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Environmental impacts of REE mining and milling

Main factors to be considered

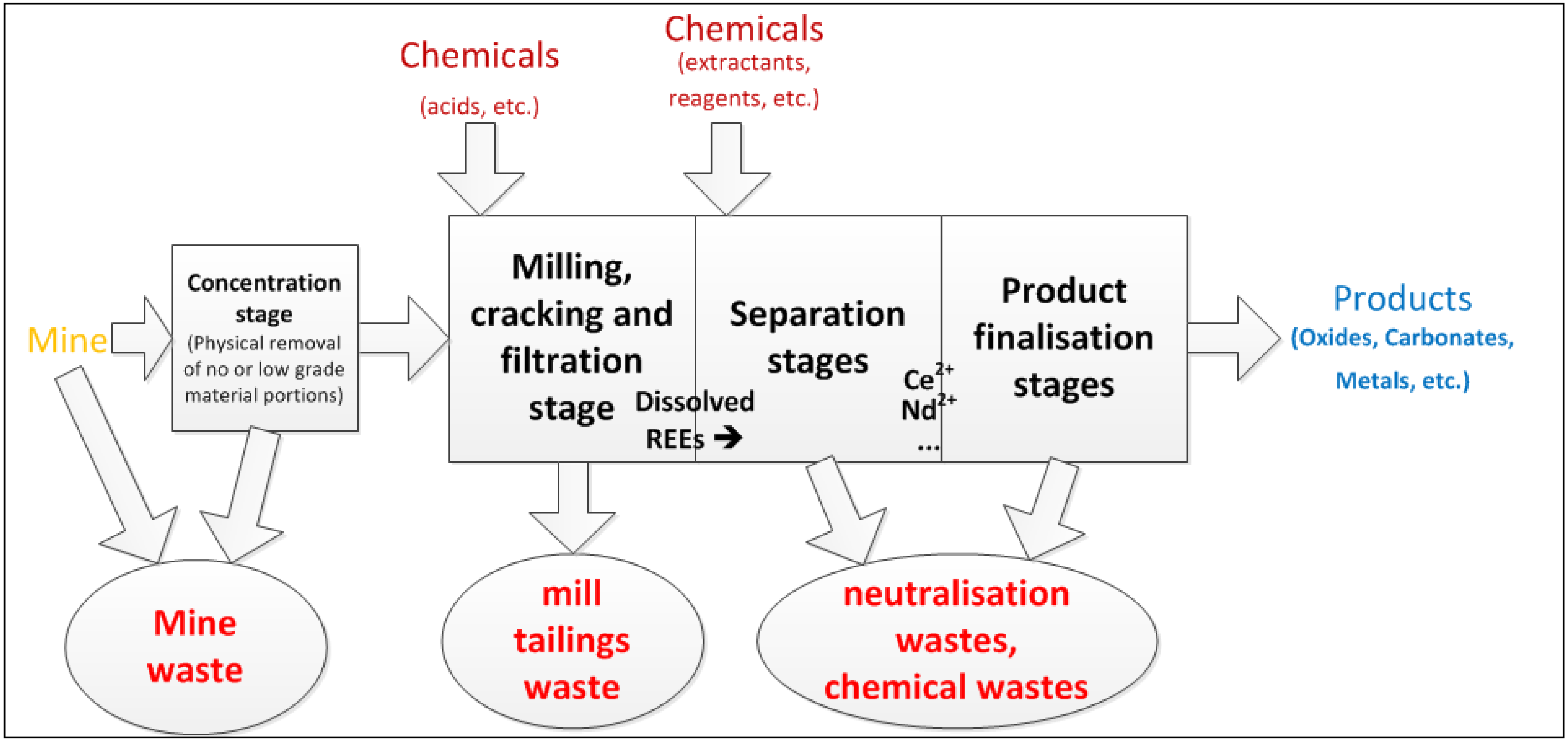
29.01.2014, ERECON WG1 meeting, Brussels

Overview

1. Technical processes
2. Relevant impacts – an overview
3. Radioactive constituents
4. Non-radioactive constituents
5. Environmental AND social impacts?

