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Early Pleistocene lacustrine sedimentation and diatom stratigraphy at Munya wa Gicheru, southern Kenya Rift Valley

R. Bernhart Owen [a,*], Ray K.L. Lee [a], Robin Renaut [b]

[a] *Department of Geography, Hong Kong Baptist University, Kowloon Tong, Hong Kong*
[b] *Department of Geological Sciences, University of Saskatchewan, Saskatoon, SK, S7N 5E2, Canada*

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ABSTRACT

This research develops a detailed palaeoenvironmental history for sediments at Munya wa Gicheru (southern Kenya Rift) and explores the roles of tectonics and climate in the formation of palaeolakes and their use in regional climate correlation. The lacustrine facies of the Munya wa Gicheru deposits were formed from ~1.9 to 1.65 Ma and consist of massive and laminated diatomites and diatomaceous silts. Fresh water diatoms include *Stephanodiscus transilvanicus*, *Stephanodiscus niagarae*, *Aulacoseira agassizi*, *Aulacoseira ambigua*, *Aulacoseira goetzeana*, *Aulacoseira granulata* var. *valida*, *A. granulata* var. *angustissima* and *Pseudostaurosira zeilleri*. One moderately saline phase is marked by the dominance of *Cyclotella meneghiniana* and by the presence of rare *Thalassiosira rudolfii*. Twenty-five diatom-based zones and subzones can be distinguished, representing eight high-lake periods and eight shallow-water phases. Erosion surfaces and desiccation cracks indicate two periods of emergence. Lake waters ranged in pH from 7.2 to 9, with conductivities of ~200–11,000 μS cm^{-1}, but mostly <1000 μS cm^{-1}. In contrast, the uppermost sediments are comprised of fluvial silts, sands and gravels formed in fluvial, sheetwash and terrestrial settings and represent termination of lacustrine conditions. REE data suggest that the Limuru Trachytes are the dominant source of siliciclastics materials. Geochemical information indicates that catchment weathering was moderate and that CaO concentrations in the sediments are very low. Carbonate rhizoliths are absent. SEM images show minimal corrosion or alteration of the diatom silica.

1. Introduction

The search for accurate climate–environment records in East Africa has been partly driven by a need to better understand hominin/hominid evolution (Feibel, 1997; Potts, 1998, 2004, 2007; Bobe and Behrensmeyer, 2004; deMenocal, 2004; Behrensmeyer, 2006; Owen et al., 2008), but in continental rift settings developing such records can be extremely difficult. Rift valleys include many depositional environments including wetlands, fresh and saline lakes, ephemeral playas, fluvial (channel) and alluvial (floodplain) settings, regions where aeolian processes are prominent, environments where volcanic deposition dominates, and substrates where sediments of diverse origin undergo pedogenesis. Rift subsidence also allows the sediments associated with these conditions to be buried, thus preserving a record of past environmental change. However, the tectonic movements and subsidence that provide accommodation for sediment preservation (Bohacs et al., 2000) can also modify the environmental conditions, locally and regionally, thus confusing attempts to interpret and decipher climatic signals.

Many researchers have tried to discriminate between climate and tectonic influences in faulted settings and over differing geological time scales (Ritter et al., 1995; Maslin and Christensen, 2007; Schulte et al., 2008; Mancin et al., 2009). One approach has been to mask tectonic signals by comparing deposition in differing sedimentary basins (Yuretich, 1982; Barker et al., 2004; Owen et al., 2009a). Trauth et al. (2005, 2007) adopted this approach to evaluate climate change through the last five million years in East Africa using sedimentary outcrops in the Kenya and Ethiopian rifts. One of the depositional basins they selected is at Munya wa Gicheru (MwG) in the southern Kenya Rift. Those deposits were interpreted as representing a large lake that existed during a period of relatively wet conditions.

