Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 43 Issue: 08-2024
DOI: 10.5281/zenodo.13309791

OPPORTUNITIES AND CHALLENGES OF POSSESSION OF THE RARE EARTH RESERVES IN VIETNAM TODAY

HUY MACH TRAN

PhD, Business Administration, Deputy Chief University Office, Ho Chi Minh City University of Economics and Finance, Vietnam. Email: huymt@uef.edu.vn

TUAN LAI DOAN ANH

M.A., Business Administration, Lecturer, Hung Vuong University Ho Chi Minh City, Vietnam.
Email: tuanlda@dhv.edu.vn

THU CHU NGOC ANH

M.A., Linguistics, Staff UEF International Institute, Ho Chi Minh City University of Economics and Finance, Vietnam. Email: thucna@uef.edu.vn

ANH NGUYEN HUYNH VAN

M.A., Business Administration, Staff University Office, Ho Chi Minh City University of Economics and Finance, Vietnam. Email: anhnhv@uef.edu.vn

ANH NGUYEN BA

M.Sc., Finance and Banking, Deputy Director UEF International Institute, Ho Chi Minh City University of Economics and Finance, Vietnam. Email: anhnb@uef.edu.vn

LAN NGUYEN PHUOC

M.A., Business Administration, Deputy Director of the UEF Center of IT and Foreign Languages, Ho Chi Minh City University of Economics and Finance, Vietnam. Email lannp@uef.edu.vn

Abstract

Rare earth elements have become indispensable raw materials for advanced technologies in developed countries, appearing in most high-tech products. Since the 1960s, scientists in Vietnam have conducted research on the application of rare earth elements in various fields, including agriculture, permanent magnet manufacturing, and steel alloying. However, the exploitation and export of rare earth elements in Vietnam have not fully tapped into their potential and remain at a small scale. Moreover, Vietnam lacks the capability to deeply process rare earth elements and separate each individual element, primarily exporting these resources in the form of low-value ore. However, the exploitation of rare earth elements also leads to various issues such as environmental pollution and the decline of biodiversity. This research aims to analyze the opportunities and challenges and provide solutions for Vietnam in its current ownership of rare earth resources.

Keywords: Rare Earths, Opportunities and Challenges, Environmental Pollution, Exploitation.

1. INTRODUCTION

In the context of economic development, an increase in the demand for green energy and high-tech equipment forces the ownership and management of Rare Earth Elements (REE) which has become a crucial issue for many countries worldwide. Rare earth elements play a major role in many fields, including industry, technology, and renewable energy. Currently, Vietnam is one of the countries that has possessed large reserves of REE. For Vietnam, owning rare earth resources seizes numerous opportunities to

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enhance production capacity, develop industry, and foster technological innovation. However, that fact also poses significant challenges in terms of environmental protection and sustainable development. Therefore, research on the opportunities and challenges of possessing rare earth reserves in Vietnam today aims to provide a comprehensive consideration of the economic, environmental, and social perspectives in the process of effective exploitation and utilization of these resources.

2. OVERVIEW OF RARE EARTH ELEMENTS AND RESEARCH METHODOLOGY

2.1. Concept of Rare Earth Elements

The International Union of Basic and Applied Chemistry (IUPAC) defines Rare Earth Elements (REE) as the general name for a group of 17 chemical ones in the Periodic Table of the Elements, including these (arranged in alphabetical order): Cerium (Ce); Dysprosium (Dy); Erbium (Er); Europium (Eu); Gadolinium (Gd); Holmium (Ho); Lanthanum (La); Lutetium (Lu); Neodymium (Nd); Praseodymium (Pr); Promethium (Pm); Samarium (Sm); Scandium (Sc); Terbium (Tb); Thulium (Tm); Ytterbium (Yb) and the last one is Yttrium (Y); and 15 elements of the Lanthanum group (La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu). Among them, Promethium is extremely rare with about 570g in the entire crust of our planet, only existing in the natural environment because it has no stable or long-lived isotopes (Castor and Hendrik, 2006). According to the United States Department of Energy, the important REE group includes 5 elements: Neodymium, Europium, Terbium, Dysprosium, and Yttrium (US DOE, 2010). The most abundant element is Cerium with a concentration of 68 parts per million (ppm), meanwhile, the least abundant elements Thulium and Lutetiu have a concentration 200 times higher than the amount of gold in nature. Despite being named “Rare earth elements”, they are not particularly rare in terms of total diversity abundance, significantly surpassing commonly utilized elements such as Copper, Zinc, Nickel, and Lead (Gupta and Krishnamurthy, 2005).

