Evidence for Northern Hemisphere forcing on climatic cycles from absolute dating of Antarctic ice cores

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Absolute chronology of Antarctic deep ice cores has been awaited to elucidate the timing of rapid glacial-interglacial warmings and accompanying CO2 increase relative to summer insolation at northern high latitudes, which is critical test of the Milankovitch theory of glacial cycles. We present O2/N2 ratio of trapped air in the Dome Fuji ice core, which records the local summer solstice insolation without lag. After correcting for post-coring depletion due to diffusive gas loss, it gives absolute chronology of the ice core for the past 340,000 years (last three glacial cycles) with mean accuracy of 2000 years. Available O2/N2 data of the Vostok core1 is also used to refine the chronology and to cover the entire duration of Termination IV. Rapid Antarctic warming for the last four terminations began 18+/-1, 137+/-2, 247+/-2, and 344+/-2 kyr BP. These are within the rising phase of 65 degrees N June 21 insolation, with Termination II and IV (I and III) being relatively early (late). Major sea level rise began 137+/-3 and 248+/-3 kyr BP for Termination II and III, respectively, which was deduced from d18O of atmospheric O2 in the Dome Fuji core. The result rejects hypotheses which require early Antarctic warming and CO2 increase in response to southern summer insolation as the trigger of the northern ice sheet collapse. The variable lag of Terminations behind northern summer insolation minima supports that the northern summer insolation ultimately triggered the deglaciation, with significant phase modulation by obliquity and ice volume. Early deglaciation occurred when obliquity and ice volume are large. The sequence of events at the onset of Terminations would be as follows: (1) northern insolation triggers initial collapse of northern ice sheets, (2) Southern Ocean and Antarctica starts to warm by bipolar see saw mechanism, (3) atmospheric CO2 starts to increase in response to Southern Ocean warming. In terms of stadial/interstadial variations, every wiggle in the northern high-latitude summer insolation is reflected in the Dome Fuji isotope record with small and variable lag (mean lag, 1.1+/-0.5 kyr at 23 kyr period), which also suggest the phase modulation by obliquity.