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Raising southern Africa: quantifying the erosional response of the African superswell

R. Brown (1), K. Gallagher (2), M. Raab (3) and M. Summerfield (4)

(1) Centre for Geosciences, Division of Earth Sciences, University of Glasgow, Glasgow, UK, (2) Department of Earth Science and Engineering, Imperial College of Science, Technology and Medicine, London, UK, (3) School of Earth Sciences, University of Melbourne, Melbourne, Australia, (4) School of Geosciences, Institute of Geography, University of Edinburgh, Edinburgh, UK (r.brown@earthsci.gla.ac.uk / Fax: +44 131 330-4817 / Tel: +44 131 330-5460)

The topography of southern Africa is both unusual and important in a global context. It is unusual because the regional topography of southern and eastern Africa is anomalously elevated (>1000m) relative to central and west Africa, and also to other continents, and this physiography is often referred to as the African Superswell. It is important because understanding its evolution is fundamental to advancing the current debate concerning the coupling between deep mantle flow and dynamic topography. Recent studies of global seismicity have identified a major low seismic velocity anomaly (the largest deep mantle anomaly on Earth) beneath southern Africa located within the mid-lower mantle and this discovery has catalysed interest in the dynamics of mantle convection and specifically in the role that this plays in generating large scale topography. The evolution of the African Superswell has therefore become the focus of much of this interest. While measuring continental uplift directly remains a difficult problem, insight into the evolution of the superswell can be gained by measuring the erosional response to this phenomenon at appropriate spatial and temporal scales.

Technical advances in low temperature thermochronometry methodology and interpretive strategies (such as apatite fission-track and U-Th/He analysis) can be used to estimate broad, long-term ($\geq 10^7$ yr) erosion rates. However, it is difficult to relate these broad estimates to specific landscape forming processes (eg. escarpment retreat, rates of valley incision), or to actual landscape elements (eg. escarpment faces, ridges or discrete low relief surfaces). Cosmogenic isotope analysis can make an important contribution by providing estimates of the pattern and variability of erosion rates over the key intermediate spatial and temporal scales and thus a means of extrapolating the wealth of information gleaned from short term process studies to the broader spatial and temporal information obtained from both apatite fission-track and U-Th/He thermochronologic data.

Such data from the Drakensberg escarpment and interior of South Africa, particularly those from deep bore holes, and the continental margin escarpment in Namibia clearly demonstrates the effectiveness of combining these complemetary analytical methods to derive integrated, quantitative denudation histories. We have been able to show that the short and long-term rates and pattern of denudation across these escarpment segments are incompatible with a steady, parallel retreat model for the evolution of these important landscape features. We suggest an alternative model where the escarpment is formed by rapid post-break-up river incision seaward of a pre-existing drainage divide located just inland of the present escarpment location, with the escarpment subsequently pinned at this divide and characterised by moderate to low retreat rates ($\leq$ 10-100 m/Ma).

Futhermore, the data suggest that the sub continent of southern Africa experienced a significant phase of accelerated erosion during the mid-Cretaceous long after continental break-up, and we suggest that this episode is linked to regional scale epeirogenic uplift driven by active upward flow within the deep mantle. If this inference is correct it provides the first direct evidence for timing of the African superswell. This interpretation supports recent geodynamic models that suggest the upward flow beneath Africa is long lived and it appears to contradict the view that a substantial component of the superswell topography formed during the Plio-Pleistocene.