RECOVERY OF RARE EARTH ELEMENTS FROM PHOSPHOGYPSUM / REE-PG

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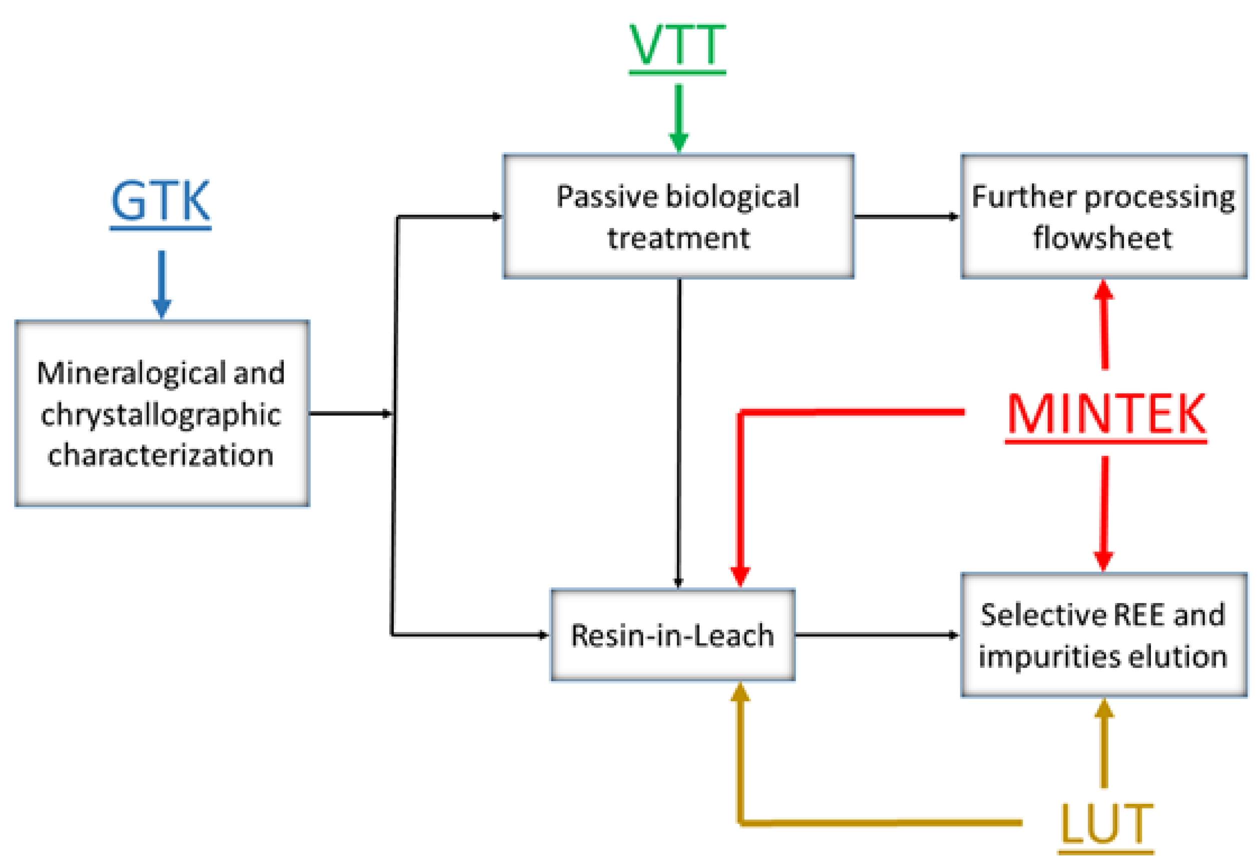

BACKGROUND AND MOTIVATION

The use of **rare earth elements** (REEs) in modern technologies has created an increasing demand for them. China is responsible for 86% of the 110 000 t REE production in the world. Due to an uncertainty in supply, REEs are included in the European Commission's list of 20 critical raw materials.

