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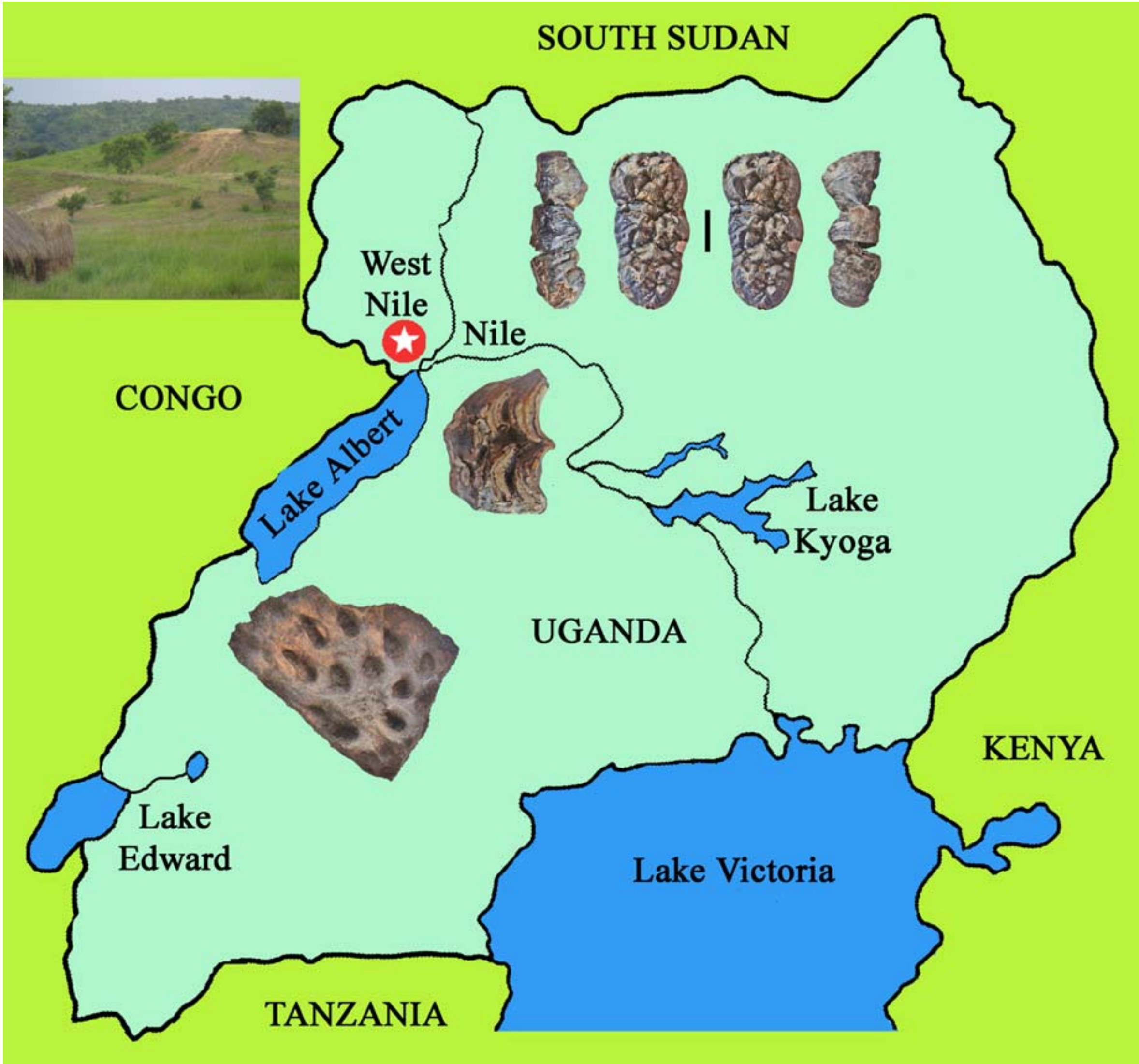

Uganda Museum, Kampala

Geo-Pal Uganda

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5 Production

Uganda Museum, P.O. Box 5718, Kampala

Miocene Vertebrates from the Packwach area, West Nile, Uganda

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ABSTRACT

Fossil vertebrates have been found in the Marama-Jupakombe sector, West Nile, Albertine Rift Valley, Uganda. This report interprets the vertebrates and their geological and stratigraphic contexts and discusses their biochronological implications which indicate that the deposits are of Late Miocene age. This contrasts with previous geological mapping in the region which proposed that all the exposed sediments are Pleistocene.

Key Words : Western Rift, Uganda, Vertebrates, Late Miocene, Biochronology

INTRODUCTION

Pioneer geological mapping in the West Nile sector of the Western Rift Valley, Uganda, suggested that the sediments were of Pleistocene age (Hepworth, 1964), although no direct evidence was found by which to make such an age estimate. In contrast, on the basis of fossil freshwater molluscs, Van Damme *et al*., (2010) demonstrated that the deposits in the Rhino Camp sector of the West Nile District (Koku, Dellu) contained Late Miocene lacustrine deposits which accumulated during the first phase of Palaeolake Obweruka, ca 8 Ma, as demonstrated by Pickford *et al*., (1993).

Despite the evidence yielded by the molluscs, which were found at four separate localities spread over a substantial area, some of the oil companies investigating the deposits have accepted a Pleistocene age estimate for the entire rift infilling, basing their decision on controversial interpretations of palynomorphs obtained from drill cores. The contradictory interpretations have been highlighted during conferences (Pickford & Senut, 2011) but so far without resolution.

During the two 2012 surveys of the Packwach area, West Nile, the Uganda Palaeontology Expedition prospected for fossils south of the main road that runs from Packwack to Arua. Fossils were found at 26 localities (Table 1) in sediments unconformably underlying a widespread sheet of conglomeratic sands and silts equivalent in stratigraphic position and lithological facies to the Tangi Formation in the Paraa Area north and east of the Nile. The latter formation has yielded classic bifaces and "bolas" stones of Acheulean industry facies, suggesting an Early to Middle Pleistocene age for the Tangi deposits and their correlative unit in the West Nile sector of the rift valley.

The Miocene fossiliferous deposits at Marama and Jupakombe dip gently towards the north. They comprise clays, silts and sands, interspersed with ferruginous oolitic and sandy ironstone horizons. The ironstone horizons and subjacent clays and silts yield rich assemblages of bivalves and gastropods which correlate best to assemblages found in the Kisegi and Oluka formations in the Semliki sector of the Albertine Rift, and the Nkondo area in the Kaiso Peninsula (Van Damme & Pickford, 1994).

Similar molluscs were found in the northern part of West Nile at Koku and Dellu in the Rhino Camp area (Van Damme *et al*., 2010).

Whilst the molluscan evidence is considered to be of high quality and to yield accurate correlations, it is clear that consultants to the oil industry consider the results to be of little value, preferring to support the much younger age estimates based on interpretations of palynomorphs obtained from drill cores. In order to resolve the impasse, independent evidence concerning the age of the West Nile strata is required. For this reason, it is important to put on record the discovery of biochronologically informative fossil mammals at several sites in two localities in the West Nile sector of the rift valley.

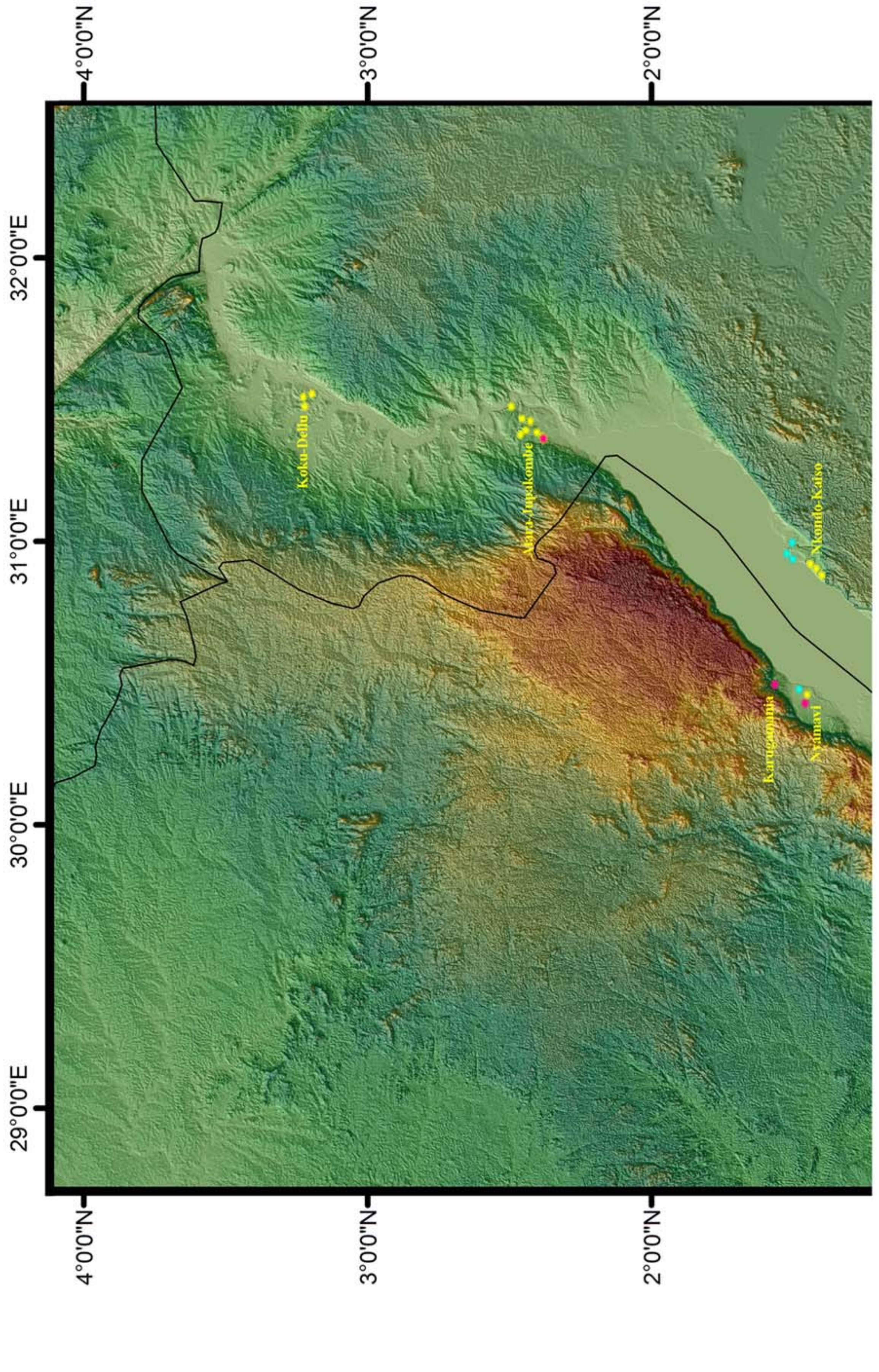
Fossiliferous localities in the Packwach sector

Table 1. GPS co-ordinates and altitudes of fossiliferous localities in the Packwach-Panyimur sector of West Nile, mapped by the Uganda Palaeontology Expedition, March and July-August, 2012.

