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Organic molecules in the polar ice: from chemical analysis to environmental proxies

Carlo Barbante (1,2), Piero Zennaro (1), Chiara Giorio (3), Natalie Kehrwald (2,1), Alisa K. Benton (4), Eric W. Wolff (5), Markus Kalberer (3), Torben Kirchgeorg (2,6), Roberta Zangrando (1), Elena Barbaro (1), Andrea Gambaro (2,1)

(1) Institute for the Dynamics of Environmental Processes, CNR, Venice, 30123, Italy, (2) University of Venice, Department Environmental Sciences, Informatics and Statistics, Venice, 30123, Italy, (3) Centre for Atmospheric Science, Department of Chemistry, University of Cambridge, Cambridge CB2 1EW, United Kingdom , (4) British Antarctic Survey, Cambridge, CB3 0ET, United Kingdom, (5) Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, United Kingdom, (6) Institute of Sustainable and Environmental Chemistry, Leuphana University of Lüneburg, Lüneburg, 21335, Germany

The molecular and isotopic compositions of organic matter buried in ice contains information that helps reconstruct past environmental conditions, evaluate histories of climate change, and assess impacts of humans on ecosystems. In recent years novel analytical techniques were developed to quantify molecular compounds in ice cores. As an example, biomass burning markers, including monosaccharide anhydrides, lightweight carboxylic acids, lignin and resin pyrolysis products, black carbon, and charcoal records help in reconstructing past fire activity across seasonal to millennial time scales. Terrestrial biomarkers, such as plant waxes (e.g. long-chain n-alkanes) are also a promising paleo vegetation proxy in ice core studies. Polycyclic aromatic hydrocarbons are ubiquitous pollutants recently detected in ice cores. These hydrocarbons primarily originate from incomplete combustion of organic matter and fossil fuels (e.g. diesel engines, domestic heating, industrial combustion) and therefore can be tracers of past combustion activities. In order to be suitable for paloeclimate purposes, organic molecular markers detected in ice cores should include the following important features. Markers have to be stable under oxidizing atmospheric conditions, and ideally should not react with hydroxyl radicals, during their transport to polar regions. Organic markers must be released in large amounts in order to be detected at remote distances from the sources. Proxies must be specific, in order to differentiate them from other markers with multiple sources. The extraction of glaciochemical information from ice cores is challenging due to the low concentrations of some impurities, thereby demanding rigorous control of external contamination sources and sensitive analytical techniques. Here, we review the analysis and use of organic molecules in ice as proxies of important environmental and climatic processes.