Geochemical and Biological Gradients in the Soudan Underground Mine

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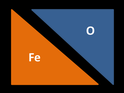
Background

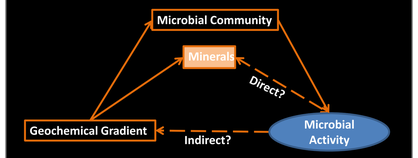
Anoxic, hypersaline shield brines seep into the lowest level (2341 feet below the surface) of the Soudan Underground Mine (Minnesota, USA), through diamond drill holes created in the early 1960's. Shortly after the diamond drill holes were made, mining activity in the 2.7 billion year old banded iron 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

Investigating Opposing Fe-O Gradients



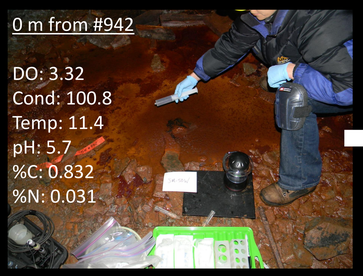
Mechanisms

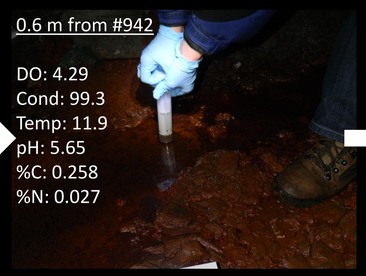
These stark gradients are due to the anoxic brine reaching an oxygenated environment where biotic and abiotic processes compete for chemical utilization, forming stable niches along the flowpath. Strong gradients occur (anoxic to oxic, neutral to acidic, methanogens to proteobacteria) on the scale of 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.

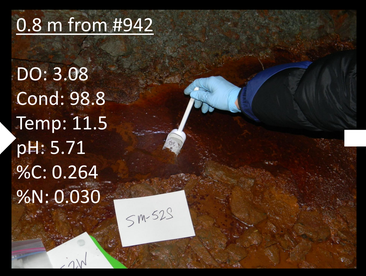


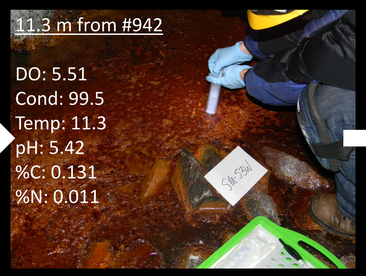
Analysis

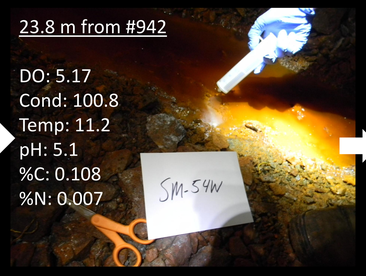
In-situ water chemical measurements, microbial ecology, scanning electron microscopy, organic and inorganic total elemental analysis, X-ray adsorption spectroscopy, scanning transmission X-ray microscopy, magnetism, Mössbauer spectroscopy, and X-ray scattering were performed to present a biogeochemical perspective as to how this complex system forms and changes, spatially and temporally.

