Strategies for joint inversion of apatite fission track and (U-Th) data: application of radiation damage and fragment models.

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Apatite fission track (AFT) and (U-Th-Sm)/He (AHe) 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 apatites with high eU concentrations or complex compositions. 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.

Here, we present new AHe data from samples collected from Fennoscandia, which have resided at temperatures < 110°C since the Precambrian, and from South Africa, which have anomalously high eU concentrations (e.g. up to 430 ppm). These data present an opportunity to investigate the extreme cases of radiation damage accumulation in natural samples. Using these data we employ the latest radiation damage annealing model and vary key parameters (e.g. trapping energy and Rmr0) to explore the structural and compositional factors influencing helium diffusion and explain the observed data. By integrating these AHe data with independent AFT data and accounting for the different phenomena causing single-grain age dispersion (e.g. radiation damage, grain size, fragmentation) we can obtain robust thermal history information from complex thermochronology data and better understand single-grain age dispersion in geologically old settings.