A Palynological Study of Neogene and Holocene Sediments from Lake Albert, Uganda, with Implications for Vegetation and Climatic Changes in East Africa*

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Abstract

Samples have been analysed palynologically from four wells (Turaco 1, 2, 3 and Kingfisher 1) and adjacent field samples from Block 3 in the south of the Lake Albert graben in Uganda. The palynological assemblages from these samples have been analysed quantitatively, and a variety of pollen, spores, algae and fungi identified, together with a visual estimate of the kerogen.

The pollen and spores have been attributed to parent plants derived from the immediate and more regional surrounding areas. These include mountain, tropical forest, savannah and swamp vegetation types. In many cases, the miospores and plants have been identified to genus level, and in most cases to family level.

From the identified plants, regional vegetation trends and changing abundances are recognised which are tied to climatic cycles/changes, related to the effects of the northern hemisphere Ice Ages and, more locally, to the effects of doming in East Africa. When calibrated using occurrences of age diagnostic pollen, this gives the basis for a robust age breakdown for these sequences, enabling accurate correlation across the southern Lake Albert area.

The character of the local vegetation source, the kerogen type and the algal/fungal recovery are also integrated with lithologies and, within the well sections, wireline data to enable interpretation of depositional style within these two very different areas.

Overall Depositional Setting

The Turaco and Kingfisher wells are located in the southern part of the Albert Basin in Uganda (Figure 1). They comprise a variety of lake, fluvial, alluvial plain, delta plain, marsh and swamp sediments, which are entirely non-marine. The Turaco section was deposited under predominantly alluvial and delta plain conditions, while the Kingfisher section comprises predominantly lake deposits.

The Turaco samples yield high palynomorph recoveries throughout, a consequence of the predominantly swampy conditions within an alluvial/delta plain depositional setting.

The Kingfisher samples exhibit variable palynomorph recoveries, with deposition under predominantly lacustrine conditions, and are considered to reflect vegetation changes in the immediately surrounding area. These vegetation changes are considered directly related to climatic changes. It is notable that the assemblages show little evidence of a direct fluvial influence.

Vegetation Types

The pollen and spores recovered can be related to parent plants and thence to specific environments. Warmer and wetter interglacial phases tend to be characterised by high abundance assemblages, whilst cooler and more arid phases are characterised by low abundance palynofloras.

Specific vegetation types related to their habitat are as follows:

- High altitude (above 1500m) mountain forest, arid and cooler climate
- Mountain and lowland tropical forest, wet climatic phase
- Savannah and bushland, humid seasonal climate
- Lowland forest swamp, wet climatic phase
- Lakeside and marsh, wet climatic phase
- Lake, streams, and rivers

High Altitude (above 1500m) Mountain Forest, Arid and Cooler Climate (Figure 2)

This vegetation belt is characterised by abundant *Podocarpus* spp., in association with *Alnus* spp., Ericaceae spp., *Juniperus* spp., *Olea* spp., and *Ilex* spp. These taxa are derived from high mountain habitats. The increase in these pollen within the study area indicates extension of the mountain forest belt towards lower altitudes as a result of lower temperatures brought on by ice-age cooling in the northern hemisphere.

Mountain and Lowland Tropical Forest, Wet Climatic Phase (Figure 3)

A variety of tropical forest taxa are recognised, which include *Costus* spp., *Croton* spp., *Euphorbia* spp., Malvaceae spp., *Margocolporites* spp., Moraceae spp., *Polygala* spp., *Proteacidites* spp., *Psychotria* spp., *Rostriapollenites robustus*, Sapotaceae spp., Solanaceae spp., *Striatricolpites catatumbus and Tournefortia* spp., together with a variety of retitricolpate, retitricolporate, tricolpate, tricolporate and psilatricolporate pollen. The tropical forest will also include a variety of ferns and tree ferns.

