



Innovative hydrometallurgy for sustainable valorisation of mining waste

Anne-Gwénaëlle GUEZENNEC – BRGM (French Geological Survey)

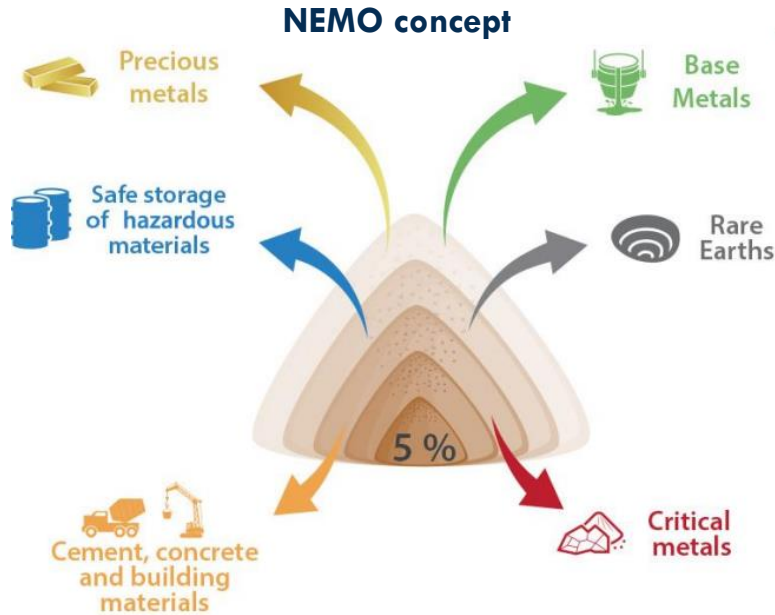


The NEMO project has received funding from the European Union's EU Framework Programme for Research and Innovation Horizon 2020 under Grant Agreement No 776846

Raw Materials Week, November 15th 2022

NEMO concept

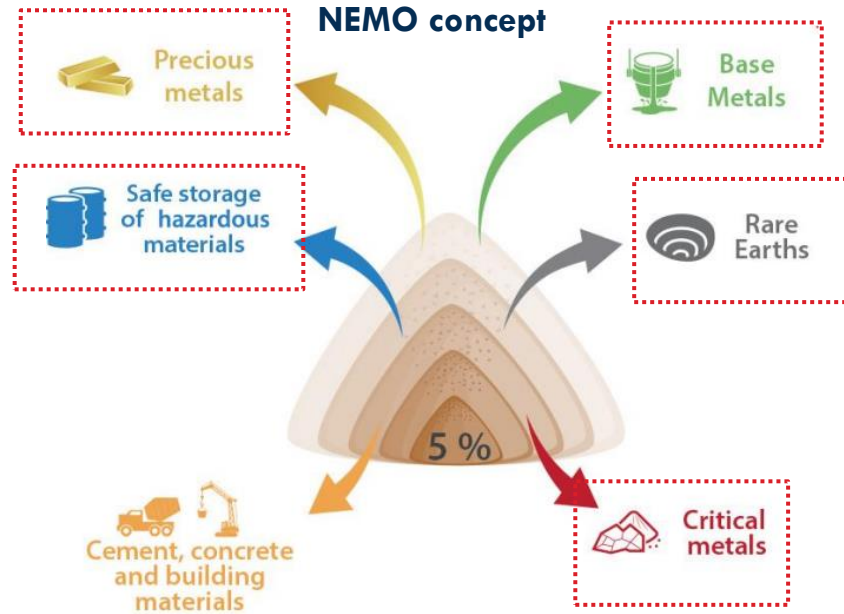
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- NEMO research project develops, demonstrates and exploits, **a first-of-a kind, near-zero waste processing scheme for sulphidic ores**
- NEMO addresses all components of the waste (metals, sulphide, gangue)
- ➔ *NEMO aims at reducing the **waste to only 5%** of its original volume*
- 3 case studies
 - ▣ Sotkamo (Finland, TERRAFAME): low-S waste containing Ni, Co, Cu, Zn and REE
 - ▣ Luikonlahti (Finland, BOLIDEN): high-S tail containing Co and Ni
 - ▣ Tara (Ireland, BOLIDEN): low-S waste, no metal to recover

