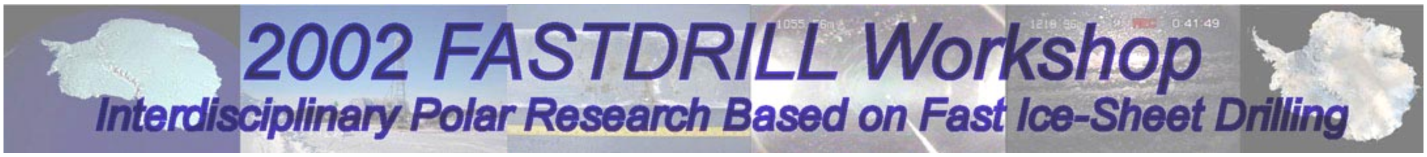

ORAL AND POSTER PRESENTATIONS

8:00 PM, Thursday, October 3rd, 2002, Casa Blanca Inn

Keynote Talk

Richard B. Alley, Environmental Institute, Pennsylvania State University

David Elliot took me to the Antarctic Peninsula on the R/V Hero almost 25 years ago. Between my bouts of seasickness, we accessed the geologic story of Hope Bay and offshore islands through judicious use of (occasionally water-filled) zodiacs and (also occasionally water filled) boots, focusing on the narrow regions beyond the ice. The beautiful Jurassic fern fossils we sampled on the side of Mt. Flora were rather eloquent testimony to the great changes that have occurred on Earth; the rather pathetically small region of outcrop frustratedefforts to learn more. Research near and on big ice sheets remains one of the great human adventures, with some of the greatest payoffs for understanding the Earth system. We have come a long way from the first Swedish South Polar Expedition discovery of those Jurassic plant fossils. Antarctic Lystrosaurus and Glossopteris painted the picture on the jigsaw-puzzle of continents to demonstrate continental drift. Most of the world's available meteorites have been found on the ice-sheet surface, and many of the neutrinos thus far studied by science are being traced using the ice. Sediments around the coast and under the ice show the mercurial nature of that ice. The records in the ice itself attest to the great sensitivity of the climate to carbon dioxide, and to the global reach of abrupt climate jumps. The ice contains microorganisms that not only are viable but that apparently are metabolizing below the bulk freezing temperature of water. Outstanding tools, deployed from space, aircraft and surface, including hot-water and core drilling and various remote-sensing and exploration-geophysical techniques, have been developed and deployed successfully to learn the secrets hidden in and under the ice. Yet it is clear that most of those secrets remain hidden in and under the ice, owing to the immense difficulty of sampling. The biggest uncertainties in global tectonic plate motions likely live in the West Antarctic rift system, which hosts sediments recording the ice-sheet history; those sediments lubricate the fast flow of ice that may control future sea-level change and hold a critical record of abrupt climate changes. Million-year-old East Antarctic ice, overlying voluminous lakes cradled in old (and possibly not-so-old) rift basins or other features, which likely contain ecosystems and their records, has the potential to change our views of the world. With the successful reconstruction of South Pole station nearing completion, a renewed and expanded effort to work in and under the ice is bound to produce fundamental insights to our planet. Deployment of new tools, such as a rapid access drill, beside successful tools already in use will allow great scientific progress.

Oral Session - Friday, October 4th, 2002, Seymour Center

9:00 AM

Sub-ice Drilling: Advancing Earth Sciences in Antarctica

David H. Elliot, Byrd Polar Research Center and Department of Geological Sciences, Ohio State University

Antarctica is 98% covered by ice, thus understanding of the tectonic history and the role of the continent in global processes is limited. Broadly, East Antarctica is a Precambrian craton bordered by successively younger orogenic belts, terminating with the Mesozoic-Cenozoic belt along the Pacific margin. The continent is an integral part of the global plate circuit and its tectonic evolution is essential for understanding earth history, particularly from the time of break-up (180 Ma) of Gondwana. The Cenozoic history, however, is dominated by extensional tectonics and the development of major rifts and rifted regions. Furthermore, Antarctica is one of the keys to understanding the course of Cenozoic climate change. Both aspects of Antarctic geologic history will be advanced by information that can be obtained through sub-ice sampling.

Geologic knowledge of East Antarctica, except in the Lambert Glacier region, is limited to peripheral areas of the craton. From 15?W to 90?E the broadly elevated craton consists of Archean and Proterozoic igneous and metamorphic rocks which have correlatives in the Africa-India part of Gondwana, in particular a Grenvillian age orogenic belt. This sector includes the sub-glacial Gamburtsev Mountains (80?S 75?W) which form an isolated intraplate mountain range which is probably a Cenozoic volcanic field. The Lambert Glacier region (70?) is a major intraplate rift system with a 300 m.y. history of intermittent alkaline magmatic activity. Much of this sector, and the 90?E to 160?E sector, is overprinted by the so-called ?500 Ma Pan-African thermal event. From 90?E to 160?E outcrops are fewer, Archean and early Proterozoic rocks less common although clearly correlative with Australia, and undeformed Precambrian strata are present. Further, this sector has thinner crust, inferred from satellite data, and broad regions of low elevation together with significant elongate troughs well below sea-level. Rifting and sedimentary basin fills are likely to be Cenozoic in age and include a high latitude, marine and/or lacustrine transition from the late Paleocene thermal maximum through to the mid Miocene onset of full scale polar glaciation. The low region at ?150?E in Wilkes Land, extending south on the polar plateau side of the Transantarctic Mountains, may contain a Cretaceous and younger marine and non-marine section with the Cenozoic part related to uplift of the mountains and glacial history. Specific targets in East Antarctica include: the Gamburtsev Mountains; the rift basins of Lake Vostok and sub-glacial deeps near Dome C; and the sedimentary basins. More generally, basement rocks are a target for understanding lithospheric evolution and properties in order to address both geological and glaciological problems.

West Antarctica comprises a rifted region of blocks and basins developed on a series of orogenic belts. Disruption began at about 180 Ma and continues to the present. The Ellsworth-Whitmore crustal block is a fragment of the Gondwanide orogen preserving the fold and thrust belt into which mid-Jurassic plutons were emplaced. Based on the Haag Nunataks, isolated blocks in the Filchner-Ronne Ice Shelf region probably are parts of the Gondwana craton. These blocks, plus Marie Byrd Land and the Thurston Island block, are targets for drilling in order to constrain: the geologic evolution of the South Africa-Antarctica sector of Gondwana and the Pacific margin of Antarctica; the possible occurrence of massive basaltic rocks related to break-up; and physical properties of rocks forming elevated regions under the ice sheet. The basins in West Antarctica have a geologic history of Gondwana break-up and subsequent episodes of rifting, magmatism, sediment deposition and glaciation, which is complementary to that of the continental shelves. The record of Cenozoic climate change will differ from that of East Antarctica, reflecting the waxing and waning of the marine ice sheets of West Antarctica. The relationship of sub-glacial geology, not simply the unconsolidated substrate, to ice sheet flow is potentially significant. Targets in West Antarctica include: inferred volcanic edifices, both point sources (volcanoes) and regional features such as the Sinuous Ridge; sedimentary basins; and sub-glacial outcrops that might record previous episodes of deglaciation. Physical properties of rocks at the base of the ice sheet hold important information for its history and dynamics.

9:20 AM

Investigating the Crustal Elements of the Central Antarctic Plate: Long-range Aerogeophysics as a Foundation for Access Drilling in East Antarctica.

D.D. Blankenship, D.L. Morse, I.W.D. Dalziel, L.A. Lawver, Institute for Geophysics, The University of Texas at Austin,
J.M. Brozena and V.A. Childers, Naval Research Laboratory, Washington, D.C.

