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Resolving the chronology of the South African landscape through joint inverse modelling of AFT and apatite (U-Th)/He data

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Application of Low temperature thermochronometry (LTT) is a powerful method of constraining thermal history information on samples as they pass through isotherms in the upper crust. Inverse modelling of LTT data generates thermal history information which can then be correlated with independent datasets to infer geological processes that are responsible for producing the observed thermal history held in the thermochronometry record. A critical consideration when choosing which LTT method to use are the closure temperatures associated with each system. In order to generate more complete and robust thermal histories a single sample can be analysed using multiple low temperature thermochronometers that are sensitive over different but complimentary temperature ranges.

The main focus of LTT work in South Africa has been on apatite fission track (AFT) analysis which is a world renowned method of constraining thermal history information between c. 60 and 110±10°C. The general conclusions that have been drawn from the South African AFT dataset is that the present day regional topography represents an eroded remnant of an elevated interior that experienced a significant uplift event with km-scale erosion in the Cretaceous following the break-up of Gondwana [1]. The exact nature of Cretaceous uplift and erosion varies both spatially and temporally, especially in south western Africa where at least two distinct denudation events are recorded at c. 130Ma and 90 Ma [2]. There are, however, alternative views suggesting significant epeirogenic-style uplift and subsequent erosion throughout the Cenozoic [3]. A key aspect of this debate which is yet to be fully resolved is the influence of mantle dynamics on the evolution of the overlying topography. To further investigate the timing and amount of Cenozoic uplift and erosion and to what degree this can be ascribed to dynamic topography, efforts have been made to complement the existing AFT record with Apatite (U-Th)/He analysis (AHe) (e.g. [4]). AHe is ideally suited to this task as it is sensitive over a lower temperature range (c. 40-75±5°C) and can therefore provide insights into erosion on the scale of 1-3 km. Correlating AFT and AHe datasets can be difficult due to variations in U and Th zonation, crystal geometry and structural defects (e.g. radiation damage) altering the closure temperature of the AHe system and resulting in significant dispersion of ages. It is therefore essential to fully understand the major cause of age dispersion and use thermal history modelling techniques that take these factors into account.

Here we present a new suite of apatite (U-Th)/He data from samples along the Orange River alongside complimentary apatite fission track data from the same samples. Two samples with a large number of analysed grains, JN2 and GGO_2 (23 and 21 grains, respectively) were modelled using HelFrag [5] which takes into account dispersion in AHe ages produced through analysis fragments of larger apatite grains. These modelled histories where compared with inverse modelling using QTQt [6] to extract thermal history information for each of the samples and provide new insights into the post-Cretaceous evolution of the SW African landscape and the behaviour of complex dispersion patterns commonly observed in AHe data sets.

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