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Rare Earth Element Recovery from Apatite

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Rare earth elements (REEs) are considered critical elements integral to advanced energy production, transmission, and storage. Growing demand and supply risks have significantly escalated the problem of their availability in recent years. Exploring methods to recover REEs from both primary and secondary sources becomes crucial. Swedish deposits of apatite iron oxide ores are the major source of iron in the European Union and host REE-rich apatite ($Ca_5[PO_4]_3[OH,F,Cl]$) that has been disposed of in large quantities for over a century. Regarded as waste for a long time, most of the apatite was dumped together with the gangue in large tailing dams rather than being recovered and reused.

We propose a new method for REE recovery that has been tested at a laboratory scale on different types of material containing REE-rich apatite as a source of REEs. The essence of our approach is the chemical conversion of REE-rich apatite into a crystalline precipitate of REE-rich lead phosphates through a sequence of dissolution-precipitation processes resulting in rapid and efficient removal (97-100%) of REEs from pregnant solutions. Leaching, precipitation, and transformation into a marketable product are relatively simple and environmentally sustainable. The method does not require energy-intensive initial mechanical pre-concentration of heavy minerals or reactions at elevated temperatures. A crystalline precipitate can be easily separated from the suspension. In the final steps, Pb is separated from REEs and recycled in the process, while the final product is REE oxalate. Due to its compatibility with existing technologies and high REE recovery even from low-content sources, the method holds promise for circular and resource-efficient use of existing mines and waste streams.