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Initiating CO_2 and ion measurements from ice cores (Hans Oeschger Medal Lecture)

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One of my first tasks when joining the group of polar glaciology at LGGE Grenoble in 1971, was to develop the chemical analysis of ice cores. In the 1970s, the acid rain issue was more popular than climate change. I suggested to analyse ice cores to document the natural level of atmospheric acidity, both in very remote locations and in pre-industrial conditions (deep ice cores). Very sensitive new analytical methods were developed in order to accurately determine the acidity and the sulphate content of melted polar ice at μEq/L concentration levels. These chemistry experiments resulted in a major observation: when no strict precautions are taken in the preparation of ice samples, a slight alkalinity can be observed due to a contamination by carbonate dust.

At the same time, glaciologists were trying to improve the quality of their measurements of CO_2 concentrations in the air extracted from melted ice. The aim was to document past CO_2 levels but observed concentrations were always markedly higher than expected. I then suspected that excess CO_2 could originate from the liquid phase and decided to crush the ice at very low temperature (-20°C) in order to recover only the gas contained in the bubbles. Doing this on ice samples from different time periods, it was clearly shown that ice-age ice has a markedly lower CO_2 content than recent ice (1980). These experiments opened the way to all future studies on reliable CO_2 data from polar ice cores, in particular the Vostok profiles later obtained by LGGE colleagues.

Thereafter, I moved to glaciochemistry, using ion chromatography measurements of several major ions such as NO_3, Cl, Na, Ca, Mg, etc. all ions which were necessary to establish an ion balanced budget of ice. It was shown that central Antarctic ice contains mainly, in addition to entrapped air bubbles, secondary aerosol (essentially sulphuric acid), sea salt aerosol in an amount which depends on the distance from the sea and two gaseous acid species HCl and HNO_3.

The atmospheric sulphur cycle is of particular importance for climate and aerosol science: in Antarctic ice cores, we investigated past volcanic activity (by using sulfate and acidity measurements) and marine biogenic sulphur through sulphate and methanesulphonate measurements.

Our glaciochemical research was linked to atmospheric chemistry activities. The IGAC (International Global Atmospheric Chemistry) community of IGBP played an indirect role in initiating new research in polar regions, in particular in Greenland. The Eurocore operation in Central Greenland (1989) was initially supported by the European Commission to document the human impact on the remote Northern Hemisphere. In order to validate ice core records, the atmospheric chemists of IGAC recommended the study of the so-called "transfer function", i.e. the transfer mechanism of atmospheric impurities to ice. The topic was investigated both in Antarctica and Greenland. By documenting past aerosol composition, the chemical analyses carried out on ice cores provide crucial data for modelling climates of the past and understanding the global atmospheric system. These analyses complement water stable isotopes and greenhouse gas measurements.