**"The Role of Federal Research in Establishing a Robust U.S. Supply Chain of Critical Minerals and Materials"**

**U.S. House of Representatives**

**Committee on Science, Space and Technology**

**November 30, 2023**

**Testimony of Thomas E. Baroody**

**President and Chief Executive Officer**

**K-Technologies, Inc.**

**Lakeland, Florida**

## INTRODUCTION

Good morning, Chairman Lucas, Ranking Member Lofgren, and members of the Committee. I want to thank you for the invitation to be on this excellent panel today. As one of the representatives of the private sector today, it is my hope that I can provide you all with information and perspective as you consider the vital topic of federal research and prudent taxpayer spending married with private sector initiatives and risk-taking. Taken together, I believe we are building a more robust and diverse U.S. supply chain of critical minerals and materials. Time is of the essence and the task is urgent.

## RARE EARTH ELEMENTS AND THE HISTORIC CHALLENGE OF PROCESSING

Rare Earth Elements (REE) are available from multiple sources such as mineral ores (generally higher grade), ionic clays (generally lower grade, bulk tonnage) and waste materials (phosphogypsum (PG), phosphoric acid sludges, coal mining tailings, end-of-life magnets). Each of these sources require different methods to liberate the contained REE, such as gravity concentration, flotation, hydrometallurgical, and pyrometallurgical processes.

For practical and economic purposes these initial processes must be undertaken at the source location. Intermediate products are then exported (predominantly to China) as a mineral concentrate, typically 40% to 60% contained Rare Earth Oxides (REO) or as a precipitate such as Mixed Rare Earths Carbonate (MREC). These concentrates and MREC intermediate products are then processed to produce separated and purified REO which feed the metal and alloy manufacturers who in turn supply the magnet manufacturers.

Historically, and presently, the final stage of separating and purifying the REE is performed by a highly inefficient, and environmentally unfriendly, Solvent Extraction (SX) process which is independent of the REE source. This SX process requires hundreds of mixer-settlers and virtually all of the world's REE are produced this way in China.

K-TECH AND THE COMMERICAL INDUSTRIAL PROCESS

I would like to talk today about some of the successful business projects K-Tech is engaged in and what we are doing to advance the goal of bringing critical minerals into the U.S.

Over the past 15 years, K-Tech has specialized in developing and bringing-to-market chemical and processing applications to extract desirable, commercial grade elements and other materials. Several alternative technologies to SX are being researched and developed in the West and by K-Tech. The most prospective of these technologies, for early adoption, is Continuous Ion Exchange and Continuous Ion Chromatography (CIX/CIC). This technology has been applied in production facilities for a variety of industries around the world for decades and has been the focus for technology development at K-Tech since 1987, including for REE.

K-Tech has been researching and developing CIX/CIC for application to REE separation and purification for several years and has demonstrated the ability to separate REE with its CIX/CIC process as a result of this research.

The CIX/CIC process has numerous advantages over the conventional SX route in terms of economics, safety, environmental impact, and size of plant, with much lower capital and operating cost intensity.

Over the past several years the REE markets and supply chain have seen some rather dramatic movements, and the global market now realizes that REE from other sources, both from a feedstock (i.e.; mining, waste tailing stacks, or recycled scrap) and geographical standpoint, are needed. As such, there has been a significant increase in REE sourcing assessments and evaluation of alternate feedstock sources.

It is worth emphasizing that often we are utilizing ore from waste by-products of other mining or processing projects from years ago. By using mining waste as a feedstock, we are in a win-win situation whereby critical minerals are being extracted at a lower, commercially viable cost at a benefit to the environment.

It is well known that many phosphate rock sources contain some level of REE, but the concentrations tend to be low, i.e., in the parts/million to hundreds of parts/million. It is also known that during the phosphate rock digestion process to produce phosphoric acid, the majority of the REE is not dissolved, but remains in the phosphogypsum waste. However, some percentage of available REE does dissolve into phosphoric acid and this is where K-Tech had initially focused its recovery efforts.

As an example, in the production of wet process phosphoric acid, elements such as uranium, rare earths, yttrium, vanadium, cadmium, fluorides, and silica are usually present in small quantities. K-Tech's extraction technologies can treat large volumes of intermediate process streams like phosphoric acid in a continuous manner, and isolate and recover certain desired target elements in a highly concentrated low volume solution. This solution in turn can then be treated separately to produce one or more target elements as marketable products.

