The genesis of high Nb-Ta signatures at the northern Tongan islands of Tafahi and Niuatoputapu

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The two northernmost Tongan islands of Tafahi and Niuatoputapu display unique compositions compared to the other central Tongan volcanoes. In particular, they have elevated isotope dilution Nb/Ta ratios as high as ~28 and $^{206}Pb/^{204}Pb$ isotope compositions >18.9. The radiogenic Pb isotopes reflect the addition of an enriched component that arises from the subducting Louisville seamount chain. The lavas are extremely depleted in incompatible elements, e.g. Ti, Zr, Sc and Yb suggesting about 6% depletion of the mantle wedge prior to 20-30% partial melting. The trace element pattern of Tafahi and Niuatoputapu imply a re-enrichment of most incompatible elements and Nb and Ta from subducting slab components. The data imply that three different slab components are involved in the formation of the lavas, i.e. fluids from altered oceanic crust, pelagic sediments and from Louisville seamount chain lavas. Mixing of fluids from altered oceanic crust and pelagic sediments occurs prior to mixing with the Louisville slab components. High Nb-Ta contents indicating residual rutile coupled with the radiogenic Pb isotopes from the Louisville seamounts result from a large slab fluid flux from focussed flow through the Louisville seamount crust that had no or little sediment coverage.

We develop a geodynamic model that provides an explanation for the occurrence of the Louisville signatures some 3-4 Ma after their subduction underneath the northern islands while the Louisville seamount chain at present is being subducted several hundred kilometres to the south. Our model suggests that the Louisville geochemical signatures are being reactivated due to slab rollback of the northern Tongan arc. The active extension in the northern Tongan arc leads to thinning of the lithospheric lid perturbing the geotherm enough to heat the metasomatised lithosphere.