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Atmospheric depositions of black carbon, inorganic pollutants and mineral dust from the Ortles, Eastern European Alps ice cores during the last 3000 years

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Reconstructions of the atmospheric content of black carbon, heavy metals and mineral dust covering millennial time scales are rare, particularly in the European region. Evaluating the human impact on the environment through mining and industrial activities, road traffic, biomass and coal burning, and the naturally emitted aerosols atmospheric load, is important to know the degree of contaminations and the quality of melting water, the radiative effect on the glacier's radiative balance, the atmospheric aerosols' climatic impacts and the recent decades pollutions emissions policies' efficiencies.

Four ice cores were drilled in 2011 from the "Alto dell'Ortles" (3859 m), the highest glacier of the Mt. Ortles massif (South Tirol, Italy). Three 74 m long ice cores were dated by mean of 210Pb, tritium, beta emissions and 14C analyses following also the new dating technique based on filtering the ice for extracting the carbonaceous component of the deposited aerosols. The depth-age curve was obtained by using a Monte Carlo based empirical fitting model (COPRA). The basal ice of core#2 and #3 was dated back to about 7000 years b.p., whereas that of core#1, about one meter shorter, to 3000 years before present.

Below the firn-ice transition, at a depth of about 24 m, the borehole temperature revealed the presence of well-preserved cold ice (Gabrielli et al, 2012). The O and H stable isotopes profiles describe well the atmospheric warming as well as the low temperatures recorded during the Little Ice Age (LIA).

The proximity of the "Alto dell'Ortles" to densely industrialized areas (Po Valley) makes these ice cores specifically suited for reconstructing the anthropogenic impacts in the Eastern European Alpine region over the last 3 millennia.

The ice core#1 was analyzed with a "Continuous Flow Analysis" system (CFA). The separation between internal and external parts of the core prevents any kind of contamination. The core was melted at about 2.5 cm min-1 and simultaneous analyses of conductivity, dust concentration and size distribution (from 0.8 to 80 μm), trace elements with Inductive Coupled Plasma Mass Spectrometer (ICP-MS, Agilent 7500) and refractory black carbon (rBC) with the Single Particle Soot Photometer (SP2, Droplet Measurement Technologies) were performed. A fraction of the melt water was collected by an auto-sampler. More than 1000 samples were analyzed discreetly with a CRC-ICP-MS (with the highest resolution of about 3 cm).

The rBC shows significant variability over the last century peaking in concentrations of about 10 ng g-1 from the 1920s to the 1970s, whereas very low values characterized the period from 1000 BC to 1850 AD. The seasonality appears to be preserved even in the firn temperate part of the core as argued from the comparison with the water stable isotopes ratios (δO18).

The overall determined trace elements are Li, Na, Mg, Al, K, Ca, Ti, V, Cr, Mn, Fe, Co, Cu, Zn, As, Se, Sr, Ag, Cd, Sb, Te, I, Cs, Ba, Hg, Tl, Pb, Bi, U. The Enrichment Factors (EF) for the crustal elements didn't show any particular trend. While mining and smelting activities appeared to be the most significant heavy metals sources before the 19th century, other anthropogenic heavy metals strongly increased from the onset of the Industrial Revolutions.