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Small-scale disturbances in the stratigraphy of ice cores: observations and numerical model simulations

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Visual stratigraphy of ice cores from Greenland as well as Antarctica revealed folding on a cm scale, with fold amplitudes varying from less than 1 cm to a few decimetres. Stratigraphy bands are visualized by an indirect light source scattering on surfaces inside the ice, mainly particles and air bubbles / hydrates.

Due to their potential influence on the integrity of the climatic record, folds have been subject to modelling studies, however, the initial formation of the disturbances is not fully understood. In this study we present a detailed analysis of the visible folds from the NEEM ice core from Greenland and the EDML ice core from Antarctica, discuss their characteristics and frequency and present examples of typical fold structures. We also analyse the structures with regard to the deformation boundary conditions under which they formed. In case of the NEEM core the structures evolve from gentle waves at about 1500 m to overturned z-folds with increasing depth. Occasionally, the folding causes significant thickening of layers. Their similar-fold shape indicates that they are passive features and are probably not initiated by rheology differences between alternating layers. Layering is heavily disturbed and tracing of single layers is no longer possible below a depth of 2160 m. C-axes orientation distributions for the corresponding core sections were analysed 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 shows a single-maximum fabric at the depth where the folding occurs. In case of the EDML ice cores the folding starts at a depth of about 1700 m and show very similar characteristics as found in the NEEM core.

Numerical modelling of crystal viscoplasticity deformation and dynamic recrystallisation was used to improve the understanding of the formation of the observed structures during deformation. The modelling reproduces 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. We conclude from these results that the observed folding is a consequence of localized deformation at the boundaries of kink bands