Microstructure investigations on grain scale of ice from Antarctica (EDML) to establish deformation and its mechanisms

Method
Thick sections (50 mm x 100 mm x 5 mm) parallel to the axis of the ice core are mapped with a microscope after microtoming and sublimation. Each scan contains approximately 1500 pictures (2.5 mm x 1.4 mm).

Which microstructure features are visible? What do they look like? Grain boundary hierarchy
(Sub-)Grain boundaries are the most common features. Their Shapes, intensity and orientation with respect to other microstructural elements (e. g. slip lines) vary with microstructural processes.

Recrystallisation regimes
Three dominant recrystallisation regimes are described in the literature (Alley 1992, Montagnat & Duval 2000):

1. Normal grain growth (upper several hundreds of meters): Average grain size increases.
2. Polygonisation/Sub-grain rotation recrystallisation (between 1. and 3.): Sub-grain boundaries perpendicular to slip lines occur.
3. Migration recrystallisation (deepest hundreds of meters at critical T close to -10°C): Rapid grain boundary migration occurs between dislocation-free nuclei and deformed grains. Interlocking grains occur.

Observations and Data
About 50 samples from maximum 100 m depth difference have been qualitatively tested. In some (10) samples statistical investigations have been done.

1. Straight grain boundaries are rare. Bulging of grains is observed already in 100 m depth. Foam texture, as expected, is not observed. First data show, that average grain size between 550 and 2260 m is modulated by changing climate variations (last glacial period).
2. Sub-grain boundaries are observed from 100 m depth. At 230 m depth already 58% of all grains contain sub-grain boundaries.
3. Deepest hundreds of meters are not yet drilled (whole length of core 2800 m). Grains in deepest available samples are not interlocking more intense than in shallower depths.

Preliminary results indicate that the recrystallisation regimes described in the ice core literature are not easy to apply to the EDML ice core.

References