WAIS in ANDRILL Future Planning

Frank R. Rack, David Harwood, Steve Fischbein (ANDRILL Science Management Office, 126 Bessey Hall, University of Nebraska-Lincoln, Lincoln, NE 68588-0341; 402-472-4785; frack2@unl.edu) and ANDRILL Science Committee (ASC) Members.

ANDRILL (ANtarctic geological DRILLing) is a multinational program with the objectives to recover stratigraphic intervals for use in interpreting Antarctica's climatic, glacial and tectonic history over the past 50 million years (m.y.), at varying scales of age resolution (0.1 to 100 thousand years [k.y.]). The key motivation for ANDRILL relates to poor understanding of the complex role of the Antarctic cryosphere (ice sheets, ice shelves and sea-ice) in the past and future global climate system. Understanding the history of ice volume variation and associated physical changes in the Antarctic region is critical for assessing the interaction of ice sheets with the ocean, atmosphere, lithosphere and biosphere. Determining the scale and rapidity of changes affecting large ice masses is of vital importance because (i) ice-volume variations lead to changing sea levels, (ii) ice sheets influence sea-ice distribution, Earth's albedo, and latitudinal climate gradients, and (iii) ice shelves generate cold bottom-waters that ventilate the world's oceans. General circulation models (GCMs) indicate that the Polar Regions are the most sensitive to climatic warming, thus the projected global rise in temperature of 1.4 to 5.8˚C by 2010 (Intergovernmental Panel on Climate Change, [IPCC], 2001) is likely to be even greater in the Antarctic, with a probable effect on the Antarctic cryosphere. The future success of ANDRILL depends on establishing strong linkages with communities studying the behavior and significant processes exhibited by the West Antarctic Ice Sheet (WAIS) and surrounding ocean in order to understand the past and future behavior and history of the Antarctic cryosphere.

Fully understanding the role of Antarctic drivers on global climate variability requires a fundamental knowledge of Antarctic cryospheric evolution, not only in recent times, which is plainly vital, but also for earlier Antarctic history when global temperatures and atmospheric pCO2 were similar to conditions that might well be reached by the end of this century. High-quality sedimentary archives that record past ice sheet behavior have become available recently from the two ANDRILL projects, namely the McMurdo Ice Shelf (MIS) and Southern McMurdo Sound (SMS) projects. These build upon the prior successes of the Cape Roberts Project (CRP), and from ODP legs 178 and 188 to the Antarctic Peninsula and Prydz Bay, respectively. Although of excellent quality, these archives are too few in number to allow comprehensive understanding of Antarctica's influence on global climate. In June 2008 ANDRILL submitted a proposal to NSF's Office of Polar Programs and began discussions among the existing international partners to drill two sites on the Coulman High (CH) to initiate the first project of the Ross Embayment Portfolio (REP). The CH project will be accomplished by moving 125 km northeast of McMurdo Station, out of the Victoria Land Basin, to an area that has been densely surveyed using multichannel marine seismic reflection techniques at the C-19 giant iceberg calving site over CH. Two sites are proposed as part of the CH project to recover over 2 km of core (1200 m-thick sediment sequence at each site) that represents a unique archive of the paleoenvironmental and tectonic evolution in the Ross Embayment. By drilling at CH we seek to discover the Cenozoic history of West Antarctica.

Through the CH project, ANDRILL proposes to develop a capability to operate from a fast moving ice shelf platform (~700 m/year lateral movement, or roughly 2 m/day) using offset holes accomplished either by coring and fast-drilling, or by re-entry into a single borehole. Demonstrating this capability will put the Ross Ice Shelf, and other Antarctic ice shelves (e.g., Ronne-Filchner, Amery) within ANDRILL's reach. These technical and engineering objectives will be complemented by process studies conducted through the ice shelf to understand tidal currents that can impact the drilling operations (e.g., through the deployment of oceanographic moorings and pilot long-term observatory installations), as well as observations of benthic processes that contribute to a basic understanding of the sub-ice shelf environment (e.g., through field surveys using ROVs and surface sampling).

Several pre-drilling surveys must be performed for the CH project to determine conditions at the drill site and along the traverse route, and for final determination of the most robust drilling strategy. Pre-drilling, over-ice surveys will include: (1) airborne and surface radar mapping of sub-ice crevassing and topography; (2) LIDAR altimetry of the ice surface; (3) deployment of oceanographic current/tidal moorings; (4) verification of ice margin migration rates; (5) site meteorology; and (6) acquisition and processing of seismic reflection crossing lines at each drill site to augment the existing marine survey coverage. The project plan critical path includes (1) refining the initial technical research/design and (2) executing the bulk of the ice shelf-based site survey requirements in the field season following authorization to proceed (3) traversing the major equipment to the CH site; and (4) drilling in the two subsequent field seasons (ideally from 2011 to 2013).

In addition to the proposed CH project, ANDRILL completed an over-ice seismic survey in Granite Harbor within the Mackay Sea Valley (MSV) in 2007, and is currently conducting a seismic survey at Offshore New Harbor (ONH) to identify future potential drill sites. Other surveys are planned across the Ross Embayment to identify future potential sites where high quality geologic sequences could be recovered by drilling. Concerted planning efforts are underway to identify promising targets where glaciological and geological processes combine to preserve records of the evolution of the Antarctic cryosphere and interactions with the Southern Ocean that impact global thermohaline circulation, sea level and climate. A key strength of the ANDRILL approach is the ability to consistently obtain high-quality core while achieving extremely high core recovery in the targeted section (e.g., proximal glacial and glacimarine sedimentary rocks). We hope to continue this successful approach, pioneer new technological capabilities in more challenging environments, engage other scientific communities in these investigations - which will likely include modern process studies, and expand the pool of involved scientists, engineers, students, technicians and educators involved in ANDRILL.