Locality	Latitude	Longitude	Altitude (GPS)	Observation
Alwi-Atara	02°27'20.0"N	31°24'22.5"E	684m	Fish in indurated gritty sandstone
Alwi-Pateng	02°27'54.0"N	31°20'54.9"E	739m	Molluscs in yellow limey silt overlying smectite
Atara Main	02°22'35.9"N	31°26'06.3"E	688m	Fish in gritty sandstone
Gengere Fish	02°24'21.4"N	31°24'09.6"E	655m	Fish in reddened grit
Gengere Main	02°24'28.0"N	31°24'15.8"E	659m	Molluscs in sandy ironstone
Jupadwonga	02°26'46.8"N	31°26'04.5"E	684m	Molluscs in ironstone
Jupadwonga clays	02°26'52.2"N	31°26'08.6"E	660m	Molluscs and leaves in clay and silt
Jupakombe 1	02°22'01.1"N	31°21'17.7"E	685m	Molluscs in oolitic ironstone
Jupakombe 3	02°22'01.4"N	31°21'16.6"E	688m	Molluscs in oolitic ironstone
Jupakombe 4	02°22'00.0"N	31°21'14.6"E	691m	Molluscs in oolitic ironstone
Jupakombe 5	02°21'58.5"N	31°21'15.9"E	693m	Molluscs in sandy ironstone
Jupakombe 6	02°21'55.3"N	31°21'15.3"E	688m	Molluscs in oolitic ironstone
Jupakombe 7	02°21'55.0"N	31°21'13.5"E	684m	Mammals in clays and silts
Jupakombe Chelonian	02°21'57.0"N	31°21'05.8"E	685m	Chelonian carapace in silts beneath oolitic ironstone
Jupakombe oolite dip slope	02°21'43.3"N	31°20'57.9"E	721m	Molluscs in clay
Marama 1	02°22'27.8"N	31°21'48.5"E	688m	Mammals and molluscs in clay and silt
Marama 2	02°22'34.2"N	31°21'38.3"E	713m	Molluscs in oolitic ironstone
Marama 3	02°22'42.6"N	31°21'34.9"E	716m	Molluscs in oolitic ironstone
Marama 4	02°22'45.8"N	31°21'38.1"E	716m	Molluscs and mammals in clay, silt and ironstone
Marama 5	02°21'56.3"N	31°21'56.3"E	692m	Wood and molluscs in sandy ironstone, some "diatomite"
Marama 6	02°22'48.8"N	31°21'59.8"E	687m	Molluscs in ironstone
Marama 7	02°22'49.2"N	31°22'00.1"E	688m	Molluscs in ironstone
Marama 8	02°22'50.5"N	31°21'34.7"E	708m	Molluscs in ironstone
Marama 1 *Anancus* site	02°22'29.0"N	31°21'47.7"E	674m	Mammals in clay and silt
Marama *Hipparion* site	02°22'29.9"N	31°21'45.8"E	693m	Mammals in clay and silt
Nyabang	02°24'14.6"N	31°23'47.9"E	689m	Molluscs in ironstone

Overview of the Albertine Rift Valley

The new geological and palaeontological observations made in Nebbi District, West Nile, complement previously available information about the sediments infilling the Albertine Rift. They reveal that the West Nile region was a depositional centre prior to the onset of Palaeolake Obweruka as a deep graben lake some 8 Ma, in which specialised molluscan faunas evolved (Fig. 1).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Koku-Delju
Mara-Jupakombe
Nkondo-Kaiso
Karugamania
Nyamavi
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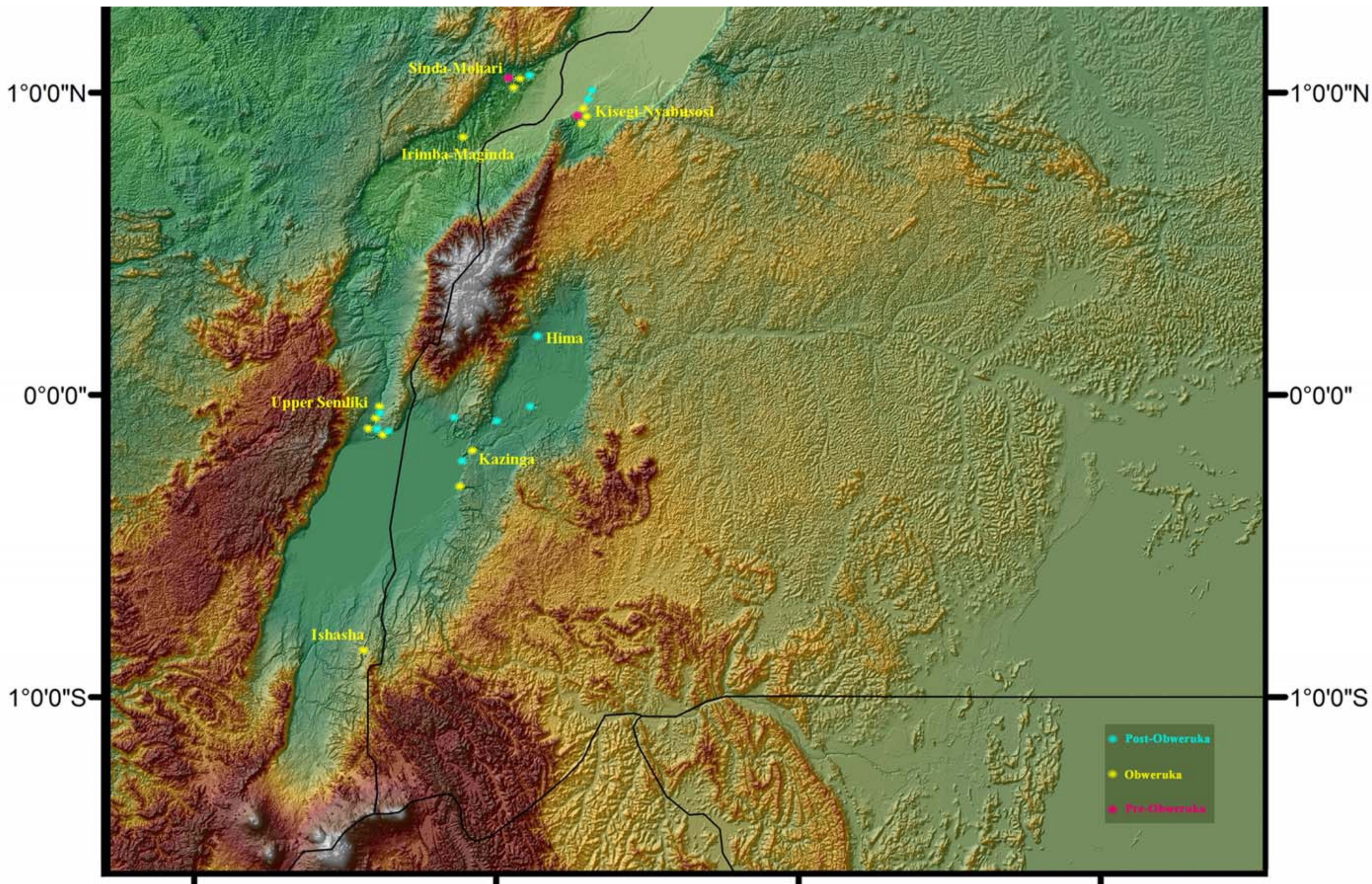
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32°0'0"E
Sinda-Mohari
Kisegi-Nyabusosi
Irimba-Maginda
Hima
Upper Semliki
Kazinga
Ishasha
Post-Obweruka
Obweruka
Pre-Obweruka

Figure 1. Fossiliferous localities in the Albertine Graben, Uganda - D R Congo. The pre-Obweruka localities comprise Early to basal Late Miocene deposits ranging in age from ca 17-18 Ma to ca 7.5 Ma (red stars), the Obweruka localities (yellow stars) correspond to the early phase of Palaeolake Obweruka (Late Miocene and basal Pliocene (ca 7.5 – 2.6 Ma)) and the Post-Obweruka localities (blue stars) correlate to the Late Pliocene to Pleistocene and Recent (2.6 - 0 Ma).

The oldest fossil mammals found in the Albertine Rift are of Early Miocene age (*Deinotherium hobleyi*, *Brachyodus aequatorialis*). These taxa came from deposits in the Sinda-Mohari area, Congo, (Hooijer, 1960; Yasui *et al*., 1992). The oldest fossils found on the Uganda side of the rift came from the Kasande Formation (from clay deposits previously interpreted to be the upper part of the Kisegi Formation, but now recognised as a distinct unit). The fossils consist of several bones of a Middle Miocene rhinoceros, *Paradiceros mukirii*, indicating an age of ca 13-14 Ma. Beneath the horizon that yielded the fossil rhino there are at least 100 metres of poorly fossiliferous Kisegi Formation, the base of which is likely to be Early Miocene, although no direct evidence of its age has been found within the Ugandan deposits. Fossil mammals of Late Miocene age have been found in many localities in the Semliki and Nkondo areas, and we here report new finds of taxa of this age in West Nile. Pliocene mammals are widespread throughout the Albertine Rift Valley on both the Congo and Uganda sides. Important occurrences have been reported at Ishasha south of Lake Edward, at Kazinga, Upper Semliki, Lower Semliki, Nyaburogo-Nyabusosi and the Kaiso areas. Lateritic ironstones of Early Pleistocene age are known from the Nyabusosi area (Pickford *et al*., 1993), Packwach (this report) and Rhino Camp (Van Damme *et al*., 2010) implying an enduring episode of laterite pedogenesis over much of the valley with relatively restricted zones undergoing sedimentation, which explains why the Early Pleistocene fossil record is scanty when compared to the Mio-Pliocene one.

