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Improving the apatite fission-track annealing algorithm

Elco Luijendijk (1), Paul Andriessen (2), Marlies ter Voorde (2), and Ronald van Balen (2)

(1) Georg-August Universität Göttingen, Geoscience center, Structural Geology and Geodynamics, Göttingen, Germany (elco.luijendijk@geo.uni-goettingen.de), (2) Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands

Low-temperature thermochronology is a key tool to quantifying the thermal history and exhumation of the crust. The interpretation of one of the most widely-used thermochronometers, apatite fission-track analysis, relies on models that relate fission track density to temperature history. These models have been calibrated to fission-track data from the Otway basin, Australia. We discuss geological evidence that the current benchmark dataset is located in a basin in which rocks may have been warmer in the past than previously assumed. We recalibrate the apatite fission-track annealing algorithm to a dataset from Southern Texas with a well-constrained thermal history. We show that current models underestimate the temperature at which fission tracks anneal completely by 19 ˚C to 34 ˚C. Exhumation rates derived from fission-track data have been underestimated; at normal geothermal gradients estimates may have to be revised upward by 500 to 2000 m. The results also have implications for the (U-Th)/He thermochronometer, because radiation damage influences the diffusivity of helium in apatites. The difference in modelled (U-Th)/He ages is approximately 10% for samples that have undergone a long cooling history. We also present a new Python code that can be used for forward or inverse modelling of fission track data using the new annealing algorithm.