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# EXPLORATION AND PROSPECTING OF RARE EARTHS IN BRAZIL: HISTORY AND CHALLENGES

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**ABSTRACT**
The prospection of Rare Earth Elements (REE) in Brazil is of great strategic importance due to the growing global demand for these resources, which are essential in advanced technological sectors, such as electronics, renewable energies (wind turbines), and electric mobility (batteries and high-efficiency motors). The exploration of compounds containing REE in Brazil began in 1885, with the extraction of monazite sand in the region of Prado, Bahia. Since then, both private companies and government institutions, such as the Geological Survey of Brazil (CPRM), have played key roles in this sector. Geological surveys and economic feasibility studies are key steps in identifying viable deposits and developing efficient extraction and processing methods. The methodology used is based on an analysis of historical and scientific sources, highlighting the main challenges, such as the environmental contamination generated by mining waste. It is concluded that, for Brazil to recover and strengthen its position in the global rare earths market, it is essential to intensify the adoption of sustainable mining practices and advance technological innovation, as demonstrated by recent efforts in projects such as LabFabITR.

**Keywords:** Rare Earths, Prospecting, Brazil.

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## INTRODUCTION

Rare earth elements (REE) are a group of chemical substances generally found in nature, associated with ores, whose extraction proves to be challenging – which justifies their name. These elements have unique characteristics, such as high magnetism and the ability to absorb and emit light, which makes them widely applied in various technological innovations, such as LED lamps, lasers, supermagnets used in computer hard drives, electric vehicle motors, in addition to playing a crucial role in the separation of petroleum components.

REEs belong to the lanthanide series, covering atomic numbers between 57 and 71 (group IIIB of the Periodic Table). This set begins with lanthanum (La) and ends with lutetium (Lu), including scandium (Sc) and yttrium (Y), which share similar chemical properties. These elements are present, above all, in minerals such as bastnaesite, monazite, ionic clays bearing rare earths and xenothymium.

The trajectory of prospecting and exploration of strategic elements in Brazil is relatively recent when compared to that of other minerals. The identification of significant deposits of these substances in Brazilian territory dates back to the beginning of the twentieth century, following the increase in world demand for strategic minerals, driven by industrial and technological progress. However, it was only between the 1950s and 1960s that the systematic interest and exploration of Rare Earth Elements (REE) in Brazil intensified in a more organized way. During this period, the Mineral Resources Research Company (CPRM) and other research institutions carried out geological surveys that showed the presence of REE in several regions of the country, especially in the states of Minas Gerais, Goiás, Bahia and Amazonas. This discovery quickly positioned Brazil among the countries with the greatest potential for the exploration of rare earths, due to the vast quantity and diversity of the deposits identified (Morato, 2019; ABC, 2018).

The initial exploration of rare earths in Brazil faced a number of technological challenges. The extraction and separation of REE from the ores in which it is found, such as bastnaesite ((Ce, La)$CO_3F$), monazite ((Ce, La)$PO_4$), xenothymium ($YPO_4$) and ionic clays bearing critical minerals, are highly complex processes that require advanced technologies. In the early years, the absence of adequate infrastructure and limited technical knowledge significantly hindered the economic exploitation of these elements. The lack of industrial development to deal with such processes resulted in low efficiency in extraction and separation operations, limiting Brazil's potential in the rare earths sector during this period (Morato, 2019; Moura, 2015; Vieira, 2012; Porto, 2019

To face these difficulties, Brazil began to invest in scientific and technological studies, often in partnership with foreign organizations. The creation of specialized laboratories and the evolution of new extraction and treatment methods were fundamental to improve the country's ability to more effectively exploit its REE resources.

On the other hand, the extraction of rare earth minerals is an activity that can have serious environmental consequences, including the emergence of harmful waste and soil and water pollution. These environmental challenges represent major obstacles to the development of REE exploration in Brazil. Brazilian environmental legislation, recognized as one of the strictest on a global scale, imposes several requirements aimed at mitigating these impacts, which also results in increased costs and the complexity of mining operations.