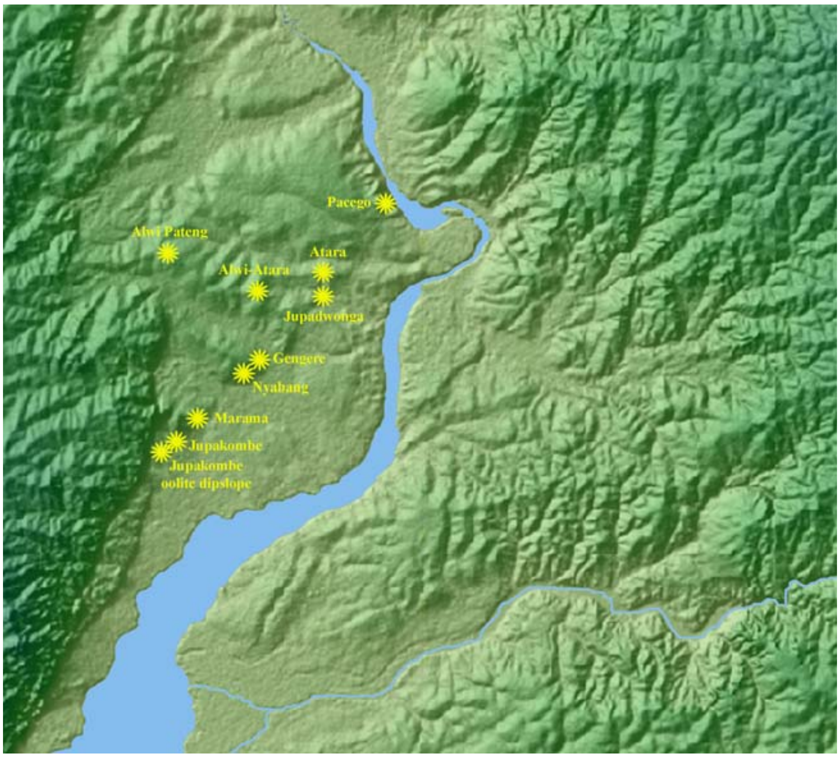

Figure 2. Fossiliferous Late Miocene and basal Pliocene deposits in the Packwach-Panyimur sector of the Albertine Graben crop out on the western, up-throw side of a major intra-rift fault that trends northeast-southwest. This fault block is tilted to the north, but locally the strata dip at various angles, sometimes towards the Nile (Marama) or even vertically (at Jupadwonga Vertical). It should be noted that much of the area is covered by Pleistocene gravels and soils equivalent in age to the Tangi Formation in the Nile Valley near Paraa. The down-thrown block comprising the Nile Valley Plain (from the river banks up to the 50 metre contour above the river) is underlain by Miocene deposits that come near to the surface at the Packwach-Panyimur road east of Jupadwonga.

Stratigraphy and sedimentation

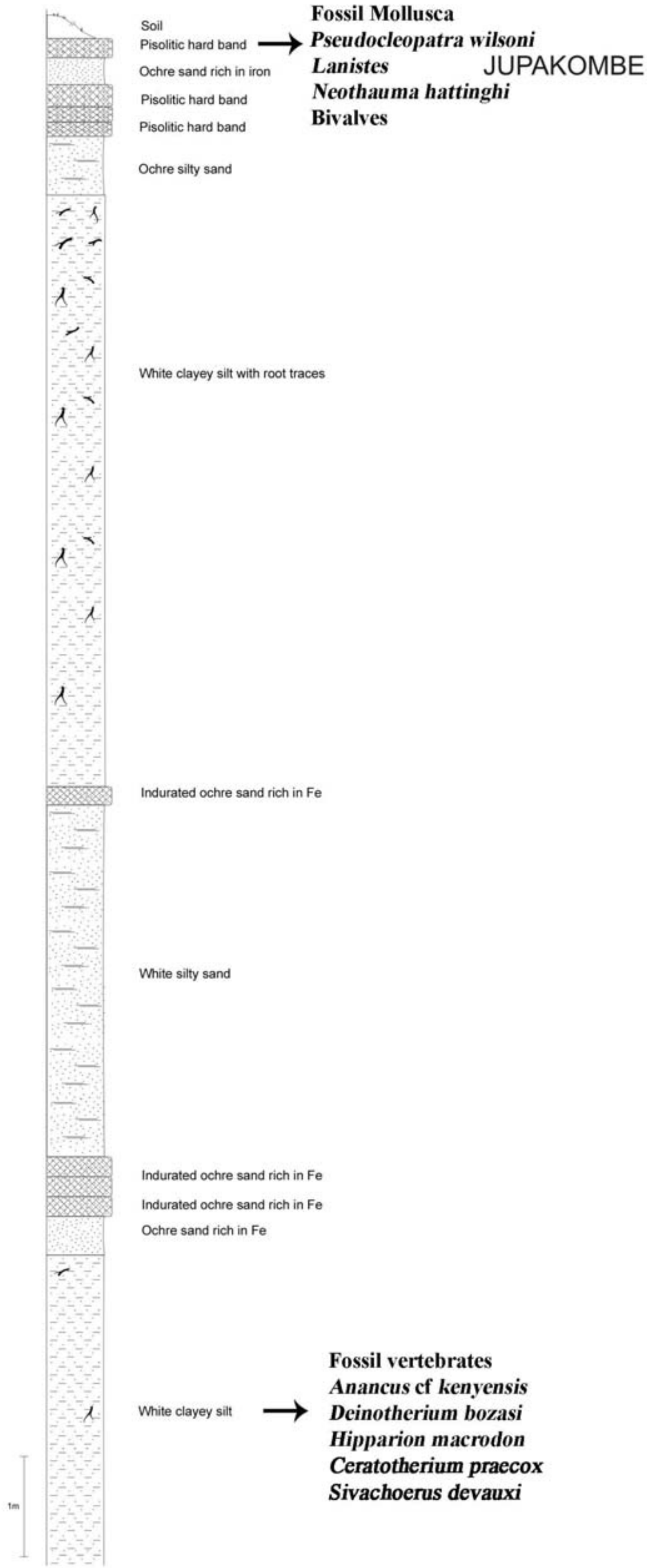

Figure 3. Stratigraphic section and fossil occurrence at Jupakombe, West Nile.

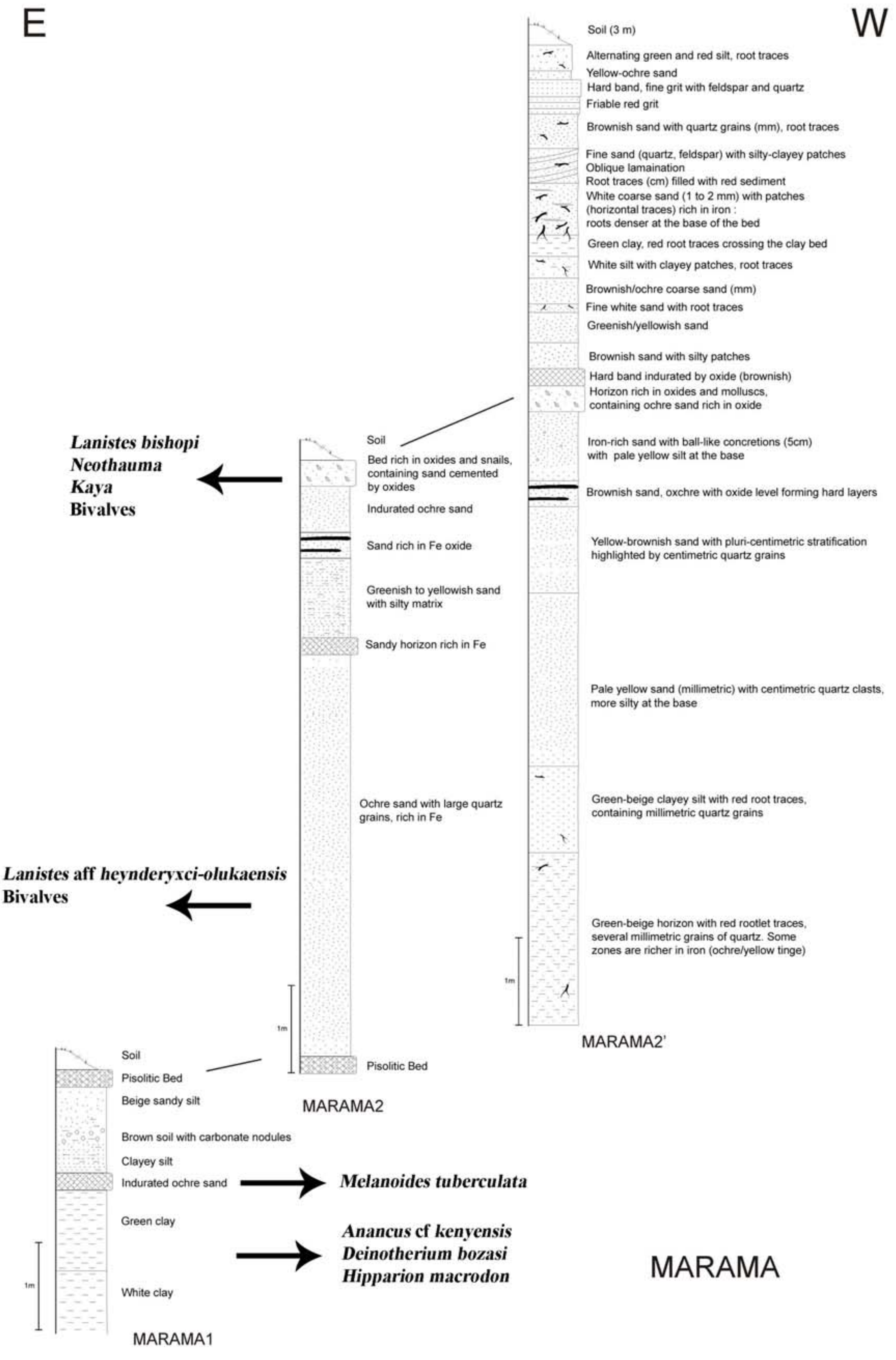

Figure 4. Stratigraphic sections and fossil occurrences at Marama, West Nile.