The East Antarctic ice sheet (EAIS), which dominates the Antarctic Plate, is the largest and least ephemeral of Earth's ice sheets. It contains ice equivalent to a global sea level rise of ~70 meters. It has been established in recent years that the bedrock of an ice sheet plays a major role in controlling its behavior. However, the inaccessibility of the central Antarctic Plate has permitted only reconnaissance geophysical studies, generally comprised of widely spaced airborne radar sounding profiles, except in a few limited areas. Hence very little is known about the bedrock geology as the region is less than 1% ice-free and the exposed rocks are almost entirely coastal. A convergence of research activity, however, has focused attention on this least known of the Precambrian shield areas of the globe. The highlands of the central Antarctic Plate have been the nursery for East Antarctic ice sheets at least since the early Oligocene separation of Antarctica and Australia. Over the last decade, great strides have been made in compiling a marine geological, geophysical and geochemical record of the deposits left by these ice sheets. In addition, enormous resources have been invested in extracting a Pleistocene paleoclimate record from the central reaches of the contemporary East Antarctic ice sheet. Most recently the scientific community has realized the importance of the isolated biome represented by the subglacial lakes that characterize the domes of the central East Antarctic ice sheet and evolve in concert with them. The impact of these research efforts and discoveries have been to spur major international research initiatives to study the evolution of the East Antarctic ice sheet and its subglacial environment. Critical to understanding these offshore and ice core records as well as the distribution/isolation of any subglacial lake systems is developing a comprehensive understanding of the crustal elements of the central Antarctic Plate which supported the nucleation of the contemporary East Antarctic ice sheet as well as its predecessors throughout the Cenozoic. A complete understanding of the evolution of these East Antarctic ice sheets of course requires knowledge of the boundaries, elevation and paleolatitude of these crustal elements through time as well as evidence of their morphological, sedimentological and tectono-thermal history. The basic impediments to gaining this understanding are the subcontinental scale of the central Antarctic Plate and the one to four kilometers of ice cover that inhibits direct access. It is possible however to provide a substantial framework for understanding these crustal elements through a comprehensive program of long-range airborne geophysical observations followed by a program af carefully targeted access drilling. Geophysical measurements required to characterize this crust in preparation for subglacial sampling include: 1.) Distribution of gravity and magnetic anomalies to characterize subglacial lithology (e.g., sediments, crystalline basement and volcanics), identify crustal boundaries and estimate lithospheric flexure through potential field modeling. 2.) Absolute bedrock elevation (from ice sheet surface elevation and thickness) at a scale suitable for models of both contemporary and paleo-ice-sheet (or lake) evolution as well as for potential fields modeling. 3.) Detailed subglacial morphology and physical character of the ice-rock interface to identify any "preserved" glacial geomorphology and map fault scarps indicative of Cenozoic (or older) tectonic processes as well as to determine the location, properties and connectivity of subglacial sedimentary units (and lakes).4.) Contemporary basal melt distribution (from ice sheet layering) to estimate the current distribution of geothermal flux for indications of tectono-thermal history and as a necessary boundary condition for models of ice sheet (and lake) evolution. We will review the airborne gravity, magnetics, ice-penetrating radar and laser altimetry techniques required to obtain these measurements and select appropriate sites for subglacial sampling. In addition, we will present a compatable plan for a program of long-range aerogeophysics over the crustal elements of the central Antarctic Plate that comprise the subglacial highlands beneath Domes A and C of the contemporary East Antarctic ice sheet.

9:40 AM

Why Drill at Grounding Lines - Geological, Glaciological and Oceanic Perspectives

Ross D. Powell, Reed P. Scherer, Department of Geology and Environmental Geosciences, Northern Illinois University, DeKalb, IL 60115 (ross@geol.niu.edu), Slawek Tulaczyk, Department of Earth Sciences, University of California, Santa Cruz, CA 95064

Developing models of West Antarctic Ice Sheet (WAIS) and Ross Ice Shelf (RIS) dynamics has been hampered by a paucity of process data due to a lack of direct observations and measurements in critical areas. Recent inferences about processes from remotely sensed data have occasionally been in apparent conflict, adding to evidence of the complexity of the system (e.g. upstream tidal forcing -- Anandakrishnan et al. (1997); positive and negative mass balances for different areas of WAIS -- Joughin & Tulaczyk (2001) and Rignot & Thomas (2002); increased grounding-line melting -- Rignot & Jacobs (2002); decreased salinity and increased water temperatures (Jacobs et al. (2002)). However, these studies do show a pressing need to obtain direct measurements of active WAIS processes, both in terms of our understanding of the complex systems and for their societal ramifications. Documentation of types of processes and quantifying their rates and magnitudes both up-stream (grounding zones) and down-stream of a grounding line, especially in ice stream areas, are important in order to constrain: (1) ice flow dynamics and ice stream behavior, (2) ocean-ice-shelf interactions, (3) dynamics in and the characteristics of grounding-line sedimentary systems, and (4) the biota living in such extreme environments.

We need to evaluate sub-ice-shelf, grounding line and up-stream subglacial processes of the RIS and WAIS ice streams using a wide spectrum of instrumentation in a range of science experiments to document: (1) P/T conditions and chemistry of basal ice, and at the glacier sole and bed. These data provide information on the source of the ice, freeze/thaw conditions at the bed, and biological and chemical reactions and interactions. (2) Physical and geotechnical properties of subglacial till and the subglacial hydrology up-stream from and at ice stream grounding-lines. This allows a comparison of bed characteristics determined farther up-stream with these down-stream areas of ice streams, to provide a continuum along flow lines. This will more tightly constrain the influence of bed character to flow velocity and sediment supply to grounding-line depositional systems. Given the fact that Ice Stream C has stopped in its lower part and that the downstream area of Whillans Ice Stream (B) is slowing down, grounding line areas may be the most important in determining transient behavior of ice streams. (3) Quantitative and qualitative documentation of physical and chemical processes at ice-stream grounding lines and sub-ice-shelf oceanography. These data will document ocean-ice-shelf interaction at the grounding lines of ice streams in order to test current models of melting/freezing thresholds and water mass characteristics. They will allow assessment of the tidal influence on periodic grounding line movements over a possible grounding zone, and the hydrological and sedimentological effects of tidal pumping. They will also enable an evaluation of the interaction between sedimentary grounding-line systems and grounding-line movement relating to ice sheet and ice shelf stability. (4) Document englacial, subglacial and sub-ice-shelf biology. These data will allow an evaluation of life in these extreme environments and potentially provide a platform for testing procedures for subglacial lake exploration. (5) Sedimentary release and dispersal processes at and beyond the grounding line. This will document the glacimarine environment adjacent to ice stream grounding-lines in order to construct models that would help interpret sedimentary records on the Antarctic continental shelf of various ages, including the last retreat. Grounding-line processes under other glacial regimes appear to be distinctly different than polar settings; however we have no direct measurements in these settings to substantiate those assumptions. (6) Analyze sediment samples for mineral and fossil content. These data will help determine the location and character of sediment sources under WAIS, and perhaps allow evaluation of past fluctuations of the WAIS. Such analyses will bridge the gap between active processes and the interpretation of past ice streams inferred to have advanced across the continental shelf during intervals of expanded ice.

Drill design will be required primarily to provide access holes, although ice cores in the lower (potentially debris-rich) ice will also be needed. Access holes will need to meet the following specifications: (1) must be sufficiently wide for instrumentation packages (e.g. oceanographic instrumentation, ROV, core barrels, etc), (2) must be maintained open over several days at least while down-hole operations are conducted, and (3) can be refrozen with an instrument string internally in the hole and also in sub-ice areas where the ice is grounded or floating.

The outcomes of such studies have important ramifications for: (1) predictions of effects on global ocean circulation if ice shelves change size and areas of sea ice formation change, (2) predictions of future timing and rates of eustatic sea level rise when WAIS dynamics are effected, (3) predictions of future paths and rates of environmental changes in the Ross Sea sector with possible consequences on its biota from initial freshening and warming waters, to potentially the eventual loss of the Ross Ice Shelf or even WAIS, and (4) understanding more of life in these extreme environments. In addition to addressing these critical science issues, such studies can provide an excellent testing ground for future exploration of subglacial lakes.

