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How can Brazil learn from China on the development of the Rare Earth Elements supply chain?

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Abstract

Rare Earth Elements have become one of the most strategically significant resources of the 21st century. Their applications range from consumer electronics to renewable energy infrastructure and military technology, making them indispensable to industries that define contemporary geopolitical power. China recognized this potential early and, through state-led planning, built a near-monopoly over the entire REE supply chain, from mining to processing to manufacturing. Brazil sits in a paradoxical position as it holds the second largest REE reserves in the world, yet produces less than one percent of global output.

This thesis examines how Brazil can learn from China's early REE development strategy to develop its own industry and avoid the role of raw material exporter. Drawing on China's Long-Term Plan for the Development of Science and Technology, formulated in the 1950s under the People's Republic of China, it identifies the key institutional, scientific, and industrial mechanisms that allowed China to build technological sovereignty over REEs from a position of relative underdevelopment. The analysis focuses on four interconnected lessons: the strategic concentration of research on a single priority mine; the alignment of the scientific and industrial sectors through state coordination; the use of long-term planning; and the pursuit of technological partnerships designed to transfer knowledge rather than create new dependencies. These lessons are then evaluated in Brazil's specific context, addressing the main differences from the two scenarios and adapting the lessons to the reality of Brazil.

It is grounded in three complementary theoretical frameworks, World-Systems Theory, Dependency Theory, and Novo Desenvolvimentismo, which together provide the analytical foundation for its policy suggestions. They emphasize state coordination, exchange rate management, and industrial planning as the instruments through which resource wealth can be redirected toward social welfare. Taken together, these frameworks highlight that Brazil's REE reserves represent a window of opportunity to transform geological abundance into industrial development, technological sovereignty, and social welfare for the Brazilian population.

The thesis concludes with a set of concrete policy recommendations, including the creation of a dedicated national REE research institution, investment in midstream and downstream

processing capacity, legislative measures to classify REEs as strategic minerals, and exchange rate management mechanisms to prevent undermining industrial development.

Zusammenfassung

Seltenerdelemente haben sich zu einer der strategisch bedeutendsten Ressourcen des 21. Jahrhunderts entwickelt. Ihre Anwendungsbereiche reichen von der Unterhaltungselektronik über die Infrastruktur für erneuerbare Energien bis hin zur Militärtechnologie, was sie für Branchen unverzichtbar macht, die die heutige geopolitische Machtlage bestimmen. China hat dieses Potenzial früh erkannt und durch staatlich gelenkte Planung ein Quasi-Monopol über die gesamte Lieferkette der Seltenen Erden aufgebaut, vom Abbau über die Verarbeitung bis hin zur Fertigung. Brasilien befindet sich in einer paradoxen Lage, da es über die zweitgrößten Seltenerdmetallreserven der Welt verfügt, jedoch weniger als ein Prozent der weltweiten Produktion erwirtschaftet.

Diese Arbeit untersucht, welche Elemente der frühen chinesischen Seltenerdstrategie auf den brasilianischen Kontext übertragbar sind , um eine eigene Industrie aufzubauen und die Rolle eines Rohstoffexporteurs zu vermeiden. Ausgehend von Chinas Langzeitplan für die Entwicklung von Wissenschaft und Technologie, der in den 1950er Jahren in der Volksrepublik China formuliert wurde, identifiziert sie die wichtigsten institutionellen, wissenschaftlichen und industriellen Mechanismen, die es China ermöglichten, aus einer Position relativer Unterentwicklung heraus technologische Souveränität über Seltene Erden aufzubauen. Die Analyse konzentriert sich auf vier miteinander verbundene Lehren: die strategische Konzentration der Forschung auf ein einziges vorrangiges Bergwerk; die Abstimmung zwischen Wissenschaft und Industrie durch staatliche Koordination; den Einsatz langfristiger Planung; und das Streben nach technologischen Partnerschaften, die auf Wissenstransfer abzielen, anstatt neue Abhängigkeiten zu schaffen. Diese Erkenntnisse werden anschließend im spezifischen Kontext Brasiliens bewertet, wobei die wesentlichen Unterschiede zwischen beiden Szenarien beleuchtet und die Erkenntnisse an die brasilianische Realität angepasst werden.

Die Arbeit stützt sich auf drei sich ergänzende theoretische Rahmenkonzepte, die Weltsystemtheorie, die Dependenztheorie und den Novo Desenvolvimentismo, die gemeinsam die analytische Grundlage für die politischen Empfehlungen bilden. Sie betonen staatliche Koordination, Wechselkurssteuerung und Industrieplanung als Instrumente, mit denen der Ressourcenreichtum zugunsten des sozialen Wohlergehens umgelenkt werden kann. Zusammengenommen verdeutlichen diese Rahmenwerke, dass Brasiliens Seltenerdmetallreserven eine Chance darstellen, geologischen Reichtum in industrielle Entwicklung, technologische Souveränität und soziale Wohlfahrt für die brasilianische Bevölkerung umzuwandeln.

Die Arbeit schließt mit einer Reihe konkreter politischer Empfehlungen, darunter die Schaffung einer eigenen nationalen Forschungseinrichtung für Seltenerdmetalle, Investitionen in Verarbeitungskapazitäten im mittel- und nachgelagerten Bereich, gesetzliche Maßnahmen zur Einstufung von Seltenerdmetallen als strategische Mineralien sowie Mechanismen zur Wechselkurssteuerung, um eine Untergrabung der industriellen Entwicklung zu verhindern.

Aknowledgments

Firstly, I would like to thank my supervisor, Dr. Kalkschmied, for the help during this project. Her insights were extremely valuable and her guidence was essential for making my ideas clearer.

Secondly, a thank you to my family for always supporting me and encouraging me to follow my dreams.

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Table of abbreviations

RE - Rare Earths
REE - Rare Earth Elements
HREE - Heavy Rare Earth Elements
LREE - Light Rare Earth Elements

On my honour as a student of the Diplomatische Akademie Wien, I submit this work in good faith and pledge that I have neither given nor received unauthorized assistance on it.

