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# A new micro sublimation technique for high-precision $\delta^{13}CO_2$ analysis of ice cores: instrumental set-up and first results

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The challenge to quantitatively explain the observed glacial/interglacial variations in atmospheric $pCO_2$ of about 100 ppmv is a task of outstanding importance for the paleo climate community. Although $pCO_2$ data will be shortly available over the last 650,000 years from the new EPICA Dome C ice core, isotopic information, which strongly constrains potential fluxes between carbon reservoirs and the atmosphere, is still sparse and restricted to the last approximate 40 ka due to methodological constraints.

Up to now the quantitative extraction of $CO_2$ from ice cores to measure its isotopic composition was restricted to the uppermost part where air still occurs in bubbles. Below the clathrate formation depth at about 700 m extraction efficiencies gradually decrease with unknown effects on gas- and isotopic composition. With our new method we are able to extract the air constituents quantitatively for both bubble and clathrate ice.

Since gas extraction from the ice is by far more time consuming than the actual measurement in the IRMS, the system was split up into a “sample preparation” and the “measurement device”. This allows us to measure several gas samples within a short time span and, thus, to take benefit of identical measurement conditions at the IRMS for a set of samples. This is crucial as changes in the performance of the IRMS are a well known problem. The “sample preparation” is based on a sublimation technique which is currently designed for ice samples from 5 to 30 g. Within a glass vacuum chamber the ice is sublimated by illuminating it with infrared light and the released air dried and $CO_2$ separated from $N_2$, $O_2$ and Ar. The pure $CO_2$ and $N_2O$ gas is frozen

in a small glass capillary, which is flame sealed. In this capillary the gas sample can be stored for measurement in the IRMS line. To calibrate and determine the performance of the system a continuous reference inlet with viscous flow conditions was designed. It allows us to mimic the continuous gas release of a sample during sublimation as good as possible. The "measurement device" is a continuous He flow system ultimately leading to the IRMS detector. Here $CO_2$is released from the glass capillary by breaking it in a flow-through, small volume cracker. After cryofocussing the peak $CO_2$ is separated from $N_2O$ and contaminations like drilling fluid and other organics deteriorating the high precision measurement of $\delta^{13}$C on $CO_2$. To check the performance of this device and monitor the linearity and temporal stability of the IRMS, $CO_2$ pulses can be admitted onto the cracker. The identical treatment of sample and standard gas during the entire process principally allows us to measure $\delta^{13}$C on ice with a precision of $<$0.05 permil.

First ice core measurements have been performed with this new extraction and IRMS setup and reveal $\delta^{13}$C heterogeneity at a cm scale in Antarctic ice as previously reported in measurements using the dry extraction technique. First measurements of deep ice from the clathrate zone - which has been not accessible until now - are shown and discussed.