Geophysical Research Abstracts,
Vol. 11, EGU2009-9352, 2009
EGU General Assembly 2009

Mineral composition of TALDICE aeolian ice core dust by means of synchrotron radiation XAS and XRF techniques

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In this work we present the first accurate non-destructive comparison of the mineral composition of atmospheric dusts contained in a deep ice core from Antarctica using synchrotron radiation. Different mineral assemblages reaching glaciated areas could be correlated to sources areas starting from the knowledge of the dust composition. In this investigation we demonstrate the possibility to characterize with SR the mineral composition of the dust in order to perform its geochemical characterization and to understand the pattern of the transport and the trajectories of the aerosol.

This study has been focused on the elemental characterization and the identification of the iron oxidation state of aeolian Antarctic dust by means of synchrotron radiation X-Ray Fluorescence and X-Ray Absorption Spectroscopy. A set of twelve ice samples from the TALDICE (TD, 72˚46'S, 159˚04'E, 2316 m a.s.l., mean accumulation rate 80 kg*m^{-2}*yr^{-1}) ice core, corresponding to the warm climatic period, Holocene, and to the cold climatic period, Marine Isotopic Stage 3 (MIS 3) have been measured.

To obtain both the elemental composition and the iron oxidation state of the mineral dust we performed experiments on specially prepared samples at the Stanford Synchrotron Radiation Lightsource (SSRL) laboratory in the framework of the Proposal N.3082B. Actually, melted ice samples were filtered and then mineral particles were deposited onto Nuclepore polycarbonate membranes in a 1000 class clean room under a 100 class laminar flow bench for both XRF and XAS experiments. A dedicated HV experimental chamber, that allows performing different type of experimental technique on very low absorber concentration samples was developed and tested in Italy. The original experimental setup, including an in-vacuum sample micromanipulator and a special alignment and docking sample system was installed at the beamline 10-2 at SSRL. For the x-ray detection a 7 mm^2 high sensitive Silicon Drift Detector was available inside the HV chamber. XRF experiments allowed the detection of Na, Mg, Al, Si, S, Cl, K, Ca, Ti, Cr and Fe elements. Differences in Ca and K concentration between Holocene and MIS3 ice dust were clearly detected and measured with high accuracy.

From the XANES analysis of mineral particles we recognised the presence of iron in an octahedral coordination state and a shift of the Fe absorption edge towards low energies, a behaviour characteristic of the reduction of the Fe^{2+}concentration from MIS 3 to Holocene ice samples. Combined XRF and XANES results clearly identify differences in the mineral composition between Glacial and Interglacial periods, we associated to different contributions from the Potential dust Source Areas (PSAs) of the Southern Hemisphere. Although limited, data demonstrate that with this fully non-destructive technique, new information about the dust mineralogy at very low concentration and transport mechanism of aerosols can be performed using an intense synchrotron radiation X-ray source.