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JOURNAL DE PHYSIQUE
Colloque C1, supplément au n° 3, Tome 48, mars 1987

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Abstract :

It is generally recognized that the fabric pattern of ice in polar ice sheets gradually changes from the random pattern to characteristic ones as the single maximum or the small circle girdle according to increase of the depth. We have considered three main mechanisms for the development of the ice fabric,

1) rotation of basal plane acompanied by deformation
2) grain groth
3) recrystallization.

With respect to the mechanism 1), we obtained a quantitative relationship between the rotation angle of c-axis of individual grains in compressed polycrystalline ice and the amount of uniaxial strain by experiments, and the obtained result of concentration tendency of c-axes with increasing strain was successfully applied to the observed fabric change to the single maximum in Dye-3 cores /1/.

The recrystallization mechanism 3) should prevail at a region where ice temperature is comparatively high. For example, at the depth deeper than 1800m at Byrd station Antarctica, the fabric transforms from the single maximum to the small circle girdle. Several laboratory experiments hitherto carried out succeeded to form the small girdle fabric pattern by the uniaxial compression tests /2-4/, no formation mechanism has ever been proposed.

In the present work, we have carried out experiments of observing recrystallization nuclei produced at the grain boundary of artifially grown bicrystals when they were subjected to the compressive deformation. Five bicrystal specimens of the planer shape were prepared so that c-axes of both crystals were parallel to the plane but rotated each other by 45°(for tests 1,3 and 5) and 30°(tests 2 and 4) around the rotation axis perpendicular to the plane. They were subjected to the uniaxial compression up to 10 % total strain at a temperature -2°C. After released from the testing machine,specimens were examined under microscope. Many recrystallization nuclei were found along the boundary. A photomicrograph of a recrystallized grain (hereafter call subgrain) etched by ethylenedichloride solution of formvar is shown in Fig. 1.

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Fig. 1
Note the c-axis of a subgrain in center makes large angle to that of matrix crystal

Orientations of many subgrains and also of matrix crystals were determined by using the etch pits. In any case of the five experiments, orientations of matrix crystals changed so as to be near to the compressive axis after the deformation. This is certainly expected from the rotation of basal plane as described as the mechanism 1). On the other hand, the subgrain orientations with respect to the compressive axis appear at larger angles than the orientation angle of a matrix crystal which has larger Schmidt factor than another. This implies that subgrains tend to have large misorientation angle θ when they are formed at the boundary of bicrystals.

The formation of nuclei or subgrains which exhibit large misorientation angle can be explained by a mechanism of the generation and annihilation of dislocations at grain boundary proposed by Hondoh /5/. It gives the maximum value of the angle (θ_m) equal to the local shear strain γ of the matrix near the subgrain,

$$\theta_m = \gamma$$

This is confirmed by plotting many observed data of θ against local compressive strain as shown in Fig. 2. In all tests, observed θ lies

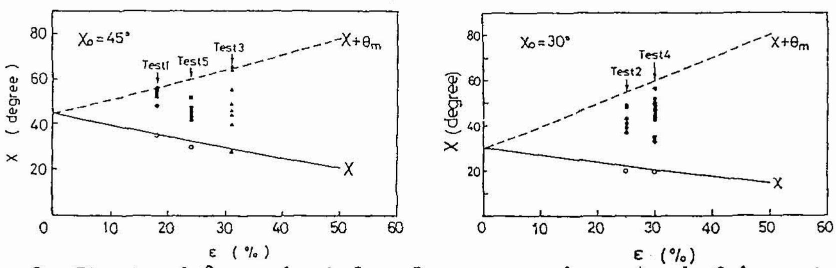

Fig. 2 Observed θ against local compressive strain ε in matrix

under the calculated θ_m(practically $\chi_0+\theta_m$, where χ_0 is the initial misorientation of c-axes of bicrystals). The lower solid lines are those derived by equation (3) in our previous paper /1/about the decreasing tendency of the c-axes of rotating matrix crystals. The curves fit very well with present experimental results represented by open circles.

Increasing tendency of misorientation angle of the c-axis with respect to the compressive axis in recrystallized grains impedes the concentration tendency of the c-axes in polycrystalline ice due to the mechanism 1), and give rise to the formation of the small circle girdle pattern when ice temperature is high enough to nucleate many subgrains under compressive stress.

Details will be published elsewhere.

References

/1/ Azuma, N. and Higashi, A., Annals of Glac. 6 (1985), 130
/2/ Tanaka, H., Jour. Geol. Soc. Japan, 78 (1972), 659
/3/ Huang, M., Ohtomo, M. and Wakahama, G., Low Temperature Science, Ser. A, 41, 13
/4/ Jacka, T.H. and Maccagnan, M., Cold Regions Science and Technology, 8, 269
/5/ Hondoh, T. and Higashi, A., Jour. Phys. Chem., 87 (1983), 4044