10:00 AM

New Science Opportunities with Ice Cores and Borehole Logging Instruments

P. B. Price, Physics Department, University of California, Berkeley

I will discuss how new research techniques and new drilling methods will expand science horizons. Biological topics include studies of microbes in liquid veins in solid ice; borehole logging of microbes; bacterial metabolic rate at low temperature; and exotic amino acids in extraterrestrial particles. Climatological topics include news ways to study abrupt climate change; rapid searches for several-million-year-old ice; long-period solar modulation of annual dust fluxes; and ancient atmospheric composition. Volcanic topics include rapid logging of ash layers and searches for periodicities of volcanic eruptions. Astrophysical topics include signatures of astrophysical events in subglacial lake sediments and ice cores. Exploration of subglacial lakes and bedrock cores can advance geology as well as all of the above disciplines.

10:40 AM

An International Plan for Antarctic Subglacial Lake Exploration

John Priscu, Department of Land Resources and Environmental Sciences, Montana State University

ABSTRACT NOT AVAILABLE

11:00 AM

Recovery and Characterization of Bacteria from Polar and Nonpolar Glacier ice

Brent Christner, , Department of Land Resources and Environmental Sciences, Montana State University

Bacteria in glacier ice from worldwide locations and in an ice core extending into accreted Lake Vostok ice have been isolated using enrichment culture and identified by amplification and sequencing of 16S rDNA. The numbers of recoverable bacteria did not correlate directly with the age of the ice, and isolates were recovered from the oldest samples examined (>500K years old). In general, ice cores from non-polar locations contained larger numbers and species of cultivable bacteria than samples from polar ices, consistent with the influx of airborne biological particles from local environments serving as the primary factor controlling the numbers of microorganisms present. Some of the isolated bacteria are closely related to species originating from permanently cold environments, other ice core sites, or different portions (time periods) of the same core. A number of the bacteria isolated from samples of Lake Vostok accretion ice are close phylogenetic relatives of species that survive for thousands of years in glacial ice. DNA and protein precursors were incorporated by ice core isolates under frozen conditions analogous to those in glacier ice, supporting the argument that bacteria trapped in glacial ice might repair macromolecular damage that occurs while immured for extended periods. Investigating microbial survival in ice and exploring potential habitats for activity within the glacial and subglacial environment has confirmed that these could have served as refuge environments for life during periods of global glaciation (Snowball Earth), and has provided data for extrapolations to the likelihood of microorganisms surviving frozen in extraterrestrial habitats or during interplanetary transport.

11:20 AM

Sea-level Changes Bring Antarctica Home: Subglacial Processes and Ice Sheet Behavior

Slawek Tulaczyk, Department of Earth Sciences, UCSC

Although Antarctica is geographically removed from populated places, it affects humanity directly through its impact on global sea level. This fact will make the Antarctic ice sheet important to human society as long as people prefer to live and do business at the rim of the global ocean. The latter preference results in high, and rapidly increasing, concentration of expensive urban and industrial infrastructure close to sea level. For instance in Santa Cruz, the market value of oceanfront property reaches already ~$1bln per several kilometers of coastline. Over the coming decades, the combined effect of increasing investment in coastal zones and (even gradual) sea-level changes will have profound social and economic consequences. In addition to being socially relevant, sea-level changes represent a fundamental driver for a number of important geological and biological processes taking place in undeveloped coastal environments.

In light of the pressing need to understand the impact of Antarctica on global sea-level changes, it is frustrating to admit how limited is our ability to predict the contribution of Antarctica to future sea-level changes or even to reconstruct recent or past contributions. The biggest problem lies in the fact that the rates of ice drainage out of the Antarctic ice sheet are determined predominantly at the bottom of the ice sheet. Ice drainage out of the Antarctic ice sheet is organized into fast-moving ice streams and outlet glaciers, which can be up to several kilometers thick. Recent measurements have shown that they can experience significant changes in the rate of motion over time periods as short as decades. Glaciologists need borehole measurements and experiments to determine the physical processes, which govern fast ice flow and its temporal variability. Without such observational constraints numerical models of the Antarctic ice sheet will never reach the sophistication needed to provide reliable prediction of future sea-level changes.

Over the last decade, understanding of West Antarctic ice stream dynamics improved rapidly thanks to a successful drilling program led for 12 years by Drs. B. Kamb and H. Engelhardt (Caltech). Using a hot-water access drill they completed dozens of boreholes spread over hundreds of kilometers through ice that was up to ~1,300 m thick. They recovered samples of subglacial till, measured sliding velocity, ice-temperature profiles, and probed the subglacial water drainage system. Antarctic glaciology community is in dire need for continuing input of data from similar drilling projects in the future as well. A few areas of priority are already emerging. Physical reasons for rapid basal melting rates at grounding lines of ice streams and outlet glaciers are poorly understood but may be key in determining future response of the Antarctic ice sheet to the warming of the global ocean. Mechanisms behind the observed fast thinning of outlet glaciers draining into the Amundsen Sea Embayment must also be elucidated to verify whether the thinning may be followed by a large-scale collapse of the West Antarctic ice sheet. These are only a few examples of the glaciological problems in Antarctica that need to be addressed with an aid of a mobile, fast drilling system accompanied by an array of instruments for borehole and subglacial measurements. As recent experience has shown, the more detailed view of ice flow of Antarctica we get, the more we realize how much more variable (in space and time) the flow is than previously anticipated. The temporal changes may represent a response to short-term climate changes (e.g. climate warming) or may still reflect the large global warming that took place at the end of the last glacial period. They may also be driven by internal ice-sheet dynamics. What we do know, is that constraining subglacial processes is absolutely necessary if we are to determine what the contribution of Antarctica to sea-level changes will be over the coming decades and centuries. Perhaps in some no-so-distant future, we may reach the point when humanity will stop treating sea-level changes as something inevitable and want to start actively managing the global sea-level by controlling the rate of ice loss from the Antarctic ice sheet. A long-term program of subglacial exploration is the only way through which we can gain the insights needed to evaluate the feasibility of such endeavor.

In the effort to understand the dynamics of the Antarctic ice sheet, glaciological interests will intersect with the objectives of

Antarctic biologists and geologists. For instance, glaciology needs to know the distribution of sedimentary basins and the variability of geothermal flux. Subglacial water flow is crucial in determining patterns of fast-ice flow but it also may provide migration pathways for subglacial microbial life forms. I am looking forward to the FASTDRILL workshop hoping that it will represent the first step of the final stage of Antarctic exploration.

11:40 AM

Development and Placement of Instrumented Probes for the Study of Deforming Subglacial Till

M. Truffer, W.D. Harrison, D. Pomraning, K. Abnett, R. Ruhkick, Geophysical Institute, University of Alaska Fairbanks, 903 Koyukuk Dr, Fairbanks AK 99775-7320

Studying subglacial till poses unique challenges. We present results from developing and testing two new methods. First, a 1000 pound hammer was developed to penetrate subglacial till in holes that have been pre-drilled through the glacier with a conventional hot water drill. The hammer is operated from the top with a cathead winch. It was designed to penetrate up to 10 m of till. However, only slightly more than 2 m of penetration was reached at two sites on Black Rapids Glacier in spring 2002, even though 7 m of till exists at that location. We will discuss some of the challenges and possible improvements for the system.

A second component of this project is probes equipped with wireless communication. Two reasons led to this development. One, it is impractical to operate a hammer with instrument cables leading past it. Two, it has long been an important limitation of tilt sensors to have attached cables that can pull on the probes and influence, or dominate, the actual deformation. The probes were at least partially successful. We will present the method, some early results, and suggestions on how to improve the system.

01:00 PM

Coiled Tubing Drilling Technology

Gary Clow, USGS Denver

ABSTRACT NOT AVAILABLE

01:20 PM

Glacial Subsurface Access Technologies in Support of In-situ Measurements of ice and Inclusion Properties

Frank Carsey, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109

Subsurface explorations of planetary ice, and some Earth science projects, call for in-situ scientific observations at significant depth. Initial efforts at such observations took the form of thermal probes, and these have been used for several decades; In general the technology of thermal probes has been challenging. In this talk I will review the thermal probe design as advanced by JPL and collaborators including initial work on scientific instrumentation for deployment at Mars and Europa.

