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VOSTOK, ANTARCTICA, ICE CORE: THE DUST RECORD OVER THE LAST CLIMATIC CYCLE (~160 ka)

(Abstract)

by

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ABSTRACT

The 2083 m Vostok Antarctic ice core provides a unique opportunity for access to many paleoclimatic and paleo-environmental proxy data. This core, which has been dated by using a glaciological model, fully covers the last glacial–interglacial cycle, and goes back to the ice age which preceded the last interglacial (~160 ka B.P.).

A continuous deuterium record is now available and we have interpreted it in terms of local temperature changes. This record is dominated by the large 100 ka glacial–interglacial oscillation, with a maximum temperature amplitude of about 11 °C; the long Last Glacial period is very well documented and it is confirmed that the warmest part of the Last Interglacial period was about 2 °C warmer than the Holocene. Comparison with the ice-volume marine record shows that the Vostok climate record is of relatively large geographical significance, which makes it possible to establish, over the last 160 ka, the link between worldwide climatic changes and the Vostok dust record that we present here.

This dust content corresponds to the non-soluble microparticles. It was obtained on a discontinuous basis (1 sample = about ~10 m). Due to the very low concentration of some samples (down to 20×10^{-9} g g^{-1}) and cracks in the ice from the first 1000 m depth, we used stringent decontamination procedures. Size distribution and total concentration were measured, using a Coulter counter and an optical microscope; the results were tested against chemical measurements (aluminium concentration). In previous studies, it has been shown that the main proportion of insoluble microparticles is of terrigenous origin and represents the small-sized (radius <2 μm) dust produced on the continents.

The Vostok record displays an increase in dust concentration of up to 20 times during the coldest climatic periods, coupled with the presence of larger particles. It confirms, on a much longer time-scale, a characteristic previously noted in Antarctic and Greenland ice cores over the Last Glacial Maximum. This large increase is attributed to a greater areal extent of global tropical aridity during the cold periods, coupled with higher efficiency of atmospheric circulation in respect of dust production and transport. Beyond this, the relationship between the dust input and the successive stages during the Last Glacial is now very well documented and will be discussed with a view to correlating the Vostok climatic record with other marine and terrestrial paleodata.

A HIGH-RESOLUTION ANION PROFILE OF AN ICE CORE FROM DOLLEMAN ISLAND, ANTARCTIC PENINSULA

(Abstract)

by

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ABSTRACT

In January 1986, a 133 m ice core, with an estimated age at the bottom of 300–350 years, was collected (using an electromechanical drill) on Dolleman Island (70 °35.2′ S, 60 °55.5′ W; 398 m a.s.l.; 10 m temperature −16.75 °C). The site lies on the east coast of the Antarctic Peninsula and has a continental-type climate dominated by perennial sea ice in the Weddell Sea. The core is being analysed for a range of chemical impurities, in order to assess their potential as indicators of past climate.

High-resolution (10–15 samples a^{-1}) continuous profiles of the anionic species Cl^-, NO_3^- and SO_4^{2-}, together with the cation Na^+, have been measured on a section of the core from 26 to 71 m depth. The core has previously been dated between 0 and 32 m depth using the $\delta^{18}O$ profile (Peel and others 1988). Lack of $\delta^{18}O$ data for the section 32–71 m forced us to seek an alternative method of dating.

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Biogenic outgassing of sulphurous gases from the ocean and subsequent photochemical oxidation contribute an excess of sulphate over that derived from the marine aerosol. We show that excess sulphate, calculated as

$$[SO_4^{2-}]_{excess} = [SO_4^{2-}]_{total} - 0.12\,[Na^+]$$

(concentrations in Eq. l^{-1} and assuming that all measured Na^+ is derived from sea salt), is highly seasonal in character, and annual horizons are well preserved over the whole of the core. This enabled us to determine the chronology to 71 m depth, and date the bottom of this section as 1844 ± 5 years.

Cl^- is derived mainly from sea salt. Its profile in the core is also seasonal in character, with peaks that tend to occur in late summer, reflecting the period of minimum sea-ice extent in the Weddell Sea, and therefore maximum source area for the uptake of sea salt. From instrumental meteorological records, Limbert (1974) showed that there were three extended periods of warm or cold weather in the Antarctic Peninsula between 1903 and 1944. During the two 4 year cold periods, when the summer break-up of sea ice in the Weddell Sea is likely to have been reduced, we found that the annual flux of Cl^- to the Dolleman Island snow-pack was lower than the average. Conversely, the 3 year warm period showed a peak in the values of annual flux of Cl^-. We therefore propose that Cl^- can be used as a palaeoclimatic indicator for sea-ice extent.

Extending our chloride data into the latter half of the nineteenth century (before the earliest continuous instrumental records for the Antarctic), we found three distinct peaks in the values of annual flux of Cl^-. We suggest that the period 1850–60 was marked by a decrease in Weddell Sea ice extent (due perhaps to a warm period), followed by an extended period of increased sea ice. There were then two periods of much-reduced sea ice during (approximately) 1885–1890 and 1895–1900, with an intervening period of greatly increased ice coverage. These events are in good agreement with the warm and cold periods which Aristarain and others (1986) identified in the deuterium profile from James Ross Island.

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ANTARCTIC ICEBERGS – PRODUCTION, DISTRIBUTION AND DISINTEGRATION (Abstract)

by

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ABSTRACT

A programme of systematic iceberg observations was initiated in 1981 by Norsk Polarinstitutt through the SCAR Working Group on Glaciology. Icebergs are recorded every 6 h and in five length groups: 10–50, 50–200, 200–500 and 500–1000 m, and those over 1000 m, which are described individually. Data on more than 100 000 icebergs are now on file at Norsk Polarinstitutt, and practically all ships travelling to and from Antarctica participate in the collection of data.

This paper presents the first comprehensive analysis of the iceberg data. The quality of the data set is discussed, with consideration of potential errors in and limitations of the data, and various statistical evaluations. Representative distribution data are presented, and used to determine iceberg production, disintegration and mean residence times, and regional and total Antarctic calving rates.

The incidence of large-scale calving in particular is evaluated, including the remarkably large break-offs in recent years. These exceed both the total annual accumulation on the Antarctic continent and the mean annual calving rate as determined from ship observations.

The results show further: (1) that there are more than 200 000 icebergs south of the Antarctic Convergence, (2) that there are large regional differences in iceberg calving rates and iceberg sizes, and (3) that the calving rate from Antarctica is higher than that given in most previous estimates, which implies (4) that the mass balance of the Antarctic ice sheet is not positive as suggested by most recent estimates.

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