Experimental modeling of sediment-peridotite interaction in a thermal gradient

A. B. WOODLAND[1], A. V. GIRNIS[1,2], V. K. BULATOV[1,3], G. P. BREY[1], H. E. HÖFER[1] AND A. GERDES[1]

[1] Inst. für Geowissenschaften, Universität Frankfurt, Germany
[2] IGEM, Russian Academy of Sciences, Moscow, Russia
[3] Vernadsky Inst., RAS, Moscow, Russia

Strong thermal and chemical gradients are inherent to subduction zones where relatively cold sediments become juxtaposed with hotter mantle wedge peridotite. This is even more extreme for mélange diapirs that rise from the slab contact into the overlying mantle and begin to melt [1]. We have undertaken a series of experiments to simulate sediment-peridotite interactions and mass transfer processes that occur in subduction zones under the regime of thermal gradients. In this way we can explore how fluids and small volume melts migrate through peridotite. The sediment was similar to GLOSS [2] and was the source of H_2O, CO_2 and trace elements. The peridotite was a depleted garnet (gt) harzburgite (natural olivine, opx and gt). Experiments were at 7.5 GPa to simulate deep subduction. The thermal gradient was achieved by displacing the sample capsule from the pressure cell center and was monitored by two thermocouples and opx-gt thermometry. Maximum T varied from 1400°-900°C and gradients of 50°-200°/mm resulted in T of 1200°-500°C at the cold end (T_{min}) of a 4mm long capsule. Thus, in some experiments melting occurred in the sediment layer and in others this layer remained subsolidus, only devolatilizing.

Major and trace elements were transported both in the direction of melt percolation to the hot zone, as well as down T, establishing discrete mineralogic zones. Peridotite olivine converts to opx due to Si addition and migration of Mg and Fe to the sediment. The sediment converts to a cpx + gt assemblage. A thin depleted zone forms directly above the sediment/peridotite boundary, defining the region of maximum metasomatic alteration.

At low T_{min}, fluid-mobile Ba, Rb, Sr and Li are more strongly transported to the melt zone than to HFSE and REE. At T_{min}>700°C, incompatible elements are transferred from the solid to the melt, with the mineral assemblage controlling which elements are held back in the solid residue (i.e. MREE, HREE, Y, Sc, Ti, Zr & Hf in gt). Negative Nb–Ta anomalies are caused by residual rutile and/or humite-group minerals.

Transport of melt or fluid from the sediment to the overlying mantle wedge produces metasomatized magma sources with sedimentary geochemical signatures. Only 1% of such melt or fluid is sufficient to produce melts with incompatible element contents similar to those observed in natural subduction-related magmas.

[1] Gerya et al. (2006) PEPI, 156, 59; [2] Plank & Langmuir (1998) Chem Geol, 145, 32.