Excellent exposures of lower Pleistocene sediments are present at MwG, at 1°11′16″S, 36°32′53″E, along the eastern flank of the southern Kenya Rift Valley (Fig. 1). The deposits crop out in a disused diatomite quarry and along two stream valleys over an area of about 0.5 km^2. The deposits are cut by numerous north–south trending normal faults and lie between the Ewaso-Kedong section of the rift valley floor and the adjacent Kikuyu Highlands. The Suswa volcanic complex lies to the north with the rift floor gradually declining in elevation southwards to the Olorgesailie and Magadi Basins (Fig. 1).

The MwG sediments were first reported by Gregory (1896) who believed they were part of a Pliocene lake (Lake Suess) that extended across the Kedong Valley and the Suswa plains to the west.

* Corresponding author.
E-mail addresses: owen@hkbu.edu.hk, mzungu@i-cable.com (R.B. Owen).

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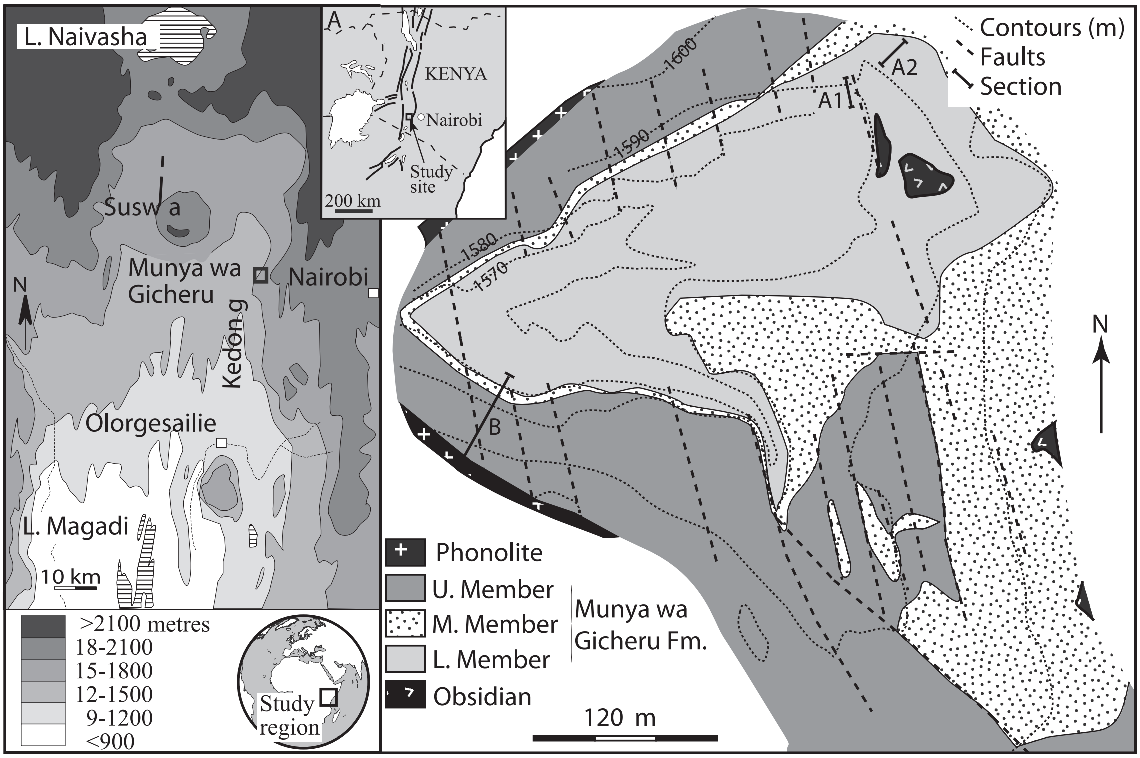

Fig. 1. Location and geological map of the Munya wa Gicheru basin. After Ngecu and Njue (1999).

