Geophysical Research Abstracts
Vol. 17, EGU2015-766, 2015
EGU General Assembly 2015

Combining detrital geochronology and sedimentology to assess basin development in the Rukwa Rift of the East African Rift System

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We have employed a multifaceted approach to sedimentary provenance analysis in order to assess the timing and magnitude of tectonic events, sedimentation, and landscape development in the Western Branch of the East African Rift System. Our approach, termed ‘Sedimentary Triple Dating’, integrates: (1) U-Pb dating via LA-ICPMS; (2) fission track; and (3) (U-Th)/He thermochronology of detrital zircon and apatite. We integrate geochronology, thermochronology, and provenance analysis to relate the initiation of rifting events to regional dynamic uplift, sedimentation patterns, and interpret the far-reaching climatic and evolutionary effects of fluctuating rift flank topography in the Rukwa Rift, a segment of the Western Branch. This work provides additional data to support the recent concept of synchronous development of the Western and Eastern branches of the East African Rift System ~25 Ma, and better constrains the age, location and provenance of subsequent rifting and sedimentation events in the Rukwa Rift Basin.

Investigation of well cuttings and outcrop samples from the Neogene-Recent Lake Beds Succession in the Rukwa Rift Basin revealed a suite of previously unrecognized tuffaceous deposits at the base of the succession. A population of euhedral, magmatic zircons from a basal Lake Beds tuff and Miocene-Pliocene detrital zircons from well cuttings suggest that Neogene rift reactivation and volcanism began ~9-10 Ma. This timing is consistent with demonstrated rifting in Uganda and Malawi, as well as with the initiation of volcanism in the Rungwe Volcanic Province at the southern end of the Rukwa Rift, and the estimated development of Lake Tanganyika to the north. Moreover, there appear to be a suite of unconformity bounded stratigraphic units that make up the Lower Lake Beds succession, and detrital zircon maximum depositional ages from these units suggests episodic sedimentation in the rift, punctuated by long hiatuses or uplift, rather than steady subsidence and sedimentation. A distinct, upward-younging trend in detrital zircon populations associated with each stratigraphic interval suggests that volcanism was also episodic through the Late Miocene-Pliocene, and linked to periods of rifting and basin filling. Detrital zircon populations are dominated by Paleoproterozoic grains of the same age as the metamorphic Ubendian Belt that underlies the rift basin and forms the flanks. This provenance, volcaniclastic-dominated sedimentation, and clasts from the rift flanks suggest an internally draining basin and high rift flanks associated with the most recent rifting episode. There are also dominant populations of Neoproterozoic and Mesoproterozoic zircons, likely reworked from the underlying Cretaceous sandstones and derived from younger metamorphic terranes of the Ubendian Belt. Volcanic pulses associated with rifting are responsible for the young magmatic zircons, and suggest the initiation of a late Cenozoic rifting event, further constraining the timing of rifting and basin development in the Western Branch, as well as the timing of landscape change associated with erosion and uplift. Our dates additionally provide important temporal context for the rich vertebrate record described from the East African Rift, illuminating the tectonic backdrop of important large-scale faunal shifts in East Africa.