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Air bubble migration rates as a proxy for bubble pressure distribution in ice cores

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Air bubble migration can be used as a proxy to measure the pressure of individual bubbles and can help constrain the gradual close-off of gas bubbles and the resulting age distribution of gases in ice cores. The close-off depth of single bubbles can vary by tens of meters, which leads to a distribution of pressures for bubbles at a given depth. The age distribution of gases (along with gas-age–ice-age differences) decreases the resolution of the gas level reconstructions from ice cores and limits our ability to determine the phase relationship between gas and ice, and thus, the impact of rapid changes of greenhouse gases on surface temperatures. For times of rapid climate change, including the last 150 years, and abrupt climate changes further back in the past, knowledge of the age distribution of the gases trapped in air bubbles will enable us to refine estimates of atmospheric changes. When a temperature gradient is applied to gas bubbles in an ice sample, the bubbles migrate toward warmer ice. This motion is caused by sublimation from the warm wall and subsequent frost deposition on the cold wall. The migration rate depends on ice temperature and bubble pressure and is proportional to the temperature gradient. The spread in migration rates for bubbles in the same samples at given temperatures should therefore reflect the variations in bubble pressures within a sample. Air bubbles with higher pressures would have been closed off higher in the firn column and thus have had time to equilibrate with the surrounding ice pressure, while air bubbles that have been closed off recently would have pressures that are similar to todays atmospheric pressure above the firn column. For ice under pressures up to ∼13–16 bar, the pressure distribution of bubbles from a single depth provides a record of the trapping function of air bubbles in the firn column for a certain time in the past. We will present laboratory experiments on air bubble migration, using Antarctic ice core samples from a range of depths, to show that air bubble migration is a valid proxy for bubble pressure and can thus be used to determine the trapping function of air bubbles and gas age distribution for past conditions.