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U-Th-Pa disequilibria constraints on the subduction processes beneath the South Sandwich island arc system

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The presence of U-series disequilibria in magmas at island arcs provides first-order insights into the dynamics of material fluxes in subduction zones. In particular, the use of coupled U-series nuclide pairs offers the opportunity to apply simultaneous constraints to chemical fractionation processes of elements during fluid mobilization and melting in the mantle wedge beneath island arcs. The South Sandwich island arc system has developed in the southernmost Atlantic region during the past 3 Ma with westward subduction of the South American plate beneath the Sandwich micro-plate. Amongst the erupted tholeiitic and calc-alkaline magma series with typical chemical arc-signatures, the wide range in incompatible element contents at similar $^{143}Nd/^{144}Nd$ (e.g. REE) have been argued to require large source or dynamic melting variations [1]. We use U-series analyses to more fully assess their petrogenesis.

Here we present the first U-Th-Pa dataset for the South Sandwich Islands, representative of the intra-island compositional variations from low-K tholeiitic basalts (Mg# = 70) to andesites (Mg# = 28) for which also new high-precision trace-element and Sr-Nd-Pb isotope data have been acquired. Large ^{238}U excesses relative to ^{230}Th are observed (>50% in some islands) as have been commonly observed in other depleted island arcs. This characteristic signature has been attributed to the addition of fluids from the down-going altered oceanic crust. The near constant ($^{230}Th/^{232}Th$) of the lavas despite their range in Th contents is difficult to reconcile with a dynamic melting model.

Although distinguished by large ^{238}U excesses, the samples all show ^{231}Pa-^{235}U excesses (up to 50%) as has also been observed in other island arcs. We argue that the production of ^{231}Pa excesses reflect the result of melting and melt transport in the mantle wedge which overwhelme initial ^{235}U excesses.

References

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Subduction processes associated with back-arc opening; Hf isotope study of Tertiary NE Japan arc

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Back-arc opening is one of the major tectonic features in island arc formation. In order to document the geochemical evolution of a subduction zone during back-arc opening, Hf isotope compositions coupled with other radiogenic isotopes and trace element compositions were determined for Tertiary and Quaternary volcanic rocks from NE Japan. The samples selected are from volcanoes along the volcanic front. The ages of the Tertiary samples range from 22 to 8 Ma, which overlaps with the period of opening of the Japan Sea back-arc basin (22-15 Ma).

Hf isotope data demonstrate a secular variation. Among the samples, the 22 Ma high magnesian andesites (HMA) have the lowest ε_{Hf} (+9). The 8 Ma tholeiitic basalts and andesites show the highest ε_{Hf} (+14). Calc-alkaline basalts and andesites between 22 and 16 Ma have intermediate ε_{Hf} from +10 to +13. Consequently, ε_{Hf} was low (enriched) in the early stages of back-arc opening but became high (depleted) after back-arc opening ceased.

The observed secular variation in Hf isotope ratios may be attributed to a change in magma source composition. (1) Injection of depleted asthenospheric mantle into previously enriched mantle wedge during back-arc opening is one possible process for such a secular variation. This occurred on the back-arc side of NE Japan, as indicated by a coupled decrease and increase of Sr and Nd isotope ratios, respectively, during and after back-arc opening. On the trench side, however, Sr and Nd isotope ratios were almost constant, suggesting that material flux was minimal on the trench side of the NE Japan arc[1]. (2) A hot asthenospheric injection into the mantle wedge, even if restricted to the back-arc side, should induce a high temperature gradient in the whole mantle wedge, which could affect the slab surface temperature, resulting in changing dehydration/melting conditions of the subducted slab. Melt from the subducted slab transports Hf more effectively into the mantle wedge than dehydrated fluid. The secular change in ε_{Hf} is consistent with a model whereby slab melt was added to the mantle wedge during the early stage of back-arc opening, and slab dehydration was dominant after cooling of the mantle wedge.

References

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