2.2. Role of Rare Earth Elements

- Utilizing Rare Earth Elements in Industry

The glass manufacturing industry relies mostly on REE such as Cerium, Lanthanum, and Lutetium, which are frequently used to color and polish glass surfaces. In 2019, 38% of global REE extractions were dedicated to permanent magnet production, catalysts manufacturing, glass polishing industry, metallurgical industry, battery manufacturing, and phosphor production, consuming 23, 13, 8, 9, and 4% of REE oxides in the global production system (Garside 2020). China dominates the global REE supply chain as the largest producer of these critical raw materials, accounting for 58% in 2020 and 60% in 2021 respectively (Gambogi 2021; Cordier 2022). REE are the preferred materials for permanent magnet and refrigeration due to their high magnetic susceptibility, saturation magnetization, and large magnetothermal effect (Berkdemir et al., 2015). Permanent magnet materials convert mechanical energy into electrical energy through a magnetic field and they are typical to achieve lightweight and high-performance energy conversion (Hinatsu et al., 2016). Permanent magnets convert electrical energy into mechanical

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energy (motors) or vice versa (generators) by creating a magnetic field. The development of wind energy technology aims to use renewable energy sources in the global energy production system and then decrease carbon dioxide emissions. Permanent magnets are also essential components in drives, small motors, speakers producing sound, electric turbines, and generators. Neodymium magnets, made from Neodymium, Boron, and Iron, are currently the strongest magnets and can be used in wind turbine motors and electric vehicles. Besides, REE are also utilized to make cathode lamps in television sets, superconducting materials, and catalysts in petrochemical refining technology and effective environmental treatment. Among the REE, some play a key role in the development and demand for AI and computer chips. Neodymium (Nd) is crucial for producing permanent magnets and is indispensable in electronic devices and components. Samarium (Sm) is used in Samarium-cobalt magnets, which are valuable in high-temperature applications for AI chip production. Terbium (Tb) and Dysprosium (Dy) are used in solid-state devices and as doping materials in semiconductors, which are key to enhancing the performance and efficiency of computer chips. Erbium (Er) is a pivotal figure for fast data transmission in fiber optic communication systems, thereby facilitating the functionality of computer technology and AI [1-4].

- Utilizing Rare Earth Elements in Military

Significant applications in infrared laser technology for military purposes, especially it can be employed in the production of sensors for missile systems. They also have a strategic role in military applications such as guidance and control, targeting and weapon systems, and communication platforms (Charalampides et al., 2015). Vehicle-mounted laser range finders, fiber optic communication systems; Optical lenses, and acoustic transducers are used in submarine sonar systems. For example, a US F-35 fighter jet requires about 427 kg of REE and a Virginia-class nuclear submarine uses nearly 4.2 tons of REE.

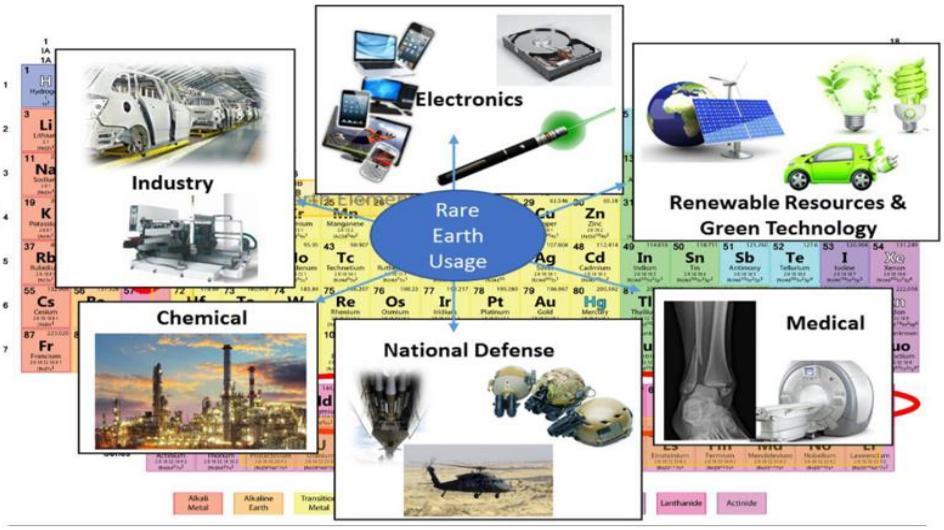

Figure 1: Applications of REE

Source: Geoscience Australia

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- Utilizing Rare Earth Elements in Agriculture

