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A Si isotope investigation of Archaean melting processes

MADELEINE E MURPHY, JANE E MACDONALD, SEBASTIAN FISCHER, DR. NICHOLAS J GARDINER, RICHARD W WHITE AND PAUL S. SAVAGE

University of St Andrews

Presenting Author: mm439@st-andrews.ac.uk

Unraveling ancient melting processes is key to understanding how the earliest, tonalite-trondhjemite-granodiorite (TTG)-dominated continental crust formed from partial melting of amphibolites. Applications of silicon isotopes to ancient crust [1,2,3] revealed that Archaean TTGs exhibit consistently high Si isotope signatures ($\delta^{30}Si$) compared to modern granitoids, attributed to seawater-derived silica introduced by either (a) anatexis of variably silicified basalts [2] or (b) authigenic silica-rich marine lithologies in the melt source [3]. However, both mechanisms can involve highly variable $\delta^{30}Si$ [4], conflicting with the strikingly consistent $\delta^{30}Si$ signatures of Archaean TTGs. This study investigates an alternative solution, whereby silicon isotopes fractionate differently during TTG melt formation compared to "modern" melting.

We measured $\delta^{30}Si$ in component parts (melanosome and leucosome) of an Archaean (2.7 Ga) mafic migmatite and coeval amphibolites and mafic granulites from the Kapuskasing uplift, Canada, to explore how Si isotopes fractionate during incipient TTG melt formation. Our data reveal leucosome (i.e., melt) exhibits consistently high $\delta^{30}Si$ values compared to a relatively isotopically lighter melanosome (i.e., restite). Inter-mineral silicon isotope fractionation factors derived for mineral separates agree well with those of *ab initio* estimates for Phanerozoic minerals [5], and the magnitude of fractionation between source rock and melt approximates that in Phanerozoic igneous rocks [6].

We conclude the effects of magmatic differentiation on $\delta^{30}Si$ have remained consistent throughout Earth history. Further, like Archaean TTGs, our amphibolites and our mafic migmatite components have high $\delta^{30}Si$ compared to modern analogues and coeval unmelted granulites. The heavy $\delta^{30}Si$ of seawater and the high SiO_2 content of amphibolites relative to coeval dry granulites imply seawater silicification is the source of high $\delta^{30}Si$ we observe. Consistently heavy Si isotope signatures in Archaean melt products define a unique aspect of ancient crust formation: silicification of TTG source rock, implying the intrinsic involvement of a primeval hydrosphere.

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[6] Savage et al. (2011) *GCA* 75, 6124-6139.