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Probing the Hf Isotope Systematics of the Sub-Continental Mantle at 3.5 Ga: The Tarssartôq Dykes of the Isua Region, Southern West Greenland

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The characteristics and development of the different geochemical and isotopic reservoirs in the Earth's mantle have aroused considerable interest in recent years. Many studies have focused on the Hf and Nd isotope systematics of Archaean rocks, where Hf and (less robust) Nd data both suggest the existence of moderately depleted mantle very early in Earth history (by ~3.8 Ga). The lack of pre-3.5 Ga juvenile rocks with negative initial εHf implies that the complementary enriched reservoir to the Archaean depleted mantle is 'hidden'. Our study of juvenile mafic dykes extends into the beginning of the 'transitional' period when, according to Bennett *et al.* (1993) and Vervoort & Blichert-Toft (1999), any enriched reservoir was mixed progressively back into the depleted mantle.

The Isua region, located within the Archaean craton of southern West Greenland, contains the Earth's oldest known supracrustal rocks (the ~3.8-3.7 Ga Isua greenstone belt), and ~3.8-3.65 Ga tonalitic and granitic gneisses. Best estimates of initial εHf values for these units are +4 ±2 and 0 to +3.4, respectively (Blichert-Toft *et al.*, 1999; Vervoort & Blichert-Toft, 1999). The intensely deformed contact between the Isua belt and the gneisses is cut by well-preserved mafic dykes: the *Tarssartôq dykes*. Gill & Bridgwater (1976) described these dykes (and the broadly correlative Ameralik dykes) as "the earliest known basaltic rocks intruding stable continental crust". Their geochemical and isotopic characteristics provide important constraints on the nature of the earliest sub-continental mantle.

The Tarssartôq dykes consist of three distinct swarms with consistent cross-cutting relationships. The oldest dykes (T1) are two ~100 m thick E-W-trending norites with a poikilitic texture (plagioclase crystals up to 3 cm enclose orthopyroxene and minor olivine and clinopyroxene. The abundant dykes of other two swarms are E-W-trending (T2) and N-S-trending (T3) dolerites with ophitic and sub-ophitic textures and primary igneous mineralogy, including clinopyroxene and rare olivine. Some of the T2 and T3 dykes contain large (up to ~15 cm) euhedral plagioclase megacrysts.

Baddeleyite (ZrO_2) and/or zircon have been separated from T1, T2 and T3 dykes. Preliminary U-Pb isotope data suggest that the T2 dykes were emplaced at approximately 3.5 Ga (work in progress). The Hf isotopic composition and precise and accurate Lu/Hf ratios of grains processed for U-Pb dating have also been determined by solution-mode PIMMS using a non-spiking procedure (Nowell & Parrish, this volume). Assuming an intrusion age of 3.5 Ga (to be modified as data become available), initial εHf values of T2 dykes are essentially chondritic at ~0 ±2. Determining the initial εHf values of the T2 dykes from baddeleyite and zircon is more robust than a wholerock-based approach, because of the increased likelihood of Hf and/or Lu mobility in the latter. It is not straightforward, however, to relate small positive or negative initial εHf values to a uniquely 'enriched' or 'depleted' source region, given the uncertainty in the composition of the chondritic uniform reservoir, and whether this reservoir truly represents bulk silicate earth. Moreover, the tonalitic host gneisses, which would have evolved to low negative εHf values by 3.5 Ga, could have contaminated and changed the initial Hf isotope composition of the Tarssartôq dyke parental magmas. Evaluation of the degree of any contamination is, therefore, vital before conclusions can be drawn about the mantle source region of the dykes. Preliminary calculations indicate that ~10% crustal contamination of the dyke parental magmas would have been necessary to cause a 1 epsilon unit shift in initial εHf values.

The abundance of existing good quality Hf data for the oldest rocks of the Isua region means that this study presents a unique opportunity to evaluate the changes in Hf isotope composition of the underlying mantle over a period of ~300 Ma. This time period includes the transition to stable continental crust, and the onset of the postulated transitional period between early Archaean mantle depletion and the 2.7-Ga-to-present-day regime. Hf data and U-Pb ages of the zircon and baddeleyite grains from the Tarssartôq dykes will be presented, together with elemental data (to assess the extent of any crustal contamination) in order to evaluate the Hf isotope systematics of this region of mantle at 3.5 Ga.

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