Neon diffusion in hematite and corundum

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The diffusivity of neon determines the conditions under which minerals may be used as geochronometers or thermochronometers in the (U-Th)/Ne and cosmogenic ^{21}Ne dating systems. Neon is expected to diffuse less rapidly than helium, but its kinetics have been determined on very few minerals. The measurements are difficult because adequate neon (natural or synthetic) is often unavailable in minerals of interest, and because some minerals break down in vacuum at the required high temperatures. We present helium and neon diffusion data from the isostructural minerals corundum and hematite.

We have probed the He diffusion behavior of polycrystalline hematite using abundant ^{3}He produced by proton irradiation. These data clearly demonstrate diffusion control by multiple diffusion domains associated with the crystallites. Interestingly, the activation energy for helium diffusion in hematite is within error of that for synthetic helium in single crystal/domain corundum.

In contrast to He, there is inadequate Ne to simultaneously characterize the activation energy, the diffusivity at infinite temperature, and the domain size distribution in polycrystalline hematite. Instead, we perform neon diffusion experiments on unirradiated samples and use a) the well-determined single-domain activation energy from proton-irradiated sapphire (consistent with the less well-determined value in the hematite) and b) the hematite diffusion domain size distribution from helium experiments, to fully characterize Ne diffusion from polycrystalline hematite.

The domains we investigated have neon closure temperatures ~250-300°C higher than that for helium in the same domain. The data indicate that > 97% of neon is retained at temperatures up to 275°C held over geologic time in our polycrystalline hematite standard. Even sub-micron hematite domains are fully retentive for Ne at this temperature and below.