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Reaction between volatile-bearing eclogite and harzburgite as a function of degree of interaction: Experimental constraints at 4 GPa

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Abstract

The mantle is known to be heterogeneous, mainly composed of peridotite and eclogite. Eclogite-derived hydrous melts may interact with harzburgite at the slab-mantle interface in subduction zones or in the sub-continental lithospheric mantle. In this study, such interactions were simulated by performing hybridization experiments in which a layer of eclogite was juxtaposed to a layer of harzburgite in the presence of H_2O-CO_2 at 4 GPa and 1200 °C, conditions where eclogite is super-solidus while harzburgite is sub-solidus. A diamond trap was placed in between the two layers to trap the fluid or melt phase, allowing direct determination of their composition. The multi-anvil was rotated at different frequencies to examine the effect of increasing degree of interaction on the melt composition as well as the mineral compositions. The interaction of eclogite-derived hydrous melt and harzburgite results in a reaction layer at the interface between the two lithologies, composed of Opx and garnet. The harzburgite above the reaction layer is metasomatized, containing various amounts of olivine, Opx, Cpx, and garnet. The eclogitic melt is modified during this interaction. With increasing interaction, a thicker reaction layer is formed. Both the eclogitic and the peridotitic garnet compositions approach each other and become intermediate between the composition of the garnet in the eclogite+H_2O+CO_2 system and the garnet in the harzburgite+H_2O+CO_2 system at these conditions. The Mg# of the peridotitic olivine and Opx decreases with increasing interaction. The initial basaltic melt in equilibrium with eclogite is metaluminous, turning to a peralkaline melt with increasing interaction with the harzburgite. The metasomatizing effect of the eclogite-derived hydrous melt on the harzburgite is observed by increasing the mode of the peridotitic Opx, Cpx, and garnet at the expense of peridotitic olivine and eclogitic garnet. A slight increase in melt fraction occurs as well. This interaction also results in a gradient in the $\log f_{O_2}$. Relatively more oxidizing conditions occur near the reaction layer, becoming more reduced into the peridotite, suggesting that the reaction zones act as partial barriers for the melt to travel through the peridotite. Increased interaction leads to higher $\log f_{O_2}$ values. These experiments demonstrate the influence of the degree of interaction on the range of melt compositions found in volcanic arcs as well as the degree of metasomatism in the mantle found in the sub continental lithospheric mantle.

Keywords: Metasomatism, peridotite, high pressure, experiments, fluid, volatiles, hybridization