Possible influence of alpha recoil track percolation on helium diffusivity in apatite

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The accumulation and annealing of alpha recoil damage is widely considered to exert a first-order influence on helium diffusivity in apatite. Experimental determinations of He diffusivity have been conducted on samples with doses of up to ~10^{16} α/g. Following from earlier modeling in radiation damage percolation in zircon, we have examined the connectivity and percolation behavior of alpha recoil damage in apatite. As with zircon, percolation is heavily influenced by the large aspect ratio of alpha recoil damage, and the fact that most damage probably occurs as sequences of tracks from decay chains. We find that percolation occurs at a dose of approximately 1.9×10^{16} α/g for 8-length chains corresponding to ^{238}U decay, and 2.5×10^{16} α/g for 6-length chains from ^{232}Th. These thresholds are slightly lower than for zircon, due to the lower density of apatite and resultant longer lengths and higher aspect ratios of alpha recoil tracks.

Although there are few experimental data that describe diffusivity at this level of damage, two data sets, from Brittany, France, and the Olkiluoto Peninsula, Finland, suggest that apatite (U-Th)/He ages reach a peak at the approximate percolation threshold dose, and diminish somewhat thereafter. It is thus apparent that percolation of alpha recoil damage may represent a significant transition in the diffusivity behavior of helium in apatite, which should be taken into account when interpreting high-damage apatites. We present a new model in which we reconsider the way that the diffusional effects of radiation damage traps are characterized, and how damage connectivity and percolation may alter bulk properties.