Role of volatiles in melting process of mantle plume: Case study in Hawaii

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In order to understand the role of water in magma genesis of a plume consisting of peridotite and eclogite (recycled ancient oceanic crust), melting experiments were carried out at 1300-1550˚C and 3, 5 and 8 GPa pressure conditions with 0 to 5wt% of water. In order to test the effect of mafic bulk rock composition on the chemistry of reacted melts, 2 basalt compositions were chosen (NMORB and CRB). Compared with NMORB, CRB is enriched in Fe, K, Ti and LREE. H_2O promotes melting of only basalt layer under low water concentration, while it enhances melting and chemical interaction between both layers. Reacted dry melts formed from MORB/peridotite layered experiments were tholeiitic (basalt/basaltic andesite/andesite) while those from CRB/peridotite layered experiments were alkalic (alkali basalt/basanite/trachy-basalt/ trachy-andesite/ phono-tephrite).
Based on experimental results combined with field occurrence of tholeiite and alkalic magmas in Hawaiian plume, a new model for the role of volatiles in melting of mantle plume is proposed. Alkali acidic magma such as mugearite, hawaiite, trachyte, and phono-teprite appears in many hot spots. These alkali acidic magmas have been considered as products of fractional crystallization from alkali basalt magma in shallow level magma chambers. However, based on our experiments, we propose a new model, that at least some alkali acidic magma may have derived directly from partial melting of elogite at 3 to 5 GPa under slightly hydrous conditions. Under activie shiled volcanoes (e.g., Kilauea and Mauna Kea) tholeiitic magma is being produced by extensive reaction melting of entrained eclogite with surrounding peridotite at the top of the plume 2.7-2.8 GPa. This model gives explanation for the origin of alkali achidic rocks found from south flank of Kilauea by Sisson et al (2002). This model can also explain why alkali acidic magma (mugearite, hawaiite) prevails in volume in the post-shield stage of Hawaiian volcanoes.

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