Long magmatic timescales (~100 m.y.) and complex polybaric petrogenesis in Proterozoic arcs

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Rapid magma ascent rates in arcs, of months to years over 35 km from Moho to surface, have recently been inferred for crystal-poor, andesitic magmas (Ruprecht & Plank, 2013, *Nature* **500**, 68). Given the importance of magma ascent rates in understanding the evolution of magmatic systems, how different are the ascent rates of crystal-rich magmas and what are the implications for differentiation and crustal interaction?

Proterozoic anorthosites formed from crystal-laden mushes ponding at the Moho, crystallizing polybarically and finally being emplaced in the upper crust (~5-10 km), most probably in a late-orogenic arc environment. Formation of these plutons in long-lived magmatic systems operating on timescales of ~80-120 m.y. has been proposed in geochronologic studies of suites of high-pressure, orthopyroxene megacrysts (HAOMs) [1]. Sm–Nd isochrons for HAOMs give ages of 1765±12 Ma (Mealy Mtns), 1041±17 Ma (Rogaland) and 1444±100 Ma (Nain), compared to the respective 1630–1650, 920–949 and 1289–1363 Ma ages of their host anorthosites. Internal isochrons between plagioclase exsolution lamellae and orthopyroxene in HAOMs yield ages identical, within error, to the ages of anorthosite emplacement, suggesting that HAOM decompression took place ~100 m.y. after crystallization (at the Moho). These lengthy timescales in Proterozoic arc environments suggests that there may be a broad spectrum of magma ascent rates in arcs, with anorthosite ascent rates representing the slowest. Such lengthy magmatic timescales are not surprising given that long periods of magma ponding, recharge and lower-crustal AFC at the Moho may be vital processes in the development of anorthosites and potentially other crystal-laden magmas.

Gauging the extent of differentiation that a magma system may experience through ascent rate is particularly relevant in Proterozoic anorthosites where we observe distinctive geochemistries resulting from ponding and enhanced lower crustal AFC. In combination with EC-AFC modeling, our observations of unexpected patterns of internal isotopic disequilibrium in anorthosites and geochemical differences in succesive pulses of magma, suggest that anorthosite petrogenesis is likely to involve significant differentiation and solidification at lower crust depths, followed by ascent of high-crystallinity (~50 %) bodies to upper crustal levels.

[1] Bybee *et al.*, 2014, *EPSL* **389**, 74).