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ANDRILL (Antarctic DRILLing): Stratigraphic Drilling for Climatic and Tectonic History

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ANDRILL (ANtarctic DRILLing) is a multinational program with objectives to recover stratigraphic intervals for use in interpreting Antarctica's climatic, glacial and tectonic history over the past 50 million years (m.y.) and 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 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-water that ventilates 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 1.4–5.8˚C by 2010 (Intergovernmental Panel on Climate Change) is likely to be even greater in the Antarctic, with a probable, but unknown, effect on 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 pCO_2 were similar to conditions that might well be reached by the end of this century. Unfortunately, limited exposures of Cenozoic strata in Antarctica due to the ice cover, too few stratigraphic drillholes on the continental margin, and the short time that Antarctica has been explored, has forced geologists to rely on information derived from lower-latitude proxy records to interpret Antarctica's history. For example, the oxygen isotope record from deep-sea cores and eustatic changes inferred from sequence stratigraphic records on passive continental margins have been shaping paradigms for interpreting Antarctic ice sheet history. However, interpretations based on proxy records of glacio-eustasy benefit from little direct confirmation from geologic records in Antarctica, a problem which has led to numerous conflicting interpretations. The ANDRILL Program will help to remedy this situation by recovering new Cenozoic sedimentary records from locations proximal to the ice sheet that are ideally suited for recording ice sheet oscillations and associated oceanic and climatic variations. These new records will provide a better understanding of the global climate system and elucidate linkages between the high and low latitude records of environmental change. Integration of these records with numerical modeling will improve understanding of the global climate system under a wide range of boundary conditions and forcings, with the potential to improve predictions that have societal relevance.

In 2006 and 2007 ANDRILL will drill two sites in the McMurdo Sound region to recover critical intervals of Earth's Neogene climate history. This region is a key location in Antarctica because over millions of years it has been influenced by a combination of the ice sheets in East and West Antarctica, the paleo-TAM ice sheet and valley glaciers, the McMurdo-Ross Ice shelf, and sea-ice. Consequently, this special setting will allow ANDRILL scientists to examine questions pertaining to: (1) Evolution and history of the East and West Antarctic ice sheets; (2) Ice Shelf response to climate forcing, including variability at a range of temporal scales (3) Global influence of the Ross Ice Shelf through ocean-atmosphere teleconnections; (4) History and impact of sea-ice on marine systems, ocean to atmosphere heat and moisture transfer, marine community development and biological productivity; (5) Processes and controls on the evolution of geomorphic-sedimentary-tectonic systems in polar conditions; (6) Continental lithosphere rheology and asthenosphere response to rifting and volcanic loading.

The age of the Meyer Desert Formation (Sirius Group) at Oliver Bluffs in the Transantarctic Mountains (TAM), and the terrestrial biota enclosed within these glacigene strata, has been a topic of discussion and disagreement. The Pliocene age derived from the occurrence of reworked late Miocene and early Pliocene marine diatoms within the enclosing sediments has been challenged by the assertion that the diatoms are surface contaminants. Reports of diatoms within Antarctic ice cores and on Antarctic surfaces in other areas of the TAM has provided an alternate explanation for the occurrence of the marine diatoms in the in the Meyer Desert Formation and other Sirius Group deposits. However, the diatom assemblage characteristics of the marine diatoms in the Meyer Desert Fm. and that of the eolian floras in ice cores and surface deposits are very different. These assemblages cannot be derived from the same source or delivered to the Meyer Desert Formation by the same processes. This paper will contrast these different diatom assemblages by comparing their (1) ecology, (2) size, (3) age, (4) taxonomic composition, and (5) potential source areas as criteria to establish the unique features of the glacial-sourced and the eolian-sourced diatom assemblages. Erosion of the face of Oliver Bluffs by a late Pleistocene advance of Beardmore Glacier, as well as ongoing erosion by wind deflation and snow-melt dissection of the Bluffs, produced fresh exposures of the Meyer Desert Formation, which were sampled for diatom analyses. These strata that yielded the marine diatom assemblages were not exposed at the time of the Eltanin asteroid impact (2.5 Ma, late Pliocene). The sampled strata have been exposed only recently to surface processes. Thus, the suggestion that marine diatoms were incorporated onto the surface of the Meyer Desert Formation by fallout of impact ejecta at this location is untenable. However, if ejecta-sourced marine diatoms did blanket the ice sheet and TAM from the 2.5 Ma event, and these diatoms were subsequently picked-up by the ice that deposited the Meyer Desert Formation, they would indicate that the Meyer Desert Formation and enclosed biota was less than 2.5 million years old. Establishing the age of this important paleontological site is critical to the correct assessment of Late Neogene climate evolution of the Antarctic region. These results affirm the Pliocene age of the Meyer Desert Formation paleoflora and associated fauna.