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Determination of the iron alloys phase diagram by *in situ* X-ray diffraction and radiography using the Paris Edinburgh press: implications for small planetary cores

High pressure-high temperature experiments have been performed on the ID27 beamline using the available Paris Edinburgh press. Samples with different compositions (pure Fe, Fe-C (20 at%), Fe-Si (10 at%), Fe-S (10-20-35-50 at%)) were studied up to 6 GPa and 2200 K. Liquid structures and density properties were acquired (Figure 1), helping us to better understand the effect of light elements on liquid iron alloys. Study of the Fe-S system has shown a strong correlation between the observed liquid structure and the measured density. Structures and densities of liquid alloys are relatively stable up to 20 at% S and comparable to pure Fe structure. The observed density decrease from 35 to 50 at% S is related to a strong lose of the close packed structure (Figure 1). Thermal expansion has also been determined for Fe-35at%S alloy, with a behavior comparable to pure Fe at ambient pressure (Assael et al., 2006).

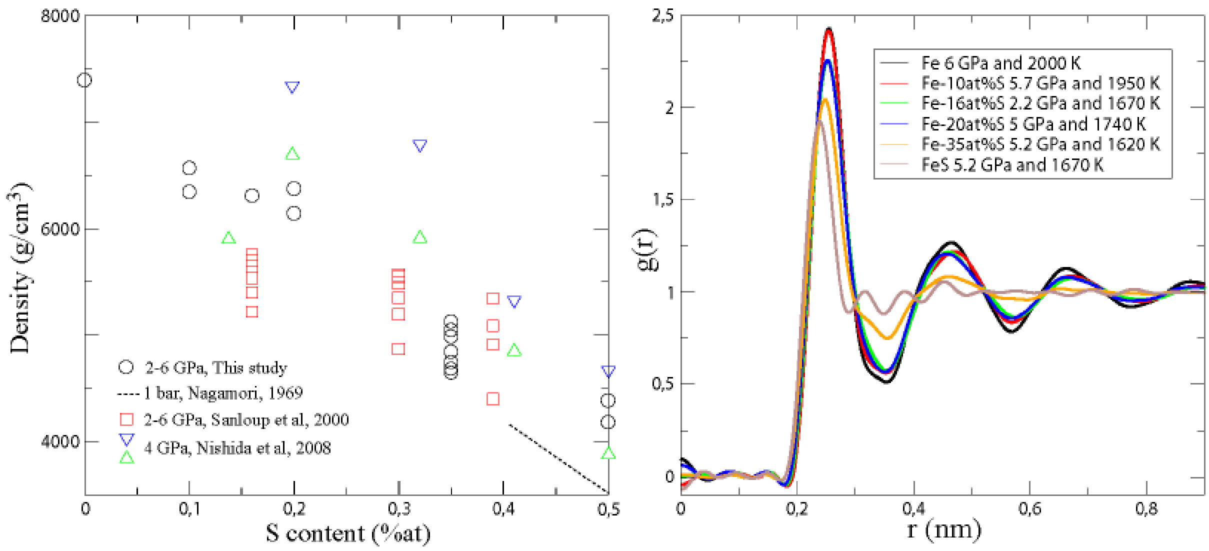

Figure 1: Density and structure of Fe-S liquid alloys. For S content inferior to 20at%, the liquid exhibits a compact structure in relation with density values superior to 6000 g/cm3. A drastic change occurs for higher S content, with a disorder structure and lower density.

Concerning the other alloys studied (Fe-C and Fe-Si), different effects on liquid density have been noticed (Figure 2). Carbon addition induces a strong increase of the atomic density, whereas Si does not affect the structure and the atomic density, implying a complete substitution of Si atoms with Fe atoms.

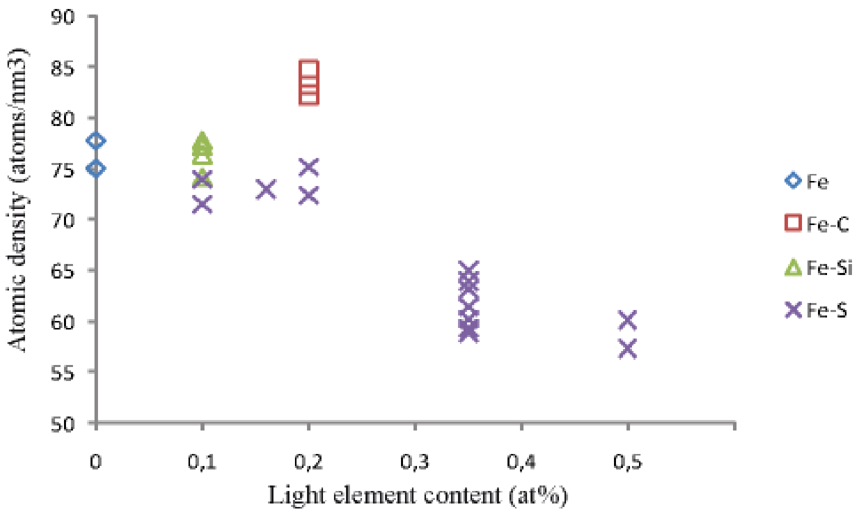

Figure 2: Atomic density measured in this study as a function of light element content.

Calibration of a new cell assembly up to 15 GPa and 1800 K has been performed. This will allow us to study liquid iron alloys on a larger pressure range, and moreover, on a wider compositional variety. Using this cell assembly, we studied the intermediate compound Fe_3S_2, from 13 to 17 GPa, up to 1100 K. Refinement of the structure of this compound is actually under progress. This compound is relatively important, as it could play an important role in the different crystallization scenarii of planetary cores in Mars or Mercury (Chen et al., 2008; Williams, 2009).

References

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