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In situ-measurement of ice deformation from repeated borehole logging of the EPICA Dronning Maud Land (EDML) ice core, East Antarctica.

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The European Project for Ice Coring in Antarctica (EPICA) ice core was drilled between 2001 and 2006 at the Kohnen Station, Antarctica. During the drilling process the borehole was logged repeatedly. Repeated logging of the borehole shape is a means of directly measuring the deformation of the ice sheet not only on the surface but also with depth, and to derive shear strain rates for the lower part, which control the volume of ice transported from the inner continent towards the ocean.

The logging system continuously recorded the tilt of the borehole with respect to the vertical (inclination) as well as the heading of the borehole with respect to magnetic north (azimuth) by means of a compass. This dataset provides the basis for a 3-D reconstruction of the borehole shape, which is changing over time according to the predominant deformation modes with depth.
The information gained from this analysis can then be evaluated in combination with lattice preferred orientation, grain size and grain shape derived by microstructural analysis of samples from the deep ice core. Additionally, the diameter of the borehole, which was originally circular with a diameter of 10 cm, was measured.

As the ice flow velocity at the position of the EDML core is relatively slow (about 0.75 m/a), the changes of borehole shape between the logs during the drilling period were very small and thus difficult to interpret. Thus, the site has been revisited in the Antarctic summer season 2016 and logged again using the same measurement system. The change of the borehole inclination during the time period of 10 years clearly reveals the transition from a pure shear dominated deformation in the upper part of the ice sheet to shear deformation at the base.

We will present a detailed analysis of the borehole parameters and the deduced shear strain rates in the lower part of the ice sheet. The results are discussed with respect to ice microstructural data derived from the EDML ice core. Microstructural data directly reflect the deformation conditions, as the ice polycrystal performs the deformation which leads e.g. to characteristic lattice orientation distributions and grain size and shape appearance. Though overprinted by recrystallization (due to the hot environment for the ice) and the slow deformation, analysis of statistically significant grain numbers reveals indications typical for the changing deformation regimes with depth.
Additionally we compare our results with strain rates derived from a simulation with a model for large scale ice deformation, the Parallel Ice Sheet Model (PISM).