In addition, adherence to international standards of sustainability and environmental care has imposed stricter requirements on mining operations in the country. Companies and organizations linked to the search and exploitation of rare minerals had to create and adopt mining methods that were more environmentally friendly and sustainable. The economic relevance of rare earths is immense, considering their vast application in different sectors of high technology. These elements are indispensable components of products such as LED lamps, permanent magnets used in electric vehicle engines, wind turbines, electronic devices and catalysts for the petrochemical industry.

Aware of the strategic importance of these resources, Brazil has sought to strengthen its position in the global rare earth market. In recent years, significant efforts have been made to attract investment, both domestic and international, for the exploration and development of REE mining projects. The formation of partnerships with multinational companies and the signing of cooperation agreements with countries that have advanced technology for the extraction and processing of essential resources have been fundamental strategies to foster the growth of the sector in Brazil.

The prospects for prospecting and exploration of REE in Brazil are favorable, although still surrounded by challenges. The need for continuous technological innovation, the improvement of sustainable practices, and the construction of a solid infrastructure are crucial elements to ensure long-term success. The Brazilian government, together with the private sector and academia, has been working to create an environment conducive to the development of the rare earths sector. Public policies aimed at sustainable mining, tax incentives for research and development projects, as well as the training of qualified professionals, are among the initiatives underway to consolidate Brazil as a prominent nation in the production of rare earths.

Consequently, the trajectory of rare earth prospecting in Brazil reflects a growing recognition of its economic and strategic potential, as well as the determination to overcome technical, economic and environmental challenges. With a constant commitment to innovation and sustainability, Brazil is in a privileged position to play a relevant role in the global supply of these essential elements for technological advancement.

This study adopts a bibliographic methodology, based on the exploration of historical and academic sources on the prospection and exploration of Rare Earth Elements (REE) in Brazil. According to Gil (2022), bibliographic research involves a systematic survey of published materials, with the aim of providing a critical and reasoned analysis of the topic. The research included books, articles, technical reports and institutional documents, selected based on relevance and topicality.

Complementing this approach, the methodology described by Lakatos and Marconi (2004) was also adopted, which emphasizes the importance of careful analysis of previously published materials to consolidate knowledge on a given topic. Qualitative analysis, according to Severino (2020), was essential to identify both technological advances and challenges related to infrastructure and environmental regulation. Data collection used reliable secondary sources, obtained through academic databases such as CAPES, Scielo and Google Scholar, ensuring the robustness of the results.

## HISTORY OF RARE EARTH EXPLORATION IN BRAZIL

According to Loureiro (2013), in 1787, in the village of Ytterby, located approximately 30 kilometers from Stockholm, Swedish army lieutenant Karl Axel Arrhenius, who also worked as an amateur mineralogist, identified a mineral, called iterbite, that contained rare earth elements. About a century after this discovery in Sweden, Brazil began the production of monazite in Cumuruxatiba, a district located in the municipality of Prado, on the coast of Bahia. This mineral resource was mainly used to meet the demand for incandescent blankets, used in gas lamps. As a vestige of this historical phase, it is still possible to observe, through satellite images, an old wooden pier hundreds of meters long, which remains a landmark of this period (Takehara, 2015).

According to Filho and Serra (2014), the exploration of rare earths in Brazil began around 1885, with the extraction of monazite on the beaches of Prado, Bahia. Initially, this extraction occurred without charge, with the sand being used as ballast for ships returning to Europe and the United States. Between 1885 and 1890, it is estimated that engineer John Gordon, at the head of the American company E. Johnston & Co., exported about

15,000 tons of monazite to Europe, after obtaining concessions to explore the beaches through contracts with the Brazilian government.

