mwansarara Formation), presumably laid down during the earlier Tertiary peneplanation event, have been identified in palaeodepressions along the seasonally active Tinde River. The central Manonga Valley is characterized by the occurrence of numerous elevated features formed from Precambrian outcrops. Some form low rounded hillocks that rise less than 10 m above the valley floor. These were probably low-lying islands when the lake was first formed, but with the onset of deposition, they subsequently became submerged. Others (e. g., Muguda Hill, Bilitiya Hill and the Kalangale Hills), are more precipitous, and peak above the present-day upper limit of the Neogene lacustrine sediments. These are presumably remnants of small islands that rose well-above the lake surface throughout the Neogene.

Unit E_1 - Kililoli-Shoshamagai-Ngofila area

Sections B-D, E-F and O-P show that the Neogene beds in the area are deposited horizontally between small islands of Precambrian rock (e. g., Kililoli Hill and Shoshamagai Hill). Field observations show that the deposits grade laterally from fine-grained sediments to coarse conglomerates over horizontal distances of less than 100 m. These facies can be interpreted as differential deposition of sediments at increasing distance from the shoreline of an island near the centre of the Neogene lake. The palaeontological localities of Kililoli and Shoshamagai are located in this unit.

Unit E_2 - Nhuliku-Masanga block

Sections G-H, I-J, K.L. and Q-R, obtained from aerial photographs, indicate that the Neogene lake beds dip slightly towards the SSE. The dip of the beds towards the Manonga River on the northern side of the Valley corresponds precisely to that noted on the southern side (in Unit A). The subsidence of the central basin is estimated to be 45 m in section G-H and 60 m in section I-J. This is concordant with the presence of an east-west fault line running through the depression, along which the Manonga River has subsequently been diverted. The faulting is probably a transversal fracture related to the formation of the Eyasi and Wembere grabens during the Pleistocene. No Precambrian outcrops occur in this area.

Unit E_3 - Ng'wabulandi-Ng'wamala area

From aerial photographs it can be deduced that the Neogene beds are almost horizontal, and, as in Unit E_2, there are no Precambrian outcrops.

V. Stratigraphy

A generalized stratigraphic section of the sediments in the Manonga Basin is presented in Figure 5. The Tertiary sediments are subdivided in to three formations, the Mwansarara Formation, the Ibole Formation and the Wembere-Manonga Formation, which are defined here for the first time.

