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In-situ observation of bubble trapping in polar firn

Christoph Florian Schaller (1), Johannes Freitag (1), Todd Sowers (2), Bo Vinther (3), Alexander Weinhart (1), Olaf Eisen (1,4)

(1) Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany, (2) Department of Geosciences and the EMS Environment Institute, Pennsylvania State University, State College, United States of America, (3) Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark, (4) Department of Geosciences, University of Bremen, Bremen, Germany

The air trapped in polar ice cores is not a direct record of past atmospheric composition but is strongly influenced by the process of firnification as bubbles are only sealed at a certain point, when the respective horizontal layer reaches a so called “critical” porosity. In order to investigate this process, we performed high-resolution (approximately 25 μm) 3D-XCT measurements of the complete lock-in zone for two polar ice cores representing opposite extremes of the temperature and accumulation rate range: B53, close to Dome Fuji, East Antarctica and RECAP_S2, Renland, Greenland. For every 1m core segment, we scanned a minimum number of five sections of approximately 3.5cm height of the full core diameter with a focus on homogenous layers. This allows us to non-destructively deduce detailed profiles of open and closed porosity on a solid statistical basis.
For each of the cores individually, we find that the trapping of bubbles in a single layer is solely determined by its total porosity and thereby independent of depth. We can confirm the existence of a distinct Schwander-type relation of closed and total porosity.
Even though the two cores deviate from each other significantly in critical porosity, 0.0907 for B53 compared to 0.1025 for RECAP_S2, we observe many similarities. We hypothesize, that the determining factors of bubble trapping are the average size and variability of pore space structures. This could potentially allow the reconstruction of past close-off porosities from the remaining pore structures in deep ice, e.g. from bubble number densities.