Single particle characterization of a snow pit at northwest Greenland

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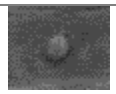
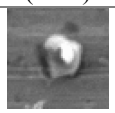
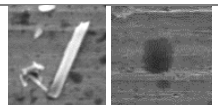
Atmospheric aerosols are conservatively archived in polar ice sheets, which can be used to reconstruct past climate conditions in their source regions as well as long-range atmospheric transport patterns. We investigated recent snow chemistry and mineral dust records in the snow pit recovered from northwest Greenland ice sheet. To examine the seasonal variations of snow chemistry and mineral dust in the snow pit, we collected a 3.2-m snow pit at the North Greenland Eemian Ice Drilling (NEEM) camp on June 2009 and measured stable water isotopes ($\delta^{18}O$, δD, and deuterium excess), major ions (Cl^-, SO_4^{2-}, MSA, Na^+, and Ca^{2+}), trace elements and mineral dust concentrations of the snow pit. The clear seasonal variations of the stable water isotopes with summer maximum and winter minimum were observed, which indicate the snow pit cover the past 7 years period from 2003 to 2009. In our snow pit, relatively high concentration peaks occurred during the spring season in 2006, 2009 and during the summer season in 2008. The ions and trace elements show high concentrations during the spring season in 2006, 2009. During the summer season in 2008, there are no high peaks for ions and trace elements concentrations.

Here we focus on analysis of chemical compositions of two snow pit samples that are a summer season in 2008 and a spring season in 2009. The main purpose of this study is to identify individual particles contained in snow pit and trace their sources by use of quantitative energy-dispersive electron probe X-ray microanalysis (ED-EPMA), which is also known as low-*Z* particle EPMA (Hwang *et al.*, 2008; Geng *et al.*, 2011; Maskey *et al.*, 2011).

Totally 300 individual insoluble particles were characterized. The particles were classified into four particle types based on their morphology and elemental concentrations of individual particles available from the low-*Z* particle EPMA: aluminosilicates, reacted sea-salt particles such as $(Na,Ca)SO_4$ and $NaNO_3$, calcium sulfate, S-rich droplets. In Table 1, the secondary electron images (SEI) of typical insoluble particles in samples and relative abundances of different particle types are shown. In summer season, aluminosilicates were most frequently encountered, followed by reacted sea-salt particles. When the fresh sea-salt aerosols react with nitrogen and sulfur oxides species in the atmosphere, reacted sea-salts are formed, resulting in chlorine loss (Hwang and Ro, 2006). Kuramoto *et al* (2011) reported NO_3^- concentrations in snow pit at NEEM and suggested that the summer peaks of NO_3^- is mainly of natural NO_x origin produced by biomass burning, biogenic soil emissions and lightning. That is reasonable because anthropogenic trace element peaks were not observed in the sample. In spring season, soil-derived particles such as aluminosilicates and $CaSO_4$ particles were predominant. That could be the deposition into the Greenland ice sheet from the arid source areas of East Asia through the long-range air transportation (Bory et al., 2003). For sulfur-rich droplets, further studies are necessary.

Table 1. Typical secondary electron images and relative abundances of different particle types for the two samples.

sample	Chemical compositions	
	Major	Minor
Summer, 2008	 Aluminosilicates (67%)	 $(Na,Ca)SO_4$(23%) $NaNO_3$(10%)
Spring, 2009	 Aluminosilicates (95%)	 $CaSO_4$(5%) / S-rich droplet

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