NEMO concept

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From Tailings to Resource

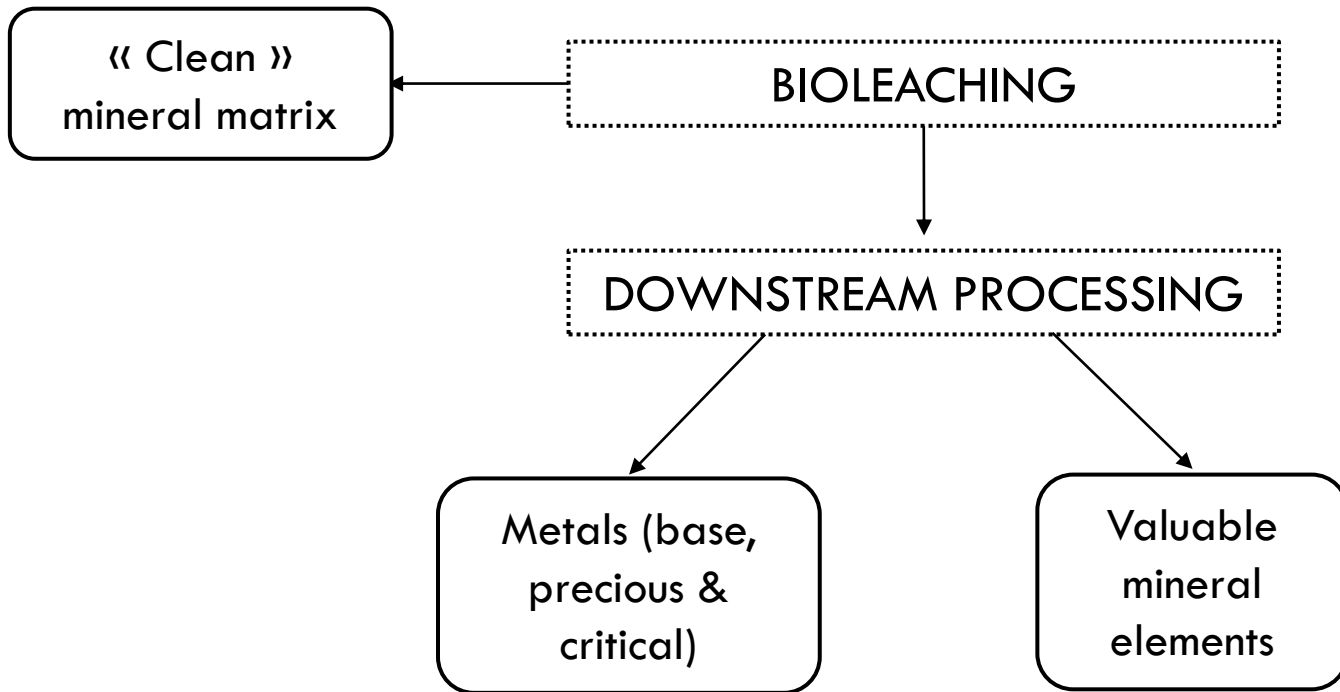
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- Some examples of industrial case studies around the world:
 - ▣ **Kasese** (former Cu mine, Uganda): production of **Co** from 2000 to 2014 (2% of world wide Co production)
 - ▣ **Vuonos** (active talc mine, Finland): production of **Ni** and **Co** from high-grade sulfide flotation tail
- ➔ **Bio-Hydrometallurgy** is a core technology for mine waste reprocessing;
- ➔ Most of current operations are focused on the **recovery of one metal (or 2)** and don't address **matrix valorisation**.



NEMO metallurgical approach

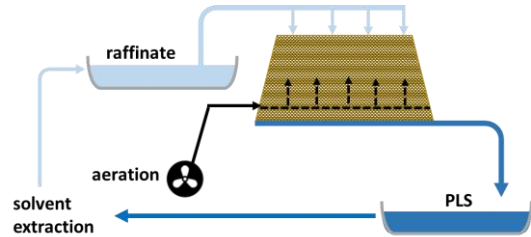


Sotkamo tailings (low sulfide)

