Interpreting the geo/thermo/compo-chronometric record of paleofluid-rock systems from hematite

P.W. REINERS[1]

[1]Department of Geosciences, University of Arizona, Tucson, AZ 85718 USA (reiners@email.arizona.edu)

Mineralization and alteration by paleofluid-rock reactions records the sources, drivers, and fluxes of paleofluid flow systems. Interpreting these records requires independent radioisotopic age constraints, but many dating systems are difficult to apply because of low initial parent-daughter ratios, complex thermal histories, and open-system behavior. Here I describe recent insights from (U-Th)/He chronometry and related systems applied to one of the most conspicuous products of fluid-rock reaction: iron oxides, mainly hematite.

1. Geochronology: Hematite in bedrock fractures, particularly specularite, often shows negligible or minimal He loss, as shown by related $^{4}He/^{3}He$ data or other complementary radioisotopic systems, preserving formation ages at least as old as 1.6 Ga in Precambrian crystaline basement. In such cases hematite probably remained within a few km of the surface after mineralization.

2. Thermochronology: In some cases partial He loss precludes directly dating crystallization, consistent with known He diffusion kinetics and inferred geologic histories, and/or $^{4}He/^{3}He$. But targeted dating of individual hematite crystals shows size-age correlations with old-age plateaux at large crystal size that constrain formation age and positive correlations at smaller size that constrain thermal histories.

3. Compochronology: Fe-oxides may form during recrystallization of earlier reduced Fe species (e.g., pyrite, siderite), in which case He ages likely reflect U-uptake associated with late, potentially exhumation-related, oxidative recrystallization. Examples include: 1) Pleistocene pyrite-pseudomorphs adjacent to Miocene primary hematite in faults and fractures of crystalline basement, 2) diagenetic early Cretaceous ages on Ordovician ironstones; 3) Plio-Pleistocene ages on sandstone-hosted concretions likely originally precipitated as siderite. Even after oxide crystallization, however, continued U-uptake may occur in some cases, complicating interpretations.

4. Dating regional subsurface paleofluid migration: Several sandstone-dominated terranes show evidence for large scale mobilization and redeposition of Fe by subsurface fluids. Dating Fe-rich cements, concretions, and fracture-fill provides constraints on the ages of these events that correspond with regional geologic events as shown in several examples.