Percolation of FeS Melts in Partially Molten Peridotite

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The mechanism which provides the segregation of molten Fe-FeS into the core of the Earth is still not fully understood. Due to the high interfacial energy between FeS melts and peridotite material the percolation flow of sulphide melts is not efficient. Two series of percolation experiments have been done on partially molten fertile garnet peridotite, sampled from a xenolith. Powders with 100-200 μm and 20-30μm grain size were mixed with 5-15 vol% Fe-FeS eutectic composition. The deformed high-T garnet peridotite with Mg# 0.90 is composed from 60 vol% Ol, 15% Opx, 5.3 % Cpx and 19% Ga. The first type of experiment has been realized in the centrifuging piston cylinder at ETH, Zürich. The samples of fertile peridotite and $Fe_{70}S_{30}$ powders were sealed in graphite capsules 2.6 mm in diameter and 3 mm in heigh and annealed at 0.8-1 GPa at temperatures of 1150-1260°C in a conventional piston-cylinder over 70 h. Then, the capsules have been rotated in a piston-cylinder at 500 g during 2-10 h at a pressure of 1 GPa and high temperature. Polished sections of samples were analysed on a JEOL microprobe and the distribution of $Fe_{70}S_{30}$ melts and silicate partial melts has been quantified. In the second type of experiments, the powder mixtures of peridotite and $Fe_{70}S_{30}$ were annealed at 1 GPa and at temperatures from 950 to 1300°C in a conventional piston-cylinder and the electrical conductivity of samples has been measured using the impedance spectroscopy method in BN-graphite-CaF_2 pressure cell with concentric cylindrical electrodes made from Mo-foil which corresponds to the oxygen fugacity about IW buffer.

The centrifuge experiments revealed a negligible percolation of $Fe_{70}S_{30}$ melts through the partially molten peridotite matrix. Only at 1260°C and starting 5 vol% of $Fe_{70}S_{30}$ the vertical gradient achieved 1-2 vol%/mm, and in samples with starting 15 vol% FeS the vertical separation achieved 2-2.5 vol%/mm after 10 h of centrifuging. The degree of partial melting of peridotite contributes only in the increase of $Fe_{70}S_{30}$ droplet size, in agreement with the results of Yoshino & Watson (2005). In conductivity experiments, during the 1st heating cycle, the initially high conductivity of powder samples drops for 1-1.5 orders of magnitude within 1h after the reaching of the melting point of $Fe_{70}S_{30}$. Below c. 1000°C the activation energy of electrical conductivity is about that of a peridotite sample, 2.2 eV. Above the melting point of $Fe_{70}S_{30}$ the activation energy slightly increases to 2.35 eV, and then drops to 0.6-0.7 eV above the melting point of peridotite. In contradiction to Yoshino et al. (2004), the electrical conductivity measurements demonstrated that the 5-15 vol% $Fe_{70}S_{30}$ melts never built an interconnected pattern in a peridotite matrix.