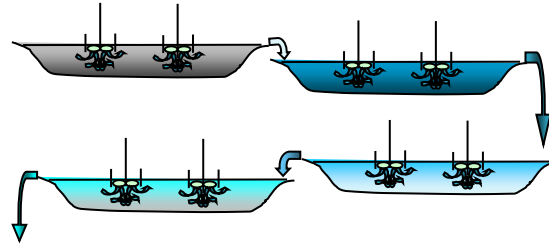
Luikonlahti tailings (high sulfide)

BIOLEACHING

Heap (TERRAFAME)



Pond (BRGM)



STR (BOLIDEN)



DOWNSTREAM PROCESSING:

recovery of valuable elements (base metals (Zn, Ni, Co); Mn; REE; Fe, Al, K and Mg salts)
through different technological approaches (solvent extraction, sulfide precipitation,
hydroxide precipitation, ammoniacal precipitation, autoclave leaching)

WP1

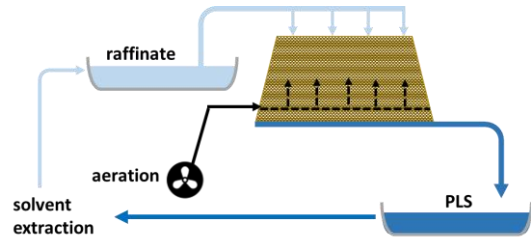
Sotkamo tailings (low sulfide)

WP2

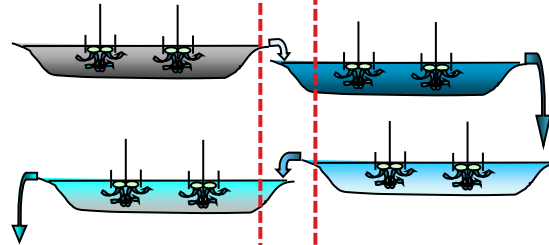
Luikonlahti tailings (high sulfide)

BIOLEACHING

Heap (TERRAFAME)



Pond (BRGM)



STR (BOLIDEN)



WP3

DOWNSTREAM PROCESSING:

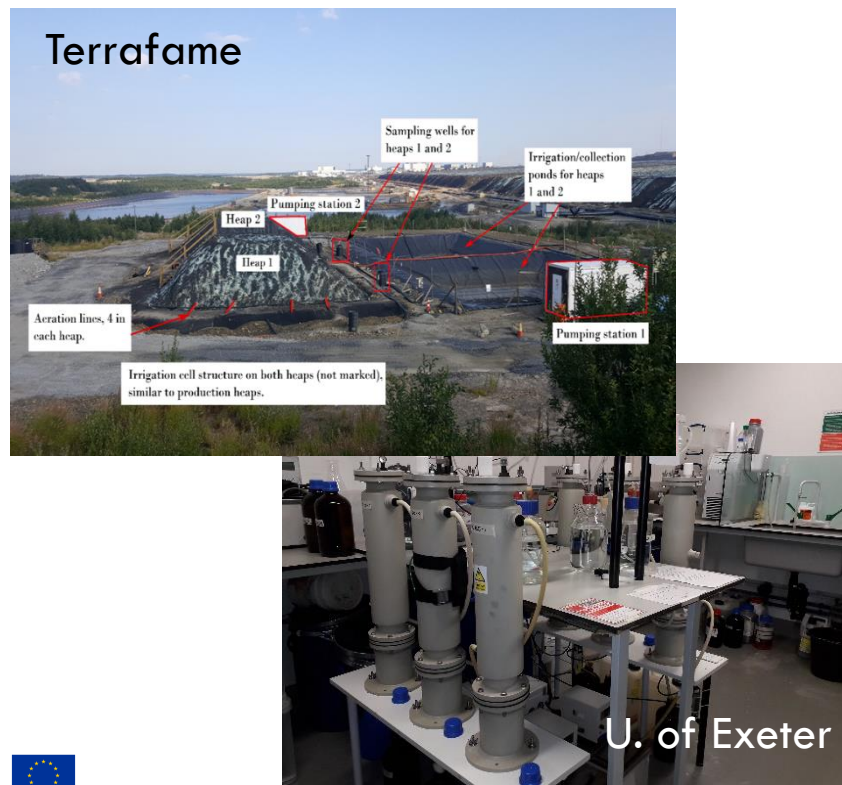
recovery of valuable elements (base metals (Zn, Ni, Co); Mn; REE; Fe, Al, K and Mg salts) through different technological approaches (solvent extraction, sulfide precipitation, hydroxide precipitation, ammoniacal precipitation, autoclave leaching)

