Hematite polydomain diffusion thermochronology of the Transvaal Supergroup, South Africa

HAYDEN B. D. MILLER[1], RYAN E. MCKEON[2], WOODWARD W. FISCHER[1], NICOLAS J. BEUKES[3], ALBERTUS J.B. SMITH[3], KENNETH A. FARLEY[1].

[1]Division of Geological and Planetary Science, Caltech, Pasadena, CA 91125, USA (hbmiller@caltech.edu, wfischer@caltech.edu, farley@gps.caltech.edu)
[2]Department of Earth Sciences, Dartmouth College, Hanover, NH 03766, USA (ryan.e.mckeon@dartmouth.edu)
[3]Department of Geology, University of Johannesburg, Auckland Park 2006, South Africa (nbeukes@uj.ac.za, bertuss@uj.ac.za)

The Transvaal Supergroup located in the Kaapvaal Craton of South Africa is a sequence of sedimentary and volcanic rocks providing some of the best-preserved geologic records from the late Archen through early Paleoproterozoic (~2.60 – 2.06 Ga), documenting a period of significant environmental change. We have implemented the combined (U-Th)/Ne and (U-Th)/He chronometers to hematite from five different ore localities along a ~250 km transect paralleling the Blackridge thrust fault in the Griqualand West region. Hematite ages for Khumani (Ne 2009 Ma, He 2048 Ma), Beeshoek (Ne 1767 Ma, He 1761 Ma), Black Rock (Ne 1708 Ma, He 1523 Ma), Rooinekke (Ne 1390 Ma, He 942 Ma), and Belgravia (Ne 1228 Ma, He 740 Ma) indicate these samples do not share a single, regional history. Therefore, we interpret multiple events of supergene and hydrothermal enrichment to have occurred through the Proterozoic, resulting in the Transvaal banded iron formations having been upgraded to the hematite ore bodies found today. Ne and He age discordance can be explained by the hematite remaining an open system to helium loss during protracted cooling or shallow burial, since He is diffused more readily than Ne.

The $^{4}He/^{3}He$ method and hematite polydomain diffusion model was applied to the Beeshoek, Black Rock, and Belgravia samples to further constrain their time-temperature history. We have fit our experimental $^{4}He/^{3}He$ diffusion data using contributions modeled from 8 discrete-sized domains. Combining the sample specific distribution of domain sizes, the diffusion kinetics derived from the Arrhenius array, and the data represented by the $^{4}He/^{3}He$ step age plot, we used QTQt to forward model best-fitting time-temperature paths for these samples. By doing so, we have created the first record of Kaapvaal Craton unroofing over billion year time scales.