Savannah and Bushland, Humid Seasonal Climate (Figure 4)

This vegetation belt is characterised by the high abundance of Gramineae pollen (grass), with associated *Acacia* spp., Asteraceae spp., Chenopodiaceae spp., *Echitricolporites maristellae, Echitricolporites spinosus, Echiperiporites estelae*, *Fenestrites* spp., *Ipomoea* spp., *Mimosa* spp. and the ferns *Asplenium* spp., *Blechnum* spp., and *Pteris* spp. In general, a drier climate with marked rainy seasons favours the development of extensive grasslands.

Lowland Forest Swamp, Wet Climatic Phase (Figure 5)

Typical swamp taxa include the tree *Pachydermites diederixi (Symphonia*), palms, and a variety of ferns. In addition, the palynofloras of this vegetation belt are characterised by an abundance of fungal hyphae and fungal spores.

Lakeside and Marsh, Wet Climatic Phase (Figure 6)

Abundances of the freshwater algae *Botryococcus* spp. and *Pediastrum* spp. are typical of the lakeside and marsh vegetation belt. These are associated with the aquatic and semi-aquatic ferns *Laevigatosporites* spp. and *Magnastriatites howardii,* the herbs Cyperaceae spp., *Ipomoea* spp., *Sagittaria* spp., Onagraceae (*Triorites* spp.), *Typha* spp., and *Polygonum* spp., and the carnivorous herb *Utricularia* spp. In addition, the palynofloras are generally characterised by an abundance of fungal hyphae and fungal spores.

Lake, Streams, and Rivers (Figure 7)

An abundance of the freshwater alga *Botryococcus* spp. is typical of open still-standing freshwater, whilst an abundance of the freshwater fluvial alga *Pediastrum* spp. is typical of input from streams and rivers.

Age Definitions

Overall changes within the total palynoflora related to changes within the climate through time enable a robust stratigraphy to be developed using these abundance variations. These palynofloral characteristics are outlined below and detailed in Figure 8.

Late Pleistocene: Defined by an abundance of *Podocarpus* spp. pollen, in association with a variety of other high-mountain-derived pollen, such as *Alnus* spp., *Erica* spp., *Ilex* spp., *Juniper* spp., and *Olea* spp.

Early Pleistocene: Characterised by an abundance of Gramineae spp., associated with the persistent recovery of high mountain-derived pollen.

Late Pliocene: Defined by the highest occurrence of *Peregrinipollis nigericus,* together with other associated pollen, including *Praedapollis* spp., *Retitricolpites amapaensis,* and *Rostriapollenites robustus* (Figure 9).

Early Pliocene: Characterised by an increase in tropical forest pollen, associated with a distinct reduction in Gramineae spp.

Climatic Definitions

Based on overall changes in abundance and types of vegetation, a number of climatic phases can be recognised. Warmer and wetter interglacial phases tend to be characterised by high abundance assemblages, whilst cooler and more arid phases are characterised by low-abundance assemblages. Within these phases, intervals dominated by savannah, marsh, swamp, forest, etc. can be identified. The dominant vegetation types and their relationship to stratigraphy and global temperature changes are summarised in Figure 10.

References

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Hardenbol, J., J. Thierry, M.B. Farley, P.C. de Graciansky, and P.R. Vail, 1998, Mesozoic and Cenozoic sequence chronostratigraphic framework of European basins *in* Mesozoic and Cenozoic sequence chronostratigraphic framework of European basins: Special Publication SEPM, v. 60, p. 3-13.

