Origin of tholeiite magma in the Hawaiian hot spot

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In order to study the origin and dynamics of mantle plumes, we have carried out both filed works and experimental work on several volcanoes in Hawaii, which is the most magma productive hot spot on our planet. The important role of recycled old oceanic crust in magma genesis in large hot spots (particularly that in Hawaii) has become clear in our study (e.g., Tanaka et al, 2002; Takahashi & Nakajima, 2002).

In order to understand the condition of melting and the source rocks for the various primary Hawaiian magmas, melting experiments with MORB/peridotite and Fe-MORB/peridotite sandwich starting materials. It was found that silica-rich Koolau-type primitive melts can be produced by extensive partial melting of basaltic source rock alone at 2.5-3.0 GPa and 1350-1400C; conditions slightly below the dry solidus of mantle peridotite. At conditions on or above the peridotite solidus, melts become saturated with olivine and are similar to picritic olivine tholeiite in Kilauea. Accordingly, we propose that the high-silica Koolau primary magma is produced by almost entirely from the recycled oceanic crust (cf. ca.10% by Hauri, 1996). Changing isotope compositions found in Koolau volcano may indicate variety of mixing ratio between eclogite derived melts and the ambient peridotite derived melts.

In the basalt/peridotite sandwich melting experiments, melt proportion within the basalt domain decreases as temperature increase near the peridotite solidus. This is due to the enhanced chemical reaction between the basalt domain and the ambient peridotite. Due to this effect, bulk melt proportion in the sandwich starting material records minimum at a temperature near the peridotite solidus. Accordingly, melts produced in the peridotite at temperatures above the peridotite solidus are more enriched in incompatible elements K, Ti and LREE than those produced at lower temperatures in the basalt domain. This may explain the difference in trace element characters among Hawaiian shield volcanoes.