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High pressure ices and sulfates in Ganymede's subsurface ocean

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Evidence for existence of subsurface ocean (internal ocean) of jovian icy satellites except Io has been observed by Voyager and Galileo survey. It has been suggested that Ganymede must be layered with subsurface ocean. The reason why Ganymede has not frozen and had a layered structure is known that volatiles play important roles. Recently it has been recognized that $MgSO_4$ is one of the abundant volatiles in the jovian icy satellites from the observed data of CI chondrite materials (Frederiksson et al. 1973). We determined the phase relations of the $MgSO_4$-H_2O system up to 5GPa and 500K to discuss the phases that expected in the deep part of icy satellites, such as subsurface ocean.

We operated a diamond anvil cell (DAC) with external heating for the in *situ* optical observations. The pressure was monitored by using the ruby fluorescence technique (Mao et al. 1986). On the other hand, the temperature measurement was made by using the K-type (Alumel-Chromel) thermocouple which contacted to the steel gasket in the DAC. Identification of the phases was made by using the X-ray diffractometer and raman spectroscope.

We have clarified the phase relations of the $MgSO_4$-H_2O binary system from the room temperature up to 500K under high pressure. At the room temperature, an eutectic point is located at 14wt.% of $MgSO_4$ where high pressure ice (iceǦY), $MgSO_4$ĄE7H_2O and fluid coexist at 1.99±0.01 GPa.

At high pressure, we recognized high pressure ices (iceĞY and ice ĞZ) and $MgSO_4$ sulfates ($MgSO_4$ĄE7H_2O, $MgSO_4$ĄE6H_2O and $MgSO_4$ĄEH_2O) above room temperature. Thus, we can conclude that a deep liquid ocean in Ganymede with the bottom pressure exceeding 1GPa (Sohl et al. 2002) must exist if $MgSO_4$ content exceeds 10wt.%. The sediment composed of mainly $MgSO_4$ sulfates may have existed in the bottom of Ganymede's subsurface ocean.