Memory of cooling process of ice printed as bubble distribution

Mie Ichihara[1]; Takatoshi Yanagisawa[2]; Yasuko Yamagishi[2]; Ichiro Kumagai[3]

[1] ERI, U. Tokyo; [2] IFREE, JAMSTEC; [3] IPGP

A block of ice made in a freezer usually contain opaque part. It consists of bubbles containing air which was solved in the water. During solidification, the air component cannot enter the solid phase and is separated. We know from our daily life that distribution and size of the bubbles and transparency of ice depend on the water, efficiency of the freezer, material and shape of the container, and so on.

Transparent homogeneous ice is in demand in the market. Therefore, they have developed methods to make ice free of bubbles. To the contrary, few recipes are known for how to distribute bubbles. That is the theme of this study.

Factors controlling the patterns of bubble desorption are speed of the solidification front, diffusion of the volatile, nucleation, growth and advection of bubbles, heat transport in the liquid by conduction and convection, energy of surfaces, and so on. These factors are coupled with one another to produce a variety of structure in an ice block. Existing models which take account of the heat conduction, volatile diffusion, and bubble nucleation predict layered distribution of bubbles due to a similar mechanism as formation of Liesegang rings (Toramaru, et al., 1996, Rogerson and Cardoso, 2000). However, a complete model including convection and bubble motion is not known to the authors.

We conducted experiments in the following way. Water is chilled by a Peltier cooler in an insulated cylindrical container with an aluminum lid as the cooling surface. Temperature distribution, speed of the solidification front, and patterns of bubble desorption are monitored during solidification. Effects of the cooling rate, gravity, and volatile concentration in the water on the bubble distribution in the final solid are investigated.

Understanding and quantifying the mechanisms by which patterns of bubble desorption will be useful in interpretation and modeling of geological phenomena such as bubble distribution in solidified lavas, and formation of melt inclusion in crystals.