Environmental impacts from mineral resource exploitation
and industry initiatives

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Outline

• The mining industry
  – Environmental issues and impact
  – Techniques for the prevention and control of environmental impact
  – Mining and sustainable development initiatives

www.bbc.co.uk

Reading

• Miller, Chapter 15, “Geology and nonrenewable resources”. (Chapter 14 in 16th edition, 2009).

Mining

• Mining is the extraction and processing of energy and mineral resources
• Use of these resources is fundamental to human well-being as they
  – Are essential to virtually every sector of the economy
  – Are the basis for the human-built environment
  – Provide desired services
• Resource consumption is generally considered a prerequisite for economic development
Mining industry in Sweden (2009)

- Iron ores in Norrbotten (but Dannemora is coming)
- Sulfide ores in Västerbotten and central Sweden
- Directly employs 4656 (995, white collar + 3661, mining).
- In northern Sweden, one person in the mine provides four jobs on the surface (ca. 15,000 people, plus their families).
- About 500,000 people live in Norrbotten and Västerbotten counties

The good and the bad

- Mineral resource extraction is also associated with problems:
  - Basic components of minerals are metals which never degrade
  - Mining may be most profitable where it is least preferable (under cities, in parks)
  - Environmental risks related to extraction and beneficiation (enrichment) methods

Tailings deposition in Zinkgruvan

- Mine (sulfide ore)
- Milling plant and Ore concentrator
- Smelter
- Ore concentrator
- Mine tailings (22.8 Mton/2009/ Boliden)
- Tailings deposit
- Rock waste (32.4 Mton/2009/ Boliden)
- Rock dump
- Tailings deposition in Zinkgruvan
The problem with mine waste

- **Amount**: The annual production of mine waste in Sweden is about half of the total amount of all other wastes combined.
- **Chemistry**: Rock waste and mine tailings can contain sulfide minerals.
- **Metals**: Metals are bound primarily in sulfide minerals. For example: pyrite contains iron, sphalerite contains zinc, galena contains lead, chalcopyrite contains copper.
- **Sulfide weathering**: Sulfide weathering results in the release of iron and other metals to the environment.
- **Weathering**: Weathering: the physical disintegration and chemical decomposition of earth materials at or near the earth's surface.

Environmental impacts

- **Large, short-term releases vs. smaller continuous releases**
  - Dam failure in Spain (Aznalcollar, 1998)
  - Cyanide release and dam failure in Romania (Baia Mare, 2000)
  - Dam failure in Gällivare (Aitik, 2000)
  - Dam failure in Hungary (Ajka, 2010)

### Amounts

<table>
<thead>
<tr>
<th>Type of waste</th>
<th>Amount (thousands of tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic waste</td>
<td>4,044</td>
</tr>
<tr>
<td>Industrial waste</td>
<td>80,061</td>
</tr>
<tr>
<td>Mine waste</td>
<td>58,699</td>
</tr>
</tbody>
</table>

- Mine waste is considered "nonhazardous waste" and is mostly deposited.

*Source: Naturvårdsverket, 2010*
**Long-term chemical threats**

**Sulfide mineral weathering**

\[\text{Sulfide mineral} + \text{oxygen} + \text{water} \rightarrow \text{Bacteria} \rightarrow \text{Heavy metals} + \text{sulfate} + \text{acidity}\]

Bacteria are actively involved in the weathering of sulfide minerals in mine wastes.

Iron released by sulfide oxidation turns into "rust" in surface water.

Local discharge from impoundment 1 in Kristineberg.

**Mine tailings before and after sulfide mineral oxidation**

Unoxidized tailings

Oxidized tailings

To avoid environmental impact: Avoid oxidation!

