Age, emplacement conditions, and thermal history of a Neoproterozoic clastic dike by hematite (U-Th)/He dating and fluid inclusion analysis

J.L. JENSEN[1]*, P.W. REINERS[1], M. STEELE-MACINNIS[1], A.K. AULT[2], C.S. SIDDOWAY[3]

[1]Department of Geosciences, University of Arizona, Tucson, AZ 85721, USA (*correspondence: jljensen@email.arizona.edu)
[2]Department of Geology, Utah State University, Logan, UT 84322, USA
[3]Department of Geology, Colorado College, Colorado Springs, CO 80903, USA

Direct constraints on the thermal and chemical evolution of hydrothermal systems are critical for understanding associated mineral deposits, tectonic setting, and upper crustal fluid migration. Many hydrothermal mineral deposits lack satisfactory age control due to the absence of suitable chronometers and thus interpretations regarding their origin are challenging to assess. Hematite, a common hydrothermal mineral, is uniquely suited to provide pressure-temperature-composition-time constraints on hydrothermal systems because of its demonstrated use as a thermochronometer and it commonly hosts fluid inclusions for microthermometry. Here, we apply these tools to refine the emplacement age and formation conditions of the enigmatic Tava sandstone, a basement-hosted sandstone injectite located in the Colorado Front Range, USA. Specular hematite veins that reside within Tava dikes were targeted for (U-Th)/He dating and fluid inclusion analyses. Microthermometric data from hematite-hosted, primary fluid inclusions indicate that hematite was precipitated by an aqueous fluid at a minimum temperature of 200-250 °C and salinity >20 wt % (NaCl equivalent). (U-Th)/He dates from individual hematite crystals show a positive correlation between observable crystal size and (U-Th)/He date, with dates plateauing at 700 ± 20 Ma for plates greater than 30 μm in width. This correlation suggests that observable crystal size corresponds to the He diffusion domain size. Collectively, these data suggest that the Tava sandstone was emplaced during the early Cryogenian, contemporaneous with major rifting in western Laurentia and widespread Sturtian glaciation. The combination of extensive rifting and glacial activity may have provided ideal conditions for the forceful injection of liquefied sediment into faulted basement. We suggest that coupled thermochronometric and fluid inclusion studies of hematite have potential to constrain formation ages, formation temperatures, and post-formation thermal histories of hydrothermal systems.