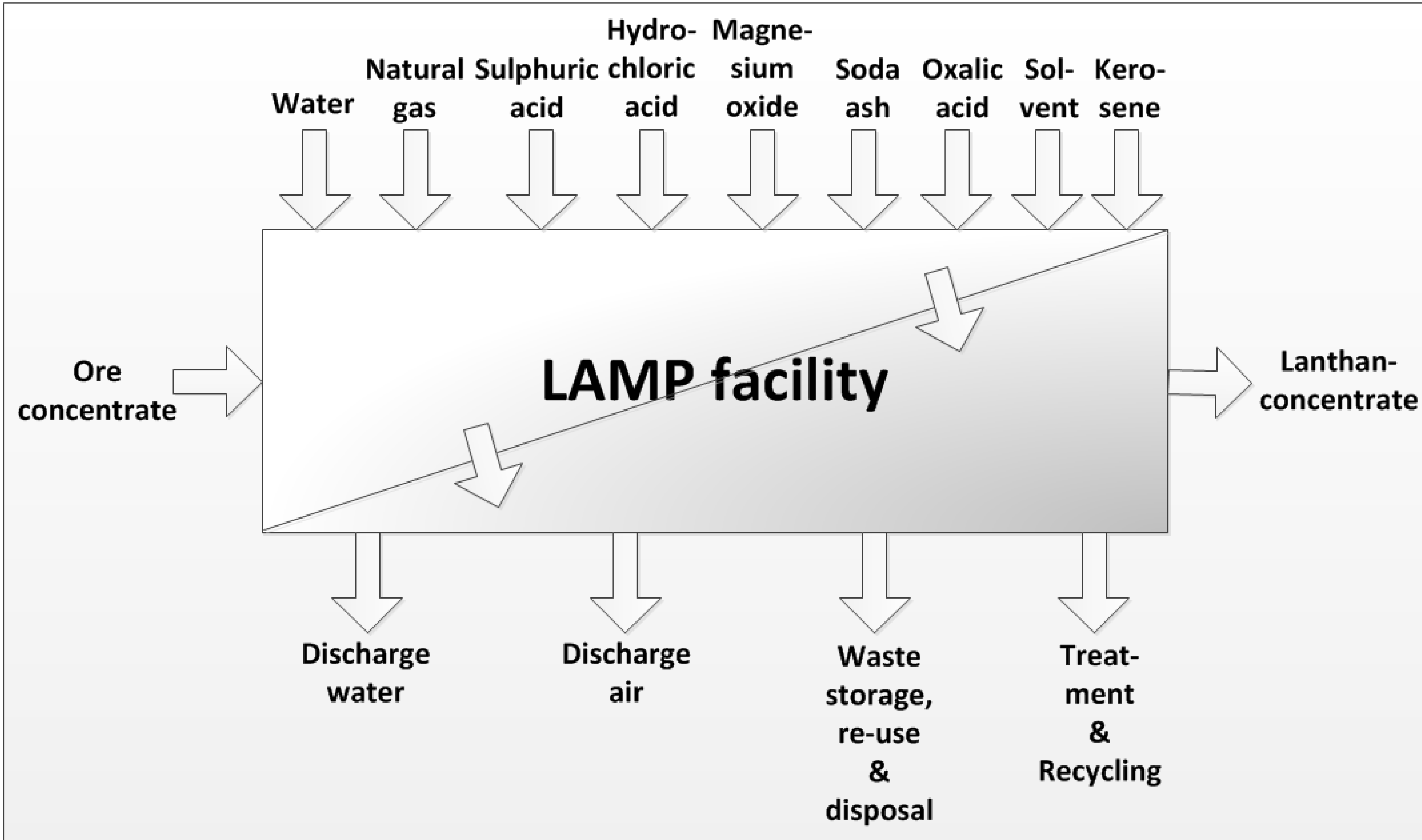
1. Technical processes

- General process stages, materials, products and wastes



A large variety of in- and output materials

Lynas, Kuantan/Malaysia



Input materials and chemicals consumed

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- Lynas (per year and in total):

Categ.	Material	Sub-category	Content	Flow, tpa*	Total, tons
Input	Ore Concentrate	Complete	-	65,000	1,270,000
		Thorium	0.16 wt-% ThO_2	104	2,030
		Uranium	0.0029 wt-% U_3O_8	1.885	37.000
		Other By-products	(unknown)	?	?
	Raw water	-	-	?	?
	Natural gas	-	-	42,912	837,000
	Sulfuric Acid	concentrated	98%	110,238	2,150,000
	Hydrochloric Acid	concentrated	36%(?)	146,776	2,860,000
	Magnesium Oxide	-	-	23,348	455,000
	Soda Ash	-	-	19,632	383,000
	Lime	-	-	52,226	1,020,000
	Oxalic Acid	-	-	8,924	174,000
	Solvent	-	-	780	15,200
	Kerosene	-	-	1,72	33,500

Four times the mass of the ore in sulfuric and hydrochloric acid is consumed!

