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Phase relation of Fe-FeS system under the core conditions

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The Earth's core consists of liquid outer core and solid inner core suggested from seismic wave observations. The outer core is about 10% less dense than pure iron at the core conditions (Birch, 1952), and it is therefore, considered to contain light elements such as hydrogen, carbon, oxygen, silicon and sulfur (Poirier, 1994). Sulfur is one of the major candidates for the light elements in the core (Murthy and Hall, 1970). Although the actual amount of sulfur is not clear, the Earth's core is likely to contains at least a few weight percent (wt.%) sulfur based on cosmic element abundances and high pressure partitioning experiments (Hillgren et al., 2000). Therefore, phase relation of Fe-S at high pressure is important for investigation of the core properties.

In previous studies, Fe-S intermediate phases, such as Fe_3S_2, Fe_2S and Fe_3S, are formed above 14 GPa in the Fe-S binary system (e.g. Fei et al., 2000; Li et al., 2001). Since these studies are based on multi anvil apparatus, pressure condition has been limited up to 25 GPa. Recently, some groups reported phase relations of Fe-S up to 80 GPa using a diamond anvil cell (Chudinovskikh and Boehler, 2007; Campbell et al., 2007). They reported the existence of Fe3S and Fe up to 80 GPa, which correspond to subsolidus phases. However, there is no report under the core conditions. In this study, high pressure experiments were performed up to 130 GPa and up to 2500 K using a laser-heated diamond anvil cell in order to clarify the subsolidus phases of Fe-S system at core conditions.

The starting materials were foiled $Fe_{87}S_{13}$ (Fe-8wt.%S) which was sandwiched by powdered NaCl which was worked as a pressure medium, a thermal insulator and a pressure scale. Powder X-ray diffraction was carried out at beamline 13A and 18C in Photon Factory and at beamline BL10XU in SPring-8. Chemical compositions of the recovered samples were analyzed using electron microprobe (EPMA).

Fe3S coexists with Fe in the range of measurement. Fe_3S is stable even at high temperature and up to 130 GPa, and Fe_2S was not observed in the pressure range studied in this work. Therefore, Fe_3S is likely to be the S-bearing iron-alloy phase at the core conditions.