

Location and stability of europium in calcium sulfate and its relevance to rare earth recovery from phosphogypsum waste

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ABSTRACT

Rare earth elements (REE) are technology drivers, essential for applications ranging from clean energy technologies to biomedical imaging. Thus they are “critical elements” and it is desirable to find additional RE domestic sources and explore green extraction technologies to overcome their supply risk. Phosphogypsum, a major byproduct of the phosphate fertilizer industry, incorporates a significant amount of RE from the apatite source rock and thus is a potential alternate source of RE. To know the accessibility and extractability of RE from phosphogypsum, it is important to understand the location and nature of RE binding. Here, we report the synthesis of analogs of RE-doped phosphogypsum, with europium (Eu) as a model RE. Using several characterization tools we conclude that the majority of Eu is on the surface of the calcium sulfate crystal as a separate secondary phase, namely a metastable amorphous/nanocrystalline precipitate in which Eu is associated with phosphate and sulfate as counterbalancing ions. The rapid precipitation at low temperature could be responsible for this behavior, which may not represent equilibrium, and our experiments are comparable in the timescale with the fast phosphogypsum precipitation in the industrial process. These results suggest that the Eu is not entrapped by ionic substitutions in the calcium sulfate lattice. Thus RE should be extracted relatively easily from phosphogypsum using methods that extract the RE from its surface.

Keywords: Phosphogypsum, rare earth elements, thermodynamics, spectroscopy