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Development of crystal orientation fabric in the Dome Fuji ice core in East Antarctica: implications for the deformation regime in ice sheets

Content

The crystal orientation fabric (COF) of a polar ice sheet has a significant effect on the rheology of the sheet. With the aim of better understanding the deformation regime of ice sheets, the present work investigated the COF in the upper 80% of the depth within the 3035 m long Dome Fuji Station ice core drilled at one of the dome summits in East Antarctica. Dielectric anisotropy ($\Delta\varepsilon$) data were acquired as a novel indicator of the vertical clustering of COF resulting from vertical compressional strain within the dome, at which the ice cover has an age of approximately 300 kyrs BP. The $\Delta\varepsilon$ values were found to exhibit a general increase moving in the depth direction, but with fluctuations over distances on the order of 10-102 m. In addition, significant decreases in $\Delta\varepsilon$e were found to be associated with depths corresponding to three major glacial to interglacial transitions. These changes in $\Delta\varepsilon$ are ascribed to variations in the deformational history caused by dislocation motion occurring from near-surface depths to deeper layers. Fluctuations in $\Delta\varepsilon$ over distances of less than 0.5 m exhibited a strong inverse correlation with $\Delta\varepsilon$ at depths greater than approximately 1200 m, indicating that they were enhanced during the glacial/interglacial transitions. The $\Delta\varepsilon$ data also exhibited a positive correlation with the concentration of chloride ions together with an inverse correlation with the amount of dust particles in the ice core at greater depths corresponding to decreases in the degree of c-axis clustering. Finally, we found that fluctuations in $\Delta\varepsilon$ persisted to approximately 80% of the total depth of the ice sheet. These data suggest that the factors determining the deformation of ice include the concentration of chloride ions and amount of dust particles, and that the layered contrast associated with the COF is preserved all the way from the near-surface to a depth corresponding to approximately 80% of the thickness of the ice sheet. These findings provide important implications regarding further development of the COF under the various stress-strain configurations that the ice will experience in the deepest region, approximately 20% of the total depth from the ice/bed interface.

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Track Classification: The Oldest Ice challenge, and the preservation of climatic signals in the deepest ice