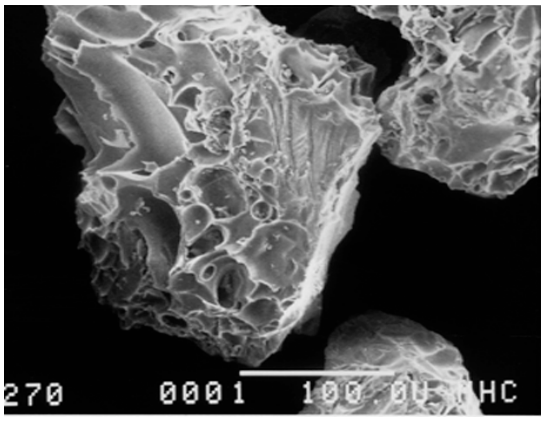
24th Annual

Five College Geology Faculty Symposium

November 21, 2002, 3:30pm
Red Barn, Hampshire College

PROGRAM

3:30	Welcome/Introductions
3:35	**Al Werner, Mount Holyoke College** Using small kettle ponds to reconstruct Holocene volcanic ash fall, Upper Cook Inlet, Alaska
3:55	**Whitey Hagadorn, Amherst College** Inside ancient animal embryos and algae – Computed tomographic analysis of Neoproterozoic multicellular eukaryotes
4:15	**Steve Petsch, University of Massachusetts** Interactions of chemical, biological and physical processes during weathering of black shale
4:35	**Jason Tor, Hampshire College** Metabolism of organic compounds in anaerobic, hydrothermal sulfate-reducing sediments
4:55	**Bosiljka Glumac and Lisa Berrios, Smith College** Origin of large serpulid aggregates: Insights from stable isotope compositions of recent examples from Baffin Bay, Texas
5:15	Pizza and Refreshments



Characteristic volcanic ash found in southern Alaska kettle ponds. Al Werner photo.

Using small kettle ponds to reconstruct Holocene volcanic ash fall, Upper Cook Inlet, Alaska

Al Werner
Mount Holyoke College

Volcanic ash is both a blessing and a curse. Geologically, ash layers can provide important timelines for stratigraphic correlations, but as an environmental hazard, ash can be costly and dangerous. Ash fall in a metropolitan area results in significant impacts on city activities and poses a serious threat to aircraft in the region. A commercial flight with over 200 passengers bound for the Ted Steven's International Airport, for example, flew through an ash cloud during the 1989 eruption of Mt. Redoubt, and temporarily lost power to all four engines. Although an engine was restarted and the plane landed safely, the incident caused $80 million dollars in damage to the aircraft and served to increase awareness of this hazard. Anchorage Alaska located in upper Cook Inlet is located downwind from the Aleutian Island Arc, a chain of 80 volcanoes associated with the subduction of the Pacific plate under the North American plate. Over half of these volcanoes have erupted historically including five volcanoes within 250 km of the metropolitan area.

I, together with MHC students and colleagues from Northern Arizona University and the Alaska Volcano Observatory are working to provide a better understanding of Holocene ash fall in the upper Cook Inlet region. Simply put, we want to evaluate historic ash fall in the context of the Holocene record of ash fall. Our approach is to recover sediment cores from small kettle basins having well-vegetated, low-relief drainage basins. Lakes provide a continuous stratigraphic context and organic matter from the surrounding sediment can be ^{14}C dated for age control. Fourteen cores from three lake basins have been studied and correlated. Ash layers generally occur as prominent light bands in the core stratigraphy, exhibit bubble wall textures – glass shard morphologies and are associated with elevated magnetic susceptibility (MS) and low organic matter content (LOI). The elevated MS values appear to be due to magnetite grains occurring with (and within ash grains), whereas, the decrease in LOI is thought to be the result of dilution. The resulting ash stratigraphies exhibit remarkable intra and inter-basin correlations lending confidence to the lake records.

