The P/Nd ratio of basalt as an indicator of pyroxenite in its source

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In principle, basalt may be produced by low to moderate degrees of melting of mantle peridotite, the usual scenario, but also, possibly, by higher degrees of melting of a source of basaltic or approximately basaltic composition, like eclogite or pyroxenite. Huge amounts of basalt have been recycled into the mantle over geological time, potentially to provide such a source. The question is whether this basaltic material preserves its major-element compositional identity long enough to take part in subsequent melting cycles, or becomes so thoroughly mixed back into peridotite that only its isotopic and trace-element signatures linger. Initial melts from eclogite are silica-rich dacitic liquids that would freeze out on contact with peridotite or its partial melts because of the pyroxene thermal divide, so are unlikely to contribute directly to basalt production [1]. However, Sobolev *et al*. [2, 3] argue that reaction of such silica-rich liquids with peridotite forms an olivine-free pyroxenite source, melt from which may contribute to the distinctive chemistry of ocean-island basalts (OIBs).

This hypothesis is difficult to test using incompatible trace elements, because most of these are held preferentially among crystalline phases in cpx and/or gt, and therefore their concentrations are not sensitive to the ol/opx ratio of the source. An exception is phosphorus, which, unusually among incompatible trace elements, substitutes for Si in silicate minerals, and prefers the isolated SiO_4 tetrahedra of orthosilicates (ol and gt) over the linked tetrahedra of chain silicates such as pyroxenes. We have measured experimentally the partition coefficients (D) for P between melt and ol, opx, cpx and gt in multiply saturated assemblages at 1.5 and 3.0 GPa, and confirmed that values of D_P for ol and gt are 2 to 3 times larger than for pyroxenes. The P/Nd ratio of a basalt should therefore be an indicator of the ol/opx ratio in its source. Interrogation of petrologic databases shows that P/Nd ratios of MORBs and IABs (derived from spinel lherzolite) are remarkably constant at 65±10, as previously pointed out [4-6]. The P/Nd ratios of OIBs are slightly lower at 55±10, consistent not with pyroxenite melting but with a peridotitic source, in the garnet facies. The elevated P/Nd ratios expected of pyroxenite sources are uncommon.

References

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Using δ^{30}Si to follow the soil-plant Si cycling in a weathering sequence of volcanic ash soils, Cameroon

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Plants take up Si as silicic acid and form phytoliths, a biogenic opal (BSi). This Si biocycling affects the availability of Si for clay formation, and for Si export through waterstreams. Si stable isotopes measurement provides a tool to quantify present and past impacts of plants on the continental Si cycle.

In order to calibrate this proxy, we report on detailed δ^{30}Si of plants, sand (>50µm), silt (2-50µm) and clay fractions (<2µm), and amorphous Si (ASi) in a weathering sequence of andesitic ash soils from the Mungo area (Cameroon). Plant communities consist of 50 years old banana stands. The soil sequence involves an increasing clay content from young (Y) to old (O) volcanic soils (vs). The δ^{30}Si values were measured by MC-ICP-MS Nu Plasma in medium resolution, operating in dry plasma with Mg doping: δ^{30}Si vs NBS28 ± 0.07‰ (±1σ).

Compared to fresh andesitic ash (-0.39‰), clay fractions displayed a gradient from -1.19‰ in Yvs to -1.62‰ in Ovs, thus confirming the trend of lighter isotopic compositions with increased weathering. The isotopic signatures of silts fractions (-0.44‰ in Ovs, -0.03‰ in Yvs) compared to clay fractions support that δ^{30}Si may reflect the ratio between primary and secondary minerals. ASi fractions (involving phytolith-rich BSi, volcanic glasses, and allophanic constituents) were heavier in surface horizons than at depth (Δ^{30}Si =+0.34‰), in agreement with the surface accumulation of phytoliths. Indeed, banana plant isotopic compositions were +0.10 and +0.55‰ respectively in Yvs and Ovs. Moreover, ASi were lighter in Yvs (-0.38‰) than in other soils (+0.44‰) pointing to a larger effect of phytoliths in ASi of weathered soils, devoid of volcanic glasses. Surrounding river waters in this area were very heavy (+1.20‰).

Our δ^{30}Si data thus support that plants can induce a strong isotopic imprint by rejecting phytoliths to soil surface. Numerous and successive plant cycles leading to phytolith accumulation would gradually produce a heavier signature in dissolved Si export. This plant impact was underestimated until now. It may have considerable implications on the understanding of the Si continental cycle and the quantitative assessment of Si transfer from land to sea and ocean.