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Interactive comment on "New observations of the distribution, morphology, and dissolution dynamics of cryogenic gypsum in the Arctic Ocean" *by* Jutta E. Wollenburg et al.

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Review paper "New Observations of the distribution, morphology, and dissolution of cryogenic gypsum in the Arctic Ocean" by Wollenburg et al.

This paper provides a first description of the morphology, size, sinking speed, and dissolution of cryogenic gypsum crystals sampled in and under Arctic pack ice at four stations. These high-density crystals, precipitated during sea ice formation and released during ice melt, may potentially act as ballast mineral for organic material but have rarely been observed using traditional sampling methods due to difficulties of crystal preservation in samples (e.g. immediate dissolution in formaldehyde). Here, targeted

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crystal sampling was carried out for the first time in situ, in the bottom of sea ice, and with a plankton net on a ROV at 0m and 6m below the sea ice. A detailed description of the sampled crystals is reported in this paper, including their morphology and size. Additional laboratory experiments were carried out to determine the sinking speed and dissolution conditions of the crystals. This work thus provides a first descriptive and quantitative sampling effort for cryogenic gypsum in the Arctic Ocean and I recommend publication of this work, but I have a number of major and minor comments that may help improve the paper.

Major comments:

This comment pertains to the potential ballast effect of cryogenic gypsum. The main motivation of this work is the potential ballast effect of cryogenic gypsum to help the sinking of organic matter through the Arctic water column. However, the excess density of cryogenic gypsum crystals derived from Equation 1 are very low, in the range 0.003-0.009 g cm-3. These values are in fact orders of magnitude lower than one would expect from the density of cryogenic gypsum; excess density = gypsum density – water density = 1.28 g cm-3. First, I think the reasons for the discrepancy between the expected and observed values should be better addressed. Second, an uncertainty assessment should be made on the measurements of particle diameter, sinking speed, and excess density. Third, how do these very low values of excess density of cryogenic crystals compare to the values of excess density of organic material? And are the excess density values of cryogenic gypsum high enough to provoke a ballast effect at all? Forth, a mineral material can only have a ballast effect on organic material if somehow the mineral gets associated with the organic material. Measuring sinking speed and density of a mineral alone does not prove its ballast effect. By which mechanisms could cryogenic gypsum get associated with organic material?

This comment pertains to the hypothesized link between sea ice texture/porosity and cryogenic gypsum crystal size/morphology (section 4.1). This is certainly a very interesting hypothesis, but it is not clear at all how your results support it. This section

needs improved clarity and better wording. The highly speculative nature of this entire section is obvious from the numerous occurrences of the words “likely”, “may”, “possibly”, etc. Clarity could for example be improved by adding two rows at the top of Figure 3, one with a description of crystals in the ice core and one with a description of sea ice texture/porosity.

This work indicates a few of the reasons why cryogenic gypsum crystals have not been observed previously in scientific sampling efforts. I think the paper would benefit from a section of recommendations for future sampling.

Minor comments:

L29: given the difficulty of showing association between mineral and organic material and the absence of this association in your results, I suggest you replace the word “indicated” by “suggested”.

L83: “to” should be “too”

L90: remove “best”

L103: insert “and” after “column”

L104: crystals (plural)

L106: the qualification of cryogenic gypsum as a ballast mineral is not demonstrated in this work in my opinion, as no association between gypsum and organic material has been clearly shown.

L122: can you add a photo or sketch of the rovnet?

Section 2.2: given all the sample handlings, the probability of crystal break up must be high?

Section 2.5: not clear how sinking speed was measured; did you have 2 cameras spaced 30 cm apart at the bottom and the top of the cylinder? What is the measure-

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ment uncertainty?

Section 2.6: You mention three tracking approaches. How did you combine them? Did you somehow average three different trajectories?

L378: please report density in g cm-3 for consistency.

L409-413: What is the relevance of these sentences?

L524: Fig 2D refers to crystals collected at station 45, not 32/80.

Fig 1: impossible to see the difference in trajectories 45 and 66.

L789: with respect to

Fig 7: please add your fitted curves to the figures.

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