Stratigraphic sections were measured at Jupakombe (Fig. 3, 5, 6) Marama (Fig. 4) and Jupadwonga. The Mio-Pliocene deposits are dominated by sand and silt with clayey fractions, but there are occasional coarser grit lenses and thin gravelly beds. In the Mio-Pliocene deposits, conglomerate is conspicuous by its absence. In contrast there are widespread gravels and conglomerates in the Tangi-equivalent beds which unconformably overlie the Mio-Pliocene strata.

Depositional environments

The Mio-Pliocene sediments are richly endowed with rhizoliths and rootlet traces, indicating shallow water to swampy depositional environments. The general lack of cross-bedding suggests a relatively high degree of bioturbation. The formation of oolitic ironstone beds suggests periods of sediment bypass or non-deposition. Fully lacustrine sediments are rare, confined to thin beds of finely laminated, possibly diatomaceous silts.

Despite their proximity to the Western boundary fault of the Albertine Graben, the Mio-Pliocene deposits examined at Marama and Jupakombe are dominated by fine-grained sediments, mainly clays and silts with lenses and beds of sand and grit, but remarkably little conglomerate. There are several ironstone horizons, up to 50 cm thick in places, ranging in facies from oolitic to pisolitic (pisoliths up to 2 cm diameter) and there are sandy varieties. These ironstone horizons probably represent subaqueous bypass units or periods of clastic sediment starvation. A previous interpretation of the pisolitic variety as being volcanic hailstones can be discounted. The pisoliths are of subaqueous origin, the deposits often containing freshwater molluscs (*Lanistes*, *Neothauma*, *Kaya*, *Pseudocleopatra*, and a diversity of bivalves) as at Jupakombe and Marama.

Overlying the Pliocene deposits is the Atara Ferricrete, a well-developed mature lateritic ironstone showing abundant murram nodules cemented together by iron-oxide “varnish”, similar to the ferricrete described in the Dellu – Koku sector of the West Nile, north of Rhino Camp. This deposit speaks for a prolonged emergence of the sedimentary deposits in a humid tropical environment. Mapping of the ferricrete laterally reveals that it overlies Basement Complex rocks in the scarp shoulders, as for example at Cille, again reflecting the situation in the Rhino Camp sector.

Figure 5. Jupakombe 7 outcrops showing a prominent band of oolitic ironstone forming a resistant horizon near the top of the scarp slope. The bulk of the sediments in this section comprises silt and clay which yield Late Miocene vertebrates and a few molluscs.

Figure 6. The vertebrate fossils from Jupakombe 7 occur in the clay and silt that underlie the coarse pisolitic ironstone horizon over 50 cm thick forming the cap of the scarp. View towards the rift boundary fault in the background.

Vertebrate Palaeontology

Vertebrate fossils found in the Packwach-Panyimur area of West Nile by the Uganda Palaeontology Expedition are the first known from this region. The biochronological evidence that they yield agrees in essence with age estimates based on freshwater molluscs (Van Damme *et al*., 2010).

Pisces

Fish remains are relatively common in the West Nile, having been found at Atara Main close to the main road from Packwach to Arua (*Hydrocynus*, *Lates*) and at Marama (Fig. 7) and Jupakombe (*Lates niloticus*, *Clarotes*, Clariidae, *Hydrocyon*). These taxa are widespread in the Albertine Rift succession (Van Neer, 1994) and do not throw much light on the age of the deposits.

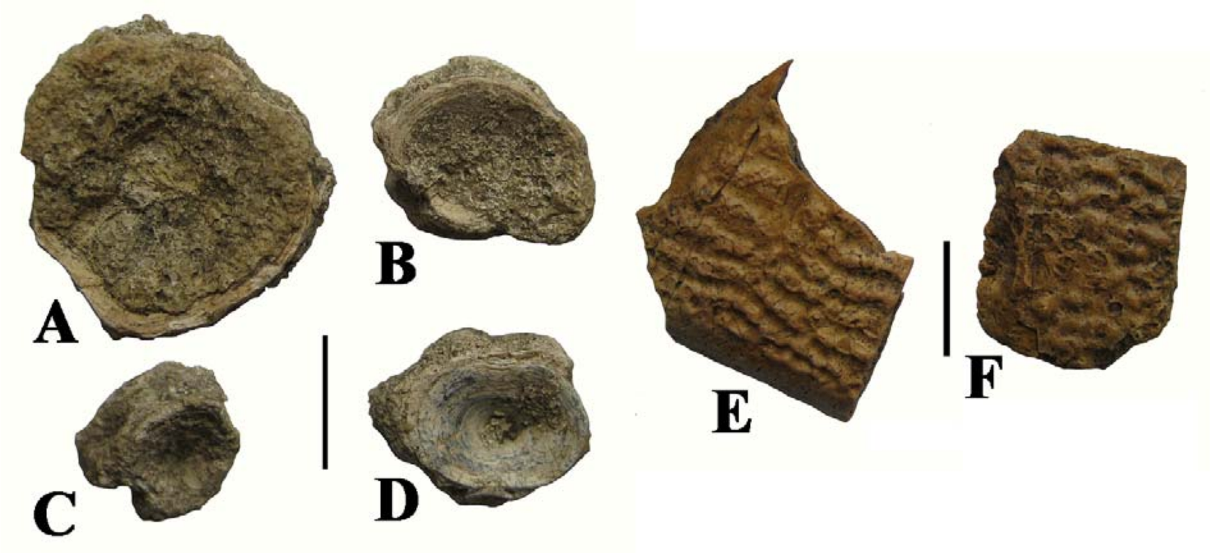

Figure 7. Fish and Chelonian remains from West Nile, Uganda. A-D) Mar 1, 7'12bis, *Lates niloticus*, E-F) Mar 1, 8'12bis, Cyclanorbid turtle scutes (scales, 1 cm).

Chelonia

Freshwater turtle scutes are rare in the West Nile, but specimens from Jupakombe comprise pelomedusids and cyclanorbids, some of large dimensions. They are also present at Marama (Fig. 7). These fossils do not contribute anything to the biochronology of the deposits, but they indicate the former presence of a lake or swamp.

Crocodilia

Crocodile scutes, vertebrae and teeth are encountered at Marama and Jupakombe (Fig. 8), some of the individuals being of impressive dimensions. They do not throw any light on the age of the deposits.

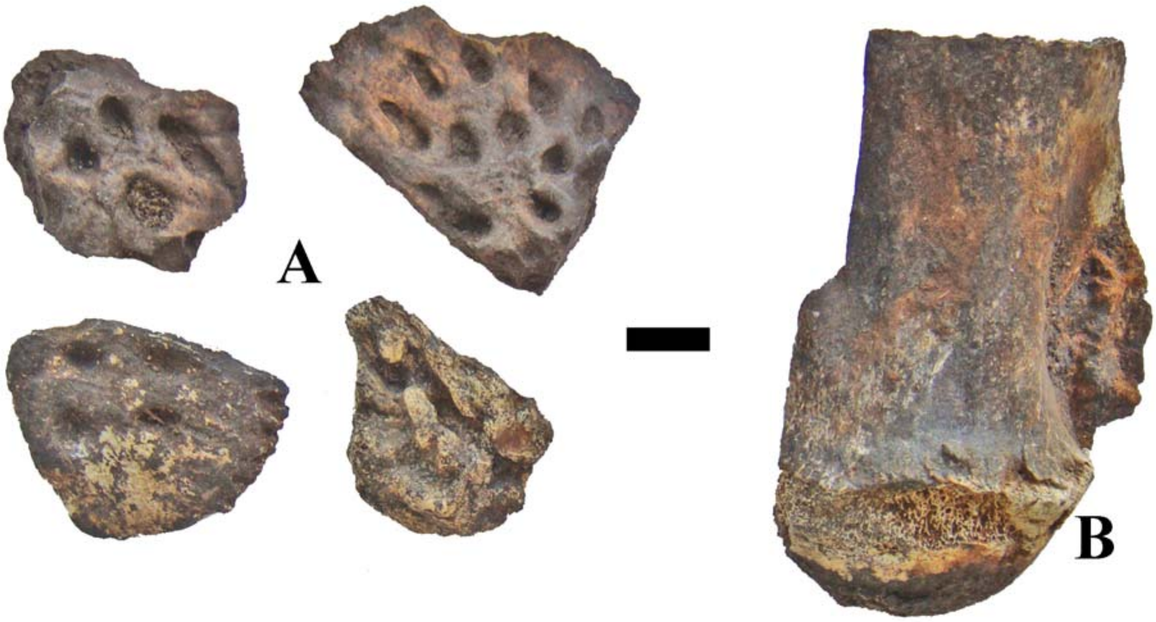

Figure 8. Crocodile scutes and vertebra from Jupakombe 7, West Nile, Uganda; A) KOM 7 6’12 scutes, KOM 7 14’12, vertebra (scale : 10 mm).

Mammalia

Mammal fossils found at Marama and Jupakombe (Fig. 9-13) are sufficiently numerous and complete enough to permit accurate identifications, and thus to provide a reliable sense of the age of the deposits, using the well established and well dated biochronological scale of East Africa (Gradstein, *et al*., 2012; Pickford, 1981, 2006, 2012).

Deinotheriidae

Fragments of teeth of large deinotheres are encountered at Marama and Jupakombe (Fig. 9). The dimensions of the specimens indicate that the species concerned is *Deinotherium bozasi*, which is common in the Eastern Rift Valley in deposits ranging in age from ca 7 Ma to ca 1.8 Ma. The deinotheres went extinct during the Early Pleistocene.

