Geophysical Research Abstracts, Vol. 8, 05607, 2006
SRef-ID: 1607-7962/gra/EGU06-A-05607

Experimental and geochemical constraints for quantifying the contribution of recycled oceanic crust in convecting mantle

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It is widely accepted that the heterogeneity of the convecting mantle is largely caused by subduction and recycling of crustal materials into the deep mantle. To understand the role of this process in creating compositional anomalies in the mantle and to find out its geodynamical consequences one must quantify the crustal contribution in the mantle sources. However the previous approach of quantitative estimates of the proportions of recycled crust in mantle plumes based on incompatible trace elements and isotope ratios in ocean islands basalts is significantly compromised by the great variability of subducted materials and involved fractionation processes. Therefore we propose an alternative approach based on major elements and compatible trace elements in parental melts because these are more uniform in the mantle and are strongly controlled by the phase petrology of melting.

Our approach is based on the new experimental finding that the high pressure melting of typical recycled oceanic crust and reaction of melt with peridotite at 3.5 GPa and T=1400-1570 C produces olivine free secondary pyroxenite. Further melting of this pyroxenite in the absence of residual olivine creates parental melts which differ significantly from peridotite-derived melts at same P and T by enrichment in Ni, Si, and depletion in Mg, Ca, Cr, Sc and Mn as well as by significantly higher melt productivity. This is due to the fundamental control by olivine on the composition of the produced melt in peridotite and the absence of this control during melting of olivine-free non-peridotitic sources. At low pressures ($P<1.5$ GPa) such a melts become saturated with olivine and crystallize olivine phenocrysts unusually rich in Ni and depleted in Ca,

Mn and Cr.

Using large database of compositions of olivine phenocrysts from mantle plumes, large igneous provinces, mid-oceanic ridges and komatiites we show that the previously under -appreciated reaction product olivine-free pyroxenite, is expected to be a common non-peridotitic source in the convecting upper mantle whenever recycled oceanic crust has contributed to its composition. In particular pyroxenite is shown to be a major source of melts derived from mantle plumes and large igneous provinces emplaced on the thick lithosphere.