

## Inclusion of brine into icy shell of Enceladus

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Investigation of Enceladus plume by Cassini spacecraft showed not only the existence of a subsurface ocean but also ocean included some salts. On the earth, it is known that sea ice includes brine into grain boundary. Similarly, icy shell of Enceladus seems to include sea water. Inclusion of sea water could cause partial melt in icy layer and could affect the geology and thermal evolution. Cox and Weeks (1975) showed that the effective partition coefficient, the ratio of concentration of sodium chloride in formed ice to that in residual liquid, depended on ice growth velocity. While, Gross et al., (1977) reported forced convection made partition coefficient low. To quantify the amount of brine included into icy shell under various condition, we investigated a partition coefficient of sodium chloride to ice by experiment and simulation.

As an experimental apparatus, unidirectional growth method used by Muraoka et al., (2016) was applied. With this method, plate-like ice can be formed in a cell and growth velocity can be controlled by controlling temperature. Ice was formed at a speed between cm/s in 5 % sodium chloride solution. As a result, effective partition coefficient of sodium chloride to ice was 1 approximately at all ice growth velocity.

To evaluate this value, ice growth in sodium chloride solution was simulated by voronoi dynamics simulation suggested by Kawano and Ohashi (2008). When ice grew under the same condition with the experiment, effective partition coefficient was 1 approximately. Next, we introduced Sherwood number into the simulation. It was found that higher Sherwood number made the effective partition coefficient lower. These results indicate that effective partition coefficient reflects condition of convection. When ice grow velocity is faster than diffusion of sodium chloride, effective partition coefficient is near 1. Since convection was not occur in this experiment, the effective partition coefficient was near 1. In subsurface ocean of Enceladus, effective partition coefficient might be low due to convection, but in crack like tiger stripe, effective partition coefficient might be high because ice growth velocity seems to be high.

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