In agriculture, REE are one of the essential trace elements for some crops such as rice, sesame, corn, bananas, oranges, tea, etc. [5-7]. Numerous studies have indicated the role of REE in crop growth [8, 9]. REE are crucial components in the growth and development of plants, influencing the development of root and leaf systems, the procedure of germination, shoot growth, and increased chlorophyll content, forcefully enhancing the photochemical process. Consequently, they promote plant growth while increasing resistance to adverse environmental conditions, contributing to increased crop productivity [10].

- Utilizing Rare Earth Elements in Medical

In addition to similar chemical properties, synthetic characteristics, and clinical management, some REE radionuclides have garnered attention due to their radioactive decay characteristics, suggesting potential for significant therapeutic applications (Cutler et al., 2000; Mishiro et al., 2019). This is one of the important applications of REE, they are used to produce surgical equipment, cancer drugs, pacemakers, and arthritis drugs. Lanthanides are also employed in many medical and health applications, such as anti-tumor agents, kidney dialysis drugs, and surgical devices. Because of their optical properties, REE have been used in many imaging techniques such as computed tomography, magnetic resonance imaging (MRI), positron emission tomography (PET), and X-ray imaging. Based on our observations, REE play an important role in various areas of modern life. They are widely utilized in technology, medicine, renewable energy, and numerous other applications. REE applications bring economic benefits and contribute to socially sustainable development and progress.

2.3. Research methodology

The article is conducted on qualitative research methods, based on synthesis and analysis of secondary data sources, to grasp the purposes of describing and explaining, clarifying opportunities and challenges of possessing the Rare earth reserves in Vietnam today. Consequently, we propose solutions to optimize economic benefits from these reserves, preserve the environment, and achieve sustainable development in this field.

3. OPPORTUNITES OF POSSESSING RARE EARTH RESERVES TODAY

3.1. Rare earth reserves in Vietnam

REE are essential in manufacturing various products, including cancer drugs, smartphones, and renewable energy technology. Currently, China accounts for 63% of the world's rare earth mining output, 85% of rare earth processing, and 92% of rare earth magnet production. According to the United States Geological Survey, global rare earth reserves are estimated at 120 million tons, with China holding 44 million tons. Following China, Vietnam has the second-largest rare earth reserves in the world, with an estimated 22 million tons (approximately 19% of global reserves), followed by Brazil with 21 million tons, and Russia with 12 million tons. Research Nester reports that the global rare earth metals market in 2022 was worth about 10 billion USD and is expected to grow at a

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compound annual rate of 8%, reaching total revenues of 20 billion USD by 2035. If Vietnam successfully develops its rare earth industry and captures 10% of the global market by then, its income potential could reach up to 2 billion USD annually.