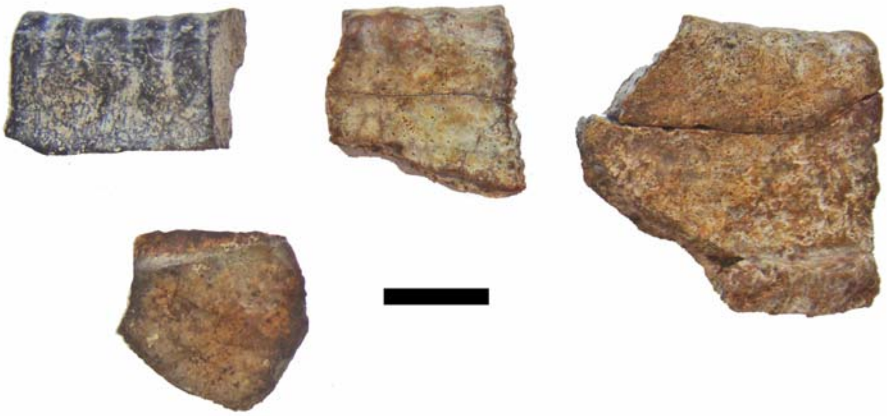

Figure 9. *Deinotherium bozasi* enamel fragments from Jupakombe 7, West Nile, Uganda (scale : 10 mm).

Gomphotheriidae
Fragments of teeth with thick enamel belonging to proboscideans are common at Marama and Jupakombe (Fig. 10). The site of Jupakombe 7 yielded several fragments of a tooth which are complete enough to indicate that the species represented is an early morph of *Anancus* cf *kenyensis*, although an identification as the older taxon *Tetralophodon* cannot, *a priori*, be ruled out. Even though the identification of these tooth fragments must remain open until more complete specimens come to light, they are of biochronologiocal interest, because such thick enamelled proboscidean teeth are unknown in African deposits younger than 4 Ma, the time when *Anancus* went extinct.

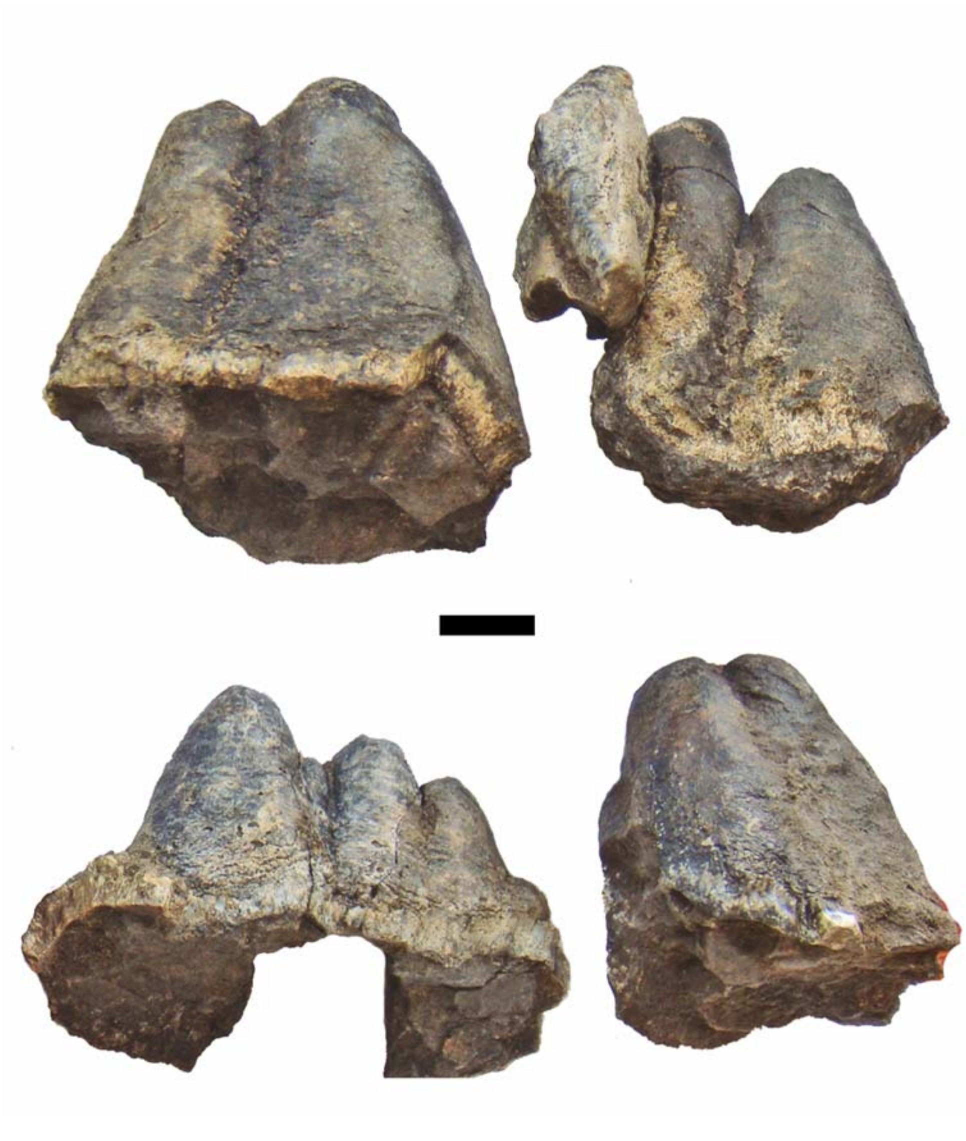

Figure 10. *Anancus* cf *kenyensis* molar fragments from Jupakombe 7, West Nile, Uganda (scale : 10 mm).

Rhinocerotidae
Jupakombe 7 yielded an almost complete talus of a huge rhinoceros (Fig. 11). The dimensions of the specimen agree with the extinct species *Ceratotherium praecox*, a White Rhinoceros which was up to 50% larger than the extant species *Ceratotherium simum*. This huge rhinoceros is known from many localities in the Eastern Rift Valley aged between ca 7.5 Ma and 4.2 Ma (Guerin, 1994, 2011) after which it was replaced by the smaller species. It is thus a reliable indicator of Late Miocene and Basal Pliocene age.

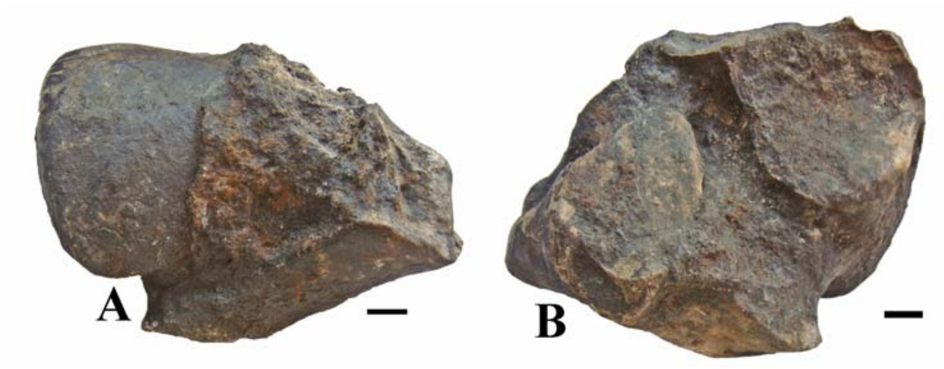

Figure 11. *Ceratotherium praecox* talus from Jupakombe 7, West Nile, Uganda, A) dorsal, B) plantar views (scale: 10 mm).

Equidae

Equids are useful for broad focus biochronology. The family originated in North America, and colonised the Old World ca 11 Ma, their arrival defining the so-called "*Hipparion*" datum. Thus, any deposits in Eurasia or Africa that yield equid fossils must be younger than 11 Ma. Early African members of the genus *Hipparion* have relatively low crowned cheek teeth. The specimens from Marama and Jupakombe (Fig. 12, 13) are large, and their crowns are relatively low, as in the species *Hipparion macrodon*, which was defined on the basis of specimens from the Oluka Formation, Semliki area of the Albertine Rift Valley (Eisenmann, 1994).

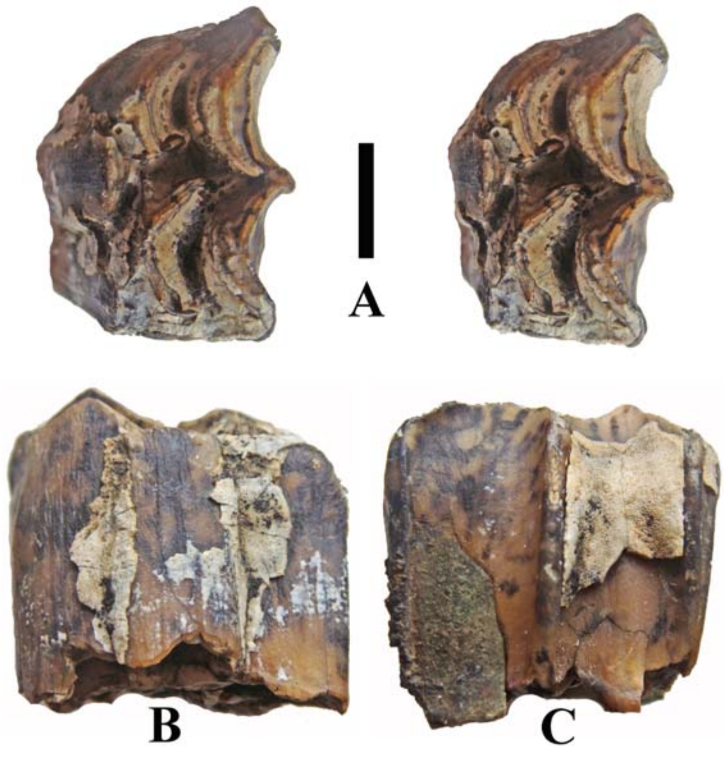

Figure 12. *Hipparion macrodon* upper cheek tooth from Marama *Hipparion* site, West Nile, Uganda, A) stereo occlusal view, B) lingual view, C) buccal view (scale : 10 mm).