1. INTRODUCTION

Over the past century, Rare Earth Elements (REE) have been increasingly important to the global industry, which led to an increase in its value. In the second half of the XX century, not many countries were interested in developing the mining and processing of Rare Earths (RE), due to the lack of knowledge and value related to it. Besides that, technologies that need a significant amount of RE were developed during the last 40 years, leading to the increase in the demand for REE just in the XXI century, such as miniaturized electronics, high-efficiency electric motors, renewable energy and advanced digital infrastructure. However, China identified their potential and started directing its effort towards developing a supply chain that could assist its position as a great power. Now, China owns a global quasi-monopoly of REEs, producing over 68% of the materials and is the only country owning the know-how of processing Heavy Rare Earth Elements (HREE). The importance of studying China's REEs supply chain development in the 1960s lies in the fact that it is the country that owns the know-how of most of the procedures related to REE processing and that other countries until today couldn't develop essential parts of the supply chain. For example, the U.S. has to send its REE to China for them to be processed. The evidence points to the plans developed in the 1960s as essentials for reaching the position it has today.

After realizing the dependence on China's RE, the United States started looking for alternative supply chains and Rare Earth reserves, in order to diversify its suppliers. In this sense, Brazil became a relevant option due to its position as the biggest reserves owner, after China. However, the position of raw commodity supplier can put Brazil in a cycle of exploitation, as described by The World System Theory. Therefore, it is necessary to look at models of Rare Earth supply chain development that generates welfare, instead of promoting a dependent relation between the two countries. Taking China's model as a good example, this thesis will look at what can be useful for Brazil to develop its own supply chain.

Several studies analyse the current success of China as a REE supplier, but not many papers look back to the beginning of the development of the RE chain in China. Therefore, this thesis will look at the 1950's, which is considered to be the decade when the plans for the development of the REE supply chain were made, which traced the pathway for China to reach the position that it has today. For that purpose, papers on China's development policies have been studied, including the work of Zhang and Zhang (2019) and Wang and Zuoyue

(2015), who detailed China’s Long-Term Plan for the Development of Science and Technology, based on governmental documents. Besides that, the work of ZHOU, HUANG, SHAO and YANG (2020) on the phases of the development of Rare Earth Elements in China will also be used to better understand the importance of each measure.

Therefore, this thesis will examine China's most important plan on the beginning stage of developing the supply chain of Rare Earth Elements, the Long-Term Plan for the Development of Science and Technology. After that, it will check the measures that can be applied to Brazil and offer policy recommendations. The thesis indicates which measures from the world’s biggest supplier can be used in Brazil, developing a pathway for Brazil to reach success in the REE field, based on what worked for China.

By acknowledging the different contexts that are being related in this thesis, China in the second half of the XX century and Brazil in the beginning of the XXI century, important differences and similarities are addressed. First, China’s proximity and cooperation with the Soviet Union are unique from that context and, in the case of technological partnership, it is acknowledged that Brazil may have difficulties finding a partner, which can imply a higher negotiation cost to Brazil with that partner. Secondly, the REEs in the XX century are under high geopolitical dispute, which increases the amount of pressure that Brazil suffers from third countries negotiating its REEs, increasing the difficulty of developing its own national project. In terms of similarities, the Brazilian government under Lula II (2007-2011) and Lula III (2023-2027) launched plans for national development and an intense campaign to use national resources for national development, similar to China’s goals in the XX century. In terms of technological partnership, Brazil also has diverse initiatives for development under BRICS. Those partnerships are at a different intensity level then China and the Soviet Union, but they represent similar purposes. In general, it is important to mention that the time factor in Brazil also represents a risk, because it is possible to see a lack of continuity in the development of the plans from one government to the other, depending if the president represents the left or right wing. In this sense, this bipolarity factor is a common factor present in the XXI century and it is acknowledged by this thesis. The differences are important because they represent the need of adapting some of the lessons learned from China in the XX century. Besides that, the context of China’s plans is carefully presented and considered during the thesis, in order for the different contexts not to represent a limitation to the analysis, but to represent important adaptations in the final policy suggestions.

The structure of the thesis is structured as follows: it first presents the context of the Rare Earth Elements industry in the 21st century in Brazil, China and geopolitically, highlighting the importance of the topic in a broad context and in the specific focus of this paper. The third chapter outlines the methodological basis for this article, explaining the key theories that explain the topic, such as the World System Theory, the Dependency Theory and the Novo Desenvolvimentismo Theory. Chapter four puts the focus on past China, presenting the context of China in the 1950's, and details of the Long-Term Plan for the Development of Science and Technology. Chapter five turns to contemporary Brazil, presenting the key institutions, mining companies and state plans related to the development of the Rare Earth Elements supply chain. Finally, the sixth chapter draws on the insights presented in Chapter Four and Five to evaluate actions from China's plan that can be helpful for Brazil's reality. The conclusion chapter reviews the main points mentioned and summarizes the presented actions into policy suggestions.

2. RARE EARTH INDUSTRY IN THE 21ST CENTURY

The level of development of the RE industry is highly unequal in geographical terms. In this sense, both the know-how and the industrial development about it is centralized in Asia and mainly in China. Due to the high complexity of the extraction and processing of RE, its supply chain is limited in most of the countries. Usually, RE are found together with other minerals and the separating process is complex.

Rare Earth Elements are objects of geopolitical disputes due to their relevance to strategic industries such as energy production and military instruments. Therefore, the United States has in its National Security goals to find new suppliers of RE and has been founding progress on it. In this sense, countries with big reserves have a high potential of developing the field (U.S. Department of War, 2026). However, until 2026, China was able to use its quasi-monopoly on RE as a political weapon due to the lack of international supplier competition.