01:40 PM

Directional Drilling and Drilling Fluids

William W. Fleckenstein, Colorado School of Mines

Directional drilling is the art of deviating a wellbore from vertical toward a predetermined target. The difficulty in successfully directionally drilling a wellbore is determined by the mechanical properties of the medium being drilled, the correct choice of technology, the experience of the directional drillers and the desired accuracy of the directional borehole. A drilling fluid is the medium that fills the wellbore during the drilling process. It is desired that the drilling fluid circulate the cuttings from the wellbore, keeps the cutting surface clean, cools the bottomhole drilling assembly and cutting surface, and is of sufficient density that the wellbore stability is maintained and pore fluids in the medium drilled are prevented from entering the wellbore. This presentation will present the current technology for directional drilling and arctic drilling fluids. Directional drilling topics to be covered are types of directional wellbores, methods of directional drilling, including whipstocks and kick-off plugs, wellbore survey accuracy, and issues specific to coiled tubing directional drilling. Drilling fluid topics to be covered are types of fluid, cuttings transport, wellbore stability, well control, and current fluids in use.

02:00 PM

A Proposed Sampling System for Antarctic Subglacial Lakes

Erik W Blake, Icefield Instruments Inc.

The proposed sterile sampling system for subglacial Antarctic lakes seeks to maintain at all times an environmental barrier between the lake and the surface in order to minimize possibilities for contamination. The access and sample recovery holes are drilled with water in an underbalanced fashion so that if the lake is breached prematurely, water from the lake will enter the hole rather than the reverse. Extensive testing of the system will be performed using terrestrial analogues such as lakes, ice shelves, and deep oceanic environments. The sterile drill proposal calls for using a hot-water drill with a sonar sounder to drill a 200mm diameter hole to a depth 10 to 20m above the subglacial lake. A deployment bus, connected to the surface via power and communications link, contains a dock for a completion drill, a winch for a sampling sonde, and a control unit. It delivers the completion drill and sonde to the bottom of the hot-water hole. Following positioning of the drill system at the bottom of the access hole, the hole will be sealed from the surface by natural freezing and/or underbalanced borehole closure. Following closure, hydrogen peroxide or another reagent will be released to perform a final sterilization of the drill. A hot-point completion drill will drill a 200mm hole through the remaining 10 to 20m of ice into the lake. The deployment bus will then slowly lower the sonde for its water-sampling program. The sonde consists of water samplers, a pump and graded filter, a sensor/instrument package, battery backup, and control computer. As the sonde is lowered, the samplers will be filled at several depths while instruments (pressure, conductivity, pH, camera, etc.) take data. Particles will be collected on the filter from ~100 liters of water. Microbes in the recirculating meltwater will be removed with a 0.2-µm filter. For redundancy, data taken by the instruments will be stored in both the sonde computer and the bus computer and transmitted to the surface. Finally, a refrigeration system on the bus, or other mechanism, will seal the hole below the bus. A recovery reamer will then drill along the cable and release the bus from the ice, after which the components will be hauled to the surface. Abandonment of the hole might involve underbalancing the hole so that it closes up.

Poster Session - Saturday and Sunday, October 5-6, 2002, Atrium of the Earth and Marine Sciences Bldg., UCSC

Poster #1

Optical Borehole Logging

Ryan C. Bay, UC Berkeley Physics Department, Berkeley

Optical borehole logging has proven to be a fast and very effective way to study past climate and volcanic ash emissions over the past ~1e5 years. Annual dust-layers in the Siple Dome A borehole have been resolved. Using data from both GISP2 and Siple Dome, we are searching for effects of long-period modulations of solar activity, such as the 11-year sunspot cycle. Evidence for this and longer-period variations in solar activity has come from records including those of sunspots, neutron monitors of cosmic ray intensity, aurorae, and cosmogenic nuclides such as Be-10 and C-14. The optical logs provide objective and continuous profiles in both hemispheres, and lend themselves easily to numerical techniques. Our progress in searching for decadal, centurial, and millennial cycles will be presented.

Poster #2

Results from Recent Logging of the GISP Drillhole

Nathan Bramall, UC Berkeley Geology Department

Poster #3

Downhole Measurements for a new Antarctic Drilling Program

Richard D. Jarrard, Dept. Geology & Geophysics, Univ. of Utah, 719 WBB, 135 S. 1460 East, Salt Lake City, UT 84112

A coiled-tubing Antarctic drilling program, capable of drilling through 3-4 km of ice and coring up to 100 m of rock, would provide a constellation of scientific opportunities based on downhole measurements: (1) ground-truth of surface and airborne geophysical surveys (gravity, magnetic, seismic); (2) intraplate stress pattern; (3) orientation of regional bedding or metamorphic fabric; (4) fracture patterns; (5) heat flow; (6) dynamics of the rock/ice interface (incl. ice flow rate, detection of basal water or moraine); and (7) surface temperature history for the last ~2000 years. In this presentation, each of these applications is illustrated with examples from previous Antarctic drilling. Although these prior studies have been intrinsically fruitful and demonstrated feasibility, most are limited to 1-3 nearby localities. In contrast, a suite of perhaps a dozen drillholes throughout Antarctica would provide a continent-scale perspective of tectonic and climatic processes.

Poster #4

The Antarctic and Alaska Ice Borehole Probe

Alberto Behar, Robotic Vehicles Group , NASA Jet Propulsion Laboratory , Pasadena, California 91109-8099, http://helios.jpl.nasa.gov/~behar

The Antarctic Ice Borehole Probe project was a collaborative (NSF, Caltech, NASA, JPL) glaciological science investigation performed during November-January of 2000-01. The field party (Behar, Kamb, Engelhardt, et. al) initially deployed the probe in 4 ice boreholes (up to 1226m) and created images of the basal contact region, the ice crystallization structure and en-glacial debris on the walls of the boreholes. The implications of those images were subsequently analyzed in terms of the basal sliding, annual accumulation rates, and basal freeze-on rates. The Probe project also served as a stepping-stone in technology development to demonstrate the capability and instrumentation packaging needed for work in extreme ice/liquid-type environments. The information gathered and equipment developed can now aid in future terrestrial and extraterrestrial missions that require exploration in ice/liquid environments, including missions to current or future ice boreholes, sub-glacial lakes such as Lake Vostok in Antarctica, the Mars Polar Caps and to Jupiter's moon, Europa. This focus of this talk is to describe the design of the probe and how it was used both in Ice Stream C, Antarctica and subsequently at Black Rapids Glacier, Alaska in May 2002.

Poster #5

Predicting Properties of the Basal Zones of ice Streams and Interstream Ridges

Poul Christoffersen, Department of Civil Engineering, Technical University of Denmark, pc@byg.dtu.dk, Slawek Tulaczyk, Department of Earth Sciences, University of California, Santa Cruz

The Caltech drilling programme has provided significant information about the basal zone of fast flowing ice streams. Although the physical properties of sub-ice stream tills are well known, their sensitivity to changes is more or less unknown. Sensitivity analysis of the basal zone is important because till property changes may influence ice dynamics and thus affect mass balance of the West Antarctic ice sheet. We have thus constructed numerical models that emulate the basal zone of drilling sites in the Ross Sea sector of the West Antarctic ice sheet. In these models we explore effects of thermal changes, mechanical changes, and hydrogeological changes.

Our models predict that basal freeze-on is capable of inducing considerable changes in the basal zone of both ice streams and interstream ridges. These changes are associated with specific signatures that compare with borehole observations and geophysical surveys. Water pressure levels are reduced and thick layers of debris-laden basal ice develop. These basal ice layers and underlying sediments contain a distinct isotopic composition. Dewatering of till may lead to an increase in solute concentration at the ice-till interface. Dewatering may thus be visible in radar profiles. The supercooling associated with basal freeze-on induces a measurable temperature signal that diffuses into the overlying ice. Such signal has been observed in the basal zone of the stagnant Ice Stream C. Till porosity represents another quantity whose evolution is influenced strongly by basal freeze-on. In particular, measurements of vertical porosity distribution beneath stopped ice streams could be used to back-calculate the timing of the onset of basal freezing.