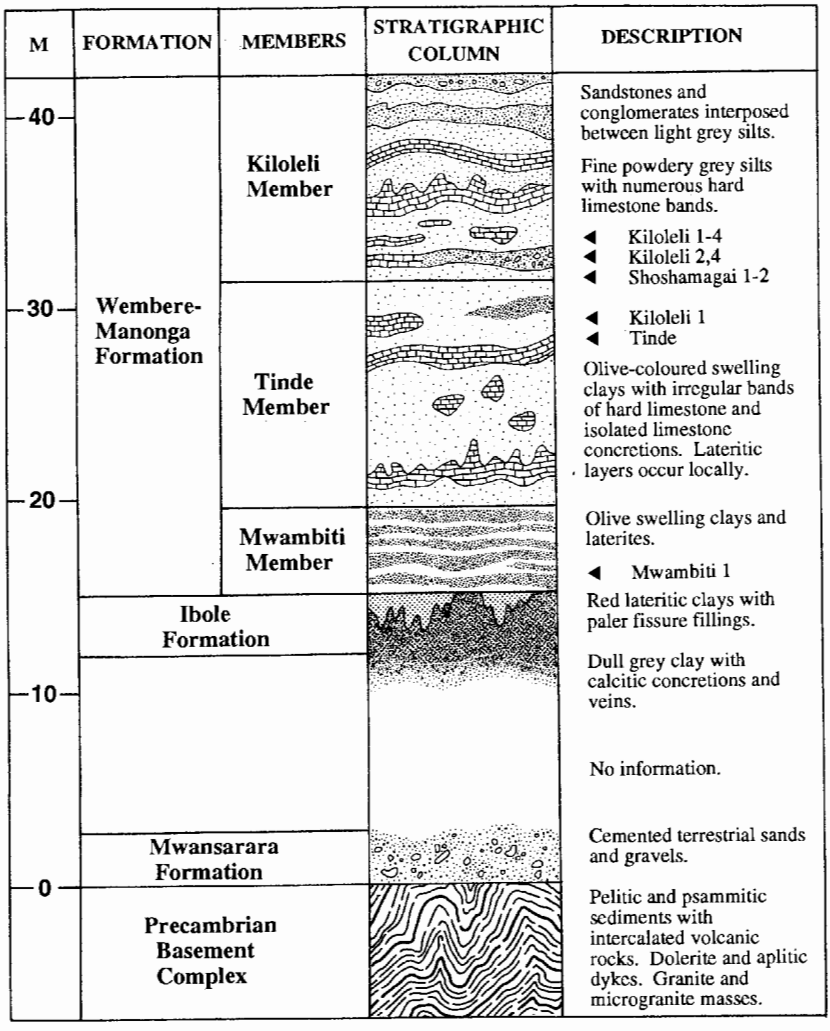

Fig. 5. Schematic stratigraphic section from the centre of the Manonga Basin. The stratigraphic position of the fossil localities is indicated by arrows in the left hand column.

The lowermost formation, the Mwansarara Formation, consisting of a cemented colluvial sandstone, rests unconformably on the Precambrian basement complex. It is poorly-sorted, with grain size ranging from fine to coarse. It consists predominantly of quartz pebbles and small angular stones derived from the underlying basement complex. Larger oval quartz pebbles (3-25 mm in diameter), ferruginous pebbles (2-20 mm in diameter) and clay nodules are sometimes included. The matrix is light grey to light green in colour, with large mottles ranging in colour from yellowish-orange through red and brown to reddish-brown. In some places subhorizontal bedding, consisting of coarse sandstone overlain by pebbly sandstone can be identified. The outcrops, which have a maximal thickness of 2.5 m, are often horizontal, and they tend to display an irregular, brain-like form.

The stratotype of the Mwansarara Formation is located in a section of the Mwansarara River, between 150 m and 350 m upstream from its confluence with the ephemeral Tinde River. Another good section is visible along the Tinde River itself, close to the site of several waterholes known locally as "Tinde". The terrestrial sediments in the Mwansarara-Tinde area have been accumulated in shallow depressions and valleys between the hilly flanks of Precambrian outcrops. Similar unnamed strata comprising terrestrial sediments in other areas of northern Tanzania, as well as the "Kilimatinde Cement" of the Singida Region, may possibly be correlated with the Mwansarara Formation (KRENKEL 1925; TEALE 1931, 1932; WADE & OATES 1938; EADES & REEVE 1938; WILLIAMS & EADES 1938; WILLIAMS 1939; GRANTHAM et al. 1945). No fossils have been recovered from the Mwansarara Formation, so it is difficult to estimate the age of the sediments, but they are almost certainly Tertiary in age, and quite possibly Oligocene or early Miocene.

The Ibole Formation, comprising previously unnamed strata, consists of a thick series of red lateritic clays. The formation is readily identifiable as a persistent layer exposed over a large area of the Manonga Valley floor by the action of seasonal rivers. The lower part of the formation (1.0 - 1.5 m thick) consists of impure clay, dull grey in colour, with numerous calcitic concretions and veins (1 - 2 cm thick with a 40-50° dip). The upper part of the formation (1.0 - 1.5 m thick) consists of strongly cemented sediments, with a granular (particle size 2 - 5 mm in diameter) and porous structure. It is orange to reddish-brown in colour, with paler subvertical fissure fillings. When weathered, the exposed surfaces exhibit a honeycomb-like structure, in which the softer clay matrix is supported by a more resistent calcite infilling. The base of the formation is obscured by Recent or Holocene mbuga clays, so the nature of its lower limit, and the relationship of its contact with the Mwansarara Formation is unknown. As a consequence, there may be up to 10 m of unexposed sediments between the Ibole Formation and the Mwansarara Formation (Fig. 5).

