A new era for Florida's phosphates: rare earth minerals for EVs instead of fertilizers

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The periodic table you may remember from chemistry class had two additional rows of elements below the main table. In the top added row are rare earth elements, metals critical in everyday technologies like cell phones and flat-screen TVs. Their global demand has skyrocketed for use in renewable energy technologies like solar panels and electric vehicles.

So-called "rare earths," metals with names like Yttrium and Scandium, are not really all that rare. Most are more abundant than silver, gold and platinum. They are found in small concentrations, rather than in large, natural stores.

The United States currently imports more than 80% of its rare earth elements from offshore suppliers. A recent federal supply-chain assessment found an "over-reliance on foreign sources and adversarial nations." Through policy and the Bipartisan Infrastructure Law, the Biden Administration has pushed to build the U.S. supply of critical minerals needed for the clean energy transition, including rare earths.

Amid this effort to expand domestic sources, some researchers assert that Florida's phosphate deposits, mined by the fertilizer industry for over a century, could have a second life as a major supplier of rare-earth minerals.

"We could satisfy nearly 50% of the U.S. demand for many of the critical rare earth elements from Florida," said Chunhong "Patrick" Zhang, director of mining and beneficiation research at the Florida Industrial and Phosphate Research Institute (FIPR) in Lakeland.

But big questions remain about who would fund the significant start-up costs— and whether the Florida communities that have hosted the industry for a century would benefit from a mineral rush, too. Or if they would be harmed.

Turning sludge into profits?

The 15 rare earth elements are split into two categories, "lights" and "heavies," based on their atomic weights. While other deposits in the U.S. have high concentrations of lights, Florida has a high concentration of heavies, owing to its coastal geologic history.

So-called REEs are better conductors and more magnetic than other metals, making them particularly valuable for electronics, clean-tech, defense and other technologies.

Who controls them is an increasing geopolitical concern. U.S. imports come mainly from China, which currently produces roughly 70% of the world's supply.

Phosphate ore is relatively soft and dissolves with water, making it easy to separate from surrounding metals. In a national evaluation of U.S. phosphate deposits, research geologist Poul Emsbo of the U.S. Geological Survey (USGS) and his team found rare earth concentrations in the U.S. that are "equal to or greater than any known resource." The team also found that the rare earths in domestic phosphate deposits are "readily extractable," Emsbo said, and pose fewer environmental concerns than conventional REE mines.

Researchers and industry professionals said U.S. phosphate reserves could be part of a new domestic supply chain. Significant levels of REEs are found in not only phosphate deposits but also phosphogypsum, a radioactive byproduct of phosphoric acid processing. Every ton of phosphate produced leaves five tons of phosphogypsum waste, according to the Phosphate Innovation Initiative, an industry group. The waste is stacked into landfill-like mountains that pose environmental hazards. The industry is on the hunt for alternative uses, such as recycling the material for road-building, a controversial measure approved for study by the Florida Legislature this year.

In Central Florida's "Bone Valley," Zhang has spent the past decade researching the potential for extracting rare earth elements from phosphate and phosphogypsum at the FIPR institute, now based at Florida Polytechnic University. Zhang said that his work on the economic and technical feasibility of REE recovery from phosphate

sludge, funded by the U.S. Department of Energy, proved that mining wastes and byproducts "are viable resources for critical elements."

As a next step, Zhang, a national research team and The Mosaic Co., the largest phosphate mining company in Florida, have proposed a commercial demonstration plant on mining lands that would process rare earth elements from phosphoric acid sludge.

Extraction without mining

With scientific advances, additional mining is not necessary to extract rare earth elements. Special polymers, repeating chains of molecules that help minerals bond, can be added to phosphates to boost their ability to pull out metals.

Joseph Laurino is the founder and owner of Sarasota-based Periodic Products, an acid and chemical company that has developed polymers for REE extraction. His background in organic chemistry inspired him to patent the technology. The biggest source for rare earth elements, he said, is not in the ground, but in phosphate industry byproducts like phosphogypsum.

"There are enough rare earths in the phosphate waste in the U.S. to meet the U.S. demand for rare earth metal annually," he said. "We don't have to mine anything, we just have to recover it from the waste products."

