	Experiment title: Fate of silicate melts in the deep Earth's mantle		Experiment number: ES-354
Beamline: ID13	Date of experiment: from: 03/02/2016 to: 08/02/2016		Date of report:
Shifts: 15	Local contact(s): Burghammer Manfred and Dane Thomas		*Received at ESRF:*

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Report:

Scientific Background

Density contrast is the main parameter that controls the entrainment or settlement of matter in the deep Earth's mantle, and is a key to understand the formation and dynamic of the deep Earth(1). However density measurements of melts at the conditions of the Earth's deep mantle are scarce due to technical challenges. Recently we have implemented a new method to measure the density of amorphous (glass, liquid and melts) material to unprecedented conditions of pressure(2). Our results on the density of $MgSiO_3$ glass to core-mantle boundary pressure show that it becomes as dense as its counterpart crystal, bridgmanite, at such pressure. Due the strong affinity of iron for melts, we could conclude that melt in the deep Earth will be denser that solid and could accumulate on top of the core to form a deep magma ocean.

To better constrain the density of melts in the deep Earth and built a density model relevant for such conditions, it is critical to collect as much data as possible on a wide range of composition from simple model to more complex ones and even natural compositions.

During beamitme ES-354, we measured the density of SiO_2 glass up to 90 GPa on the nano branch of ID13 beamline. A small beam of 0.5 micrometres was used during this beamtime improving the data quality and uncertainties of such measurements.

Experimental procedure

The SiO_2 starting material was a suprasil glass and was either grinded in powder for high-pressure runs or double polished in plates of 20 micrometre thickness for low pressure runs.

To allow radial access to the sample, we used 3mm diameter beryllium gaskets to seal and compress the sample to high pressure in between the diamond anvils. For low pressure runs, a piece of glass with sharp edges was cut from the double polished plate and immersed in a methanol-ethanol mixture in the Be gasket sample chambers together with a 3000ppm Cr doped ruby sphere to record the pressure using the Cr^{3+} luminescence R1 line shift with pressure. For high-pressure runs, the sample chamber was filled with SiO_2 powder only, and pressure was recorded using the Raman shift.

The measurements were performed as follow:

1- A map was made through the Be gasket to obtain the absorption of the sample
2- The DAC was rotated by 90 degrees and a second map was made to extract the path length of sample exposed in the previous map
3- The combination of both maps, i.e. absorption and path length, gives the linear absorbance of the sample which is directly linked to the density of the sample.

Preliminary results

We measured the densities of SiO_2 glass from 0 and up to 90 GPa and the results are presented in Figure-1. Above 60 GPa the density of SiO_2 glass is extremely close to the density of the crystalline counterparts (i.e. Stishovite and CaCl2 -phase) and confirms our previous findings that melts become extremely dense at high pressure. For the next beamtimes, we will need to complement our measurement on SiO_2 to core-mantle boundary pressure and measure iron-bearing glasses as well as natural basaltic glasses.

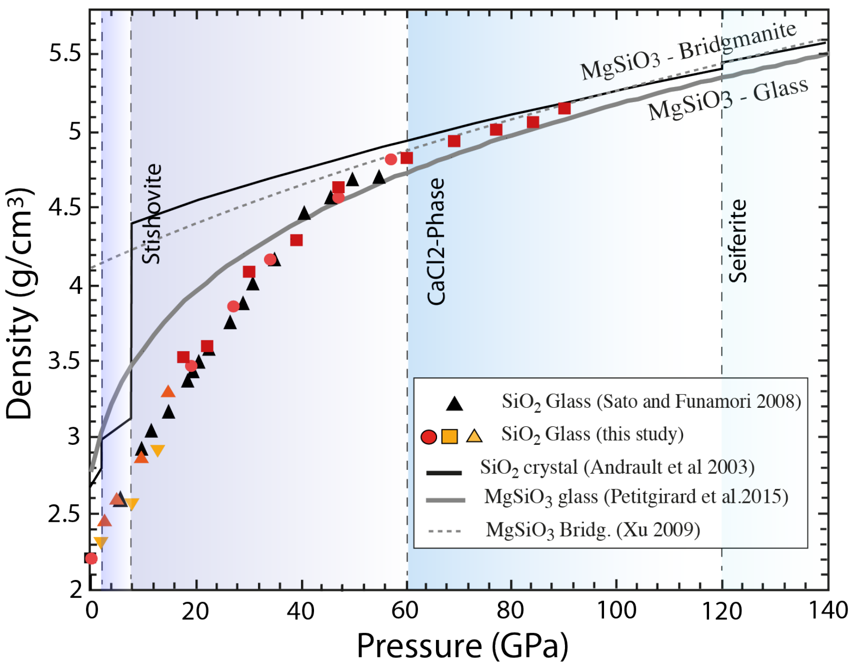

Figure-1. SiO2 densities as a function of pressure for four different loading (coloured symbols) and compared to previous results in black. Also reported are the densities for the crystalline phases as well as MgSiO3 glass measured recently on ID13.

References:

1. Labrosse S, Hernlund J, Coltice N (2007) A crystallizing dense magma ocean at the base of the Earth's mantle. *Nature* 450(7171):866–869.

2. Petitgirard S, et al. (2015) Fate of MgSiO3 melts at core-mantle boundary conditions. *Proc Natl Acad Sci U S A* 112(46):14186–14190.