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Melting Process in the Hawaiian Plume

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In order to constrain the chemistry and temperature of the hot rising material (mantle plume), we have studied growth history of Koolau volcano in Hawaii based on reconstruction of giant submarine landslides (Evolution of Hawaiian Volcanoes, AGU Monograph, 2001). Based on petrology of the Koolau lava and high-pressure melting experiments, we propose a model that the Hawaiian plume has a potential mantle temperature (PMT) of only 1400C and the primitive magma at the final growth stage of Koolau volcano (Makapuu stage) was formed by extensive melting of a large block of recycled old oceanic crust (eclogite block of 1000km3 in volume). Our PMT is much lower than the estimate for the modern Hawaiian plume by Watson and McKenzie (1991, PMT=1558C) assuming homogeneous peridotite source. Melting experiments of basalt/peridotite hybrid source at 3 GPa (Takahashi and Nakajima, 2001) show that only slight temperature increase (less than 50deg) will shift the Koolau type primary melts (SiO_2=53, MgO=7 wt.%) to the parental Mauna Loa and Kilauea type melts (SiO_2=49, MgO=14). Geometry of the partial melt zone surrounding upwelling eclogite blocks may cause the inter-shield chemical variation among the Hawaiian volcanoes. The lower plume temperature and the existence of large blocks of former oceanic crust in the plume require reconsideration on the origin of the mantle plume and the mechanism of its upwelling transport. Presence or absence of the old oceanic crust in the plume will explain chemical diversity and the contrasting melt productivity between hot spots (e.g., Iceland vs. Azores). The large low velocity anomaly down to the CMB underneath the South Pacific hot spots (most distinct in global tomography), presently yields smaller magma flux than a single Hawaiian hot spot. The South Pacific plume may consist of upwelling warm hurzburgite (depleted ancient oceanic lithosphere). The South Pacific hot spot however was very magma productive in the Cretaceous time when large amount of recycled oceanic crust was entrained in the same plume. High-pressure experiments on density of subducted oceanic crust suggest that much of the subducted eclogite is stored above the 660km discontinuity. The fluctuation in magmatism in given hot spots may be explained by the interaction of the eclogite stock layer and the ascending plume.