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MEETINGS

Paleoceanography and Paleoclimatology of the Southern Ocean

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Among the greatest successes of the Ocean Drilling Program were the concerted drilling efforts and exciting results recovered from the Southern Ocean (SO) surrounding Antarctica. Scientific drilling in the SO and on the Antarctic margin has recovered material from hundreds of sites for scientific analysis. The dynamic nature of ice sheet development and ice/margin interactions through time has been observed, as has the role that the SO plays in the development and persistence of Antarctic glaciation. The SO has been documented as a sensitive mixing pool of global water masses that is at times a locus of high biological sedimentation. Also, the SO has been found to contain high-resolution records of climate forcing and response, and as such it may hold clues to future climate.

These results from scientific drilling over the past several decades have significantly increased the understanding of Cenozoic to decadal processes affecting oceanography and climatology of the SO and Antarctica. Now, it is important to mine these results from scientific drilling over the past several decades, and also to provide a scientific, framework for future expeditions in this region to solve unanswered questions. What, for example, was the role of iron as a biolimiting nutrient through time? How does sea ice cover relate to ventilation of the SO and thus to gas fluxes of carbon dioxide on glacial timescales? Was Antarctic glaciation related to the opening of ocean gateways, to decreases in atmospheric carbon dioxide, or to some other factor?

To this end, 26 researchers from five countries attended a synthesis workshop on the campus of the University of Colorado, Boulder, in January. The workshop, funded by the U.S. Science Support Program of Joint Oceanographic Institutions, Inc., focused on Southern Ocean paleoceanography and paleoclimatology. It began with plenary overview talks about the critical aspects of SO development, and continued with poster presentations and discussions in breakout groups, by the group as a whole, and over social events.

The underlying themes of the discussions focused on extracting what is and is not known about a number of critical processes, including ice sheet development, tectonics, ecosystem dynamics, biogeochemical responses, and SO thermal structure, on various timescales. After the discussions, what seemed like a good idea before the workshop (i.e., conducting a synthesis workshop on a regional or topical theme) now seems a must-do for a number of fields related to scientific drilling. Although often the push to recover more samples from critical places is what necessarily drives much of the science, workshop attendees agreed that mining the physical and intellectual archive left from decades of scientific drilling results is also an important activity that should be encouraged and funded as a priority mission of the program.

As summarized by the plenary speakers, several decades worth of scientific drilling in the sea and on land have provided many answers and questions. Peter Barker (British Antarctic Survey) presented the Cenozoic context to SO development, with several aspects of Antarctic glaciation that are well-known: (1) Significant glaciation started ~34 Ma, and cooling intensified from 16 to 13 Ma and in the late Pliocene; (2) except for glacial/interglacial changes there has likely been little change over the past 9–10 Myr in Antarctic ice sheet volume; and (3) atmospheric carbon dioxide is not the whole answer to Antarctic glacial history. Several important questions were also presented: (1) How glaciated was Antarctica during the Oligocene, and how deglaciated was it during the early Miocene? (2) What caused end-Oligocene warming and mid-Miocene cooling? (3) How did high-latitude cooling operate before glaciation?

In addition, Barker focused on the development of the Antarctic Circumpolar Current (ACC), noting that: (1) ACC transport occurs in narrow but meandering frontal jets, (2) the ACC may not have caused glaciation, and (3) increased primary production alone is not a safe ACC indicator. Several unanswered questions remain: (1) When did a deep-reaching ACC begin? (2) How did the ACC evolve? (3) What was SO circulation before the ACC?

Carlota Escutia (University of Grenada) focused on geomorphology and ice dynamics in Antarctica, highlighting an Integrated Ocean Drilling Program (IODP) proposal to drill the Antarctic Wilkes Land margin. The Wilkes Land is the only known Antarctic margin where the unconformity separating pre-glacial strata below from glacial strata above in the continental shelf can be traced to the abyssal plain, allowing sequences to be linked. Because strata below and above the "glacial onset" unconformity can be sampled at relatively shallow depths, the record of the onset of glaciation can be obtained from (1) the shelf foreset section, which provides a direct record of occurrence of grounded ice but one that is less continuous and hard to date, and (2) the abyssal plain hemipelagic (distal continental sediment) section, which provides an indirect record of glaciation but one that is more continuous and easier to date.

