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What causes the millennial scale jumps in total air content at Dome C?

Content

Measurements of the total air content (TAC) in ice cores have a long history and were motivated to reconstruct past changes in the altitude of the ice sheet at the drill site. To allow this one has to know the porosity when the bubbles close off (pore volume) and correct for temperature. Temporal changes in the porosity are difficult to constrain thus limiting its use as paleo altitude proxy. However, orbital changes in the local insolation were found to modulate the TAC signal which allows this parameter to be used as additional orbital dating tool without a clear process understanding of the driving mechanism. With a compilation of previous TAC data by Raynaud et al. 2007 and about 300 new TAC measurements done in Bern covering the last 450 kyr we increased the temporal resolution and achieve about 1 kyr resolution between MIS 9 and MIS 7 (around 350 to 210 kyr). Our high-resolution record revealed the well-known orbital TAC variations but also rapid jumps within 2 kyr that were not visible so far due to a lack in resolution. These jumps are especially pronounced for early MIS 7 and 9, where we have highest resolution, but for MIS 5.5 we see a similar pattern. The sequence is a follows: From a TAC maximum that is reached about 10-20 kyr before the start of the termination, TAC is slowly dropping to reach a pronounced minimum right at the interglacial temperature maximum (coinciding with the maximum in d15N of N2). TAC minimum values for all glacial cycles of the last 450 kyr are similar with about 88 mL/kg. After this minimum, TAC values rapidly increase within only 2 kyr, thus at a time scale comparable or less than the age of firn column at Dome C. This suggests that the millennial scale changes of Antarctic climatic forcing (temperature and accumulation rates) at the start of the interglacial leads to a transient disequilibrium in firnification. We suggest that during the early interglacial warming the significantly growing snow accumulation, hence overburden pressure, on top of a firn column that had been in equilibrium with lower temperatures and accumulation, leads to a transient creep-related reduction of porosity, hence to the pronounced TAC minima. We already observed these dynamic millennial-scale features for Greenland ice cores (Eicher et al. 2016) during rapid DO events. However, these features have not been observed in Antarctica due to the slower firnification processes and longer response time of the firn column.

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Track Classification: Progress in proxy development and interpretation