Mining Wastes Overview

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Assessing the Toxicity Potential
of Mine-Waste Piles Workshop
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U.S. Department of the Interior
U.S. Geological Survey
Types of Mining

- Hard-rock (metallic) mines
- Coal mines (includes coalbed methane)
- Industrial minerals (non-metallic)
- Petroleum (oil and gas)
## Types of Mine Waste

<table>
<thead>
<tr>
<th>Type</th>
<th>Physical Characteristics</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock waste</td>
<td>Igneous, metamorphic, sedimentary; very coarse fragments, unprocessed heterogeneous</td>
<td>High permeability, acidic leachate</td>
</tr>
<tr>
<td>Tailings</td>
<td>Silt size, processed</td>
<td>Wind erosion before consolidation, acidic leachate</td>
</tr>
<tr>
<td>Coal waste</td>
<td>Sedimentary Rock, interbedded coal, processed</td>
<td>Acidic leachate</td>
</tr>
<tr>
<td>Radioactive/ Uranium waste</td>
<td>Processed</td>
<td>Low-level radiation, radon</td>
</tr>
</tbody>
</table>
Hard-Rock versus Coal Mining

Greater amount of rock waste  Lesser amount of rock waste
Complex mineralogy, geology, and alteration halos  Less diverse mineralogy, simple stratigraphy
A variety of mining methods (e.g. underground, open-pit, placer, solution)  Underground and (or) open-pit (strip mines)
Composition of Historical Mining Wastes

Related to:

- Geology
- Mining methods
- Milling and smelting technology
- Market demand
  - WWII vs. Great Depression
- Governmental policy

Stamp mill in Colorado

(photo from the William L. Fick Colorado Mining Collection, Western History/Genealogy Dept., Denver Public Library)
Segregation of Historical Mining Wastes

Early miners segregated mined materials

Ibex #4 ore bin in Idaho Park near Leadville, Colorado
(photo from the Western History/Genealogy Dept., Denver Public Library)
Placement of Historical Mining Wastes

Often adjacent to or in stream channels

Often on steep slopes

Alma Lincoln mine, Colorado
(photo from the William L. Fick Colorado Mining Collection, Western History/Genealogy Dept., Denver Public Library)

Argo mill, Idaho Springs, Colorado
(photo from the William L. Fick Colorado Mining Collection, Western History/Genealogy Dept., Denver Public Library)

Gregory Gulch, Colorado
(photo by Donald Campbell Kemp, Western History/Genealogy Dept., Denver Public Library)
Placement of Historical Mining Wastes

Effluent from draining adits frequently flows over or into waste piles
Mining Wastes and Regional Hydrology

Silver Plume, Colorado
(photo from the L.C. McClure collection, Western History/Genealogy Dept., Denver Public Library)
Mining Wastes and Regional Hydrology

Mine workings often alter the regional hydrology

Silver Queen mine, California

(photo from the Western History/Genealogy Dept., Denver Public Library)
Tracer Injections

- Determine how much metal enters a stream
  - Mass loading (concentration x discharge)
- Determine how much metal stays in a stream
- Provide accurate discharge measurements
  - Difficult to obtain in mountain streams
- Differentiate between multiple sources
- Monitor effectiveness of remediation efforts
- Usually combined with synoptic sampling
  - Collection of samples from many locations during a short period of time, typically a few hours

See USGS Fact Sheet FS–245–96
Mining Wastes and Airborne Transport

Mining wastes are often near former smelting operations.

Fine-grained material from mining wastes can be transported by wind.

(photo from the Western History/Genealogy Dept., Denver Public Library)
MINE WASTE CHARACTERIZATION

Non-Invasive Screening Tools

Site Characterization Tools

Sampling and Geochemical Screening Tools

Improved Remediation Strategies
Non-Invasive Screening Tools

- Physical Characterization
- Geological Characterization
- Imaging Spectroscopy
- Geophysical Methods
Geological Characterization

Geologic Setting:
- pH buffering capacity
- Ease of subsurface transport
- Routes to receptors

Historical Mine/Mill Activities:
- Efficiency of sulfide removal
- Predict COC (e.g., Hg, cyanide)

Mineral Deposit Type:
- Which metals are present
- Acid-generating capacity
Sampling and Geochemical Screening Tools

- Bioaccessibility Tests
- Sampling Strategy
- Leaching Tests
- Acid/Base Accounting
Site Characterization Tools

- Mineralogy
- Weathering Sequences
- Metal Partitioning
- Sulfur Speciation
## Mineralogical Characterization

### Elemental Residence Phases
(from mineral separates, 4 Colorado mine-waste sites)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Formula</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarosite</td>
<td>$\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$</td>
<td>Pb, Ag, Cu, Bi</td>
</tr>
<tr>
<td>Pyrite</td>
<td>$\text{FeS}_2$</td>
<td>Cu, Bi, Ag, As</td>
</tr>
<tr>
<td>Sphalerite</td>
<td>$\text{ZnS}$</td>
<td>Cd, Cu, Mn, Ag</td>
</tr>
<tr>
<td>Galena</td>
<td>$\text{PbS}$</td>
<td>Ag, Bi</td>
</tr>
<tr>
<td>Anglesite</td>
<td>$\text{PbSO}_4$</td>
<td>Zn, Cd, Bi, Cu</td>
</tr>
</tbody>
</table>
Potential Environmental Impact of Mine Waste

- Degraded water quality
- Decreased species diversity
- Decreased population level
- Kill zones around waste piles
- Visual impact; esthetics
Potential Environmental Impact

A complex function of:

- Geology
- Geochemical and biogeochemical processes
- Climate
- Topography
- The mining and mineral processing methods used
- Age of wastes and reclamation history
Types of Mineral Deposits

- Conceptual models (geoenvironmental models) have been developed to predict drainage quality and potential environmental impacts.

- Geoenvironmental models of mineral deposits describe pertinent earth science and engineering information about the environmental characteristics of geologically similar mineral deposits:
  - prior to mining (= Baseline conditions)
  - resulting from mining and mineral processing