The stratotype is located in steepsided gullies 250 - 500 m north of Mwamakona cliff, and in the sides of the promontory west of these gullies, 1 - 3 km W to WSW of the village of Ibole. The formation may be the local equivalent

of the Neogene red soils and laterites that have been identified in other areas of northern Tanzania (EADES 1936; WILLIAMS & EADES 1938; EADES & REEVE 1938; WILLIAMS 1939; GRANTHAM et al. 1945). No fossil have been recovered from the Ibole Formation.

The Wembere-Manonga Formation lies unconformably on the Ibole Formation. It consists of of a series of lacustrine sediments, up to 30 m thick, that cover a large part of the Manonga depression. The sediments have been briefly described by a number of earlier authors (TEALE 1931, 1932; WILLIAMS 1939; WILLIAMS & EADES 1938; GRANTHAM et al. 1945; QUENNELL et al. 1956; PICKERING 1958), and more detailed descriptions were provided by STOCKLEY (1929) and GRACE & STOCKLEY (1930). The sediments were laid down during the late Miocene and Pliocene in an extensive lake basin. The beds consist of deep marls in the centre of the basin, that can be subdivided locally into three members, and sandy conglomerates located somewhat closer to the littoral fringes of the lake.

The lower member, the Mwambiti member, is formally described here for the first time. It consists predominantly of olive-coloured swelling clays, with five to six intercalated lateritic layers. Weathered exposures demonstrate that several clay horizons have been infilled with a weakly-developed honeycomb-like calcite matrix. This latter feature, in conjunction with the occurrence of successive laterite layers in the sequence, suggests that the shallow lake underwent periods of regression, during which the lake floor was occasionally exposed to desiccation. The stratotype of the Mwambiti Member is located along the northwest-facing cliff of Mwambiti point, about 3 km east of Mwambiti village along the Igurubi-Sakamaliwa road, and 3 km north of Beledi Village. Additional sections of the member were studied in other areas of the Mwambiti region, along the Mwamakona cliff and in the vicinity of the village of Kiloleli. Numerous fossilized remains of turtles and fish, obtained in situ in this member, from the site of Mwambiti 1, represent the oldest known occurrence of vertebrate fossils in the Manonga sequence, and are possibly as old as late Miocene in age.

The middle member of the Wembere-Manonga Formation, the Tinde Member, consists of a thick bed of olive-coloured calcareous swelling clays. Interposed in the clays are thin irregular bands of hard, nodular limestone and isolated limestone concretions. In addition, several of the clay layers show evidence of having undergone desiccation, and the resulting polygonal fractures have been infilled with calc tufa. When exposed to weathering, the calcite infillings form a resistant honeycomb-like matrix around the softer and more easily degradable calcareous clay. In the Mwamakona area a distinctive red lateritic bed appears in this formation as a local occurrence. The nature of the sediments in the Tinde Member suggests that they were laid down when the freshwater lake was extensive, relatively deep and quite stable, with only occasional periods of localized subaerial emergence.

The Tinde member was described in some detail by STOCKLEY (1929) and GRACE & STOCKLEY (1930), as a result of their work at the fossil locality at Tinde

in the late 1920s. The single fossiliferous horizon at Tinde was referred to as the Tinde Bone Bed by these authors. The stratotype for the Tinde Member (initially identified as the Tinde Beds by STOCKLEY 1929) is located at the section provided by the cliffs at Tinde, 7 km SE of the village of Igurubi and 3.5 km NW of the village of Lubeho. Ten profiles of this member were compiled from sections at Tinde, Ibole, N'goholyambiti, Mwambiti and Kiloleli. Vertebrate fossils from this member have been recovered principally from Tinde, but smaller collections have been made at Kiloleli 1 and Mwambiti 2.