Bioleaching Heap Pilot

Terrafame (University of Exeter)



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- ❑ Sotkamo, low sulphide tailings
 - ❑ 900 tons, 2 years
 - ❑ Robust and cheap
 - ❑ Low level of control
 - ❑ Three key results:
 - ▣ Optimisation of nutrients addition
 - ▣ Large temperature range
 - ▣ Adaptation of microbes to raffinate composition
- ➔ **A methodology for bioheap upscaling!**

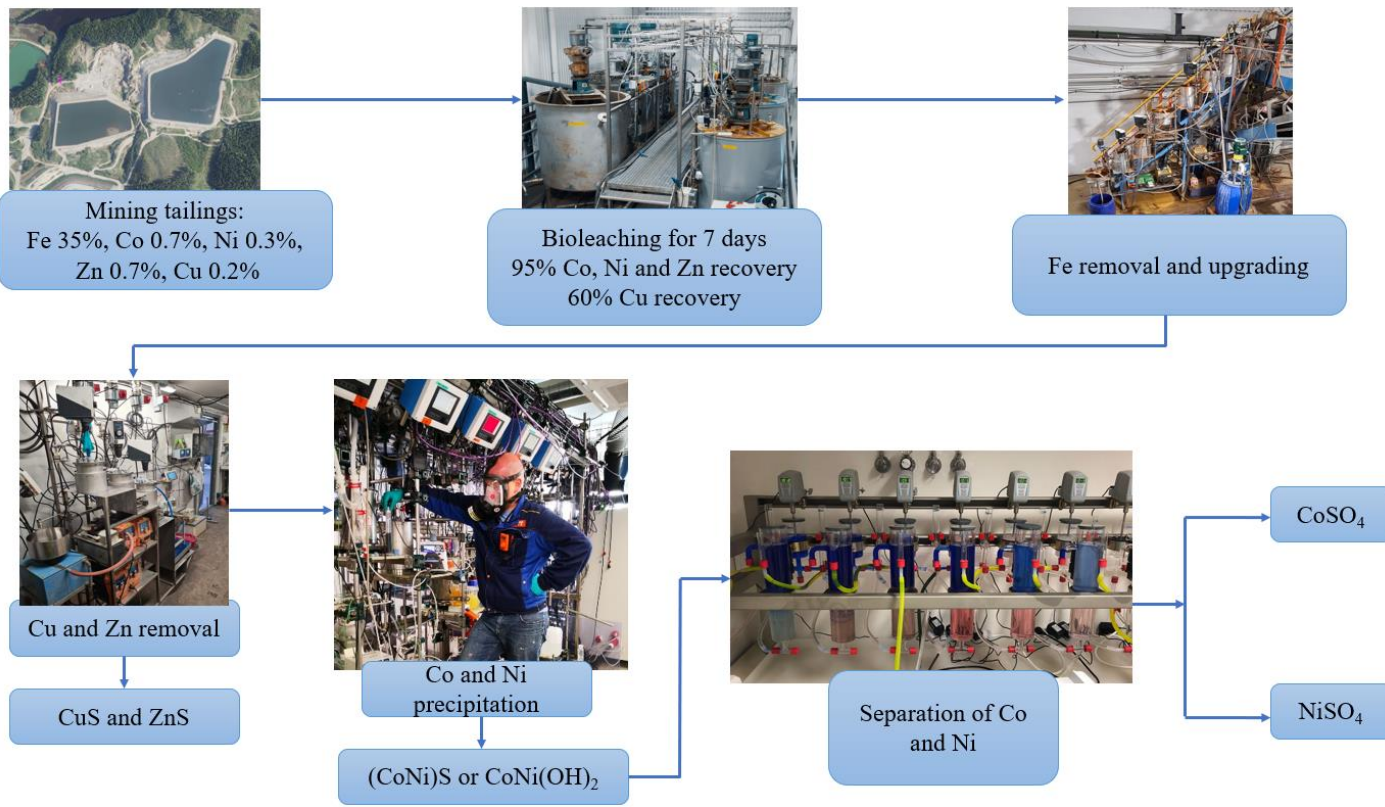


Bioleaching STR pilot

Boliden, VTT, KU Leuven



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Bioleaching STR pilot

Boliden, VTT, KU Leuven



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- ❑ Robust, high level of control
- ❑ Suitable for high sulfide materials (control of the heat production)
- ❑ Reduction of retention time -> CAPEX/OPEX
- ❑ High metal recovery (96% Co, 92% Ni, 93% Zn, 99% S²⁻)
- ❑ Production of high purity intermediate products for battery sector
- ❑ Benchmark with alkaline pressure leaching (IMNR)