In general, our model results show that the basal zone of ice streams and interstream ridges responds sensitively to changes in basal melting/freezing rates. This sensitivity may allow reconstruction of past conditions beneath ice streams and interstream ridges from measurements made on basal ice samples and subglacial sediment samples.

Poster #6

Basal Melt Beneath Whillans Ice Stream and Ice Streams A and C

Ian R. Joughin, Jet Propulsion Lab, 4800 Oak Grove Dr., Pasadena, CA 91109; ian@radar-sci.jpl.nasa.gov; Slawek Tulaczyk, Department of Earth Sciences, University of California, Santa Cruz, CA 95064, Hermann Engelhardt, California Institute of Technology, Pasadena, CA 91125

We have used a recently derived map of the velocity of Whillans Ice Stream and Ice Streams A and C to help estimate basal melt. Temperature was modeled with a simple vertical advection-diffusion equation tuned to match borehole temperature profiles. We find that most of the melt occurs beneath the tributaries where larger basal shear stresses and thicker ice favors greater melt (e.g., 10-20 mm/yr). The occurrence of basal freezing is predicted beneath much of the ice plains of Ice Stream C and Whillans Ice Stream. Modeled melt rates for when Ice Stream C was active suggest there was just enough melt water generated in its tributaries to balance basal freezing on its ice plain. Net basal melt for Whillans Ice Stream is positive due to smaller basal temperature gradients. Modeled temperatures on Whillans Ice Stream, however, were constrained by a single temperature profile at UpB. Basal temperature gradients for Whillans B1 and Ice Stream A may have conditions more similar to those beneath Ice Streams C and D, in which case, there may not be sufficient melt to sustain motion. This would be consistent with the steady deceleration of Whillans stream over the last few decades. Additional borehole derived temperature profiles are important as further constraints on the modelled temperature and melt rates.

Poster #7

Studying the Subglacial Hydrological System in West-Antarctica - Opportunities and Challenges

Vogel, S.W.; Tulaczyk S., Anderson, S., Department of Earth Sciences, UCSC; Engelhardt, H.; Bolsey R., California Institute of Technology, Pasadena, CA

Chemical and isotopical signature of subglacial water has extensively been used to reveal subglacial hydrological processes. In glacial systems, where surface melt can reach the bed, oxygen rich surface melt mixes with basal water enriched in solutes and weathering products from its interaction with the glacier bed. Changes in the englacial and subglacial hydrological system throughout the annual cycle are reflected in the chemical and isotopical composition of run-off, englacial and subglacial water. At many alpine glaciers glacier run-off is routinely monitored and samples for chemical analyzes taken. More challenging is the access of the glacial bed through boreholes, which however is regularly done on alpine glaciers.

In the case of the West-Antarctic Ice Sheet rare surface melt refreezes within short time close to the surface in the firn layer. Subglacial water is therefore the result of basal melt caused by geothermal and frictional heat trapped at the base of the ice sheet. Basal melting delivers like a conveyor belt dust particles and oxygen from the air trapped in the ice from the ice surface to the subglacial system. Over a long timescale of possibly hundreds to thousands of years basal melt water interacts with the glacial bed. In this process the subglacial water enriches in solutes from mineral dissolution, chemical weathering and microbial activity. In areas of basal melting fresh basal melt dilutes solute enriched basal water, while in areas of basal freezing solute concentrations increase as solutes are expelled from the ice during the freeze-on process. Differences in solute concentrations and the portion of different chemical elements from one sample location to the other, as seen at the UpC Sticky Spot (Vogel and others, unpublished data), therefore reflect the history of the basal water and the catchment area it originated from. In addition the accretion of basal ice in areas of basal freezing also bears valuable information about the subglacial environment. The presence of accretion ice itself contains information about the freeze-on history while isotopical and chemical composition of the ice reflect the water source.

Studying the subglacial regime of polar ice sheets however bears large logistical and technological challenges. Geophysical investigation can generally distinguish between a frozen and unfrozen or wet bed. However they are yet unable to identify characteristics of the hydrological system or to detect smaller features like subglacial cavities. Shielded by 1000 m and more ice, direct observations and sample collection are only possible through boreholes. Due to the great ice thickness and the remoteness drilling in WAIS bears more technological and logistical problems then drilling on alpine and arctic glaciers. Water pressures at the bottom of the boreholes are similar to the deep-sea environment. Instruments, sampling and insitu analyzing systems, routinely used in other areas, have therefore to be modified or specially designed to withstand and operate in this environment or to fit through the narrow shaft of a borehole. For long-term monitoring of the basal water or the glacial bed sensors and analyzing systems have to be placed to or close to the bed and data transmitted to the surface. Similar challenging for future drilling operations is to avoid contamination of the subglacial environment, in particular through drilling fluids, which might be possible through a combination of different drilling technologies (hot-water, coiled tubing, rotary or cryobot) dependent on the individual scientific question.

Poster #8

Shallow Source Aeromagnetic Anomalies Observed over the WAIS inferred to have Volcanic Origin at the Base of the Ice Compared with Coincident Bedrock Topography

John C. Behrendt, INSTAAR University of Colorado, Boulder, CO 80309-0450 (also USGS Denver) ; behrendj@stripe.colorado.edu; D.D. Blankenship, UTIG, University of Texas; D. L. Morse, UTIG, University of Texas, C.A. Finn, USGS, Denver, and R.E. Bell, LDEO, Columbia University

Aeromagnetic and radar ice sounding results from the Central West Antarctica (CWA) aerogeophysical survey have enabled detailed examination of specific anomaly sources, previously interpreted as caused by late Cenozoic subglacial volcanic centers, compared to bedrock topography. A great deal of technical effort by the CASERTZ and SOAR operation was needed to produce magnetic data having the observed accuracies of a few nT. As a result, the data contoured at 2 and 10 contour interval are proving quite valuable in resolving subtle features. Considering the approximately 1-km flight elevation over the snow surface and the 2-3-km ice thickness of the WAIS anomaly amplitudes are surprisingly high over most of the CWA area. In contrast is the essentially non- magnetic, interpreted non-volcanic, terrane east of the CWA (Ellsworth crustal block) which was originally recognized in the 1960s from magnetic profiles, as geologically quite different. Using large scale, 2- and 10-nT-contour interval magnetic and 20-m bedrock elevation maps we compared a few hundred specific anomalies, which all correlate with bedrock topographic expression, to quantify the relative abundance of interpreted volcanic anomalies having shallow magnetic sources. Of course, deeper magnetic structures in the bedrock are present but have longer wavelengths, lower gradients and mostly lower amplitudes than the highly magnetic late Cenozoic volcanic rocks. Although late Cenozoic volcanic activity may have had a significant influence on the behavior of the WAIS in the past, any Holocene influence is highly uncertain despite the presence of at least one active subglacial volcano (Blankenship et al., 1993) and sparse active volcanism throughout the area of the WAIS. Because the WAIS and the volcanic rocks are roughly of similar age it is critical that datable samples from subglacial volcanic centers be obtained when new ice drilling technology come on line in the near future (e.g. Clow et al., 2002).

Beneath the divide of the WAIS in the complex volcanic topography of the Sinuous ridge there are 30 high amplitude (40-1200-nT), steep-gradient, shallow-source anomalies which can be correlated with bedrock topography. Most (21 of 30) of these sources correlate with slight to moderate (60-600 m) topographic expression at the base of the ice. We have interpreted previously (Behrendt et al, 1995;2002) that likely hyaloclastites and other volcanic debris (e.g. pillow breccia) were removed concomitantly with their injection into the moving ice as is the case in Iceland. Beneath the divide area of the WAIS some hyaloclastite(?) ridges have probably been preserved also as observed in Iceland.

There are eight examples of about 1 km or greater topographic relief on the bedrock beneath the WAIS divide. These anomaly sources at the base of the ice would rebound to elevations above sea level were the ice removed. We interpret these anomaly sources as evidence of subaerial eruption of volcanos whose topography was protected from erosion by competent volcanic flows similar to prominent volcanic peaks that are exposed above the surface of the WAIS. Further we infer these eight volcanoes as erupted volcanic edifices at a time when the WAIS was absent.

