Mining Impacts

Reading
- Today: Ch. 12 pp. 306-309, also Ch. 16 pp. 424-426
- Wed: Ch. 13

Metal Recycling

Benefits
- resource conservation
- less land disturbed by mining
- saves landfill space
- reduces energy consumption

<table>
<thead>
<tr>
<th>Metal</th>
<th>US % Recycled (2002)</th>
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<tbody>
<tr>
<td>Aluminum</td>
<td>36</td>
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<tr>
<td>Chromium</td>
<td>29</td>
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<tr>
<td>Copper</td>
<td>30</td>
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<tr>
<td>Iron+Steel</td>
<td>58</td>
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<tr>
<td>Lead</td>
<td>71</td>
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<tr>
<td>Magnesium</td>
<td>45</td>
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<tr>
<td>Nickel</td>
<td>45</td>
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<tr>
<td>Tin</td>
<td>20</td>
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<tr>
<td>Titanium</td>
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<tr>
<td>Zinc</td>
<td>26</td>
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</table>

Recycling one kilogram of aluminum can save about 8 kilograms of bauxite, four kilograms of chemical products and 14 kilowatt hours of electricity.
Recycling of other mineral resources

100 million tons of concrete recycled annually in US

Hazardous Work

U.S. Department of Labor
Mine Safety and Health Administration

Fatalities YTD
Total: 14 (as of 4/14/04)
Coal: 7 (04/03/2004)
M/NM: 7 (03/24/2004)

Highwall collapse

Flooding of underground workings
Aggregate Mining and NIMBY

Committee Votes Against Gravel Pit Permit
Wisconsin State Journal :: LOCAL/WISCONSIN :: B5
Friday, April 16, 2004
Sandy Cullen For the State Journal
Members of an Extraterritorial Zoning Committee voted 4-2 Thursday night against recommending a permit for a controversial gravel pit on Highway MM in the town of Oregon, just north of Brooklyn.

About 60 people attended the meeting, half of them wearing green signs that read "No Brooklyn Pit."

Issues: Noise, dust, traffic, landscape degradation, impacts on springs and other water resources

Landscape Disturbance

Pit and strip mining

Collapse and subsidence over subsurface mines
Strip mine reclamation

Revegetation of spoil piles

Grading and accelerated revegetation

Dealing with Mine Subsidence

Detecting and mapping hazardous areas

Insurance

Over 1 million Pennsylvania homes sit on top of old, abandoned mines.

Mine Subsidence Insurance, a non-profit fund administered by the Department of Environmental Protection (DEP), can protect a homeowner's investment. Often for less than $100 a year.
Pit Mines

Water in pits from metallic mines may contain concentrations of metals or other inorganic constituents that greatly exceed water quality standards.

Limestone quarry lake in Florida  Metallic mine pit lake in Nevada

Filled pit Flambeau mine

Mine Dewatering

Treatment and discharge of water

Underground or surface mines
Potential Impacts on Surface Water Features

Discharge from mines near the Humboldt River, NV, currently augments stream flow, but when mining ceases the cumulative loss of ground water will result in lower stream flow.

Recipe for Acid Generation From Sulfide Minerals

Ingredients: sulfide minerals (e.g. pyrite, FeS₂), oxygen, and water.

1. Mix pyrite with atmospheric oxygen and a little water to get sulfuric acid (H⁺) and ferrous iron (Fe²⁺) according to the following reaction:
   \[ \text{FeS}_2 + \frac{7}{2} \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{Fe}^{2+} + 2\text{SO}_4^{2-} + 2\text{H}^+ \]

2. Add more oxygen and water and get even more acid by the reaction
   \[ \text{Fe}^{2+} + \frac{1}{4} \text{O}_2 + \frac{5}{2} \text{H}_2\text{O} \rightarrow \text{Fe(OH)}_3 + 2\text{H}^+ \]
   or get ferric iron (Fe³⁺) by
   \[ \text{Fe}^{2+} + \frac{1}{4} \text{O}_2 + \text{H}^+ \rightarrow \text{Fe}^{3+} + \frac{1}{2} \text{H}_2\text{O} \text{ (consumes H}^+) \]

3. As acid production increases and the pH drops to less than 4, ferric iron (Fe³⁺) is used with pyrite to generate even more acid
   \[ \text{FeS}_2 + 14 \text{Fe}^{3+} + 8 \text{H}_2\text{O} \rightarrow 15 \text{Fe}^{2+} + 2 \text{SO}_4^{2-} + 16 \text{H}^+ \]
Consequences of Acid Production

Fish kills
\[ \text{pH} = -\log_{10}[\text{H}^+] \]

Increased trace metal loading to streams

<table>
<thead>
<tr>
<th>The pH Scale</th>
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<tbody>
<tr>
<td>Acidic</td>
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<td>Neutral</td>
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*Courtesy of Environment Canada (www.ec.gc.ca)*

Acid Mine Drainage at Iron Mountain CA

Acid production at current weathering rates will continue to release effluent for approximately 3,000 years. Remedial actions have greatly reduced metal loads into downstream drainages and the Sacramento River, primarily by capturing the major acidic discharges and routing them to a lime neutralization plant.

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

Stalactite dripping pH = 0.7 water into plastic beaker.
(Photograph by D.K.N. and C.N.A.)
Lead Zinc Mines of SW WI

- Uplift of mountains drives fluid flow through deep basins.
- Warm fluids dissolve trace metals from crustal rocks.
- Ore deposits form in sedimentary rocks at the discharge end of the basin.

Galena with calcite

Solid Waste From Mining

- Animals 39%
- Crops 14%
- Municipalities 5%
- Industry 3%
- Mineral extraction and processing 36%
Mine and Mill Tailings

Potential for mass wasting  Acid and heavy metals in leachate

Tailings Ponds and Dams

Uranium tailings near Moab, Utah
Contaminated ground water discharges to the Colorado River
High ammonia concentrations lethal to fish
Also elevated U concentration
Interim remediation by ground water pump-and-treat system

Tailings dam failure in Spain

BEFORE

AFTER

max displacement 60 m
Other Effluent From Ore Processing

Cyanide leaching of gold ore leads to acidic effluent with high metal concentrations

Smelter Waste

$600 million spent between 1988 and 1994 to reduce sulfur emissions

Table 2: Inco Copper Cliff Release Data (tonnes)

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Flambeau Mine Case Study

Open-pit, copper-gold mine near Ladysmith WI, adjacent to Flambeau River
Mining began in July 1991; reclamation activities completed in 1999.
Open-pit backfilling by blending stockpiled waste rock with limestone to
minimize the potential for the development of acid conditions prior to reflooding
After reflooding, the concentration of dissolved oxygen is greatly reduced and
not available to oxidize the waste rock and produce acidity.

Continued monitoring
of ground water after
reclamation