

Implication of the nephelinite-alkali basalt transition on alkaline lavas petrogenesis

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Alkaline lavas from continental volcanoes or oceanic islands characterized by thick lithosphere (>50 km) define a compositional continuum from nephelinites to alkali olivine basalts and often to tholeiites. The origin of this continuum is a fundamental question in igneous petrology (e.g. [1]). The decrease in incompatible trace-element concentrations from nephelinitic to tholeiitic magmas in single volcanoes is consistent with this continuum reflecting an increase in the degree of partial melting of a common source [2]; however, no experiments on mantle lithologies (peridotite, pyroxenite) have reproduced the observed compositional continuum (nor even the observed range of silica contents: ~40 to 48 wt. % SiO₂). Alternatively, this continuum could be explained by reaction between nephelinitic/basanitic liquid and surrounding peridotite [3, 4, 5]. To test this latter hypothesis, “sandwich” experiments were performed in which a layer of hornblende (producing nephelinitic magmas [5]) was packed between layers of moderately depleted peridotite. Experiments were done at 1.5 and 2.5 GPa, 1225-1325°C. These experiments show that key features of the major- and trace-element trends from nephelinites/basanites to alkali basalts/tholeiites can be explained by interaction between hydrous nephelinitic melt and peridotite. This interaction generates a higher-silica melt plus olivine *via* dissolution of orthopyroxene from the peridotite.

In addition to trace-element variations, isotopic compositions also correlate with the major-element trend from nephelinite to alkali/tholeiitic basalt in some OIBs. For example, in EM-2 type lavas (Samoa, Society Islands) increasing Sr isotopic ratios are correlated with increasing silica (i.e., as lavas range from basanitic to tholeiitic in composition). This observation is consistent with the interaction between alkaline partial melts and peridotite, and may place constraints on the nature of the peridotite (i.e., depleted, primitive, or metasomatized).

[1] Green (1970) *Phys. Earth Planet. Inter.* **3**, 221-235; [2] Frey *et al.* (1978) *J. Petrol.* **19**, 463-513; [3] Shaw *et al.* (1998) *Contrib. Mineral. Petrol.* **132**, 354-370; [4] Lundstrom (2000) *Nature* **403**, 527-530; [5] Pilet *et al.* (2008) *Science* **320**, 916-919.

Transient geochemical and hydrogeological coupling during weathering and the carbon cycle in the critical zone

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Reactive transport mechanisms and transit times in unsaturated fractured crystalline rocks have been determined from field-scale observations using long-term and high-resolution monitoring. In the Roselend natural laboratory (French Alps), a tunnel provides access to the heart of the critical zone, 55 m below ground surface. Two sampling sites allow collection of dripwater from zones with contrasting contributions from matrix and fracture flow, as shown from major & trace elements, U-series and Sr isotopes. These crystalline rocks belong to the Hercynian basement of Europe, which has a significant outcropping surface area. These rocks bear minor amounts of sulfide and carbonate minerals. Iron sulfide dissolution is coupled with water fluxes and variations in water saturation of the rocks. Air entry promotes SO₄ (and associated As) production via microbiological activity. Transient drought conditions followed by infiltration enhance weathering rates by one order of magnitude. In matrix and fractures, carbonate dissolution is mainly coupled with pyrite dissolution, and promoted by protons. In fractures, carbonate dissolution is sometimes promoted by biogenic CO₂ infiltrated from the soil above. CO₂ concentration and stable isotope measurements in the various compartments allow the determination of the origin and fluxes of carbon. The net CO₂ budget reveals that these crystalline massifs are a carbon source.