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Using an Ice Core to Characterize the Climatic History of Antarctica

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Table 1. Radium-226, thorium-230, and uranium-234 activity excesses in the Cul de Sac ice samples[a]

Dust (grams) / Ice (kilograms)	Radium-226–uranium-238 (indecays per minute per kilogram)	Thorium-230–uranium-238 (indecays per minute per kilogram)	Uranium-234–uranium-238 (indecays per minute per kilogram)	Radium-236 excess / Thorium-230 excess	Radium-226 excess / Uranium-234 excess
0.30	0.192±0.008	0.134±0.020	0.056±0.004	1.43±0.22	3.42±0.28
0.15	0.100±0.008	0.071±0.007	0.036±0.004	1.41±0.18	2.78±0.39

[a] The errors are one standard deviation.

Table 2. Calculated activity ratios[a] versus age

Age (in years)	Radium-226 activity / Uranium-234 activity	Radium-226 activity / Thorium-230 activity
0	147.4	44.4
50,000	9.5	3.10
100,000	5.5	2.04
150,000	4.4	1.70
200,000	3.5	1.53
250,000	3.0	1.42
300,000	2.7	1.35
350,000	2.5	1.28

[a] Inside the shards, uranium and its daughters are assumed to be initially in equilibrium.

Fireman, E.L., and T.L. Norris. 1982-a. Ages and composition of gas trapped in Allan Hills and Byrd core ice. *Earth and Planetary Science Letters*, 60, 339 – 350.

Fireman, E.L., and T.L. Norris. 1982-b. Preliminary studies on dating polar ice by ^{14}C and ^{222}Rn, nuclear and chemical dating techniques. *American Chemical Society Symposium Series*, 176, 319 – 329.

Nishiizumi, K., J.R. Arnold, D. Elmore, X. Ma, D. Newman, and H.E. Gove. 1983. ^{36}Cl and ^{53}Mn in Antarctic meteorites and ^{10}Be-^{36}Cl dating of Antarctic ice. *Earth and Planetary Science Letters*, 62, 407 – 417.

Nishiizumi, K., M.T. Murrell, J.R. Arnold, D. Elmore, R.D. Ferraro, H.E. Gove, and R.C. Finkel. 1981. Cosmic-ray produced ^{36}Cl and ^{53}Mn in Allan Hills-77 meteorites. *Earth and Planetary Science Letters*, 52, 31 – 38.

Whillans, I.M., and W.A. Cassidy. 1983. Catch a falling star: Meteorites and old ice. *Science*, 222, 55 – 57.

Using an ice core to characterize the climatic history of Antarctica

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Between 20 November and 14 December 1984, a remote tent camp was operated in the Dominion Range (center point, 85°15'S 166°10'E) on an ice-covered massif located at the confluence of the heads of the Beardmore and Mill Glaciers in the Transantarctic Mountains. The camp was occupied by four members of the Glacier Research Group (University of New Hampshire) and three members of the Polar Ice Coring Office (PICO) (University of Nebraska). The main task at the site was to retrieve an ice core from which chemical and physical time-series will be made available to help in assessing: (1) current stability of the east antarctic ice sheet, (2) current models concerning the recent glacial history of the Transantarctic Mountains, (3) the presence of relatively high frequency (10° per 100 years) climatic signals, and (4) the possible relationships between volcanic and/or solar activities and climatic change.

