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Pedogenic stable isotope records of Plio-Pleistocene southern hemisphere vegetation dynamics (Chiwondo Beds, Northern Malawi)

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Oxygen and carbon isotope geochemistry of pedogenic carbonates is a powerful tool to reconstruct paleoenvironmental and paleoclimatic conditions in particular when climate seasonality plays a key role in the evolution of ecosystems. Numerous studies have documented the impact of long-term vegetation change on the evolution of hominids with a strong regional focus on East African sites in Kenya and Tanzania.

Here we present the first Plio-Pleistocene long-term East-African pedogenic carbon and oxygen isotope data from the mid latitude southern hemisphere located within the Chiwondo Beds in the Karonga-Chilumba area at the northeast shore of Lake Malawi. These ca. 5.0 to 0.6 Ma old sediments are situated between the well-known hominid-bearing sites of eastern and southern Africa. They are home to two hominin fossil finds, a maxillary fragment of Paranthropus boisei and a mandible of Homo rudolfensis, both found among other mammal fossils in paleosol, fluviatil, swamp, beach, deltaic, and lacustrine deposits of the Chiwondo formation. Since this is the first southern hemisphere record in the East African Rift, the region is particularly interesting for reconstructing vegetation patterns and correlate these across the ITCZ with data on the evolution and migration of early hominids.

We use pedogenic carbonate δ^{13}C values to assess the evolutionary history of C_3 and C_4 biomass in the Malawi Rift Valley during the time of early hominid evolution. The reconstruction of the development of C_4-grasslands give insights of changing atmospheric CO_2-concentration, seasonality and distribution of precipitation, and the retreat of tree cover.

Almost 500 pedogenic carbonate samples from over 20 sections show δ^{13}C values that average around -8.5 ‰ over the past 5 Ma with no significant short-term δ^{13}C excursions. The absence of long-term trends towards more positive δ^{13}C values and hence the increasing role of C_4-grasslands that is well documented for northern hemisphere sites in Kenya and Tanzania points to regional changes in vegetation dynamics during the Plio-Pleistocene in the East African Rift Valley.

The emergence of C_4 grass biomes and development of open landscapes has frequently been correlated with the importance of bipedalism during hominin evolution. The persistence of a mixed C_3/C_4 vegetation through the Plio-Pleistocene with a large proportion of C_3 trees and shrubs in a region that played a key role in developing the first hominid populations hence requires additional parameters such as rainfall or temperature seasonality/cyclicity to be major drivers of human evolution.