2.1. Prospects and Challenges

The world's demand for Rare Earth Elements is increasing due to the increase of the demand from individuals who are consuming more products that need REE (electronic devices in general) and due to the need for these elements for military products. Besides that, the need to diversify the suppliers of REE comes from an dependence and insecurity of relying only on the Chinese supply. Some of the key industries that use REE are the production of permanent magnets, high technology batteries, semiconductors and phosphorus. The clean energy industry and military industries are highly dependent resources (Silva, 2025). The table below shows the main industries that use Rare Earth Elements.

Table 1: Rare Earth Elements per industries

REE	Symbol	Application
Scandium	Sc	Aerospace lightweight high-strength Al-Sc alloys, electron beam tubes
Yttrium	Y	Capacitors, phosphors, microwave filters, glasses, oxygen sensors, radars, lasers, superconductors
Lanthanum	La	Ceramics, car catalysts, phosphors, hydrogen storage, special optical glass, accumulators
Cerium	Ce	Polishing powders, ceramics, phosphors, glasses, catalysts, pigments, misch metal, UV filters, abrasives
Praseodymium	Pr	Ceramics, glasses, pigments, high strength magnesium alloy, lasers
Neodymium	Nd	Permanent magnets, catalysts, IR filters, pigments for glass, lasers
Promethium	Pm	Sources for measuring devices, miniature nuclear batteries, phosphors
Samarium	Sm	Permanent magnets, microwave filters, nuclear industry
Europium	Eu	Phosphors (red and blue), lasers, fluorescent glass
Terbium	Tb	Green phosphor, permanent magnets, laser
Dysprosium	Dy	Phosphors, ceramics, nuclear industry, permanent magnets
Holmium	Ho	Ceramics, lasers, reactor control rods, pigments
Erbium	Er	Ceramics, dyes for glass, optical fibers, lasers, nuclear industry
Ytterbium	Yb	Metallurgy, chemical industry, lasers
Lutecium	Lu	Single crystal scintillators, petrochemical catalysts, high refractive lenses, positron tomography
Thulium	Tm	Electron bean tubes, visualization of images in medicine
Gadolinium	Gd	Visualization of images in medicine, optical and magnetic detection, ceramics, glasses, crystal scintillators

Source: Yan, D., Ro, S., Sunam, O. and Kim, S. (2020). On the Global Rare Earth Elements Utilization and Its Supply-Demand in the Future

As it is possible to observe above, Rare Earth Elements are key components to a diverse range of essential industries. It is important to highlight sectors that are closely related to geopolitics, such as the nuclear industry, lasers, permanent magnets, and aerospace. The health and energy production sectors are also dependent on the REE, the first is represented on the table by tomography, visualization of images in medicine, and the latter is represented on the table by petrochemical catalysts, chemical industries and others.

The graph below shows the world's biggest REE by country in 2024 in million tonnes of rare earth oxides. China is the biggest reserve owner, with 44.000 million tones of oxides, followed by Brazil with 21.000 million tones. The other countries in the ranking have less than one third of Brazil's reserves. However, the table also shows that Brazil doesn't have a relevant production.

Table 2 - Rare Earth Elements Mining Production per Country

	Mine production[e]		Reserves[11]
	2023	2024	
United States	41,600	45,000	1,900,000
Australia	[12]16,000	[12]13,000	[13]5,700,000
Brazil	140	20	21,000,000
Burma	[12]43,000	[12]31,000	NA
Canada	—	—	830,000
China	[14]255,000	[14]270,000	44,000,000
Greenland	—	—	1,500,000
India	2,900	2,900	6,900,000
Madagascar	[12]2,100	[12]2,000	NA
Malaysia	[12]310	[12]130	NA
Nigeria	[12]7,200	[12]13,000	NA
Russia	2,500	2,500	3,800,000
South Africa	—	—	860,000
Tanzania	—	—	890,000
Thailand	[12]3,600	[12]13,000	4,500
Vietnam	[12]300	[12]300	3,500,000
Other	1,440	1,100	NA
World total (rounded)	376,000	390,000	>90,000,000

Source: U.S. Geological Survey, Mineral Commodity Summaries, January 2025

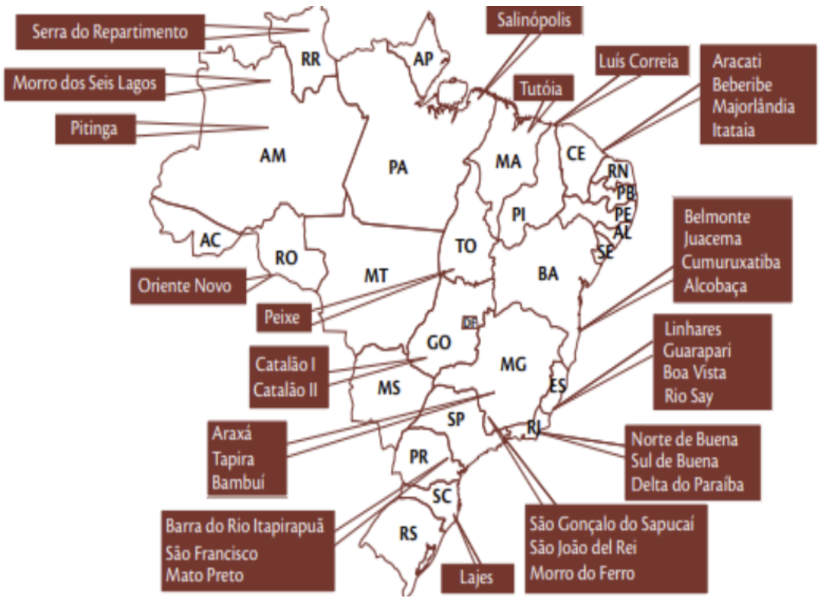
2.2. Aspiring Potential for Brazil

Brazil has a huge amount of Rare Earth Elements reserves, but only a few of them are being explored by a few companies, the most known company is Serra Verde. From a national interest perspective, the reserves have a great potential for the creation of social and economic development in Brazil if used correctly. Therefore, by looking at successful cases such as China, it is possible to understand how to better use these resources for national development and avoiding exploitation cycles explained by the World System Theory.