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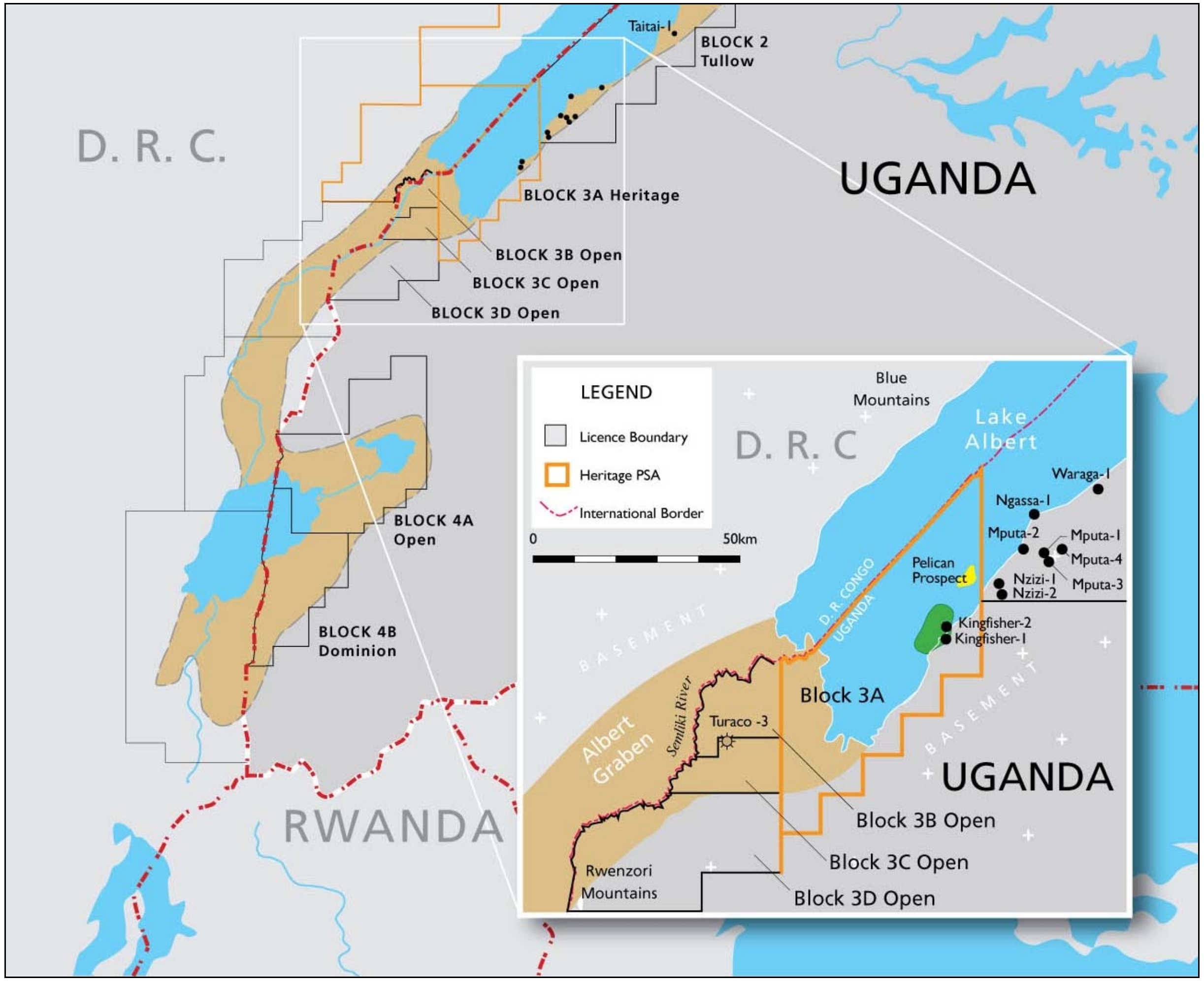
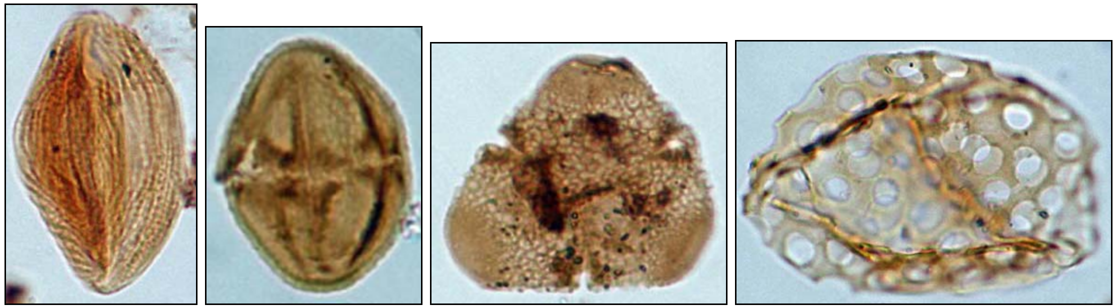


