Geophysical Research Abstracts,
Vol. 10, EGU2008-A-03766, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-03766
EGU General Assembly 2008

Radiocarbon dating of glacier ice on a microgram level – examples from the Alps and the Andes

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Appropriate and precise age-depth models are essential for palaeo-environmental studies. However, often there is a lack of sufficient dating options in ice core archives especially close to bedrock. To overcome this problem a method has been developed using the insoluble organic carbon (OC) fraction of aerosols incorporated in past precipitation to determine ^{14}C concentrations in samples at a microgram level.

Detailed procedures on sample decontamination and preparation, separation of the OC fraction and AMS ^{14}C determination on solid graphite and gaseous CO_2 samples using the MICADAS system are shown. Overall blank values for the decontamination, filtration and combustion steps are 1.55 ± 0.74 μg for the carbon mass (m_c) and 0.62 ± 0.10 for the fraction of modern carbon (f_M). Measurements of different reference materials assure the high quality of the AMS based ^{14}C determination.

Until now samples from the following two ice cores have been analyzed: Colle

Gnifetti, 4450 m a.s.l., Swiss Alps, 82 m depth, drilled 2003 and Illimani, 6300 m a.s.l., Andes, 125 m depth, drilled 1999.

Sample sizes reach from 0.3 m up to 1.3 m in length, with an according mass range of 263 g up to 1055 g after decontamination processes. OC concentrations vary between 17 μg/kg (Colle Gnifetti) and 242 μg/kg (Illimani) giving concentrations of 8-90 μg C in the finally measured CO_2 samples. All conventional ^{14}C ages were calibrated using OxCal v3.10 software with the IntCal04 calibration curve.

At Colle Gnifetti the ages of nine samples are continuously increasing with depth and indicating the presence of more than 10,000 year old ice near bedrock. Fitting a simple two parameter flow model through well known reference horizons in the upper part and the ^{14}C dating points in the lower part gives a continuous depth-age model for the Holocene period.

In the Illimani samples an increase in age with depth was also observed. The ages of the lowermost three samples are however equal within their uncertainty, indicating the possibility that ice may be frozen to bedrock 11,000 years ago. Wiggle matching with independently dated ice from a parallel core corroborates the accuracy of our ^{14}C-based dating.