The uppermost member of the Wembere Manonga Formation, the Kiloleli Formation, formally described here for the first time, consists primarily of fine powdery silts, light grey in colour. These silts form distinct layers, 0.5 - 1.0 m thick, separated by thin bands of nodular limestone and hard calcareous sediments up to 25 cm in thickness. Evidence of surface beds exposed to desiccation also occur in this member, but are much less frequent than in the lower members of the formation. The sediments grade upwards to sandstones and conglomerates in the upper part of the Kiloleli member. Fossils from this member are known from Kiloleli 1-4 and Shoshamagai 1-2.

VI. Palaeontology

During 1990, WMPE recovered several thousand vertebrate fossils, including over eight hundred taxonomically identifiable mammals from ten different localities. The most productive sites were undoubtedly Tinde East and Tinde West, although smaller collections were made at Kiloleli, Shoshamagai and Mwambiti. A list of the individual sites is presented in Table. 1.

A preliminary study of the mammalian fauna from Tinde (Table 2) allows at least a tentative biostratigraphic correlation of the site with other fossil localities in East Africa. The remains of bovids are common at Tinde, with at least four species being represented. The most common species is a medium-sized bovid, represented by several dozen horn cores, a partial skull, and numerous jaw fragments, isolated teeth and postcranial bones. The morphology of the horn cores and the primitive reduncine molar pattern confirms that the material should be referred to *Kobus*. The horn cores are considerably smaller than those of *K. sigmoidalis, K. ellipsiprymnus* and *K. ancystrocera* from Olduvai Gorge, Koobi Fora and the Shungura Formation, and can be distinguished morphologically and metrically from *K. oricornis* from Shungura Member B and the Hadar Formation (GENTRY & GENTRY 1978a, 1978b; GENTRY 1978, 1981, 1985). The horn cores are similar in size to material referred to *Kobus* cf. *kob* from Shungura Member B, but the Tinde material is more conservative in its morphology (GENTRY 1978, 1981). The species from Tinde has its closest affinities with *Kobus porrecticornis*, a small primitive reduncine from the Upper Dhok Pathan and Tatrot Formations of the Siwalik Hills, Lukeino, Mpesida and Baard's Quarry, but is somewhat larger in size (THOMAS 1980;

Table 1. List of fossil localities in the Manonga Valley, northern Tanzania.

Locality	SASES No. [1]	Coordinates	District	Region	Location
Tinde West	HiIx/1	4° 02'S 33° 46'E	Igunga	Tabora	7 km SE of Igurubi; 3.5 km NW of Lubeho
Tinde East	HiIx/2	4° 02'S 33° 46'E	Igunga	Tabora	7 km SE of Igurubi; 3.5 km NW of Lubeho
Mwambiti 1	HiIx/3	4° 01'S 33° 50'E	Igunga	Tabora	15 km E of Igurubi; 3 km N of Beledi
Mwambiti 2	HiIx/4	4° 01'S 33° 50'E	Igunga	Tabora	15 km E of Igurubi; 2 km N of Beledi
Kilolelì 1	HhIw/1	3° 51'S 33° 42'E	Shinyanga	Shinyanga	1 km N of Kilolelì Village; just W of Igurubi-Shinyanga road
Kilolelì 2	HhIw/2	3° 52'S 33° 43'E	Shinyanga	Shinyanga	Just S of Kilolelì Village; 50 m W of Igurubi-Shinyanga road
Kilolelì 3	HhIw/3	3° 52'S 33° 42'E	Shinyanga	Shinyanga	300 m S of Kilolelì Village; 100 m W of Igurubi-Shinyanga road
Kilolelì 4	HhIw/4	3° 52'S 33° 42'E	Shinyanga	Shinyanga	1 km S of Kilolelì Village; 800 m W of Igurubi-Shinyanga road
Shoshamagai 1	HhIw/5	3° 53'S 33° 42'E	Shinyanga	Shinyanga	2 km S of Kilolelì; just W of Igurubi-Shinyanga road
Shoshamagai 2	HhIw/6	3° 53'S 33° 42'E	Shinyanga	Shinyanga	3 km S of Kilolelì Village; just E of Igurubi-Shinyanga road

[1] Standardized site enumeration system for Africa

Table 2. Preliminary list of the mammalian fauna from Tinde and Kiloleli.

