

Rare Earth Elements: Building a Best Practices Roadmap to Sustainable Mining

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Outline

- Introduction
- Stream Mapping of the Production Process
- Identification of Stakeholders
- Hazards and Vulnerabilities
- Summary and Conclusions



Introduction

Relevant importance of REEs in terms of: trade, number of initiatives, number of geopolitical events/reports, and level of REEs mitigation

- China is considered a dominant player in REEs world production
- The US, EU and Japan are the major importers of Chinese REEs
- The main end uses of REEs include the energy and defense sectors.
- Applications of REEs may provide low cost / energy efficiency.
- A significant number of initiatives & critical geopolitical events/reports related to REEs have been identified since 2010.
- The mitigation techniques of REEs are rare and/or impossible and/or in preliminary status and/or suffers by a number of constraints.



Mining of REEs: two attributes

- **Presence of Thorium and/or Uranium:
Unwanted radioactivity**
- **15 different elements:
Uncommon to find identical REEs ores**



Stream Mapping of the Production Process

Limited info due to:

- China dominant player: lack of data for production process
- Illegal mines – smuggling (1/3 of total Chinese exports)
- Mining sector of REEs in other industrialized countries did not exist until recently



Stream Mapping of the Production Process

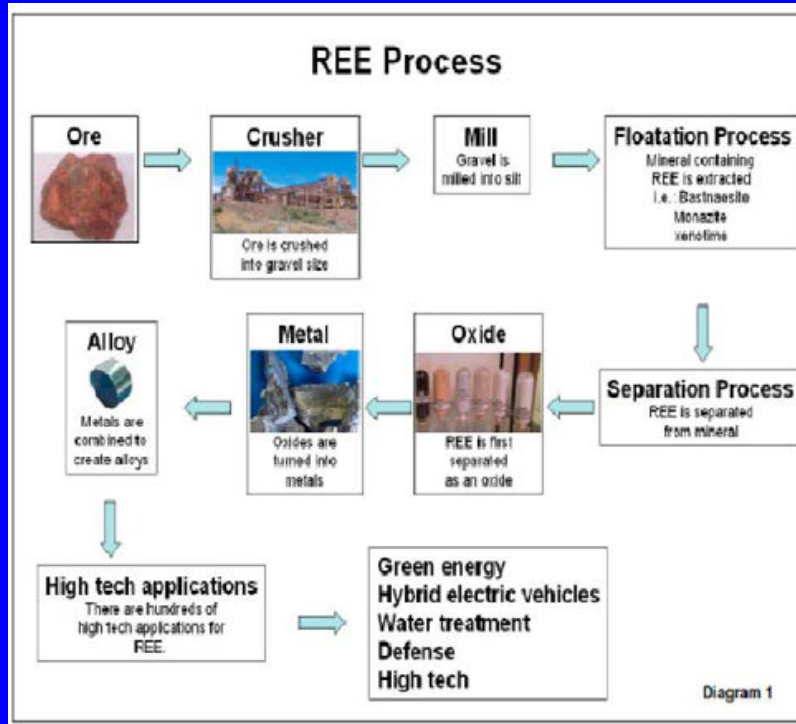


Figure 1: Main process steps in REEs mining processing. Figure was obtained from (EPA, 2011).