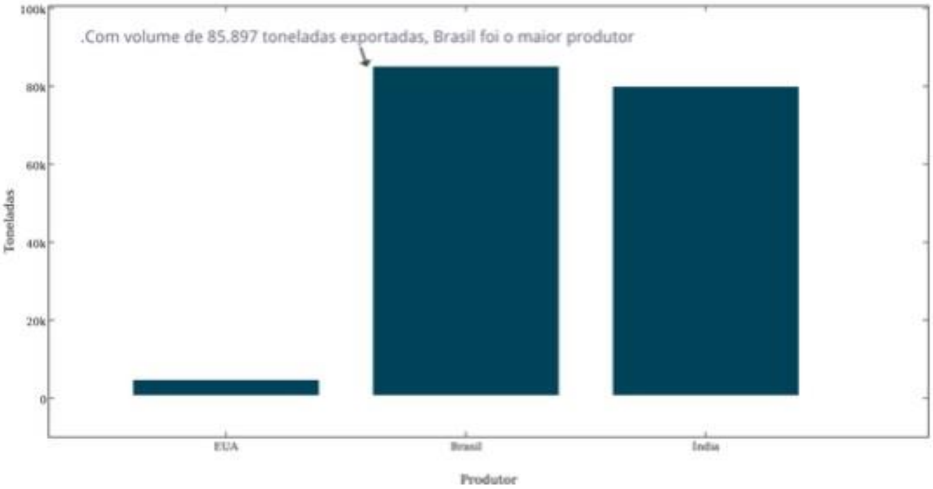
At the beginning of the twentieth century, the prospecting of rare earths in Brazil was marked by the use of relatively simple and rudimentary methods. The extraction of monazite, the main source of rare earth elements in the country at the time, occurred mainly in the sands of beaches and rivers, especially in the regions of the Brazilian coast. Figure 1 illustrates the process of monazite extraction on the beaches of Guarapari, in Espírito Santo, one of the areas best known for this activity (Takehara, 2015).

Figure 1 - Removal and transport of monazite sand from Guarapari in the early twentieth century.

Source: A Gazeta (2015)

The mineral rich in rare earth elements, such as monazite, was extracted manually or with the use of simple mining equipment. Extraction was largely carried out by foreign companies, which saw in Brazil an abundant and easily accessible source of these resources. After extraction, monazite sand was often exported to industrialized nations, where the processes of separating and refining the rare earth elements were more advanced. As indicated in Graph 1, the volumes of monazite sand extraction in the United States, Brazil and India, between the years 1887 and 1949, reveal the significant role of Brazil in the world production of rare earths in this period" (A Gazeta, 2015; Takehara, 2015)

Graph 1 - Extraction of monazite sand - 1887 to 1949.




Source: A Gazeta (2015)

The lack of strict regulations and the lack of knowledge about the potential environmental and radioactive impacts of monazite have led to the adoption of extraction practices that, from a contemporary perspective, would be considered unsustainable and unsafe. However, this initial phase of prospecting laid the foundations for the subsequent industrial exploitation of rare earths in Brazil, which would be consolidated over the subsequent decades, driven by technological advances and a deeper understanding of the available resources (A Gazeta, 2015).

From the 1940s onwards, formal agreements were signed between Brazil and the United States, institutionalizing practices that were already being conducted by private companies, without proper supervision or inspection. Then-President Getúlio Vargas pledged to supply Brazilian monazite sand to the United States at reduced prices, in accordance with the so-called "Good Neighbor Policy" between the two countries. However, part of the Brazilian intellectual elite defended that the raw material should remain in the country, in order to promote a national policy for the development of nuclear technology, a proposal that did not prosper (A Gazeta, 2015).

Furthermore, despite several attempts at negotiation, the United States refused to share technology and atomic knowledge with Brazil, which culminated in a political malaise that resulted in the creation of a Parliamentary Commission of Inquiry (CPI) in 1956, with the objective of investigating Brazilian interests in the agreements with the Americans (A Gazeta,  2015).

According to Nishioka (2023), until 1949, Brazil already stood out as one of the main global suppliers of rare earths, thanks to the Santo Amaro Plant, located in São Paulo and operated by the company Indústrias Químicas Reunidas (Orquina). In 1962, the federal government nationalized part of this company, due to the fact that monazite — the main ore extracted — contained radioactive elements, the exploitation of which became a monopoly of the Union. As a result, the production of rare earths was under the responsibility of the National Nuclear Energy Commission (CNEN).

