Coupled major element-lead isotope variability in Hawaiian lavas

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Lead isotopes on lavas from the different evolution stages of Koolau Volcano—subaerial Makapuu stage, main shield stage lavas from the Koolau Scientific Drilling Project (KSDP) and Honolulu Volcanics (HV)—have identifed three end member components in Pb isotope space: Makapuu, Kalihi, and a depleted component unique to the rejuvenated stage HV (Fekiacova *et al*., 2007). When plotted against SiO_2, the Pb isotope data define two trends consistent with a ternary mixing: a negative correlation defined by shield stage building lavas and a positive correlation defined by the post-erosional HV. Similarly, CaO/Al_2O_3 ratios, a proxy for pyroxene-to-garnet ratio in the source are negatively correlated with Pb isotope ratios and demonstrate the co-existence of peridotite and eclogite in the Koolau source.

The approach was extended to other Hawaiian volcanoes from the two geographic alignments Kea and Loa which have been shown to be compositionally distinct in Pb isotope space (Abouchami *et al*., 2005). CaO/Al_2O_3 and Pb isotope ratios display a negative correlation at the scale of the whole chain: most Kea-trend lavas cluster at high Ca/Al ratios (0.8) while Loa-trend lavas display a large range (0.6-0.7), overlapping Koolau data, with Makapuu lying at the extreme low end of the correlation. This coupled major element-Pb isotope variability in Hawaii is interpreted in terms of mixing of pyroxenite and peridotite, in agreement with previous studies (Sobolev *et al.*, 2005; Ren *et al*., 2005; Herzberg, 2006). Mixing calculations show that most Kea lavas are derived from a mantle peridotite source with small amounts of pyroxenite (10-20%) whereas Loa lavas contain up to 90% of the eclogitic (pyroxenite) component. In addition, the proportion of this component along the Loa track decreases with decreasing age of the volcano (~90% in Koolau to 50-70% in Mauna Loa). This feature might be related to a change in the thickness of the lithosphere along the Hawaiian chain. This suggestion is sustained by seismic data showing a thinning of the lithosphere from 100 km under Big Island to about 50-60 km under Kauai (Li *et al*., 2004), and also the observation that the amount of recycled component in mantle-derived melts is partly controlled by the thickness of the lithosphere (Sobolev *et al*., 2007). Alternatively, changes in potential mantle temperature across the Hawaiian plume might produce variations in the composition of the melts (Herzberg, 2006).

The major-element Pb isotope correlation demonstrates that the Pb isotope "bilateral asymmetry" (Abouchami *et al*., 2005) also extends to the ratio of peridotite to pyroxenite in the source of the Hawaiian mantle plume.

Si isotopes as a clue for understanding Eoarchaean silicifications

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The Si isotopic composition of cherts has recently been proposed as a potential tracer for Precambrian external Si cycles because it is not sensitive to post-depositional resettings [1, 2]. In particular, long-term gradual changes of oceanic $\delta^{30}Si$ have been suggested to reflect the ocean cooling through time [2]. Unfortunately, this model is hampered by: (1) the poor precision of the ion microprobe analyses (~0.5-3‰, 2σ); (2) poor constraints on the actual outputs of sedimentary and hydrothermal silica isotopic fractionations in the Precambrian.

Here we show high precision (~0.15‰, 2σ) MC-ICP-MS measurements of $\delta^{30}Si$ on a series of variably silicified basalts and overlying bedded cherts from the 3.47 Ga Hooggenoeg Formation of the Barberton greenstone belt, South Africa.

The studied pillow lava flow shows silicification related to low temperature hydrothermal seafloor alteration vertically increasing towards the overlying chert horizon (from 40 up to 75wt% SiO_2, from -150m to the lava flow top) [3]. The deepest unsilicified basalts yield $\delta^{30}Si$ values from –0.15 to –0.40‰ which are in the range of Hawaiian rock standard values.

The $\delta^{30}Si$ for silicified basalts shifts towards more positive values (up to +0.79‰) with increasing grade of silicification and decreasing depth while the overlying chert horizon shows heavy $\delta^{30}Si$ (+0.50‰ to +1.12‰). The latter fit in the middle of the ion probe $\delta^{30}Si$ values obtained on coeval Barberton and Pilbara chert series[2].

These preliminary results provide new constraints on seawater-basaltic interactions with implications on the Si budget of the Eoarchaean ocean. Moreover, Barbeton cherts yield heavier $\delta^{30}Si$ than their Isua counterparts (-1.28‰ to -0.13‰) [1]. This implies a rapid change of the Eoarchaean ocean towards heavier Si isotopic signatures from 3.8Ga and 3.5Ga.

References

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