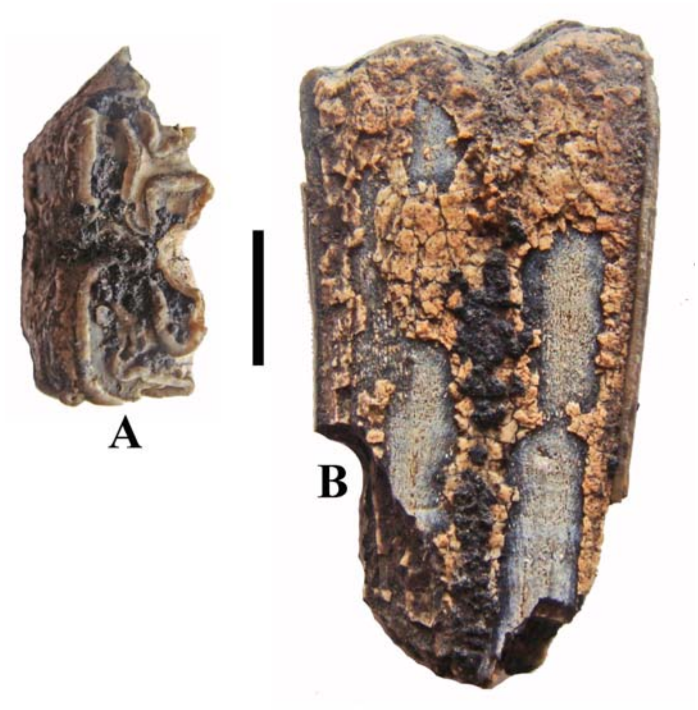

Figure 13. *Hipparion macrodon*, lower cheek tooth (Marama I, 45’12) from Marama 1, West Nile, Uganda, A) occlusal view, B) lingual view (scale : 10 mm).

Suidae

Suids are particularly useful for African biochronology (Pickford, 2006, 2012). Their remains are often abundant, the lineages tended to evolve rapidly in morphology and dimensions, and there were several colonisations of the continent by suid lineages that had evolved in Eurasia, providing first appearance “datums”.

The suid lower third molar from Jupakombe 7 is of a bunodont tetraconodont (Fig. 14). By its lower cusps, less open buccal and lingual notches, and the more sloping buccal and lingual walls of the main cusps, the specimen differs from the slightly more hypsodont molars of *Nyanzachoerus waylandi* from Nyaburogo and Nkondo, Uganda, which ranges in age from ca 6 to 5 Ma (Cooke & Coryndon, 1970; Pickford, 1989, 1994). The Jupakombe tooth resembles specimens of *Sivachoerus devauxi* from localities in Northern and tropical Africa, including Beglia (Tunisia) (Pickford, 1990), Bou Hanifia (Algeria) (Arambourg, 1968), Sahabi (Libya) (Cooke, 1982), Nakali (Kenya) (Tsujikawa, 2005), Samburu Hills (Kenya) (Tsujikawa, 2005), Lothagam (Kenya) (Harris & Leakey, 2003) and the Middle Awash (Ethiopia) (Haile-Selassie, 2009). The deposits at which the species has been found spans the Late Miocene from ca 11 Ma in North Africa, to ca 7 Ma in Tropical Africa. This taxon is thus a reliable indicator of Late Miocene time.

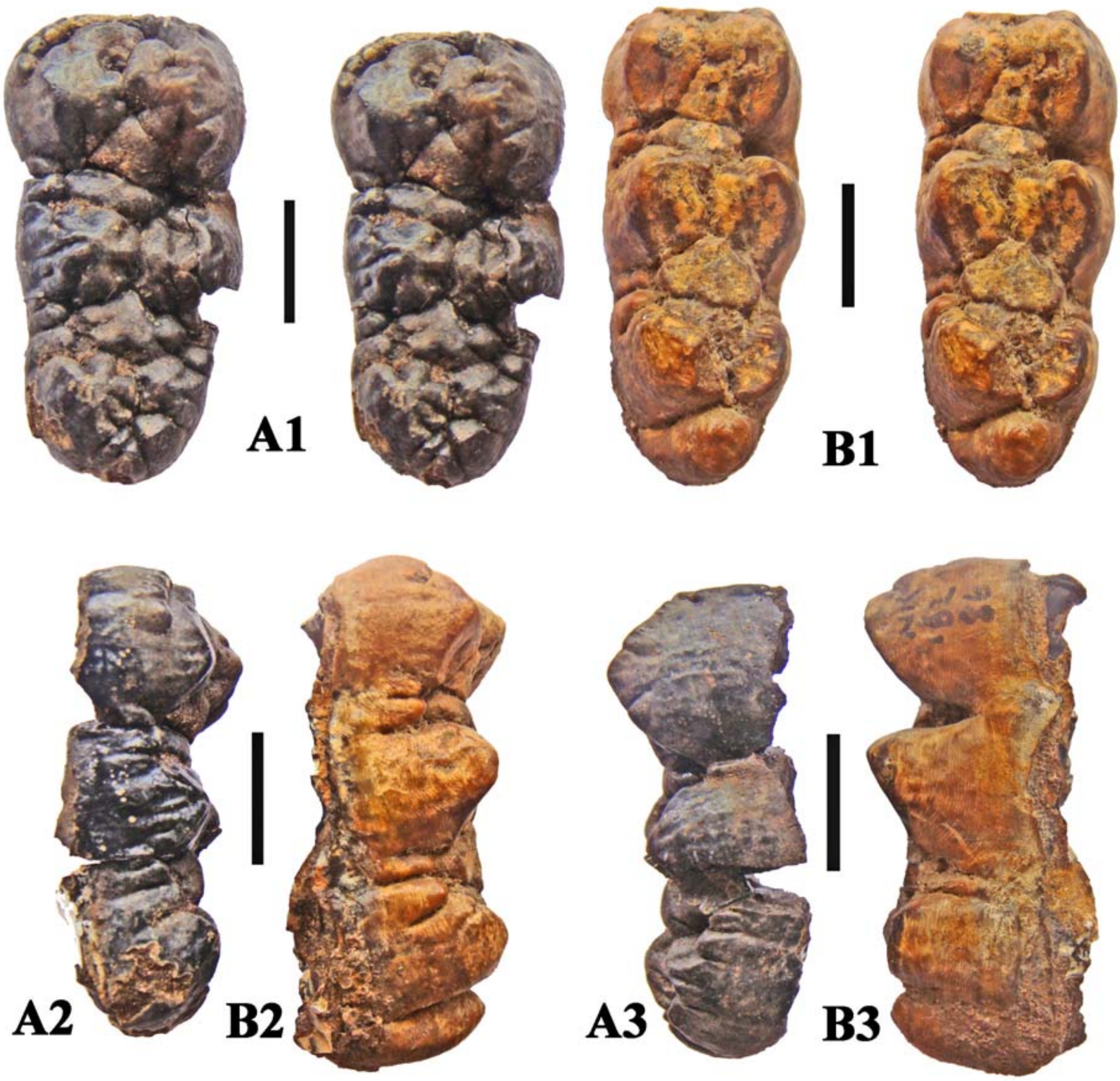

Figure 14. Left lower third molars of tetraconodont suids from Uganda. A) *Sivachoerus devauxi*, Kom 7, 8'12, from Jupakombe 7, West Nile, and B) *Nyanzachoerus waylandi*, NK 182'86 from Nkondo, Uganda. 1) stereo occlusal views, B) buccal views, C) lingual views (scale : 10 mm).

Biochronology

Even though the diversity of mammal fauna from Marama and Jupakombe is low (five biochronologically significant taxa) the assemblage provides clear evidence that the deposits that yielded them are of Late Miocene age (Fig. 15). Three of the taxa span the Late Miocene and Basal Pliocene, but a Pliocene correlation for Marama and Jupakombe can be excluded because two of the taxa have only been found in Late Miocene deposits, having gone extinct before the onset of the Pliocene epoch. As a whole, the combination of species at the two localities indicates a Latest Miocene correlation ca 7 Ma +/- 1 Ma.

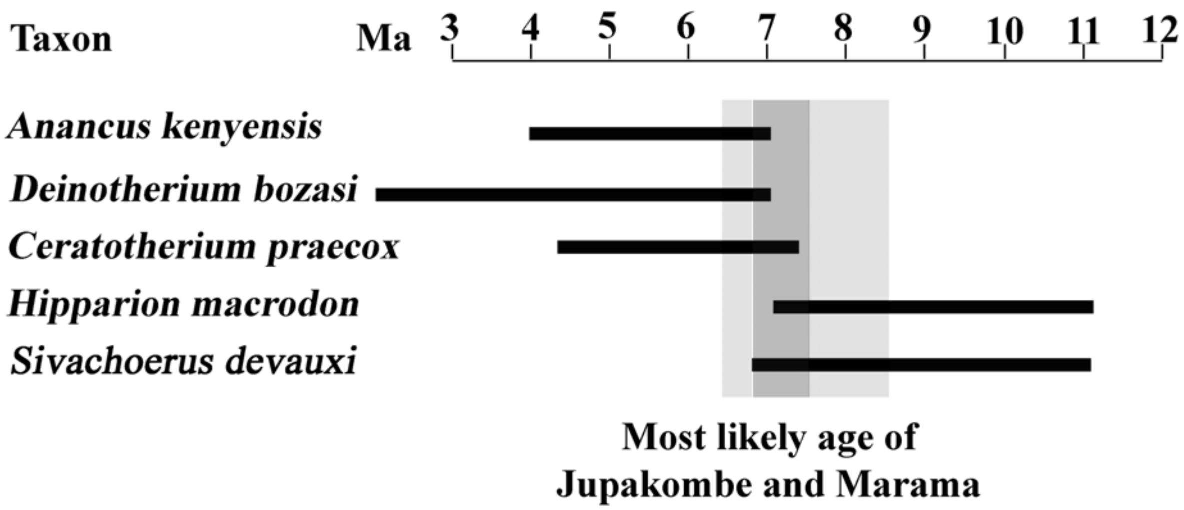

Figure 15. Biochronological correlation of the Jupakombe and Marama mammal-bearing outcrops, West Nile, Uganda, based on fossil mammals. Marama 2, which yielded only molluscs, is younger (*Lanistes bishopi*).