Phosphogypsum (PG) waste is generated in large quantities (up to 250 Mt a year) in the wet phosphoric acid process. Light and middle REE are concentrated into PG.
- In total 21 Mt of REE has been locked into PG over the past decades.
- PG is a potential secondary source for sustainable REE production.

South Africa has been one of the largest phosphoric acid producers in the world. Finland, with its apatite and carbonatite deposits, is one of the few countries within the EU where REE are found. Approximately 2-3 000 t/a of REEs are dumped with PG in Finland and 20 000 t/a in South Africa.

Table 1. REE composition of Siilinjärvi PG and production potential calculated with estimated 1 Mt annual processing.

	Ce	Dy	Er	Eu	Gd	La	Nd	Sm
REE content, ppm	1000	23	240	24	<20	650	890	114
Amount dumped, t/a	1093	24	246	25	<23	694	934	116

Known issues in REE recovery from PG:

- High chemical costs in conventional direct H_2SO_4 leaching and solvent extraction
- Low yield in conventional concentration by flotation and magnetic separation because most REE are distributed in ultrafine particles
- PG is highly variable in terms of REE content and physical properties. The impact of PG origin on metallurgical response is not well understood.
- Purification of individual REEs is very difficult and traditionally requires a complex multistage SX process

OBJECTIVES

The main goal is to **develop and evaluate novel flowsheets for economic recovery of REEs from PG**. For this purpose, the REE−PG project focuses on

- **understanding the cause of varying response of different PG samples** to a certain recovery process
- further developing previously proposed **microbial pretreatment of** PG with sulphate reducing bacteria for increasing the **REE recovery yield**
- **increasing the selectivity** of previously proposed **resin-in-leach** (RIL) process for REE recovery
- **purification of REEs** to improve process economy

TASKS AND RESEARCH METHODS

1. Mineralogical characterization of PG samples and their residues
Leader: GTK

In order to optimize REE recovery proceses, the physical and chemical reasons behind the wide variance in hydrometallurgical response of different PG samples must be understood.

- Mineral Liberation Analysis (MLA) for identification of modal mineralogy, grain size distribution, and mineral liberation of PG samples from Finland and South Africa
- Electron Probe Microanalysis (EPMA) for measurement of REE distribution in minerals
- SRB precipitates and leaching residues are analysed with MLA and EPMA to understand the mechanisms of REE liberation

2. Optimization of SRB precipitation and physical/chemical REE beneficiation
Leader: VTT

Selective enrichment of REE from low grade PG by low cost passive microbial treatment and high yield in further recovery of the enriched precipitates would be a breakthrough in the area of low grade REE raw material processing.

- Isolation and cultivation of *Desulfovibrio*, *Desulfobulbus* and *Desulfomaculum* strains from environmental samples
- Optimization of bioreactor media and conditions for SRB-based beneficiation of PG
- Physical and chemical enrichment (froth flotation, high gradient magnetic separation) of SRB precipitates

3. Development of Resin-in-Leach process
Leader: Mintek

Mintek has developed an RIL process for REEs recovery from PG where gypsum is not dissolved, reducing the chemicals consumption.

- Investigating the influence of process conditions on the RIL process with PG samples from Finland and South Africa
- Improving the selectivity by using novel ion exchange materials developed at LUT and elsewhere

4. Advanced ion exchange technology for improved selectivity
Leader: LUT

Separation and purification account for majority of costs in REE recovery from secondary sources. Novel ion exchange materials, aqueous feed or eluent modifications, and advanced process configurations are investigated aiming at breakthroughs in REE processing.

- Novel separation materials currently developed at LUT and Univ. Toulon, France, are employed in RIL process at Mintek
- Fundamental phenomena in selective elution of loaded resin (phase and speciation equilibria, kinetics). Mechanistic modeling and validation of models with laboratory experiments.
- Fractionation of REE mixtures to pure products with advanced ion exchange process configuration.

5. Economic evaluation of suggested flow sheets
Leader: Mintek

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