Location, morphology and size distribution of solid particles in an ice core retrieved from NEEM, Greenland

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Microparticles in polar ice sheets are closely linked to deformation of ice sheets and also to climate and environment. To understand their roles in ice sheet deformation and to reconstruct the past climate and environment accurately, it is essential to understand location, morphology and size of particles. However, most of previous studies have analyzed particles in melted ice samples.

We performed in-situ particle observations using optical and cryogenic scanning electron microscopes (OM and cryo-SEM) to understand location, morphology and size of particles in a Greenland ice core retrieved by the NEEM (North Greenland Eemian Ice Drilling) project. Using an OM, we analyzed the locations of particles in ice samples from the Holocene (124 and 775 m), the last glacial period (1548, 1966, and 2158 m), and the last interglacial period (2406 m). Using a cryo-SEM in the selected ice samples from each climate stage, we analyzed the morphology and sizes of particles. We also measured size distributions of particles after melting the ice samples from the same depths analyzed with the cryo-SEM.

In the ice samples from the Holocene (124 and 775 m depth) and the glacial period (2158 m depth), the particles existed randomly, while they existed inhomogeneously in ice samples from the last glacial period (1548 and 1966 m depth, where the particle concentrations were high: > 20000 mL^{-1}) and those from the last interglacial period (2406 m depth). Especially, most particles aligned horizontally in the ice from the glacial period (1548 and 1966 m depth). The cryo-SEM observations showed that around half of the particles existed as aggregates of smaller particles in all ice samples analyzed. The mode diameters of the particles ranged from 1.1 – 5.2 μm in ice samples observed by the cryo-SEM, while they were close to 0.5 μm or smaller in the melted samples. The smaller diameters measured in the melted samples suggest that most particles in aggregates were dispersed in the melted samples. The particle sizes measured by the in-situ observations are therefore useful for better understanding of the effects of particles on ice deformation.