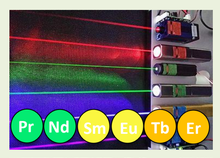
# SEM² BIO CHEM - Rare Earth Elements Metallurgy -

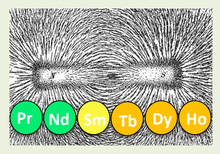
# Advanced (bio)hydrometallurgical methods for the optimized extraction and beneficiation of Rare Earth Elements from Ion Adsorption Clays

**Lisza Zeidler[1], Meinolf Stützer[2], Gotthard Kunze[3], Sabine Kutschke[4], Norbert Jordan[5], Michael Haschke[1], Wilfried Hüls[1], Romy Matthies[1*]**

[1] **G.U.B. Ingenieur AG**, Glacisstr. 2, 01099, Dresden, [2]**GMBU**, Halle (Saale), [3]**IPK Gatersleben**, Stadt Seeland, [4] **HZDR**, Helmholtz Inst. Freiberg for Resource Technology, Freiberg, [5] **HZDR**, Inst. of Resource Ecology, Dresden; *romy.matthies@gub-ing.de; **//r4-sem2.gub-ing.de/en**



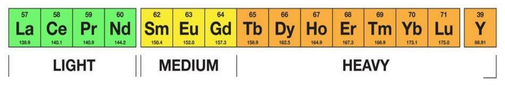



## Challenge

- **Rare Earth Elements** (REE) are essential components of devices produced by the **high-tech, green-energy and communication industry** but are defined as **critical raw materials** due to their reduced short- and medium-term supply.
- **Ion-adsorption clays** (IAC) in China have been the **main source of REE worldwide** (≈ 80 %) for more than two decades.
- **Traditionally applied** extraction and processing **techniques** have caused **severe environmental impact** such as ground-water contamination, soil erosion and the loss of entire ecosystems.

## Objective

- Develop **efficient, economic and environmentally sustainable mining technologies** for the extraction and processing of Rare Earth Elements from about 200 ion-adsorption clay deposits worldwide.



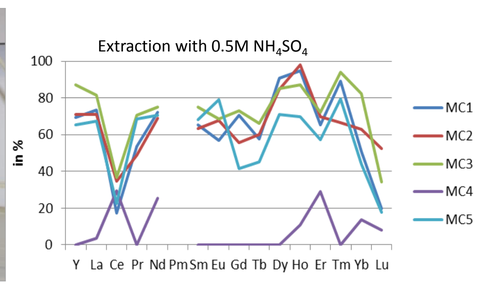

## Developing an Alternative Bio-Mining Technology

### In-Situ Recovery


- IAC assessment of physical properties (e.g. triaxial tests)
- Application of cryo-technology to enhance IAC permeability
- Develop environmentally sustainable injection and extraction technology for IAC deposits
- Devise best-practice guide on IAC extraction and processing


### Leaching

- Ion-exchange based extraction of REE from ion-adsorption clays.
- Evaluation of the leaching performance and selectivity of various lixiviants.
- Assessment of influencing parameters on leaching performance (particle size, T, t, pH).
- Test of sequential leaching processes.




### Bio-Leaching

- Assessment of bio-lixiviants e.g. cellular metabolites: tricarbonic acids, amino acids, chelators and cell components: phospholipids.
- Biotechnological production of selected substances with established microbial strains.
- Application of bio-lixiviants as sole leaching agents or in combination with conventional lixiviants.

| Organic Acids | Amino Acids | Chelators / Metallophores |
|---|---|---|
| - Yeast or Fungi<br>- PGA: *B. licheniformis*<br>- Oxalic Acid: *B. glumae*<br>- Acetic Acid: *K. xylinus*<br>- Citric Acid: *Y. lipolytica* | - Corynebacteria<br>- Burkholderia<br>- Glutamic Acid: *C. collunae, C. stationis* | - Bacilli<br>- *P. fluorescens*<br>- *S. melonis*<br>- *S. oneidensis* |

### Sorption

- Selection of suitable resins with sulfonic or carboxylic exchange groups (Monoplus S-108, S-100, SP112H, S100 G1, CNP80).
- Testing eluants for selective, fractionated elution (acids, amendment with complexants, pH).
- Optional: combination with precipitation.
- Comparison with liquid-liquid extraction using commercial extractants.

### Geochemical Simulation

- Database consolidation.
- Experimental verification for Eu, Tb and Lu.
- Reverse modelling to derive thermodynamic parameters of REE sorption as site densities and affinities.
- Forward process modelling to optimize process efficiency.

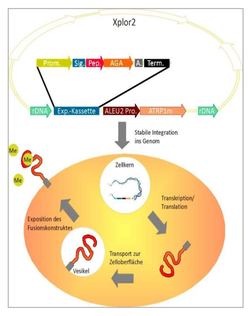
### Bio-Sorption

- Retention of REE on biomaterial: algae, cyanobacteria, duckweed, industrial by-products (chopped straw).
- Chemical surface modification, immobilization and stabilization, e.g. alginate beads.
- Sequential desorption of REE, application of e.g.: acids, complexing agents, alternative application of bioleaching agents.

### Marketable REE-Product

### Bio-Separation

- Identification of proteins with high selectivity for critical REE e.g. Prothrombin-fragment binding Eu.
- Combine with cell membrane proteins.
- Transfer gene complex via Xplor®2 **[2]** into yeast cells (e.g. *S. cerevisiae*, *A.Adeninivorans* or *H. polymorpha).*
- Separation of REE via selective binding of single REE on genetically produced yeasts.




**References: [1]** Moldoveanu et al. 2013. *Hydrometallurgy*, v131-132 (158-166), **[2]** Böer et al. 2009. *Applied Microbiology and Biotechnology, v*84.3 (583-594).