Molluscan biochronology

Three time-successive molluscan assemblages have been identified in the West Nile sector of the Albertine Rift (see faunal lists in appendix 1). The oldest fossil assemblages occur at Jupakombe and Marama 1 where the molluscs indicate a late pre-Obweruka correlation, ca 8 +/- 1 Ma. At Marama 2, a younger ironstone horizon yielded a specimen of *Lanistes bishopi*, indicating a correlation to the Nkondo Member further south (Molluscan Association G3a, ca 6.5 – 6 Ma). The Gengere and Jupadwonga localities yielded good samples of molluscs most likely correlating to Molluscan Association G3c (4.5 – 4 Ma) or a more evolved assemblage, but in any case older than Molluscan Association G4. Thus the deposits that were sampled by the UPE belong to the pre-Obweruka phase of the graben at the base, ranging upwards to the first phase of Palaeolake Obweruka for the younger associations. No fossils belonging to the second phase of Palaeolake Obweruka were found, suggesting either 1) the presence of a hiatus in sedimentation, or 2) the lack of outcrop, or 3) the removal of such deposits by pre-Pleistocene erosion.

Further mapping of the region is necessary to determine which of the possibilities is the correct one, but it is pertinent to point out that the Atara Ferricrete which crops out widely but sporadically in the region is observed to overlie Pliocene deposits at Atara and Jupadwonga, and to underlie the Tangi Formation, suggesting that there was a prolonged phase of pedogenesis at the end of the early phase of Palaeolake Obweruka followed by a period of erosion prior to the deposition of the Tangi deposits.

The fact that the oldest faunas (Jupakombe) crop out in the south, and the younger ones (Jupadwonga) to the north, agrees with the observed northwards dip of strata in the fault block, analogous to the Kisegi area and the Nkondo-Kaiso blocks further south in the graben, which are also tilted to the north.

Thus the molluscan associations do not contradict the biochronology deduced from the mammals – on the contrary, they reinforce the previously established correlations, summarised in figures 17 and 18.

Summary of the biochronology of the Albertine Rift Valley

In order to put the new discoveries in the Packwach area into their regional perspective, we provide a revision of the mammalian biochronology of the Albertine Rift deposits (Pickford *et al*., 1993; Senut & Pickford, 1994; Vanoverstraeten *et al*., 1990). The revised ranges of the Mio-Pliocene mammals is based on those published in Werdelin & Sanders (2010) which is the most recent overview of all African fossil mammals.

It should be noted that the onset of sedimentation in the Albertine area began during the Early Miocene some 18 Ma, as is shown by the discovery of *Deinotherium hobleyi* (Hooijer, 1963, Yasui *et al*., 1992) and *Brachyodus aequatorialis* (Hooijer, 1963) on the Congo side of the valley. The Late Miocene and Pliocene deposits yield the greatest quantity of fossils and the highest diversity of large mammals in the graben (34 taxa) in strong contrast to those of Pleistocene age which have yielded only six taxa.

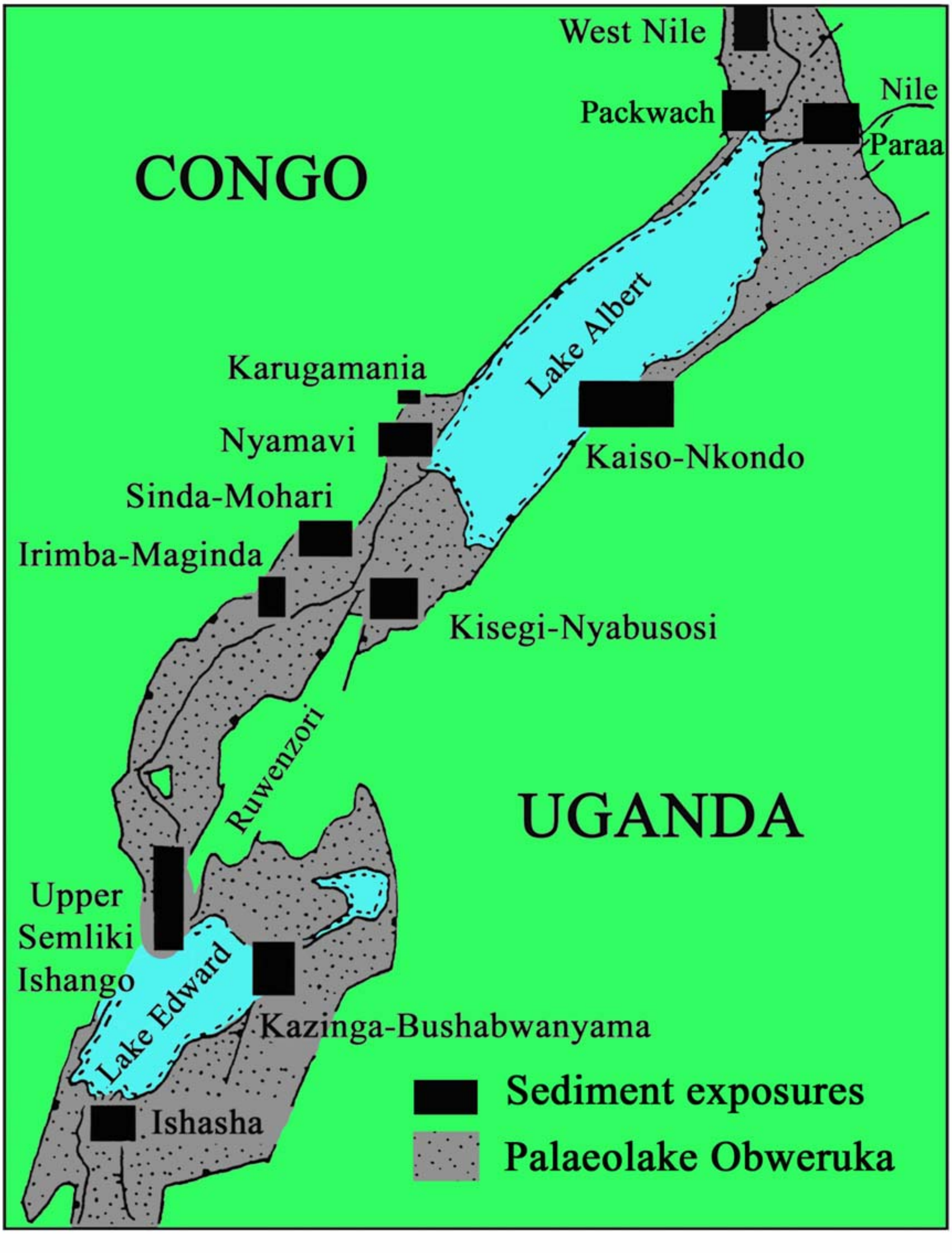

Figure 16. Summary of fossiliferous areas exposed in the Albertine Rift Valley, Uganda-Congo (modified and extended from Pickford *et al*., 1993).

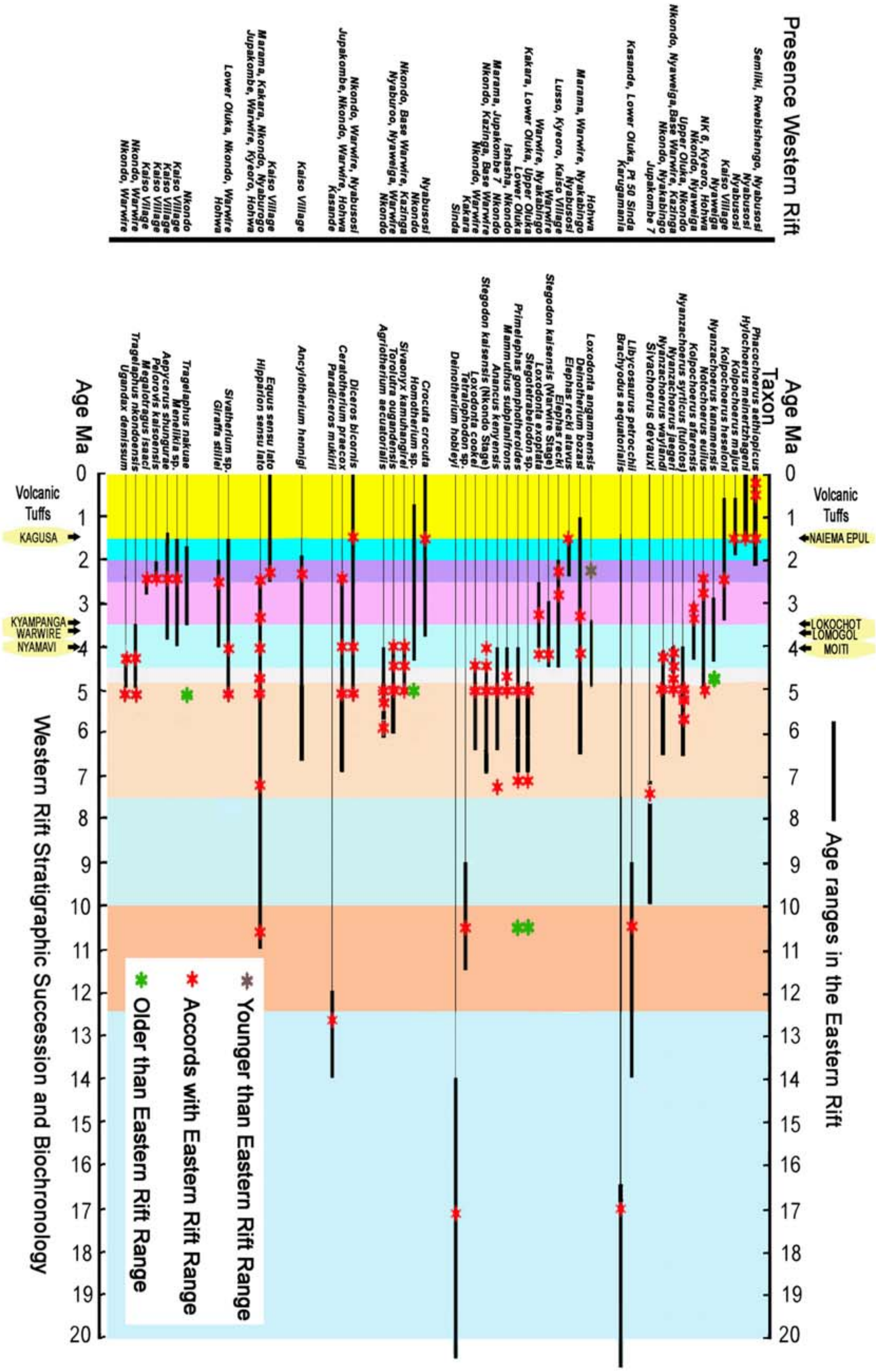

Figure 17. Summary of the mammalian biochronology of the Western Rift Valley based on updated ranges published in "Cenozoic Mammals of Africa" (Werdelin & Sanders, 2010). Note that the volcanic tuff correlations between the Eastern and Western Rift agree with the mammalian biochronology.

