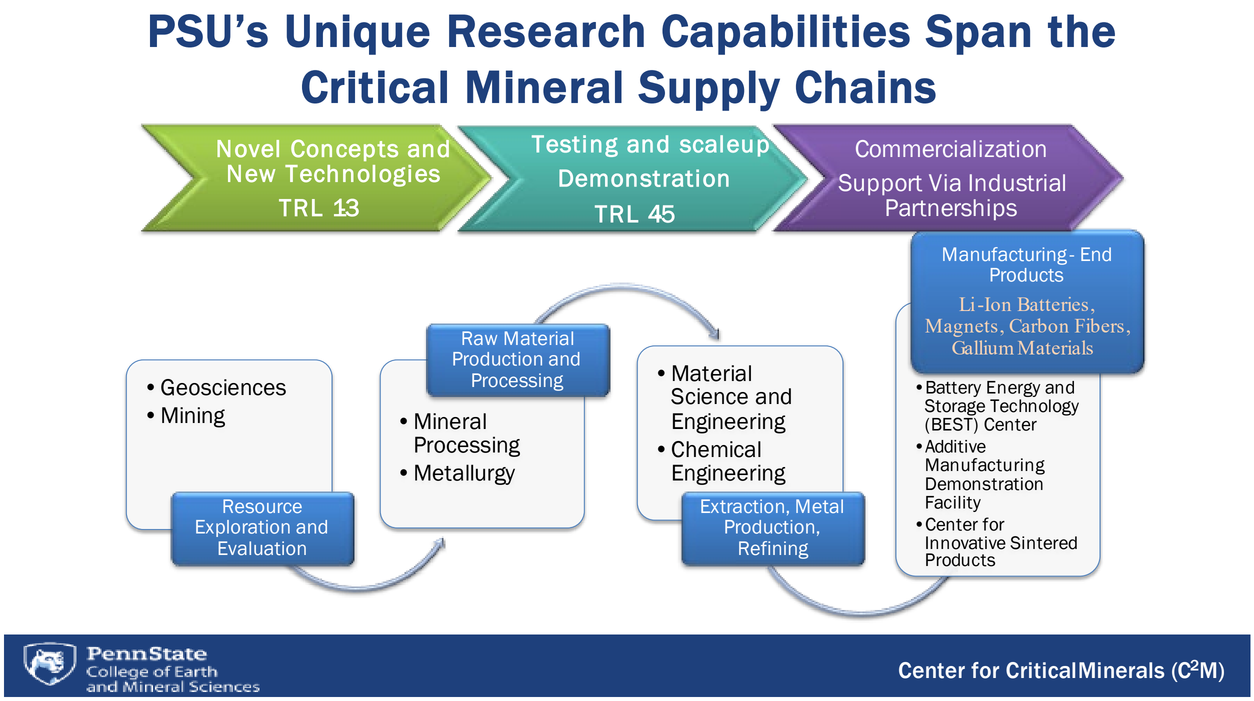
**Domestic Critical Mineral Production Opportunities in PA for National Security**

**Sarma V. Pisupati**
**Professor of [Energy and Mineral Engineering] and [Chemical Engineering]**
**Director, [Center for Critical Minerals]**
**College of Earth and Mineral Sciences**
**The Pennsylvania State University**
**Tel: 814-865-0874**
**Email: sxp17@psu.edu**




Chairman Causer and members of the House Majority Policy Committee,

Thank you for giving me this opportunity to offer testimony and answer your questions regarding Pennsylvania's Emerging Critical Mineral and Rare Earth Element Industry and the role of these critical minerals in the United States for economic progress and national security.

I am a Professor of Energy and Mineral Engineering and Chemical Engineering and Director of The Center for Critical Minerals In the College of Earth and Mineral Sciences at the Pennsylvania State University.

The United States is 100% import reliant for 30 of the 50 critical minerals and at least 50% for another 14 of the 50 elements. The United States has only 1% of the world's reserves, whereas China has 37%. Russia is also a global mineral powerhouse. As a result of the war with Ukraine and ensuing sanctions on Russia critical mineral supply chain is affected even more. The only way to break this foreign reliance is to build a robust domestic supply chain.

