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A re-evaluation of geological timescale benchmarks and temperature sensitivity of fission-track annealing in apatites

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Current models of the temperature sensitivity of fission track annealing in apatites have been calibrated using fission track data from boreholes, with the assumption that these samples are currently at maximum burial depth and temperatures. The most detailed data-set comes from boreholes located in the Otway basin, Australia. However, several lines of evidence suggest that these samples are not at their maximum burial depth and temperature and consequently the cooling temperature of the apatite fission track thermochronometer would then be higher than previously assumed. Significant late Cenozoic exhumation in the Otway Basin was suggested by earlier studies that document a major late-Miocene erosional unconformity, folding and trusting of underlying sediments and elevated strandlines along the coast. In addition, anomalously young apatite (U-Th)/He ages in several boreholes in the basin suggest that the basin's sediments have been exhumed and cooled in the late Cenozoic. We explore the effects of late Cenozoic exhumation on fission track data in the Otway basin using a 1D model of burial and thermal history. We show that simulating several 100s of meters of exhumation in the basin results in significant misfit between current annealing models and observed fission track data. The additional exhumation reconciles the Otway basin data with a second detailed fission track dataset from boreholes in Southern Texas with a well-constrained thermal and burial history. We combine vitrinite reflectance data and U-Th/He data from the Otway basin to recalibrate the burial history of the Otway basin. Subsequently we combine the new thermal history of the Otway basin with the Southern Texas dataset to recalibrate the fission track annealing algorithm. The results suggest that fission-track annealing in apatites is underestimated by approximately 20°C by current annealing models, with significant implications for studies that use apatite fission track thermochronology to quantify the thermal and geological histories.