

26th Annual

FIVE COLLEGES/UNIVERSITY GEOLOGY FACULTY SYMPOSIUM



Thursday, February 24, 2005
Pratt Room 5
Amherst College

Announcing the John B. Reid Jr. Memorial Five College Geology Faculty Presentation: Promoting Observation, Creativity, and Enthusiasm in the Geosciences.

Steve Roof, School of Natural Science, Hampshire College

John Reid was a professor of geology at Hampshire College for over 30 years but we lost him to cancer in 2003. From skating rocks in Death Valley to meandering rivers in Massachusetts to strontium geochemistry of Icelandic sheep's teeth, John inspired us all with his amazing ability to find and develop unique and fascinating projects. Not all of these projects were successful, but he cheerily pursued trivial questions for the joy and insight they provided. John taught us all how to observe every day situations and look beyond the obvious, to explicitly observe the minute details we too commonly overlook. A photo of a burned out candle could provide hours of discussion – why does a moat of wax form around the lip? Why is there an upstanding pinnacle of wax left where a drip ran down the side? John would help us define dozens of careful observations, then he would encourage us spin creative interpretations. He usually led us on a path that deepened our understanding of Earth processes.

Scientific inquiry is fertilized by keen observation and abundant creativity. John would often display these traits at Five College Geology events like this one. To keep the spirit of John's creativity and passion for observing and questioning alive, the chairs of the Five College Geology departments have initiated the John B. Reid Jr. Memorial Presentation. Each year at the Five College Geology Faculty Symposium, an honored faculty member will have the opportunity to present their more creative and speculative ideas. Probably none of us will be able to generate them as fast as John Reid did, but we hope his spirit will inspire us to observe the minute details and generate the perceptive questions that lead to insightful new ideas.

I will probably now fail completely in this challenge!

In recently glaciated regions, there are not many options for determining when glaciers last retreated. A traditional dating method relies on lichens growing on boulders in the glacierized rubble. It is assumed that lichens colonize the bare rocks following glacier retreat and grow larger over time. If we know how fast the lichens grow, we can potentially determine the time since the glaciers retreated by the size of the largest lichens. The trouble is, no one really knows how fast lichens grow in different environments! Back in 1984 and 1985, Al Werner measured dozens of lichens on glacial moraines on the far northern Arctic islands of Svalbard that were created by ice advances during the Little Ice Age. He and I returned to these sites in 2002 and 2004, and were able to find the same boulders, and re-measure the exact same lichens. We analyzed the changes in size and shape of the lichens using digital photographs and GIS analyses. Conventional wisdom (based on quite a few studies and publications) says that small, presumably young, lichens grow fast whereas larger, presumably old, lichens grow more slowly. We have found the opposite results – larger lichens seem to have grown faster than small ones. I will share with you our observations and data, and perhaps you can help us solve this enigma.

The Art and Science of Economic Geology – Exploration for gold and the effect of fluorine activity on magmatic features

Lawrence D. Meinert, Department of Geology, Smith College,
Lmeinert@smith.edu

Although classic images of gold exploration involve sourdoughs panning gold in far away streams, modern exploration uses basic chemical and physical principles to understand the movement, concentration, and precipitation of the noble metal in the earth's crust. In the Seward Peninsula of Alaska gold was (re)discovered in a complex structural setting near the brittle/ductile transition. Mapable fabrics in the rocks led to studies of phase separation of aqueous-carbonic fluids, the proximal cause of gold precipitation. In a sense, the new Smith fluid inclusion lab led to a gold discovery.

Another exploration program for Cu and Zn led to the discovery of extremely vermicular textures in quartz phenocrysts at the Empire Cu-Zn skarn deposit associated with the Mackay Stock in central Idaho and similar features at the Antamina deposit in Peru. What do these phenocrysts tell us about fundamental magmatic-hydrothermal processes?

SEM-CL analysis reveals cryptic, concentric primary bands in the vermicular quartz phenocrysts, that are crosscut by deep embayments, with the bands curving toward the embayments and pointing toward the interior. Fluid inclusions in quartz phenocrysts contain multiple daughter minerals including fluorite. Th ranges from 420 to >700°C, suggesting a magmatic origin of the high F activity fluid consistent with fluorite as an accessory mineral and high F content in magmatic biotite (1.43-3.80 wt%) and amphibole (1.53-3.03 wt%). These features are explained by a bubble nucleation model in which the F-rich hydrothermal fluid acts as a chemical drill to form the vermicular texture. Further consumption of red wine will be necessary to understand the complete implications of this model.

