Poster Abstracts

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Geochemical and Biological Gradients in the Soudan Underground Mine

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Anoxic, hypersaline shield brines seep into the lowest level (2341 feet below the surface) of the Soudan Underground Mine (Minnesota, USA), through diamond drill holes created in the early 1960's. Shortly after the diamond drill holes were made, mining activity in the 2.7 billion year old banded iron formation ceased, and the entire site was turned over to the Department of Natural Resources where they have carefully preserved and maintained the site as a State park. Overtime, the brine water has formed a stable flow system along the West tunnel where stark gradients of water chemistry, mineralogy and microbiology occur and form iron microbial mats of varying morphologies. These stark gradients are due to the anoxic brine reaching an oxygenated environment where biotic and abiotic processes compete for chemical utilization, forming stable niches along the flowpath. Strong gradients occur (anoxic to oxic, neutral to acidic, methanogens to proteobacteria) on the scale of centimeters to tens of meters as additional diamond drill holes contribute fresh brine to the flowpath. While the population of microbial communities is changing along with the geochemical gradients, it is unclear if the microbes are occupying the sites due to the geochemical niche already present, or if they are actively changing the geochemical environment using metabolic processes to provide a suitable niche where they can establish stable populations. In-situ water chemical measurements, microbial ecology, scanning electron microscopy, organic and inorganic total elemental analysis, X-ray adsorption spectroscopy, scanning transmission X-ray microscopy, magnetism, Mössbauer spectroscopy, and X-ray scattering were performed to present a biogeochemical perspective as to how this complex system forms and changes, spatially and temporally.

Designing a Smart Well Field to Optimize Groundwater Production Costs

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Municipal well field operators face many factors that drive up the cost to produce water. Energy to extract groundwater, treatment to remove natural and manmade constituents, infrastructure for distribution systems, and operation and maintenance costs all require management by well field operators. Many well fields were constructed decades ago and have been expanded piece by piece in response to population growth. As such, there is a tendency to seek out and favor incremental improvements rather than large-scale changes. Smart well field technology can be added incrementally to achieve cost improvements.

Components of an optimal well field design include:

- Wells that yield the most available water with the least amount of head based on the aquifer and well hydraulics;
- Wells that produce clean water that is protected from existing and future contamination sources; and,
- Wells that provide continuous feedback to managers with which to assess their operational status and efficiency.

The smart well field technology includes equipping wells with continuous water level measurement sensors for compilation in the SCADA system along with flow rates and other information. Innovative computer technologies are then used for sophisticated trend analysis essential for understanding the dynamic operation of the system. Kriging algorithms and other visualization tools enhance this understanding in real time or for any segment within the period of record. Thus, a smart well field can minimize energy costs for pumping – for example by analyzing well interference, highlight the need for basic well maintenance, and focus well head protection areas for existing and proposed wells. Examples of these uses are presented on this poster.

Determination of Deicing Ions (Na+ and Cl-) in the Kinnickinnic River

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Specific conductance and NaCl concentrations were monitored in the Kinnickinnic River at two sites near River Falls, WI during the spring of 2013. The purpose was to: determine the nature of dissolved NaCl in the river, compare the mass of NaCl municipally applied with an experimentally determined mass present in the river, identify a potential relationship between specific conductance and dissolved NaCl, and compare NaCl concentrations with biota toxicity limits. Analysis of ions in the river indicated a one-to-one stoichiometric ratio between sodium and chloride, suggesting an anthropogenic source. Baseflow surveys and USGS data were used to determine unique discharges downstream; mean monthly salt concentrations and cumulative discharge downstream were used to determine a salt load generated between the two sites. The City of River Falls applied 1,373 tonnes of deicer during the 2012/13 winter; private and commercial entities were not considered. It is estimated that a wastewater treatment facility contributed an additional 157 tonnes of NaCl to the river. Water sample analysis accounted for the presence of 780 tonnes NaCl in the river during the study. Sodium chloride concentrations did not exceed a threshold required to dominate specific conductance readings. Downstream maximum and mean chloride were 93.4 mg L-1 and 35.5 mg L-1 respectively, which is below the toxicity threshold of most organisms. It is unlikely that NaCl loading poses a significant threat to the Kinnickinnic River.

Minnesota Well Owners Organization – MNWOO
A New Nonprofit for Private Well Owners

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The Minnesota Well Owner's Organization (MnWOO) was recently incorporated to provide education and resources to private well owners so that they can preserve, protect and restore Minnesota's groundwater. MnWOO recognizes that there are 1.1 million private wells in the State and that the owners of these wells may not be knowledgeable about the hydrogeology, laws, policies, and behaviors affecting their well water. To bridge the gulf between well owners and groundwater policy makers and scientists, MnWOO will provide practical information and services to well owners so they understand their rights and responsibilities as a private water utility. MnWOO, moreover, will advocate for well owners to protect their rights to clean water. Private well owners have a large affect on an important Minnesota resource – groundwater. MnWOO will be an effective partner to speak on behalf of Minnesota's well owners.

