Metamorphic replacement of mineral inclusions in detrital zircon from Jack Hills, Australia: Implications for the Hadean Earth

Birger Rasmussen¹, Ian R. Fletcher¹, Janet R. Muhling², Courtney J. Gregory³, and Simon A. Wilde¹
¹Department of Applied Geology, Curtin University, Kent Street, Bentley, WA 6102, Australia
²Centre for Microscopy, Characterisation and Analysis, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia

We welcome a discussion on the origin of mineral inclusions in detrital zircons from Jack Hills, Australia, which have previously been interpreted to be primary and magmatic and, hence, to constrain the composition of the earliest crust.

In our recent paper (Rasmussen et al., 2011), we used multiple lines of evidence to suggest that at least some, and possibly most, of the inclusions in zircons from Jack Hills formed after deposition. In-situ U-Pb dating of xenotime and monazite inclusions showed they formed during two discrete metamorphic events (Rasmussen et al., 2010), whereas monazite-xenotime and Ti-in-quartz thermometry indicates that at least some monazite, xenotime, and quartz inclusions are metamorphic. Based on the lack of apatite inclusions in Jack Hills zircons relative to common igneous rocks, we argued that apatite was once much more abundant but had been pseudomorphed by matrix minerals during metamorphism. We concluded that zircon is susceptible to fluid-mediated alteration and cautioned against the use of muscovite and quartz inclusions to infer the composition of the host melts of the Hadean zircons.

Hopkins et al. (2012) question our scholarship for failing to cite previous work that apparently discusses the resetting of isotopic systems in phosphate inclusions. The paper by Caro et al. (2003), which they quote as an example, actually applies to short-lived 146Sm–142Nd chronometry on rocks from the 3.7–3.8-Gyr Isua greenstone belt in West Greenland, and mentions nothing about phosphate inclusions in zircon or isotopic resetting. This paper is therefore not relevant to the discussion. However, another paper by Caro et al. (2008) may be more relevant. It reports 146Sm–144Nd systematics for Hadean zircon grains from Jack Hills, suggesting that there was post-crystallization disturbance of the 147Sm–143Nd system (Rasmussen et al., 2010), whereas monazite-xenotime and Ti-in-quartz thermometry indicates that at least some monazite, xenotime, and quartz inclusions are metamorphic. Based on the lack of apatite inclusions in Jack Hills zircons relative to common igneous rocks, we argued that apatite was once much more abundant but had been pseudomorphed by matrix minerals during metamorphism. We concluded that zircon is susceptible to fluid-mediated alteration and cautioned against the use of muscovite and quartz inclusions to infer the composition of the host melts of the Hadean zircons.

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