Mantle heterogeneity and recycling of subducted crust constrained by pyroxenite melting experiments

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It has widely been suggested that subducted oceanic crust is an important constituent of long-lived mantle heterogeneities and that it plays a significant role in the petrogenesis of ocean island basalts (OIB). However, experimentally derived partial melts of mafic oceanic crust are invariably silica-saturated, whereas many OIB are silica-undersaturated olivine basalts or basanites. In addition, CaO enrichments and Al2O3 depletions of OIB cannot be produced from partial melting of peridotite or mixtures of MORB-like basalt and peridotite. Another drawback of crust recycling is that MORB-like basalt in the deep mantle transforms to stishovite eclogite that is too heavy to be carried by upwelling mantle. Thus, subducted oceanic crust does not seem to be a likely source for OIB.

We have done a series of partial melting experiments on a Mg-rich garnet clinopyroxenite (Mix1G: Mg# = 79), which has clinopyroxene, garnet and a small amount of olivine under subsolidus. The experiments indicate that olivine does not appear above the solidus at more than 2.5 GPa, although partial melts are silica-undersaturated. In addition, the garnet field expands with increasing pressure. This relationship drives partial melt compositions to lower Al2O3 and higher CaO without changing MgO contents, producing melts with notable similarities to OIB. The solidus temperatures of Mix1G are cooler than the anhydrous peridotite solidus. If similar materials are present in a hot (mantle potential temperature = 1550C) plume, they will begin to melt at about 5.0 GPa.

Thus, OIB magmas can be produced from pyroxenites which have no olivine above solidus but have garnet as the liquidus phase. Since such pyroxenites have no SiO2 phase under any P-T conditions, it is less dense than MORB-like eclogite in the deep mantle and can be involved in upwelling mantle plumes. If subducted oceanic crust partially melts at subduction zones, its residue loses SiO2 component and may become eclogite without SiO2 phase in the deep mantle. Recycling of such residual oceanic crust is a potential origin of heterogeneity in OIB sources.