The exploitation of Rare Earths in Brazil started in 1885, with a colonial approach, when American ships took minerals from the beaches in Bahia to take to Europe (Souza, 2014). The main mineral exploited was Monazite, a source of Light Rare Earth Elements (LREE). Brazil became the world's biggest supplier of Monazite until 1914 (Souza, 2014). It also had a state company called ORQUIMA, which processed Monazite from the beaches of Espirito Santos and Rio de Janeiro (Souza, 2014). However, the technology needed to extract Monazite from the beaches were much more simple than extracting other Rare Earths from the underground reserves, given that Monazite was found in the sands and they were LREE (Souza, 2014). In the 1970s, the company reduced drastically their production, limiting it to only extracting Monazite and stopping completely its production in 2002 (Souza, 2014). Brazil's position in the supply of Monazite shows its potential of developing mining technology and building a complex supply chain. However, since the 1970s it has lost its competitiveness and the investments in the sector (Souza, 2014) due to international competition, environmental concerns and lack of national interest. The international competition is related to Japan's new projects in the 1970s in the field of Monazite processing, in addition to China's export incentives. The presence of the two new competitors led the price to decrease (IBRAM, 2026), making Brazil's minerals not competitive in the new international context. Secondly, the environmental concerns are related to the high radioactive residues related to the processing of Monazite, contaminating floors and buildings due to the lack of legislation in that field (Costa and Rochedo, 2005). Finally, Brazil's Nuclear Industries Organization (INB) decided that there was not enough domestic demand for the minerals due to the lack of continuity in the supply chain from a national perspective, and the minerals were not competitive internationally due to the new competitors (IBRAM, 2026).

The map below shows the known occurrences of Rare Earth in Brazil, highlighting the diversity of the regions that own reserves of a diverse range of RE, from north to south, as it is possible to see in the map. Despite the primary focus on Monazite in the 1960s, Brazil also has an intense presence of Heavy Rare Earth Elements, which demand higher technology for extraction and have a higher price on the global market.

Map 1 - Rare Earth Discovered in Brazil since 2010



Source: Centro de Gestão e Estudos Estratégicos (2013)

Brazil's biggest energy and mining companies Petrobras and Vale are not interested in Rare Earths because the national RE market is small compared to steel or oil markets and the international context is associated with big risks, not worth making big investments in the sector. In order to reduce the risks, investors demand a higher government effort on establishing regulations on the RE market (Souza, 2014), but the present regulations are not enough to provide a trust-worthy environment for big investments. Therefore, the recent development of supply chains on RE are in small scale and from the Companhia Brasileira de Metalurgia e Mineração and the MbAC in Araxá (MG) and the Mineração Serra Verde in Minaçu (Souza, 2014), which have the international market as main target audience.

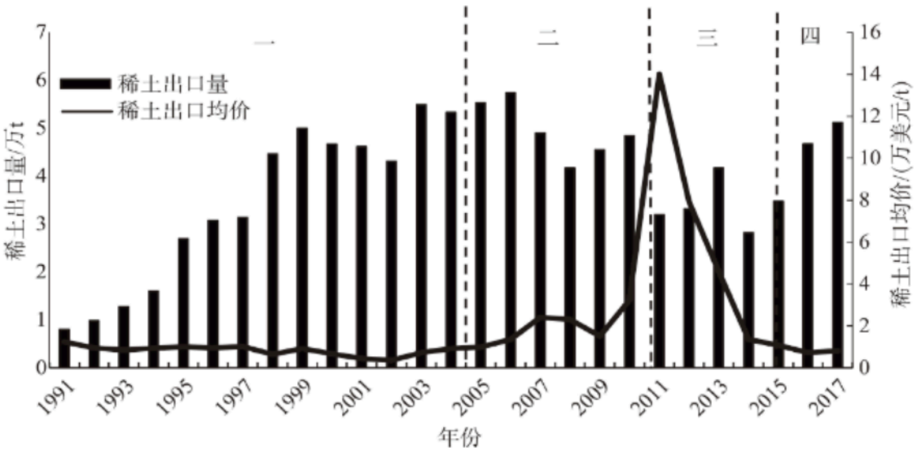
Other Brazilian reserves with high supply potential are Pitinga (AM), Catalão (GO), Morro do Ferro (MG) and Rio Sapucaí (MG), due to their high volume and concentration of Rare Earth Elements (Souza, 2014). However, a big amount of these minerals need a complex system of processing, that requires advancing technologically the mining, chemical, geologic, physical and engineering sectors. Therefore, it is essential to analyse successful cases of developing Rare Earth Elements supply chain to see how to apply effective measures in Brazil.

2.3. Realized Potential in China

China produces 68,6% of the world's REEs, owning a global quasi-monopoly on the production of RE, in addition to 10,9% of Myanmar production, which is under Chinese control (Pistilli, 2025), both due to the significant amount of Chinese companies and investors and due to the close supply chain integration in China, having the RE ores exported directly to China. However, some factors made China increase its RE prices, such as the domestic demand, the environmental concerns of mining, international trade conflicts and export quotas (Zhow, 2020).

The position of quasi-monopoly gives China a big control on the market price of the elements, due to their commodity aspect of price definition. Therefore, the price of the elements become extremely vulnerable by a single player and China manipulates it using export quotas and other types of export limiting. For example in 2010, when China introduced export quotas and led to an immediate price hike, as it is possible to see in the graph below, which shows a direct relation between the decrease in the production and price hike. The bars represent the Chinese exports and the line represents the price of Rare Earth Elements.

Graph 1: Price and Exports of Chinese Rare Earth Elements (1991-2017)



Source: "Change and Adjustment Direction of China's Rare Earth Policy" (Zhow, 2020)

The second moment when China imposed export quotas on Rare Earth Elements was in 2025, responding to President Trump's tariffs. The restrictions were specifically for goods to be exported to the U.S., including mined minerals and permanent magnets (Perera, 2025), leading to an increase in the price and a shortage of supply. The quotas had a strong impact on the U.S., because 80% of the U.S. 's REE consumption relies on imports and 77% of it is supplied by China (Carporal, 2025).

