Ne and He MDD Geochronology of hematite from a Michigan BIF

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Hematite shows potential for recording cooling histories over a very wide range of temperatures through the coupling of the (U-Th)/Ne and (U-Th)/He systems. Two museum-quality hematite specimens from neighbouring iron ore mines in Ironwood, Michigan USA, were analysed to explore He and Ne systematics and multi-domain diffusion (MDD) behaviour. The botryoidal hematite specimens used for this study are dense aggregates of sheet-like crystallites that range in thickness from several nm to several μm. PPM level U concentrations produce abundant nucleogenic ^{21}Ne through α particle capture on ^{18}O, constituting ~97% of the total ^{21}Ne measured, and yielding (U-Th)/Ne ages of 756 ± 18 and 789 ± 48 Ma. (U-Th)/He ages of 571 ± 18 and 595 ± 37 Ma are considerably younger and therefore must be cooling ages. After proton irradiation to make ^{3}He, step heating of these samples yields highly-reproducible He release patterns that indicate a roughly 3 order of magnitude span in diffusion domain size, implying a range of closure temperatures from <0 to ~160˚C. Observations that support the MDD interpretation are (1) reducing the physical grain size prior to step-heating eliminates the most retentive (largest) diffusion domain, and (2) activation energy is consistent at 160 ± 7 kJ/mol both for different domains within a sample and between the two samples. ^{4}He/^{3}He age spectra derived from these same experiments exhibit a monotonic rise from near 0 up to ~780 Ma, where He step ages define plateaus over a series of consecutive steps constituting the final ~40% of gas that are indistinguishable from the (U-Th)/Ne age. This observation strongly suggests that the largest domain(s) have been closed to He (and Ne) loss since formation. Inversion of these data for temperature history will be discussed.