	Tinde	Kiloleli
Mammalia		
Artiodactyla		
Bovidae		
Kobus sp.	X	X
Hippotragus sp.	X	
Medium-sized bovid indet.	X	
Large bovid indet.		X
Large reduncine bovid indet.	X	
Hippotragine bovid indet.		X
Giraffidae		
Palaeotragine indet.	X	
Suidae		
Nyanzachoerus cf. *kanamensis*	X	X
Hippopotamidae		
Hexaprotodon harvardi	X	X
Perissodactyla		
Equidae		
Hipparion sp.		X
Proboscidea		
Elephantidae		
Mammuthus subplanifrons	X	X
Carnivora		
Carnivora indet.	X	

GENTRY 1980, 1981; GENTRY, pers. commun.). Other horn cores from the site establish the presence of a second larger species of reduncine bovid and a hippotragine, probably referable to *Hippotragus*.

Several teeth and a number of isolated postcranial bones can be identified as belonging to a large species of giraffid. The brachyodont molars with finely rugose enamel indicate that it is a palaeotragine giraffid. The material is larger than *Okapia*, *Zarafa* and *Prolibytherium*, and much smaller than *Sivatherium*. It is comparable in size to modern *Giraffa* and to the extinct *Palaeotragus germaini*, but appears to be morphologically distinct. There is insufficient material to firmly establish its taxonomic affinities, but it would seem to be a primitive and perhaps previously unknown palaeotragine.

Suids are rare at Tinde, but several isolated teeth and a number of postcranial bones confirm the occurrence of *Nyanzachoerus*. Comparisons indicate that the material can tentatively be referred to *N. kanamensis*, a species which is common at Pliocene sites in East Africa (COOKE & WILKINSON 1978; HARRIS & WHITE 1979).

Hippopotamid remains are extremely abundant, and all of them appear to be referable to a single species, *Hexaprotodon harvardi*. The Tinde material is characterized by brachyodont molars with a waisted crown, a well-developed

cingulum and typical hexaprotodont wear pattern; relatively large premolars in relation to the molars; tusks with thin enamel bearing fine, suid-like crenulations and a deep groove on the posterior aspect of the upper tusks; and hexaprotodont incisors. *Hexaprotodon harvardi* has been recovered previously from Lothagam, Kanapoi and the Omo Mursi Formation (CORYNDON 1977, 1978). The extensive series of isolated postcranials from Tinde indicate that *H. harvardi* was a medium-sized, lightly built fast-running species.

Proboscidean remains are rather rare at Tinde, consisting mainly of tusk and molar fragments. However, in the late 1920s GRACE recovered a mandibular fragment of an immature proboscidean containing an incomplete first molar. HOPWOOD (1931), who briefly described the specimen, was impressed by its primitive molar morphology and the presence of an unerupted P_4. These features, along with the probable retention of an alveolus for the root of the lower tusk, are all primitive elephantid characteristics. On the basis of its small size and the morphology of the molars (i. e., the molars are low-crowned and broader than high; the worn plates produce simple, continuous enamel loops with thick unfolded enamel; there are wide V-shaped cementum-filled valleys between the plates; the median cleft has a weakly developed anterior loop; and the individual plates have six apical digitations, in which the medial digitations are more elevated than the lateral ones) the material can all be assigned to *Mammuthus subplanifrons*. This species is known from sites in East and South Africa dated to early and middle Pliocene (MAGLIO 1973).

