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# Strategies for joint inversion of AFT and AHe data: application of apatite (U-Th-Sm)/He fragment and radiation damage models.

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Apatite fission track and (U-Th-Sm)/He thermochronology has the potential to constrain rock cooling paths through a temperature range of c. 120 – 30°C. The annealing behaviour of fission tracks in apatite has been well calibrated and it has been shown that the annealing rate of tracks decreases with temperature through a temperature range of 110 – 60°C. Retention of He within apatite, however, occurs over a wide range of temperatures with the closure temperature of an individual grain being dependant on the grain size and, significantly, the amount of radiation damage accumulated within the crystal.

The influence of radiation damage is particularly important for apatite crystals that are enriched in U and Th and have experienced protracted cooling histories over 10 – 100 million year timescales. At present, current models of radiation damage accumulation and annealing are not ideally parameterised for natural samples with high eU values. For this reason, single-grain AHe ages from high eU and/or slowly cooled samples are typically highly dispersed and poorly reproduced during thermal history inversion modelling.

Apatite fission track thermochronology from outcrop and borehole samples have been instrumental in reconstructing the geological history of southern Africa. Apatite (U-Th-Sm)/He data from these samples typically exhibit high levels on intra-sample dispersion (e.g. 12 – 56 %) and apatites can with yield extremely high eU concentrations (e.g. up to 430 ppm). Using these data we employ the latest radiation damage annealing model (Gerin et al., 2017) and vary key parameters (i.e. trapping energy, Rmr0) to better reproduce the observed AHe during thermal history modelling. We also perform forward and inverse modelling of AHe ages from multiple-fragmented apatite crystals (0 and 1 termination) using QTQt (Gallagher, 2012) in an attempt to extract additional thermal history information from the structure of the He diffusion profile. By integrating independent apatite thermochronology techniques and accounting for different phenomena causing single-grain age dispersion we can obtain robust thermal history information from complex thermochronology datasets.

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