Observation of the interface between ice and water under high pressure with gas as a simulation of the bottom of ice crust in icy bodies

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Gas hydrates are clathrate compounds where hydrogen-bonded water cages include a guest gas molecule. Methane hydrate is one of famous gas hydrates because it is naturally found in deep-sea and permafrost sediments on the Earth. Gas hydrates would exist in icy bodies as well. One of the candidates is Pluto where the presence of subsurface ocean is suggested. Gas hydrates may exist between the ice shell and the subsurface ocean and play an important role as insulator to keep warm inside. The presence of subsurface ocean is also suggested in some icy satellites like Enceladus. INMS (Ion and Neutral Mass Spectrometer) aboard the Cassini orbiter has investigated composition of the plumes there that includes H2O (< 90 %), CH4, CO2, NH3, and other various organic materials. These results could reflect the composition of the subsurface ocean and imply the presence of clathrate hydrates in the ocean. Density of gas hydrates depends on guest gas molecules. For example, methane hydrate is lighter than the water, whereas CO2 hydrate is heavier. If CO2 hydrate forms at the bottom of the icy shell, the average density may become large and the ice (water ice + CO2 hydrate) may start to sink locally. If the size of each gas hydrate become small and granular gas hydrates exist in subsurface ocean, heat can be transferred by not only thermal conduction but also convection. This means that icy bodies may be cooled faster. To elucidate how gas hydrates form in the subsurface ocean in icy bodies, we developed the observation system of gas hydrate formation and dissociation below the ice sheet. The observation system was set in the thermostatic cooling bath after it was filled with water. As temperature in the cell degreased, water ice was formed in the lower part of the cell and high pressure gas was supplied. In this study, we used CF4 gas to increase the pressure in the system to form CF4 hydrate. It is heavier than water and should sink in the water cell, if it is formed. After several experiments, we found that the surface of water ice slightly changed to hold CF4 gas on the ice surface.

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