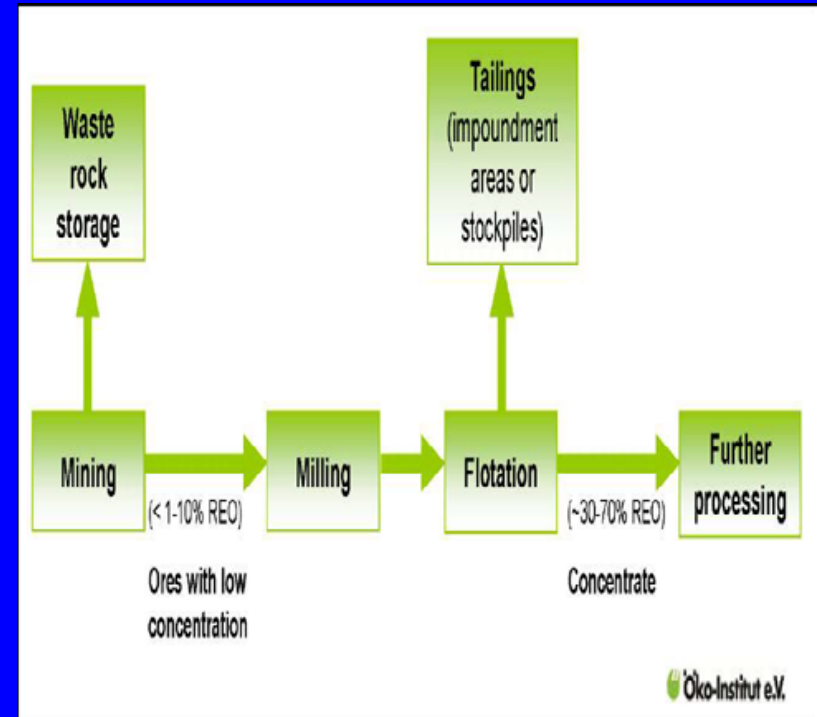
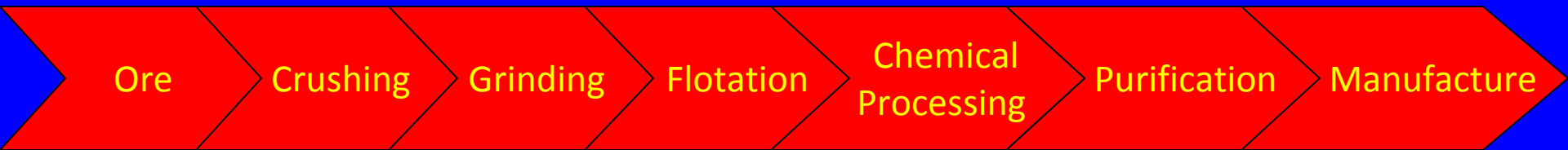


Figure 2: Flowchart depicting the REEs refining process. Figure was obtained from (Öko-Institut, 2011).



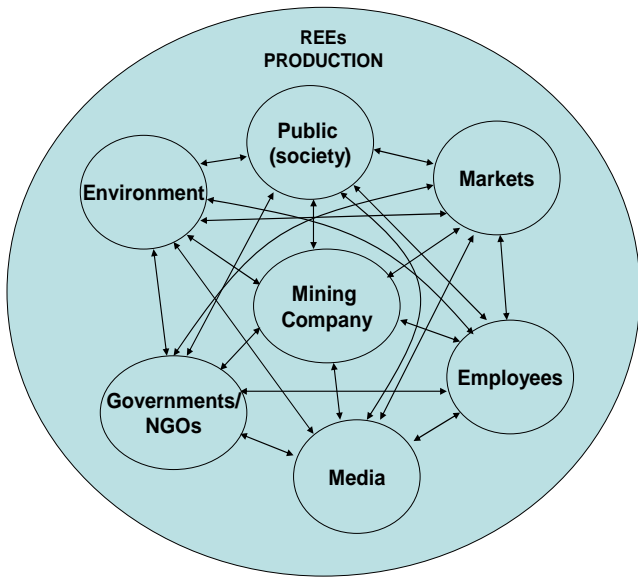
Stream Mapping of the Production Process



