

EVIDENCE OF ENVIRONMENTAL CHANGE SINCE THE LAST GLACIAL MAXIMUM INFERRED FROM CHEMICAL ANALYSIS OF AN ICE CORE FROM LAW DOME, ANTARCTICA

(Abstract)

by

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An ice core, drilled near the margin of the Law Dome ice cap at Cape Folger, has been analysed for trace chemical content. The concentration of the major anions and cations has been measured on samples selected from the ice core to give information on the major environmental changes which have occurred in the period 6–26 ka B.P. The chemical species can be divided into two fractions representing the two major sources of trace chemicals; marine and continental sources. Four species are chosen to illustrate the main features in the record; aluminium as an indicator of the continental fraction, sodium and magnesium as indicators of the marine fraction and methane sulphonic acid (MSA). Sodium and magnesium concentrations in the Law Dome core are predominantly derived from marine sources, although they usually include also small contributions from the continental sources. MSA has a marine biogenic source and exhibits a pattern which is generally unrelated to the variations in the two main fractions. Measured oxygen isotope ratios provide an additional data source. Concentrations of the same species in the Dome C core (De Angelis and others, 1982; Saigne and Legrand, 1987) are used as indicators of the global background atmospheric chemical content, and by inter-comparison of the records from the two cores are used to derive a proxy chronology for the Law Dome core.

The interval in each core corresponding to the final stages of the Last Glacial Maximum (LGM) can be identified from the oxygen isotope records (Budd and Morgan, 1977; Lorius and others, 1984). Both cores have high aluminium concentrations in this interval reducing to very low concentrations towards the end of the transition to the Holocene. A similar sharp change from high to very low concentration is also observed for MSA. Very low concentrations of other species are also observed in this interval in the transition period. By assuming that these changes in the two cores are contemporaneous, the age scale from the Dome C core (Lorius and others, 1984) can be applied to the Law Dome core. An age of 13 ka B.P. is assigned to the very clean interval near the end of the transition. Other, less obvious, events in the chemical and isotope records distinguish intervals corresponding to ages of approximately 7.5, 15.5, and 26 ka B.P. Ages for intermediate intervals are derived by interpolation and reference to a modelled age-depth relation.

The records from each of the cores for MSA and the continental fraction, represented by aluminium, show similar features at the Law Dome site as at Dome C. But the records for the marine fraction show distinct differences. On Law Dome there is a clear trend of decreasing concen-

tration with depth, consistent with the ice at greater depth having an origin at higher elevation further inland on the ice cap. Very low concentrations occur in the lower part of the core, which includes the interval corresponding to the LGM. By way of contrast, at Dome C the concentration of sodium in the interval corresponding to the Holocene is low, but relatively higher in the LGM interval. The concentrations during the LGM, of both the marine and continental fractions, are lower in Law Dome by a factor generally between 1 and 2 than those at Dome C as a result of dilution caused by the higher precipitation and snow accumulation rates near the coast.

For interpretation of the records, the concentrations in the Dome C core are assumed to indicate changes in the global background atmospheric loading and atmospheric circulation. On Law Dome, the general trend of decreasing concentration with depth for the marine fraction is modulated by variations in the background atmospheric loading, and the effect of variations in past ice sheet and sea ice extent and thus distance to the source. At about 11 ka B.P., sodium and magnesium concentrations increase sharply to about three times the background level, and are maintained till about 9.5 ka B.P. This event is not apparent in the Dome C record. During the period 6–8 ka B.P., sodium and magnesium concentrations are higher by a factor between 1.5 and 2 in conjunction with colder (more negative) values of the oxygen isotope ratio. There is some evidence of similar variations in the Dome C record.

This suggests two separate scenarios. For the period 9.5–11 ka B.P., one or more of the following events probably occurred: a change in the seasonal pattern of variation in sea ice extent and distribution; lesser sea ice extent; more open water closer to the coast; increased storminess in the coastal region, each of which could lead to an increased supply of material with marine source (sodium and magnesium) by either more vigorous atmospheric circulation or less distance to the source. Coincidentally, increased storminess is consistent with an increased fraction of open water in the sea ice zone. But there is apparently no change in the concentration of MSA above background levels during this period. This could provide a constraint on the possible mechanisms causing the observed event. For the more recent period, 6–8 ka B.P., the changes found in both cores probably reflect climatic variation on a broader hemispheric or global scale, involving lower temperatures in at least the high latitudes, probably increased zonal atmospheric circulation, and perhaps changes in the seasonal sea ice distribution and total extent.