Constraining time and temperature from $^4He/^3He$ thermochronometry of polycrytalline Fe- and Mn-oxides

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Polycrystalline Fe- and Mn-oxides are commonly found in geochemical weathering horizons, on fault surfaces, and associated with hydrothermal deposits. As these oxides can contain ppm concentrations of U and Th, they are amenable to (U-Th)/He geochronology, provided that open system behaviour of ^4He (as well as U and Th) can be adequately understood. Here, we discuss applicability of $^4He/^3He$ thermochronometry to quantify the kinetics of He diffusion in these polycrystalline, multiple diffusion domain (*MDD*) aggregate systems, and numerical modelling methods to constrain both the timing of oxide precipitation and the thermal conditions following precipitation. Since relative proportions of crystallite sizes can vary broadly between samples, and between individual aliquots within a sample, this approach has a broad range of temperature sensitivity, and provides important tests for internal consistency. Thus, each individual aliquot may have unique resolving power on a given temperature interval. In certain cases, it can be possible to constrain the timing of fracture filling associated with fluid flow and/or metamorphic conditions, as well as the timing and temperatures during fault motion and brittle slip. In near surface weathering horizons, the diffusive loss of ^4He constrains the long-term effective diffusion temperature (*EDT*) that the oxides experienced after precipitation. Such information can be related to changes in local temperature and climate conditions over geologic time. We present datasets from different geologic settings, discuss numerical modelling approaches to interpret the data for different geologic scenarios, and discuss resolving power and non-uniqueness of quantitative constraints.