An analysis of the influence of deformation and recrystallization on microstructures of the EGRIP ice core

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New and more detailed investigations from the EGRIP physical properties dataset down to 1650m of the ice core will be presented. EGRIP is the first deep ice core through one of our Earth's ice sheets partly motivated by ice dynamics' research. It is drilled just downstream of the onset of the largest ice stream in Greenland (*North East Greenland Ice Stream*). Data processing of the collected ice core physical properties data was done at the Alfred Wegener Institute Helmholtz Centre for Marine and Polar Research. The two main findings regarding CPO (c-axes fabric) pattern, 1) a rapid evolution of c-axes anisotropy and 2) partly novel characteristics, were further, and in more detail, investigated. To gain a better understanding of the dominating deformation mechanisms of *NEGIS*, different approaches considering different length scales were chosen (1650m versus 0.55m and 0.09m scale), including several case studies.

A large-scale statistical analysis of the entire dataset results in new information about the depth-dependent evolution of parameters as for example the strength of c-axes anisotropy and grain-size in the polycrystal. In general, mean grain-size decreases with depth as we drill through the Holocene ice and approach the Glacial material. The grain size variability with fine and coarse grain layers is extreme in the Holocene ice but decreases in the Glacial ice. Microstructure properties were examined, with the aim to investigate the relationship between the remarkable rapid evolution of CPO-pattern and grain properties evolution. Furthermore, the evolution of a grain-size dependent anisotropy, found in the first 350m of the ice core, is investigated and examined also in deeper sections of the core.

The large-scale evolution of density distributions of c-axes orientations differ significantly from observations in deep ice cores made so far: A novel "hourglass shaped" girdle was observed, characterized by a high density of horizontally oriented c-axes within the vertical girdle. In some parts of the core, this shape develops into a "butterfly shaped" cross girdle, varying in intensity and strength. It is the first time that this cross girdle was observed in polar ice and by combining approaches considering different length scales, we aimed to verify one of our three hypotheses for its origin: a) activation of multiple dislocation slip systems (in analogy to quartz), b) a memory effect or reminiscent features from older deformation modes, further upstream or even outside of *NEGIS* or c) horizontal uniaxial extension causing an early onset of dynamic migration recrystallization.

Small-scale high-resolution studies were carried out on several selected bags (0.55m long) from different depth regimes and were chosen as case studies to better understand the formation mechanisms of the novel CPO patterns found in the EGRIP ice core. One approach is the examination of thin sections (9 x 7 x 0.03cm) regarding the occurrence of patches of grains with similar orientations, which was observed in several samples from different depths. Small grains with similar orientations seem to cluster around large grains with a different orientation.

High-resolution images (5 to 20µm/pix), derived with a Large Area Scan Macroscope (*LASM*), enable detailed investigations of grain shape, grain boundaries and sub-grain boundaries and therefore the possibility to find distinct features from deformation and recrystallisation in the microstructure. Grains are rarely horizontally aligned and usually show irregular, circular or rectangular shapes rather than elongated shapes. Characteristic for our case studies are also amoeboid grain shapes

and sutured grain boundaries, typical features of grain boundary migration. Furthermore, layering, "sandwiched grains" and strong gradients in grain-size over distances of only a few centimetres were observed in several samples.

Although still under progress, at the current state of investigation, combining fabric data and microstructure analysis, the novel CPO patterns found in the EGRIP ice core are strongly influenced by dynamic migration recrystallization.