Historically, 6-8 ash fall events (ranging from light dustings to several millimeters) have occurred during the last century. Extrapolated for the entire Holocene, one might expect ca. 600 to 800 ash layers in the lacustrine stratigraphy! Although most of the identified layers do show evidence that they represent multiple ash fall events, only 14 ash layers have been identified in the Holocene lacustrine records. Is the last 100 years anomalous regarding volcanic ash fall in the upper Cook Inlet area, or are lakes not the faithful recorders that we imagine them to be? We speculate that factors including; blowing snow, lake ice, bioturbation etc. may complicate these records and we are beginning to question the fidelity and sensitivity of these records to resolve closely spaced and relatively thin ash fall events. Current work is focusing on records from high sedimentation (glacier-fed) lakes and lakes having anoxic bottom water.

Inside ancient animal embryos and algae – Computed tomographic analysis of Neoproterozoic multicellular eukaryotes

Whitey Hagadorn
Amherst College

Phosphatized animal embryos and algae from the ca. 600 Ma Doushantuo Formation provide critical information about the evolution of early multicellular organisms and exhibit spectacular cellular-level preservation. Previous work on these fossils has been limited to examination of their three-dimensional external morphology using SEM or their two-dimensional internal morphology using thin-section observation. These approaches have limited our ability to identify features which can be used to assess the taxonomic affinity of these embryos, largely because three-dimensional internal information is needed to accurately characterize cell numbers, cell morphologies, and features found within individual cells. Using microfocus X-ray computed tomography (microCT), it is possible to begin to bridge this knowledge gap. Preliminary results from analysis of 9 morphotypes of animal embryos, 3 algal forms, and 2 problematic fossils from Doushantuo exposures in the Weng'an region of South China are presented.

For each of these samples, three-dimensional volumes of X-ray attenuation were created. Based on comparison with SEM and thin-section analyses, this attenuation correlates with variations in the mineralogy and density of cell walls and other internal structures. Thus isocontouring and volume rendering of these attenuation variations allows visualization of the internal biological characteristics of the fossils, including the morphology of individual cells, the three-dimensional arrangement of cells, and the nature of possible organelle-like structures, as well as the visualization of inorganic structures such as fractures, pyrite tunnels, and diagenetic voids. For example, models were constructed of the cells that are not exposed on the surface of 16-celled embryos; these cells are 15-sided polyhedrons mostly characterized by flat irregular pentagonal faces. Additionally, 4-celled animal embryos contain two similarly-sized ovoidal structures within each cell; such ovoidal structures have been tentatively interpreted, on the basis of thin-section observations, as organelles by previous authors. With further work, this data can be used to test hypotheses about the number of cells in each embryo, the geometry of individual cells, the orientation of cleavage in embryos and algae, and the nature of organelle-like structures.

Interactions of chemical, biological and physical processes during weathering of black shale

Steve Petsch
University of Massachusetts

Most organic carbon on the earth is contained in sedimentary rocks buried far beneath the surface. Long believed to be largely chemically and biologically inert, the fate of this organic carbon when exposed to oxygenated earth surface environments has been unclear. Certainly, the oxidative weathering of this carbon plays a strong role in controlling fluctuations in the carbon dioxide and oxygen content of the atmosphere. However, rates of this process in natural environments remain largely unexplored.

We have examined the concentration, abundance and biological utilization of sedimentary organic matter during weathering and soil formation on sedimentary rocks. Our study explores the chemical composition of shale organic matter within weathering profiles, and the identity of and carbon sources available to microorganisms living in these environments. From this, a clearer picture of this key component of the global carbon cycle is emerging, one that is much more active and less sterile than had previously been imagined.

