

## The melting curve of FeSi to 150 GPa: Implications for D''

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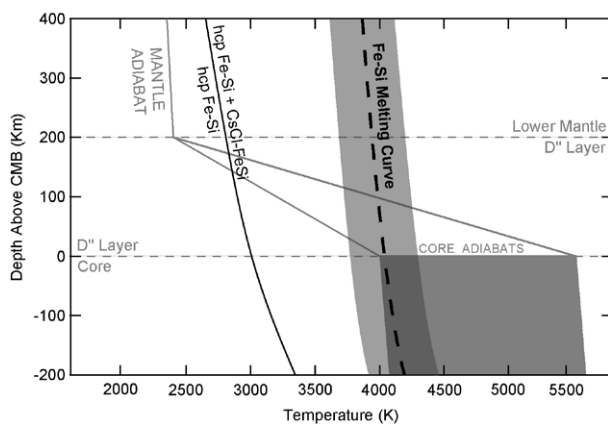
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FeSi has been suggested as a possible constituent of the Earth's D'' layer as a reaction product between the (Mg, Fe)SiO<sub>3</sub> perovskite or post-perovskite of the lower mantle and the Fe alloy of the outer core [1]. FeSi may also occur as a result of exsolution from the outer core during secular cooling [2].

We have measured the melting curve of FeSi up to 150 GPa using the LH-DAC and standard methods described elsewhere [3]. We utilize discontinuities in the laser power vs. temperature function as our primary melting criterion, and have successfully corroborated our melting curve with multi-anvil experiments at 12 GPa.

The resulting melting curve reaches 4000K at the CMB (see figure below). Based on a simple estimate of the adiabat throughout the D'' layer, this result suggests that FeSi might be solid in the upper part of the D'' layer, but is likely to be molten toward the base. Such melts are likely to have a density intermediate between the mantle and core, and would therefore pond at the CMB. Molten FeSi is expected to have seismic wave velocities significantly lower than PREM at these depths, making it a plausible component of the deep melts thought to result in the Ultra-Low Velocity Zones [4].



- [1] Knittle & Jeanloz (1991) *Science* **251**, 1438–1443.  
[2] Buffet, Garnero & Jeanloz (2000) *Science* **290**, 1338–1342. [3] Lord, O. T. *et al.* (2010) *J. Geophys. Res.*, in press.  
[4] Caracas & Wentzcovitch (2004) *Geophys. Res. Lett.* **31**, L20603.

## Carbonation of forsterite exposed to water-saturated supercritical carbon dioxide

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One of the strategies for combating global warming is to sequester vast quantities of CO<sub>2</sub> by hydrodynamically trapping it as a supercritical fluid (scCO<sub>2</sub>) in unusable saline aquifers in deep geological formations. The buoyant scCO<sub>2</sub> plume held in place by low permeability caprock will initially be out of equilibrium with host and caprock minerals and residual trapped formation fluids. Mineral transformations are expected to play an important role in determining long-term caprock performance by affecting porosity and the capillary entry pressure of scCO<sub>2</sub> into caprock fractures. We developed an *in situ* spectroscopic method for studying reactions between minerals and scCO<sub>2</sub> at geologically relevant formation temperatures and pressures. We present results for the transformation of forsterite (Mg<sub>2</sub>SiO<sub>4</sub>), a model magnesium silicate, to magnesium carbonate, emphasizing fluid compositions between neat and water-saturated scCO<sub>2</sub> as the long-term dominant fluid phase.

Experiments were performed using a flow-through system and a high-pressure transmission mid-infrared cell. One ZnSe window of this cell was coated with a thin overlayer of a synthetic forsterite. Absorbance spectra were recorded as a function of time after exposing the forsterite to single-phase water-saturated scCO<sub>2</sub> at 50 °C and 180 atm. The water concentration in the scCO<sub>2</sub> was quantified using the HOH bending mode of monomeric H<sub>2</sub>O at 1608 cm<sup>-1</sup>, and compared for consistency with literature values. The forsterite was reacted for a 24 hour period, and any transformation to magnesium carbonate was monitored by following changes and the growth of specific bands in the spectra. The above experiment was compared to a modified scenario where small amounts of immiscible bulk liquid water were allowed to condense and coat forsterite surfaces in simultaneous contact with the scCO<sub>2</sub> fluid. The presence of the liquid water was evidenced by a broad OH stretching band at 3200 cm<sup>-1</sup>. The forsterite was allowed to react for another 24 hours.

Preliminary results demonstrate marked differences in the metal carbonation rates in the two scenarios. The presence of a thin liquid water film coating the mineral surfaces dramatically increases carbonation rates even though water is available in both scenarios. This finding has important implications for long-term CO<sub>2</sub> storage.