

Interactive comment on “X-ray computed microtomography of sea ice – comment on “A review of air–ice chemical and physical interactions (AICI): liquids, quasi-liquids, and solids in snow”, by Bartels-Rausch et al. (2014)” by R. W. Obbard

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RESPONSES TO REFEREE #1

COMMENT: "The author cites precipitates and temperatures of initial precipitation from McCarthy et al. (2007), yet that work deals exclusively with single-salt binary systems, not the multi-salt system of seawater. I would suggest the author confer with Marion

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et al. (1999) for a more appropriate description of the species and their temperatures for this system. In particular, the work of Marion et al., casts light on the lowest temperature at which liquid likely exists in sea ice (-36.2 C, not -60C as stated on page 13169, line 11) and the absence of MgSO₄ – 11 H₂O in the seawater system, and the much lower temperature of the initial precipitation of KCl than the -10.7 C cited (p 13169, line 15). I appreciate that the precipitation pathway presented by Marion et al. is an alternative, but that paper also presents the previously existing paradigm for the multi-salt seawater system, which also indicates no MgSO₄-11H₂O precipitation, and the much lower temperature of KCl formation."

RESPONSE: Many thanks to Referee #1 for his/her comments, and especially for the very helpful suggestion of a more appropriate citation for precipitation in the seawater system. I found its discussion of the Ringer-Nelson-Thompson pathway and the alternative Gitterman pathway especially thought provoking and have change the principle citation in the paper to Marion et al. (1999) and adjusted the text accordingly. . .

"The brine volume and chemistry of sea ice are clearly temperature-dependent, although the exact freezing pathway, with respect to phases, especially precipitates, present at each temperature is still an area of controversy. In the following discussion we accept the Gitterman pathway, described in Marion et al., 1999. Key is that as seawater begins to freeze, at about -1.9 °C, salt ions are excluded, producing low salinity ice crystals and leaving high salinity brine in pockets and channels. As the system is cooled, the brine becomes more concentrated and salts saturate and begin to precipitate when solubility limits are reached. These include mirabilite (Na₂SO₄ - 10H₂O) which begins to precipitate by -7.3 °C, hydrohalite (NaCl - 2H₂O) which begins to precipitate at -22.9 °C, probably gypsum (Ca₂SO₄ - 2H₂O) at -22.2 °C, and magnesium chloride at -36.2 °C (Marion et al., 1999)."

COMMENT: "Minor points: P13169, line 5 “and the literature”?"

RESPONSE: Thank you for spotting this typo. It has been changed to “in the literature.”

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COMMENT: "P 13169, line 11: "and salt saturated and when solubility limits.." should be "the brine becomes more concentrated and salts saturate when solubility limits are reached""

RESPONSE: Agreed and changed accordingly.

COMMENT: "Line 18: most of the other "cations" contribute only a tiny fraction of the overall salinity..." Why "cations"? I think should be "most of the other precipitates contribute only..."

RESPONSE: Agreed that it should not refer only to cations. The sentence has been changed to read,

". . . most of the other salts contribute only a tiny fraction of overall salinity."

COMMENT: "p. 13170, Line 8: who is "we"? Obbard et al., 2009? This is confusing."

RESPONSE: Yes, I meant Obbard et al. (2009), or more generally anyone doing XMT of sea ice with an equivalent system. This has been clarified in these sentences as follows:

"Saturated salt solutions and solid salts would have very similar X-ray attenuation coefficients, so one cannot determine analytically the phase present in brine inclusions in the reconstructed XMT images. However, an understanding of the thermodynamics of freezing seawater, allows those conducting such experiments to accurately predict what they are seeing."

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/15/C3964/2015/acpd-15-C3964-2015-supplement.pdf>

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 13167, 2015.

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