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Melting relations of FeS-H and Fe-Ni-H systems under high pressure

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The Earth's core consists of FeNi alloy. In addition, the core is about 10% less dense than the iron alloy (e.g., Birch, 1952). Thus, it is considered to contain light elements such as hydrogen, carbon, oxygen, silicon and sulfur (Poirier, 1994). The Earth's core is likely to contain at least a few weight percent of sulfur (Hillgren et al., 2000), and about 1 weight percent addition of hydrogen could be enough to account for the density deficit of the core (Stevenson, 1977). Therefore, sulfur and hydrogen are the possible candidates of the light elements in the core. However, it has never been reported whether hydrogen affects the melting temperature of FeNi alloy and FeS although it is known that hydrogen significantly lowers the melting temperature of pure iron (e.g., Sakamaki et al., 2009).

In situ X-ray experiments were carried out using a Kawai type multi anvil apparatus installed at BL04B1 beamline, SPring-8 in Japan. Fe10%Ni alloy was used for the starting material of FeNi alloy. The FeS powder or Fe10%Ni alloy was packed into a NaCl container with $LiAlH_4$which was separated from the sample by thin MgO disk. Hydrogen was supplied by thermal decomposition of $LiAlH_4$. The experimental pressure range was between 1.9 and 16.5 GPa for FeS-H experimentals and between 2.7 and 13.4 GPa for FeNi-H experimentals.

In this study, the observed volumes of FeS and Fe10%Ni, which were estimated from the diffraction peaks, were significantly larger than those of the pure FeS and pure Fe at high pressure and temperature, respectively. These volume expansions can be explained by dissolution of hydrogen in the interstitial sites of FeS and Fe10%Ni, and FeSHx and FeNiHx could be formed at high pressure and temperature. The melting temperature of FeSHx was reduced by 150-250 K comparing with that of pure FeS and that of FeNiHx was reduced by 400-500 K comparing with that of pure Fe. The hydrogen concentrations of FeSHx were determined to be x = 0.02-0.4 just before the melting between 1.9 and 16.5 GPa and those of FeNiHx were determined to be x = 0.1-0.8 just before the melting between 2.7 and 13.4 GPa. The results of this study strongly indicate that hydrogen can affect the structure of temperature of the core and and hydrogen is certainly important for understanding the internal structures of planets.

Keywords: hydrogen, iron sulfide, iron-nickel alloy, melting temperature, high pressure, core