Bioleaching Pond Pilot

BRGM (+Terraframe & U. of Exeter)



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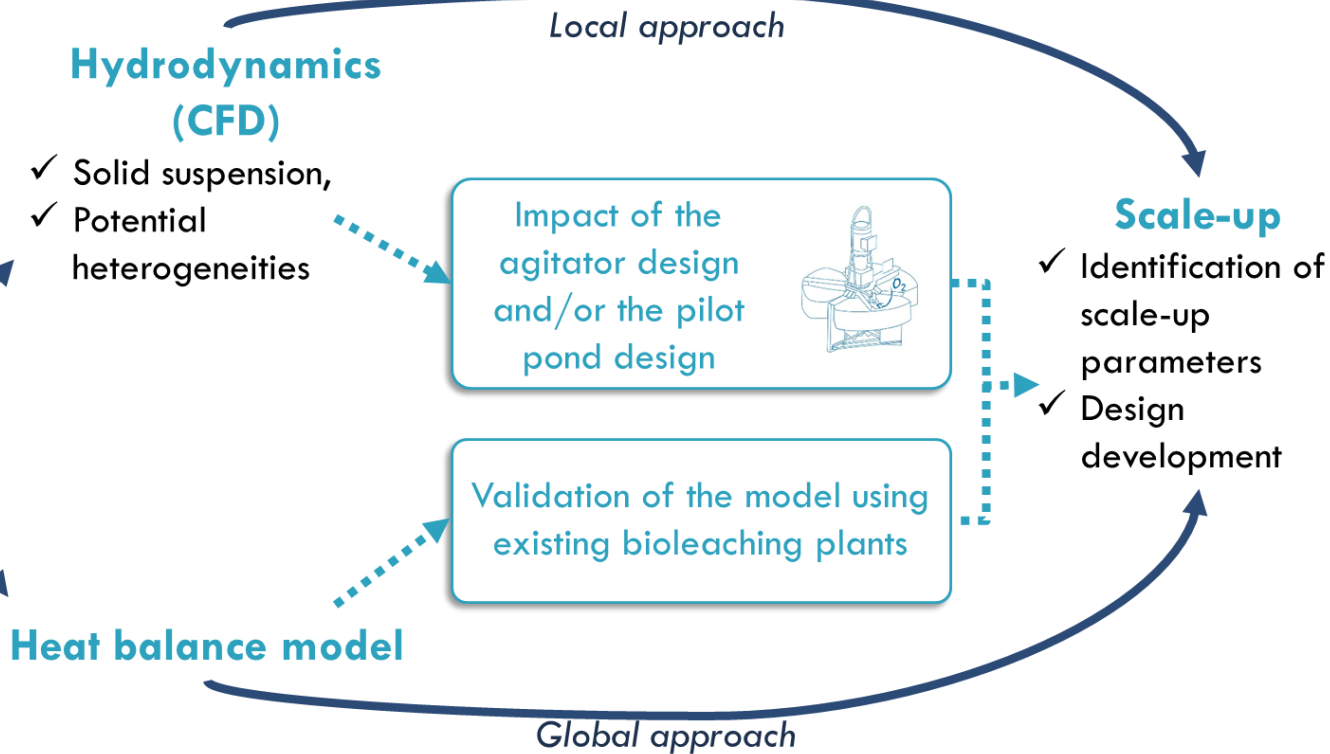
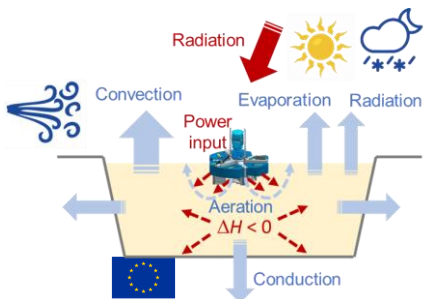
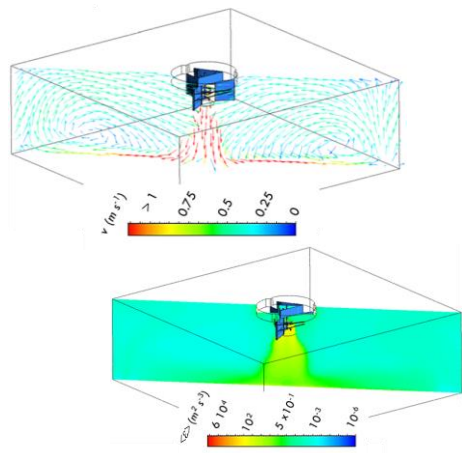
- Sotkamo/Luikonlahti
- 5 tons for each case study
- Highly versatile: suitable for low or high sulfide tailings
- Large range of solid load: up to 30%
- Good mixing
- Production of mineral matrix suitable for aggregate production