Early days in the field were devoted to establishing an optimum site for the proposed 200-meter core (the final outcome was a 201-meter core). Maps, visual observations of ice surface topography, and the presence of bedrock ridges all validated initial estimates that Dominion Range ice cover is, in fact, separate from plateau ice and hence is a catchment for local precipitation. Exposed bedrock ridges flanking the Dominion Range are cavernously weathered suggesting that plateau ice has not flowed into the Dominion Range for probably thousands of years. Using an estimated mass balance for the area of 15 to 20 centimeters of snow per year, based on snow stratigraphy, the full record represented by the 201-meter core, unless remnant ice is present, ought to be representative of local precipitation only. As part of the original site assessment, a radio-echo sounding survey was undertaken to provide a three-dimensional view of the area. Based on this survey and surface topography, the Dominion Range ice mass can be divided into three major drainage basins. Ice thicknesses measured were all less than 400 meters. The readings were calibrated based on previous usage of our radio-echo sounding system as well as interpolation during traverses to bedrock ridges. A coring site was chosen just off the crest of the southwestern basin, approximately 1.7 kilometers up-flowline from the tent camp. The drill site has a relatively simple subglacial topography, is sufficiently far from camp to be free from contamination, and is in an area of relatively minimal wind activity based on an evaluation of sastrugi. Shallow (approximately 1-meter) snowpits were dug at several sites around the drill site, a 6-meter snowpit was dug immediately adjacent to the drill site, and fresh and old surface snow samples were collected throughout the study area. These samples and the core samples will all be analyzed for sulfate, nitrate, chloride, fluoride, sodium, reactive silicate, oxygen isotopes (University of Washington, Stuiver and Grootes), and total-β activity. The snowpits will provide samples necessary for estimating spatial variability applicable to the interpretation of the time-series retrieved from the core and the 6-meter pit samples because the latter are easily collected in large volumes and therefore can be used to calibrate chemical analyses, to replicate studies, and to assess seasonal signals in the chemical species. In addition to collecting samples for various chemical analyses, several other data sets were collected including a temperature profile (provided using a new PICO temperature logging system), density, and stratigraphy.

The field party included P.A. Mayewski (leader), William Berry Lyons, Mark Twickler, and James James of the Glacier Research Group, Bruce Koci and Scott Watson (PICO), and Henri Rufli (Swiss Physical Institute). Our special thanks go to VXE-6. This research was supported by National Science Foundation grant DPP 84-11018.

Composition of ancient atmosphere, based on ice-core analyses

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Air entrapped in bubbles of cold ice has essentially the same composition as the atmosphere at the time of bubble formation. The main purpose of our investigations is to determine the age of the enclosed gas and to analyze the air extracted from ice samples of different age. Based on such measurements, the history of the atmospheric composition, especially the history of the carbon dioxide and methane concentrations, can be reconstructed.

Field work. During the 1984–1985 austral summer, air samples from different depth layers in the firn at South Pole Station were collected using a new sampling device. Henry Rufli was in Antarctica from 26 November through December 1984. After assisting with the core drilling in the Dominion Range, (Mayewski and Lyons, *Antarctic Journal*, this issue), he collected the samples at South Pole Station from 19 December until 27 December. He was using a bore hole drilled by the Polar Ice Coring Office (PICO) at the University of Nebraska. The age of the collected air samples will be determined by measuring the krypton-85 activity. The radioactive noble gas krypton-85 has been increasing since about 1950 and is, therefore, well suited to date atmospheric air in the range of 0 to 30 years. Using the measured ages as a base, we will determine the mixing ratio of air in the firn. The mixing ratio is needed to be able to improve the estimate of the age difference between ice and enclosed air (Schwander and Stauffer 1984).

Laboratory work. We measured mainly the carbon dioxide and methane concentrations of air extracted from ice samples from an ice core drilled during the 1983–1984 austral summer at Siple Station (Stauffer and Schwander 1984). The time resolution in this core is excellent due to the rather high and regular annual accumulation rate at this station. The ice core from Siple Station is therefore especially well suited to investigate the recent past in detail.

The atmospheric carbon dioxide concentration influences the radiation balance of the Earth's surface. An increase of the concentration leads to a global warming. The atmospheric carbon dioxide concentration increased from 315 parts per million by volume in 1958, when precise and continuous measurements began, to 345 parts per million by volume at present. A detailed knowledge of the carbon dioxide increase since preindustrial times is important to understand the causes of the increase and to determine the sensitivity of climate to the carbon dioxide concentration in the atmosphere. The carbon dioxide measurements on ice samples from Siple Station are plotted in figure 1 and discussed in more detail by Neftel et al. (1985). The results allow us to trace the development of the atmospheric carbon dioxide concentration from a period overlapping direct atmospheric measurements back over the past two centuries. The preindustrial concentration around 1750 was 280 ± 5 parts per million by volume, according to these measurements. The main reason for the increase of atmospheric carbon dioxide is the burning of fossil fuel. The trend of the increase shows, however, that biomass burning was also an important source, especially at the beginning of the increase.