Also according to Filho and Serra (2014), in the 1970s, the company was renamed NUCLEMON (Nuclebrás Monazita), starting to dedicate itself to the extraction of monazite and the production of rare earth concentrate and low-purity cerium oxide ($CeO_2$). However, the company gradually became obsolete. In 1988, Nuclebrás was renamed Indústrias Nucleares Brasileiras (INB), and, in 2002, the production of rare earths was practically deactivated. This process resulted in the loss of a large part of the investments in technology and in the training of human resources. When rare earths began to acquire greater added value in the 1970s and 1980s, mainly due to their use in luminophores and magnets, Brazil had already lost its competitiveness in this sector.

According to Souza, Nascimento and Gisele (2019), in 2012, Brazil became the world's second largest reserve of rare earth elements, highlighting the monazite reserves located in Araxá, Minas Gerais, and Catalão, Goiás, as shown in Table 1. Currently, China accounts for about 90% of the global production of raw materials containing rare earth elements (TRs) and 85% of the production of rare earth oxides (RTOs), which corresponded to 122,220 tons of RTOs in 2016. The rest of the world's production is distributed between Australia (10%), Malaysia, Brazil, India, Russia and Vietnam (CETEM, 2020).

Table 1 - Brazilian Rare Earth Nature Reserves.

| Local | Minério | % de Óxidos de Terras Raras | Reservas de Terras Raras (MT) |
|---|---|---|---|
| **Araxá-MG** | Monazita | 3,25 | 26,69 |
| **Araxá-MG** | Monazita | 3,99 | 0,9 |
| **Araxá-MG** | Monazita | N.D. | 8,0 |
| **Catalão-GO** | Monazita | 5,5 | 6,6 |
| **Minaçu-GO** | Argilas | 0,12 | 1,1 |
| **Mata Azul-TO** | Granitóides | N.D. | N.D. |
| **Serra do Ramalho-BA** | Similar à Baotou (Mongólia) | 0,05-2,61 | N.D. |
| **Morro Seis Lagos-AM** | Monazita/ Bonatitas | 1,4 | 43,5 |

Source: (Campos et al., 2014)

## PROSPECTING FOR RARE EARTHS IN BRAZIL

Currently, the world is facing a growing crisis in the supply of rare earths, essential elements for several high-tech industries, fundamental for the maintenance of critical activities in contemporary societies. Brazil, which once played a prominent role as a supplier of these materials, is now seeking to reposition itself in the global rare earth market, reaffirming its strategic importance. Both the Ministry of Science, Technology, and Innovation (MCTI) and the Ministry of Mines and Energy (MME) are committed to this task, aiming to reverse international dependence and promote the sustainable development of these production chains in the country (Silva, 2021; CETEM, 2019). The recovery of this role is seen as crucial for Brazil to fully exploit its potential and meet the global demand for these strategic resources (Cidade Verde, 2021; Click Oil and Gas, 2021).

According to Brasil (2024), based on the 2020 Brazilian Mineral Summary, published by the National Department of Mineral Production (DNPM), in 2019 several initiatives were implemented in order to strengthen research institutions in Brazil, especially with regard to the development of the industrial production chain of rare earths. Among these initiatives, the Government of Minas Gerais, in partnership with the Minas Gerais Development Company (Codemge), stands out in the continuity of the works — which began in December 2015 — for the installation of the laboratory-factory of rare earth alloys and magnets in Brazil, the LabFabITR, located in Lagoa Santa, in the Metropolitan Region of Belo Horizonte (Figure 2). This venture aims to meet part of the national demand for sintered neodymium-iron-boron (NdFeB) magnets, crucial components for the modern technological industry. The start of operations of the plant was scheduled for the first half of 2020, with the expectation of reaching an initial production capacity of 23 tons per year (LabFabITR, 2021).

Figure 2 - Laboratory-Factory of Rare Earth Alloys and Magnets


Source: LabFabITR (2021)

As previously stated, the venture will manufacture neodymium-iron-boron (NdFeB) magnets, used in equipment such as high-efficiency motors, wind turbines, magnetic resonance machines, elevator devices, magnetic separators, magnetic bearings, sensors, among others. In addition, it will be able to develop customized solutions for the market, meeting one-time orders, prototypes, and new products. With the integration of the production facility and research laboratories, it will be possible to manufacture magnets in a variety of classifications, sizes, shapes, and coatings. The project combines an industrial plant focused on market applications with a research and development environment, which has an advanced laboratory structure and a specialized team (LabFabITR, 2021). Figure 3 shows a diagram of the company's operation, highlighting research, development and production.

