Pressure-volume relation for Fe0.95O at 1500 K and estimation of oxygen content in the Earth''s core

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Geophysical evidence shows that the density of the Earth''s core is lighter than that of pure iron, implying that the Earth''s core contains one or more light elements. Oxygen is considered as one of the most likely candidates of major light elements. FeO is one of the major components in the Earth''s mantle. If FeO component also exists in the Earth''s outer core, it is expected that the behavior of FeO at high pressure-temperature is important for understanding possible chemical reactions of the core-mantle boundary.

Quasi-isothermal compression experiments were conducted on Fe0.95O for an equation of state at 1500 K using a laser heated diamond anvil cell combined with synchrotron x-ray at the GeoSoilEnviroCARS (beamline 13-ID-D) at Advanced Photon Source (APS), USA [Shen et al. 2001]. The composition of the starting material (provided by Dr. Y. Fei) was estimated from a unit cell parameter of a=4.311+/-0.002 angstrom [McCammon and Liu 1984]. A DAC with beveled diamonds of 0.15 mm tip diameter and 0.3 mm culet diameter, was used for generating high-pressure conditions. NaCl was used as pressure medium and thermal insulator for laser heating. The monochromatic x-ray beam was at 0.4066 angstrom wavelength (30.491 keV). A CCD detector (Bruker-2k) and an IP detector (mar345) were used for diffraction measurements. Exposure time for diffractions was 2 minutes. Pressures were determined from the lattice parameters of the B2 phase of NaCl [Sata et al. 2002]. The experimental procedure was as follows: (i) increase the pressure at room temperature to the desired point, (ii) heat at 1500K+/-50 K for 3-5 min., (iii) quench by turning off laser shutter, and (iv) increase the pressure to the next desired point. During this procedure, x-ray diffraction patterns were obtained before, during, and after heating.

The FeO-B1 phase was only observed at 1500K up to 147GPa. The experiment was stopped at that point, because of an anvil failure. The result was fitted to the modified Birch-Murnaghan equation of state [Sata et al. 2002]. Results of the least square fits are Pr=0.0+/-1.1 GPa and Kr=123.06+/-0.59 GPa with Vr = 12.74 cm3/mol. The reference volume was slightly larger but consistent with the estimated zero pressure volume at 1500 K, 12.62 cm3/mol, from thermal expansion data [Fei 1995]. The bulk modulus at 1500 K is smaller than those at room temperature (140-155GPa of Fe0.91-0.95O [Zhang et al. 2000]), which is considered to be reasonable.

From the equation of state for Fe0.95O together with the equation of state for Fe [Dubrovinsky et al. 2000] and the Earth''s density profile from seismic observations [Dziewonski and Anderson 1981], the required oxygen content in the Earth core was estimated, assuming that oxygen is the only light element. Estimated contents were about 27+/-6 atomic % in the outer core and about 15+/-6 atomic % in the inner core at the inner-outer core boundary. Comparison with the current phase diagram of Fe-FeO system [Ringwood and Hibberson 1990] will be discussed

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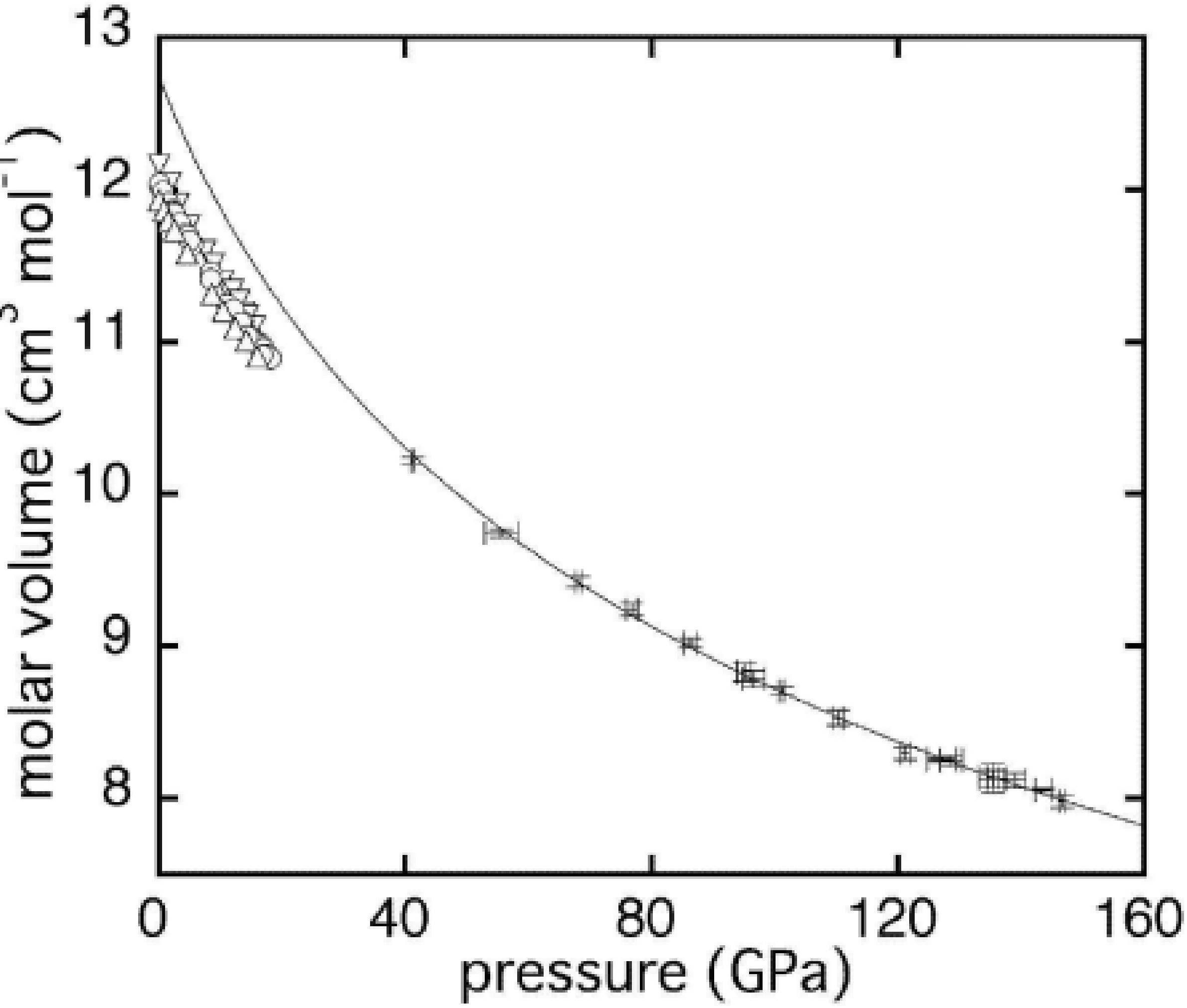

Figure 1: Pressure-volume relations of $Fe_{0.95}O$ in this study and results from the literature. Line: the fit on the data of $Fe_{0.95}O$. The data at 300K are for comparison with literatures [Triangle: $Fe_{0.98}O$ and $Fe_{0.92}O$, Fei 1996, circle: $Fe_{0.94}O$, Shu *et al.* 1998,Hazen *et al.* 1981].