Besides China's interventions in the REE market for political strategy, it also has its own industrial strategic use of the RE. In fact, its internal demand represents more than 70% of its production (Souza, 2014). China's intense demand for RE can be explained by its ownership of the industries that require REE, such as magnets, alloys and technology in general. The Chinese government and private companies own a wide range of industries that need RE within China, such as wind turbines, lightning and batteries, adding more value to the initial Rare Earth Element and transforming it to a final product.

China is not only an industrial power on the production of Rare Earth Elements and final products, but also an academic power on the publication of technical and scientific papers on these minerals. The three elements of higher industrial demands are Monazite, Bastnasite and Xenotime, and China owns the biggest amount of technical articles on these materials (Souza, 2014). Due to its position as a dominant supplier and as an owner of technological knowledge, its actions became a key example that can be taken in account in order to develop the Rare Earth Elements supply chain.

2.4. Geopolitics

The geopolitical interests and actions have a potential of driving the development of the REE industry and its welfare or to hamper it. In this sense, if the owner of REE uses the resources to develop a supply chain, to generate jobs and to produce technological products, then it is possible to increase its welfare. However, if it exports the raw REE it has a high chance of having its welfare hampered, taking in account that the high-agreggated value goods will be sold by a third country and the technology behind it will not benefit the owner of REE.

Many countries are looking for new REE suppliers, due to the risk of relying only on China's REE supply. China's monopoly and China's quotas presented in chapter 2.2. motivated the main countries that consume Rare Earth to reach better deals and to diversify their supply chain, including fomenting the internal production, such as Japan, U.S. and Brazil (Souza, 2014). Two examples of responses to China's decrease of production were the partnership between the U.S. and Australia in Mount Weld and Mountain Pass (Souza, 2014) and the purchase from the U.S. of Terra Verde RE mining company in Brazil. Besides that, the U.S., Australia, Germany and Japan invested in the production of Rare Earths in countries with big reserves other than China (Souza, 2014). In this sense, deals such as U.S. partnership with Australian companies is seen as a way of increasing national development and welfare, as new technologies and jobs are developed in the country.

Examples of actions that can ramper the warfare of a country and its supply chain development is the exploitation of reserves only by a third country, which pays low salary to the local employers and brings high-level employers from abroad without knowledge exchange. In this sense, this scenario is seen in Myanmar, where China controls the REE supply chain. Besides that, it is common in mineral supply chains such as cobalt, having the Democratic Republic of Congo as the main example of welfare hampering.

China's actions on manipulating the prices using quotas can also hamper the development of the supply chain, given that a country that is starting to invest on the REE field will be fragile to the volatile prices. In this sense, both in terms of Brazilian and international law, there are no regulations to protect the companies from price hikes. Besides that, the industrial sector points to Brazilian regulation to lack of protection to the enterprises (Santos, 2025). On a multilateral level, China's policies were questioned under G20 and WTO (Souza, 2014), leading to the removal of the quotas. However, in 2025, other exporting barriers were imposed against the U.S., influencing the price of the commodity again and leading to the conclusion that countries have to reduce their dependence on China.

3. METHODOLOGY

The last subchapter presented the potential impacts of geopolitical actions in the development of the Rare Earth Elements industry and in welfare, which can be connected to the theories on development. In this sense, Brazil has historically been a commodities exporter and, the geopolitical actions were often hampering the welfare and the industry development, limiting Brazil to export only raw materials, for example during colonial relations with Portugal until the XIX century.

The development theories that simply suggested replacing the colonial system by an industrial system are not sufficient to guide and set frameworks for a developing country. In fact, the first development theories were based on a kenesyan model based on metropolis and that considered a short-term period, which doesn't work for a post colonial economy, due to the lack of capital and social structure (Singer et al., 2023). Based on the empirical and practical study that the first development theories didn't work, a set of new theories were developed focusing on the post colonial countries, considering their complex reality and exploitation past.

The World System Theory recognizes that the countries have a different position in the world system and that it has to be taken into account for the analyses because it defines many aspects of the economy and the social structure. The theory considers Brazil a semi-peripheral state, with aspects from the core and aspects from the periphery at the same time, having some industrial activities and financial services but still dependent on material extraction (Wallerstein, 1976).

The Dependency Theory is an opposition to the kenesynist development theories. The latter one defends that the post-colonial economies will thrive by industrializing and participating in world trade, in the same model that the developed countries adopted. However, the Dependency Theory defends that it is necessary to cut the dependency ties between the post-colonial countries and the developed countries, because they hold a dependent relation via international trade (Singer et al., 2023). This theory was applied to Latin America to analyse its process of industrialization.

As an attempt to create projects that provide a sustainable social structure and social welfare, the Novo Desenvolvimento Theory defends the state as the actor responsible for coordinating the main economic activities in order to avoid exploitation and to convert capital transfer into sustainable development. One of the key ways of coordinating, according to the theory, is by interfering in the exchange rate (Bresser-Pereira et all, 2014). It also opposes the kenesyanist development theories, as it believes that the participation in international trade without a strategy will lead to exporting only low-aggregated value commodities (Bresser-Pereira et all, 2014). This theory has been heavily applied in Brazil since 2003, when Lula launched state plans (Bresser-Pereira et all, 2014). However, the plans lack government continuity.

By selecting the three theories, the thesis will bring a perspective focused on post-colonial countries and gather the most recent studies on how to better reach welfare, considering the complex context of Brazil. They have a key role of highlighting the potential of Rare Earth Elements to be used for social and economical development for the country, as they analyse the development opportunities taking in account a historical perspective. Besides that, they show a certain degree of similarity between China and Brazil, as both of them can occupy similar roles according to the theories, as both of them are semi-peripheral countries looking for ways of developing the country technologically with the use of national resources.

