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Small scale folding observed in the NEEM ice core

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Disturbances on the centimeter scale in the layering of the NEEM ice core (North Greenland) can be mapped by means of visual stratigraphy as long as the ice does have a visual layering, such as, for example, cloudy bands. Different focal depths of the visual stratigraphy method allow, to a certain extent, a three dimensional view of the structures. In this study we present a structural analysis of the visible folds, discuss characteristics and frequency and present examples of typical fold structures. With this study we aim to quantify the potential impact of small scale folding on the integrity of climate proxy data. We also analyze the structures with regard to the stress environment under which they formed.

The structures evolve from gentle waves at about 1700 m to overturned z-folds with increasing depth. Occasionally, the folding causes significant thickening of layers. Their shape indicates that they are passive features and are probably not initiated by rheology differences between layers. Layering is heavily disturbed and tracing of single layers is no longer possible below a depth of 2160 m.

Lattice orientation distributions for the corresponding core sections were analyzed where available in addition to visual stratigraphy. The data show axial-plane parallel strings of grains with c.axis orientations that deviate from that of the matrix, which has more or less a single-maximum fabric at the depth where the folding occurs. We conclude from these data that folding is a consequence of deformation along localized shear planes and kink bands. The findings are compared with results from other deep ice cores.

The observations presented are supplemented by microstructural modeling using a crystal plasticity code that reproduces deformation, applying a Fast Fourier Transform (FFT), coupled with ELLE to include dynamic recrystallization processes. The model results reproduce the development of bands of grains with a tilted orientation relative to the single maximum fabric of the matrix and also the associated local deformation.