Subsequently, he assigned the deposits to the late Pleistocene (Gregory, 1921). Sikes (1926) illustrated the main outcrop. Shackleton (1955) suggested that the lake might have been confined to a narrow faulted trough. The deposits at MwG rest on obsidian that formed at a late stage in the eruption of the Limuru Trachytes, which Baker et al. (1988) dated at about 1.96 Ma. Dates of 1.75–1.65 Ma (Strecker, 1991; Boven, 1992; Trauth et al., 2007) are reported for hyaloclastic rhyolites in the middle of the MwG succession (Fig. 2). Trauth et al. (2007) also reported a date of 1.65 Ma for a pumice lapilli tuff in the upper part of the sequence and an age of 0.724 Ma for phonolites that disconformably cap the deposits.

Baker and Mitchell (1976) reported the presence of a 35-m-thick sequence with a middle Pleistocene fauna and suggested that the palaeolake was formed by "post-Plateau Trachyte fault movements, possibly aided by damming of the [southward flowing] Kedong river by south-flowing Suswa lavas". Saggerson (1991) outlined the general features of the deposit and gave details of its chemistry and economic potential. Ngecu and Njue (1999) outlined the stratigraphy of the deposits, which they divided into three members, noting that the sediments generally thickened westwards to an observed maximum of 25 m. Trauth et al. (2007) presented a 29-m-thick section of the formation that showed the occurrence of diatomites, silty diatomites, tuffs, silts and gravels, as well as reporting that the diatom floras were dominated by *Stephanodiscus* and *Aulacoseira* spp. (*Stephanodiscus niagarae*, *Stephanodiscus transylvanicus*, *Stephanodiscus carconensis* and *Aulacoseira granulata*), but gave no detailed diatom stratigraphic record.

This paper presents a sedimentological and diatom analysis of the MwG deposits. The major aims of this study are to develop: 1) a high-resolution diatom stratigraphy; 2) to integrate the diatom data with sedimentological and geochemical evidence in order to develop a palaeoenvironmental history for the area, and 3) to relate the environmental record to the broader tectono-climatic history of the rift system.

2. Methods

Samples were collected from three sections (Fig. 1). Local correlation is very good for Sections A1 and A2, which lie only 40 m apart and reach a composite thickness of 15 m. Section B is 17.5 m thick with a gap due to a lack of exposure at 11.5–11.9 m. Correlation between these two sections is less clear, but field relationships indicate that Section B overlies Sections A1 and A2.

Samples for diatom analyses were collected at 10–15 cm intervals and at lithological boundaries. Carbonates were removed using 10% HCl, followed by washing in distilled water. The cleaned diatoms were mounted in Naphrax on smear slides and observed on an Olympus microscope with phase contrast and brightfield illumination at 1000x magnification. Diatoms were also examined using a LEO 1530 Field Emission Scanning Electron Microscope. Taxa were identified using the works of Gasse (1980, 1986) and Krammer and Lange-Bertalot (1986–1991) and updated according to the Integrated Taxonomic Information System (ITIS; http://www.itis.gov). A minimum of 400 diatoms were counted on the smear slides, except where diatoms were rare in which case all diatoms were included. Visual estimates were made of the percentage of the carbonate-free sample that consisted of diatoms and the proportion of broken frustules. The occurrence of phytoliths and sponge spicules was documented relative to number of diatoms in a sample.

Agglomerative Hierarchical Cluster Analyses (AHC) using Pearson Dissimilarity and Unweighted Pair-group Mean Averaging (UPGMA) were carried out using XLSTAT-PRO for the entire flora. Only common taxa that constituted $>5\%$ of the flora in at least two samples or $>10\%$ in at least one sample (33 taxa) are shown in the resulting species dendrogram. CANOCO 4.51 was used to carry out correspondence analyses (CA) for diatoms that comprised $>2\%$ of the flora in at least one sample (90 taxa) in order to develop a broader perspective of the floral assemblages. Stratigraphic diagrams were plotted using the programme C2 (Juggins, 2011).