Natural Attenuation of Acid Mine Drainage from Microcosms of Davis Mine in Rowe, Massachusetts

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Introduction

Acid Mine Drainage

Acid mine drainage (AMD) is an acidic, iron-rich leachate that is generated when sulfur-rich minerals are exposed to oxygen and moisture. See picture on left.

- Generation of AMD involves both geochemical and microbial processes. The resultant product, sulfuric acid, acidifies the water, which dissolves contaminants in the water system.
- Typically, AMD is exacerbated because of mining activity, thus AMD has become a widespread problem occurring in every industrial nation.

Natural Attenuation

- In some instances, AMD is naturally attenuated by the system.
- Davis Mine in Rowe, Massachusetts is an AMD site where natural attenuation is occurring. See picture on left.
- Within a few hundred meters from the mine effluent, the acidic leachate is neutralized and the heavy metal content decreases.
- This self-remediating phenomenon involves both geochemical and biological processes. However, microbial sulfate reduction and iron reduction are believed to be the main processes responsible for attenuation at Davis Mine.

Davis Mine: Study Site

- Between 1882 and 1911, Davis Mine was mined for pyrite and copper.
- Located in Rowe, Massachusetts, the mine was abandoned in 1911 after its collapse.
- Davis Mine is an AMD site where natural attenuation is occurring.
- Over the past 20 years of monitoring, consistent zones of AMD generation and attenuation have been identified.
- It is from these zones that the microcosms were constructed from.

Objective

To study the process of natural attenuation through the use of Microcosms of Davis Mine.

Methods

Microcosms

- Batch-type experiments of environmental samples.
- Allows easier measurement of microbial activity under controlled laboratory conditions.
- Samples were incubated in the dark, under anaerobic conditions at 12°C or 16°C (incubation temperatures reflect measured average temperatures of the sediment during the winter and summer months).
- Compare microcosms of AMD attenuating and generating zones by stimulating microbial activity by varying the substrate and nutrients, or incubation temperature.
- The pH was measured over time to detect changes in the acidity.
- The ORP (oxidation-reduction potential) was measured to indicate whether reduction reactions are occurring within the microcosms. Reduction reactions like sulfate reduction are brown reactions that contribute to natural attenuation.

Unamended Microcosms

- Unamended microcosms contain only the groundwater and sediment from their respective zones.
- Throughout incubation, microcosms displayed characteristic pH and ORP measurements.
- Microcosms of the AMD attenuating zone have higher pH and lower ORP throughout the incubation than microcosms of AMD generating zone.
- Unamended microcosms also appear in samples with higher pH.
- Microcosms were amended with algae collected from the site as a source of organic substrate.
- Microcosms of the AMD attenuating zone have higher and increasing pH. The measured ORP is lower and drops faster than the microcosms of the AMD generating zone.
- Black precipitate also appeared in the microcosms of the AMD attenuating zone. Black precipitates are an indication of sulfate reduction, an AMD attenuating process.

Algae Amended Microcosms

- The pH of the microcosms of the AMD attenuating zone is larger and increases over time, while the ORP continues to drop faster than the ORP of the microcosms AMD generating zone.
- Black precipitate also appeared in the microcosms of the AMD attenuating zone. Black precipitate are an indication of sulfate reduction, an AMD attenuating process.

Amended with Glycerol, Nitrogen, and Phosphorous

- An increase in pH and a decrease in ORP indicates attenuation of acid mine drainage.

Future Work

- Measure concentration of sulfate over time.
- Measure concentration of reduced iron over time.
- Measure dissolved organic carbon over time.
- Characterize microbial community.

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Conclusion

- Higher pH and lower ORP were measured in all microcosms of the AMD attenuating zone.
- Higher incubation temperature resulted in a larger and faster increase in pH.
- Black precipitates, an indication of an attenuating reaction, appeared in samples with higher pH.
- pH of microcosms amended with algae was higher than glycerol, nitrogen, and phosphorous amended microcosms for the first 80 days of incubation.