	Experiment title: Melting processes at the core mantle boundary	**Experiment number**: HS3701
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Report:

Interrogating physical processes that occur within the lowermost mantle is a key to understanding Earth's evolution and present-day inner composition. Among such processes, partial melting has been proposed to explain mantle regions with ultralow seismic velocities near the core-mantle boundary, but experimental validation at the appropriate temperature and pressures regimes remains challenging. Using laser-heated diamond anvil cells, we constructed the solidus curve of a natural fertile peridotite between 36 and 140 GPa. Melting at core-mantle boundary pressures occurs at 4180 ± 150 K, a value matching estimated mantle geotherms. Molten regions may therefore exist at the base of the present-day mantle. Melting phase relations and element partitioning data also show that these liquids could host many incompatible elements at the base of the mantle.

We used X-ray diffraction and the observation of a diffuse X-ray scattering by the liquid as an unambiguous melting criterion Other features preceding or accompanying partial melting are used in our study as well. The first observation is a re-crystallization process taking place at the onset of melting. Since this re-crystallization affects specific phases, this process can be used to identify the melting sequence. This is illustrated in Fig.1 below, where $CaSiO_3$ perovskite is shown to re-crystallize at 105 GPa and 3875 K (shown by dark single spots observed in the diffraction images) before vanishing at 3925 K after complete melting.

Peridotite 85 GPa
After transformation @2500 K
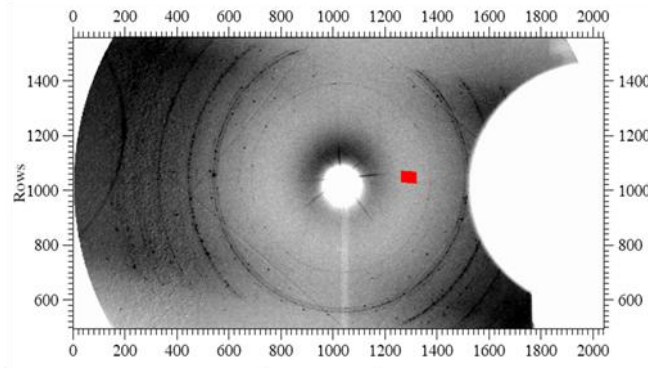
Peridotite 105 GPa – 3875 K
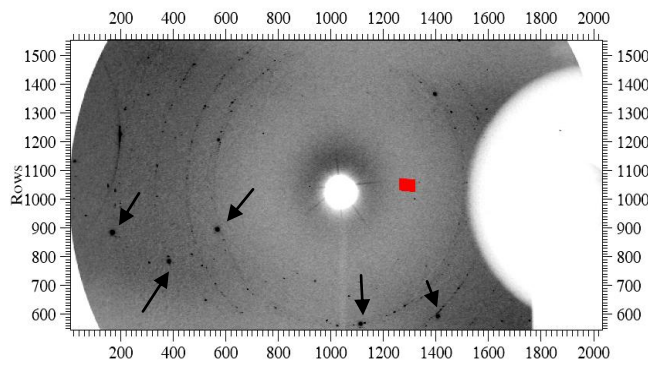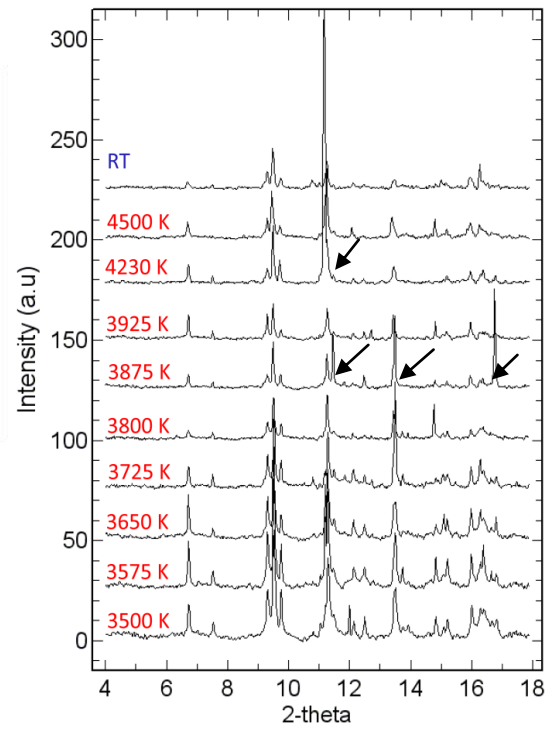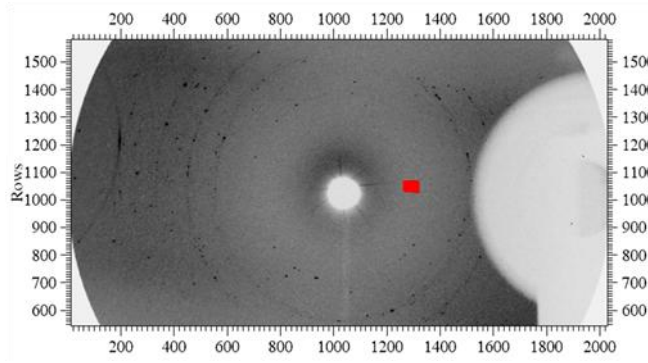

Peridotite 105 GPa – 3925 K

Figure 1: 2D diffraction images of peridotite at initial pressure of 85 GPa as a function of temperature. Re-crystallization of $CaSiO_3$ perovskite is evidenced by the appearance of dark spots on the diffraction plate (arrows on the left) and pronounced peaks in the integrated diffraction pattern (arrows on the right). Dark spots observed at 3875 K are no longer visible at 3925 K, following complete melting of $CaSiO_3$ perovskite. Re-crystallization of ferropericlase is possibly observed above 4230 K as shown on the right hand side by the change in intensity of a diffraction peak around 11 degrees 2-theta. The pressure increase from 85 to 105 GPa is a consequence of thermal pressure developed at high-temperature in the experimental charge.

We obtain a solidus curve which is about 1400 K above an average mantle adiabat at mid-mantle pressures, but the difference shrinks rapidly above 120 GPa as we approach the core mantle boundary. At 135 GPa, the peridotitic mantle solidus temperature extrapolated from our data set is at 4180 ± 150 K. This value is within the range of proposed temperatures on the core side of the CMB, as calculated from an outer core adiabat and melting experiments on iron alloys or as constrained by the reverse transition from the $CaIrO_3$-type to the perovskite phase at the base of the D" layer. Partial melting in the deepest part of the mantle is therefore highly plausible. This process could therefore explain the presence of ultra-low velocity zones at the base of the mantle.