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Is the magma on old Pacific plate really derived from the Earth's asthenosphere?

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Origin of alkali basalt magma that has erupted on old Pacific plate (Hirano et al, 2001; 2006) is enigmatic. The basalt samples are suitable for estimating their origin by melting experiments, because they are fresh, nearly aphyric to slightly olivine-phyric and little fractionated (judging from the presence of abundant mantle xenoliths in them). We have estimated the volatile concentration in the alkali basalt magma based on the H2O+ data of fresh samples and the abundance of vesicles. We estimated a primary magma composition for the young alkalic basalts near the Japan Trench (JPT-CW; 44.3 wt% SiO2, 17.3 wt% MgO, 9.9 wt% FeO, 2.9% K2O, 1.6 wt% H2O and 1.9 wt% CO2). High-pressure melting experiments were carried out on JPT-CW composition and we found that this magma has a multiple-saturation point with olivine + orthopyroxene + clinopyroxene + garnet assemblage at about 3 GPa and 1400C on its liquidus. In other words, the JPT-CW magma can be in equilibrium with mantle peridotite at 3 GPa and 1400 degreeC (100 degreeC below the solidus of dry peridotite KLB-1, Takahashi, 1986 JGR).

In order to study the role of partial melting under the oceanic lithosphere, experiments were carried out using a mixture of 97 wt% peridotite KLB-1 and 3 wt% JPT-CW in the pressure range between 2.2 and 3.5 GPa and the temperature range between 1250 and 1500 degreeC. Typical run durations are 100 hrs for low-temperature and 20 hrs for high-temperature runs. Three melting regimes were recognized in our experiments; 1) within the stability of phlogophite (less than 1300 degreeC) neither signature of melting nor that for mobilization of elements were detected, 2) between 1300 and 1400 degreeC, almost all potassium has been lost from the peridotite matrix by migration of H2O-rich fluid, 3) at higher than 1400 degreeC, K-rich partial melts were formed and distributed throughout the peridotite matrix.

Based on our experiments, we propose a model for the role of partial melting in the asthenosphere; 1) The upper bound of partially molten asthenosphere is most probably controlled by inflected peridotite solidus due to the stabilization of carbonate and breakdown of phlogophite at around 3GPa and 1300 degreeC. 2) In the asthenosphere, super-critical fluids promote segregation of alkali elements from deep mantle regime. 3) Oceanic plate would act as an impermeable lid for the asthenospheric and a thin melt-enriched layer would be produced beneath the oceanic lithosphere after the long term melt segregation. 4) This partial-melt layer may act as a slip-plane and would define the mechanical thickness of oceanic plate. 5) Alkali basalt magma similar to those reported by Hirano et al.(2006) may be ubiquitously present beneath old oceanic plates.