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Mesoclimatic imprints on palaeoclimate records from rift graben sediments: Implications from stable and radiogenic isotope data from mammalian tooth enamel

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The Neogene of East Africa is regarded as a period of long-term increasing aridity. It has been proposed that this is the result of a cooling of Indian Ocean surface waters or is caused by tectonic processes leading to the updoming of East Africa. However, mesoclimatic effects induced by the dynamics of the formation of rifts involving uplift of the rift shoulder and subsidence of the rift valley have been largely neglected so far.

We have studied mesoclimatic variability by monitoring the evolution of the Albertine Rift (western branch of the East African Rift System) for the last 7 Ma using the tooth enamel of hippopotamids (Mammalia) as environmental archive. These non-migratory, water-dependant terrestrial mammals are particularly useful for palaeoclimate reconstructions because they have no dietary preferences with respect to C3 – C4 vegetation. By inhabiting lakes and rivers, Hippopotamids document mesoclimates of topographic depressions such as rift valleys and, therefore, changes of relative valley depth rather than entirely global climate changes. Average stable isotope compositions of oxygen and carbon were obtained from transects along drill cores through enamel. The Sr isotopic composition was determined by laser ablation multi-collector ICP-MS (Nu Plasma).

13C/12C isotope values in enamel imply the presence of pure C3 browsers (delta 13C < -9 per mil VPDB) from 7.0 to 3.0 Ma and pure C4 grazers (delta 13C > -1 per mil VPDB) from 2.3 to 1.0 Ma. This suggests a spread of grasslands during a maximum in aridity from 2.3 to 1.0 Ma. 18O/16O shows a systematic increase from values of -4.5 at 7.0 Ma to +1.4 per mil (delta 18O VPDB) 2.0 Ma ago. The Sr isotopic composition also increases systematically from 0.713 to 0.717 during this time period. This parallel evolution of 18O/16O and 87Sr/86Sr being climate and water provenance proxies, respectively, is interpreted in terms of rift shoulder uplift/subsidence of the rift valley floor. The oxygen isotopic composition of tooth enamel reflects the evolution of the meteoric water within the habitat of the hippopotamids and implies increasing evaporation of lake waters in the Albertine Rift. The variation in the Sr isotopic composition documents variable Sr fluxes from the Albertine Rift catchments composed of radiogenic Archaean, less radiogenic Proterozoic crustal rocks and unradiogenic Neogene mantle derived volcanic rocks. Lake Albert is located in Archaean rocks. Therefore, the most radiogenic strontium isotopic composition at 2 Ma implies contributions of meteoric waters draining dominantly Archaean crust and maximum isolation of the lake. This is consistent with its maximum evaporation state reflected in 18O/16O values and vegetation change inferred from 13C/12C. Our data show that mesoclimate variation induced by graben formation and rift shoulder uplift must be taken into account when interpreting rift floor related climate archives such as palaeosols.