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Radiogenic isotopes in minerals and melt inclusions reveal that mantle hetereogeneity is masked by mixing

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Radiogenic isotope compositions of bulk lavas have been used for decades to infer the extent and length scale of mantle heterogeneity resulting from extraction of partial melts and subduction recycling processes. However, owing to melt mixing, fractional crystallisation, and assimilation, lavas do not reliably record the mantle compositional heterogeneity.

Recent advances in thermal ionisation mass spectrometer (TIMS) detection combined with ultra-low blank wet-chemistry techniques now allow determination of combined Sr-Nd-Pb isotope composition of primitive minerals and their melt inclusions to be compared to bulk lava compositions.

We have recently successfully applied the techniques to: 1) study subduction recycling processes in Italy [1] and the Mariana arc; 2) evaluate magma evolution at Oldoinyo Lengai, East-African Rift; and 3) reveal more extreme mantle depletion and enrichment at the Azores OIB setting [2] and at the Atlantis Massif along the Mid-Atlantic Ridge [3].

Olivine-hosted melt inclusions (MIs) from Italy and the Marianas reveal the signatures of subduction recycling at the two fundamentally different tectonic settings. In Italy, the extreme compositions result from recycling different sediment types and lower crust; whereas the Marianas MI compositions reflect recycling of modest amounts of fluids and sediments. Isotopic compositions of olivine- and nepheline-hosted MIs at Oldoinyo Lengai, Tanzania illustrate how melt compositions are homogenised as a function of magma evolution at this continental rift carbonatite volcano.

Our studies at various tectonic settings all indicate that melt homogenisation processes after extraction from the source mask the true heterogeneity of the mantle, hampering our current understanding of Earth's compositional evolution controlled by plate tectonics and mantle convection.

[1] Koornneef, J.M., Nikogosian, I., van Bergen, M.J., Vroon, P.Z., Davies, G.R., (2019). Nature Communications 10, 3237; [2] Stracke, A., Genske, F., Berndt, J., Koornneef J.M., (2019). Nature Geoscience 12 (10), 851-855; [3] Lambart, S., Koornneef, J.M., Millet, M.A., Davies, G.R., Cook, M., Lissenberg, C.J., (2019). Nature Geoscience 12 (6), 482