Proterozoic Metamorphism in the Tobacco Root Mountains, Montana: The Big Sky orogeny

Jack Cheney, Department of Geology, Amherst College
with John Brady, Department of Geology, Smith College, Tekla Harms, Department of Geology, Amherst College, and Bob Burger, Department of Geology, Smith College

There are three suites of Precambrian rocks in the Tobacco Root Mountains (TRM): the Indian Creek Metamorphic Suite (ICMS), the Pony Middle Mountain Metamorphic Suite (PMMMS), and the Spuhler Peak Metamorphic Suite (SPMS). The ICMS and PMMMS are quartzofeldspathic gneiss suites that contain variable amounts of meta-supracrustal rocks. The SPMS contains primarily mafic volcanic rocks and was possibly ocean crust. Metamorphosed mafic dikes and sills (MMDS) that intruded the ICMS and the PMMMS, but not the SPMS, indicate assembly of the terrane after intrusion of the dikes at ~2060 Ma.

Textures and mineral assemblages (ky+opx) are consistent with early metamorphism of all rocks at $P > 1.0$ GPa followed by differential re-equilibration on a clockwise P-T path at lower pressures (0.6-0.8 GPa). Partial to complete overprinting of the coarse-textured, high-pressure assemblages, with lower-pressure assemblages and textures (cord+opx & cord+saph symplectites) occurred across the TRM, especially where assisted by the availability of water. The development of these features appears to require nearly isobaric cooling at pressures near 0.8 GPa, followed by nearly isothermal decompression at temperatures near 700°C. The resulting P-T path is believed to be the result of tectonic denudation late in the orogenic cycle.

Two-hundred and seventy-two $^{207}\text{Pb}/^{206}\text{Pb}$ spot ages of monazite grains from seventeen SPMS, five PMMMS, and eight ICMS rocks have been obtained from the UCLA ion microprobe. Based on the distribution of the ages, the samples can be divided into three groups. (1) All seventeen SPMS, one PMMMS and two ICMS samples have relatively homogeneous spot age populations that vary from ~1720 to ~1780 Ma. (2) A group of seven ICMS and PMMMS samples has spotages from monazite grains that form an array near 2450 Ma. (3) A group of four ICMS and two PMMMS samples are bimodal in that they contain spot ages from both the 1720-1780 Ma group and the 2450 Ma array. There are younger and a few older spot ages in these samples that likely represent mixed age domains, the former between the 1720-1780 Ma and the 2450 Ma age domains and the latter between older detrital grain cores and the 2450 Ma array.

The near absence of $^{207}\text{Pb}/^{206}\text{Pb}$ ages older than 1780 Ma in the SPMS and the common occurrence of these ages in monazites from the ICMS and PMMMS are consistent with assembly of the Tobacco Root suites during a prolonged 60 Ma collision event, the Big Sky orogeny, beginning at ~1780 Ma and culminating at ~1720Ma. These results are consistent with a sequence of early Proterozoic events that significantly overprinted an earlier ~2450 Ma orogenic event. This older event modified pre-existing Archean rocks.

Coupled Processes in Hydrogeology: Fluids and Fractures

David Bout, Geosciences Department, University of Massachusetts,
dboutt@geo.umass.edu

Fluids play a fundamental role in many geological processes, operating over huge spatial and temporal scales. Fluids can be responsible for energy transfer, mass transfer, and even the mitigation of tectonic stress. Understanding the role of fluids in these processes often requires a multifaceted approach using combined techniques and data from a variety of sources. In this talk I present a brief example of this type of interdisciplinary work focusing on the role of fluid pressure in the genesis of opening mode fractures in the shallow crust. In laboratory experiments I show that regions of elevated fluid pressure can fracture the rock in an extension mode. Numerical modeling of the system using discrete numerical models extends the laboratory observations and investigates the role of permeability and storage on resulting fracture distributions. The permeability of the system is shown to play an important role in fracture genesis.

An assessment of interactively coupled paleoclimate-vegetation models

Persaram O. Batra, Mount Holyoke College

Accurately modeling future climates is becoming more and more critical. Interaction between the land surface and the atmosphere has been shown to be a key component of climate models. Failure to include realistic vegetation-climate interactions can cause significant discrepancies in predicted surface temperature and precipitation. In this study, four different vegetation models – BIOME4, EVE, IBIS and SIVM – were coupled to the GENESIS global climate model and simulations run for four paleoclimatic time periods in the Miocene and late Pleistocene. The simulated vegetation from each model was compared to observed paleo-distributions derived from pollen and plant macrofossils. The BIOME4 model best reproduces the paleovegetation, and analysis suggests that this is at least in part due to its inclusion of parameterizations of fire disturbance and the effects of atmospheric carbon dioxide levels on plant growth. Furthermore, using one model instead of another can result in differences in simulated regional temperature of up to 4 °C for annual means and 7 °C for seasonal means, confirming the need to use accurately modeled vegetation in climate models.