Figure 1. Location Map.

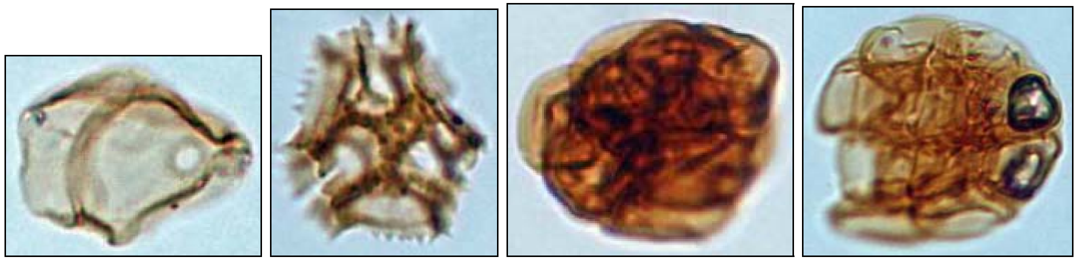
Podocarpus sp. *Juniperus* sp. *Ilex* sp. *Alnus* sp.

Figure 2. Vegetation types of environment characterised as high altitude (above 1500m) mountain forest, arid and cooler climate.



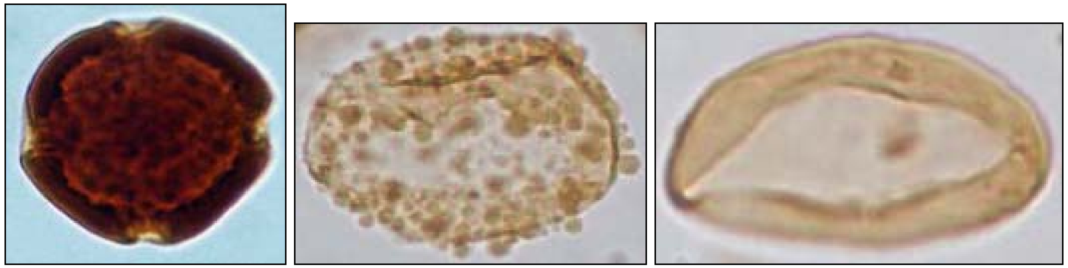
Crudia sp. *Euphorbia* sp. *Bombax* sp. *Costus* sp.

Figure 3. Vegetation types of environment characterised as mountain and lowland tropical forest, wet climatic phase.



Gramineae sp *Asteraceae sp.* *Mimosa sp.* *Acacia sp.*

Figure 4. Vegetation types of environment characterised as savannah and bushland, humid seasonal climate.

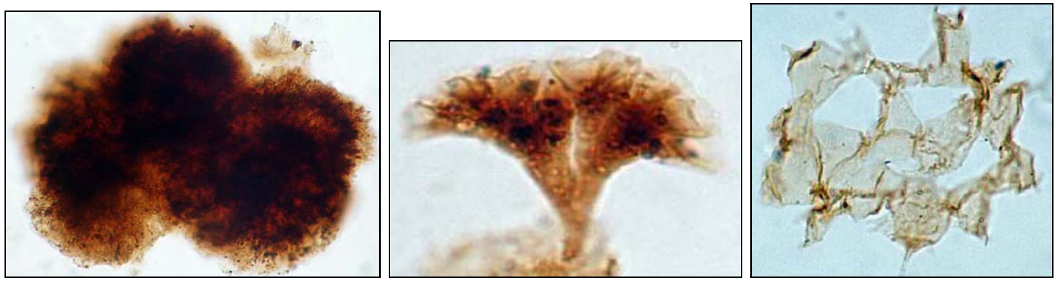


Pachydermites diederixi *Hyphaene thebaica* *Monocolpites* sp.

