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The magmatic evolution of Tubuai Island, Cook-Austral chain, South Pacific

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Tubuai Island in the Cook-Austral chain, South Pacific is one of the rare occurrences of HIMU-type Ocean Island Basalts (OIB). Here, we present new trace element and Sr, Nd, Hf isotopic analyses on mafic lavas from the island in order to constrain the geochemical and isotopic variations during the magmatic evolution of the Tubuai volcanoes.

The mafic lavas from Tubuai evolve from alkali basalt and basanite (earlier stages of volcanism) to analcitite and nephelinite (late stages of volcanism). Sr, Nd and Hf isotopic data on the entire lava suite are homogeneous and typical for the HIMU-type OIB and thus confirm the cogenetic nature of the different mafic lavas from Tubuai Island. The trace element patterns show progressive enrichment of incompatible trace element concentrations and ratios with increasing alkaline content in the lavas, which reflects progressive decrease in the degree of partial melting towards the later volcanic events. Considering a garnet peridotite source mineralogy, partial melting modeling suggests that alkali basalts and basanites were produced by $\sim 7 - 8$ % melting and that nephelinites and one analcitite sample were produced by ~ 3% melting. In addition, the progressive enrichment of incompatible trace elements is associated with a relative depletion in Rb, Ba, K, Nb, Ta and Ti in the nephelinites and analcitites. This requires the presence of small amounts of residual phlogopite and of a Ti-bearing phase (ilmenite or rutile) during formation of the younger analcitic and nephelinitic magmas. Adding ~ 1% phlogopite to the residual phases during melting is sufficient to reproduce the Rb, Ba and K variations in the analcitites and nephelinites while adding ~ 0.6% ilmenite or ~ 0.2% rutile to the residual phases reproduce the HFSE and most of the Ti variations in the analcitites and nephelinites.