Research Networking Programmes

Short Visit Grant ☒ or Exchange Visit Grant ☐

(please tick the relevant box)

Scientific Report

The scientific report (WORD or PDF file – maximum of eight A4 pages) should be submitted online within one month of the event. It will be published on the ESF website.

Proposal Title: Effects of microparticles on crystal formation and macroscopic deformation of ice

Application Reference N°: 7130

1) Purpose of the visit

Ice in Antarctica or Greenland is being deformed and flows into the ocean under its own weight, playing crucial roles e.g. for sea level evolution. Clarification of the mechanism of ice flow is important to predict the effects of climate change in the future. On the other hand, mineral-, salt-, bio-microparticles have been captured in the ice sheets because of precipitation of aerosols. Inclusions in crystal material behave as a factor in crystal formation, which can affect deformation characteristic of ice. In order to clarify the effects of included microparticles on the formation of crystal structure and macroscopic deformation of ice, observation of microstructure, analyses of crystal orientation and microparticles are conducted.

At Alfred-Wegener-Institut in Bremerhaven, Germany, microstructure mapping device, fabric analyzer and Raman spectroscope used for the observation (incl. subgrain boundaries and slip bands), analysis of c-axis orientations and identification of the impurities, respectively, are available. Meanwhile, secondary electron microscope (SEM) equipped electron backscatter diffraction (EBSD) detector for high-resolution indexing crystal orientations (incl. a-axis) is used in Utrecht University in the Netherlands. Our aim of visit is to combine these methods and understand the effects of the microparticles on the crystal structure and deformation of ice, therefore, travels between Bremerhaven and Utrecht is necessary.

2) Description of the work carried out during the visit

Two NEEM (North Greenland Eemian Ice Drilling) ice core samples were prepared for this campaign. In these samples, mean grain size is 1-2 square mm, which is finer than the most of the other parts in this core. In general, Finer grains are correlated with concentration of impurities in polar ice. Before the campaign, grain boudary networks were observed with laser and c-axis orientations were analyzed by fabric analyzer with the samples having ca. 90 × 55 mm^2 surface. These samples subsequeantly were cut into ca. 8×8×7 mm^3, shaved and observed with microstructure mapping deivice (light microscopy). This procedure was conducted at Alfred-Wegener-Institut. The samples were carefully placed in the transport boxes and shipped to Utrecht University by a styrofoam box filled with dry ice. At Utrecht University, the samples were placed onto the sample holder and transferrd into SEM chamber via the cryo-preparation chamber. Both chambers have cold stage cooled by liquid nitrogen and are able to keep the ice samples stable under the high vacuum condition. During the transfer, the samples were sublimated at -100 to -90℃ for 5-6 min. at the cryo-preparation chamber to remove the frosts from the surface. The observations by SEM were conducted with 5kV of accerelation voltage, 0.4-1.6 nA of beam current at -150 to -130℃ of temperature of cold stage under the high vacuum (5×10^-6 to7×10^-7 hPa). For EBSD, 10-20 kV of accerelation voltage, 2.1-8.4 nA of beam current were choosed. In this campaign, 26 ice samples were prepared at Alfred-Wegener-Institut and 8 samples were observed and analyzed at Utrecht University. 2 samples were lost due to failures of transfer into the SEM chamber and the rest of them are still waiting to be analyzed.

3) Description of the main results obtained

The microstructures of polar ice were observed with SEM. They showed same feature as observed with light microscope. This reveals a possibility to compare the features in microstructures by two microscopes. Crystal orientations (incl. a-axis) were identified by EBSD method. The results show locations of grains/subgrains and grain/subgrain boundaries based on the crystal orientations and misorientation angles. Misorientation gradients were also revealed. They would indicate the development of dislocation walls and formation of grains and subgrains in the microstructure in polar ice. Combined with the large area observations and anlyses, mechanism of deformation of ice is discussed.

4) Future collaboration with host institution (if applicable)

In this campaign, 16 samples still remain for SEM/EBSD observation and 2 samples were lost due to the transfer into the SEM chamber. This shows that the campaign requires more time to observe/analyze and has difficultities of sample transfer. To get more information of crystal orientations and develop the sample transfer technique, the future collaboration is still necessary.

We focused on fine-grained samples in this campaign, for finer grains are generally correlated with concentration of impurities in polar ice. However, investigations of location and compositions of the microparticles combined with the crystal texture are demanded to understand the effects of microparticles on the crystal formation even if the grain size is one of the important factor of impurities in ice. The

Raman spectrometer at Alfred-Wegener-Institut will be effective for the impurity analysis in ice. Collaboration of large area observations of the microstructure and analyses of the impurities at Alfred-Wegener-Institut, and crystal orientation analyses by SEM/EBSD at Utrecht University is therefore still important in the future.

5) Projected publications / articles resulting or to result from the grant *(ESF must be acknowledged in publications resulting from the grantee's work in relation with the grant)*

Still not projected

6) Other comments (if any)