In-situ observations of solid particles in a deep ice core from Greenland

*Wataru Shigeyama[1,2], Naoko Nagatsuka[2], Tomoyuki Homma[3], Morimasa Takata[3], Kumiko Goto-Azuma[2,1], Ilka Weikusat[4], Martyn R Drury[5], Ernst-Jan N Kuiper[5], Gill M Pennock[5], Ramona V Mateiu[6], Nobuhiko Azuma[3], Dorthe Dahl-Jensen[7]

1. The Graduate University for Advanced Studies (SOKENDAI), 2. National Institute of Polar Research, 3. Nagaoka University of Technology, 4. Alfred-Wegener-Institut Helmholtz-Zentrum fuer Polar- und Meeresforschung, 5. Utrecht University, 6. Technical University of Denmark, 7. University of Copenhagen

Analyses of impurities in ice cores provide us with valuable information on past climate and environment. Conventional analyses of impurities have been carried out by melting ice core samples, which have prevented understanding of state of the impurities in ice (viz. particulate or solute, their composition, size, morphology and spatial distribution). In order to understand the state of the impurities in ice cores, we performed in-situ observations of solid particles in an ice core retrieved by the NEEM (North Greenland Eemian Ice Drilling) project. Observations using a scanning electron microscope equipped with a cryo-transfer system (cryo SEM) allowed us to observe particles with the size of sub-μm to μm. To analyze the elemental composition, energy dispersive X-ray spectroscopy (EDS) was used along with the cryo SEM observations. Irradiation by electron beams and exposure to vacuum could cause transformation and movement of impurities during cryo-SEM observations (e. g. Baker and Cullen, 2003). To eliminate this problem, we performed optical microscopic (OM) observations prior to the cryo SEM observations, and confirmed that solid particles have not changed. Spatial distribution, size, morphology and composition of the particles were investigated. In glacial samples (1548 m depth, ca. 19.2 kyr BP), particles existed both within grains and at grain boundaries. Both the particles in the interior of grains and at grain boundaries were aligned along nearly straight lines. The sizes of majority of the particles were around μm, while many of them were compound aggregates of sub-μm particles. EDS analyses showed that most of the particles were silicates, while a few particles of calcium sulfates and calcium carbonates were also found. Contrary to our findings, previous studies on the NEEM interglacial samples by OM and Raman spectroscopy (740 m depth, ca. 4 kyr BP, Eichler et al., 2017; Kleitz, 2015) reported that majority of particles existed in interior of grains and that they were mainly sulfates. Particles in the NEEM ice core showed different chemical compositions and spatial distributions between glacial and interglacial periods. Combination of our method and conventional liquid analyses is expected to give more detailed information on past climate and environment.

References

Baker, I. and Cullen, D., 2003. J. Glaciol., 49 (165), pp. 184-190.
Eichler, J. et al., 2017, Cryosphere, 11, pp. 1075-1090.
Kleitz, I., 2015, MSc thesis, Martin-Luther Universitaet Halle-Wittenberg, Germany

Keywords: in-situ observation, solid particles, cryo SEM, the NEEM ice core

