The upper 1650m in EGRIP - First results from physical properties of NEGIS

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We will present the EGRIP CPO (***c***-axes fabric) dataset and give preliminary interpretations concerning the processes leading to its evolution. 120 bags were selected, with a minimum depth resolution of 15m. Bags were mostly measured continuously, and in total 778 thin sections were prepared, measured and pre-processed on site. Thus, ***c***-axes distribution CPO data are already available, while other parameters on grain stereology are still to be processed at this stage. The CPO patterns found in the upper 1650m at EGRIP show (1) a rapid evolution of ***c***-axes anisotropy compared to lower dynamics sites and (2) partly novel characteristics in the CPO patterns.

(1) Starting the measurements at 118m of depth we find a very broad single maximum distribution. The ***c***-axes align with depth in the upper 400m much more rapidly than seen in ice cores from divides or domes. Down to only 140m depth the almost random CPO develops into a very broad single maximum which is similar to those CPOs found in the shallowest samples of other ice cores. Possible interpretations of these distributions are deformation by vertical compression from overlying layers, or alternatively a temperature-gradient snow metamorphosis. This weak CPO pattern is, however, quickly overprinted in the depth zone below 140m where a progressive evolution towards a vertical girdle distribution is observed. As vertical girdles are produced by extension along flow, the observed distribution indicates that the ice at this depth is deforming rather than just being translated by rigid block movement. From approximately 600m of depth downward we observe crystal orientation anisotropy of a strength comparable to samples from ~1400m of depth at divides (NEEM and EDML). This strong girdle CPO remains rather stable down to approximately 1300m depth, where we reach the ice deposited during the last glacial period. A novel pattern, not observed before in natural ice, is a higher densities of ***c***-axes horizontally oriented within the vertical girdle.

(2) The early onset of deformation seems further supported by the observation of a broad “hourglass shaped” girdle, which seems to develop in some depths into a “butterfly shaped” cross girdle. Another characteristic deserves attention: the distribution density within the girdle. In contrast to observations in deep ice cores so far, the highest density seems to deviate from the vertical direction being (sub-)parallel to the horizontal. The origin of this may lay in the main deformation modes, e.g. a combination of along flow extension with additional deformation modes.

Especially interesting is the cross girdle, which has not yet been observed in polar ice cores so far. We suggest three possible interpretations for its origin: a) In other materials, such as quartz, cross girdles can be interpreted as activation of multiple dislocation slip systems. b) Alternatively, the CPO pattern may reflect reminiscent features from previous deformation modes, which the ice experienced upstream or possibly even outside of the ice stream. This memory effect would point to a relevance of strain dependence of the CPO. c) The cross-/double-girdle might be caused by the early onset of dynamic migration recrystallization under horizontal uniaxial extension.