MEETINGS

The Future of Ice Core Science

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Cores drilled through the polar ice sheets provide information about past climate and environmental conditions on timescales from decades to hundreds of millennia, and direct records of changes in the composition of the atmosphere. As such, they are cornerstones of global change research.

In the past 15 years, several major projects have increased our understanding of past climate change on a variety of timescales. These include the Greenland Ice Sheet Project 2 (GISP2), the Greenland Ice Core Project (GRIP), and North GRIP deep ice cores in Greenland. They also include the Taylor Dome, Siple Dome, Law Dome, Vostok, and European Programme for Ice Coring in Antarctica (EPICA) Dome C ice cores in Antarctica, the latter of which has pushed the record for the oldest ice core back to 720,000 years.

Important work on shorter timescales includes the Program for Arctic Regional Climate Assessment (PARCA) and the International Trans-Antarctic Science Expedition (ITASE) in Greenland and Antarctica, respectively, and a variety of other projects at both poles and on tropical and temperate glaciers.

With the completion of these major efforts, the international ice coring community is now planning for the next several decades of ice coring science. Future projects will require drilling in more challenging locations to access ice older than 720,000 years, and drilling in many locations to develop understanding of the spatial variability of climate change. The costs and scope of this future work create the need for coordinated international collaboration. Developing this international collaboration is the charge of International Partnerships in Ice Core Sciences (IPICS), an informal planning group that recently held its second meeting (IPICS2).

The IPICS2 meeting was hosted by the European Polar Consortium (EPC) and received financial support from EPC and the U.S. National Science Foundation's Division of Polar Programs. Representatives from 17 nations (Australia, Belgium, Canada, China, Denmark, France, Germany, Italy, Japan, the Netherlands, New Zealand, South Korea, Russia, Sweden, Switzerland, United Kingdom, and the United States) attended, and participation in IPICS projects is open to interested researchers from other nations.

The first IPICS meeting, held in Sterling, Va., in 2004, was similarly well attended and provided the framework that grew into a four-part plan for future ice coring, discussed at length at IPICS2. This plan, developed around key scientific questions uniquely suited to ice coring, now includes the following:

1. A deep ice core in Antarctica is needed that extends through the mid-Pleistocene transition, a time period in which the Earth's climate shifted from 40,000-year to 100,000-year cycles. This core, with a total record length of at least 1.2 million years, would allow investigation of the role of greenhouse gases in this transition, as well as provide a detailed land-based record of the evolution of temperature and other environmental variables over this time period. Discussion on this project was led by Eric Wolff (British Antarctic Survey, Cambridge, U.K.), Nobuhiko Azuma (Nagaoka University of Technology, Japan), and Jeff Severinghaus (Scripps Institution of Oceanography, La Jolla, Calif.). One outcome of the meeting was the identification of the substantial logistical and survey needs in East Antarctica for site selection and drilling operations. A critical need, identified at the meeting, is the ability to collect several deep ice cores to maximize the chances of obtaining an intact section of the oldest ice. It was agreed that radar survey work for site selection should start as soon as is feasible.

2. A deep ice core in Greenland is needed at a location where an intact record of the last interglacial period can be obtained. Such a record has so far been missing from deep Greenland ice cores, because subglacial conditions at existing drill sites were not appropriate for preserving stratigraphically intact sections this old. This time period is important because the last interglacial period is believed to have been slightly warmer than the present, and it is a possible analog for the near future. Critical questions about the behavior of the Greenland ice sheet in a warmer climate can be addressed if an intact record can be obtained.

Dorthe Dahl Jensen (University of Copenhagen, Denmark) and Jim White (University of Colorado, Boulder) led discussion of this project, which is now moving forward in advanced planning stages with leadership from the University of Copenhagen glaciology group. A site in northwest Greenland has been selected based on radar surveys, and at the meeting, several other groups expressed interest in participating.

3. The past 40,000 years is a period that encompasses the last transition from a glacial to interglacial state as well as earlier large climate oscillations, and therefore samples a wide spectrum of large-scale climate change. A spatial array of ice core records spanning this time period would provide accurate records of these changes and, thus, important targets for comprehensive models of the climate system. Cores in Greenland, Antarctica, and possibly some smaller ice caps in the Arctic are envisioned. Hubertus Fisher (Alfred Wegener Institute, Bremerhaven, Germany) presented the basic concept for this project. Subsequent discussions led by Ed Brook (Oregon State University, Corvallis) and Rob Mulvaney (British Antarctic Survey) focused on logistics needs (lightweight ice core drills, for example) and possible locations for sites in the array.

4. A spatial array of ice core records spanning the last 2000 years is also required. Polar regions, and high-altitude temperate and tropical regions, are underrepresented in analyses of recent climate changes. Understanding climate variability over this time period is critical, however, for evaluating climate change since the Industrial Revolution. This program would involve coring in Antarctica, Greenland, other parts of the Arctic, and high-altitude glaciers and ice caps around the world. Eric Steig (University of Washington, Seattle) presented the concept of this project, and Valerie Masson-Delmotte (Laboratoire des Sciences du Climat et de L'Environnement, IPSL, CEA, Gif-sur-Yvette, France), and Joe McConnell (Desert Research Institute, Reno, Nev.) led a discussion of feasibility and logistics needs.

In addition to these scientific projects, IPICS recognizes that improvements in drilling and logistics are needed, including new drilling technology, drilling fluids, and ice core drills. An expert group on ice drilling technology, led by Joan Fitzpatrick (U.S. Geological Survey, Lakewood, Colo.), has been set up, and representatives of that group discussed new developments in drilling technologies and possible approaches to major challenges.

Key issues at the meeting included replacing commonly used drilling fluid components—such as butyl acetate or various petroleum distillates that have correct physical properties at low temperatures—that are being phased out for environmental reasons, developing a system for replicate coring from the same ice core borehole, and drilling in relatively warm ice near the bed/ice interface, the latter of which has proved difficult in a number of recent projects.

A fluid that will allow drilling in very cold ice in East Antarctica, where the longest ice core records are expected, is a particular need, and potential fluids for this purpose are being examined by drilling engineers. Logistics concerns include problems of aircraft-based access to remote sections of east Antarctica, and the need to develop lightweight drilling equipment and additional overland traverse capabilities for supplying drilling sites.

Major goals of IPICS2 were to establish consensus around the four IPICS projects and develop a steering committee and timeline for future work. With this consensus established, writing teams have finalized 'white paper' documents for each subproject, and will then move on to develop science plans. These white papers and science plans will provide a framework for requesting support for these projects from national and international funding agencies. A steering committee has been formed with representatives from most of the nations involved, and a third meeting is planned to discuss and adopt the science plans. Initial stages of IPICS projects will be under way by then, and the scientific community can look forward to a richer spectrum of ice core data in the future.

The second meeting of the International Partnership in Ice Coring Science was held on 15–18 October 2005 in Brussels, Belgium.

—EDWARD BROOK, Department of Geosciences, Oregon State University, Corvallis, Ore.; E-mail: brooke@geo.oregonstate.edu; ERIC WOLFF, British Antarctic Survey, Cambridge, U.K., E-mail: ewwo@bas.ac.uk