Let me first distinguish between rare earth elements and critical elements. Rare earth elements 15 lanthanide elements plus two other elements scandium and Yettrium as defined by their chemistry. Critical elements are determined based on their need for economic progress, demand, availability, and import reliance. According to The United States Geological Survey, a critical mineral is identified based on 1. A quantitative evaluation of supply risk, 2. a semi-quantitative evaluation of whether the supply chain had a single point of failure, and 3. a qualitative evaluation when other evaluations were not possible. This year 50 minerals are defined as critical by the US DOI, which includes all the rare earth elements and some others. These rare earth elements are not rare but are distributed in very low concentrations everywhere. So, we need to process a lot of material to get small quantities of the products at the end. These elements are used in a wide range of applications, from commonly used touch screen smartphones and computers to life-saving medical devices to state-of-the-art defense systems.

Everything that we use today, we expect to be smaller and stronger. For example, when 10 parts per million of scandium is added to aluminum, strength increases by 10-fold. When the size is smaller, it takes less energy to move, hence higher efficiency. Therefore, to make materials lighter and stronger, we desperately need these rare earth elements. Sustainable energy sources such as windmills require stronger magnets which can be made only by using rare earth elements such as neodymium. Similarly, solar energy capture and conversion devices need elements like gallium, indium, and germanium etc.

About 28% of the country's energy is used for transportation. The transportation industry is moving away from gasoline vehicles to electric vehicles, and this is placing high demand on these elements for energy storage in batteries. For example, a hybrid automobile needs approximately 1 kilogram of rare earth elements and half a kilogram of graphite. In addition, batteries in electric vehicles require elements such as cobalt, manganese, lithium, and graphite to store the energy. A single F35 fighter aircraft needs about 1/2 of a ton of rare earth elements, and Stryker armored fighting vehicles, predator drones, and tomahawk missiles require these rare earth elements. This demand for critical minerals for strategic defense systems makes them critical for our progress. In the 1960s and 70s, the demand was less, and the United States produced most of these elements for the needs of the world. Later in the 90s, the rare earth element and other critical mineral production moved away from the United States to countries like China and the Republic of Congo, where the human rights and environmental regulations are not as stringent as in the United States. According to the United States Geological Survey, as shown in figure 1, most of the nonfuel mineral imports are from China. China was responsible for more than 80% of rare earth imports in 2019.

**Major Import Sources of Nonfuel Mineral Commodities for which the United States was greater than 50% Net Import Reliant in 2020**


**Source: U.S. Geological Survey**

Figure 1: Imports sources for non Fuel Minerals for the United states.

According to the International Energy Association (IEA, 2020), China produces 63% of the world's output of rare earth elements and 45% of molybdenum. More than 70% of cobalt is mined in the Democratic Republic of Congo and processed in China, with China having the majority ownership of these mines. Australia produces 55% of the world's lithium, with China as its major importer.

The supply chain of rare earth elements and other critical minerals was disrupted by COVID in 2020, affecting the manufacturing sector. Consumer electronics was the most affected industry due to the high demand for communication electronics at the same time, production was shut down due to Lockdowns in many parts of the world. The shortage of computer chips that use rare earth elements has created delays in the delivery of automobiles even after COVID-19 shutdowns.

The main challenges faced by the United States are:

1. There are no commercial rare-earth separation plants in the United States. Even the rare earth oxides produced from the only operating mine in the United States are sent abroad for separation and reduction to metals.
2. No commercial metal making, alloy making, or rare earth permanent magnet manufacturing occurs in the United States of America.

3. There is only one facility in North America (Canada) capable of processing the concentrate into battery-grade cobalt

COVID-19 supply interruptions act as a wake-up call for monitoring the critical mineral supply chain to counter the vulnerability. Since the United States' primary ore reserves are only 1% of the world's, we need to explore secondary resources, including industry byproducts such as coal mining wastes, drainage from abandoned coal mines, refuse piles, and fly ash from coal-burning power plants. Pennsylvania is rich in these resources. Locked inside those waste streams are significant quantities of rare earth elements and other critical minerals. Abandoned Mine Drainage (AMD) is one of the largest sources of stream impairment in Pennsylvania. Billions of gallons of AMD impair over 5,500 miles of streams within the Commonwealth according to PADEP. So how can we solve this environmental problem and at the same time overcome the import reliance for these critical minerals? Pennsylvania is rich in secondary sources i.e byproducts of another operation. We already must treat this drainage before releasing it into the environment to meet the environmental regulations for discharging water. By modifying existing treatment processes, we can address multiple problems: getting the material we need for national security and remediating long-standing environmental problems at the same time. If we do it right, we can create jobs and an economic boost for the communities coal has left behind. Penn State is a leader in the remediation of these sites and the extraction of valuable minerals from these sources. This is a multidisciplinary problem that involves mining, mineral processing, material science and engineering, metallurgy, chemistry, chemical engineering, and also mineral economics. Penn State is strong in all these disciplines. Our team has worked diligently and developed a patent-pending three-stage process (Figure 2). In this process, by gradually changing the acidity and adding less harmful and less expensive chemicals than those currently used, we can recover over 90% of the cobalt and manganese at higher than commercial ore grades. We also have recovered over 85% of the rare earth element oxides at a grade (purity) of over 88%. The preliminary estimate is that 60 metric tons of cobalt and over 5,500 metric tons of manganese are being discharged with acid mine drainage into the Commonwealth's waterways every year.