Kathy Licht (Indiana University–Purdue University Indianapolis) discussed the dynamics of ice-sediment interactions from Antarctica to the SO from the Last Glacial Maximum (LGM) to the present. She reported that LGM conditions in Antarctica are reasonably well constrained—for example, ice sheet extent is well defined in most places and indicates that an equilibrium configuration was not achieved. Deglaciation records to date show that the ice sheet did not retreat until well after 18 ka, and therefore had a complex response to global sea level rise. Additionally, chronological data of the ice marginal positions do not show evidence of catastrophic retreat of the West Antarctic ice sheet in the Ross Sea. Licht noted that several aspects of ice-sediment dynamics are not as well known, most notably the fate of sediment transported to the continental slope and the role of ice shelves; these unknowns reduce the certainty about the relationship between ice margin fluctuations and SO sedimentation.

Bernard Diekmann (Alfred Wegener Institute Potsdam) presented a summary of Pleistocene sedimentation patterns in the SO. During glacial stages, the locus of prominent opal deposition is shifted to the north in response to a wider extension of seasonal sea ice and a displacement of the polar front to the north, but little quantitative data and proxies exist for calculating the spatial and temporal mass budget of opal deposition. Terrigenous (continentally-derived) fluxes are mostly enhanced during glacial stages, particularly in the Atlantic sector of the SO, but little quantitative information is available to assess the individual effects of stronger glacial input, eolian sediment supply from Patagonia, and particle advection in the ocean. The supply of coarse-grained ice-rafted debris (IRD) shows inconsistent spatial and temporal patterns in the SO, because IRD supply is influenced by both terrestrial ice sheet dynamics and the extent of cold surface water masses that control the dispersal and survival of icebergs.

Rainer Gersonde (Alfred Wegener Institute Bremerhaven) presented the Pleistocene variability of the SO surface and implications for climate development, noting that the impact of SO physical oceanography on climate, productivity and carbon export, ocean/atmosphere heat and gas exchange, and albedo is well recognized. Important remaining uncertainties on this topic include the role of iron supply on productivity, albedo feedbacks, and the relationship between ice volume and sea level. In addition, there is a critical need to reconstruct physical environment, have accurate dating, and examine internal versus external forcing. Reliable proxies also need to be developed and/or tested for sea surface temperature, surface water stratification/ventilation, winter and summer sea ice extent, nutrient utilization/productivity, and eolian nutrient import.

Jose Abel Flores (University of Salamanca) examined the paleoecological history of the SO, noting that calcareous and siliceous microfossils are abundant in the sedimentary record in the SO. Analysis of these microfossils, combined with other biochemical and geochemical proxies, offers the possibility to reconstruct past environments. The development of transfer and/or analogue functions in siliceous and calcareous microfossils from present-day assemblages in different regions and environments is one of the most significant and successful advances in recent years. A review of the available data reveals, however, substantial differences between regions: Whereas the Atlantic sector has a robust database and precise patterns for the late Pleistocene, the Pacific sector lacks enough data for similar paleoreconstructions.

Jennifer Latimer (Indiana State University) presented a summary of nutrient dynamics and nutrient limitation in the SO. Nutrient dynamics and biogeochemical cycling in the glacial SO potentially played an important role in the drawdown of atmospheric carbon dioxide. In the modern-day SO, vast areas are limited by the bioavailability of Fe, and it is assumed that Fe limited productivity in the past. However, dust fluxes and estimates of bioavailable Fe remain poorly constrained for the glacial SO. In addition, proxies suggest that north of the Antarctic Polar Front (APF), productivity increased during glacial intervals; however, less is known about regions south of the APF. In addition, high-resolution records of phosphorus burial and phosphorus/titanium ratios across the entire frontal zone suggest that glacial terminations are actually the intervals of highest export production both north and south of the APF.