Bioleaching Pond Pilot

BRGM



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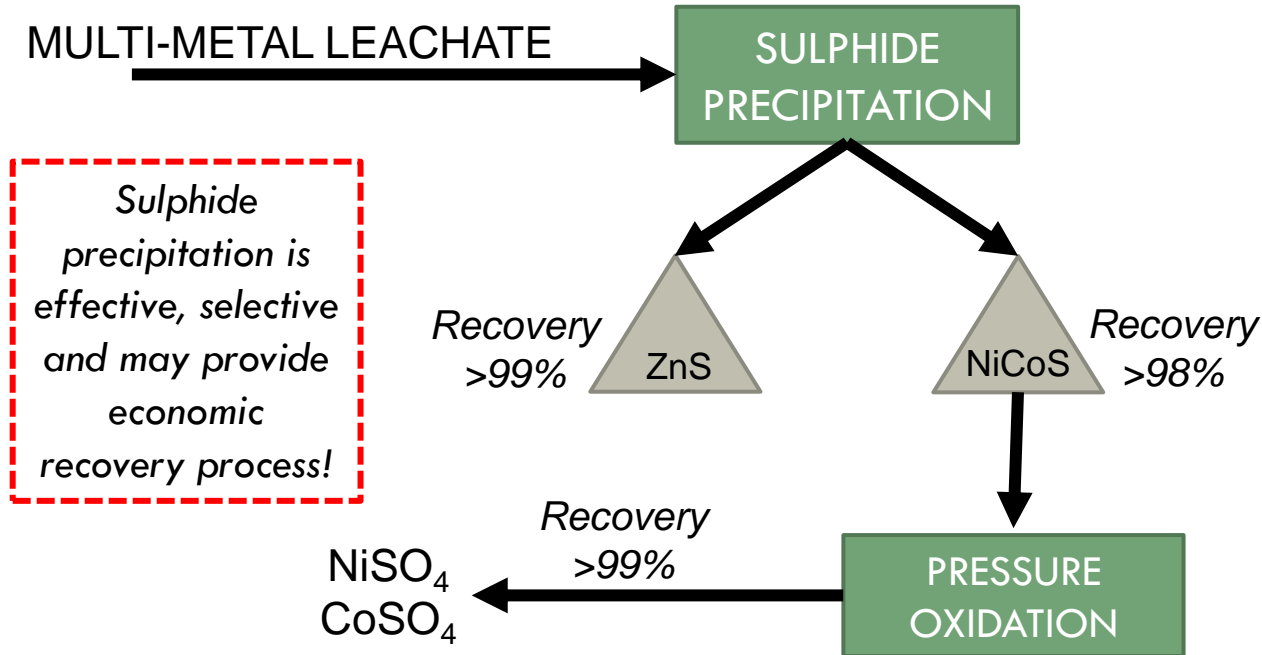
WP3 Metal and mineral recovery

- Objective: full utilization of multi-metal leachate originating from leaching of sulphide tailings.
 - Base metals (zinc, nickel, cobalt).
 - Manganese.
 - Rare earth elements.
 - Iron, aluminum.
 - Potassium and magnesium salts.

