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New consideration of ice fabrics development in the light of a-axes orientation of the GRIP and the Dome Fuji ice core

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In order to better understand how ice fabric development in polar ice sheets, we use X-ray Laue method to measure ice crystal orientations. An X-ray measurement equipment which can measure the orientation of c- and a-axis of each crystal in a thin section with high measurement accuracy was developed. In this study, we present a-axes orientation distribution of the deep part of summit ice cores, the GRIP ice core, Greenland and the Dome Fuji ice core, Antarctica.

The thin sections cut from a depth from 1932 m to 2647 m of the GRIP ice core and from 1679 m to 2450 m of the Dome Fuji ice core. Around these depths, the fabric pattern of c-axis orientation shows weak single maximum to strong single maximum. We expect that the azimuth of the a-axes is randomly distributed. Instead, an anisotropic distribution of a-axes occurred at the depths of 2374, 2483, and 2647 m of the GRIP ice core. In particular, the a-axis distribution of a depth of 2483 m of the GRIP ice core tends to align in the almost same direction. We cannot observe a gradually alignment of the a-axes with increasing depths as observed in the c-axis distribution, because an almost random distribution of a-axis azimuths occurs at the depth of 2537 m of the GRIP ice core. The Dome Fuji ice core has also anisotropic distribution of a-axes in a depth of 1976 m. It is common phenomenon in the Greenland and the Antarctic ice sheet. The average grain diameter of such depth is relatively small as compared with the depth around it. Such a small grain suggests that the structure occurs under a shear deformation zone in the deep part of ice sheet.

The simple shear deformation tests are performed on the GRIP ice core samples from a depth of 2427 m and 2593 m at –15˚C. The objective of this test is to investigate the ice fabric development process under the simple shear stress field. We suggest that anisotropic distribution of a-axes is attributed to local simple shear parallel to the horizontal direction of the ice sheet. After 30% shear strain of the both GRIP ice core sample, a weak concentration of a-axes is observed in direction to shear deformation. We now propose an explanation of these anisotropic distributions of a-axis orientations by using the anisotropy of crystallographic slip directions ($e.g.$ parallel to [11-20] and [10-10]) of ice single crystal across the basal plane. The preferred glide direction is parallel to [11-20] in the basal plane, and then a-axis of each grain tends to align to the simple shear direction. However, the glide direction between parallel to [11-20] and parallel to [10-10] has no obvious anisotropy like the glide in basal plane and non-basal plane. Hence, slight anisotropic distribution of a-axes occurs at 30% shear strain. These results and considerations may help us to a better understanding of ice sheet structure and history of ice sheet deformation. Also it leads to improved ice sheet flow models that include finer details of ice fabric development.