In contrast, the bedrock topography in the survey area surrounding Ice Stream D is very smooth in compared to that over the WAIS divide, yet there are a number of shallow source, volcanic appearing magnetic anomalies. Probably the volcanic edifices were removed at a more rapid rate here because of fast glacial flow. Alternatively, the shallowest subglacial volcanic sources may be overlain by glacially deposited sediments too thin to resolve from the magnetic survey.

Poster #9

Combining Aerogeophysical Mapping and Geological Sampling as a Powerful Tool to Explore East Antarctica

Michael Studinger, Robin E. Bell, Garry D. Karner, Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W, Palisades, NY 10964, mstuding@ldeo.columbia.edu

East Antarctica, the size of the conterminous United States, is the largest unexplored region of the Earth. Existing geological and tectonic models for the development of East Antarctica are derived mostly from sparse geologic outcrops mapped along the perimeter of the continent and DSDP-ODP drilling of the continental margins. In recent years, several aerogeophysical transects have provided important constraints for unraveling the tectonic development and geologic structure of parts of East Antarctica. Two transects across the Transantarctic Mountains from McMurdo to Dome C and from Ice Stream A to the South Pole acquired gravity, magnetics, and subglacial topography data. Both transects occur in areas also with rock outcrops over the Transantarctic Mountains. In addition to theses two transects, aerogeophysical data were acquired along several long profiles across Lake Vostok in the interior of East Antarctica. We have tested a variety of conceptual tectonic models using the observed gravity and magnetic data to infer the existence of a zone of thrusting across a former passive continental margin. Presumably this was a Proterozoic event. Minor, young normal reactivation of the thrust resulted in the development of the Lake Vostok Basin. No data exist to directly date either the timing of passive margin formation or the subsequent shortening phase due to a lack of rock samples. The analysis of the aerogeophysical profiles across Lake Vostok demonstrates the power of geophysical measurements, which when integrated with a process-oriented approach to the interpretation of geophysical transects, can lead to a regional geological understanding of a region. Aerogeophysical transects can be surveyed in a relative short amount of time and with moderate logistic support compared to the surveying entire areas.

Combing geologic, geophysical, and glaciological themes and objectives into one drilling effort offers unique opportunities to explore East Antarctica. A potential target area includes an aerogeophysical transect from Dome Argus over the Gamburtsev Subglacial Mountains towards the Lambert Rift with a core drilling at Dome Argus. This transect would shed light on the poorly understood Gamburtsev Subglacial Mountains that are one of the largest subglacial landforms in East Antarctica. A second possibility could be a transect from Dome C over the Aurora Subglacial Basin towards Wilkes Station. Glaciological goals, subglacial lake research and geological interests could be combined with a core drilling at Dome C, while an aerogeophysical transect over the Aurora Subglacial Basin would provide valuable insights into the nature of this feature.

Poster #10

Measuring In Situ Stresses in the Antarctic Continental Interior

T.J. Wilson , Dept. of Geological Sciences, Ohio State University, Columbus, OH 43210 (wilson.43@osu.edu), R.D. Jarrard, Dept. of Geology & Geophysics, Univ. of Utah, Salt Lake City, UT 84112 & T.S. Paulsen, Dept. of Geology, University of Wisconsin-Oshkosh, Oshkosh, WI 54901

The Antarctic plate is virtually devoid of contemporary stress data (World Stress Map Project, http://www-wsm.physik.uni-karlsruhe.de/) due primarily to the lack of commercial drilling and the lack of recorded seismicity. Yet, Antarctica is key to developing a better understanding of the net effects of plate-boundary and glaciotectonic forces on plate-interior stress regimes. From a tectonic perspective, the Antarctic intracontinental stress regime is expected to be compressive, because midocean spreading ridges surround the plate. The Cenozoic history of West Antarctica, however, is dominated by extensional tectonics and faults that cut the seafloor in the westernmost rift suggest that this regime may still be active. The crust of the Antarctic continental interior is also expected to be profoundly influenced by the growth and decay cycles of the Antarctic ice sheets through postglacial rebound and uplift/subsidence associated with glacial erosion and surface mass redistribution. One long-standing hypothesis is that the mass of the present Antarctic ice sheets, superimposed on a presumed compressive tectonic stress regime, promotes fault stability and aseismicity by decreasing the net differential stress (Johnson, 1987). Our research group has obtained the first in situ measurements of the orientation and relative magnitudes of the contemporary stress field in the Antarctic interior, from analysis of drilling-induced fractures observed in boreholes drilled by the international Cape Roberts Project drilling program. These results are inconsistent with suppression of seismicity by the present ice mass. It is unlikely, however, that stresses at this site are representative of the Antarctic plate interior. It is essential to obtain additional stress measurements across Antarctica to fully characterize the nature of the intraplate stress regime. Obtaining plate-wide stress data is one of the goals of the SCAR-sponsored ANTEC (Antarctic Neotectonics) initiative, aimed at improving understanding of the unique neotectonic regime of the Antarctic plate (Wilson, 2002). Two strategies for obtaining stress data should be considered. First, borehole and core fracture studies and hydraulic fracture measurements can be undertaken during bedrock coring at sites selected for other primary science objectives. A targeted campaign to obtain stress data at key localities should also be planned. Such drillholes would also provide an opportunity for geological and glaciological sampling, and for additional geophysical investigations, such as heat flow and paleotemperatures of the last few hundred years.

Poster #11

Drilling in the Antarctic Interior: Neotectonic Objectives

Terry J. Wilson, Department of Geological Sciences and Byrd Polar Research Center, Ohio State University, Columbus, OH, 43210, USA, Wilson.43@osu.edu

Antarctica provides a unique laboratory to explore the influence of ice sheets on continental-scale crustal motions, on the stress and strain regimes in the lithosphere and on rates and volumes of magmatism, and, conversely, the influence of tectonics on ice sheets, sea level and climate processes. Active crustal deformation (uplift, faulting) and active volcanism (plume-related?) are widespread in West Antarctica and may occur beneath the ice sheet in East Antarctica where subglacial mountains and basins are present. Antarctica is also undergoing active glacial loading and unloading, which induces isostatic motions and applies unusual stresses to the crust. These active tectonic processes may influence the stability of the Antarctic ice sheets. The Scientific Committee for Antarctic Research (SCAR) sponsors the ANTarctic NeoTECtonic (ANTEC) program to improve understanding of the unique neotectonic regime of the Antarctic plate. The ANTEC program is promoting a range of interdisciplinary research. Neotectonic objectives that can be addressed by drilling in the Antarctic interior include:

* Where are there crustal boundaries - active or ancient?
* Are there unique driving forces on the Antarctic lithosphere?
o What is the intraplate stress regime?
o How do changing ice mass loads influence the continental stress regime?
o Is the apparent low level of Antarctic seismicity due to ice mass load?
* What is the interplay between ice sheets and tectonics?
* What are the mantle processes (thermal anomalies/mantle plumes) controlling magmatism?
* What is the relationship between glaciation and volcanism?
o What are the true distributions and volumes of magmatism through the Cenozoic?
o Are these linked with glacial/deglacial load changes and/or with ice dynamics?
* What are the rates, styles, and mechanisms of erosion around Antarctica?
o How does glacial erosion relate to uplift processes?