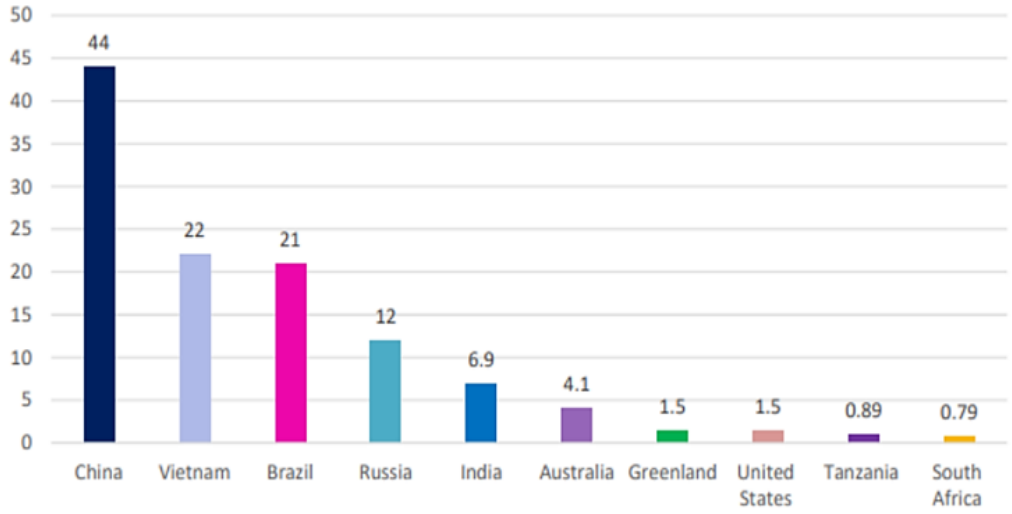

Figure 2: Total global REE reserves

Source: U.S. Geological Survey, 2022

In July 2023, the Vietnamese Government announced a mineral industry master plan to exploit and process more than 2 million tons of rare earth ores by 2030 and produce up to 60,000 tons of rare earth oxide equivalent annually. On October 18, 2023, in Hanoi, the Vietnam Academy of Science and Technology, in collaboration with the Ministry of Science and Technology, organized the scientific conference "Vietnam Rare Earths: Current Technology of Exploitation, Processing, and Prospects." Vietnam also plans to auction mining rights for rare earth mines mainly distributed in the Northwest and Central Highlands. Numerous sites with rare earth mineral reserves have been identified, such as Bac Nam Xe, Nam Nam Xe, Dong Pao (Lai Chau), Muong Hum (Lao Cai), and Yen Phu (Yen Bai). Additionally, several small rare earth mines are scattered along the coast from Quang Ninh to Vung Tau.

3.2. Sustainable economic development

It is known that REE are indispensable materials in many high-tech industries such as information and telecommunications, healthcare, energy, transportation, military, etc. Therefore, owning REE, which are irreplaceable strategic materials, is crucial for many countries, especially developed ones. Vietnam has the advantage of abundant rare earth reserves, valued at about $3,000 billion, offering significant potential for sustainable economic development in this industry.

According to the "Planning for Exploration, Exploitation, Processing, and Utilization of Minerals in the Period 2021-2030, Vision to 2050," it is expected that, up to 2030, Vietnam will exploit about 2 million tons of raw rare earth ore annually. Developing the rare earth

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industry has the potential to create a large number of jobs for employees. Mining, processing, research, and development activities in this sector require the participation of various professions, including engineers, workers, managers, researchers, and technological specialists. This helps create job opportunities and improves residents' living standards.

3.3. Attraction of foreign investment

With the primary goal of expanding economic relations with foreign countries, developing the economy, and promoting exports by effectively exploiting Vietnam’s resources, labor, and other potentials, the Law on Foreign Investment in Vietnam was promulgated on December 29, 1987. So far, Vietnam has had more than 36 years of implementing policies to attract FDI. The foreign-invested economic sectors have developed rapidly and become economic sectors gradually with an important position in the Vietnamese economy.

Low labor costs are an attractive advantage for foreign investors. Labor costs in Vietnam (329 USD/month) are only one-third of those in China (1,119 USD/month) and lower than in Malaysia (862 USD/month). In addition to preferential investment policies, a favorable investment environment is a significant factor that attracts foreign investors to register new investment projects and disburse investment capital. In Vietnam, main investment incentives focus on three groups: (i) Corporate income tax incentives, (ii) Import and export tax incentives, and (iii) Financial and land incentives. The flow of foreign capital invested directly into Vietnam has maintained positive growth despite global economic fluctuations. The competition among enterprises has led to Vietnam attracting many FDI projects in high technology, particularly from the United States. However, compared to the substantial overseas investments by the United States (about 200-300 billion USD/year), FDI from the United States into Vietnam is relatively small, averaging just over 1 billion USD/year.

3.4. Building a global value chain

The global demand for REE is increasing sharply, especially in high-tech industries such as the production of phone batteries, electric vehicles, and medical equipment. The Vietnamese Government has issued numerous policies to support the development of the rare earth mining and processing industry. These policies include tax exemptions, reductions, and credit incentives to create favorable conditions for business operations in this field.

Vietnam's developed transportation infrastructure is an important advantage for building a global value chain based on REE. A convenient transportation system supports the easy and efficient transport of REE to international markets. Additionally, Vietnam's favorable geographical location offers unchallenging access to key regional markets such as China, Japan, and Korea, which are large importers of rare earth minerals. Furthermore, Vietnam boasts young, dynamic, and eager-to-learn human resources, contributing to the development of the rare earth value chain. Workers in Vietnam can

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quickly absorb new knowledge and techniques in the field of rare earth mining and processing, enhancing the capacity and competitiveness of this industry.