Figure 5. Vegetation types of environment characterised as lowland forest swamp, wet climatic phase.

Cyperaceae sp. *Typha sp.* *Polygonum sp.*

Figure 6. Vegetation types of environment characterised as lakeside and marsh, wet climatic phase.



Botryococcus spp. *Pediastrum* sp.

Figure 7. Vegetation types of environment characterised as lake, streams, and rivers.

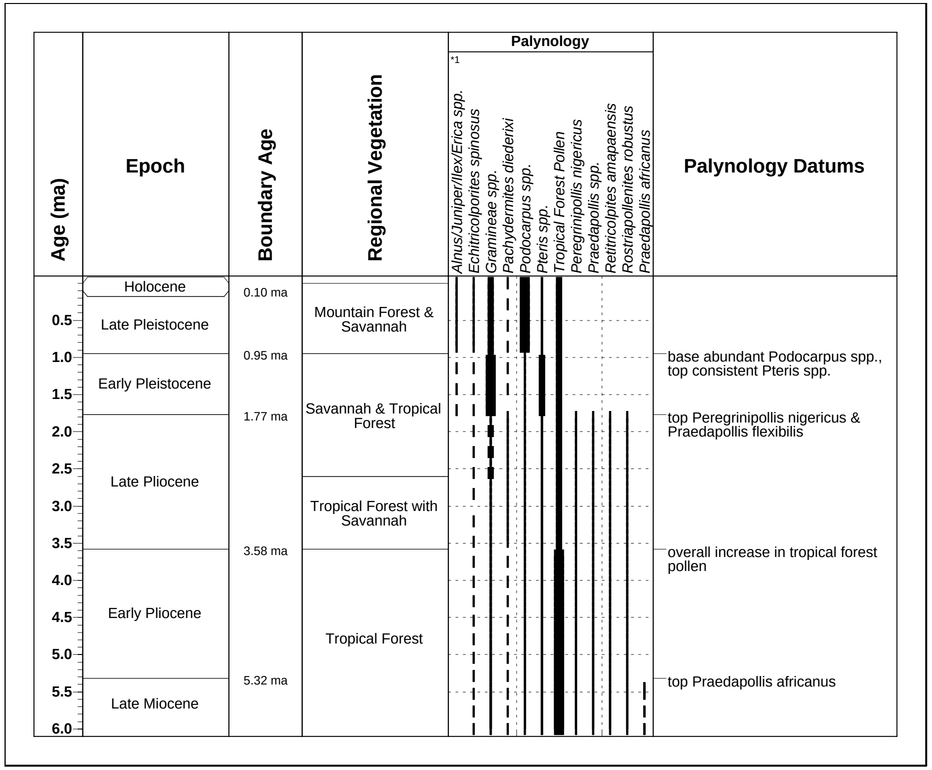
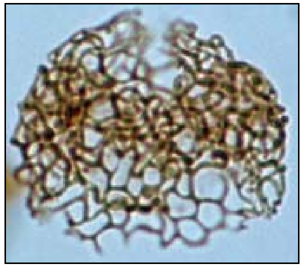
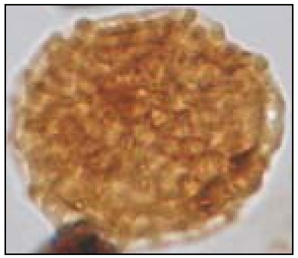


Figure 8. Characteristic late Pliocene (and older) taxa.

Peregrinipollis nigericus



Praedapollis spp.



