EXPERIMENTAL REPORT

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TITLE **Pilot Experiment for Complete Determination of Orientation Distribution of Ice using Position Sensitive Detector Diagrams**

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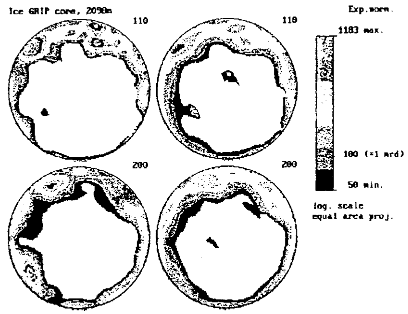
The development of textures as ice is transported into the depths of polar ice sheets has been revealed by the study of deep ice cores from Antarctica and Greenland. Owing to the large anisotropy of ice crystals and the predominance of intracrystalline dislocation glide in polar ice (Pimienta and Duval, 1987), initially isotropic ice near the surface becomes anisotropic when texture develops, exhibiting a different viscous response to shear stress on different planes. Textures reflect the entire thermomechanical history of ice and basically develop as the result of lattice rotation by intracrystalline slip (Castelnau et al. 1996a). But, textures are also influenced by recrystallization, which extensively occur in polar ice sheets (Duval and Castelnau,1995). A ViscoPlastic Self-Consistent (VPSC) deformation model was used to simulate texture development (Castelnau et al. 1996b) in order to emphasize the respective contributions of the various processes involved in this complex deformation mechanism.

The only experimental proof of the ice texture stabilization were up to now brought used polarized microscopy. However, such techniques access only the c-axis ditribution of the ice hexagonal crystal system, without a complete determination of the orientation distribution (OD) of the grains. Hence any possible in-plane texture are not probed. Determining the complete OD would offer a possible calculation of the resulting mechanical properties, of particular importance in the deformation processes. As, x-ray techniques cannot bring enough statistical evaluation for several reasons, we developped an easy handled cryostatic system to allow neutron diffraction studies, with cm^3 probed volumes, to tentatively assess the complete determination of the OD.

The first results are incouraging. We measured a sample coming from the GRIP core at 2098m depth, North Pole. In spite of the relatively large grains (some mm^3) and of the strong incoherent diffusion coming from hydrogen, we successfully extracted several diffracted peaks of ice. The background to peak ratio was however of the level of 5, but the fifth of the signal allowed a clear enough integration of the peaks. It is not here the matter of describing the following texture procedure (Chateigner et al., 1997)

We refined the 110 and 200 pole figures from approx. 900 positions of the sample in the eulerian cradle. This gave enough orientation space coverage taking into account the blind area. Other reflections (202, 112) were partly overlaped by the sample holder peaks. The experimental pole figures were smoothed in order to avoid as much as possible the strong contributions coping from big grains. Figure 1 shows the {1 10} and (200) measured and normalized pole figures (left column), and the recalculated figures from the OD (right column). We can see a quite good agreement between experimental and recalculated figures, as an indication of a correct convergency of the OD solution. Except in the regions where large grains diffract the overall texture is nicely reproduced by the refinement.



Figure

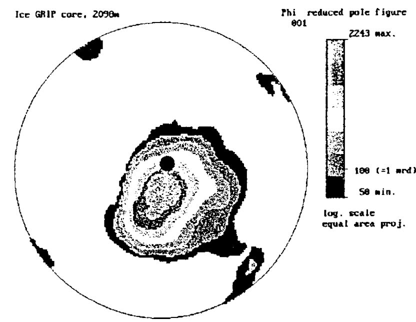


Figure 2

Once the OD calculated, every necessary pole figure can be calculated. Figure 2 is the (001 } recalculated pole figure, which shows the dispersion of the c axes of ice. The core axis is indicated as a black dot, normal to the projection plane. The c-axes dispersion is in good agreement with the one measured by polarized microscopy. However, the apparent in-plane orientation visible on both { 1 IO} and (200) pole figures could come from a lack of statistics in term of number of grains which were probed. From the grain size we can estimate this number to 100 approximately. We need to analyze larger volumes, i.e. larger beam sizes or more samples of the same depth successively measured.

From this pilot experiment it is important to note that the incoherent scattering produced by hydrogen has not induced a significant pertubation of diffraction signals. It is then becoming possible to work on real natural samples, and this is, to our knowledge, the first investigation of this kind. More neutron beam time, combined with the under process synchrotron investigations could bring a better understanding of deformations in deep ice sheets.

References

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