3.1. World Systems Theory

The World-Systems Theory by Immanuel Wallerstein changed how theories analyze countries, as it started considering the world as a system and that interactions between countries also shape the perspective of each country. It shifted the analysis from the dynamics inside a country to an analysis of the country as a part of a system, taking in account which role that country plays in the World System. By doing that, it shifted the perceptions of origin of a diverse range of topics involving developing countries, such as inequality, development and also history.

The theory considers that each part of the world, core, periphery or semi-periphery has a different function in the division of labor, the core with concentration of high-profit, high-technology, high-wage production and the periphery with low-profit, low-technology, low-wage and less diversified production (Wallerstein, 1976). Besides that, the-semi peripheral countries act as a peripheral zone for core countries and as a core country for some peripheral zones (Wallerstein, 1976).

Both Brazil and China are considered semi-peripheral states by this theory. They have a mix of core-like activities such as industrial production and financial services combined with periphery activities such as raw material extraction. Semi-peripheral states are pointed by Wallerstein as ones with higher ability to take advantage of the flexibilities offered by downturns of economic activity (Wallerstein, 1976). In terms of economic strength and political background, they are extremely diverse, ranging from Latin American countries such as Brazil, Mexico, Argentina; European countries such as Portugal, Spain, Italy and Greece; to Arab states such as Algeria, Egypt, Saudi Arabia, Israel. The theory also points to them as regional leaders and buffers between core and periphery, saying that they are not only regional powers but also function as mediators between the regional peripheral countries and the core.

Furthermore, the theory associates technology ownership to a privileged position in the core, meaning that countries that own higher technological products are also in a position of more power in the relations with peripheral countries. The relation is established in a way that the core has well-developed towns, flourishing manufacturing, skilled and relatively well-paid labor, and high investments (Hall, 1982). But it is in the periphery where the core extracts the surplus and fuels its expansion (Hall, 1982). In this sense, the periphery is responsible for producing primary goods, and it has a stagnated technology, coerced and unskilled labor and low costs of production (Hall, 1982). In this relation, the money is centered in the core (Hall, 1982).

The studies on cycles of exploitation inside the World System focus on moments when new techniques for exploiting previously unused resources are found, which causes a rise in profit for the countries who control the technology and the exploitation of new peripherals in each cycle (Hall, 1982). For example, the last cycle has been characterized by American dominance (Hall, 1982).

The development of a verticalized REE supply chain is an opportunity for Brazil to overcome its position as a peripheric country and to obtain the technology needed to be a technological manufacturer and avoid a new cycle of foreign exploitation. In this sense, the key factor that will enable Brazil to overcome its position will be the ownership of the technology and the know-how to process RE. In other words, it is necessary for Brazil to be able to produce goods with a high aggregated-value, instead of just having the raw products exported.

3.2. Dependency Theory

Despite its similarities to the World System Theory and its importance in analysing why countries remain poor despite integrating to the global economy, the Dependency Theory has the state as the main focus of the analysis, instead of the system. It is relevant because it challenges the first development theories and it also considers the history and context of the developing countries.

Jaguaribe describes how the process of industrialization in Latin American countries created new forms of dependence and new sociopolitical imbalances, comparable to colonial economies (Miguel, 2020). The theory challenges the Modernization Theory and the idea that all countries develop through similar stages. In fact, it sees the kenesyan idea of development as something created by western countries with a lot of capital available, which is not the same reality as post-colonial countries. Together with other Latin American countries, Brazil was one of the objects analysed for the development of the theory, especially when addressing the topic of import-substitution industrialization.

While the first development theory defends the success by industrialization, the Dependency theory defends the importance of reaching autonomy towards other countries, avoiding the role of supplying low-aggregated value goods to third countries and the dependent relation created via international trade (Singer et al., 2023). Although the theory refers to the XX century, it can also be applied to the Rare Earth context, showing that Brazil has a colonial legacy and it has to avoid repeating the cycle of exploitation, looking for new ways of developing its own autonomy.

Later, Celso Furtado writes about the problem of the availability of technology and how controlling technology constitutes the structure of international power. In this sense, he says that the struggle against dependence is the effect of the monopoly of technology ownership by the countries that compose the core (Hall, 1982). Therefore, owning technology would mean owning power and being independent from third countries, instead of depending on their technology. In fact, China has been using its control over REE technology to impose export barriers to the U.S., exemplifying the technological ownership as a political weapon, as it was presented in previous chapters.

3.3. Novo Desenvolvimento (New Developmentalism)

The theory of New Developmentism from the author Luiz Carlos Bresser-Pereira, defends the state intervention to promote industrialization and overcome the dependency (Santos, 2025). It is relevant because it adapts the theories of development from the 20st century to the reality of the economy of the 21st century. In this sense, it addresses exchange rate and macroeconomic conditions, two factors not addressed previously by classical developmentalism theories. Besides that, it is influential because it offers suggestions of measures to deal with problems previously addressed, such as dependency and general issues from peripheral countries.

Its key argument is that, in order for developing countries to successfully achieve development, it is necessary to fully harmonize the public policies, especially the industrial policies and the macroeconomic regime (Nassif, 2026). The theory defends heavily the management of the exchange rate avoiding the Dutch Disease, when the appreciation of the home currency leads to industrial stagnation.

This theory is used by the literature on Rare Earth Elements to highlight the necessity of a government plan to direct the earning from the natural resources to strengthening the industry and generating jobs for the society. Besides that, it dialogue well with the World System Theory and the Dependency Theory, because it also defends that Brazil should overcome its dependent periphery role.

The Novo Desenvolvimentismo theory can be used to analyse China's Rare Earth Elements planning, because they both recognize the state role of coordinating development actions and its importance to protect the national resources, recognizing the state as a main actor. China's REE development plan will be presented in the next chapter and has a strong alignment with this theory. It not only recognizes the relevance of owning technology, as the previous theories, but also puts the government as a key actor responsible for planning and directing the development of the supply chain in a way that strengthens the industry.

