Water and Mining

ENSC 407 Global Water Issues
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Mining

Uniqueness of mining relative to other industry:
- deposits have a fixed location
- mine life is limited by ore reserves
- 90 to 99% of material processed is discarded

Impact of Mining on Water

- Surface and ground water quality may be affected by metal leaching
- Acid rock drainage (ARD) is the largest problem (but not the only one)
- Tailings dam failures may release toxic water
- New mines are required to comply with regulations
- Environmental legacy of abandoned mines and mines in developing world are large problems

Aqueous solutions (effluent, leachate, water) containing hazardous concentrations of metals are particularly problematic.
5 things needed for acid mine drainage

1. Sulfide minerals
2. Oxygen
3. Water
4. Bacteria (*Thiobaccillus*)
5. Absence of calcite

These items are present at many mine sites.

PYRITE OXIDATION BY OXYGEN

\[
\text{FeS}_2 + \frac{7}{2} \text{O}_2 + \text{H}_2\text{O} = \text{Fe}^{2+} + 2 \text{SO}_4^{2-} + 2 \text{H}^+
\]

Other sulfides dissolve under acid conditions:

- PbS (galena) releases Pb
- (Zn, Fe, Cd)S (sphalerite) releases Zn, Fe, Cd

Most of these reactions involve bacteria. This increases reaction rates.

Acid drainage is neutralized by presence of calcite.

\[
\text{CaCO}_3 + \text{H}^+ = \text{Ca}^{2+} + \text{HCO}_3^-
\]

Acidity is consumed

Commonly limits acid generation – calcite may be present naturally or added as part of remediation.

Untreated water at Iron Mountain, California (pH = 0) showing red and white mineral precipitates and green filamentous algae.

History of Iron Mountain, California

- Mined for copper, zinc, gold, silver and pyrite (for sulfuric acid) from 1860’s to 1960’s
- Acquired in 1970’s by pharmaceutical firm in merger
- Sold to mining promoter with no assets
- $150 million spent so far in cleanup

Sludge is trucked to open pit on mountain top.

The pit has capacity for 70 yrs of sludge production. The mine will produce acid waters for >2000 years.
Impact of Iron Mountain on surrounding environment

- Drains into Sacramento river – water source for 70,000 people in local area
- Fish Kills were numerous in the past
- Winter run Chinook salmon endangered in this area

Major Tailings Dam Failures

- **2002** Philippines 250 families evacuated
- **2001** Brazil Tailings traveled 6 km, 5 miners killed
- **2000** China >15 people killed
- **2000** USA Tailings traveled 120 km, fish kill, water supplies damaged
- **2000** Romania Fish kill, drinking water supplies for >2 million people poisoned
- **1998** Spain 1000’s hectares farmland flooded
- **1995** Philippines 12 people killed
- **1974** South Africa 12 miners killed
- **1965** Chile 200 people killed

Tailings flood along Rio Guadiamar just south of mine. April 28, 1998

Flooding near village, 12 hours after spill

Impact of tailings dam spill

- Spilled slurry consisted of acid, metal-rich water and sulfide solids in ratio of 5:1
- Fish (30,000 kg), waterfowl and one water rat killed
- No human injuries (spill at 3 am)
- Miners and farmers both unemployed for > 1 year
- Subsurface impact (groundwater contamination) still unknown

Post-spill Damage

Sampling groundwater
Abandoned gold mines in Nova Scotia

- Arsenic is often associated with gold
- Mercury may be used to extract gold
- Many small abandoned minesites in Nova Scotia are contaminated with both
- These sites are now used for recreational purposes (ATV tracks, clam digging)

Tidal flats (mine tailings) near Goldboro, NS

Sampling tailings and pore water with 'peepers', August 2004

Extracting peepers and analysing water, September 2004

Water quality prediction and environmental monitoring at Canada’s first diamond mine

- Diamond mining is not expected to release toxic metals
- Environmental impact of diamond mining never studied previously
- Arctic waters are very pure
- Diamond mines are in the environmental spotlight, also very profitable

Ekati - Canada’s first diamond mine
Water quality issues at Ekati

- Processing increases Mg, Ca, SO₄ in water
- Small amounts of other potentially toxic metals are increasing
- Treatment may be necessary
- New water licence requirements will be more stringent