Structure of molten fayalite at high pressure

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We have collected x-ray diffraction data on molten fayalite, Fe₂SiO₄, at extreme conditions using the laser-heated diamond anvil cell set-up on P02.2. Fayalite is the Fe end-member of olivine, the most abundant mantle mineral, and was chosen for its geological importance. In situ data on silicate melts have never been collected at pressures exceeding 6 GPa, and all published data were obtained in large-volume presses using the EDX technique [1,2]; this technique is indeed well suited for weakly scattering materials confined in a high P environment but it requires very long acquisition times (7 hours in the case of fayalite) and is limited in pressure. During our 4 days of friendly beamtime in October 2011, we have clearly observed the melt signal from 5 GPa and up to 37 GPa (Fig.1), i.e. way above the major coordination change from $^{IV}$Si to $^{VI}$Si in crystalline silicates. The data obtained at 5 GPa are in very good agreement with our own data collected at the APS using the large-volume press EDX technique, although only 10s were enough on P02 (Fig.2). It is the first time that the scattered signal from a silicate melt is ever reported from diamond-anvil cell experiments. Up to now, only the disappearance of crystalline silicate peaks was used as a criterium of melting [3]. However, one problem we have encountered is the stronger than expected signal from the thermal insulation medium, i.e. MgO. In order to process the x-ray scattered data into radial distribution functions describing the melt’s structure, one needs first to totally remove the background signal (diamond anvils, MgO layers). That was not possible for all our collected spectra due to a too strong MgO signal. We will therefore work on optimising the thermal insulation layers in our next allocated beamtime.

Figure 1: x-ray diffraction data collected in the molten state (red) and in the crystalline state (black). The remaining peaks on the red curves are MgO peaks.

Figure 2: X-ray scattered signal from molten fayalite at 5 GPa; in black: data collected at P02.2, colour: EDX data collected at the APS.
References