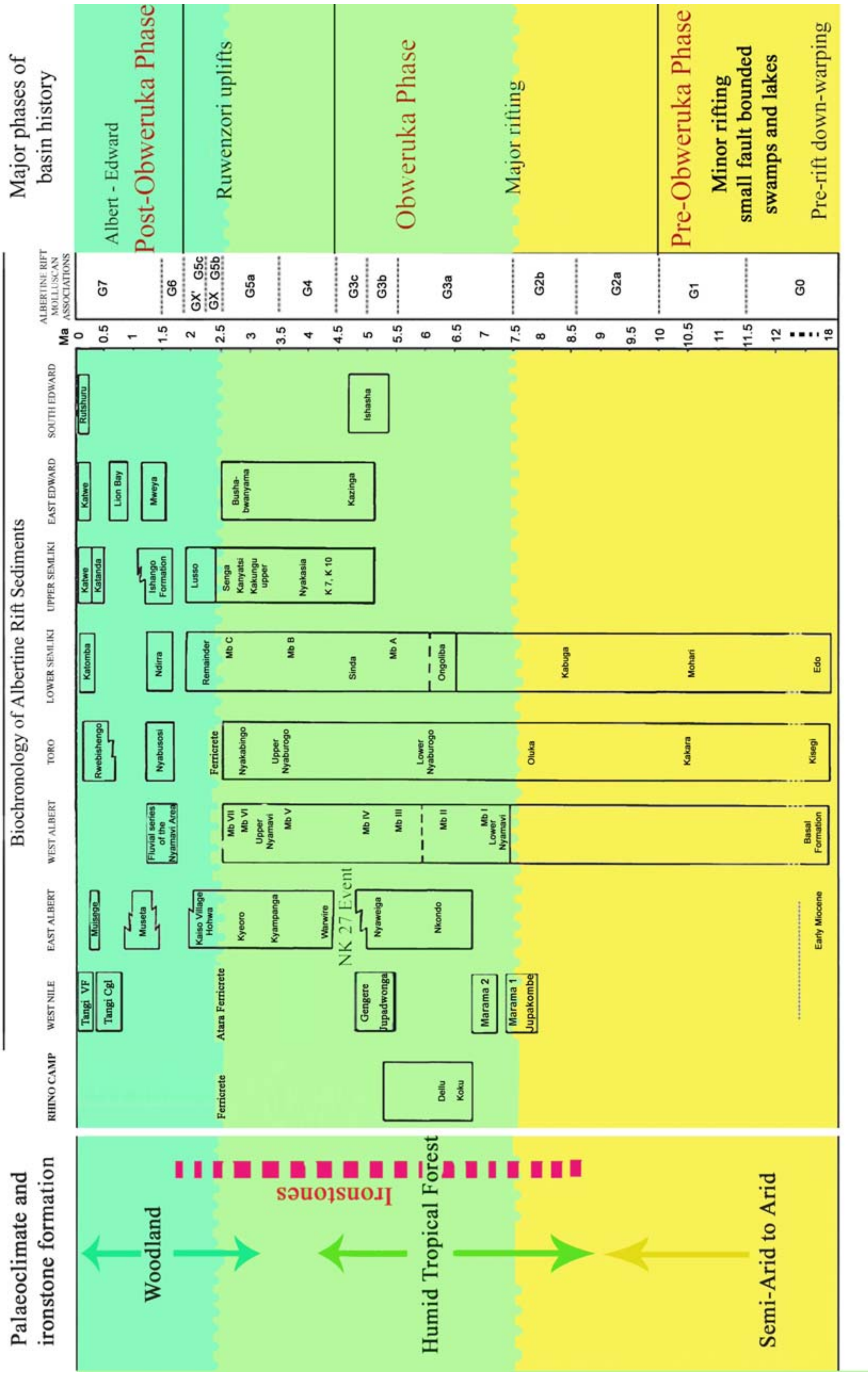

Figure 18. Proposed correlations of the Neogene and Quaternary deposits in the Albertine Graben based on molluscan and mammalian biochronology. The new samples of molluscs, and above all, the mammals from the Jupakombe and Marama suites of sites, indicate that the West Nile deposits long predate the Pleistocene.

Conclusions

Most of the sediments infilling the Albertine Graben in the West Nile region are Miocene. They underlie a relatively thin but widespread layer of Pleistocene conglomerates and soils which are younger than a lateritic ironstone horizon of Late Pliocene or Plio-Pleistocene age. Four major fossiliferous areas (Jupakombe, Marama, Gengere, Jupadwonga) comprising over two dozen separate biochronologically significant fossiliferous occurrences, yielded Mio-Pliocene fossils equivalent in age to late Pre-Obweruka, and Early Obweruka phases in other parts of the Albertine Basin. Four other localities (Pacego, Atara, Alwi-Atara, Alwi-Pateng) yielded fossils but for the moment not of biochronological importance. There is widespread evidence of an important phase of laterite pedogenesis which formed the Atara Ferricrete, pre-dating the Pleistocene deposits, which, in places, contain reworked blocks of this ferricrete.

Close to the rift boundary fault scarp, the Pleistocene strata comprise conglomerates and red soils which yield stone tools (probably Oldowan-Acheulean) similar to those in the Tangi Formation, Paraa, north of the Nile upstream from Lake Albert. In the alluvial plain to the west of the Nile, extending from the river banks up to about 50 metres above river-level, the Pleistocene deposits are dominated by black cotton soils, often with carbonate nodules, but there are patches of red deposits here and there. This alluvial plain is underlain by Miocene deposits at a roadcut on the Packwach-Panyimur track a few km south of the tarred road that runs from Packwach to Arua.

It is concluded that correlation of the West Nile deposits to the Pleistocene on the basis of interpretation of palynomorphs from drill cores, is erroneous, and that the basis of such correlations provides a good example of circular reasoning, not only in the Rhino Camp sector of the Albertine Rift, but also in all other parts of the graben. The bulk of the deposits are Mio-Pliocene and underlie an extensive, but relatively thin, sheet of Pleistocene conglomerates and sand which accumulated after a period of pedogenesis marked by the Atara Ferricrete of Late Pliocene to Early Pleistocene age. These discoveries open a new area for palaeontological prospecting, potentially of interest for research on the origins of the hominids, as it spans the late Miocene epoch and is close to the equatorial tropical forest zone of Africa.

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Appendix I
Faunal and Floral Lists of the West Nile sector of the Albertine Rift, arranged from youngest to oldest

---

Pacego Early Pliocene?
Plants
Bivalve

Alwi Pateng Early Pliocene?
Bellamya sp.
Melanoides tuberculata

Alwi-Atara Early Pliocene?
Pisces

Atara Main Early Pliocene?
Lates niloticus
Hydrocyon
Mammals indet.

Atara 2 Early Pliocene
Plants

Atara 3 Early Pliocene
Etheria elliptica
Pseudobovaria
Viviparidae
Plants

Atara 4 Early Pliocene
Pseudobovaria
Viviparidae
Plants

Gengere Main Early Pliocene
Kaya nodulosus
Neothauma rotundum
Neothauma dubium
Neothauma nov. sp. keeled
Neothauma cf *concavum*
Melanoides tuberculata
Cleopatra
Pseudobovaria
Mutelidae
Iridinidae
Etheria elliptica
Fish

Nyabang Early Pliocene
Viviparidae

Jupadwonga Early Pliocene
Kaya nodulosus
Neothauma rotundum
Neothauma dubium
Neothauma sp.
Pseudobovaria
Nkondonaia
Coelatura
Etheria
Chambardia sp.
Iridina atrox
Iridinidae
Fish
Plants

Marama 2 Late Miocene
Molluscan Association G3a
Kaya nodulosus
Neothauma dubium
Lanistes bishopi
Bivalves
Plants

Marama 1 Late Miocene
Molluscan Association G2 and G3a
Melanoides tuberculata
Kaya nodulosus
Neothauma dubium
Lanistes aff *heynderyxci-olukaensis*
Mutela sp.
Mutela cummingsi?
?*Etheria elliptica* (internal mold)
Coelatura sp.
Lates niloticus
Clarotes
Hydrocyon
Hipparion macrodon
Anancus cf *kenyensis*
Deinotherium bozasi
Rhinocerotidae
Plants

Marama 3 Late Miocene
Viviparidae

Marama 4 Late Miocene
Lanistes aff *heynderyxci-olukaensis*
Neothauma hattinghi
Kaya nodulosus
Pseudobovaria
Iridinidae
Fish

Chelonia
Proboscidea
Plants

Marama 5 Late Miocene
Melanoides tuberculata
Iridinidae
Plants

Marama 7 Late Miocene
Viviparidae
Bivalves
Fish
Plants

Marama 8 Late Miocene
Lanistes aff *heynderyxci-olukaensis*
Pseudobovaria
Coelatura
Iridinidae
Plants

Marama Hipparion Site Late Miocene
Pseudobovaria
Iridinidae
Fish
Chelonia
Anancus
Hipparion macrodon

Jupakombe 1 Late Miocene
Neothauma hattinghi
Pseudocleopatra wilsoni
Pseudobovaria
Rhinocerotidae
Clariidae
Lates
Chelonia
Crocodylia
Anancus cf *kenyensis*
Deinotherium bozasi
Hipparion macrodon
Ceratotherium praecox
Sivachoerus devauxi

Jupakombe 3 Late Miocene
Bivalves
Gastopods
Plants

Jupakombe 5 Late Miocene
Bivalves
Gastropods

Jupakombe 6 Late Miocene
Bivalves
Gastropods
Hipparion

Jupakombe 7 Late Miocene
Melanoides tuberculata
Bivalves

Jupakombe Oolite Dipslope Site Late Miocene
Bivalves
Coprolite

Jupakombe Tortue Late Miocene
Bivalves
Clariidae
Chelonia
Mammals

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