

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

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Prairie Creek Mine, Canadian Zinc Cantung Mine

Both mines are near the Nahanni National Park

Virginia Falls

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

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TYPES OF POTENTIAL CONTAMINATION ASSOCIATED WITH MINING.

SOIL **SMELTER EMISSIONS** **AIR**

WATER

Labels in diagram: WASTE ROCK, FLAG, TAILINGS

Secondary Contamination:
 Surface and ground waters, downstream sediments, downwind surface waters and soils.

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Aqueous solutions (effluent, leachate, water) containing hazardous concentrations of metals are particularly problematic.

	Richmond portal, MI	Geno tailings pore water	Giant tailings pore water	Rio Agrio May '99	Canadian Metal Mining Liquid Effluent Regulations	Ontario drinking water stds
pH	6.4	4.1	7.0	4.42	>8.0	6.5-8.5
Fe (mg/L)	18 000	1648	0.17	nd	3	0.3
SO ₄	122 000	9000	3291	833	500	500
Cu	296	2	0.03	0.74	0.3	1
Zn	2160	11	0.30	24	0.5	3
As	60	nd	2.84	0.001	0.5	0.025
Cd	20	nd	nd	0.04	0.005	0.005
Pb	4	nd	nd	0.03	0.2	0.01
		nd = not detected				
		nd = below detection				

Values shown in bold indicated exceedances with respect to the Metal Mining Liquid Effluent Regulations.

Note: Ni, Ra²²⁶ and total suspended solids are also regulated under the Canadian Metal Mining Liquid Effluent Regulations. These regulations fall under the Fisheries Act.

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5 things needed for acid mine drainage

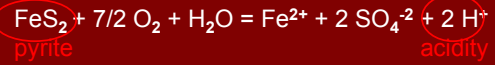
1. Sulfide minerals
2. Oxygen
3. Water
4. Bacteria (*Thiobacillus*)
5. Absence of calcite



These items are present at many mine sites

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PYRITE OXIDATION BY OXYGEN



Other sulfides dissolve under acid conditions:

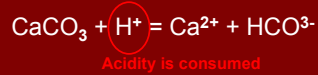
PbS (galena) releases Pb

(Zn, Fe, Cd)S (sphalerite) releases Zn, Fe, Cd

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

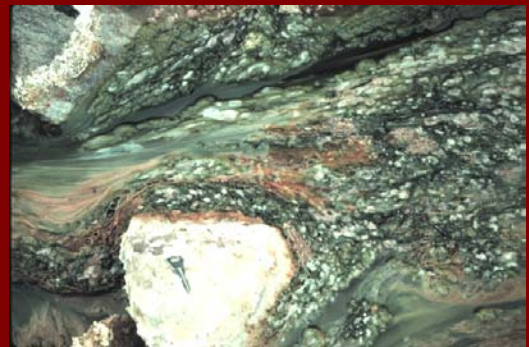
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Acid drainage is neutralized by presence of calcite.



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

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Untreated water at Iron Mountain, California (pH = 0) showing red and whitemineral 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

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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.

Treatment plant produces large quantities of metal-rich sludge.



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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



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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

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



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Flooding near village, 12 hours after spill



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Scraped field just south of mine



Post-spill Damage

Sampling groundwater

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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

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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)

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Tidal flats (mine tailings) near Goldboro, NS



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



Extracting peepers and analysing water, September 2004



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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

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Ekati - Canada's first diamond mine





Water quality issues at Ekati

- Processing increases Mg, Ca, SO_4 in water
- Small amounts of other potentially toxic metals are increasing
- Treatment may be necessary
- New water licence requirements will be more stringent