One immediate outcome of the workshop was the synergy of top researchers enjoying top science in a retreat-type atmosphere, with quite a few "Why don't we know that yet?" moments.

The final outcome of this workshop will be a set of synthesis papers to be published as a special issue in a journal focused on the following broad themes: (1) steps in climate evolution in the Southern Ocean during the Neogene, (2) chronology in the Southern Ocean, (3) development of Antarctic glaciation, Southern Ocean circulation, and productivity during the Cenozoic, (4) comparative integration of Antarctic proximal events with Southern Ocean proxies, and (5) Antarctic margin history. This collection of papers will serve as a science guide for researchers, and will provide a framework for planning future research and scientific drilling expeditions to this beautiful, cold, and critical part of the Earth.

The Paleoceanography and Paleoclimatology of the Southern Ocean: A Synthesis of Three Decades of Scientific Ocean Drilling workshop was held in Boulder, Colorado, 21–23 January 2005.

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NEWS

Consortium Forming to Standardize Oceanographic Instrument Protocols

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The U.S. National Science Foundation's Ocean Observatories Initiative has identified the need for innovations to support straightforward, practical integration and communication with the wide variety of oceanographic instruments on observing platforms and networks, such as the North East Pacific Time-Series Undersea Networked Experiments (NEPTUNE) and the Monterey Accelerated Research Program (MARS).

A discussion group of oceanographic instrument developers, users, and manufacturers formed in March 2005 as a first step toward the creation of a Marine Plug and Work Consortium.

"Plug and work" describes an instrument or device that works immediately when connected to a platform, without the need for installation procedures or reconfigurations. The strategy mirrors "plug and play" computer technologies (for example, the Universal Serial Bus (USB)) that reduce conflicts between a computer and peripheral devices (such as printers, cameras, and scanners) by automatically configuring them when they are connected. Currently, when an oceanographic instrument is connected to a sensor network, the instrument's communications port must be configured, and the software necessary to "drive" or operate the instrument must be installed on the system. If data retrieved from the instrument are to have scientific value, the data must be associated with metadata that provide the context, including the identity of the instrument, its calibration coefficients, and other information.

Smaller platforms such as profiling floats and drifters, particularly those used infrequently or by a single science group, can easily be configured manually before use. However, the installation procedures become more complicated for the operations staff of large-scale facilities responsible for installing a wide variety of instruments for multiple science users. The process also can be time-consuming, error-prone, and potentially dangerous when performed at sea on moorings, remotely operated vehicles, human-occupied vehicles, and cabled observatories.

A plug-and-work strategy minimizes the time, risk, and cost of installing various instruments into observatory systems. The strategy provides the instrument's metadata, drivers, and other information to the observing system when the instrument is plugged in. This allows the instrument to sample and have its data processed automatically. Plug-and-work instruments can be easily added or removed from the system and should be simple and inexpensive to develop, manufacture, and use. Plug-and-work technology should have broad application in the oceanographic community, be suitable for multiple observing system schemes, and not be limited to a particular observatory structure, operating system, or programming language.

The plug-and-work discussion group is focusing on how to standardize marine instrument interfaces and plug-and-work protocols for ocean observatories. The group will solicit input from the Ocean Research Interactive Observatory Network (ORION) and the Alliance for Coastal Technology (ACT). The group will discuss the formation of the marine plug and work consortium, similar to the Universal Bus (USB) Consortium, with representatives of oceanographic instrument users (as promoters), and manufacturers (as adopters), to develop interface standards, create and maintain interface specifications, and establish a standards compliance program.

Members of the discussion group will have the opportunity to join the consortium or leave the discussion when the consortium is established. To learn more about the plug-and-work discussion group and consortium, and to join the discussion list, see http://www.mbari.org/pw/.

—Judith Connor, Monterey Bay Aquarium Research Institute, Moss Landing, Calif.