Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS23-P03 会場:コンベンションホール 時間:5 月 23 日 18:15-19:30

月核条件での Fe-O-S 系の融解と オリビン・鉄メルトの反応： 月核マントル境界への応用
Melting of the Fe-O-S system and reaction between olivine and iron melt at lunar core conditions

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Despite recent insight regarding the Moon from satellite sensing and analyses of Apollo-era seismic data, there are still several unknown issues on the deep lunar interior. It is suggested that the Moon has a small iron-rich core with a radius between 220 and 450 km based on the calculated value of the mass and moments of interior (Konopliv et al., 1998), but the question about its feature is still under debate. Recent studies suggest the presence of a solid inner core and liquid outer core in the Moon (Weber et al., 2011). If we could constrain the temperature and composition of the lunar outer core, this would help us for better understanding of the lunar interior. Here, we focused on the interaction between liquid iron-alloy and solid silicate, and revealed the nature of the outer core of the Moon. The lunar mantle is characterizes by high FeO content compared to the Earth's mantle. This implies that Moon is oxidizing and oxygen can be in the lunar core. Therefore, Fe-O-S system is considered and we performed the partition experiments of oxygen between silicate and molten metal in this study.

High pressure experiments were conducted at 5 GPa from 760 C to 1400 C using 3000 ton Kawai-type multi-anvil apparatus of Tohoku University. We used powder mixtures of Fe, FeO and FeS as the metallic component of the starting material. Olivine crystals with Mg number of about 83 from Miyakejima, which is similar to the lunar mantle olivine, were used for the silicate component of the starting material. The sulfur content was 24 wt.% and the oxygen content varies 0 ~ 7 wt.% for the starting iron-alloys. Scanning electron microscope (SEM) was used for the texture observation of the recovered samples, and the electron probe micros-analyzers (EPMA) with Energy-dispersive X-ray spectroscopy (EDS) and wavelength-dispersive X-ray spectroscopy (WDS) were used to obtain the chemical compositions of recovered run products.

Some differences in reactions between the experiments made at 1000 C and at 1400 C were observed in the recovered samples. At 1000 C, the metallic sample melted partially and liquid phase had magnesiowustite crystals were observed at the boundary between the molten iron alloy and olivine. The Mg number of the olivine crystals increased with increasing the distance from the metal phase. At 1400 C, the metallic sample was totally-melted. Pyroxene and olivine crystals with reverse zoning were observed in the silicate phase, whose Mg number was higher than starting materials. The effects of oxygen content in metallic phase on silicate phase were not observed in this experimental condition. We calculated the distribution coefficient D of FeO between metal liquid and olivine crystal. Using this value, the amount of FeO in the lunar liquid outer core is 4.45 at.% at 1000 C and 1.63 at.% at 1400 C when the mantle Mg number is 80. If the amount of FeO is 4.45 at.%, the lunar outer core might have two layers because of existence of the immiscible two-liquid regions in the Fe-S-O system.

キーワード: 月核, Fe-O-S 系合金, カンラン石, 融解, 高圧
Keywords: lunar core-mantle boundary, Fe-O-S system, olivine, melting, high pressure