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On formation of stratified firn near surface around Dome Fuji, East Antarctica, using physicochemical analyses

Content

The physicochemical properties of polar ice, originally developed in the atmosphere and near-surface snow, not only record past climate signals but also affect the densification and bubble close-off process of firn. For example, microstructure and impurities influence densification rate and thus degree of density variability (Hörhold and others, 2012; Fujita and others, 2016). The density variability in deep firn may be a factor to determine the depth range of bubble close-off zone, which, in turn, may affect the degree of molecular-size-dependent fractionation of gas components through the influence on pressure difference between bubbles and open pores. To better understand paleoclimatic signals in ice cores, it is thus important to better understand the formation of stratified physicochemical properties in near-surface firn, especially at low accumulation site where deep coring is peformed. For the purpose to study this subject, we use a part of 152-m firn core collected in December 2017 at a site about 54 km south of the Dome Fuji station (NDF, 77°47'18S, 39°3'15E, 3763 m a.s.l.), as an activity towards identifying the next deep coring site (3rd Dome Fuji coring for IPICS Oldest Ice project). The accumulation rate at the site is lower than at the Dome Fuji station, and the surface snow is exposed to sublimation and condensation for a long period. Here, we mainly focus on microstructural and chemical stratigraphy in the the top few meters of the core. In order to clarify the several mm or larger scale stratigraphy, we performed high-resolution (2.5-20 mm depth increment) continuous measurements of multiple physical and chemical properties including the following: (1) density measured by a gamma-ray absorption method, (2) microwave permittivity ε as a proxy for density, (3) dielectric anisotropy Δε as a proxy for vertical elongation of ice and pore spaces, (4) near-infrared reflectance R as a proxy for specific surface area, and (5) δ18O and δD, (6) concentrations of Na, Mg, Al, S, K, Ca, Fe (5 and 6 are measured by a continuous flow analysis system). We found significant positive correlations between ρ, ε, Δε, R, δ18O, and δD, calculated within 1-m segments, in the top several m of the core. We also found significant negative correlations between these properties and the concentration of all the major elements listed above. Using the unprecedented multiple high-resolution datasets, we will discuss the formation of both microstructural and chemical stratigraphy and the relationship of these properties.

Fujita S and others (2016) Densification of layered firn in the ice sheet at Dome Fuji, Antarctica. Journal of Glaciology 62(231).
Hörhold MW, Laepple T, Freitag J, Bigler M, Fischer H and Kipfstuhl S (2012) On the impact of impurities on the densification of polar firn. Earth and Planetary Science Letters 325–326, 93–99.

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