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Interactive comment on "Crystallographic preferred orientations of ice deformed in direct-shear experiments at low temperatures" *by* Chao Qi et al.

Anonymous Referee #2

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Summary

I have reviewed the manuscript, "Crystallographic preferred orientations of ice deformed in direct-shear experiments at low temperatures", submitted to The Cryosphere by Qi et al. In this study, the authors utilize a series of laboratory experiments and advanced materials characterization techniques to elucidate the microstructural properties of laboratory prepared specimens of polycrystalline ice under direct shear, taken to various strains at temperatures between -5°C and -30°C. In summary, the authors found through electron backscatter diffraction that the c-axis of the individual ice grains became clustered in an orientation perpendicular to the shear plane in all experiments,

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Discussion paper

with an additional c-axis clustering found at the lowest temperature and highest strain experiments. The authors go on to present a detailed discussion relating to the strains, temperatures, and stresses associated with the observed microstructures for each tested specimen and how they correlate to the various known modes and mechanisms of solid deformation. . .including dynamic recrystallization, strain induced grain boundary migration, and grain boundary sliding. These findings are thought to be of significance in that the easy-slip plane of ice Ih is along the basal plane perpendicular to the c-axis and because the resultant laboratory microstructures and that of natural ice are very comparable, such that the topic lends itself well to the intended scope of The Crysosphere.

Overall, I found the manuscript to be very well-written and the laboratory experiments and microstructural analysis presented robust. The conclusions, although perhaps a bit lengthy, were generally supported by the evidence shown throughout the manuscript and the discussion/interpretation of the results. Except for a few minor comments and questions for the authors, I recommend the timely publication of this manuscript in The Cryosphere and congratulate the authors on their work.

Recommendation: Minor Revisions

Comments/Questions

1. During the sample preparation, when the samples are cooled to -60°C for the welding of the indium jacket, is there any possibility for the thermal/confinement stresses to alter the microstructure as it would relate to the grown-in dislocation density?

2. From looking at Figure 1, I am perplexed as to how the piston is able to translate laterally while also remaining rigid and in-line with the axis of compression? Could you please explain?

3. Could you include the data (via personal communication) related to the flow law of the indium jacket and perhaps also the company/supplier that is used? Such that these

experiments could be repeated?

4. Please add a citation for Line 1-2, page 5, regarding using the minimum strain rate in creep tests.

5. In Section 3.4, please comment on the skewed distribution of grain sizes. Is this log-normal? As would be expected? Was this distribution used for calculating the mean? How was the anisotropy in the elongated grains accounted for?

6. Discussion Section. Although I appreciate the detail of this section, it seems to me that it could be more concise, such that the most relevant findings and results are more impactful.

7. In Section 4.1, should any consideration be given to the recrystallized grains experiencing primary creep in this scenario?

8. Page 11, line 30, replace “in” with “are”

9. Line 13-14, Page 13, please add a citation for this statement.

10. Regarding GBS mentioned in Section 4.6, was there any evidence of this in the observed microstructure? Quadruple points? If not, how would this be incorporated into models for ice if it has yet to be directly observed?

11. Conclusions Section. Could also be more concise. (e.g. no need to summarize the method and/or results before presenting a conclusion)

12. Figure 3b – and with regard to Question 2. . .Am I correct to interpret the increase in the shear stress in these tests as related to the piston becoming displaced and the onset of frictional effects? If not, could you further explain the cause of the increase in the shear stress?

13. Figures 5,6,7 – It’s not clear to me what is being indicated with the blocky black arrow on the left of these maps. Is this a transverse view/map?

14. Figure 10 – Is it possible to also quantify the Key Processes related to the Final microstructure? Such that these 2-D characteristics could be identified with an automated algorithm? Perhaps see Lehto et al. 2016, Characterization of local grain size variation of welded structural steel, as a good starting point. It seems that there needs to be a better method of identifying and/or quantifying the differences in these microstructural regimes.

15. Lastly, after reading Maurine Montagnat's insightful comments pertaining to this manuscript, I would have to agree that it is difficult to ascertain with any certainty the nucleation mechanisms responsible for recrystallization from a 2-D post-mortem analysis alone.

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