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LGM accumulation-temperature relationship from air bubble studies in EPICA DC, Vostok and Dome Fuji ice cores

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The reconstruction of past accumulation rates in the low-accumulation area of East Antarctica plateau relies largely on the assumed inversion temperature – accumulation relationship. According to conventional practice, the temperature history is deduced from the ice core isotope profiles calibrated with a present-day spatial isotope/temperature slope. This approach however may lead to an underestimate (up to 30%) of the amplitude of corresponding temperature changes in the past (Jouzel et al., 2003). Using other independent sources of paleoclimatic information such as physical properties of ice cores could help to reduce the uncertainties of local climate reconstruction and associated uncertainties in ice and gas age dating.

It has been shown that the size and abundance of air bubbles in polar ice at the end of bubble disintegration are primarily controlled by the temperature and accumulation rate prevailing during the time of snow-to-ice transformation (Lipenkov et al, 2000). Under present-day (Holocene) conditions, the number of bubbles in ice varies from 250 g^{-1} (at sites with relatively low accumulation rate and high temperature, e.g., Byrd Station) to 650 g^{-1} (at sites with high accumulation rate and low temperature, e.g., Komsomolskaya). The standard deviation between modelled bubble number concentrations and experimental data from 16 Antarctic and Greenland ice cores is less than ± 50 g^{-1}.

The bubble concentrations in LGM ice have been measured in three East-Antarctic ice cores retrieved at EPICA DC, Vostok and Dome Fuji drilling sites. It has been found that the bubble number increases by a factor of 1.3-1.7 between Holocene and

LGM ice strata thus reflecting temperature and accumulation changes associated with last glacial termination. Using the bubble model, we have constructed accumulation-temperature relationships (curves) that correspond to the bubble concentrations measured in the LGM ice and compared these curves with the LGM temperatures and accumulation rates deduced from available isotope and borehole temperature data. Although none of existing climate reconstructions fully coincides with the bubble-related accumulation-temperature curves, the latter appear to be more consistent with the LGM climate properties inferred from borehole-temperature analysis than with those reconstructed using the conventional approach to interpret isotope profiles. Judging from our study, the air-bubble records obtained in East Antarctica provide independent constraint on past climate change which might become particular useful when being incorporated into the isotope-borehole temperature calibration procedure based on heat- and ice-flow modeling.