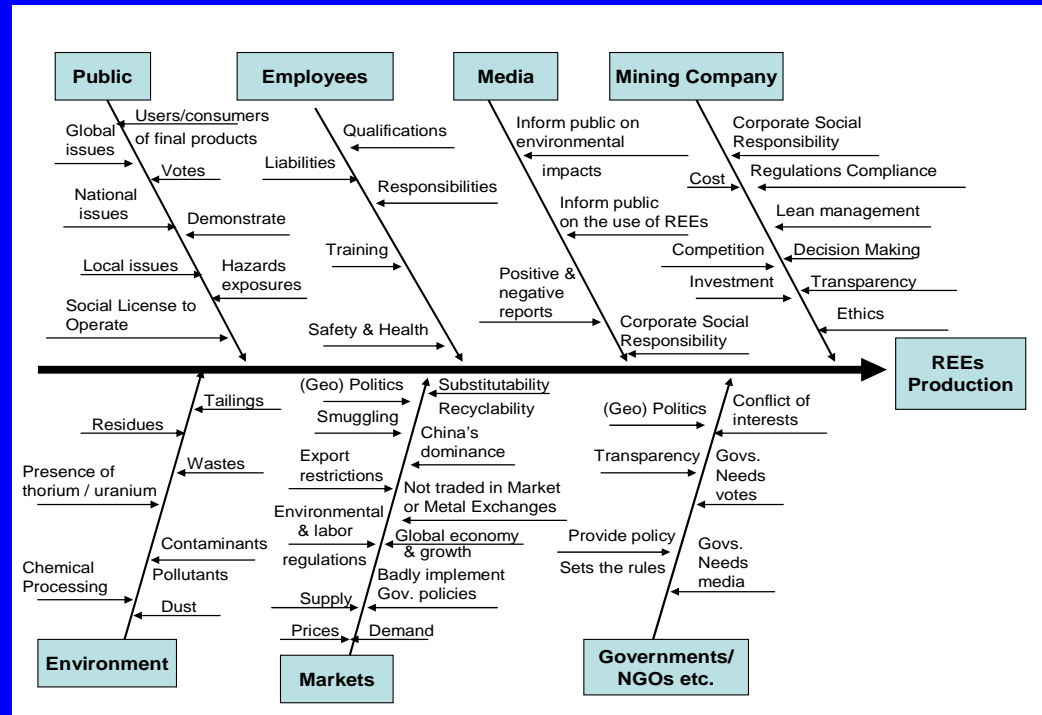
- The scope of stream mapping is to only provide the big picture and is not focusing in detailed pieces of the processes.
- The mining processes of REE ores does not differ from any other hard rock mining processes
- Deposits are mined by surface “open pit” mines and/or underground mines



Identification of stakeholders



Main stakeholders in REEs production



Fishbone diagram representing the "effect" of each stakeholder to REEs production



Identification of stakeholders:

Environment

- Mining of REEs is expected to be similar to any other hard rock mining procedures
- *“...except for the radio-activity of uranium and thorium the potential waste emissions would be comparable to a typical hard rock mine” (EPA, 2012)*
- Special attention should be given to the radiation risk management
- Other possible contaminants:
barium, beryllium, copper, lead, manganese, zinc, sulfide minerals, carbonate minerals, fluorine and asbestos minerals



Identification of stakeholders: Public (Society)

- **Social License to Operate: an important asset**
- **It creates the necessary social agreement/“contract” between the mining company and the local-national-global society**
- **Public - two faces:**
 1. **a user/consumer of the final REE products (i.e., electrical cars)**
 2. **has the right to vote.**
- **June 2012: the issue of a new REEs processing plant in Malaysia became the main issue of the national Malaysian elections**



Identification of stakeholders:

Employees

- **Contribution of employees to the production of REEs: similar to any other hard rock mining operation**
- **Special consideration: Radiation**
 - occupational safety and health,
 - training,
 - qualifications and responsibilities



Identification of stakeholders:

Media

- **Role of the media: negative and/or positive**
- **The positive effect:**
necessity, importance and linkage of REEs to green economy and to the stop-page of climate change
- **The negative effect:**
distribution of “bad news” due to a probable mishap and/or environmental impacts.



Identification of stakeholders:

Markets

Main factors:

- Dominance of China
- Demand, Supply, Price mix
- Export restrictions by Chinese government
 - Export quotas
 - Export taxes
 - Value Added Tax (VAT)
 - Production quotas
- Smuggling/Illegal mining
- Reluctant and/or lack of ESH regulations in China
- Strict ESH regulations in west countries
- Status of global economy/growth
- REEs are not traded through Market or Metal Exchanges
- (Geo)political aspects
- Substitution or REEs is rare and/or impossible and/or in preliminary status
- Limited recycling potential



Identification of stakeholders:

Governments/NGOs

- Role of the government:
same importance as in any other hard rock mining process.
- Since 2010, a large number of REEs-related governmental initiatives - critical geopolitical events/reports
- Many commercial intergovernmental transactions related to REEs the last three years
- Politicians: are elected
- Governmental decisions are sensitive to public opinion, media and NGOs.
- Conflict of interests: governments - environmental NGOs - politicians

