

25th Annual
Five College Geology
Faculty Symposium

Friday February the 13th, 2004, 4pm
Red Barn, Hampshire College



PROGRAM

4:05	Welcome/Introductions
4:10	Darby Dyar, Mount Holyoke College Mössbauer Spectroscopy on the Surface of Mars: New Results from the Mars Exploration Rovers
4:30	Robert M. Newton, Smith College Hydrology of a Riparian Wetland in the Adirondacks of New York State
4:50	Rob DeConto, University of Massachusetts Exploring the Cenozoic Climate and Glacial Evolution of Antarctica
5:10	Peter Crowley, Amherst College The Heart Mountain Fault: The Electron Backscattered Diffraction (EBSD) View of an Old Problem
5:30	Steve Roof, Hampshire College The Sirius Problem: Clues to Past and Future Stability of the Antarctic Ice Sheets
6:00	Pizza and Refreshments



The Barne Glacier meets
the McMurdo Sound Sea Ice,
Antarctica

Mössbauer Spectroscopy on the Surface of Mars: New Results from the Mars Exploration Rovers

Darby Dyar, Mount Holyoke College

Mars has always been known as the Red Planet. The color red in minerals is often caused by the presence of iron, so it is likely that iron-bearing minerals contribute to spectra of Mars. Satellite images have suggested the presence of minerals such as hematite ($\alpha\text{-Fe}_2\text{O}_3$), ferrihydrite ($5\text{Fe}_2\text{O}_3 \cdot 9\text{H}_2\text{O}$), goethite ($\alpha\text{-FeO(OH)}$), and carbonate group minerals ($\text{Ca(Fe}^{2+}, \text{Mg, Mn)(CO}_3)_2$). For this reason, Mossbauer spectrometers, useful in the identification and interpretation of Fe-bearing minerals, were included in the instrument packages of both the NASA Mars Exploration Rovers (MERs), Spirit and Opportunity, and the lost ESA Beagle 2 lander. In this talk, I'll present a brief overview of how Mössbauer spectroscopy works, and talk about how we've been preparing for the mission through work at Mount Holyoke. I will show all the Mössbauer spectra collected to date on the martian surface, and discuss possible interpretations of them. Finally, I will discuss results on the same rocks obtained by the Mini-TES and APXS spectrometers on the rovers, and how the results of all three of these techniques can be integrated to gain an understanding of the mineralogy on the surface of Mars.



The rock known as
“Adirondack” on Mars

Hydrology of a Riparian Wetland in the Adirondacks of New York State

Robert M. Newton, Smith College

A riparian wetland in the Sunday Lake watershed was instrumented as part of a study of mercury in Adirondack wetlands, lakes and terrestrial systems. Multiple arrays of shallow groundwater piezometers were installed adjacent to the inlet stream and along the shore of Sunday Lake. Dataloggers equipped with pressure transducers continuously monitor groundwater stage at 4 of the piezometers and surface water stage at 3 gage stations. Water samples are taken monthly and analyzed for major ion chemistry as well as ^{18}O and ^2H .

Head measurements show that the riparian wetlands discharge water to the streams from surrounding areas of stratified drift throughout most of the year. During baseflow periods in the growing season, water levels in piezometers display a daily oscillation in stage of as much as 3 cm due to evapotranspiration. During hydrologic events the groundwater flow system in the riparian wetland can be reversed with water from the stream flowing into the groundwater. Groundwater hydrographs show a rapid rise in stage associated with rapid infiltration from rainfall or snowmelt events. This is immediately followed by a rapid decline and then a slow rise. The slow rise appears to be due to infiltration of stream water into the groundwater during peak stream flow. The peak in the stream hydrograph occurs 10-12 hours after the initial rise in groundwater stage. The reversal of hydraulic gradient extends completely across the riparian wetland.

