1988

Ice Cores and Global Change

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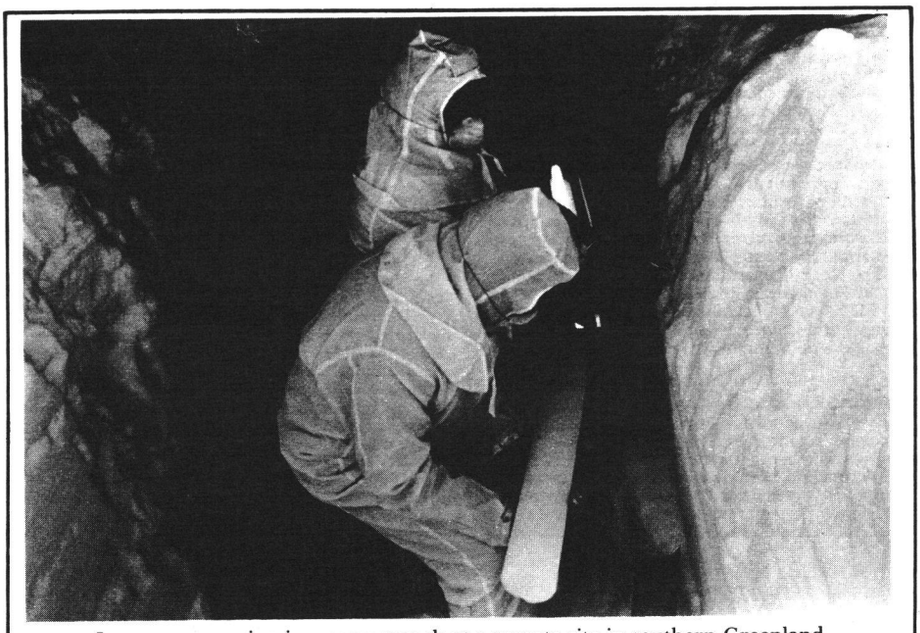

Ice-core processing in a snow trench at a remote site in southern Greenland.

TABLE 1. Ice Core Measurements

Measurements Currently Being Made	
Stable Isotopes	$^{18}O/^{16}O$, D/H, S, Cl, C, N, . . .
Gases	total gas, CO_2, CH_4, N_2O, $\delta^{18}C$ of CO_2, $\delta^{13}C$ of CH_4, $\delta^{18}O$ of O_2, O_2, $\delta^{15}N$ of N_2, N_2, Ar, He, Ne, H_2, . . .
Cosmogenic Isotopes	^{10}Be, ^{14}C, ^{26}Al, ^{36}Cl, ^{81}Kr, . . .
Major Chemistry	$SO_4^=$, Cl^-, NO_3^-, F^-, Na^+, NH_4^+, K^+, Ca^{++}, Mg^{++}, H^+, H_2O_2, . . .
Trace Metals	Ir, Au, Se, Os, K, Rb, Cs, Ca, Sr, Ag, Bi, Cu, In, Pb, Tl, Cd, . . .
Organics	MSA, formate, acetate, . . .
Particulates	concentration, morphology, composition (e.g., major minor, trace elements, organics), . . .
Physical and Mechanical Properties	stratigraphy, texture, fabric, density, bubble characteristics, viscosity, clathrates, surface conductivity, . . .
Borehole Studies	temperature, creep, seismic wave velocity, . . .

TABLE 2. Global Change Components Than Can Be Documented Using Ice Core Records

Component	Documentation
Global Climate	greenhouse gases aerosols atmospheric temperature stratosphere/troposphere exchange air mass sources precipitation patterns
Global Ice	distribution of glaciers, snow, and sea ice ice volume and sea level glacier dynamics and ice properties
Biogeochemical Cycles (C, N, S, etc.)	biogenic gases marine aerosols continental aerosols atmospheric interconversions
Anthropogenically Derived Material	radiatively active gases and aerosols inorganic and organic pollutants
Geologic and Extraterrestiral Activity	volcanic activity geomagnetic field solar activity extraterrestrial fluxes

ter case the requisite large spatial arrays and/or multiple measurements dictate that the measurement methodologies be as low cost as possible. A second topic that recurred in several sessions was aggregated particles and their role in estuaries. Several new measurement tools for investigating macroaggregates "in situ" were described and recent observations using them presented. The conferees also acknowledged the role of theory and models in the interpretation of data, though it was felt that many models are too complex to be widely used. In the general discussion the Uruguayan researchers emphasized the importance of coordinating efforts in studying the Rio de la Plata estuary, one of the widest in the world.

