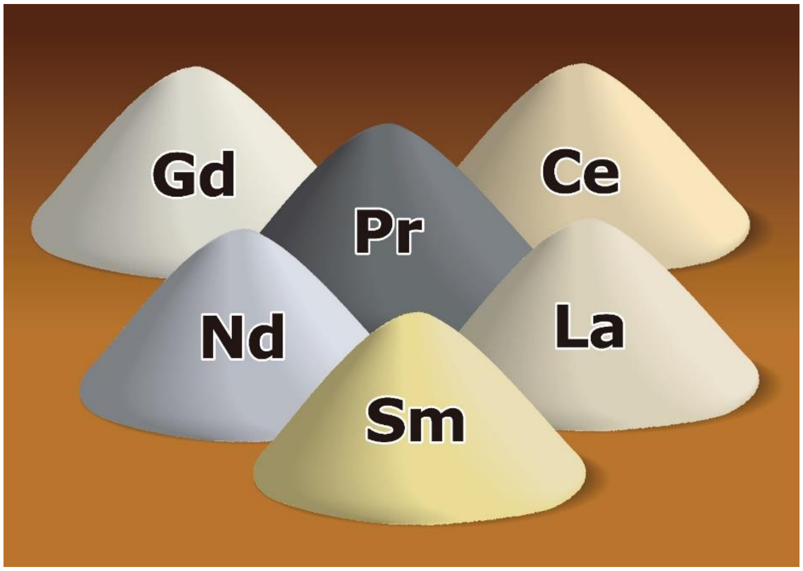


# Rare Earth Elements: Developing efficient extraction and purification processes

Conversations with OLI Experts on Science of Electrolyte Chemistry
Issue 3.0

**OLI Expert:** Dr. AJ Gerbino

**Key Questions for the OLI Expert:**

- What do we mean by Rare Earth Element processing? Can you give us some context on why it is important?

Rare earth elements (REE) are extracted from several natural and processed resources. Natural resources include a REE-containing mineral and clays. Processed resources include REE found in waste materials like phosphogypsum, coal fly ash, and recycled phones. There are around fifteen REE and several of them are critical to the modern economy.

- What are the different ways to 'mine' or extract REE?

REE mining is done in two general ways. The first is the one everyone would expect, dig the ore out of the ground, separate the gangue and chemically extract the elements. The second way is to extract the REE from the source without disturbing the ore body, this is in-situ extraction. OLI are not experts in mining and beneficiation area and will leave further explanation to those more qualified to describe it.



May 2020

- Is one process better than the other? What makes each technically challenging?

The difference in this case is the ore type, and therefore the process best for it. There are many REE containing minerals, but only a handful account for most global production. Three ores include bastnaesite, monazite, and xenotime. Since these minerals have different chemical compositions, they are processed differently. For example, bastnaesite is a carbonate-fluoride mineral and monazite and xenotime are phosphate-minerals. Thus, the extraction process is optimized based on this chemistry. Roasting and digestion is the most common extraction method. This process decomposes the mineral matrix, allowing the desired elements to be extracted.

By comparison, REE extracted from clays, is done via ion exchange using solution washing. Such a procedure keeps the mineral matrix intact and simply removes the REE adsorbed onto the surface. Thus, if we were to make a qualitative decision in which is better, then perhaps clay exchange because it has the potential to disturb the area less. However, since there are not sufficient clay resources to meet demand, other ores, with their accompanying extraction method, must be used.

There are technical challenges associated with each extraction process. Roasting and digestion for example can cause precipitation or dissolution of unwanted elements. Also, digestion creates potential corrosion problems from the volatilized acids. Lastly, there are the chemical/energy costs associated with digestion and extraction. In-situ clay exchange requires chemical injection into the ground/rock and therefore the risk of permeability problems, environmental discharge, and lower recovery efficiencies.

- How are water chemistry and electrolytes relevant to REE processing?

The core of REE processing is water/electrolytes chemistry. The key mechanisms include acid-base reactions, species-complexation, precipitation-dissolution reactions, surface reactions, phase partitioning, amongst others. Each of these mechanisms must be quantified in order to optimize REE processing and extraction.

- What is the science behind the effective REE extraction including the potential scaling/corrosion/other chemistry problems that can occur during the process?

The mechanisms described above require that the chemical speciation and activity of each element be studied. That means each of the fifteen or so REE and their reactivity with acids, precipitants, complexing agents must be known. The matrix shown below contains the current coverage of REE with different chemicals. The green cells have been studied. The yellow cells are under development, and the red cells are chemistries yet to be done.

Table 1 - Current implementation of Rare Earth Chemistry. Green – complete treatment of solution chemistry and solid phases. Pale green – preliminary treatment of solution chemistry and solid phases is available and a complete treatment will be included in v11. Orange – only solid phases are included in the databank (GEMSE); solution chemistry has not been modeled. Red – outstanding

| | O, OOH, (OH) | $SO_4$ | Cl | Br | I | F | $PO_4$ | S | $CO_3$ | Acetate | Citrate | Gluconate | DTPA | $NO_3$ | $MoO_4$ | Total phase |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| La | | | | | | | | | | | | | | | | 10 |
| Ce | | | | | | | | | | | | | | | | 11 |
| Pr | | | | | | | | | | | | | | | | 10 |
| Nd | | | | | | | | | | | | | | | | 12 |
| Sm | | | | | | | | | | | | | | | | 8 |
| Eu | | | | | | | | | | | | | | | | 7 |
| Gd | | | | | | | | | | | | | | | | 27 |
| Tb | | | | | | | | | | | | | | | | 11 |
| Dy | | | | | | | | | | | | | | | | 8 |
| Ho | | | | | | | | | | | | | | | | 5 |
| Er | | | | | | | | | | | | | | | | 8 |
| Tm | | | | | | | | | | | | | | | | 6 |
| Yb | | | | | | | | | | | | | | | | 8 |
| Lu | | | | | | | | | | | | | | | | 8 |
| Y | | | | | | | | | | | | | | | | 8 |

- What specifically is OLI doing to improve the design and operation of processes for REE extraction?

Our role in this industry is the chemistry and getting it right. We are therefore completing the chemistry for the above matrix and are also starting research into the more novel chemistry technologies. These includes solvent extraction, ion-exchange on resins and natural clays, and the secondary chemistry associate with these technologies.

We will eventually work directly with chemical suppliers and operators so that the priority chemicals like extractive agents can be part of the chemistry database.

- What are the key technology elements of OLI's solution for optimizing the REE extraction process?

The critical goal is maximum extraction of the key RE element in the process. The current market value of terbium for example, is 100 times greater than that of lanthanum. Therefore, maximizing extraction of the high value metals is critical to success. The technology that maximizes extraction of these higher values elements will be determined by the chemical properties of these high value metals (solubility, speciation, etc.). This is in comparison to the general approach of maximizing total REE yield.

- How can our viewers learn more about improving the design and operations of more effective REE extraction processes?

We have several presentations, journal articles, and reports written about REE. Also, several OLI technologists have researched the fundamental and applied chemistry of REE and their extraction process. Thus, we recommend that those interested contact us to see if our capabilities can help them improve their developments.

Click here to read the abstract and download the paper.