2. Relevant impacts

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- Mining impacts
  - emissions to air (mining operations, transportation, etc.)
  - impacts on groundwater (levelling, leachate, etc.)
  - noise (transportation, blasting!), flora and fauna, landscape, historical and cultural places, etc.
- Operational impacts
  - emissions to air (acidic gases such as sulfuric acid or fluoric acid, sulfur dioxide, dust particles, radon, etc.)
  - emissions to surface water (wastewater, toxic ore constituents such as As/Cd/Pb/Mo/Cr/Cu, REEs, Mg/Na/Ca salts from neutralisation, organics, etc.)
  - emissions to groundwater (leachate from mine wastes and tailings wastes, accidential spills, etc.)
- Post-operational impacts
  - leachate from mine wastes (AMD, depending from ore type and disposal conditions)
  - leachate from mill tailings (salts, toxic constituents, etc.)

3. Radioactive constituents

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- Thorium and uranium and their decay products: wide ranges of concentrations over three orders of magnitude
  - Th: 10 ... 10,000 ppm in ore
  - activity concentrations 0.04 Bq/g ... 40 Bq/g
  - for comparison only:
    - Unrestricted use of materials (e.g. for building purposes) in the latest EU radiation protection regulation from 2014: 0.2 Bq/g Th OR 0.3 Bq/g U
    - Limit in Germany for the re-use of ore or tailings (release e.g. for road construction, former GDR regulation but still valid): 0.2 Bq/g U
    - Currently lowest economically mined U ore (@ Rössing Namibia): 0.03% U or 3,7 Bq/g U
    - Lynas: 6.5 Bq/g Th in pre-treated ore (original ore ca. 2 times less)

„Bq“ in this context means decays per second of the mother nuclide (Th-232 or U-238), equal to all of the decay product‘s activities in equilibrium.

Consequences

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- Operation requires a permit that includes radiation protection rules
- Scales enrichment can, in certain stages of the facility, lead to highly contaminated equipment (e.g. by highly specific radium sulfate cristallisation on filter surfaces, as well known in the phosphate industry) with very high dose rates (requires a strict precaution regime to protect workers and to store/dispose this equipment)
- All releases of materials (equipment, wastes, etc.) require a permit following radiological release rules
- The higher contaminated wastes (mill tailings) require secure long-term isolation on a carefully selected site and with a sustainable isolation design.
- In the Th decay chain are some strong gamma emitters, so keeping an effective distance and shielding is required.

Fortunately ...

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- The products are absolutely uncontaminated as Th and U are completely removed in earlier stages.
- Only the early stages of the facility (and the mill tailings storage) have to be run under radiation regulation rules, the larger part of the facility is free from those limitations.
- Th and U can be properly enclosed because they are not geochemically mobile. Leaching etc. can only move other constituents out of the tailings, such as salts or arsenic.
- Site selection, layout and design of the disposal facility are really high-tech, but neighbors have to be and can be convinced that all credible future development do not lead to the release of the encapsulated materials.

4. Chemical environmental consequences

- Do not forget that salt is environmentally harmful even though it is only toxic at very high concentrations.
- A toxicity balance has to be made on the basis of a complete analysis of the ore constituents, not only the ones that first come to your mind.
- Filter equipment for acidic gases should not be worse than what is standard in today‘s sulfuric acid production facilities.
- A rare earth producing facility should in any case monitor those elements in its wastewater.
- If the chemical oxygen demand of your wastewater is high, a thorough investigation into the root cause should be triggered to avoid adverse environmental consequences.

... and more

- Filling natural lakes with mill tailings is not a good idea (outside Canada), even if your leaching model signals that lead concentrations in the lake will be low.
- Small mining companies, so-called start-ups, might have not enough reserves to, in any case, fulfill their accumulated long-term obligations. There are too many historic examples for early bankruptcy leaving the expensive clean-up work for the general public.

5. Social impacts?

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- Mining has some positive, but also some adverse social impacts.
- Those adverse impacts should be planned for, minimised and/or compensated, as it is the case for adverse environmental impacts.
- Social impacts are by now underrepresented:
  - Only positive impacts are identified (and marketed).
  - Adverse impacts are often not taken for serious.
  - A systematic and objective impact analysis is currently not state of the art.