## THE EXAMPLE OF RAINBOW RARE EARTHS

Rainbow Rare Earths Limited (Rainbow) is in the business of establishing an independent and ethical supply chain of the rare earth elements that are driving the green energy transition and the most advanced defense articles and systems. They have a focus on the permanent magnet rare earth elements neodymium, praseodymium, dysprosium and terbium. All four of these elements are categorized by the U.S. Government as being vital in both the short term and medium term.

I note that Rainbow, traded on the London Stock Exchange, desires to have its products processed and used in the U.S., North America, or allied European markets.

Their corporate strategy meshes well with the Department of Energy's critical mineral strategy detailed in the department's July 2023 "Critical Materials Assessment". That strategy document focuses on diversifying and expanding U.S. supplies, developing alternative manufacturing processes, enhancing material and manufacturing efficiency to reduce waste, and assisting in stockpiling and international engagements to benefit the U.S. (https://www.energy.gov/sites/default/files/2023-07/doe-critical-material-assessment_07312023.pdf)

Rainbow is developing its Phalaborwa REE project in South Africa to recover REE from phosphogypsum and has opted for the CIX/CIC process with K-Tech for the separation and purification of the REE to produce the selected REO products. This presents a unique opportunity for K-Tech to utilize its process allowing separated REO to be produced, independently from China, for sale to the U.S. and allowing development of a U.S. down-stream supply-chain including specialist alloy, REE permanent magnets, drive trains, and ultimately EV/wind turbine manufacture. From a national defense standpoint, magnets are a driving force behind continuous innovation in defense technology such as precision-guided munitions, tank navigation systems, and electronic countermeasures equipment. Without guaranteed independent supply these investments could not be made in the US.

The Rainbow process to produce rare earths from historic industrial waste, cleans up legacy environmental issues and delivers a true circular economy benefit – not just producing REE from waste, also allowing the cleaned gypsum residue to be sold for agricultural/construction purposes.

Rainbow is also focusing on other global opportunities, including recovery of REE from PG waste from Mosaic Fertilizantes' Uberaba operation in Brazil owned by The Mosaic Company, a New York Stock Exchange listed U.S. multinational. That project is at an earlier stage of development, but the Brazilian undertaking is currently operating and would involve processing a great deal more PG over a much longer life than in South Africa.

The overall process is split into two major parts:

1) <u>Front-end</u> - production of a mixed REE carbonate from the PG, along with restacking of the cleaned-up benign PG into the new lined stack for sale;
2) <u>Back-end</u> - processing of the REE carbonate through K-Tech's propriety CIX/CIC system to produce the four target REE oxides.

If Rainbow is successful in developing a Brazilian operation like it plans in South Africa, the back-end of the processing facility (K-Tech's CIX/CIC system) could logically be located in the U.S. I understand that Rainbow is starting the process to consider potential sites for a commercial plant in the U.S. If so, this would greatly benefit U.S. production of critical rare earth materials.

K-Tech is currently concluding a bench scale test program on the Phalaborwa material and has assembled a CIX/CIC pilot plant for Rainbow at its Lakeland, Florida facility. This pilot plant will commence operation shortly on samples of MREC shipped from Rainbow's pilot plant operation in South Africa, to demonstrate the production of on-specification separated REO for the alloy and magnet industry. The process in Lakeland will, for the first time, allow for the production of separated REE battery metal oxides on a commercial basis in the U.S. That represents a major step forward in bringing this type of supply into the U.S.

I would also like to stress that by both public financing, private capital, and U.S. research we are doing something else that makes the U.S. unique—developing significant intellectual property that ensures our nation is the technological leader for decades to come. At K-Tech, my colleague Wes Berry (CTO of K-Tech), the company, and I hold eight patents (soon to be nine as one is scheduled to be issued in December 2023), of which three have been sold to a third party. Also, our CTO was the inventor of the CIX/CIC process, and holds some thirty other patents. The Rainbow and K-Tech process teams have developed an innovative process to recover REE from PG which has the potential to unlock the vast resource of this material worldwide with a significant environmental benefit for these polluted sites. Rainbow and K-Tech are jointly progressing a patent application for the process to be lodged in the U.S.

