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Electrical conductivity of partially-molten olivine aggregate and melt interconnectivity in the oceanic upper mantle

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A consistent explanation for mantle geophysical anomalies such as the Lithosphere-Astenosphere Boundary (LAB) relies on the existence of little amount of melt trapped in the solid peridotite. Mathematical models have been used to assess the melt fraction possibly lying at mantle depths, but they have not been experimentally checked at low melt fraction (< 2 vol. %). To fill this gap, we performed in situ electrical conductivity (EC) measurement on a partially-molten olivine aggregate (Fo92-olivine from a natural peridotite of Lanzarote, Canary Islands, Spain) containing various amount of basaltic (MORB-like composition) melt (0 to 100%) at upper mantle conditions. We used the MAVO 6-ram press (BGI) combined with a Solartron gain phase analyser to acquire the electrical resistance of the sample at pressure of 1.5 GPa and temperature up to 1400°C.

The results show the increase of the electrical conductivity with the temperature following an Arrhenius law, and with the melt fraction, but the effect of pressure between 1.5 and 3.0 GPa was found negligible at a melt fraction of 0.5 vol.%. The conductivity of a partially molten aggregate fits the modified Archie's law from 0.5 to 100 vol.%. At melt fractions of 0.25, 0.15 and 0.0 vol.%, the EC value deviates from the trend previously defined, suggesting that the melt is no longer fully interconnected through the sample, also supported by chemical mapping. Our results extend the previous results obtained on mixed system between 1 and 10% of melt. Since the melt appears fully interconnected down to very low melt fraction (0.5 vol.%), we conclude that (i) only 0.5 to 1 vol.% of melt is enough to explain the LAB EC anomaly, lower than previously determined; and (ii) deformation is not mandatory to enhance electrical conductivity of melt-bearing mantle rocks.