**Prevention of environmental impact**

- To avoid environmental impact, the intrusion of oxygen and the infiltration of water into the deposit must be prevented.
- Water infiltration results in the production of leachate (water that can contain metals at high levels).
Methods to minimize sulfide oxidation and leachate production

Deposit should be covered with a cover that is wet and impermeable

1. Soil cover
   a) Sealing layer
      • Material with a high capacity for remaining wet (for example, a fine-grained clay)
      • Material with a low permeability (e.g., clay)
   b) Protection layer – protects against erosion

2. Water cover

Water covers

Effective because:
• Only a small amount of oxygen is present in water, compared with the air.
• Oxygen spreads much more slowly in water compared with air

Mine waste deposit with soil cover

Oxygen + water

Waste (pyrite)

Water

Sealing layer

Protection layer

Environmental impact of cover construction (!)

• Acquiring the natural materials required for a soil cover is in itself an environmental impact
• Large amounts of soil (often glacial till in Sweden) are needed
• Using alternative materials can be a much more sustainable and economical solution
Alternative materials
• Waste products may be a viable alternative to natural material
  – Activated sewage sludge
  – Fly ash and bottom ash from municipal solid waste incinerators
  – Residues from the paper industry
• What is meant by viable alternative?
  – High functionality and low impact on human health and the environment is critical
  – Regulatory criteria fulfilled
• Example of industrial symbiosis

Mining and sustainable development

Global dependence on mineral resources
• A tension exists – between the demand for minerals and demand for control or mitigation of negative impacts of mineral extraction.
• How can the mining of a finite resource be sustainable?
Mineral resources: A part of our natural capital

Natural capital = Natural resources + Natural services

Natural resources:
- Air
- Water
- Soil
- Land
- Life (biodiversity)
- Nonrenewable minerals (iron, sand)
- Renewable energy (sun, wind, water flows)
- Non-renewable energy (fossil fuels, nuclear power)

Natural services:
- Air purification
- Water purification
- Water storage
- Soil renewal
- Nutrient recycling
- Food production
- Conservation of biodiversity
- Wildlife habitats
- Grassland and forest renewal
- Waste treatment
- Population control (species interactions)
- Pest control

Capital preservation

- Weak sustainability
  - Preserves the net amount of capital, but not necessarily each of the four types of capital
  - Different types of capital are seen as interchangeable
- Strong sustainability
  - Each type of capital is preserved independently
  - One type of capital cannot substitute for another

Sustainable development and the preservation of capital

Natural capital
- (natural resources)
- (physical capital, the built environment)

Human-made capital
- (health and well-being of individuals)

Social capital
- (social relations, norms, and institutions)

Weak vs strong sustainability

- Sustainable development can be thought of as:
  - the process by which societies transform economic (human-built), environmental (natural) and social capital in ways that yield constant or increasing opportunities for satisfying human needs, generation after generation (weak SD)
  - development that leaves at least the same amount of the four forms of capital to future generations as is accessible for current generations (strong SD)
- Obstacles to applying SD to mineral resource exploitation often stem from differences of opinion about the relative validity of weak versus strong sustainability.

Adapted from Shields, Mining and sustainable development, 2000
The conflict between natural resource exploitation and SD

- Countries with an abundance of natural resources and, hence, natural capital could be considered to be “wealthy” countries.
- History speaks for itself – countries with large endowments of natural resources often perform worse in terms of economic development and good governance
- The “Resource Curse”

Natural resource wealth

- Why this paradox?
- Natural resource wealth does not need to be produced, only extracted
  - Since no production process, it is independent of economic processes in the country
  - Can take place without the participation of large segments of the domestic work force
  - Does not need cooperation of its citizens; independent of political processes
- Many natural resources are non-renewable
  - Less like a source of income, more like an asset.

Escaping the resource curse


The classic resource curse – ”Dutch disease”

- In 1970s, the Dutch discovered natural gas in the North sea. Boom in oil and natural gas exports follows.
- What happened?
  - Soon after, the Dutch domestic manufacturing sector began performing more poorly than expected.
  - Increase in exchange rate makes it difficult to export non-natural resource commodities
  - Domestic resources (labor force, materials) are diverted to the natural resource sector
- Extraction of natural resources gives this industry preferential treatment, at the expense of traditional export industries (e.g. manufacturing, agriculture).
- Dutch disease prevents economic diversification. “All your eggs in one basket”.
Avoiding the resource curse