Riparian groundwater is chemically dilute ($\text{SC} < 40 \mu\text{S}$). Base cation concentrations tend to be slightly higher in the groundwater while acid anions such as sulfate tend to have lower concentrations than the adjacent surface waters. Measurements of low dissolved oxygen during the summer show that sulfate reduction is an important process. Stable isotope measurements show significant differences between riparian wetland waters and surface waters for all sample periods. Annual oscillations in piezometer ^{18}O suggest residence times of 90-180 days for riparian groundwater.

Piezometers in the riparian wetland immediately adjacent to the inlet stream have the highest methyl Hg concentrations (6 ng/L). This appears to be due to methylation of Hg by sulfate reducing bacteria that flourish in the riparian zone where upwelling groundwater under the wetland provides an abundant supply of sulfate. Riparian wetlands appear to be the principal source of methyl mercury to surface waters.

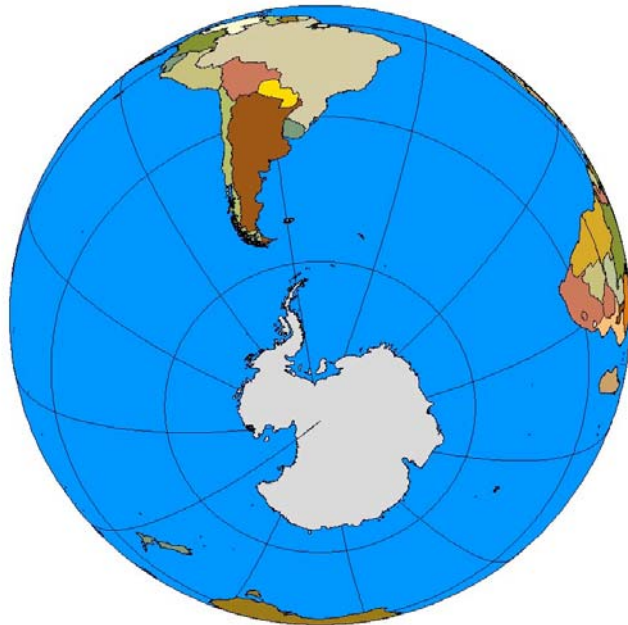
Exploring the Cenozoic Climate and Glacial Evolution of Antarctica

Rob DeConto, University of Massachusetts

The sudden glaciation of Antarctica and the associated shift toward Colder global temperatures at the Eocene-Oligocene boundary represents one of the most dramatic reorganizations of the global climate system recognized in the geologic record. This "greenhouse" to "icehouse" transition has long been associated with the tectonic opening of ocean gateways in the Southern Ocean and resulting changes in ocean circulation. Recent advances in numerical modeling, allowing long (10^6 year) climate-ice sheet simulations, are revealing highly dynamic climate system behavior in response to changes in atmospheric carbon dioxide and the Earth's orbit, with smaller climatic effects induced by changes in ocean circulation. These model results reinforce the importance of pCO_2 as a fundamental factor for Cenozoic climate change

UMass is contributing to new international research initiatives, including ACE (Antarctic Climate Evolution) and ANDRILL (ANtarctic DRILLing). These programs are aimed at using numerical models, like those used in this study, integrated with geological data from Antarctic outcrops, offshore seismic surveys, and stratigraphic drilling, to explore the climatic and glacial history of the Antarctic region through the entire Cenozoic.

<http://www.ace.scar.org>



The Heart Mountain Fault: The Electron Backscattered Diffraction (EBSD) View of an Old Problem

Peter Crowley, Amherst College

For more than a century, geologists have argued about the nature of the Heart Mountain Fault (HMF) in Northwestern Wyoming. The HMF is a very low-angle surface that separates a SE-transported hanging-wall of Paleozoic carbonate rocks and Eocene volcanic rocks from an autochthonous footwall of Paleozoic through Eocene sedimentary rocks. Although the HMF allochthon extends for more than 100 km across the Bighorn basin, it has a geometry that is similar to that of a landslide. Near its head it cuts down section like a normal fault but near its toe, it ramps up section like a thrust fault. For much of its exposed length, the HMF follows a stratigraphic horizon or decollement that is approximately 1-2 meters above the base of the Bighorn dolomite. Although there is general agreement about the geometry of the HMF, controversy exists about the mechanism and rate of formation of the HMF. Is the HMF a landslide that formed at a catastrophic rate over a period of minutes to hours or is the HMF a fault that formed at plate-tectonic velocities over ca. 10^6 years.