The presence of *Hexaprotodon harvardi, Nyanzachoerus* cf. *kanamensis, Mammuthus subplanifrons* and a primitive species of *Kobus* at Tinde suggests that the site is broadly comparable in age to Lothagam, Lukeino, Chemeron, Kanapoi, Kanam East, the lower Kaiso Formation, the Omo Mursi Formation and the Sagantole Formation of the Middle Awash (COOKE 1978, 1983; KALB et al. 1982; HILL & WARD 1988). This provides an estimated early Pliocene age for Tinde, probably dated to about 4-5 Myrs.

The strong faunal similarity between Kiloleli and Tinde, with the presence of *Mammuthus subplanifrons, Hexaprotodon harvardi, Nyanzachoerus* cf. *kanamensis* and *Kobus* sp., suggests that the fossil localities in the vicinity of Kiloleli are broadly contemporaneous with those at Tinde. However, the presence of an equid at Kiloleli 1 and 2, clearly identifiable as *Hipparion*, represents a significant difference. There is insufficient material at present to identify the species of *Hipparion* to which the Kiloleli specimens belong, but the moderately hypsodont lower molars with large ectostylids would tend to support attribution to *H. primigenium*. This species is known from middle Miocene to late Pliocene sites in East Africa (CHURCHER & RICHARDSON 1978). The development of large ectostylids on the lower cheek teeth is apparently a progressive feature in the East African members of the species, and is most commonly found in later Pliocene representatives (post-dating Shungura Member B) (EISENMANN 1976; CHURCHER & RICHARDSON 1978). The occurrence of *Hipparion* with prominent ectostylids at Kiloleli, in conjunction with the

fact that the main fossiliferous horizon is located slightly higher in the stratigraphic sequence, would therefore tend to suggest that Kiloleli is somewhat younger than Tinde. However, the combination of relatively large cheek teeth with a low degree of hypsodonty serves to align the Kiloleli material most closely with samples from Laetoli, the lower Kaiso Formation and Shungura Member B (EISENMANN 1976), indicating a mid-Pliocene age. In addition, it should be noted that the differences in composition between the faunas at Tinde and Kiloleli may also, in part, be a reflection of facies differences. The greater abundance of elephantids in relation to hippopotamids, and the presence of an equid, supports the geological evidence that the depositional environment at Kiloleli may have been in closer proximity to the emergent land surface than was the case at Tinde. We may conclude from the balance of the evidence that the sites of Kiloleli 1 and 2 are slightly younger than those at Tinde.

Small collections of fossil mammals were also made at several localities at Shoshamagai and Mwambiti, but the samples are not yet adequate enough to yield any useful information concerning biochronology or taxonomic diversity.

VII. Conclusions

In 1990 the Wembere-Manonga Palaeontological Expedition (WMPE) conducted preliminary geological and palaeontological research in the Manonga Valley of northern Tanzania. The primary aim of the expedition was to investigate the potential of the fossil localities in the Manonga Valley for long-term palaeontological research. Geological studies in the centre of the Manonga basin, in the region of the villages of Igurubi and Kiloleli, have provided a more detailed understanding of the local geological context, and the data have been used to establish a new lithostratigraphic framework. The expedition also succeeded in recovering several thousand fossil vertebrates, including over eight hundred taxonomically identifiable mammals, from ten different localities. During the 1990 field season, only about 15 km^2 of the research area were prospected, but, based on aerial photographs and preliminary reconnaissance work, it is estimated that over 1500 km^2 of productive exposures still remain to be explored. The fossils were recovered from a series of fine-grained calcareous sediments that were deposited in an extensive, but relatively shallow lake basin in the Manonga depression. A preliminary analysis of the fauna indicates that the fossil localities may range in age from late Miocene to late Pliocene (ca. 6-3 myrs).

The preliminary results of the expedition have served to identify the Manonga Valley as a productive and significant new region in eastern Africa for future palaeontological research. The estimated late Miocene to late Pliocene age of the sites, and their close geographical proximity to major hominid-bearing localities in Tanzania, such as Laetoli and Olduvai Gorge, makes further exploration of the Manonga Valley of especial importance for research into human origins.

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