Large Isotopic Database on Lacustrine Carbonates of the Horse Spring Formation Characterizes the Extreme Variability of Continental Rift Lakes

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The Oligo-Miocene Horse Spring Formation (HSF) in the Lake Mead region of southern Nevada comprises a thick and diverse suite of continental clastic and chemical sediments that formed in pre- and synextensional basins. Paleozoic marine limestones and dolomites encompassed these basins, providing a vast carbonate source. As a result, lacustrine carbonates form thin (1-5 m) to very thick (100-200 m) accumulations in the HSF that show microbially-influenced calcite precipitation and a lack of higher-order organisms. Thus, these carbonates formed in alkaline lakes that were inhospitable to multi-cellular life. We have lithologically and isotopically characterized four stratigraphic intervals in the HSF, yielding a database of >740 isotopic observations that highlight temporal and lateral variation in these significant lacustrine units. δ18O of pre-extensional lakes range over 19‰, from -18-1‰, with δ13C ranging from -5-6‰, reflecting a complex range of groundwater and meteoric inputs and a patchwork of ephemeral, short-lived lakes and wetlands.

Peak extension is recorded by the second stratigraphic interval, the Thumb Member. Lacustrine carbonates are limited in lateral extent and show less isotopic variability, but are enriched with respect to δ13C, suggesting either higher primary productivity and/or a spring-fed source. As extension evolved into transtension, a large lake formed, exemplified by the third interval the Bitter Ridge Limestone Member. This unit is isotopically similar to earlier lakes in terms of δ13C, but shows a strong (3-4‰) δ18O depletion that we interpret as potentially climatically forced, with a shift toward more aridity. The final stratigraphic interval shows a return to smaller lakes that are isotopically similar to those of the Thumb Member with respect to δ18O, but have a very wide range and strong enrichment in δ13C (0 to 14‰). Interbedded tuffs are common in this unit and the River Mountain volcanic field, located nearby, was active during this time interval. We attribute the carbon enrichment to hydrothermal activity associated with this magmatism, although there is a lack of travertine facies that might be expected if hot springs were more prevalent. All told, these deposits and their chemistry illuminate a wide range of lake chemistries possible during continental rifting.

The Evolving Environmental Geology Concentration at St. Cloud State University: Soliciting Feedback

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The Atmospheric and Hydrologic Sciences Department at St. Cloud State University recently established an Environmental Geology Concentration. The aim of the concentration is to provide students with a pathway to careers in environmental geology across the spectrum of consulting, state and federal agencies, watershed districts, and nonprofit organizations. The concentration also provides a means for the Atmospheric & Hydrologic Sciences Department to package the existing geology courses in a manner that both attracts students and prepares them for employment. The concentration draws on courses across multiple colleges (College of Science and Engineering, School of Public Affairs, College of Liberal Arts), and is multidisciplinary in nature. The aim of this poster is to solicit feedback on the content and structure of the concentration. We would like to know whether you think that the courses included prepare students adequately for employment. Our questions for you include: What is missing? What could be eliminated? How much math, physics, and chemistry should be required vs. recommended? We will be able to request some changes to the concentration if we are able to demonstrate that potential employers have reviewed, commented on, and made specific suggestions regarding the concentration.

The Effects of Water Discharge on Suspended Sediment Concentrations in the St. Croix River, MN/WI

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Suspended sediment transport is an important part of a dynamic river system. It is especially important for the freshwater mussel population in the St. Croix River, because they depend on suspended material in the water column to survive. In addition, they burrow into bed sediment and are sensitive to grain size distribution there. Dams like the St. Croix Falls Dam can impede and change the rate of suspended solid transport, affecting downstream habitat. Due to a decline in juvenile mussel density below the St. Croix Falls Dam over the past two decades dam operations have been scrutinized. The goal of this project was to better understand the factors that affect sediment transport.

We focused on determining if relationships between SSC and water discharge changed seasonally or annually, as well as comparing the relationships between sites. In addition, we constructed an annual sediment budget each site to consider the role the St. Croix Falls Dam has on the mussel beds downstream. This was done by taking biweekly water samples during the annual flow cycle from 2008 to 2011 at four sites along the river, two sites above the the dam, and two sites below. The samples were filtered, dried, and weighed to determine total suspended solids (TSS) concentration. The filters were then burned and weighed again to determine the suspended sediment concentration (SSC). We found that water discharge and rainfall events influence sediment transport, with low water discharge and flashy discharge decreasing the correlation between water discharge and SSC. The sediment budget for the river shows a decrease in SSC in the reservoir above the dam, and an increase in sediment below the dam. This indicates that sediment is being trapped in the reservoir above the dam, and then may be periodically moving across the dam. It is also possible that there is a source of sediment between the dam and the sampling site. These results indicate that the St. Croix Falls Dam is impacting sediment transport in the St. Croix River, and as a result may be impacting the downstream mussel beds.