Complementary and aligned to the New Developmentism theory, the literature on commodity-dependent economies, such as Brazil, highlights the need for investing in infrastructure development and public services as a way of dealing with the development of REE and avoiding the impacts of a mineral with volatile price (Ayoo, 2022). The volatile aspect of REE was already presented in previous chapters and will continue to be present in the analysis, due to the high risk related to it. In this sense, the theory defends the investment of part of the revenue generated by REE on infrastructure and public service in order to create social welfare and employment in the public field, investing in a secondary industry that can thrive with a relative independence from the REE industry.

4. CHINA’S RARE EARTH ELEMENTS DEVELOPMENT PLAN

China’s Rare Earth industry began in the 1950s, but the country was a small producer and exporter prior to the 1990s (Mancheri et al., 2019). From 2000 onwards, China became the leading producer and exporter, achieving its current nearmonopoly control over the whole REE supply chain (Mancheri et al., 2019), as presented in the context chapter. In order to reach the leading position it has nowadays, many investments and strategies were developed, as it will be presented in this chapter.

The Long-Term Plan for the Development of Science and Technology is considered to be the stage zero (1949–1985) of the development of Rare Earth Elements in China, marked by the initial scientific findings and mining projects, based on governmental plans. It was the moment when technological breakthroughs were achieved, which enabled large-scale production in later stages. The idea of focusing on a period when Rare Earths were still in the beginning of their development is due to the similarities to the current moment of Brazil. In other words, this stage is relevant to investigate how China dealt with the challenges when starting the development of Rare Earth Elements.

All the actions developed during that period were reflected in the Long-Term Plan for the Development of Science and Technology. The plan is considered a success in the perspective of domestic literature, as it set the basis for using REE for national development and the development of a wide range of technologies. The chapter will present the plan in detail, highlighting the process of its creation, the main actors involved, the priorities, the impacts of it and key takeaways.

4.1. State issued the Long-Term Plan for the Development of Science and Technology (1956-1967)

The Long-Term Plan for the Development of Science and Technology is considered to be a key plan for the development of the supply chain of Rare Earth Elements in China because it established a solid foundation for the long-term development of China’s science and technology and the progress of economic and social development (Zhang, 2019). In this sense, a key highlight of the plan was the ability to align trends in scientific and technological development with national development needs, managing complex demands and issues through a model of “driving disciplines through tasks” (Zhang, 2019).

4.2. Context

The period from 1949 to 1956 can be considered the most crucial for understanding the development of the Rare Earth Elements plan, because it is when China is starting to develop key industries, including the REE industry. In 1949, the Chinese civil war ended and China’s People’s Republic of China was established. Therefore, the country was trying to modernize and to develop its own autonomous industries, culminating in the Long-Term Plan for Development of Science and Technology in 1956. The context of China by the time of the creation of the plan offers great insights on the motivations and actors behind it. Besides that, it will later be useful to understand which of the points of the plan can be applied to Brazil and which of them don’t make sense and were conditioned by the context of the time.

The 1950’s in China were a decade of State establishment in the models of the People’s Republic of China (Ohio State University, 1982) and the attempt of making China a Great Power (Franke, 2026). After the civil war ended in 1949, the PRC was founded under Mao Zedong, the party was ruling when the plan was developed, responsible partially for its coordination. After the war and with the victory of the Red Army, the PRC took actions to make China’s system ideal in the perspective of their ideology and to make the PRC strong internally and externally. Therefore, the plan was developed with the intention of making China stronger, comparable to a great power.

The Sino-Soviet relations played a key role in the development of the plan, because at the same time that China was trying to be autonomous, it also relied on intense Soviet aid, besides a close ideological view (Ohio State University, 1982). In 1950, China signed the Sino-Soviet Treaty of Friendship, Alliance and Mutual Assistance, which will benefit China in terms of security and development partnership (Ohio State University, 1982). The treaty will be relevant during the development of the Long-Term Plan for the Development of Science and Technology, as it will be the basis for technological partnership between China and the Soviet Union, which led to the successful conclusion of projects established by the plan, as it will be presented in the subchapter 4.1.2..

Although the Sino-Soviet ties weakened during events such the Korean War (Franke, 2026) and the disagreement on nuclear technology, the Soviet Union remained a reference for industrial development and financial aid, having its role in the plan recognized widely by both Chinese and American literature (Wang, 2015). In this sense, the aid happened by sending Soviet equipment and personnel to China, besides receiving Chinese scientists in order to transfer technology.

After the establishment of PRC, the role of the state coordinating actions was intensified, which led to the reorganization of many areas of the country, most notably the rural area. The land redistribution took place in 1952, when all land deeds were destroyed and the lands were distributed (Ohio State University, 1982). The use of land for the collectivization of agriculture intensified, revealing how the government coordinated the social distribution of labor and how the PRC's ideology focused on the collectivization of the government lands, in contrast to the previous private ownership of lands. Although the land redistribution is not directly related to the plan, it is a great example of the role and the power of the state during the context of the development of the plan.

In 1954, the first PRC's constitution was promulgated, strengthening the basis of the party and establishing the rules and changes in a written form (Ohio State University, 1982). In addition to that, to strengthen the party image and to spread China's image abroad, Premier Zhou Enlai participated in key diplomatic events, such as the Geneva Convention and the Bandung Conference (Ohio State University, 1982). These events show a willingness of China to dialogue and find partners abroad, besides being a key way to assess how other countries were developing their economy and their politics. These actions relate to the Long-Term Plan for the Development of Science and Technology in the sense that the plan had a pillar of observing and analysing what other countries were doing, in order to incorporate their strategies. Therefore, the moment when China opens its diplomatic relations is aligned to the plan's goal of catching up technologically with other countries.

