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Densification of layered firn of the ice sheet at Dome Fuji, Antarctica

FUJITA, Shuji[1*] ; GOTO-AZUMA, Kumiko[1] ; HIRABAYASHI, Motohiro[1] ; HORI, Akira[2] ; IIZUKA, Yoshinori[3] ; MOTIZUKI, Yuko[4] ; MOTOYAMA, Hideaki[1] ; TAKAHASHI, Kazuya[4]

[1]National Institute of Polar Research, [2]Kitami Institute of Technology, [3]Institute of Low Temperature Science, Hokkaido University, [4]RIKEN Nishina Center

In order to better understand the densification of polar firn, firn cores from three sites within approximately 10 km of Dome Fuji, Antarctica, were investigated, using surrogates of density: dielectric permittivities ε_v and ε_h at microwave frequencies with electrical fields in the vertical and the horizontal planes, respectively. Dielectric anisotropy $\Delta\varepsilon$ (= ε_v - ε_h) was then examined as a surrogate of the anisotropic geometry of firn. Firn was found to become denser as a result of complex effects of two phenomena that commonly occur at the three sites. Basically, firn with initially smaller density and smaller geometrical anisotropy deforms preferentially throughout the densification process due to textural effects. Second, layers having a higher concentration of Cl^- ions deform preferentially at depths from the surface to ˜30 m. We argue that Cl^- ions dissociated from sea salts softened firn due to modulation of dislocation movement, but that the layered deformation ceases when Cl^- is smoothed out by diffusion. Moreover, firn differs markedly between the three sites in terms of strength of geometrical anisotropy, mean rate of densification, and density fluctuation. We suggest that these differences are caused by textural effects resulting from differences in depositional conditions within various spatial scales.

Keywords: Firn, Antarctica, ice sheet, Antarctic glaciology, glacial rheology