Characteristics of Na^+ and Cl^- distributions in shallow samples from an Antarctic ice core DF01 (Dome Fuji) drilled in 2001: Result of strong atmospheric high-pressure blocking events?†

Y. Motizuki,*1 H. Motoyama,*2 Y. Nakai,*1 K. Suzuki,*3 Y. Iizuka,*4 and K. Takahashi*1

Ice cores record aspects of the geological history of the Earth, including past climate changes. Dome Fuji station, situated in inland Antarctica (77.3°S, 39.7°E; 3,810m above sea level), is one of the best drilling locations for obtaining ice cores to reconstruct past climates and environments. We present the concentration profiles of certain dissolved ions in samples of the part of a Dome Fuji ice core (DF01) drilled in 2001 that was 7.7m to 65.0m deep.

The anions analyzed were $HCOO^-$, CH_3COO^-, $CH_3SO_3^-$, F^-, Cl^-, NO_2^-, NO_3^-, SO_4^{2-}, $C_2O_4^{2-}$, and PO_4^{3-}, and the cations were Na^+, K^+, Mg^{2+}, Ca^{2+}, and NH_4^+. The temporal resolution of the depth profiles of the ionic concentrations was about one year (Fig. 1). No significant correlations were observed between any ions except for Na^+ and Cl^-.

The ratios of the averaged ionic concentrations in samples of the ice core differed from the ratios in sea salt, a result consistent with the findings of previous studies. This suggests that the ionic components of the samples may mainly be of stratospheric origin. Only several synchronous peaks appear in the concentrations of the Na^+ and Cl^- profiles (Fig. 1).

The Cl^-/Na^+ ratios of the DF01 ice core samples analyzed in this study are different from those reported previously for the surface snow at Dome Fuji[1]. This implies that Cl^-, but not Na^+, was redistributed after deposition[2]. High concentrations of SO_4^{2-} in some DF01 samples may account for the difference between the ice core Cl^-/Na^+ ratios and the surface snow Cl^-/Na^+ ratio.

There were indentifiable synchronous peaks of Na^+ and Cl^- in several samples of the DF01 ice core (Fig. 1). In the samples with synchronous peaks, the corresponding Cl^-/Na^+ ratios were confirmed to be close to the ratio in sea salt (=1.8), indicating the presence of strong sea salt components. This implies that the some critical climatic change in the troposphere occurred to cause precipitation with enhanced sea salt components to fall in the Dome Fuji area.

Our results suggest that there were, intermittently, large-scale intrusions of sea salt particles into the interior of Antarctica – the Dome Fuji station is about

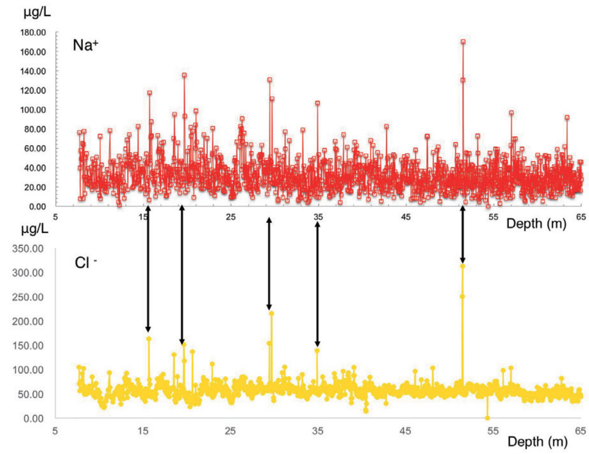

Fig. 1. Depth profiles of Na^+ and Cl^- of DF01 ice core with temporal resolution of about 1 year. Synchronous Na^+ and Cl^- peaks are shown by arrows; the Cl^-/Na^+ ratios of these samples were confirmed to be close to the ratio in sea salt.

1000 km from the coast. The intrusion events appear to have lasted for certain (cumulative) duration that affected one or two of time-resolution periods (Fig. 1). We conjecture that our analyses could be chemical evidence that the usual Antarctic airflow was distorted by high-pressure blocking events[3–6]. High-pressure blocking events convey warm and moist air masses from the Antarctic coast in the troposphere to inland. A blocking event at Dome Fuji was observed in 1997 to persist for about a week[3,4], but one particular event observed in 1994 lasted as long as several weeks[5]. Our findings may indicate that several much larger events occurred in the ~1300-year period investigated in this study. Those events may have been unusually strong atmospheric high-pressure blocking events.

It is important that the same DF01 samples analyzed for Na^+ and Cl^- be analyzed for $\delta^{18}O$ and δD isotopes, so that the four profiles can be compared in order to confirm that blocking events actually caused the synchronous ionic peaks in our data.

References

1) e.g., Y. Iizuka et al.: Tellus B **68**, 29285 (2016).
2) S. Fujita et al.: J. Glacilology, doi:10.1017/jog.2016.16.
3) N. Hirasawa et al.: Geophys. Res. Lett. **27**, 1911 (2000).
4) N. Hirasawa et al.: J. Geophys. Res. **118**, 6916 (2013).
5) H. Enomoto et al.: J. Geophys. Res. **103**, 23103 (1998).
6) K. Fujita et al.: Geophys. Res. Lett. **33**, L18503 (2006).

† First part of this article was condensed from the paper in Geochemical J., **51**, 293 (2017) doi:10.2343/geochemj.2.0458

*1 RIKEN Nishina Center
*2 National Institute of Polar Research, Research Organization of Information and Systems
*3 Department of Environmental Sciences, Shinshu University
*4 Institute of Low Temperature Science, Hokkaido University