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Temperature reconstruction through ~18.5 ka at the South Pole Ice Core site: bubble number-density estimates.

Content

Using samples from the South Pole Ice Core (SPC14), we present new bubble number-density measurements and a modeled temperature history reconstruction for the South Pole site back through ~18.5 ka. Additionally, we show that 3D micro-CT sample imagery can accurately quantify bubble number-density, enabling more rapid and efficient future analyses.

Applying sampling and imaging techniques previously established for analyses of the WAIS Divide ice core (Spencer et al., 2006; Fegyveresi et al., 2016), we measured bubble number-density as well as other bubble characteristics (e.g. size, orientation, aspect ratio, etc.) from just below pore close-off depth starting at ~160 m, down to ~1200 m, at 20-meter intervals (53 total samples). Typical values range between 800 and 900 bubbles cm-3 over this interval. These values are higher than any previously measured in ice-core samples, indicative of both the colder mean annual temperatures, and higher mean annual accumulation rates at South Pole. Below ~1100 m, we noted significant bubble loss owing to the onset of clathrate-hydrate formation.

Using micro-CT technology (Bruker SkyScan 1172), we also tested the use of 3D imagery to accurately measure and evaluate bubble number-density as a supplement and future alternative to painstaking thin-section measurements. We imaged a secondary set of ice-core samples at 100-meter intervals beginning at 200 m, and across the sample total depth range. Once corrected for cut- and micro-bubbles, our results show comparable values and thus similar trends to the traditionally-prepared thin-section data.

For our temperature model, we determined an accumulation record using both measured annual layer thicknesses, as well as estimated d15N-derived firn-column thicknesses estimates. Our temperature reconstruction was calculated using the model developed by Spencer et al. (2006), and using a South Pole site-specific bubble-to-grain ratio (G) of 1.6. the reconstruction reveals a warming across the glacial-interglacial transition of ~7℃, with a relatively stable trend through the Holocene (< 0.4℃ warming). These results are in close agreement with those reported by other independent paleothermometers (i.e. isotope- and firn-derived reconstructions). Results of our temperature reconstruction also reveal that using 3D micro-CT imagery in place of traditional thin-section techniques produces comparable results, but with even greater accuracy, and lower measures of uncertainty.

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