Poster #12

Exposure Histories from Cosmogenic Ssotopes in Bedrock Above and Beneath ice Sheets

John Stone, University of Washington

ABSTRACT NOT AVAILABLE

Poster #13

Stratigraphic Drilling for Climatic and Tectonic History in Antarctica: ANDRILL and the McMurdo Sound Portfolio

Fabio Florindo#, Jane Francis+, David Harwood, Richard Levy*, Tim Naish§, Frank Niessen€,Ross Powell$, & Gary Wilson_*
#Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna murata 605, 00143, Roma, ITALY
+School of Earth Sciences, University of Leeds, LS2 9JT, UK
**ANDRILL Science Management Office, Dept. of Geosciences, Univ. of Nebraska-Lincoln, Lincoln, NE 68588-0340, USA*
§Institute of Geological and Nuclear Sciences, NEW ZEALAND
€Alfred Wegener Institute for Polar and Marine Research, Columbusstrasse, 27515 Bremerhaven, GERMANY
$Department of Geology and Environmental Geosciences, 312 Davis Hall, Northern Illinois University, DeKalb, IL 60115, USA
_Department of Earth Sciences, University of Oxford. Parks Road, Oxford, OX1 3PR, UK

ANDRILL is a new initiative that uses and expands the technology employed during the Cape Roberts Project to use floating ice (fast-ice and ice shelves) as a drilling platform to recover stratigraphic records. This multi-national project proposes to investigate Antarctica's role in Cenozoic-Recent global environmental change through stratigraphic drilling for Antarctic climatic and tectonic history. Four drilling seasons are proposed in the McMurdo Sound area to address diverse scientific questions spanning the last 50 million years, and at varying levels of stratigraphic resolution. Due to the immense ice sheets and major erosional episodes, the Antarctic region is conspicuously lacking in long records of Cenozoic paleoclimate. Stratigraphic records from the Antarctic margin are comparatively more complete, often with expanded sections, and their locations are ideally suited for recording and dating ice sheet oscillations and associated oceanic variations. ANDRILL aims to obtain high-resolution (0.1 to 100k.y.), seismically-linked and chronologically well-constrained stratigraphic records from key locations around the Antarctic continental margin to address key scientific objectives and questions in a series of discrete portfolios. The first of these is the McMurdo Sound Portfolio. Five countries, Germany, Italy, New Zealand, United Kingdom and United States are leading the ANDRILL initiative, and the invitation is open for membership of other nations. McMurdo Sound is located on the margin of the Victoria Land Basin and is influenced by ice and sediment input from both the East and West Antarctic ice sheets. Through persistent sediment supply and subsidence, the McMurdo Sound region has acted like a sedimentary tape recorder for most of the last 45 m.y. It has the best-understood marginal sedimentary record in Antarctica due to the past 30 years of integrated seismic and drill-hole data, which will provide confidence in target location to answer specific scientific questions. Location on the rift margin of the Transantarctic Mountains and within a major Cenozoic volcanic province will allow assessment of the role of tectonics in climate and ice sheet development and provide an excellent chronological framework through input of datable volcanic tephra.

Three phases of data collection and analysis are planned: Phase I - three seasons of geophysical surveys (2001-2004) (aeromagnetic, gravity, and seismic) to document basin extent, architecture and correlate target drilling areas to known drillcores; Phase II - four seasons of drilling (2004-2008) to recover target strata to address key objectives and questions; Phase III - four years of data analysis and integration into glacial, climate and ocean models (2006 to 2010), in conjunction with 'ACE' to determine global links and the role of the Antarctic cryosphere in global environmental change. Major aims of the McMurdo Sound Portfolio are: (1) To determine the fundamental behavior of the Antarctic cryospheric system (ice sheet, ice shelf, and sea-ice), including the magnitude and frequency of its changes on centennial to million-year time-scales; (2) To obtain geological records from critical intervals in the development of the Antarctic cryosphere to guide and constrain glacial and climate models; (3) To document the evolution and timing of major Antarctic rift and tectonic systems and the stratigraphic development of associated sedimentary basins; and (4) To determine, through correlation of near-ice margin and southern Ocean stratigraphic records, the role of Antarctic ice sheets on long- and short-order Cenozoic climate change, particularly in modulating thermohaline ocean circulation and changes in sea-level elevation.

The ANDRILL initiative is developing a framework for international collaboration that will continue beyond the McMurdo Sound Portfolio. Other portfolios will develop to address these and other scientific questions around the Antarctic margin. Current target areas of the McMurdo Sound Portfolio are in New Harbour (Eocene to Pliocene targets, with a focus on the middle and late Miocene), Mackay Sea Valley (Holocene targets), McMurdo Ice Shelf (Plio-Pleistocene targets) and Southern McMurdo Ice Shelf (Paleogene targets). Workshop reports from the ANDRILL International Workshop in Oxford (April, 2001) will be available soon, as well as the ANDRILL Science and Logistical Implementation Plan. A new, powerful drilling system is being developed for ANDRILL to be able to reach deep-water (<1000m) targets and to operate through a thick (>200m) shelf ice. This will expand the capability of the successful Cape Roberts Project technology, which operated from a fast ice platform and achieve consistent core recovery (>95%) and the recovery of a 939m core in the CRP-3 drillhole. This new capability will be able to address diverse geological and geophysical questions. ANDRILL technology may provide a future means of sampling key targets beneath the East Antarctic Ice Sheet and Ross Ice Sheet that are identified by geophysical reconnaissance surveys, but yet unsampled. Stratigraphic drilling offers a range of geological data to help interpret crustal evolution, basin history, climate and ice history and the influence and feedback of these on biotic, geomorphologic and structural evolution. Drilling, combined with downhole logging and ground-based and airborne geophysics, can provide complementary physical data to constrain and direct interpretations of airborne geophysical data, which will lead to a better understanding of the Antarctic lithosphere. Geophysical data will, in turn, help identify Mesozoic and Cenozoic sedimentary basins as drilling targets. Critical constraints on vertical motions of crustal blocks and feedbacks between surface processes and tectonic processes can be addressed with the recovery of stratigraphic records. Climate and glacial models, fed by geological information of past environmental change will contribute to the resolving the effects of lithospheric loading, ice sheet mass balance, and climate and surface processes. An integrated geophysical and geological program will ensure that drillsites will have the potential to meet scientific questions of broad interest.

Correspondence and requests for materials and further information should be addressed to dharwood1@unl.edu and the ANDRILL web site at http://andrill-server.unl.edu/

Poster #14

ANDRILL Drilling Challenges

<u>Alex R. Pyne</u>, Antarctic Research Centre, Victoria University of Wellington, New Zealand

The ANDRILL program is proposing to core several sedimentary sequences of varying age and origin in the McMurdo Sound Region to obtain records of Antarctic climate, glacial and tectonic history. Continuous coring techniques will allow the most complete recovery of the sequences possible in this polar setting. Most targets are in the marine environment either beneath annual sea ice that fringes the coast or below an ice shelf. A drilling capability will be developed to drill from either type of ice platform in up to 1000 metres of ice and water and continuously core unfrozen sedimentary sequences in excess of 1000 metres below the sea floor.
The drilling systems will be based on "minerals industry slim hole diamond" coring techniques adapted for deep hole sedimentary coring. Previous drilling programs have used this technology to achieve quality core recovery of 98% in similar situations from the continental shelf marine glacial sediments in Antarctica. Wire line coring equipment will be compatible with both soft sediment coring techniques and with rotary diamond coring for semi lithified and lithified sediments.

Operation in a glacial marine environment provides some unique challenges for minerals industry technology because sea riser casings are more common in the offshore oil industry but will be necessary to operate slim hole drill strings in the sea water column. The deep coring systems and deep water riser required for the ANDRILL targets are significantly heavier than used in past drilling programs. This will be especially critical for operation on sea ice platforms which have limited load bearing capacity. An inflatable air bag system deployed beneath the sea ice was pioneered by the Cape Roberts project and used to support both the sea riser and drill rig. This approach should be suitable to accommodate the greater loading for ANDRILL deep water deployments from sea ice. The ice shelf platform can accommodate heavy equipment loads. However active heating of the part of the riser passing through the ice hole is necessary to enable sea floor anchoring of the riser, tide compensation and to prevent the sea water based drilling fluids freezing in the sea riser and drill strings. Both types of ice platforms are subject to tidal motion and also lateral movement that causes deflection of the drill strings and therefore limits the effective period of drilling. Recent small scale experimental coring of ice cored sediments in the McMurdo Dry Valleys Region by VUW programs has pioneered "aseptic" compressed air flush techniques to recover quality rock and ice core. This work has shown the practicality of chilled compressed air for cooling diamond drill bits and flushing cuttings from shallow holes. However it has also identified the difficulties of designing drill bits that are effective in mixed ice and rock formations.