Retitricolpites amapaensis

Rostriapollenites robustus

Figure 9. Principal palynology ranges and datums, and regional vegetation for the Late Neogene of the Lake Albert Area

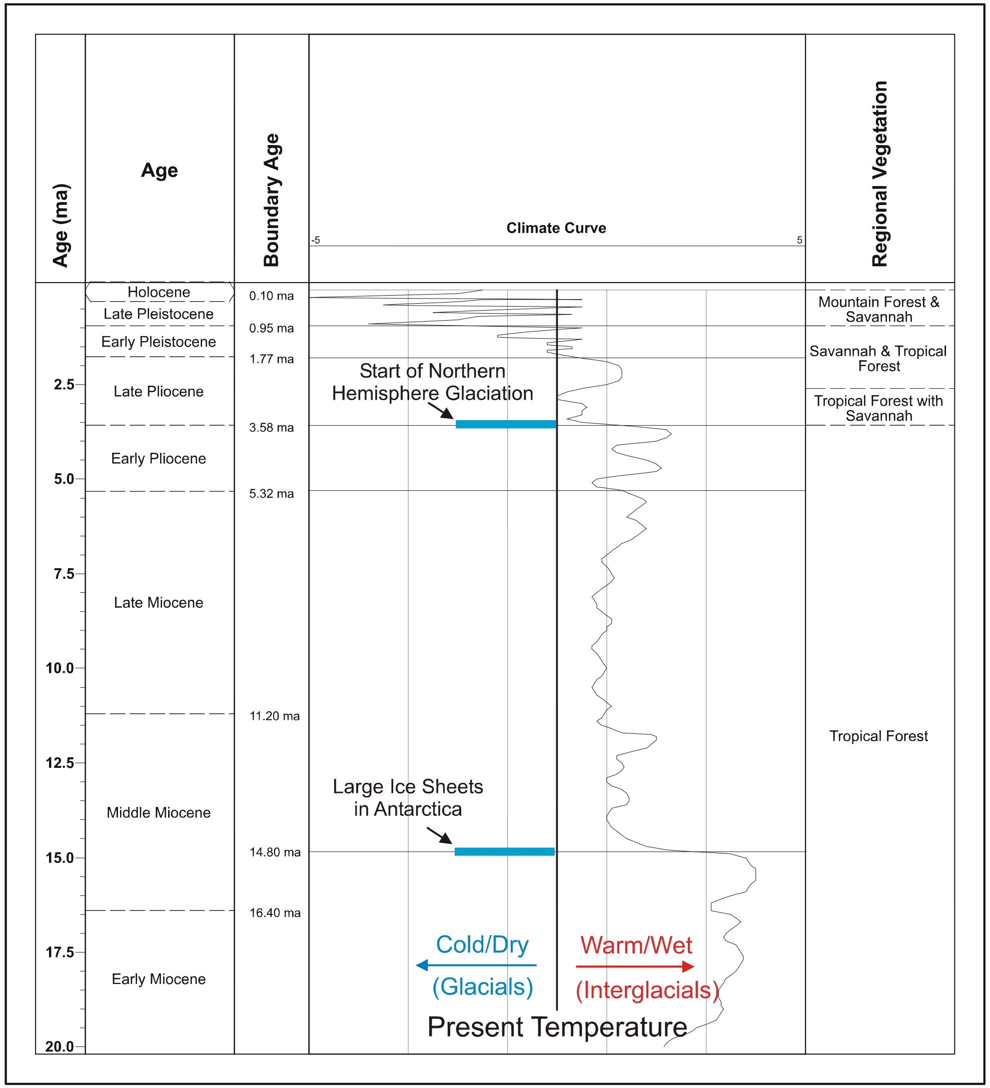


Figure 10. Mean global temperature change (based on oxygen isotopes and plant macrofossils, vegetation, and climatic cycles for the Neogene of East Africa (after Frakes 1979; Hardenbol et al., 1998)