Further exchange of ideas, addresses, and goodwill took place following the formal sessions. Following the last morning session, conferees met for a "good-bye" asado, a memorable Argentine barbecue. Many also availed themselves of a chance to tour the new laboratory rtrbuilding of IADO. The last scheduled activity was a field trip onto the Bahía Blanca estuary on Saturday, in part to observe the large sand wave fields to be found there. On the same trip, participants had an opportunity to tour the *Puerto Deseado*, the largest oceanographic research vessel in Argentina.

One of the most important results of the conference was the numerous contacts between researchers of developed countries and their Latin American counterparts. Immediate collaborative research efforts were arranged for at least four estuaries, and several others are in the discussion stages. There are relatively few scientists in Latin America working in this subject field, and the conference expanded the contact among them. Through the financial support of AGU and the UNESCO Coastal Marine Project, several young Latin American researchers and graduate students were able to attend the meeting. For its promotion of communication with and within the Latin American estuarine research community alone, the conference is regarded as a success.

This report was contributed by Gerardo M. E. Perillo, Instituto Argentino de Oceanografía, Bahía Blanca, Argentina, and J. William Lavelle, NOAA/Pacific Marine Environmental Laboratory, Seattle, Wash.

Ice Cores and Global Change

For scientists interested in global change problems, ice core records provide a unique and invaluable medium for studying the past. These records yield both direct and proxy links to the paleoenvironment over periods potentially as long as hundreds of thousands of years with resolution down to seasonal scale for time-series on the order of hundreds to thousands of years. In addition, the fact that most ice core records are retrieved from locations rarely, if ever, occupied by observers, adds to the value of these data sets.

In response to the growing importance of such records, the National Science Foundation's Division of Polar Programs recently

sponsored the U.S. Ice Core Research Workshop in Durham, N.H. At the workshop, 45 U.S. scientists actively involved in ice core research together formulated a globally based strategy planned through the 1990s that would result in the development of an ice core program integrally tied to global change issues. Representatives from the European ice core research community also attended, to aid in discussions of anticipated joint international efforts.

A prime stimulus for the workshop was the newest planned major U.S. ice core effort, GISP II (Greenland Ice Sheet Project II). A proposal solicitation for this project appeared in the May 24, 1988, *Eos*. GISP II and a corresponding European effort, GRIP (Greenland Icecore Program), plan to retrieve a ~3200-m-deep core which would extend to the base of the central Greenland ice sheet. Both programs are expected to run from 1989 to 1994. Conditions at the proposed drill site are such that seasonal resolution will be possible back to ~10,000 years, and the total record could include the last ~200,000 years. A section of the workshop dealt with detailed discussions of the properties to be measured on the core, drill technology, core processing, and data management.

At the workshop, plans were also drafted for drilling efforts in both West and East Antarctica. Emphasis was given to sites in West Antarctica in light of the extensive programs already undertaken by U.S. glaciologists interested in the dynamics and potential stability of this ice mass. Participants proposed a 1991 start for drilling to the base of the Antarctic ice sheet.

Data comparisons between GISP II and Antarctic deep-drilling programs, as well as deep-sea sediment, lake sediment, and glacial geologic records will be necessary to answer questions dealing with the hemisphere to hemisphere synchroneity of global change events.

Considerable enthusiasm was also expressed for immediately expanding the current array of low- to middle-latitude, high-elevation coring sites. The suitability of sites in Asia, South America, Europe, and North America for the recovery of ice core records has been well documented, but they remain a virtually untapped paleoenvironmental resource. These sites can provide documentation of the remote atmosphere and of major atmospheric circulation phenomena, such as ENSO (El Niño-Southern Oscillation) events, while also completing the global linkage between Antarctic and Arctic ice core records.

Workshop participants detailed the analyses (Table 1) that can be conducted on ice cores, noting the considerable potential for new types of measurements and additional new technologies. The repertoire of measurements has been expanded in the last few years as more geochemists, atmospheric chemists, geophysicists, climatologists, and modelers have become involved in the analysis and interpretation of ice cores. As a result of these new interactions, ice core programs now integrally relate a range of measurements on not only ice cores, but also on the atmosphere, surface snow, and snowpit samples.

The documentation of global change is a major key to understanding the history of and the current changes in the global system. As ice core programs such as GISP II come on-line, they will provide an exciting new look at the past; the global array of ice core retrieval sites proposed at the workshop has the potential to add important details (Table 2) concerning the changes in and characterization of major components in the global system.

This report was contributed by Paul A. Mayewski, director of the Glacier Research Group, Institute for the Study of Earth, Oceans and Space, University of New Hampshire, Durham.