Rare Earth Elements

Potential Contaminants

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Contaminant Concerns

• REE mining
  ▫ similar concerns as other hardrock mining
  ▫ unique concerns too

In a nutshell,
• Mining Expose rocks to bacteria, oxygen, water, and wind

• Mining causes chemical and physical alteration
  ▫ Increases the surface area for these reactions
  ▫ accelerates the release of potential contaminants

• Refining also isolates and concentrates contaminants
• **Site Assessment**
  ▫ Sources
  ▫ Pathways
  ▫ Targets

• **Risks**
  ▫ Ecological
  ▫ Human health

• **Potential Contaminants**
## Sources

<table>
<thead>
<tr>
<th>Mine Site</th>
<th>Refinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom and walls of open-pit</td>
<td>Product piles</td>
</tr>
<tr>
<td>Pit water</td>
<td>Byproducts piles</td>
</tr>
<tr>
<td>Underground workings</td>
<td>Waste piles</td>
</tr>
<tr>
<td>Low grade ore piles</td>
<td>Tailings impoundment</td>
</tr>
<tr>
<td>Stockpiles</td>
<td>Air emissions</td>
</tr>
<tr>
<td>Wasterock</td>
<td>Dust</td>
</tr>
<tr>
<td>Mill and wastes</td>
<td></td>
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</tbody>
</table>
Affected Media (pathways)

- Surface Water
  - Direct contact with sources
  - Discharges or seeps
  - Run-on run off
- Groundwater
  - Infiltration or
  - pit water
  - Underground workings
- Soil
  - At site localized
  - Transport of ores or wastes
  - Processing
  - Air deposition
- Air
  - Milling
  - Processing and refining
  - Off gassing of tailings ponds

Targets

- Water resources
  - Use can reduce amount of resource – sometimes significantly
  - Deplete aquifer
  - Deplete surface water in streams and rivers
- Water quality
  - Recreation
  - Fishing
  - Drinking water
- Populated areas and workers
  - Soil contamination
  - Air contamination
  - Recreational contact
Possible Contaminants

- Radionuclides
  - Thorium and uranium
- Monazite
  - \((\text{REE, Th})\text{PO}_4\)
- Radioactive daughter elements
  - Radium
  - Radon
Possible Contaminants

- Dissolution of minerals
  - Metals including aluminum, arsenic, barium, beryllium, copper, lead, manganese, and zinc
    - Sulfides
    - Amphoteric
  - Release REE’s into environment
  - Other elements like fluorine
    - Bastnasite
China

Every ton of rare earth elements produced creates:

- 8.5 kg of fluorine and 13 kilograms of flue dust
- 9,600 to 12,000 cubic meters of gas laden with dust concentrate, hydrofluoric acid, sulfur dioxide, and sulfuric acid
- Approximately 75 cubic meters of acidic waste water
- Almost one ton of radioactive waste residue

Bayan Obo REE mine in China.
Possible Contaminants

• **Every deposit chemically unique**
  ▫ Asbestos minerals
    • Riebeckite
  ▫ Some of these contaminants could even be considered a product based on their quantity and the market

• **Extensive geochemical analysis of rocks and minerals**
  ▫ Including a good baseline
Pre-planning & Permitting

- NEPA Process
- State Permitting Authority
- Federal Permitting Authority (if applicable)
  - BLM, USFS, NRC
- Clean Water Act
  - 404
  - NPDES
  - Stormwater
- Other State Permits
Conclusions

- Planning is key
  - Work with regulators and community
  - Potential contaminants and targets need to be identified & analyzed
  - Best Management Practices and Monitoring
Contact Information

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