Se7en: A He isotope story of the Auckland Volcanic Field

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Despite its reputation as one of the most intensely studied monogenetic basalt fields, the existence of the Auckland Volcanic Field (AVF) still defies a straightforward explanation. Active from ~193 ka to 550 ybp, magmatism in the AVF has been variably ascribed to subduction modificaton in the lithospheric mantle, extension associate with the Hauraki Rift, and even "hot spot" activity. Variable causes/sources of magmatism are associated with trace element and isotopic compositional diversity observed in lavas. Three distinct AVF mantle sources have been proposed, including subduction-modified lithospheric mantle, a fertile garnet-asthenospheric mantle, and a HIMU-like component (variably ascribed to both ecologitic and carbonatized mantle).

Olivine from tephra and lava from eruptive "end-members", best representing contributions from each of the interpreted mantle components, were analyzed for $^{3}He/^{4}He$ by noble gas mass spectrometry to further constrain potential mantle sources, and in particular evaluate the potential for both a deeper and/or subduction-modified mantle source. Olivine grains from tephra samples were cleaned in HBF_4 to reduce potential contamination from young basaltic glass coating olivine grains. Isotopic ratios across all 14 samples range from 6.57 to 7.26 R/R_A. In comparison, a young arc basalt from the Taupo Volcanic Zone has an isotopic ratio of 5.27 R/R_A. The average He isotopic value of ~7 R/Ra is consistent with an asthenospheric mantle source. Prior geochemical modeling is also suggestive of a garnet-bearing asthenospheric mantle source.

We use La/Yb and Gd/Yb as proxies for source enrichment. We observe a negative correlation between these proxies and CO_2 abundance and CO_2/He, with greater REE-fractionated magmas showing systematically lower CO_2 concentrations and CO_2/He. He abundances and isotopic compositions do not appear to be correlated to indices of source enrichment or melting. These results suggest the He isotopic composition of AVF mantle sources are indistinguishable, but that the LREE enriched magmas contain significantly less CO_2 at the time of olivine crystallization.