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High electrical conductivities in the mantle: an experimental study on low melt fractions

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Many regions in the Earth's mantle show elevated electrical conductivities. Under mid-oceanic ridges, electrical conductivities are in the range 0.1 $S.m^{-1}$ to 0.3 $S.m^{-1}$whereas off-axis conductivities show slightly lower values, which, however, remains well above expected conductivity for conventional peridotitic rocks. A correct interpretation of the petrological nature of the conductive mantle is critical for our understanding of mantle geodynamics.

Conductive mantle regions most likely reflect partial melting. The presence of melts in the Earth's mantle has long been proved by geochemical observations and experimental petrology on peridotite rocks by the presence of volatile species (water, carbon dioxide, halogens) which produce small melt fractions (either silicated or carbonated in composition). Hydrated basalts show elevated conductivities, but high melt fractions that carbonated melts are very conductive: 100 to 300 $S.m^{-1}$. Pressure and chemical compositions have little effect on their electrical conductivities. Using different mixing laws (Hashin-Shtrikman upper bound (HS+) or tube law) between carbonated melts and olivine, it is possible to anticipate that we need less than 1% of carbonated melts in the mantle to explain high electrical conductivities.

However the electrical conductivity depends on the melt configuration in grain boundaries (sheets, tube, ...). So it is very important to perform new electrical conductivity measurements on peridotite samples containing carbonated melt fraction less to 1%. Since it is very difficult to observe small melt fractions, we can only compare predicted conductivities using different mixing laws with the electrical response of partially molten peridotitic samples. We will report here new measurements of electrical conductivities of peridotitic rocks impregnated with low fractions of carbonated melts. Measurements of sample containing 0.1 to 1% will be presented. The solid matrix will be constituted of dry forsterite and multi-component synthetic peridotites. With these experiments, we will be able to deduce the melt configuration in grain boundaries and to provide a more quantitative interpretation of elevated electrical conductivities imaged in Earth's mantle.