ESRF	Physical properties of geophysically relevant liquid Fe and Fe-Si alloys at high pressures and temperatures investigated by x-ray absorption technique.	**Experiment number:** HS2132
Beamline: ID30	**Date of experiment:** from: 06/03/2003 to: 11/03/2003	**Date of report:** 14/02/2004
Shifts: 15	**Local contact(s):** M. Mezouar	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):
C. Sanloup*, Laboratoire Magie, Université Paris-6
G. Morard*, Institut de Physique du Globe de Paris and ESRF
G. Fiquet, LMCP, Université Paris-6

Report:

Knowing the physical properties of Fe-based liquids would greatly improve our understanding of the current state of planetary cores as well as their formation. Two major scientific issues are: 1) what are the equations of state of these liquids?, and 2) what are the structural changes in the liquid at the atomic scale with increasing pressure and temperature, and their dependency upon the nature and amount of alloying light element?

These questions have been answered for Fe-S liquid alloys from previous ESRF runs [1]: a strong effect of sulfur on the bulk modulus (K_0) of liquid iron was evidenced (see Fig. below) correlated with a large degree of disorder in structural data compared to pure liquid Fe [2]. From structural data only, we could infer that Si does not strongly affect K_0 since it only slightly modifies the structure of liquid Fe. The preliminary results we got during the run HS1828 tend to confirm this prediction but unfortunately, most of the cell-assemblies got destabilized upon increasing temperature by extrusion of material in the slits. These technical problems were fixed during run HS2132 which allowed us to obtain reliable data on the density of two compositions in the Fe-Si system in the liquid state.

Density of liquid Fe-Si alloys was therefore measured *in situ* up to 5 GPa-1725 K by an X-ray absorption technique in the Paris-Edinbourgh cell. A high energy monochromatic beam was used. As the absorption coefficient of X-rays, μ, for a given element increases both with its atomic mass and with the wavelength, an optimum value was found for E=46.7 keV. For a given composition, ρ_{liq} values at different pressures are fitted to a second order isothermal Birch-Murnaghan equation of state to extract the bulk modulus (Figure)

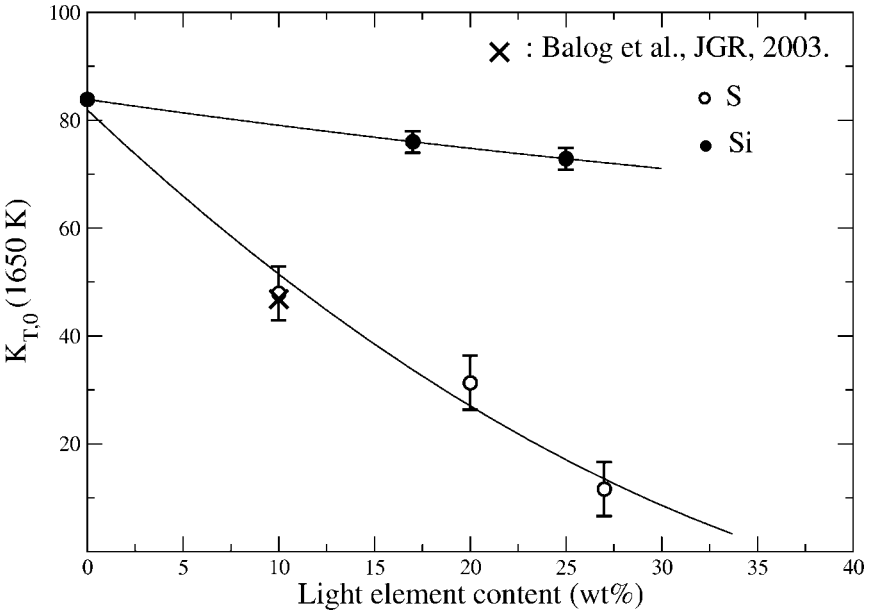

Figure: Effect of light element content on the bulk modulus.

Increasing the amount of silicon in liquid iron decreases the bulk incompressibility by only -0.5 GPa per 1 weight% of Si [3]. These data confirm our previous prediction of a negligible effect of Si on liquid Fe bulk properties, prediction based on the observation of a similar local structure in liquid Fe and liquid Fe-Si alloys. Si and S have therefore opposite effects on P-waves velocity ($v_P = \sqrt{(K/\rho)}$), both elements reduce the bulk density of liquid iron but only S affects its compressibility. Since compression-wave velocities in the Earth's outer core are slightly higher than in pure liquid Fe in the same P-T conditions, it implies that Si would correct this discrepancy while S would increase it.

References:

1 C. Sanloup et al., 2000a, Geophys. Res. Lett., 27, pp.811.
2 C. Sanloup et al., 2002, J. Geophys. Res., 107, pp.ECV-4.
3 C. Sanloup et al., submitted to Geophys. Res. Lett.