The HMF itself is marked by a thin (generally mm's to cm's thick) layer of microbreccia. The microbreccia occurs in part as clastic dikes that intrude into the HMF hanging wall. Delicate and wispy clasts interpreted to be volcanic glass and accretionary lapilli occur in the microbreccia. Taken together, these observations suggest that the microbreccia may have formed from a low density fluid layer and lend support to a catastrophic origin for the HMF. Potential sources for catastrophic fluidization of the HMF include coeval Eocene volcanics and frictional decarbonation of Paleozoic carbonates adjacent to the HMF.

Calcite from the HMF microbreccia and the immediate footwall of the HMF was examined in an attempt to determine the conditions of HMF deformation and to place constraints on the rate of HMF motion. The crystallographic fabric of calcite was determined by EBSD. Calcite in the HMF footwall displays a moderate to weak crystallographic preferred orientation (CPO) defined by a c-axis maximum that is systematically oblique with the normal to the HMF. This CPO formed by low temperature e-twin gliding on twin planes that are sub-parallel to the HMF. Calcite in the microbreccia has a weak CPO defined by a c-axis maximum that is normal to the HMF. A weak e-twin fabric again suggests low temperature deformation of calcite by twin gliding. The orientation of the c-axis maximum suggests that this fabric formed by compaction of the microbreccia following HMF motion. These observations might lend support to a catastrophic origin for the HMF. However, it cannot be by frictional decarbonation of carbonate as the calcite CPO's form by deformation at temperatures well below those at which carbonate could decarbonate.

The Sirius Problem: Clues to Past and Future Stability of the Antarctic Ice Sheets

Steve Roof, Hampshire College

For the last several glacial-interglacial cycles, the ice sheets on Antarctica have remained locked in a deep freeze. Conventional wisdom, based primarily on ocean core records, suggests Antarctic ice sheets have been stable during all of Neogene time. Recently, however, evidence from pre-Quaternary deposits scattered throughout the Transantarctic Mountains provide some controversial evidence that the ice sheets have been warmer and more active than previously believed. The evidence comes from widely scattered glacial, lacustrine, and marine sediments known collectively as the Sirius Group. These sediments clearly show evidence of warm-based glaciers, abundant meltwater, and fossils of plants and insects from much warmer conditions. The age of these deposits, however, is controversial. Diatoms found in the glacial diamicts range from Miocene to Pliocene in age. However, some scientists argue that these diatoms were introduced by wind transportation and therefore are not age diagnostic. These scientists believe Antarctica has been in a deep freeze for at least the last 15 million years and they have good evidence from the Dry Valleys region that the Antarctic climate and landscape has been very cold and stable over this time span. Understanding the past history of the Antarctic ice sheets is critical to help us understand how these ice sheets might respond to future climate change.

I was invited to join a research expedition to Antarctica this past austral summer (November and December 2003) to help interpret the stratigraphy and depositional environments of the Sirius Group deposits exposed at 85 degrees south, adjacent to the Polar Ice Cap and the Beardmore Glacier. We found an amazing variety of glacial sediments, from sub-glacial lodgement tills to water-washed outwash to finely laminated lacustrine deposits. We also recovered numerous plant fossils, including leaves of the Southern Beech (*Nothofagus*) and in-situ small plants. All of these features suggest an environment similar to today's Alaskan proglacial environments. However, we have no age control for these sediments (yet) so our work does not resolve the debate of Antarctic ice sheet stability. I will share our preliminary evidence and discuss the evidence in favor of recently dynamic Antarctic ice sheets and report our plans for helping to resolve this debate.



Cross bedded fluvial sands sandwiched between glacial diamicts, Oliver Bluffs, Antarctica