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

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Presentation Outline

• Background
  • Acid Mine Drainage
  • Natural Attenuation
  • Study Site – Davis Mine

• Objective

• Study Overview
  • Microcosms

• Results

• Conclusions

• Future Study
Acid Mine Drainage

- Natural process propagated by mining activity
- Created by both geochemical and biological factors.
- Condition of high acidity
- High concentration of dissolved metals.
- Toxic to Aquatic life.

Geochemical:
\[
\text{FeS}_2 + 3.5 \text{ O}_2 + \text{H}_2\text{O} \rightarrow \text{Fe}^{2+} + 2 \text{SO}_4^{2-} + 2\text{H}^+
\]

Biological: \textit{Thiobacillus ferrooxidans}
\[
7 \text{Fe}^{2+} + 1.75 \text{O}_2 \rightarrow 7 \text{Fe}^{3+} + 3.5 \text{H}_2\text{O}
\]

Geochemical:
\[
\text{FeS}_2 + 14\text{Fe}^{3+} + 8\text{H}_2\text{O} \rightarrow 15\text{Fe}^{2+} + 2\text{SO}_4^{2-} + 16\text{H}^+
\]
Natural Attenuation

- Self-remediating process
- pH increases to neutrality
- Decrease in dissolve metals.
- Process involves microbial and geological processes.
- Microbial sulfate reduction and iron reduction are main processes responsible for attenuation.

Sulfate Reduction:
\[ \text{SO}_4^{2-} + 8\text{H}^+ \rightarrow \text{H}_2\text{S} + 2\text{H}_2\text{O} + 2\text{OH}^- \]

\[ \text{H}_2\text{S} + \text{M}_2^+ \rightarrow \text{MS} + \text{H}^+ \]
Davis Mine as a Model

- Rowe, Massachusetts
- Mined for copper and pyrite
- Abandoned in 1911
- Acid mine drainage (AMD) site
- Natural Attenuation
- Consistent zones present over the past 20 years.
Objective

To study the process of Natural Attenuation through the use of Davis Mine Microcosms.
What are Microcosms?

- Batch experiments of environmental samples.
- Allows easier measurement of microbial activity under controlled laboratory conditions.
Overview of Study

- Microcosms
  - Unamended
  - Glycerol+N+P Amended
  - Algae Amended
- Measurements
  - pH
  - ORP (oxidation-reduction potential)
Davis Mine Sampling Sites

• AMD Attenuating
  – Higher measured pH
  – Lower concentration of sulfate and dissolved metals

• AMD Generating
  – Lower measured pH
  – Higher concentration of sulfate and dissolved metals
Unamended Microcosms

- Throughout incubation, microcosms displayed characteristic pH and ORP measurements.
- Microcosms from AMD Attenuating zone has higher pH and lower ORP.
**Algae Amended Microcosms**

- Microcosm of Attenuating Zone has higher pH and lower ORP.
- Black precipitate in microcosms of Attenuating zone, indication of Sulfate reduction.
Amended with Glycerol, Nitrogen, and Phosphorous

- Black precipitate appears in Microcosms of AMD Attenuating zone.
- Indication of microbial sulfate reduction.
pH Differences of Microcosms

- **AMD Attenuating:**
  - Unamended
  - Glycerol + N + P
  - Algae

- **AMD Generating:**
  - Unamended
  - Glycerol + N + P
  - Algae

- **Killed Controls:**
  - AMD Attenuating
  - AMD Generating
Unamended Microcosm at Higher Temperature

- The differences in pH is greater.
- pH increases faster.
- ORP drops faster.

Unamended Microcosms (16°C)

AMD Attenuating
AMD Generating

Day

pH

0  20  40  60

Days

ORP (mV)

0  20  40  60

0  100  200  300  400

Unamended (16°C)

AMD Attenuating
AMD Generating
pH Differences with Varying Temperature

- AMD Attenuating Unamended: 12ºC, 16ºC
- AMD Generating Unamended: 12ºC, 16ºC
Conclusions

• Higher pH and lower ORP were measured in all microcosms of AMD attenuating zone.
• Increasing temperature resulted in a larger and faster increase in pH.
• Black precipitates appeared in samples with higher pH.
• pH of microcosms amended with algae was higher than glycerol, nitrogen, and phosphorous amended microcosms.
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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