Radiometric dating of recent lake sediments from a highly eroded area in semiarid Tanzania

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Abstract

Semiarid regions are vulnerable environments with a series of important and often discussed problems such as land degradation, water scarcity and desertification. These regions are dynamic and respond quickly to climatic and environmental changes. Unlike lakes in temperate zones, lakes in semiarid regions are yet poorly utilized as climatic and environmental indicators. In this study aquatic deposits are used to uncover the environmental history of a severely degraded area in central Tanzania. The 210 Pb and 137 Cs chronologies date a 360 cm long sediment sequence to 155 years. The sediments show that lake Haubi basin changed from a seasonally waterlogged depression to a lake at the turn of the century. Calculated sedimentation rates show that the catchment of the lake has been subject to varied and enhanced soil erosion during the last 155 years.

Description of study area

Lake Haubi (4° 47′ S, 35° 57′ E), with a lake area of 2.1 km², has been used to uncover the environmental history of a severely degraded area in Kondoa Irangi Hills, central Tanzania. Lake Haubi (Figure 1) is located about 1800 m a.s.l. in a hilly landscape where large parts of the slopes are dissected by gullies up to 20 m deep, and badlands are common (Payton et al., 1992). Sheet erosion, which occurs over the whole area, has removed up to 2–3 m topsoil of the hillslopes (Payton & Shishira, 1994). More details on the erosion history of the Haubi basin is given in Eriksson & Christiansson (1997). Average yearly precipitation varies between 600 and 900 mm for different parts of Kondoa Irangi Hills and falls with great intensity between November and May. Variations between humid and dry years are, as often in semiarid climates, of great magnitude (Kas-sas, 1995). Landuse in the last few hundred years in Kondoa Irangi Hills has been characterized by agropastoralism (Mung’ong’o, 1995). A grazing prohibition came into force in 1979 and since then the vegetation has recovered remarkably and some gullies have stabilized. Alteration of rainfall and landuse intensities affects soil erosion (Olsson & Rapp, 1991) and results in a very dynamic sedimentation environment. In Lake Haubi, dried out and permanent lacustrine conditions, with high and low sedimentation rates, have succeed each other. Eriksson & Christiansson (1997) found evidence for the lake to have formed around 100 years ago. It was previously a seasonally inundated valley floor which developed gradually, probably over more than a decade, to a lake. There are no written records on the lake history, but according to people living in the surrounding the lake dried out completely in the early 1940’s. Since 1994 the lake has turned into a well vegetated seasonally inundated swamp. In such lake environment, which differs from the most dynamic areas in temperate regions, the reconstruction of recent sediment chronologies using radiometric dating proved to be a demanding task.

Material and methods

In July 1992 seven sediment cores were retrieved from Lake Haubi using a modified Livingstone piston corer operated from a Zodiac rubber boat. The depth of the
Figure 1. The severe land degradation in the Kondoa Irangi Hills, including sheet and gully erosion, has put the area in focus for land rehabilitation schemes. The gullies feed directly into Lake Haubi via low-angle sand fans. Note person on gullies, for scale.

Lake was 1.3 m at the time of coring. This shallow lake water in combination with very soft character of the surface sediments caused problems in taking long continuous cores. However, by combining four overlapping cores a sediment sequence covering a depth of 16 to 361 cm beneath the sediment surface was obtained. The sediment sequence consists of three main stratigraphical zones; A, B and C, where C is divided into six subunits, C1–C6. Zone A consists of stiff clay with a mineral composition of montmorillonite (30%), kaolinite (30%), illite (30%) and goethite (10%). Nodules rich in Ca and Mg were also found in zone A. Large portion (30–70%) of the carbon content of zone A consists of charcoal. The high contents of preserved organic matter in Zone B indicate that this material was formed in more permanent aquatic conditions as compared to zone A (Eriksson & Christiansson, 1997). Zone B, therefore, represents the transition from a seasonally waterlogged depression, probably a swamp like environment, to a lake. The organic content presented in Figure 3b shows average values and peaks of high organic content which occurs in zone B are not shown. Zone C has laminated sediments where laminae varies in colour, thickness and plainness. The variation of the brownish colour in zone C seems to be related to the presence of Fe compounds. The three different zones (Figure 2, upper part) reflect the general development of the lake system. Zone C, however, represents the actual history of Lake Haubi where each subunit is the result of certain developments. Chronological changes of such dynamic environments (Roberts et al., 1993), if the dating of semi-arid lake sediments is possible, can be linked to known human activities, environmental changes and climatic fluctuations as is usually done in temperate zones (Battarbee et al., 1990; Berglund, 1991; MARC, 1985; IAEA, 1983).

Four bulk samples from zones A and B were 14C-dated using Accelerator Mass Spectrometry (AMS). The two samples from A (300–301 cm and 250–251 cm) gave calibrated ages ranging from 2350 BP–2740 BP and 470 BP–650 BP (using 2σ), while samples from B (237–238 cm and 230–231 cm) proved to be ≤260 BP and recent respectively. Because of the absence of microplant remains 14C-dating was performed on the NaOH-soluble fractions. The AMS results are in agreement with two ages made on bulk