New double spike Pb-isotope results for primitive Icelandic lavas

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The origin of isotopic variations in Icelandic lavas continues to be a topic of controversy. Models range from mixing between a homogeneous plume component and ambient upper mantle through to diverse heterogeneities intrinsic to the upwelling plume mantle itself. Pb isotope variations have been central to this debate, but significant inter-laboratory differences in analytical procedures, e.g. leaching & mass fractionation corrections, have hindered discussions. Recent studies have shown that Pb double or triple spike (DS) techniques represent the most precise and accurate method for Pb isotopic determinations: 5-20x better than traditional TIMS techniques.

Here, we focus on samples from the Icelandic neovolcanic zones, covering a wide range of mafic rock types from picrites, tholeiites to alkali basalts (MgO 6-15 wt%). Hand-picked chips were leached in hot 6M HCl for ~2 hrs, prior to sample digestion and chemical separation of Pb. Samples were analysed on an Axiom MC-ICPMS using both thallium and a ^{207}Pb-^{204}Pb DS to correct for mass bias. The external reproducibility of Pb isotope ratios determined for the standard SRM981 was ca. ± 100 ppm (DS correction), and replicate analyses of samples have a similar reproducibility. However, thallium-corrected standard (& sample) data display considerably more imprecision (5-10x worse) and are somewhat inaccurate compared with the DS-corrected data.

Our preliminary observations are based on 46 analyses of tholeiitic lavas (Reykjanes Peninsula, Northern Rift Zone) and alkaline lavas (Snaefellsnes, Snaefell, Vestmanna-eyjar).

(1) Vestmannaeyjar and Snaefellsnes alkalic lavas have ^{206}Pb/^{204}Pb > 18.9, and plot as a single trend along the NHRL on the ^{208}Pb/^{204}Pb - ^{206}Pb/^{204}Pb diagram. However, in ^{207}Pb/^{204}Pb - ^{206}Pb/^{204}Pb space they lie on two distinct but sub-parallel trends (and also have distinct ^{143}Nd/^{144}Nd).

(2) Reykjanes Peninsula and Northern Rift Zone samples have ^{206}Pb/^{204}Pb < 18.9, and plot as a single trend on the ^{208}Pb/^{204}Pb - ^{206}Pb/^{204}Pb diagram with a shallower slope than the NHRL. Snaefell lavas show a similar trend, but displaced to higher ^{208}Pb/^{204}Pb.

In ^{207}Pb/^{204}Pb - ^{206}Pb/^{204}Pb space, all samples lie below the NHRL except for low ^{206}Pb/^{204}Pb samples from Reykjanes and Snaefell. Significant variations in ^{207}Pb/^{204}Pb in low ^{206}Pb/^{204}Pb samples appears to be a real feature, but will be investigated further with additional analyses, in particular of picrites from Reykjanes & Theistareykir. In conclusion, our new high precision Pb isotopic analysis of Icelandic lavas is resolving a complexity of mixing relationships amongst different suites of samples that will reveal more about the nature of the mantle underlying Iceland.

PGEs are fractionated by olivine-melt partitioning

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Olivine fractionation plays a significant role in the evolution of komatiites and basalts. In this regard we report (Table 1) olivine-melt partition coefficients for the PGEs at conditions appropriate for basalt petrogenesis. Experiments were conducted at 1 bar and 1335-1400 ºC in a vertical tube furnace with CO-CO$_2$ mixtures used to control fO$_2$ over the range FMQ+3.6 to FMQ-1. Iron-bearing basalt-analogue powders were encapsulated in crucibles of San Carlos olivine and experiments employed a time-temperature history resulting in large (100+ micron) olivine crystals grown from the crucible walls. All runs were saturated in the metal phase. PGE abundances in run-product phases were characterised by laser ablation ICP-MS.

Glasses and olivines produced in experiments were found to be homogeneous in their concentration of Rh, Ru and Pd, as revealed by stable signal intensity on individual spots, and good precision (<10%) between separate spots. In contrast, time-resolved spectra revealed an inhomogeneous distribution of Os, with variable concentration domains sequentially sampled over short time intervals during laser ablation. This behaviour was observed in all experiments containing Os, regardless of fO$_2$ or experiment duration, and is probably due to undissolved Os micronuggets suspended in the melt.

TABLE 1	FMQ+3.6	FMQ+1	FMQ-1	predicted
Rh +2	1.8	2.6	---	3.1
Ru +3	0.6	2.2	---	2.5
Pd +1	0.018	0.014	0.006	0.004

Olivine/melt partition coefficients (Ds) were predicted using the lattice strain model of Beattie (1994) and assuming valence states determined in previous metal solubility experiments. Measured Ds for Rh and Ru increase with decreasing fO$_2$, whereas values for Pd decrease; in each case, Ds approach those predicted for the assumed oxidation state. Such behaviour is consistent with higher-than-assumed oxidation states at FMQ+3.6, and reduction in PGE valence with decreasing fO$_2$. Rh^{2+} and Ru^{3+} are compatible in olivine due to their similarlity in size to the optimal radius for octahedral coordination, whereas Pd^{1+} is strongly excluded due to its larger size and low valence. The relative partitioning of Ru, Rh and Pd at FMQ+1 indicates that olivine will play a role in producing the depletion in Ru and Rh relative to Pd observed in primitive mafic igneous rocks.

References

Beattie, P. (1994) *Chem. Geol.* **117**, 57-71.