3.8 Ga arc related basalts from Southwest Greenland

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The significance of convergent margin processes in generating ancient crust remains problematic. Previous studies of parts of the Isua supracrustal belt (ISB) have revealed distinct geochemical characteristics that can confidently be attributed to subduction related processes. Is this a rare occurrence however, or do other Eoarchaean sequences display arc-like chemical signatures?

We report the first geochemical data from a distinct lithostratigraphic unit preserving pillow basalts in the south of the ISB. Results are also presented from >3.8 Ga supracrustal rocks from islands south of Ameralik Fjord in the vicinity of Nuuk. These islands preserve the world's oldest metavolcanic rocks and provide a rare opportunity for studying early earth processes. All selected samples show minimal secondary element mobility.

Some of the ISB pillow lavas show extreme enrichments in LREE ($La/Yb_{(pm)}$ ratios of 9.2-11.9) and large depletions in Nb, Ta, Zr, Hf and Ti. These characteristics cannot be generated by partial melting alone, and there is no evidence for crustal contamination or significant fractional crystallisation. Key trace element characteristics (e.g. high La/Sm and low Nb/Th ratios) of these pillow lavas are diagnostic of subduction related magmas, whereby slab melts were enriching the overlying mantle wedge. The ISB samples show inverse correlations between Nb/Ta and Zr/Sm suggesting the presence of residual rutile in a subducting slab. Trends in Ba/La vs. Ba/Nb ratios are comparable to modern day arc related rocks and indicate that the subducting oceanic crust may have had a pelagic sediment cover, which affected the chemistry of the slab-derived fluid.

Analysis of >3.8 Ga mafic rocks from the islands south of Ameralik show high field strength element depletions comparable to the ISB lavas, suggesting that these rocks were also formed in a subduction related environment. Samples have a large range in Zr/Hf ratios (30.8-39.1), which are correlated with Yb/Sc, indicating that pyroxene fractionation was controlling these element ratios. Overall, fractional crystallisation processes had a stronger control on the chemistry of the supracrustal rocks from the islands than the rocks from the ISB.

The compositional affinities with modern arc basalts for these two 3.8 Ga -3.9 Ga mafic sequences provide strong evidence for the role of slab fluids and melts in basalt genesis in the early Archaean.