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Timing of East African Rift development in Southern Ethiopia and evolution of topography

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The precise determination of rifting chronology and timing of associated uplift is a crucial point to understand the evolution of the East African Rift System and to decipher the relative role of mantle plumes in continental break-up and topographical evolution. It is now admitted that the arrival of the deep-rooted Afar mantle plume under the African lithosphere triggered the emplacement of a thick pile of continental flood basalts 30 Ma ago and was associated with a large scale domal uplift (Pik et al., 2003). In this study (Pik et al., 2008), we examine rift related denudation along one of the major fault scarp in Southern Ethiopia in order to precise (1) the timing of rifting development as well as (2) its morphological and topographical consequences. These results have implications for a model of plumes-lithosphere interaction. They also precise the timing and relative role of rift-related uplift in a portion of the EARS where the evolution of topography could have played a major role in controlling aridification and hominids evolution history (Sepulcre et al., 2006).

In southern Ethiopia rifting developed in an anomalously broad region (Broadly Rifted Zone: BRZ, Ebinger et al., 2000) which now connects the N-S Gregory rift in Kenya to the NE-SW Main Ethiopian Rift. This BRZ is lying in a remarkable topographic depression in-between the uplifted Kenyan and Ethiopian volcanic plateaux, and is characterized morphologically by alternation of basins and variously dissected ranges from a bottom altitude of about 500 m to pinnacles that can reach 3000 m We have investigated rift-related cooling history along one of the major fault scarp in southern Ethiopia (the Hamer range) using (U-Th)/He thermochronometry (Pik et al., 2008). A spatial reconstruction of the He-PRZ position along the Hamer Range has been used to better constrain the history of rift shoulders uplift and related denudation since 20 Ma. This analysis clearly shows that the northern Chew Bahir rift segment experienced the higher amount of exhumation. According to our reconstruction (1) the original base level before uplift of the range was lying at an altitude of 600-800 m, and (2) the estimated maximum uplift experienced by the initial pre-rift surface is $\sim$ 2200 m. Because of associated erosion during shoulder formation, the real uplift of the topography has been much more limited, and is estimated to a total of only $\sim$ 1000 m..

These new data indicate that rifting started 20 Ma ago, and stress the absence of significant rift activity synchronous to the earliest Eocene volcanics. This initial magmatic episode, which preceded the main flood basalts and rifting events, is attributed to convective instabilities above the rising Afar mantle plume. The amount of uplift along the Hamer Range scarp, can be totally accounted for by considering continuous denudation since the Miocene, at a rate of 110 m/Ma, which corresponds to the value recorded by He-ages from 20 to 12 Ma. This direct evidence of denudation contradicts the generally admitted hypothesis that a massive Plio-Pleistocene increase of uplift and rifting activity triggered recent East Africa aridification (e.g. Sepulcre et al., 2006), and rather supports a major contribution of plume related doming for creation of topographical barriers.

Ebinger et al., 2000, GSA Bull., v. 112, p. 163–176

Pik et al, 2003, EPSL, v. 215, p. 73–88

Pik et al., 2008, Geology, v. 36, p. 167–170

Sepulcre et al., 2006, Science, v. 313, p. 1419–1423.