
 [EE] Evening Poster | S (Solid Earth Sciences) | S-IT Science of the Earth's Interior & Tectonophysics

[S-IT22] Interaction and Coevolution of the Core and Mantle in the Earth and Planets

convener: Tsuyoshi Iizuka (University of Tokyo), Hidetoshi Shibuya (Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University), Taku Tsuchiya (愛媛大学地球深部ダイナミクス研究センター, 共同), Kenji Ohta (Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

Tue. May 22, 2018 5:15 PM - 6:30 PM Poster Hall (International Exhibition Hall7, Makuhari Messe)

Recent observational and experimental investigations have significantly advanced our understanding of the structure and constituent materials of the deep Earth. Yet, even fundamental properties intimately linked with formation and evolution of the planet, such as details of the chemical heterogeneity in the mantle and light elements dissolved in the core, remained unclear. Seismological evidence has suggested a vigorous convection in the lower mantle, whereas geochemistry has suggested the presence of stable regions there that hold ancient chemical signatures. The amounts of radioactive isotopes that act as heat sources and drive dynamic behaviors of the deep Earth are also still largely unknown. We provide an opportunity to exchange the achievements and ideas, and encourage persons who try to elucidate these unsolved issues of the core-mantle evolution using various methods, including high-pressure and high-temperature experiments, high-precision geochemical and paleomagnetic analyses, high-resolution geophysical observations, geo-neutrino observations, and large-scale numerical simulations. Since this session is co-sponsored by geomagnetism, paleomagnetism and rock magnetism division of the SGEPSS, contributions in geomagnetism and geodynamo simulation are also encouraged.

[SIT22-P16] Dissolution of multi light elements in iron-silicate system using high pressure and high temperature experiments: Implications for the Earth's evolution

*Riko Iizuka-Oku¹, Hirotada Gotou², Hiroyuki Kagi¹ (1. Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2. The Institute for Solid State Physics, The University of Tokyo)

Keywords: Hydrogen, Sulfur, In situ high pressure and high temperature observation, Core-mantle formation

Introduction

The Earth's outer core is considered to consist of Fe-Ni alloy and some light elements (O, S, Si, H, C). Hydrogen is the most abundant element in the solar system and one of the promising candidates of the light element in the Earth's core. However, the amount of hydrogen dissolved in the core and its process are still unknown because hydrogen cannot be detected by X-ray and it easily escapes from iron by the release of pressure. Recently, hydrogen content in fcc-Fe at high pressure and temperature has been determined using in-situ neutron diffraction measurements at J-PARC [1,2]. Furthermore, it was observed that the water which is released from hydrous mineral at about 4 GPa reacts with iron and they form both iron oxide and iron hydride. The formation of iron hydride occurred below 1000K, at the temperatures where no materials melted. This suggests the possibility that hydrogen had preferentially dissolved into iron before any other light elements have dissolved in the very early stage of Earth's evolution. For future prospects, it is important to study the partitioning of the other light elements between iron hydride and silicates. In this study, we focused on sulfur and investigated its effect on hydrogenation.

Experimental

As a starting material, the powder mixture of iron (#300 mesh), quartz, $\text{Mg}(\text{OH})_2$ (or MgO) and S (or FeS) was used. The mixing ratio was slightly changed.

High-pressure and high-temperature quench-experiments were carried out using a 500-ton press at ISSP. A multi-anvil 6-6 type (MA6-6) assembly was used with an improved anvil assembly optimized for the neutron experiments [2]. The second-stage anvils were made of Ni-bonded cylindrical tungsten carbide with truncated edge lengths of 10 mm. A hybrid pressure medium made of a Cr-doped MgO cube and a ZrO_2 cylinder was used. A graphite cylinder and disks were used as a furnace, and the electrodes were molybdenum foils. Preformed gaskets made of pyrophyllite, which were fired in advance at 700°C for 15 min were used. The pressure was increased up to 6 GPa and heated up to $750\text{--}1650^\circ\text{C}$. The quenched samples were analyzed by XRD and SEM-EDS.

In-situ X-ray diffraction measurements were also conducted at PF-AR, NE7A and NE5C. The products were identified under high pressure (4-6 GPa) and high temperature (up to 1050°C).

Results and discussion

From the quench experiments, liquid Fe-FeS was observed in the recovered sample from $>1000^\circ\text{C}$. Liquid iron and solid FeS coexisted in the recovered sample from 950°C . This was in good agreement with the Fe-FeS binary system. In the recovered sample from 750°C , solid FeS and solid Fe coexisted and the iron contained many small vacant holes of a few microns in diameter, indicating the evidence of hydrogen dissolved into iron.

From in-situ XRD observations, Fe transformed from bcc into fcc phase at $<500^\circ\text{C}$. At the same time, dehydration of $\text{Mg}(\text{OH})_2$ and formation of FeS were observed. At 850°C , fcc-Fe started to melt and FeS and olivine remained in the recovered samples. For the sample, which does not include water, FeS formation occurred before the phase transition of Fe from bcc into bcc at $\sim 600^\circ\text{C}$. Melting of fcc-Fe started at $\sim 900^\circ\text{C}$ and the recovered sample from 1050°C consisted of FeS and FeC. The results between in-situ experiments and quench experiments were well consistent.

The cell volume of fcc-Fe in the Fe-silicate-water system was several % larger than that of pure Fe at the same condition, which suggested the obvious hydrogenation. In the presentation, hydrogen content in fcc-Fe and FeS will be discussed to more clarify the formation process of iron hydride and FeS and the effect of sulfur on hydrogenation.

[1] A. Machida, H. Saitoh, H. Sugimoto, T. Hattori, A. Sano-Furukawa, N. Endo, Y. Katayama, R. Iizuka, T. Sato, M. Matsuo, S. Orimo, K. Aoki, *Nature Commun.* 5, 5063 (2014).

[2] R. Iizuka-Oku, T. Yagi, H. Gotou, T. Okuchi, T. Hattori, A. Sano-Furukawa, *Nature Commun.* 8, 14096 (2017).