Geochemistry and petrogenetic significance of natrocarbonatites at Oldoinyo Lengai, Tanzania

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Oldoinyo Lengai, Tanzania, is the only active carbonatite volcano on Earth. However, Oldoinyo Lengai carbonatites are unique in most aspects of their petrological and geochemical characteristics and are distinguished from pre-modern carbonatites elsewhere as extremely alkali-rich natrocarbonatites, with Na_2O+K_2O generally >40wt%. No magmatic calciocarbonatites have been found at Lengai (Zaitsev and Keller, 2006). We present and discuss the composition and chemical variation of natrocarbonatites sampled in regular intervals from 1988 to 2006. Oldoinyo Lengai is a young, upper Quaternary volcano, and natrocarbonatites represent only the very recent stage of its evolution. Silicate lavas and pyroclastics constitute far more than 90% of the cone.

All silicate lavas of Oldoinyo Lengai show a high degree of peralkalinity and are highly evolved (low Mg, Ni, Cr etc). Prominent examples in the Recent evolution are the unusual wollastonite-combeite nephelinites (Klaudius and Keller, 2006). Bulk geochemical composition, trace element systematics and Sr, Nd, and Pb isotopic ratios suggest a liquid immiscible separation of natrocarbonatite from combeite-wollastonite-bearing nephelinites. Primitive olivine melilitites in the vicinity of Oldoinyo Lengai are the only candidates for primary mantle-melt compositions (Keller *et al*. 2006). Geochemistry and isotope systematics reveal different lineages. The spread in Sr, Nd, and Pb isotopic ratios of olivine melilitites, phonolites, combeite-wollastonite nephelinites and natrocarbonatites is explained as mixing line between HIMU and EM1-like mantle components. Liquid immiscible separation of natrocarbonatite melts is interpreted to occur a very shallow level within the volcano.

References

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Constraints from Earth's heat budget on mantle dynamics

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One of the largest challenges in modeling mantle convection is the need to reconcile the global heat budget with the time and spatial scale of geochemical heterogeneity observed in mid-ocean ridge basalts (MORB) and oceanic island basalts (OIB). Most models include at least one reservoir that is enriched in radiogenic elements relative to the mid-ocean ridge basalt (MORB) source, as as this appears to be required to account for most current estimates of the Earth's heat budget. This reservoir would also be responsible for the geochemical signature in some ocean island basalts (OIBs) like Hawaii, but must be rarely sampled at the surface. Our current knowledge of the mass- and heat-budget for the bulk silicate Earth from geochemical, cosmochemical and geodynamical observations and constraints enables us to quantify the radiogenic heat enrichment required to balance the heat budget. The current work has two parts. First, without assuming a specific model for the structure of the reservoir, we determine the inherent trade-off between heat production rate and mass of the reservoir. Using these constraints, we then investigate the dynamical inferences of the heat budget, assuming that the additional heat is produced within a deep layer situated initially above the core-mantle boundary. We carry out dynamical models of layered convection using four different fixed reservoir volumes, corresponding to deep layers of thicknesses 150, 500, 1000, and 1600 km, respectively, and including both temperature-dependent viscosity and an instrinsic viscosity jump between upper and lower mantle. We then assess the viability of these cases against some of the multiple criteria that must be satisfied by any model of mantle convection: stability of the deep layer through time, topography of the interface, effective density profile, intrinsic chemical density and a positive heat flux at the core-mantle boundary.