Penultimate glacial-interglacial transition viewed from the Dome Fuji ice core, Antarctica

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Paleoclimatic proxies provide information about the variations of climate forcings and responses, such as atmospheric CO_2concentration, temperature and sea level, as well as their magnitudes and phase relationships. Accurate chronological constraints are particularly important for numerical simulations, both for their input and validation data, to better understand the transient behaviors of climate and ice sheets. During the last interglacial period (˜130 to ˜120 thousand years before present (kyr BP)), the peak global mean surface temperature was ˜1 degree higher than the preindustrial period, and the global sea level was ˜6 –9 m higher than today with significant contribution from the Antarctic ice sheet, whereas atmospheric CO_2levels were similar to those in the preindustrial period (Dutton et al., 2015). The last interglacial period and the preceding transition from the penultimate glacial period are important targets for the paleoclimatic research to investigate the mechanisms for warming and ice-sheet reductions. However, responses (sequences, timing or magnitude) of ice sheets, temperature or ocean circulations to climate forcing during this period are much less well understood, partly because the number of proxies and time resolution are limited, and the chronological uncertainties are relatively large. A chronology of the Dome Fuji (DF) ice core was constructed by synchronizing variations in O_2/N_2ratio of occluded air with local summer insolation (Kawamura et al., 2007), but relatively large errors were later reported around the last interglacial (Fujita et al., 2015). Here, we reanalyzed the O_2/N_2ratio of the DF core by improving the methods for sample treatment, air extraction and mass spectrometry between 57 and 165 kyr BP to revise the DF chronology. The new chronology agrees within 1.2 kyr with a radiometric (U-Th) chronology of Chinese speleothems, the whose stated error is less than 1 kyr (Cheng et al., 2009), suggesting successful improvement of our ice-core chronology. Using $\delta^{18}O$ of atmospheric O_2($\delta^{18}O_{atm}$) and CH_4records measured on the same ice samples as used for the O_2/N_2measurements, we investigate climatic variations during the penultimate glacial period and deglaciation. We found that $\delta^{18}O_{atm}$ becomes heavier while CH_4concentration increased at 138.4 kyr BP during the penultimate glacial maximum; this characteristic relationship was observed at Heinrich Event 2 (at ˜24 kyr BP) during the last glacial maximum (Severinghaus et al., 2009; Rhodes et al., 2015). Other well-dated paleoclimatic records show major climatic changes around 138 kyr BP; an abrupt weakening of the Asian monsoon occurred at 138 kyr BP (Wang et al., 2008), and the onset of relative sea level rise was suggested at 139±1 kyr BP from seawater $\delta^{18}O$ of Red Sea (Grant et al., 2012) and at 137 kyr BP from U-Th dating of Tahiti fossil corals (Thomas et al., 2009). The similarity of these ages suggests that a massive iceberg discharge event occurred at ˜138 kyr BP, and it marked the onset of penultimate deglaciation. Our new data may provide better chronological constraints on the climatic forcings and responses around the penultimate deglaciation and last interglacial period.

References

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