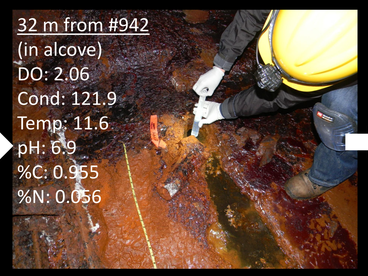




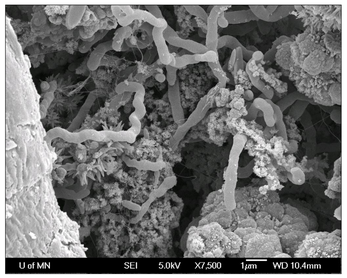




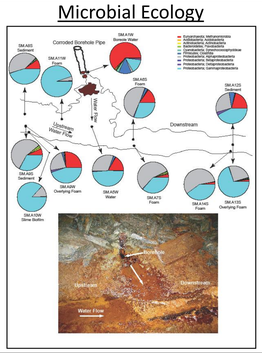




Scanning Electron Microscopy

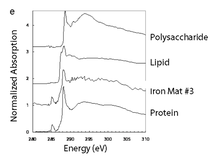


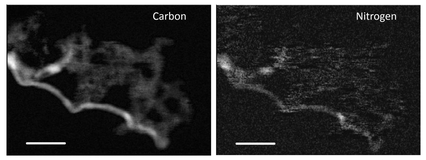
Microbial Ecology



Scanning Transmission X-ray Microscopy

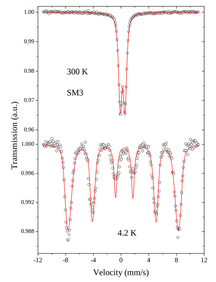
Carbon Spectra: Protein-like



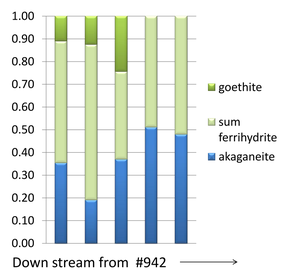


1 μm

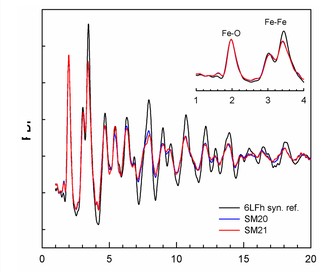
Mössbauer Spectroscopy

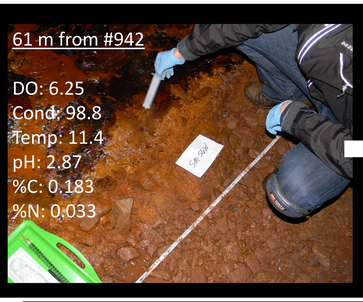


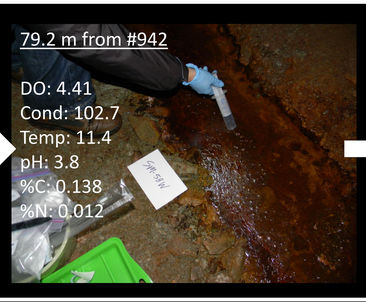
Extended X-ray Adsorption Spectroscopy

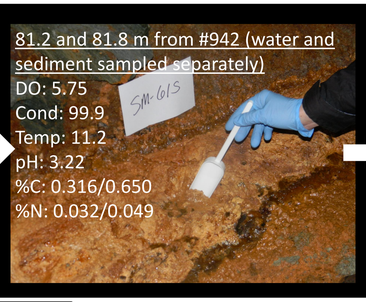


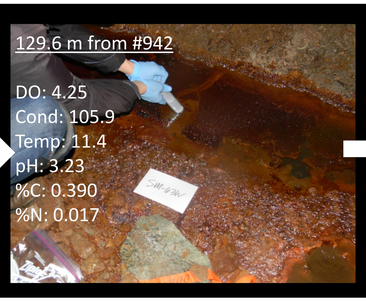
X-ray Scattering

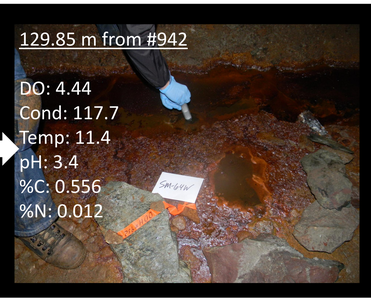




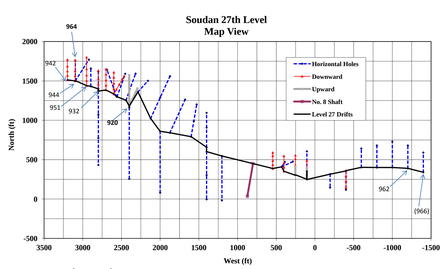




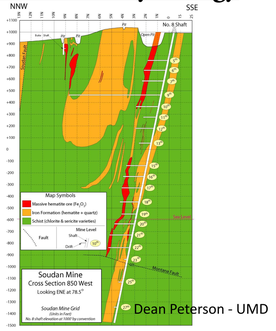




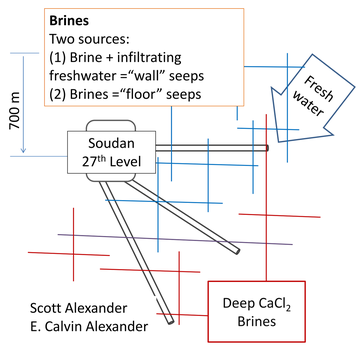
Structure and Hydrology



Scott Alexander
E. Calvin Alexander



Dean Peterson - UMD



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Future Work

1. Full biotic and abiotic geochemical modeling of West-end flowpath
2. Microbial ecology, cell-counts, and FISH of co-registered samples of full flowpath
3. Mineral characterization of co-registered samples
4. In-depth magnetic study of FeOOH mineral suite found in flowpath

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Minnesota State Parks