



## The study of ikaite formation in sea ice

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Ikaite ( $\text{CaCO}_3 \cdot 6\text{H}_2\text{O}$ ) is a metastable mineral of calcium carbonate, which is usually found in environments characterized by low temperature (below  $5^\circ\text{C}$ ), high pH, high alkalinity, high concentration of phosphate and organic matter. Although synthetic  $\text{CaCO}_3 \cdot 6\text{H}_2\text{O}$  was already known from laboratory studies in 1865, ikaite was first observed in nature in 1963. Recently, Dieckmann et al. (2008, 2010) discovered this mineral in sea ice, which at the same time, was the first direct proof of  $\text{CaCO}_3$  precipitation in sea ice.

However, little is known about the mechanism of ikaite formation in sea ice. Our study focuses on how physico-chemical processes in sea ice affect the formation of ikaite. Experiments were set up at pH ranging from 8.5 to 9.0, and salinity ranging from 0 to 105 at  $0^\circ\text{C}$ , in order to examine the effect of pH, salinity and also phosphate on the formation of ikaite. Preliminary results read:

- (1) Experiments show that ikaite can form at different pH levels (8.5~9.0). At high pH, the induction time (the time when the crystals start to precipitate) is shorter which means high pH favours the formation of ikaite. This might be expected given higher  $\text{CO}_3^{2-}$  concentrations and thus higher saturation levels for ikaite with increasing pH.
- (2) The results of experiments with different salinities show that ikaite can form over wide range of salinities from 0 to 105 both in Artificial Sea Water (ASW) and NaCl solution in the presence of phosphate. In ASW, the induction time increases with salinity from  $S = 0$  to  $S = 105$ ; while in NaCl solution, the induction time first increases with salinity and then decreases with the further increase of salinity. Salinity plays both positive and negative roles in the formation of ikaite. On the one hand, the increase in salinity will increase the fraction of  $\text{CO}_3^{2-}$  in DIC. On the other hand, the increase in salinity means more ions are involved in the solution, which will reduce the activities of  $\text{Ca}^{2+}$  and  $\text{CO}_3^{2-}$  by forming ion pairs with them. This effect is more obvious in ASW, as there are more ion species in ASW than in the NaCl solution.
- (3) The effect of different phosphate concentrations at high salinity ( $S = 70$ ) medium show that in ASW, the precipitate is ikaite both with and without the presence of phosphate. In NaCl solution, the precipitate is ikaite in the presence of phosphate; however, the precipitate is no longer ikaite but vaterite in the absence of phosphate. These results suggest phosphate plays an important role in the formation of ikaite. However, besides phosphate, there must be other ion(s) in ASW, which also favour the formation of ikaite.