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Evolution of the Lake Victoria basin in the context of coeval rift initiation in East Africa: a 3D numerical model approach

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Over the last four years sedimentologic and thermochronologic studies in the western and eastern branches of the Cenozoic East African Rift System (EARS) have supported the notion of a broadly contemporaneous onset of normal faulting and rift-basin formation in both segments. These studies support previous interpretations based on geophysical investigations from which an onset of rifting during the Paleogene had been postulated. In light of these studies we explore the evolution of the Lake Victoria basin, a shallow, unfaulted sedimentary basin centered between both branches of the EARS and located in the interior of the East African Plateau (EAP). We quantify the fluvial catchment evolution of the Lake Victoria basin and assess the topographic response of African crust to the onset of rifting in both branches. Furthermore, we evaluate and localize the nature of strain and flexural rift-flank uplift in both branches. We use a 3D numerical forward model that includes nonlinear temperature- and stress-dependent elasto-visco-plastic rheology. The model is able to reproduce the flexural response of variably thick lithosphere to rift-related deformation processes such as lithospheric thinning and asthenospheric upwelling. The model domain covers the entire EAP and integrates extensional processes in a heterogeneous, yet cold and thick cratonic block (Archean Tanzania craton), which is surrounded by mechanically weaker Proterozoic mobile belts, which are characterized by thinner lithosphere ("thin spots"). The lower limits of the craton (170 km) and the mobile belts (120 km) are simulated by different depths of the 1300 °C lithosphere-asthenosphere boundary. We assume a constant extension rate of 4 mm/a throughout the entire simulation of 30 Ma and neglect the effect of dynamic topography and magmatism. Even though the model setup is very simple and the resolution is not high enough to calculate realistic rift-flank uplift, it intriguingly reveals important topographic trends. The model shows that elevation differences of 120 to 180 m between the plateau interior and bordering rift shoulders are pronounced enough to form a closed basin after 6.5 Ma of extension. By that time the catchment area is already comparable to the present-day Lake Victoria catchment. Moreover, the final modeled topography, including 1000 m of dynamic and 500 m of pre-plume topography, yields a base basin elevation of 1110 m, which is also in good agreement with the present-day elevation of Lake Victoria. The combined effects of the formation of an extensive lacustrine depositional environment in the interior of the EAP after 6.5 Ma and rift-shoulder uplift may have forced far-reaching environmental impacts. These may have included the onset of the Lake Victoria microclimate, the influence of the basin and surrounding orographic barriers on precipitation patterns in East Africa, and the establishment of a unique flora and fauna.