Some of the successful techniques used previously and new ANDRILL developments for coring unfrozen glacial sediments and recent experience coring mixed ice rock sediments may have applications to future FASTDRILL technology in particular for geological targets.

Poster #15

Interpreting occurrences of microfossils within and beneath Antarctic ice sheets

<u>Lloyd Burckle</u> and Ray Sambrotto, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York 10964

From our perspective, there are two ways to emplace remains of micro-organisms (marine, fresh water or terrestrial) beneath present day ice sheets. One way is obvious; get rid of the ice sheet, or part of it, sometime during its history and have marine or terrestrial environments cover the deglaciated regions. That this happened in the past in many polar and subpolar regions is well documented. The second way is less obvious. Burckle et al. (1997) asked the question, "Is there a mechanism that will emplace microfossils beneath an ice sheet without getting rid of the ice sheet?" They considered the fate of a sedimentary particle placed on top of a moving ice sheet that was melting at its base and concluded that, under such conditions, the particle would follow a trajectory taking it beneath the ice sheet. Sambrotto and Burckle (2002) suggested that this was the most likely explanation when they reported the presence of Pliocene-Pleistocene marine diatoms, as well as fresh water diatoms, pollen grains, filamentous algae, fungus, bacteria, nematodes (?) and tardigrades (?) in the "marsh" ice recovered from just above Lake Vostok. The regional setting of Lake Vostok excluded the ice sheet/subice interface as a possible source. In order better to interpret occurrences of microfossils beneath Antarctic ice sheets we need a more complete inventory of biogenic particles that occur in Antarctic ice. To that end we would like to obtain ice and subice samples. Our processing would include grow out experiments for bacteria and fungi as well as light microscope and SEM examination of the solid particles many of which are biogenic in origin.

Poster #16

Exploration of Subglacial Lakes in East Antarctica

Robin Bell, LDEO, Columbia University

ABSTRACT NOT AVAILABLE

Poster #17

Molecular Biology Findings in Vostok Accretion Ice

Sergey Bulat, Petersburg Nuclear Physics Institute, Russia

ABSTRACT NOT AVAILABLE

Poster #18

From Genomes to Biomes: Developing new Molecular Techniques to Explore the Mysteries of the Natural Microbial World

José R. de la Torre & Edward F. DeLong, Monterey Bay Aquarium Research Institute

The past two decades have seen a sea change in our understanding of the natural microbial world and in the approaches used to study it. Advances in recombinant DNA technologies and molecular phylogenetics have resulted in new ways of defining and classifying organisms based on objective parameters. Ribosomal RNA (rRNA)-based molecular surveys of natural microbial communities have expanded the known diversity of microbes on Earth, revealing numerous novel phylogenetic lineages, many with no known cultivated relatives. These cultivation-independent surveys have also revealed the ecological significance of these as yet uncultivated microbes, many of which represent major components of natural microbial assemblages. However, this approach has significant limitations when trying to understand the function of these organisms in their natural communities. It is not always possible to infer the properties of newly-defined microbes solely on the basis of the characteristics of their closest cultivated relatives in an rRNA phylogeny. Consequently, the physiology, biochemistry and metabolic properties of many of these microorganisms remains a mystery. The advent of environmental genomics represents a promising approach to further our understanding of the function and life history of uncultivated microorganisms. Many of the techniques developed for genome sequencing projects, such as bacterial artificial chromosome (BAC) libraries and shotgun libraries, can now be applied to studies of environmental genomics. Recent strides in cloning techniques have enabled the efficient cloning and analysis of large genome fragments (40 to 200 kb) isolated directly from the environment. Analysis of these libraries provides a means of linking phylogenetic identity with biological function. We will discuss these different approaches and their usefulness in light of our studies of microorganisms in the ocean, one of the planet's largest cold biomes (mean temperature ~5˚C). Molecular surveys have demonstrated that planktonic archaea represent a significant proportion of oceanic microbial communities. One group of archaea in particular, the planktonic crenarchaeota, account for up to 40% of the bacterioplankton at depths greater than 100 meters, making them some of the most abundant organisms on the planet. Yet, because these organisms have so far resisted laboratory cultivation, very little is known about their physiology and metabolism. Our laboratory has constructed genomic libraries from bacterioplankton collected at various depths (0m to 750m) in Monterey Bay and Antarctica, and has characterized several large genome fragments from uncultivated marine crenarchaeotes from different oceanic provinces. In addition, we have undertaken the sequencing and analysis of the full genome of one species of marine crenarchaeotes, the uncultivated psychrophile Cenarchaeum symbiosum, a specific symbiont of a marine sponge. We will discuss the insights into the biology of marine crenarchaeotes obtained from our genomic studies, as well as consider the challenges involved in assembling genomes from heterogeneous population of microorganisms.

Poster #19

Effective Decontamination of Outer Ice Core Surfaces for Biological Studies

Scott O. Rogers, Bowling Green State University, SUNY College of Environmental Science and Forestry, John D. Castello, SUNY College of Environmental Science and Forestry, William T. Starmer, Syracuse University

The reliability of results from studies of ancient biological materials (viable and dead organisms, nucleic acids, and other biological molecules) depends on the assurance of complete removal of contaminating biological materials prior to characterization and identification. This is extremely difficult, but vital to these studies. We have been rigorously testing methods for decontamination for several years by creating ice cores in our labs that we have seeded with a various concentrations of microbes and nucleic acids. We have then treated the cores in a number of ways to determine the degree to which they can be used reliably to decontaminate the outer surfaces of the cores. Mechanical methods, UV-irradiation, as well as treatment with chemicals have been tested.

Poster #20

Sterilization Problems in ice Drilling Systems: Field Evidence and Potential Solutions

Mark Skidmore and Brian Lanoil, Department of Environmental Sciences, 2217 Geology Building, UC Riverside, Riverside, CA 92521, USA. Tel: 909 787 4789 Fax: 909 787 3993 Email: skidmore@citrus.ucr.edu

The use of Coiled Tubing Drill for Ice (CTDI) technology provides the potential to collect multiple ice/sediment cores facilitated by directional drilling from a single borehole. This would potentially generate dedicated cores for parallel geophysical, geochemical and microbiological investigation. The prospect of improved access to deep subglacial environments utilizing CTDI is both exciting and challenging from a microbiological perspective.

A major concern for microbiological studies of ice cores and sub-glacial samples collected from boreholes is the potential for contamination from outside sources (e.g. drill fluid), a problem that is exacerbated by the relatively low abundance of organisms in the environment. This problem is compounded in ice core studies since the samples are generally not collected with the intention of studying microbiological parameters and hence are not handled aseptically. Furthermore, due to the low abundance of organisms and loss of much of the sample during decontamination, larger sample volumes are required for biological analyses than are often available from traditional coring or drilling approaches. Mechanical drilling also has the disadvantage of inducing fractures in the ice cores, increasing the possibility of contamination from microbes carried in drilling fluids. Theoretically, hot water drilling is significantly "cleaner" microbiologically than mechanical drilling and coring. First, the water supply to the drill tip is heated to ~ 60-90oC and hence, significant lysis of cells in the drill water is expected. Second, locally derived water is the only drilling fluid used for hot water drilling, unlike mechanical drilling which uses organic chemicals such as n-butyl acetate or kerosene, which may persist in cracks and fissures, thereby increasing the risk of contamination. Finally, few to no cracks are observed by visual inspection under normal light or under cross-polarized light in ice cores obtained by hot-water coring devices.

Fieldwork using two different hot water drilling systems was undertaken in 2002 at Bench Glacier, Alaska and Vatnajökull, Iceland. Microbial concentrations were determined for snow (the drilling fluid source), water collected in the borehole, and drill output. In both Alaska and Iceland microbial concentrations in snow were similar to those for borehole waters. These results suggest that simply heating the waters to ~ 60-90oC is not an effective sterilization technique. We believe a more effective method would be filter sterilization of the drilling fluid. We consider filtration of the drilling fluid to be important in improving the microbiological sampling capabilities of the CTDI technique whether using a non-freezing liquid or hot water as a drilling fluid. A design for the filtration system will be discussed.