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Critical Fracture Toughness Measurements of an Antarctic Ice Core

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Fracture toughness is a material parameter describing the resistance of a pre-existing defect in a body to further crack extension. The fracture toughness of glacial ice as a function of density is important for modeling efforts aspire to predict calving behavior. In the presented experiments this fracture toughness is measured using an ice core from Kohnen Station, Dronning Maud Land, Antarctica.
The samples were sawed in an ice lab at the Alfred Wegener Institute in Bremerhaven at $-20°C$ and had the dimensions of standard test samples with thickness 14 mm, width 28 mm and length 126 mm. The samples originate from a depth of 94.6 m to 96 m. The grain size of the samples was also identified. The grain size was found to be rather uniform.
The critical fracture toughness is determined in a four-point bending approach using single edge V-notch beam samples. The initial notch length was around 2.5 mm and was prepared using a drilling machine. The experimental setup was designed at the Institute of Materials Science at Darmstadt. In this setup the force increases linearly, until the maximum force is reached, where the specific sample fractures. This procedure was done in an ice lab with a temperature of $-15°C$. The equations to calculate the fracture toughness for pure bending are derived from an elastic stress analysis and are given as a standard test method to detect the fracture toughness. An X-ray computer tomography (CT scanner) was used to determine the ice core densities. The tests cover densities from $843\,\mathrm{kg\,m^{-3}}$ to $871\,\mathrm{kg\,m^{-3}}$. Thereby the influence of the fracture toughness on the density was analyzed and compared to previous investigations of this material parameter. Finally the dependence of the measured toughness on thickness, width, and position in the core cross-section was investigated.