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Constraining the Cenozoic evolution of South Africa using (U-Th)/He thermochronology: the influence of dynamic topography at a passive margin

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The escarpment of southern Africa bounds the second largest elevated plateau on Earth, the “African Superswell” [1]. The escarpment separates the high elevation plateau from the coastal plain and formed in response to the opening of the South Atlantic; however, the regional elevation anomaly ($\sim$1 km) is thought to reflect dynamic support provided by deep mantle flow observed beneath southern Africa. The temporal relationship between passive margin formation and the onset of deep mantle flow is unknown. The importance of coupling between deep mantle flow, rift related tectonic processes, and past and present dynamic topography therefore remains poorly understood. This is largely because direct measurement of the timing and magnitude of surface uplift remains challenging. Improving our understanding of this coupling requires better quantitative constraints on the relatively modest ($\sim$1 km) long wavelength surface uplift.

Apatite thermochronometers are uniquely suited to addressing this lack of understanding, as they record the cooling of rocks through near surface temperatures (35-120ºC) in response to erosion. Apatite fission track thermochronology (AFT, Tc $\sim$ 70-120ºC) has been widely used to constrain the denudation history of the South African passive margin [2, 3]. However, AFT alone is relatively insensitive to the small amounts of denudation predicted to occur during the onset of the African Superswell. Consequently, the timing of plateau uplift relative to phases of Cretaceous continental breakup and passive margin formation remains unclear. Recent advances in the combined interpretation of AFT and apatite (U-Th)/He (AHe, Tc $\sim$ 35-80ºC) data sets now enables us to provide quantitative constraint on the pattern of denudation in southern Africa through the Cenozoic.

We present AFT and AHe data from a suite of deep boreholes from inland of the south African escarpment, from the high elevation plateau. Near surface samples yield AFT ages of $\sim$ 130-140 Ma and AHe ages of $\sim$ 40 Ma. Ages decrease systematically down section to zero. The maximum AHe ages are significantly younger than published AHe ages ($\sim$ 100 Ma) from eastern southern Africa [4]. We use novel whole-profile multi-chronometer joint inversion techniques to constrain the thermal history of this region, and describe the temporal and spatial distribution of denudation across southern Africa. We provide new constraints on the timing and rate of emergence of the African Superswell. These data elucidate our understanding of the role of dynamic topography in the modification of theouth African passive margin, and provide quantitative constraints on the processes controlling the formation of first-order topography in southern Africa.

References: [1] Nyblade & Sleep, 2003, [2] Brown et al. 2002, [3] Tinker et al. 2008, [4] Flowers et al. 2010