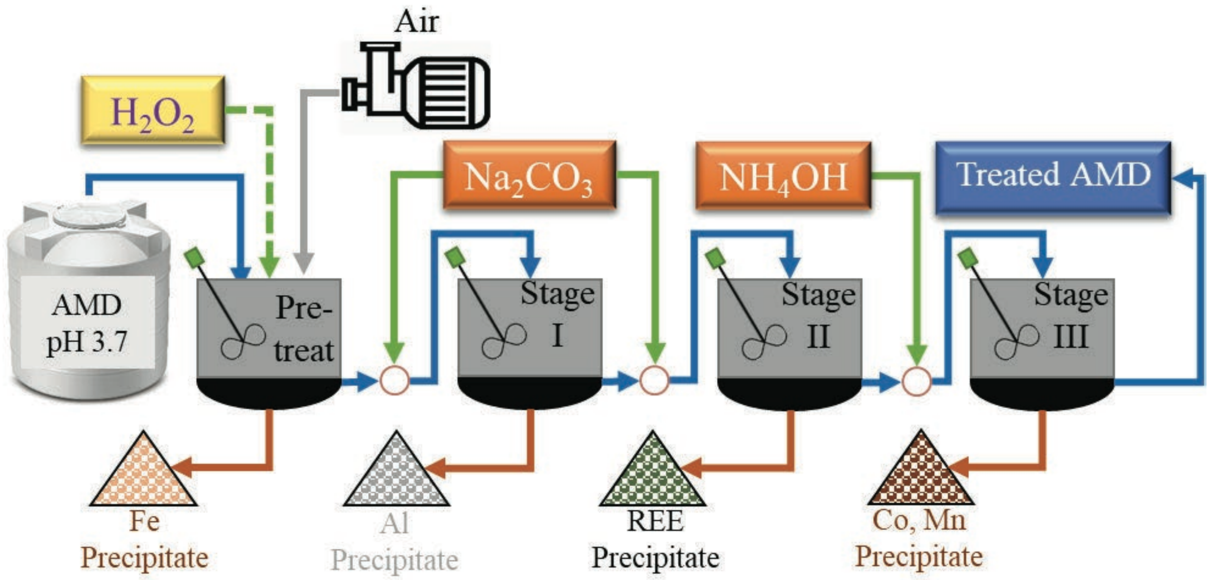



**Figure 3. Penn State Process to treat AMD to extract critical minerals**

The developed process also works for lithium-rich Mercer clay to pull out over 90% of lithium from the feedstock. The proof of concept and process technical feasibility have been established. This is a perfect time to scale up some of the novel extraction technologies that have shown such promise to build a small demonstration facility to integrate all components and show potential investors that this can work to attract private venture capital funding. Penn State has developed a Power and Mineral Industrial Stakeholders group which consists of 40 industries from the entire supply chain for these critical minerals.

Another critical mineral for energy storage in batteries is graphite. The Commonwealth of PA is a state rich in coal (a carbon source); ironically, we import 100% of natural graphite. St. Marys, Pennsylvania, is a carbon manufacturing hub in the U.S. With the availability of domestic carbon sources from coal, there is an opportunity to develop synthetic graphite producing capabilities in PA based on PA resources. Penn State is working with PennCara Energy (holder of WVU patented technology) to install a pilot scale plant to produce Synpitch. The pitch produced is being graphitized at Penn State, and its properties are being evaluated. This graphite produced from Synpitch from domestic coal is proving to be much superior to the graphite produced from a commercial pitch.

In another study funded by DOE, Penn State estimated that coal refuse in Pennsylvania contains approximately 52,000 metric tons of cobalt. Over a half-million metric tons of manganese are contained in these accumulations.

So, Pennsylvania has a significant secondary critical mineral resource. Current technology can jumpstart the development of this industry, and research and development work is beginning to identify greener processes for the extraction and separation of these elements from waste.

The need is urgent, and you will witness this afternoon through visits to our labs, that Penn State is ready and able to help with the characterization of the resources for technology development to help the industry to commercialize the processes. Thank you very much again for this opportunity and your attention.