Melting of peridotite to 140 GPa*

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At 2900 km under our feet, geophysics and mineral physics acknowledge very large contrasts of density and acoustic wave velocity between the Earth's mantle and the core. Indeed, the Earth's core is mainly constituted of liquid iron, whereas the solid mantle is essentially made up of oxides of magnesium, iron and silicon. With a pressure of around 1.4 million times the atmospheric pressure and a temperature of more than 4000 Kelvin, this region is also the location of chemical reactions and changes in states of matter not completely understood. For instance, seismologists have revealed an abrupt reduction of the speed of the seismic waves, which sometimes reach 30% when getting close to the core mantle boundary (CMB). These observations correspond to localized features, which have been called ultra-low velocity zones or ULVZs. For the last 15 years, these observations have led scientists to formulate the hypothesis of the partial melting of the Earth's mantle at the CMB.

To check this hypothesis, we carried out melting experiments on a natural peridotite[1] composition. These experiments were carried out over a range of lower mantle pressures between 36 and 140 GPa, using a laser-heated diamond-anvil cell (DAC) coupled with *in situ* synchrotron measurements at the high-pressure beamstation ID27. We then used *in situ* X-ray diffraction as primary criterion for melting and to determine the order in which crystalline phases melt. We could establish, without any extrapolation, fusion curves of the deep Earth's mantle and we show that the partial melting of the mantle is possible when the temperature approaches 4200 K. This temperature is within the range of temperatures proposed for the core side of the CMB. Partial melting in the deepest part of the mantle is thus highly plausible.

This observation reinforces the hypothesis of the presence of a deep magma ocean on the top of the Earth's core, which could be as thick as 50 km and explain the presence of ULVZs shown by seismology. It is also attractive to link these observations with an episode of extensive melting that probably affected the primitive Earth, leading to the formation of a deep magma ocean. If the evolution of a terrestrial magma ocean resulted in the formation of a layer of melt at the base of the mantle early in Earth history, our experiments show that it is likely some relics of this early magma ocean has been kept at the core mantle boundary.

[1] Peridotite is the dominant rock of the Earth's mantle above a depth of about 400 km; below that depth, olivine is converted to denser higher-pressure mineral phases.