WP3 Metal and mineral recovery

Recovering Zn, Ni and Co

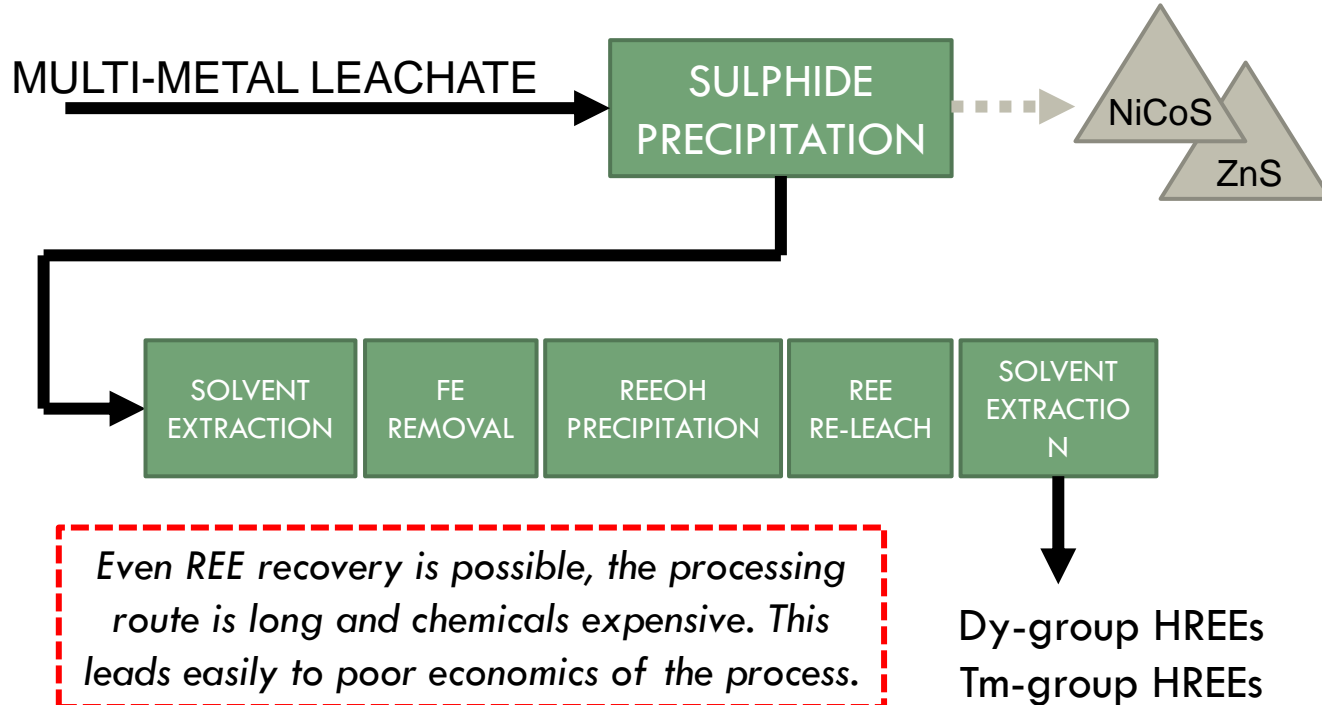
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WP3 Metal and mineral recovery