- If revenues from earnings are spent, this is a consumption of capital, and country’s total capital declines.
- Strategies to avoid the curse
  - Convert natural capital into financial assets and treat the interest as an income
  - Needs to be timed well. Often wiser to leave resource in the ground, preserving capital.
  - Invest in human capital (education, diversified workforce)
  - Support a diversified economy; prepare for days when resource declines

If the curse strikes

- Politicians with an uncertain hold on power have an incentive to spend revenues from resource exploitation sooner rather than leave the opportunities to future political opponents
- Corruption, for example...
  - Lower costs of obtaining resources by obtaining at below market value through bribes
  - Resource sold to domestic firms with government officials getting a kickback
  - Can take very many forms
- Transaction transparency can help to prevent corruption

Multi-stakeholder initiatives

What is it?
A risk assessment framework for relations between extractive industry (EI) companies and public and private security providers to ensure respect for human rights

Verification/publication of company payments and government revenues from EI sector. Child security involvement to increase government accountability

Mandatory principles, reporting, and third-party assurance

OECD

IFC Performance standards - “do no harm” social and environmental safeguards

Extractive Industries Transparency Initiative (EITI)

Verification/publication of company payments and government revenues from EI sector. Civil society involvement to increase government accountability

Mandatory principles, financial industry benchmarks, and environmental risk assessment and management in project

The Kimberley Process Certification Scheme is an innovative, voluntary system requiring Participants to certify that shipments of rough diamonds are free from conflict diamonds
Another promising new mechanism is the Extractive Industries Transparency Initiative, a voluntary code that a score of African countries have adopted, with governments and foreign firms accounting openly for their dealings...
The EITI Process

Companies Disclose Payments

Government Discloses Receipt of Payments

Government Spending

Award of licenses & contracts

Regulation & monitoring of operations

Independent Verification of Tax & Royalty Payments

Revenue Distribution Management

Implementation of Sustainable Development Policies

Oversight by a Multi-Stakeholder Group

The EITI provides a Forum for dialogue and a Platform for broader reforms

Implementing countries

Supporting countries
SD & mining

- Sustainability is of great importance to the mining industry, as suggested by the amount of effort invested in reporting their activities.
  - Can a mining company that invests in sustainable development obtain an advantage over "non-sustainable" companies, or does this simply cost money?

Sustainability and the mining industry

- The mining industry is very serious about including sustainability issues in its operations
- In Sweden, SveMin is the association for mines and mineral and metal producers. (www.mining.se)
  - Ethic rules for member companies: “The company will promote sustainable development and efficient, balanced, long-term management of energy and natural resources while showing due consideration for people, the economy, the environment and the society in general.”

Sustainability and the mining industry

- International council on mining and metals
  - ICMM represents leading international mining and metals companies.
  - Vision: “viable mining, minerals and metals industry that is widely recognized as essential for modern living and a key contributor to sustainable development.”
  - All member companies are required to implement the ICMM Sustainable Development Framework
    - www.icmm.com/sd_framework.php
- Euromines
  - The recognized representative of the European metals and minerals mining industry in Europe.

Example: BHP Billiton

- Sustainability reports published annually with numerous goals. Material sustainability addressed in terms of:
  - Access to and management of resources
    - Reduced water consumption, water recycling
    - All sites have rehabilitation plans
    - Responsible marketing and stewardship
  - Greenhouse gas emissions
    - 6 per cent reduction in emissions by 2012
- Sustainable community development and closure
  - Protecting the human rights of our people and host communities
  - Distributing economic contributions (local suppliers)
  - www.bhpbilliton.com/bb/sustainableDevelopment.jsp
Role of governments

• Legislation and enforcement

• What can governments do to encourage industry?
  – Prevent obvious problems / increase credibility
  – Adopt acceptable standards for environmental performance
    • ISO 14001; independent auditors evaluate the environmental processes and systems
    – Encourage better performance / go beyond required standards

• SD requires action that goes beyond the requirements of regulatory control
  – Cooperation between businesses and environmental interests