Iron-nickel alloy-water reaction under high pressure and high temperature

Naohisa Hirao[1], Eiji Ohtani[2], Tadashi Kondo[3], Takumi Kikegawa[4]

[1] Tohoku Univ., [2] Institute of Mineralogy, Petrology, and Economic Geology, Tohoku University, [3] Sci., Tohoku Univ., [4] IMSS, KEK

Introduction

One of the most important unresolved issues about the Earth's core is its chemical composition. Seismic data indicate both the inner and outer cores are less dense than pure iron at core condition [Jephcoat et al., 1986; Mao et al., 1990]. The density deficit of the core has been explained by the dissolution of some light elements as hydrogen, sulfur, oxygen, silicon, carbon, magnesium [e.g., Poirier, 1994]. Hydrogen in the Earth's core was proposed from reaction between water and iron [Stevonson, 1977; Fukai, 1984]. Experimental works showed that substantial enhancement of the solubility of hydrogen in iron was observed with increasing pressure [Antonov et al., 1980; Fukai et al., 1982]. These experiments led to be of interest in hydrogen in the core, including a study of iron-water reaction. In quenching experiments on the iron-water reaction, it was found that iron reacted with water to form iron hydride as and iron oxide [Fukai and Akimoto,1983; Yagi and Hishinuma, 1995]. In situ X-ray diffraction experiments of iron hydride under pressure was carried out by Badding et al. [1991] using a diamond-anvil cell (DAC). It was found that iron hydride which has a double hexagonal close-packed (dhcp) structure formed at 3.5 GPa and room temperature and was stable up to at least 62 GPa. They suggested that iron hydride should be stable at core pressure. Recently, Saxena et al. [2002] conducted the experiments fot iron-water system by DAC up to 85 GPa and to 1860 K, and showed that iron hydride and wuestite exsited stably under these conditions.

Previous experiments were performed for iron-water and iron-hydrogen. However, the Earth's core might contain significant (5-15 %) amount of nickel, based on cosmochemistry arguments and results from the studies of iron meteorites. It is necessary that the iron-nickel-hydrogen and/or iron-nickel-water system are studied in order to understand and interpret the properties of the Earth's core and the core formation. We conducted the experiments for iron-nickel-water system at high pressures and temperatures.

Experimental Procedure

In situ High-pressure X-ray diffraction experiments were performed using laser-heated diamond-anvil cell. Fe-10at.%Ni and water were loaded in rhenium gaskets. The samples were heated with multimode continuous wave Nd: YAG laser using single-side laser heating technique. Pressures were measured by the ruby fluoresence method. Powder X-ray diffraction experiments were obtained at BL13A beamline of the Photon Factory, National Laboratory for High Energy Physics (KEK). The synchrotron radiation beam was monochromatized to the wavelength 0.4241 A. Powder X-ray diffraction experiments under pressure were carried out by the angle dispersive method using an imaging plate detector.

Results and Discussion

Experiments for this system were performed to a pressure of 40 GPa. As a preliminary result, we can demonstrate that iron-nickel reacted with water at low temperature below 1000 K. The detail analysis are now in progress and the results will be reported.