Figure 3 - LabFabITR operation diagram


Source: LabFabITR (2021)

As highlighted in the second Brazilian Mineral Summary of 2020, it is relevant to mention the continuity of research on rare earths within the scope of the National Institute of Science and Technology in Processing and Application of Rare Earth Magnets for the High-Tech Industry (INCT PATRIA) project, established in 2014. This project encompasses a network of laboratories and associated research groups (USP, IPT, UFCAT, IPEN, CETEM, UFAM, UFSC, CDTN) and strategic partners (CBMM, WEG, CODEMGE). The INCT PATRIA is part of the program of the National Institutes of Science and Technology (INCT), an initiative of the Ministry of Science, Technology and Innovation (MCTI), carried out through the National Council for Scientific and Technological Development (CNPq).

Also within the scope of the initiatives of the Ministry of Science, Technology and Innovation (MCTI), in 2019 the creation of the Laboratory of Advanced Materials and

Strategic Minerals, called GraNioTer, was implemented, located on the campus of the Federal University of Minas Gerais (UFMG), in Belo Horizonte. GraNioTer is considered a priority project of the MCTI, funded by FINEP and headquartered at the Center for the Development of Nuclear Technology (CDTN), a public institution focused on research, development and innovation (RD&I) in the field of strategic materials. Initially, the laboratory will focus its efforts on production chains related to advanced materials, such as graphene, niobium and rare earths, with the aim of promoting national technological development. The CDTN, which houses GraNioTer, is a unit of the National Nuclear Energy Commission (CNEN), linked to the MCTI (FAPESP, 2018; ABC, 2021).

In this context, the actions of GraNioTer – a project linked to the MCTI – seek to foster the development of strategic projects in Research, Development and Innovation (RD&I) that have already reached the initial stages of technological maturity. The objective is to accelerate the advancement of production chains based on advanced materials and strategic minerals, such as graphene, niobium, and rare earths, whose global demand continues to grow consistently, driven by high-tech industries (GraNioTer, 2023; CDTN, 2023; Escalab, 2023).

## FINAL CONSIDERATIONS

The trajectory of rare earth exploration in Brazil is marked by a continuous process of adaptation and evolution, going through several phases of production, overcoming challenges and transforming exploratory practices. From the initial discovery of these elements in Sweden and with the subsequent production of monazite in Brazil in 1885, the country assumed an important role as a supplier of strategic minerals, although using rudimentary extraction methods and operating in an environment of scarce regulation. As the twentieth century progressed, the rare earths sector in Brazil experienced profound changes, including the nationalization of companies and the subsequent decline of its competitiveness in the international scenario, especially in the 1970s and 1980s.

In recent decades, Brazil has made significant efforts to regain its leading role in the global rare earth market. These efforts have manifested themselves in strategic government initiatives and substantial investments directed at research and development (R&D) to strengthen the country's technological capabilities. In this context, the creation of projects such as the Laboratory of Advanced Materials and Strategic Minerals (LabFabITR) stands out, which symbolizes the national commitment to technological innovation and the sustainability of production chains.

However, for Brazil to fully regain its relevance and strengthen its position as one of the main global players in the rare earths sector, it is imperative that sustainable mining practices are intensified, in line with international standards of environmental responsibility. In addition, the continuous advancement in exploration and processing technologies will be crucial to ensure the country's competitiveness in the strategic minerals market, whose global demand grows exponentially due to the development of cutting-edge technologies.

It is necessary to emphasize that, although recent efforts represent a significant advance, Brazil's full integration into the global rare earths market depends on a combination of technological, economic, and regulatory factors. Future success will depend on the country's ability to attract investments, develop innovative technologies, and implement public policies that favor the responsible and efficient exploitation of these resources. In this sense, challenges remain, but the opportunities are equally promising, especially if there is a strategic alignment between government, academia and industry.

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