Forum Comment

Eoarchean within-plate basalts from southwest Greenland

Kristoffer Szilas[1], J. Elis Hoffmann[2], Carsten Münker[2], Annika Dziggel[3], and Minik T. Rosing[4]

[1]*Lamont-Doherty Earth Observatory, Columbia University, Route 9W, PO Box 1000, Palisades, New York 10964, USA*

[2]*Institute of Geology and Mineralogy, Cologne University, Zülpicher Str. 49b, 50674 Köln, Germany*

[3]*Institute of Mineralogy and Economic Geology, RWTH Aachen University, Wüllnerstrasse 2, 52056 Aachen, Germany*

[4]*Natural History Museum of Denmark, Copenhagen University, Øster Voldgade 5-7, 1350 Copenhagen K, Denmark*

Jenner et al. (2013) report the occurrence of, what they interpret as, Earth's oldest ocean island basalts (OIBs) on the island of Innersuartuut, southwest Greenland. However, this interpretation hinges critically on the incompatible trace element contents of the presented rocks. Compared to Phanerozoic OIBs, the data of Jenner et al. exhibit lower Nb/La and Gd/Yb ratios, have negative Zr-Hf anomalies and very low U and Th abundances. Thus, the highly incompatible trace elements are depleted relative to Hawaiian OIB and the compositions are completely different from HIMU-, EM1- and EM2-type OIB (see Hofmann, 2003).

Although they briefly mention that the rocks where exposed to granulite facies metamorphic conditions and associated in situ partial melting, they do not consider the possibility that the low Th and U contents could have been caused by melt extraction during peak

metamorphism. Rocks in the study area are known to be significantly disturbed, both structurally and chemically, due to multiple high-grade metamorphic events (Nutman and Friend, 2007). Surprisingly, Jenner et al. reject post-magmatic disturbance arguing that “the major- and trace-element compositions for the majority of samples from Innersuartuut presented show coherent trends” (p. 327). However, small-scale partial melting during granulite facies conditions would also produce coherent melt depletion trends without significantly affecting compatible and moderately incompatible trace element abundances.

The main difference between their presented geochemical data and Isua basalts, with which they compare their data, is the significant depletion in Th and U. However, these two highly incompatible elements will readily partition into a melt or high-temperature supercritical liquid even at small melting degrees. Furthermore, the selective depletion of Zr-Hf relative to Sm-Gd and enrichment of Nb-Ta relative to La would be expected in an amphibole-bearing residue according to the modeling of Foley et al. (2002), in agreement with granulite facies melt depletion. Positive anomalies of Zr-Hf combined with elevated Th-U have in fact been observed in felsic aplites derived by partial melting of Mesoarchaean supracrustal rocks in southwest Greenland (Szilas et al. 2012). Therefore, we argue that partial melting at granulite facies conditions of Isua-type basalts can be expected to produce residues with the same trace element patterns as those observed for the Innersuartuut rocks.

Indeed, mafic granulites from the well-preserved Mesozoic Kohistan island-arc complex (Garrido et al., 2006) show the very same Th- and U-depleted trace element patterns, as presented by Jenner et al. Garrido et al. (2006) concluded that this depletion was due to partial melting of the lower crustal lithologies. Furthermore, a recent study of Mesoarchaean mafic granulites from southeast Greenland (Bagas et al., 2013) shows remarkably similar major and

trace element characteristics, as those presented by Jenner et al. Several of those granulites have the same type of Th- and U-depleted trace element patterns, whereas others display patterns similar to Isua-type basalts interpreted by Jenner et al., 2009, to be analogues of Phanerozoic island arc tholeiites (IAT). Although not part of the conclusion of Bagas et al. (2013), we would argue that the rocks with variable Th and U contents in southeast Greenland originate from protoliths similar to the Isua basalts, but underwent variable degrees of partial melting during high-grade metamorphism, rather than originating from contrasting geodynamic settings within the same region. Similar mafic pods are also found in the Mesoarchaean Lewisian granulite complex, NW Scotland, which show evidence for significant rare earth element mobility, as well as depletion of Th and U during a high-grade partial melting event (Weaver and Tarney, 1981; Rollinson and Gravestock, 2012).

Given the regional evidence for partial melting around Innersuartuut, and the fact that Th and U are known to be mobilized in mafic rocks at similar metamorphic conditions, we suggest that a more reasonable interpretation of the rocks on Innersuartuut would be that they represent reprocessed lower crustal equivalents of Isua-type IAT and not OIB as claimed by Jenner et al.

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