The phase relation of sulfate-water binary system in the large icy satellites

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The internal structure and composition of large icy satellites of giant planets are very important topics in planetary sciences. Based on the observed data of CI chondrite materials, it has been expected that three-quarters of the volatiles are sulfates, and 73wt.% of aqueous sulfate is magnesium sulfate MgSO4 (Frederiksson et al. 1998).Recently, it has been considered that MgSO4 is the most abundant volatiles in the icy objects. In the brine of orgueil meteorites, 97 wt.% are composed of MgSO4 and Na2SO4. Magnesium sulfate, MgSO4, is the most important brine in CI chondrites.

We need to investigate the phase relations of the sulfate-water system up to the pressure of 5GPa to discuss the phases expected in the deep icy mantle or, ice-rock mixed core in the large icy satellites. Kargel(1991) suggested that the quantity of MgSO4 in the model of icy satellites is about 8-20wt.%, which is close to the eutectic composition at 0.1MPa, 17wt.% MgSO4. Therefore, we adopted his estimation for the present starting compositions, i.e., the compositions of 0-30wt.% MgSO4 in the MgSO4-H2O system.

We used a diamond anvil cell with external heating for the in situ optical observation. We used the ruby-fluorescene method (Mao et al. 1986) to determine the pressure. The temperature measurement was made by using the K-type thermocouple which was contacted to the steel gasket of the DAC. We generated temperatures more than 600K at high pressure by this cell. Identification of the phases was made by using the X-ray diffractometer and Raman spectroscope.

We have clarified the phase relation in the MgSO4-H2O binary system. A eutectic point locates 14wt.% of MgSO4 where high pressure ice, MgSO4.7H2O (magnesium sulfate hepta-hydrate), and fluid coexist at 1.99GPa at 298K. We investigated this MgSO4-H2O binary system up to 600K and 5 GPa with using the diamond anvil cell. At high pressure, we recognized MgSO4.7H2O phase and some high pressure ices above 293K.

From the temperature pressure conditions of Ganymede presumed by Sohl (2002) and Prentice (2001), we discuss the behaviors of the brines in the deep part of Ganymede when it was formed, and propose the model about the origin and present condition of the internal ocean described by Kronrod et al. (2003).