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Unravelling (CO_2+H_2O)-bearing melt distribution in the upper mantle using experimental nano-petrology

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Mantle melting has often been proposed to cause the low velocity zone (LVZ) in the shallow oceanic mantle. However, geophysical anomalies such as decreases in shear wave velocity (Vs) and increases in electrical conductivity are observed up to lithospheric regions where volatile-free melting and H_2O-assisted melting are not possible. Actually, both CO_2 and H_2O are required for lowering mantle melting temperatures down to ~1000°C. Given the minute amounts of CO_2 and H_2O present in the mantle, only minute amounts of (CO_2+H_2O)-rich melts are predicted at these temperatures. Moreover, those very small fractions of melt must be interconnected to enable the modification of macroscopic properties of the mantle and geophysical signals. We experimentally re-equilibrate a naturally (CO_2+H_2O)-bearing mantle rock at mantle-relevant pressure and temperatures, down to lithospheric temperatures [1]. Thanks to extensive, nanoscale characterizations, we evidence that incipient melting produces minute amounts of (CO_2+H_2O)-rich and interconnected melts, down to ~0.1 vol.% melt at 1050°C (Fig. 1). Hence, the correspondence of the region where geophysical anomalies are observed and the region where (CO_2+H_2O)-melting is possible strongly supports that the LVZ is a melting zone. Geophysical surveys appears to depict *in situ* the very low and highly heterogeneous distribution of melt in the mantle, in line with the very low and highly heterogeneous distribution of volatiles reported from geochemical surveys. The average background melt fraction in the upper mantle appears very low, estimated at ~0.03-0.05 vol.%, leaving global-scale geophysical signals mainly unaffected. Increases in melt fraction appear to be local, giving rise to strong geophysical anomalies (above ~0.2 vol.%). Deepening the distribution of volatiles and melts and their influence on mantle dynamics calls for investigations on the seismic velocity, permeability and rheology of partially molten rocks with the diversity of mantle melt compositions, melt fractions and temperatures.

[1] Gardés, Laumonier, Massuyeau & Gaillard (2020) *Earth and Planetary Science Letters* 540, 116242

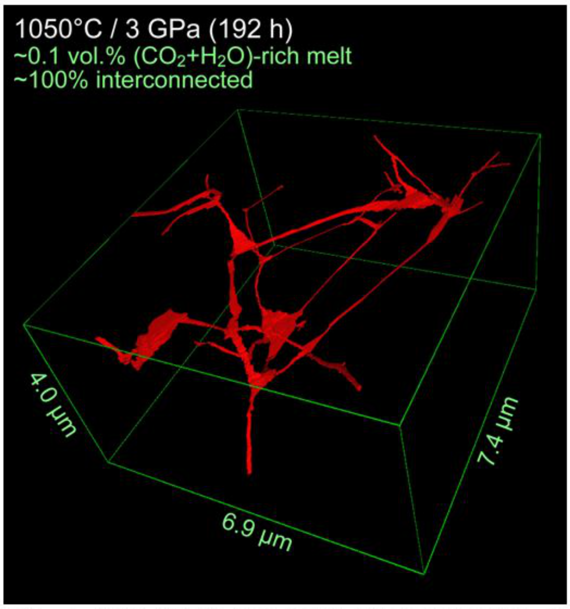

Fig. 1 (CO_2+H_2O)-rich melt interconnection in (CO_2+H_2O)-bearing mantle rock experimentally re-equilibrated at shallow mantle temperature and pressure.