The Cryosphere Discuss., 6, C2916–C2919, 2013
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The Cryosphere Discussions



# *Interactive comment on* "Ikaite crystal distribution in Arctic winter sea ice and implications for $CO_2$ system dynamics" *by* S. Rysgaard et al.

**Anonymous Referee #1**

Received and published: 2 February 2013

This paper presents observations of Ikaite crystal distributions and other physical/chemical properties from two sea ice cores sampled on thick and thin ice in Greenland. Although I have not closely followed the recent advances in this field and am not very familiar with most of the chemical and crystallographic analysis techniques, it seems that some of the applied methods are novel and very worth publishing. In fact, owing to the new methods used the observed amount of Ikaite in first-year sea ice was much larger than reported before. This paper seems to be a valuable addition to the already existing body of literature on Ikaite crystals in sea ice. However, the conclusions about air-sea fluxes of CO2 drawn from its occurrence are not new, and the discussion could be shortened in places. The discussion of the actual location of crystals in the "interstices between platelets" or within the "ice matrix" could be clarified as suggested below. Also, the paper draws on only two ice cores and a discussion of

their representativeness and potential lateral variability should be included. I suggest to publish the paper if these minor aspects and those outlined below are addressed.

Specific comments Title Maybe “Arctic” should be removed as these cores may not be representative of the Arctic, or if so, may be representative of any winter sea ice, too. I am not sure either that this paper presents really new insights into CO2 system dynamics.

Study site and sampling

It strikes me that there was so much snow on both the thick and thin ice. Please discuss what the freeboard of the ice was and if there wasn't any flooding? How would the occurrence of flooding modify your conclusions?

P. 5042, l. 9-10: Why did you not calculate brine salinity directly from brine/ice temperature? This is the most common approach and is not affected by errors which could be introduced into the brine volume calculations.

L 13: how does the warming of the glass plates affect the crystals?

P. 5043 top and fig 6: The concentrations look great, but are derived by significant extrapolation to sample reference volumes. How many crystals (N) were really sampled/counted during the initial, original analysis?

The totality of all results was obtained from a larger number of cores at the two sites. How would small-scale, lateral variability affect your results?

Results

P. 5045, l 25: are you sure this was polygonal granular ice? Polygonal granular ice does normally form from thaw-freeze cycles in the snow and the crystals are relatively large. This can of course happen sporadically during winter at the relative southern location of the study site. Polygonal granular ice would indicate that this ice has formed from snow, which would imply different chemical processes and conclusions. Better to



TCD

6, C2916–C2919, 2013



just call granular ice indicative of snow-ice formation. However, snow-ice would form from flooding events, which would probably lead to different chemical processes than "normal" sea ice formation.

P 5046, l. 8-9: Here and elsewhere, what do you really mean? Individual ice crystals consist of ice platelets/lamellae with brine layers in-between. If the crystals are in these interstices (brine layers), they would still be in contact with the brine. In addition, in young sea ice, the brine layers are well connected to the larger drainage network including brine pockets and channels, and thus are not separated from the brine as stated. Please describe more carefully the situation you think you observe.

Also, it is not clear why you point out this fact repeatedly. Do you expect that Ikaite crystals forming in larger brine channels would be flushed out together with the brine, and that therefore their location within the much smaller interstitial pore space is require to retain them and protect from flushing? Please clarify.

In any case, don't you think that Ikaite crystals would form anywhere in the brine space and that therefore the actual initial concentration would even be higher than you have observed?

Discussion

P 5048: Please better introduce and describe the FREZCHEM model.

P 5049, l. 3-13: Related to my comments above, please be more clear about what the difference is between the "brine system" and interstitial space, and why this is important.

P 5051, l. 20-22: In which season? Or is this number an annual average?

P 5052: This discussion is confusing in places. Be more careful about describing the effects of ice formation, advection, and melt, and distinguishing between processes within the polynya in winter, the polynya region in summer, and the region away from the polynya.



TCD

6, C2916–C2919, 2013

P. 5053: The discussion of the effect of water masses from Fram Strait is interesting. However, how long would it take for that water to equilibrate with atmospheric pCO2, and thus not to be depleted any more when it reaches the study region?

Conclusions

P5054, l. 3-6: Can you be more carefully differentiate between the polynya region and regions downstream where the ice melts?

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Interactive comment on The Cryosphere Discuss., 6, 5037, 2012.