A challenging political environment



Identification of stakeholders: Mining Companies

- A challenged cost sensitive and competitive environment
- Strict regulatory frame
- Rule of thumb: Lean, environmental and sustainable management, ethical policies and transparent business rules
- Past experience (Molycorp '90s):
 - combination of strict ESH regulations
 - low prices market environment
 - bad decision making



Hazards and Vulnerabilities

Table 1. Hazards/vulnerabilities of REEs production		
PROCESS	HAZARD/VULNERABILITY	EFFECTED STAKE HOLDER
Ore Mining	<ul style="list-style-type: none"> - Air dust - Mine water/dredge water - Overburden - Waste rock - Heavy metals/acids/fluorides to surface/groundwater - Acid Mine Drainage (AMD) - Turbidity - Radiation - CO2 emissions - Common Occupational Safety & Health Hazards 	<ul style="list-style-type: none"> Environment Employees Public Mining company Media Governments Markets
Crushing	<ul style="list-style-type: none"> - Air dust - Radiation - CO2 emissions - Common Occupational Safety & Health Hazards 	<ul style="list-style-type: none"> Environment Employees Public Mining company Media Governments Markets
Grinding	<ul style="list-style-type: none"> - Air dust - Radiation - CO2 emissions - Common Occupational Safety & Health Hazards 	<ul style="list-style-type: none"> Environment Employees Public Mining company Media Governments Markets



PROCESS	HAZARD/VULNERABILITY	EFFECTED STAKE HOLDER
Grinding	<ul style="list-style-type: none"> - Air dust - Radiation - CO2 emissions - Common Occupational Safety & Health Hazards 	<ul style="list-style-type: none"> Environment Employees Public Mining company Media Governments Markets
Floatation	<ul style="list-style-type: none"> - Tailings - Air dust - Radiation - CO2 emissions - Heavy metals/acids/fluorides to surface/groundwater/soil - Acid Mine Drainage (AMD) - Turbidity - Volatile Organic Compounds(VOCs) - Common Occupational Safety & Health Hazards 	<ul style="list-style-type: none"> Environment Employees Public Mining company Media Governments Markets
Chemical Processing	<ul style="list-style-type: none"> - Tailings - Radiation - CO2 emissions - Heavy metals/acids/fluorides to surface/groundwater/soil - Acid Mine Drainage (AMD) - Turbidity - Volatile Organic Compounds(VOCs) - Common Occupational Safety & Health Hazards 	<ul style="list-style-type: none"> Environment Employees Public Mining company Media Governments Markets



PROCESS	HAZARD/VULNERABILITY	EFFECTED STAKE HOLDER
Purification	<ul style="list-style-type: none"> - Radiation - Air dust - CO2 emissions - Heavy metals/acids/fluorides to surface/groundwater/soil - Volatile Organic Compounds (VOCs) - Common Occupational Safety & Health Hazards 	Environment Employees Public Mining company Media Governments Markets
Manufacture	<ul style="list-style-type: none"> - Air dust - Radiation - CO2 emissions - Heavy metals/acids/fluorides to surface/groundwater/soil - Volatile Organic Compounds (VOCs) - Common Occupational Safety & Health Hazards 	Environment Employees Public Mining company Media Governments Markets



Summary & Conclusions

- The Stream Mapping of REE Production process includes
 - the ore mining,
 - crushing grinding,
 - flotation,
 - chemical processing,
 - purification, and
 - manufacture
- The main stakeholders are:
 - the mining companies,
 - the environment,
 - the markets,
 - the public,
 - the governments/NGOs,
 - the employees, and
 - the media.



Summary & Conclusions (cont.)

- From the environmental perspective, mining of REEs is expected to be similar to any other hard rock mining procedures.
- Except for the radioactivity of uranium/thorium the potential waste emissions would be comparable to a typical hard rock mine.
- Media plays a major role as a stakeholder in REE production. The role of media would be negative and/or positive.
- Many factors affect the market of REE such as the dominance of China in REE production, the demand/supply/prices mix, the export restrictions, etc.



Summary & Conclusions (cont.)

- Several hazards exist at each process of REE production
 - air dust,
 - radiation,
 - CO2 emissions,
 - heavy metals/acids/fluorides to surface/groundwater/soil,
 - occupational safety & health hazards.
- The effect of these hazards/vulnerabilities is expected to incorporate all stakeholders.



Thank you