3.5. Developing renewable energy

REE are key enablers for technologies aimed at cutting emissions, minimizing energy consumption, and increasing efficiency, speed, performance, longevity, and thermal stability (Balaram, 2019). These metals are also important components in technologies that aim to create lighter and more miniaturized products (Gibson and Parkinson, 2011). They are widely used in daily applications due to their unique physical and chemical properties, ranging from catalytic, metallurgical, nuclear, electrical, and magnetic properties (Long et al., 2017).

According to IEA forecasts, renewable energy will account for nearly 30% of global electricity sources by 2023, with hydropower contributing 16%, followed by wind at 6%, solar energy at 4%, and biomass at 3%. To achieve the goals of the Paris Agreement, renewable energy expansion needs to increase at least sixfold. The renewable energy roadmap issued by IRENA indicates that renewable energy must expand into various fields. The proportion of renewable energy electricity is expected to rise from 25% in 2017 to 85% in 2050, primarily from solar and wind energy. In the context of countries with high demand for renewable and energy-saving technologies to meet environmental goals, the demand for rare earths is expected to increase. We must focus on the research and development of technology that uses REE in renewable energy sources such as solar and wind power. A team of human resources with specialized knowledge and skills in this field is necessary for researching and developing these technologies. Training and developing experts in REE and renewable energy is crucial for ensuring the success of REE use in renewable energy, helping reduce dependence on fossil energy and carbon emissions.

3.6. Strengthening international cooperation

With the world's second-largest rare earth reserves, Vietnam has significant potential to strengthen international cooperation in REE. Other countries may be interested in collaborating with Vietnam due to the benefits REE can bring to their technological and industrial development.

In September 2023, the President of the United States - Joe Biden, visited Hanoi, where Vietnam and the United States agreed to sign a Memorandum of Understanding (MOU) to assess and develop the potential of rare earth resources in Vietnam while encouraging the participation of quality investors in this industry. Earlier, in August 2023, Emily Blanchard, Head of Economics at the United States Department of State, emphasized the importance of Vietnam as a strategic partner in ensuring mineral supplies and affirmed that the United States is willing to support Vietnam in auctioning rare earth mining rights and providing technical assistance to this industry. During South Korean President Yoon Suk Yeol's visit to Hanoi in June 2023, another MOU was signed to establish a joint supply center for REE and other minerals such as tungsten, aiming to build a reliable supply chain for Korean businesses. Additionally, investors from Australia, including Blackstone,

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have expressed interest in participating in the auction of Dong Pao's rare earth mining rights.

The dependence on rare earth supplies from China poses potential risks for the United States and its allies. If Vietnam can develop its rare earth industry and become a reliable supplier, it will strengthen its position in the international arena and enhance relationships with other developed economies. In the long term, effectively exploiting rare earth resources can also bring potential economic benefits, including integration into the global supply chain for high-tech products. Achieving this ambition aligns with Vietnam's goal to become an industrialized and high-income economy by 2045.

4. CHALLENGES OF EXPLOITING AND USING THESE MINERALS IN VIETNAM

Vietnam, with the second-largest rare earth reserves in the world, has many great opportunities to develop the mining and deep processing industry. However, possessing and exploiting REE brings economic benefits and poses numerous challenges.

First, Impacts on the Environment

The production and mining of REE is a major competitive advantage for China. According to local government data, Ganzhou produces 70% of the world's medium and heavy rare earths. However, despite the economic benefits, rare earth mining has resulted in toxic water and contaminated soil, negatively affecting the residents of Ganzhou. Government efforts to clean up mining sites have been untenable due to a lack of funding and technology.

Figure 3: Polluted ponds caused by rare earth mining in Ganzhou

Source: thinkchina.sg

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It is seen that the environmental pollution in China serves as a clear example of the harmful effects of rare earth mining when outdated technology is used. Rare earth mining in Vietnam also faces many difficulties due to the presence of toxic elements, especially radioactive ones. The mining process often involves significant water usage and waste disposal. Water used during mining can be contaminated with chemicals and heavy metals from REE.