ROLE OF FEDERAL GOVERNMENT

K-Tech is highly supportive of the federal government's efforts to support domestic and foreign sourcing and processing, research, and project funding to diversify a secure and sustainable supply chain for minerals that are vital to our national defense and the global economy. Programs undertaken by the Departments of Energy, Defense, and Commerce and the U.S. International Development Finance Corporation (DFC) are playing a key role in unlocking capital to fund promising opportunities in mining and processing of REEs and other critical minerals.

I understand that Rainbow has entered into an option agreement whereby TechMet has the right to invest US$50 million to fund a substantial part of the equity component for Rainbow's project in South Africa. The DFC is an important shareholder in TechMet.

At the state government level, we work closely with the Florida Industrial and Phosphate Research Institute (FIPR) affiliated with the Florida Polytechnic University. K-Tech, FIPR, and Pacific Northwest National Laboratory (PNNL) are currently cooperating on a joint submission to DOE for funding to examine the extraction of REE from phosphoric acid sludges. Also, in 2014-15, K-Tech worked with Texas Mineral Resources Corp. (TMRC) on a DOE grant to successfully recover several targeted high purity REE from TMRC's Round Top rhyolite orebody in West Texas. K-Tech also participated with TMRC, and two other entities, in recovering REE from coal fly ash waste from a Pennsylvania coal mine under a DOE grant in 2017-18.

CONCLUSION

Science at its essence is about trial and error—experimentation based on systematic methodology based on evidence. The U.S. has always led the world in the field of science. At K-Tech we are devoted to furthering science that leads to better and practical outcomes in the area of critical minerals.

I would like to thank the Committee for the opportunity to provide you with testimony today. This Committee and all the other Congressional committees with jurisdiction over the federal government's role in shaping policy on science and technology, national security, foreign relations, and appropriations must continue to be well-versed on the rapidly changing environment on critical minerals.

# **Thomas E. Baroody**
# **Biography**

My name is Thomas E. (Tom) Baroody. I was born in Richmond, VA, and lived there through my elementary school days and one year of high school. Then I moved to Geneva, NY, where I graduated from high school, and where I played football, basketball, and baseball. After that I attended Rensselaer Polytechnic Institute, graduating in 1967 with a BCE degree. I played football and baseball for RPI during my time there. I then attended the University of Missouri-Columbia, getting an MSCE degree in 1969.

After college I started working as a staff engineer for AMAX Inc., which was a large mining company with diversified operations around the world. While at AMAX, I progressively worked my way up to a VP of their chemical division, having lived in New York City, Stamford, CT, and then Lakeland, FL., where I have resided since 1980. During my career, I have traveled to some 50 countries in the world mostly on business related to iron ore mining and processing, and later to phosphate and potash mining and processing.

After leaving AMAX in 1986, I started my own consulting business TEBCO Associates LLC, and K-Technologies, Inc. with a partner, both in 1987. As TEBCO, I have undertaken many technical, marketing, and economic studies for a number of private companies and several government agencies. At K-Tech, we got our start by providing a new technology (CIX) for a U.S. based company to build a potassium carbonate production facility, and later expand into a separate plant that produced technical grades of certain phosphate products.

After that, we expanded K-Tech's private shareholding to 15, and have worked with a number of companies around the world in providing our CIX/CIC technologies for use in various industries. These include the extraction, separation, and purification of materials such as uranium, rare earths, fluorides and silica, and certain deleterious elements from phosphoric acid. We can also do the same thing from leach solutions of various mineral ores, and from waste materials like phosphogypsum, acid mine drainage and sludges, and scrap. The company has also undertaken separations of organic materials like tocopherol/sterol mixtures leading to production of Vitamin E, as well as target proteins from plant-based feed stocks, leading to production of various meat and dairy products. We have been granted 8 U.S. patents with one more being issued in December.

During the 1996-2000 period I was a senior VP at Mulberry Corporation, a privately held company which owned and operated a phosphate mine and two phosphate chemical plants in Central Florida. I was in charge of successfully revitalizing one of their chemical plants and restarting and expanding their phosphate rock mine.

During the 2003-2006 period, I worked as COO for an entrepreneur who started a company to develop a large ammonia/UAN project that would be built in Trinidad.

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November 28, 2023