Report:
Experiment HS 3953 generated data published in a *Science* paper by Fiquet et al. (2010). The aim of the study was to provide experimental constraints on the chemical consequences of the crystallization of Earth's early magma ocean. Solidus curve and melting phase relations for a primitive mantle bulk composition (peridotite) were determined at conditions of pressure and temperature relevant to a deep magma ocean. Our results obtained using laser-heated diamond anvil cells, X-ray diffraction and transmission electron microscopy greatly expand previous results obtained at moderate pressures and temperatures (<35 GPa and <2800 K) using large volume presses (e.g. Trønnes and Frost, 2002; Ito et al., 2004).

Our new results can be summarized as follows:

- At 36 GPa, melting begins at 2800 K, with Mg- and Ca-perovskite melting first. The produced melt is far more laser-absorbent; a sharp increase in temperature accompanies melting. This leads almost instantly to conditions above the liquidus, preventing an accurate characterization of a detailed melting sequence. Transmission electron microscopy examination of a focused ion beam section made across the laser-heated spot on the recovered sample and the large temperature increase at melting may indicate that Mg-perovskite melts early in the sequence. At this pressure, the liquidus temperature is ~3850 K, as determined during cooling from a fully molten state by a large temperature drop when the first phase crystallizes.

- At 61 GPa, melting of ferropericlase (Mg,Fe)O indicates the solidus temperature is ~3050 K, closely followed by melting of Ca-perovskite with increasing temperature. Mg-perovskite is the last stable phase below the liquidus, which is ~ 4200 K. The observation of the recovered sample reveals the presence of connected veins of ferropericlase in a matrix made of Mg-perovskite. Ca-perovskite grains are found along these veins as well as within the Mg-perovskite matrix, suggesting that Ca- perovskite was partly mobilized by melting. Ferropericlase veins also collected small (<100 nm) globules of metallic iron, which is consistent with the disproportionation of ferrous iron in the stability field of Mg-perovskite.

- At pressures above 61 GPa, it is more difficult to distinguish whether ferropericlase or Ca-perovskite melts first. It is clear, however, that Mg-perovskite is the last solid phase below the liquidus. We observed a smooth increase of melting temperatures with increasing pressures. At 112 GPa, the solidus is located at 3910 K. At CMB pressure and temperature conditions (136 GPa and >4000 K) and above, the melting sequence remains the same: Ca-perovskite and ferropericlase melt first, followed by Mg-perovskite. Mg-perovskite is thus the liquidus phase between 60 GPa (perhaps less) and pressure conditions at the CMB.

- Above 61 GPa, the observed liquidus phase deviates from previous observations made at 24 GPa in multi-anvil experiments, in which ferropericlase was shown to be the liquidus phase, followed by Mg-perovskite 50 K below the liquidus (located at 2600 K) and Ca-perovskite 150 K lower, near the solidus (Trønnes and Frost, 2002). However, our observations are in qualitative agreement with other multi-anvil experiments (Ito et al., 2004), which suggest that Mg-perovskite should replace ferropericlase as the liquidus phase at pressures above 30 GPa, whereas our measurements suggest that this should happen at pressures above 36 GPa.

Complementary chemical analyses using electron microscopy and nano-SIMS techniques will be carried out in the near future to determine the chemical composition of the phases evolved in the melting process.

References:

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