Additionally, the treatment of waste from rare earth mining can pollute surrounding water sources. Toxic chemical solutions can remain underground for long periods, potentially polluting groundwater and deep underground sources. The mining process often involves digging, destroying, and disturbing land, leading to soil degradation, loss of fertile soil, and changes to the natural landscape. This degradation can affect plant growth and local ecosystems.

Vietnam aims to complete exploration at all licensed mines and start mining by 2030, with rare earth processing reaching a total output of more than 2 million tons/year (Decision 866/QD-TTg of the Prime Minister). However, with lessons from other countries about the trade-off between economic benefits and environmental impact, careful consideration and calculation are necessary.

Second, Human Resources and Technology

- Human Resources: Rare earth research in Vietnam began in the late 1970s, and we have trained human resources to serve this industry. For example, the University of Mining and Geology provides in-depth training in mineral selection and processing. However, our human resources in the rare earth industry are primarily focused on theoretical research and laboratory work, lacking practical experience.
- Technology: We have not yet mastered the technology of refining rare earth ores, particularly the processes of separating each REE and removing harmful impurities. Although the Bac Nam Xe mine has applied for a mining license, domestic investors must collaborate with foreign companies to achieve ore concentrates with content exceeding 95%. However, countries that possess rare earth processing technology are reluctant to transfer it or ensure ore refining capabilities. In laboratories, Vietnamese scientists can increase the refining rate of oxide ore to 45%, 60%, 70%, or even higher. However, scaling up from laboratory testing to pilot scale (larger than laboratory but smaller than production scale) and then to industrial exploitation requires more time.

Third, Loss of Resources

Currently, rare earth mines are often small in scale because mining conditions are simple, leading to many loopholes in management. There have been instances where new enterprises granted licenses for rare earth exploration have actually exploited and sold the products [19]. Rare earths are sold on the market without strict state control, violating legal regulations but also resulting in the loss of the country's valuable resources.

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Fourth, Competitive Markets

Although China remains the leader in the rare earth mining industry, Chinese rare earth mining and refining companies are experiencing reduced revenues as other countries increase their production capacity. In 2023, a subsidiary of the state-owned conglomerate China Rare Earth Resources and Technology reported a 5.4% year-on-year decline in annual revenue, down to 3.98 billion RMB (550 million USD), with net profit dropping 45.7% to 417.67 million RMB. According to the latest data from the United States Geological Survey (USGS), China led global production in 2023 with 240,000 tons, about two-thirds of the total. The United States was the second-largest producer, followed by Myanmar, both of which tripled their output during the year. The United States, Australia, and Southeast Asia have established supply chains to compete with China.

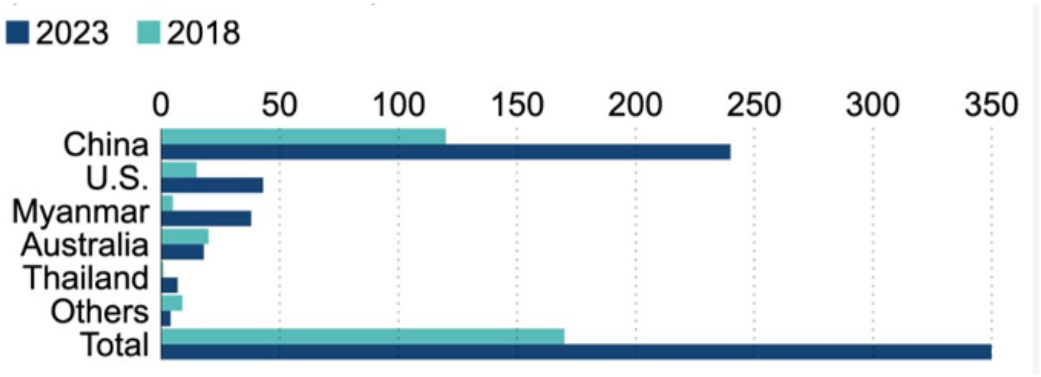

Figure 4: Rare earth mining output of countries (unit: thousand tons)

Source: U.S. Geological Survey

With increased production from other countries, price competition in the rare earth market is likely to intensify. This could reduce the value of Vietnam's exports and impact the revenue of domestic rare earth mining and refining companies, thereby affecting Vietnam's foreign currency sources.

