The Cryosphere Discuss.,
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The Cryosphere Discussions

Interactive comment on "Microstructure and texture evolution in polycrystalline ice during hot torsion. Impact of intragranular strain and recrystallization processes" *by* Baptiste Journaux et al.

Tielke (Referee)

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General Comments

The manuscript "microstructure and texture evolution in polycrystalline ice during hot torsion. Impact of intragranular strain and recrystallization processes" by Journaux et al. describes the results of a series of challenging deformation experiments carried out on ice using a torsional deformation geometry. The detailed microstructural analyses carried out in this study provide a significant advance in characterization of the dis-

location processes that are involved in the development of crystallographic preferred orientation in water-ice aggregates. The organization and writing is generally crisp, but there are a few instances where the English could be more clear. A slightly wider discussion of this work in the context of previous studies, especially with respect to grain-size sensitive deformation and rheological behaviour, would potentially place this manuscript in a more meaningful context. Therefore, once the minor issues below are addressed, I can fully recommend this manuscript for publication in The Cryosphere.

Sincerely,

Jacob Tielke

Specific Comments

1) A deeper discussion of grain-size sensitive deformation mechanisms may be appropriate. For example, the different nature of the distribution of GND's near grain boundaries is an interesting and important observation. One interpretation of this observation is that there is a heterogenous distribution in the magnitude and orientation of stress near grain boundaries. In other words, the presence of grain boundaries may enhance deformation, which would lead to a grain-size sensitive rheological behaviour such as described by Goldsby and Kohlstedt (2001). A grain-size sensitive rheological behaviour may operate at the higher strain conditions where weakening (increasing strain rate with time) is observed. Although it is possible that the weakening is entirely due to the alignment of grains with favourable orientation to operate easy slip at larger shear strain (i.e. geometric softening).

2) A stress exponent of 3 is used to estimate the stress at the outside radius of the samples. Although probably appropriate for this study, it would be better to have a stronger justification for this selection. For example, if a grain-size sensitive mechanism is operation at higher strain (smaller grain size) conditions, a lower value of stress exponent may be more appropriate. Additionally, values of n of 4 have been observed in ice deforming by dislocation creep (e.g., Durham et al., 1983). A stronger justification

for using n=3 would place more confidence in your calculated values of stress and make future comparison of this work more straightforward.

3) A discussion of some more of the recent work on the controls of ice CPO at low strain conditions would help strengthen some of the arguments in this manuscript. For example, Qi et al. (2017, JGR), discussed the importance of stress on controlling the nature of CPO in ice, and noted the importance of grain boundary migration at low stress and lattice rotation at high stress. Although those experiments were carried out at different conditions and using a different deformation geometry, they may provide some insight into the various conditions at which the texture with the M2 maxima are important.

4) Sample TGI0.012 was deformed to very low strain and its data are missing from Figure 1. How certain are you that this small amount of plastic strain was imposed on the sample? The grain size of TSGI0.012 appears smaller than the unstrained sample, which suggests at least some plastic deformation occurred. Was a correction made for the compliance of the rig? Was there any evidence of elastic strain?

Technical Corrections

Title: It is rather unusual to have a two-sentence title, can it be reduced to one sentence?

Page 2, line 3: “compression and extension are the dominant deformation mechanisms” – this is a bit awkward as most people discussion deformation mechanisms as related to flow behaviour, e.g., dislocation creep, diffusion creep, etc. It may be more clear to replace “deformation mechanisms” with “deformation geometries”.

Line 6: remove “s” from “orientations”

Line 10: remove “olivine”

Line 23: replace “in return” with “consequentially”

Line 27: add “rate” after “strain” ?

Lines 28 – Page 3, line 2 – The statements made in this paragraph are a bit debatable. I am not sure if ice is a great analogue for mantle rocks. Hundreds (if not thousands) of high temperature experiments have been carried out to study the flow behaviour and microstructural characteristics of mantle rocks. Ice is significantly more anisotropic, in a viscous sense, than olivine and other mantle material.

Page 3: line 10: remove “has”

Line 28: add “either” before “not”

Line 29: remove space after “mechanisms”

Page 4 Line 6: replace “packing evenly” with “evenly packing”

Line 17: replace “control visually” with “allow for observation of”

Page 5 Line 18: replace “does” with “do”

Line 31: replace “identify” with “identified”

Page 6 Line 20: replace “reminded” with “noted”

Page 7

Line 1: here you say the noise was too large to distinguish any primary creep hardening in TGI0.012

Line1: add space after at end of sentence

Line 5-6: Can you say for certain the TGI0.012 stayed in the primary creep regime? The strain was very small and the data for that experiment is not presented in Figure 1

Line 21: add “essentially” before “random”

Line26-27: Did TGI0.012 really achieve the strain indicated? How did you account for compliance and elastic deformation of the sample?

Page 8

Figure 1: missing data for TGI0.012

Figure 1 caption: replace “experiments” with “experiments”, or change this sentence unless you add data for TGI0.012 to the figure. Replace “The blank part of the curve corresponds to” with “the blank parts of some of the curves correspond to”. Remove “represented”.

Page 9

Line 10: add “(by gamma = 0.2)

Page 10

Figure 3: This is a nice plot but the large gab between gamma 1 and 2 suggests that maybe it is worthwhile mapping an axial section of TGI1.96? This would allow you to calculate the J-index at all strains by mapping form the center (almost unstrained) to the outside (almost gamma=2) of the sample.

Line 1: replace “develops” with “develop”

Line 9: remove sentence about spatial resolution, that is already in the methods section

Page 12

Figure 5: what is represented by the pole figures? c-axes?

Line 2: add “dislocations” after “those”

Line 9: add “investigated” after “strain”

Page 13

Line 3: replace “identify” with “identified”

Line 5: replace “kinds” with “types”

Line 16: remove “ t “

Page 17

Line 15: replace “these study” with “those studies”

Page 19

Line 7: Replace “advices” with “advice”

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