Recovering REE

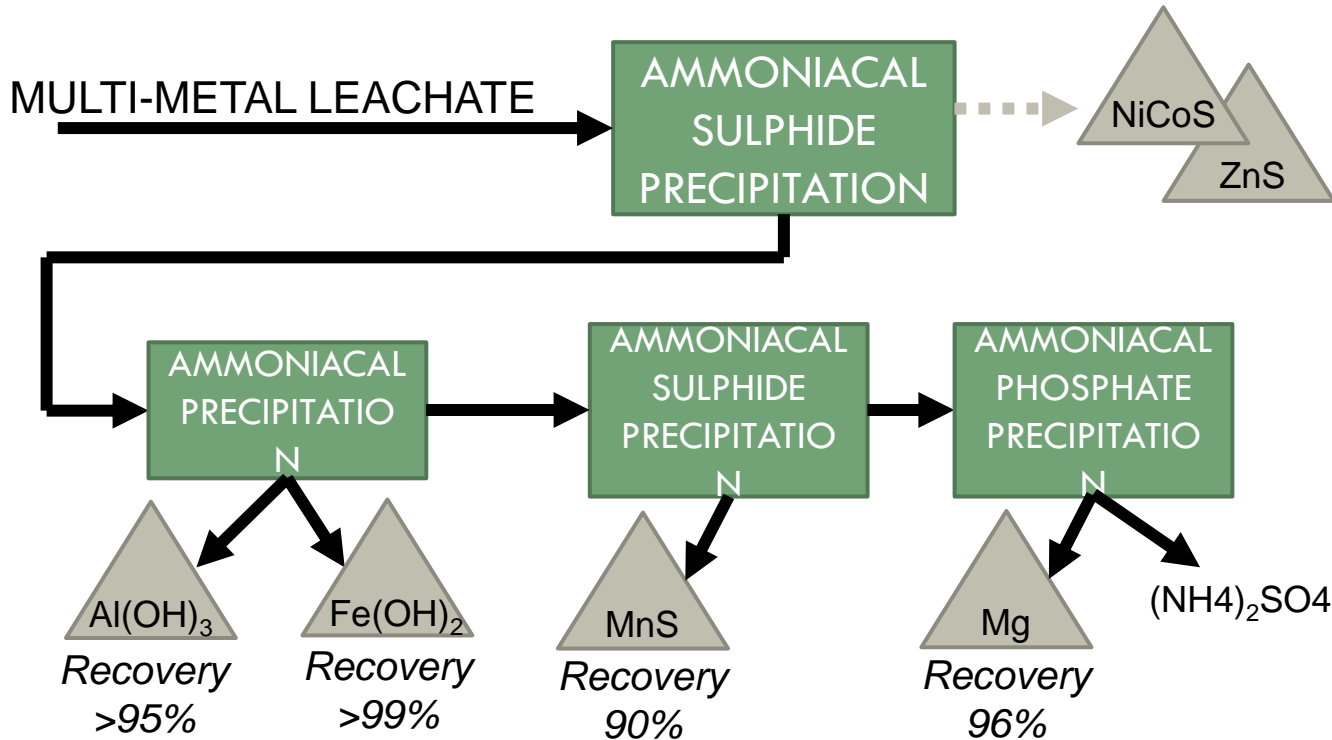
Corresponding partner: VTT Technical Research Centre of Finland, KU Leuven



WP3 Metal and mineral recovery

Recovering Al, Fe, Mn, Mg and NH₄

Corresponding partner: Skyscape Oy





Conclusions

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- ❑ A large portfolio of hydrometallurgical technologies to address the challenge of mining waste
- ❑ Demonstration of the technologies at TRL 7 with large scale pilot operation and representative tailings materials
- ❑ Delivery of mineral matrix for further valorisation in construction materials
- ❑ Consistent data for environmental and economic assessment





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Thank you!

<https://h2020-nemo.eu/>

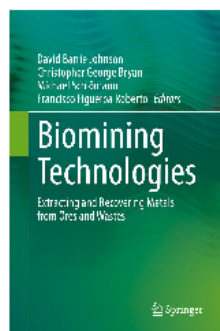


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Biomining Technologies

Extracting and Recovering Metals from Ores and Wastes

- Explores the biology, diversity and ecology of microorganism involved in biomining processes
- Provides insights into industrial case studies from diverse countries
- Highlights emerging biotechnologies for the recycling of metals from waste

This book describes emerging and established industrial processes of biomining technologies used for the recovery of metals of economic interest from, e.g. mineral ores, mining and electronic wastes using microbiological technologies. Multiple chapters focus on engineering design and operation of biomining systems. Several industrial case studies from China, Chile, Peru, Russia/Kazakhstan and Finland are included, which emphasises the practical approach of the book. The reader not only learns more about the biology, diversity and ecology of microorganisms involved in biomining processes, but also about microbial biomolecular and cultivation tools used in the biomining industry. Special emphasis is put on emerging biotechnologies enabling the use of biomining for recycling metals from e-wastes, waste streams and process waters. Finally, the future impacts and direction of biomining towards sustainability in a metal-demanding world are also highlighted. The book is aimed at an interdisciplinary audience involving operators and researchers working across disciplines including geology, chemical engineering, microbiology and molecular biology. This is reflected by the content of this book, as well as by its authors, who are all leading practitioners and authorities in their fields.

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