A concentration of 4% of rare earth elements is needed in the waste wash solution for the REEs to be successfully separated, Laurino said. The polymers can further concentrate REE levels, making them easier to extract. The most economically efficient way to extract them from phosphate sludge, Laurino said, would be to co-locate REE sites at current phosphate operations.

"This process has to be done at the site where the material is generated, which is really good for the phosphate industry," Laurino said.

Mining companies like Mosaic would have a lot to gain financially from housing the processing, he said. New polymer technologies for extracting rare earths could also reduce the amount of waste going into phosphogypsum stacks, lowering both costs and radiation risks. Still unclear, Laurino said, is just how much of the material could be processed. It will depend on the size and capacity of the plant.

So far, Mosaic officials have deemed the steep capital and operating costs too high to justify beyond the lab and pilot scale. In a presentation to the U.S. Energy Association, the company reported the process is not yet economically viable "without significant government financial support, cooperative arrangement or other business incentives."

A benefit instead of a burden?

Zhang's latest progress report to the Department of Energy makes the case that REEs could be an important source of revenue for Florida's Polk County, which the report describes as "a disadvantaged community bearing a century-long environmental impact by phosphate mining." The county is home to the greatest concentration of phosphate mines, plants and gypstacks in Florida, carrying the industrial burden for much of the nation's phosphorus demand.

In the early decades of the industry, that burden was labor. Then it was water, and even community. Mines have wiped out natural streams and springs and displaced neighborhoods. The industry rips up thousands of acres of soils and vegetation before restoring it to habitat or other uses, a decades-long process. It stacks radioactive waste in small mountains that neighbors and environmental advocates worry pose contamination threats.

Zhang said he believes REEs could bring a significant benefit to local communities. But questions include how and how much. A data analysis for this project showed that the industry tends to be concentrated in areas with more poverty than the state average.

Omanjana Goswami, an interdisciplinary scientist with the food and environment program at the Union of Concerned Scientists, said the communities disproportionately burdened by the fertilizer industry need models for how that can change.

Also important are innovations to move society away from mining altogether, she said, and toward more sustainable sources for phosphorus and other elements. "At the end of the day, deposits are finite," she said. "What is and should be the solution is how to extract more efficiently and ensure the environment, people, especially, and communities around these mines are not being harmed."

New uses for phosphogypsum include the recapture of struvite, a fertilizer containing magnesium, ammonium and phosphate, from sludge and wastewater.

In addition to roughly $500,000 in in-kind support for Zhang's demonstration plant, Mosaic has awarded about $500,000 to the University of Florida over the past three years for other research projects to find plausible uses for phosphogypsum and paths toward a cyclical economy for phosphate.

Environmental engineering professor Timothy Townsend in UF's Sustainable Materials Management Research Laboratory has been working on the potential for using phosphogypsum waste as a road-building material to reduce the size of gypstacks.

Townsend said his research suggests a path for phosphogypsum

innovation in the industry. His next steps are sample road base projects that will test the viability and structural capacity of roads that contain phosphogypsum compared to traditional road material. He'll also test radiation leaching.

Environmentalists charge that the process could release radioactive materials into the air and waterways and expose construction workers to cancer risks; they have urged Gov. Ron DeSantis to veto this year's bill approving the demonstration project.

An MRI for the Earth

Over the next decade, the U.S. Geological Survey, working in partnership with state geological offices, will map the nation to identify areas that contain critical mineral supplies, said research geologist Warren Day, Science Coordinator for the Earth Mapping Resources Initiative.

"That's never been done," said Day of the mapping project, nicknamed Earth MRI. "It's a huge mission, it's a great challenge."

Day said the Bipartisan Infrastructure Law appropriated $320 million for the first five years of mapping.

Geologists with the Florida Geological Survey are currently working with USGS to investigate the potential for REEs from Florida phosphate mining waste. The state Department of Environmental Protection did not respond to interview requests to discuss the work.

On top of domestic security and supply chain issues, Day said, reliance on minerals from countries with lax human rights and environmental protections means we're "exporting our problems to those countries."

Goswami of the Union of Concerned Scientists said the way forward is to turn the "vicious cycle" of mineral extraction through mining into a virtuous cycle that doesn't cause problems for people here or elsewhere.

"It's a matter of policy, of course, money, as well as community push too," she said. "For short-term gains, we are doing long-term damages that would be so hard to repair. It is almost irreparable and irreversible."