

Interactive comment on “Morphology and distribution of liquid inclusions in young sea ice as imaged by magnetic resonance” by R. J. Galley et al.

Anonymous Referee #1

Received and published: 3 December 2013

————— General comment —————

This paper documents an experiment where an ice core stored at -20°C was imaged using magnetic resonance.

The merit of the paper is to show that MR gives nice and precise images of the brine microstructure.

This is an interesting result, but regarding writing and analysis, the paper is a bit light.

For making the paper suitable for publication, a few items should be addressed.

1- The writing of the paper could be more concise and precise. The objective of the

C2628

study could be clearer and should be narrower. The introduction goes in many directions. Instead it should be more focussed towards the goal of the paper. Besides, it is not clear what the paper brings compared to previous studies (e.g. Perovich et al., 1996; Eicken et al. 2000).

2- At first order, brine volume fraction depends on $1/T$. Hence, cooling the whole core at -20° will not "freeze" the microstructure, but will largely modify it. Therefore any conclusion on the sea ice desalination based on such an experimental protocol is biased. This should be made clear and discussed.

Furthermore, the temperature of the ice core during measurement is unknown, which renders the comparison with Cox & Weeks formula difficult. You should inform that the comparison is made just to check that your measured brine volume fractions make sense.

In this context, the only conclusion I retain as valid is that imaging sea ice microstructure with MR is possible; but other conclusions (on sea ice desalination and permeability) are hard unless the experimental control of temperature is better handled.

3- The contents are quite light. More quantitative analyses of the produced images would be worthwhile. The uncertainties on the method, especially the alleviated linearity of the relationship between brine volume fraction and the DN should be discussed.

In conclusion, I recommend to give a precise scope to the paper, which I think is feasible, and rewrite each of the sections accordingly.

————— More specific comments —————

*** Abstract

- Should explain that this is a study of feasibility, but that the experimental control of temperature was weak.

- Contains a few redundancies (e.g. sentence line 20-31)

C2629

- line 33, use brine inclusions instead of permeability (which cannot be counted and located)

- line 34-37, this sentence could be more compact

*** Introduction

The introduction clouds the issue.

- There are too much details on some aspects (importance of brine microstructure, location of the various experiments of previous authors). There is an almost chronological list of previous work. I would have expected a more synthetic presentation of the state-of-the-art for the different techniques to visualize sea ice microstructure. I am not sure that the sequential (historical) approach to describe previous work is ideal. I would divide previous work into 1) the techniques used to map sea ice microstructure; 2) the morphology of brine channels. Then a last paragraph describing how the technique used by the authors compares to this previous work.

- Second and third paragraphs are built from very old references, while more recent work contributed a lot.

e.g., Line 76-78. This statement is not in line with recent research summarized by Notz and Worster (JGR 2009). Ice forms at the salinity of the seawater. Brine drains simultaneously. It is likely that this old result - that the apparent S is a function of growth rate - is because brine convection removes salt more efficiently when the growth rate is slow.

- Line 81-82 - It would be nice to give more information on how Cox and Weeks 83 measured brine volume fraction to construct their relationship

- Line 110: "fracture of air and brine pockets" is not clear

- Lines 148-156: This is the core of your paper, the rest should be based on it. However, I would think that addressing all these objectives is not feasible in the context of your

C2630

experiment. Testing the law of fives with a core stored at -20° is not possible, unless the core is progressively warmed, which was not done. Similarly, investigating brine channel formation is hard, as the storage must have largely modified the microstructure of the ice.

*** Section 2

Second paragraph. The error on temperature is likely higher than what you state, just because your core might get colder or warmer before you measure temperature. I think the paper by Zhou et al. in JGR recently showed that the error locally can be up to $\pm 1-2^{\circ}\text{C}$. Similarly, for salinity, the error due to brine drainage during coring can be high when brine volume is high. There is work by Eicken et al. 1991 illustrating this. Because of these errors, using CW formula underestimates brine volume.

You took three cores. The presentation would be clearer if you labelled them. You should have re-measured S on the stored core since storage changes salinity.

Line 225 typo "to quantify"

Line 228-232. Show the histogram of DN (if meaningful) to illustrate this.

Line 232. Is there any reason to believe that the relation between L_f and DN could be non-linear. This should be part of the discussion.

Line 234 typo: remove "were"

Line 265 "caused the sea ice volume to cool" -> "cooled the ice" (there are many instances where the wording could be more concise).

* Section 3 There could have been more analyses of the images.

* Section 4 and 5. Errors and scope of the results are under-discussed.

Lines 422-427: the sentence questioning the sackhole technique is not clear

Line 427: just explain how rather than saying that they "fall in line with"

C2631

Line 435 "pemeability of the sea ice volume" is ambiguous

Line 441 "contained less bulk salinity" -> "contained less salt"

Line 443-445: it is also possible that some salt was expelled during the storage of the core

Line 459-477: why discussing this here ?

Line 491-494: the brine channel could have formed before if it moves downwards within the ice as ice grows. 10 days is not a speed, it is a time.

Figure 3 - how the brine volume fraction was computed ?

Figure 5 - The field that is depicted with the gray scale should be described. Captions for 5a and 5b should be different

Interactive comment on The Cryosphere Discuss., 7, 4977, 2013.