Fifth, National Security

History has shown that the ownership and management of REE are crucial factors in the geopolitical strategies of nations. Countries that control these elements wield significant influence and power in the international arena. REE are not only valuable resources but also strategic tools in international relations. For instance, in 2010, following the arrest of a Chinese fisherman who collided with the Japanese Coast Guard in the disputed waters of the Senkaku/Diaoyu Islands, it was widely believed that China retaliated by banning REE exports to Japan. While Japanese companies reported that their REE shipments were stuck at customs, a Chinese Ministry of Industry and Information Technology spokesman stated that "China will not use REE as a bargaining tool."

Currently, much of Europe, including the European Union, has prioritized the transition to green energy, which will require a substantial amount of REE. Africa, South America, and Asia have become key regions where the United States and China vie for influence in the

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competition for minerals. Brazil, India, and Vietnam hold some of the world's largest REE reserves. China's "One Belt, One Road" initiative aims to establish major corridors of economic cooperation. Ensuring national sovereignty in managing and exploiting rare earth resources is a significant challenge for Vietnam, especially amid intervention from powerful international actors.

5. SOLUTIONS AND RECOMMENDATIONS

In the context of globalization, rare earth mining has become an integral part of countries' economic development strategies. The energy transition is increasing the demand for key minerals needed for low-carbon technologies used in wind turbines and electric vehicles. For Vietnam, with its large rare earth reserves, effectively utilizing this resource not only contributes to economic growth but also enhances its strategic international position. Below are some solutions and recommendations to support Vietnam in exploiting and using rare earth resources effectively and sustainably.

Firstly, to mitigate the negative environmental impacts of rare earth mining, it is essential to implement specific and effective measures. The application of advanced and environmentally friendly mining technologies is necessary to minimize the impact on land and water resources. Additionally, modern toxic waste treatment systems are needed to prevent pollution from mining and processing activities. Recycling and reusing materials should be an integral part of the sustainable production chain to reduce waste and increase resource efficiency. Environmental management must be strictly enforced through rigorous monitoring of air, water, and soil quality in mining areas. Raising public awareness about the importance of environmental protection and sustainable development is also crucial, especially in local communities near mining areas. Strengthening international cooperation to learn from best practices and apply them is an important step to help Vietnam develop its rare earth industry sustainably and responsibly.

Secondly, to exploit rare earths effectively and sustainably, significant investment in research and development of rare earth mining and processing technology is needed to create high-value products from this resource. Vietnam can develop the rare earth mining and processing industry by collaborating with advanced countries, learning and applying their technologies, and promoting technology transfer. The goal should be to achieve the capability to separate each type of rare earth element from highly refined oxide ores, at least 95% or even 99%. Additionally, developing high-quality human resources through in-depth training programs and sending personnel abroad for training is essential to ensure Vietnam has knowledgeable, skilled, and experienced workers.

Thirdly, to minimize the loss of rare earth resources, it is crucial to strengthen resource management capacity through training and coaching for professional staff. Developing and implementing strict policies and legal regulations on rare earth exploitation and use is vital to prevent illegal mining and trading. Only companies with rare earth separation and processing technology should be granted mining licenses to prevent the sale of raw

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materials at low prices and resource loss. Regular, strict inspections and strong sanctions are necessary to prevent unauthorized exploitation.

Fourthly, although Vietnam currently lacks many rare earth application industries, it has attracted foreign companies to invest in battery and semiconductor production. With the high global demand for rare earths and its potential, Vietnam can enhance its position in the global mineral raw materials market and negotiate better terms. Focusing on improving knowledge and techniques for mining and processing rare earths will help Vietnam access advanced technology and modern techniques, improving mining efficiency and creating high-value products from rare earths while reducing costs.

Fifthly, strengthening international cooperation is necessary, including establishing links with other countries and participating in international agreements and organizations related to rare earth supplies. Vietnam needs to maintain an independent, self-reliant foreign policy, and multilateral and diversified relations while enhancing its international prestige and position, protecting national interests, and maintaining a peaceful environment.

6. CONCLUSION

In the future, research and technology development in the effective exploitation and use of rare earth resources will play a crucial role. Vietnam needs to invest in its research and development capacity to create efficient methods for mining, utilizing, and recycling rare earths. A clear national strategy is essential, along with strengthening international cooperation, investing in research and technology development, and ensuring good management and sustainable use of rare earth resources. By doing so, Vietnam can achieve economic growth and contribute to the advancement of global science and technology.

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