Metabolism of organic compounds in anaerobic, hydrothermal sulfate-reducing sediments

Jason Tor
Hampshire College

Previous studies of hot (> 80 °C) microbial ecosystems have primarily relied on the study of microorganisms in pure culture or analysis of 16S rDNA sequences. In order to gain more information on anaerobic metabolism by natural microbial communities in hot environments, sediments were collected from a shallow marine hydrothermal vent system in Baia di Levante, Vulcano, Italy and incubated under strict anaerobic conditions at 90 °C. Sulfate reduction was the predominant terminal electron-accepting process in the sediments. The addition of molybdate inhibited sulfate reduction in the sediments and resulted in a linear accumulation of acetate and hydrogen over time. [U-^{14}C]- acetate was completely oxidized to $^{14}CO_2$, and the addition of molybdate inhibited $^{14}CO_2$ production by 60%. [U-^{14}C]-glucose was oxidized to $^{14}CO_2$, and this was inhibited when molybdate was added. When the pool sizes of short-chain fatty acids were artificially increased, radiolabel from [U-^{14}C]-glucose accumulated in the acetate pool. L-[U-^{14}C]-glutamate, [ring-^{14}C]-benzoate and [U-^{14}C]-palmitate were also anaerobically oxidized to $^{14}CO_2$ in the sediments, but molybdate had little effect on the oxidation of these compounds. These results demonstrate that natural microbial communities living in a hot, microbial ecosystem can oxidize acetate and a range of other organic electron donors under sulfate-reducing conditions and suggest that acetate is an important extracellular intermediate in the anaerobic degradation of organic matter in hot microbial ecosystems.

Origin of large serpulid aggregates: Insights from stable isotope compositions of recent examples from Baffin Bay, Texas

Bosiljka Glumac and Lisa Berrios
Smith College

Serpulids are sessile polychaetous annelids that secrete tubes made of calcium carbonate. Individual encrusting serpulid worms are common in a diverse range of environments, but large serpulid aggregates are fairly rare. To better understand the origin of such aggregates, this study examines isotopic compositions of aragonitic serpulid tubes from Baffin Bay, Texas. This hypersaline lagoon has a small tidal range, 1.5m average depth, 10°-30°C water temperatures, and salinity that averages 40-60‰ and ranges 0-100‰. Serpulid aggregates are rarely exposed and form patch reefs at the bay mouth and larger reef fields within the bay in 0.5 to 2.5m deep waters (Andrews, 1964). Reef fields consist of randomly intertwined tubes, whereas patch reefs have alternating layers of random and oriented tubes. Oriented tubes are nearly straight, vertical, up to 3cm long, with diameters of 1-2mm, and walls 0.2 to 0.3mm thick. Random aggregates have smaller, curved tubes. Radiocarbon dating by others indicates serpulid growth within the last 3,000 years.

Previous isotopic studies suggest that serpulids secrete tubes with $\delta^{18}O$ values in equilibrium with ambient water, but their $\delta^{13}C$ values may deviate by about -7 to -4‰ due to vital effects. Isotopic compositions of oriented tubes from patch reefs in Baffin Bay vary substantially ($\delta^{18}O$=-4.9 to +0.6‰; $\delta^{13}C$=-4.1 to -0.3‰; VPDB), indicating growth under variable conditions. The most negative values correspond to samples from the base of oriented layers, suggesting that their initiation may be promoted by lowered salinity and enhanced input of terrestrial carbon during intervals of increased freshwater input. During formation of oriented aggregates salinity fluctuates, but the water generally becomes more saline. This is suggested by the variable compositions of individual tube segments and by isotopic enrichment of many samples from the uppermost parts of oriented layers. The overlapping compositions of random tubes from the patch reefs and the reef fields suggest similar conditions during their formation. Their $\delta^{13}C$ values (-4.7 to -0.8‰) are similar to those of the oriented tubes, but the random tubes have a narrower $\delta^{18}O$ range (-1.9 to +0.5‰), indicating lower environmental variability during formation of random serpulid aggregates. The results suggest that even though serpulids can grow under extremely variable conditions, which eliminate competing species and allow eurytopic serpulids to flourish, the aggregates of randomly oriented tubes likely form by periodic rapid accumulation of numerous individuals during optimal growth conditions.

Reference cited:

Andrews, P.B., 1964, Serpulid Reefs, Baffin Bay, Southeast Texas, *in* Depositional Environments of South-Central Texas Coast, Field Trip Guidebook: Gulf Coast Association of Geological Societies Annual Meeting, Corpus Christi, Texas, p. 102-120.