The election of Mao Tsé-Tung as Chairman of the PRC influenced the preparation of the Long-Term Plan for the Development of Science and Technology, because he was against the inclusion of the scientific sector in the planning. He was suspicious about the western background of the scientific elite (Wang, 2015). As it was mentioned before, China was receiving intensive aid from the Soviet Union and therefore Mao was reluctant about including western-related people (Wang, 2015). On the other hand, Premier Zhou Enlai together with mayor of Shanghai Marshal Chen Yi and Head of China's Defense Science and Technology Commission Marshal Nie Rongzhen, were responsible for weakening the political suspicion that the government had over the scientists and allowing science to be used for development purposes (Wang, 2015). This attempt of including the scientific sector and balancing its influence will be constantly seen in the plan, when the government coordinates the relations between the industry and the scientific sector.

The willingness of the PRC to make China a great power was a key motivation for the creation of the plan. Besides that, the proximity with the Soviet Union as a key partner was also reflected in the plan, as it was seen as an easy contributor from China's perspective. On an individual level, the presence of Premier Zhou Enlai in the diplomacy of China opened the possibility of assessing the development of third countries in order to inspire China on the plan. Besides that, the Premier was also essential in making political pressure to include the scientists on the development of the plan. These conclusions are based on an historical perspective and they will be further developed in the next chapters on how they relate to the plan and with the actions taken by China.

4.3. Main Goals

The Long-Term Plan for the Development of Science and Technology, as the name implies, had a broad scope of developing China's Science and Technology and, due to its broad scope, this chapter focuses on the general goal of "catching-up" and the further chapters will focus on its system of smaller goals. In this sense, it is important to analyse which goals can be similar to Brazil's goals on the development of Rare Earth Elements, in order to understand the proximity of the motivations behind the development of the supply chain of Rare Earth Elements.

The literature on the plan reinforces the core goal of the plan was "catching-up" with the world's scientific and technological standards by assessing the cutting edge technologies and developing the scientific and technological fields in which China was most deficient in comparison to other countries (Zhang and Zhang, 2019). This assessment resulted in 55 academic subjects and 12 priority projects to be "caught up" through the plan instructions and specific action plans (Wang, 2015).

The goal of “catching-up” can be seen from the lens of World System Theory as a way of reaching the position of the Core States, leaving the peripheral position. This is proved by the strong focus on developing new technologies in order to overcome the position that China had in the 1950’s, which also dialogues to the Dependency theory, which addresses technology ownership as a way of overcoming dependency. These indicators are relevant because they show that China was looking for ways of owning technology and overcoming dependency, which are key ways, according to the literature, for Brazil to promote the welfare in the country while developing its REE supply chain, revealing the proximity between the two countries’ goals.

In terms of references for the goals, China had the Soviet Union (Franke, 2026) and Eastern European countries as main references in the beginning of the plan (Zhang and Zhang, 2019), due to their close relation and relatively easy access to their technologies. However, the literature insists that it had a global vision and analysed the world’s cutting edge technologies (Zhang and Zhang, 2019), which can be reinforced by the intensification of China’s diplomacy abroad in the 1950s, when the plan was being developed. It highlights the importance of having other countries as references for developing the technologies and making technological cooperation, which will later be analysed in the case of Brazil.

4.4. Key Actors Participating in the Plan in China and in the Soviet Union

The mapping of actors was made by highlighting the actors mentioned in the plan itself, but also in secondary literature on the people and organizations that influenced the plan. As the context chapter suggests, it found a wide range of actors. In this context, it made sense to divide the chapter in one first part that will present the key actors from China and a second part that will present the role of the Soviet Union in the plan. The mapping of participating actors highlights the key relevant people to develop a successful plan as China did, being essential later to identify if Brazil owns similar actors and which actors could occupy similar positions as China’s actors.

4.4.1 The Relationship Between Industry, Scientific Sector and Government in China

The government played a key role in developing the plan, especially because of the PRC's agenda of establishing China as a great power. The strong presence of the government in industrial planning is seen as a positive factor according to the Novo Desenvolvimentismo theory, as it is considered as key to an ideal use of national resources. Therefore, it is essential to analyse how China balanced the influence of all the authors.

The first indicator of government's influence over the plan is represented by the strong control that the centralized government had over economic policy and strong institucionalization of the central government in Beijing by the time of the development of the plan, in the 1950's (Franke, 2026). There was a "top down" system established through ministries that controlled all economic policies, including the ones related to development (Franke, 2026).

In terms of specific governmental institutions and actions, the goal of assessing the scientific and technological field in which China was more deficient on as basis for "catching up" was an instruction from the State Council (Zhang, 2019), showing how the set the focus of the plan. Another key institution was the Ministry of Higher Education, which developed training plans for scientific personnel and recommending research topics for the scientists (Zhang, 2019).

The academia participated intensively in the development of the plan (Wang, 2015), having the Chinese Academy of Sciences (CAS) in Beijing as the main institution to offer recommendations and establish actions (Wang, 2015). The industrial sectors participated in indirect cooperation with the universities, as they created major research topics based on their needs, for the academia to work on (Zhang and Zhang, 2019). In this sense, the main participation of the CAS was the creation of research institutes to cover the "Urgent Measures", establishing the institutes in computing technology, automation, electronics and semiconductors (Wang, 2015). Other important institutions mentioned in the plan as key research and development efforts providers were the Fifth Academy of the Ministry of National Defense and the Ninth Institute of the Second Ministry of Machinery, responsible for achieving major military goals, developing short-range and long-range missiles (Wang, 2015).

In conclusion, the major actors in China that contributed and influenced the development of the plan are the government, via the State Council. Besides that, specific ministries were in charge of putting in practice the strategies of the plan, such as the Ministry of Education. In addition, academia also played a key role, via the Chinese Academy of Sciences and its research institutes. Other military universities were essential to convert the military part of the plan, the Fifth Academy of the Ministry of National Defense and the Ninth Institute of the Second Ministry of Machinery.

4.1.2. Soviet Aid and Technological Transfering

The choice of making a part of the chapter dedicated to the Soviet Aid was based on the wide range of fields and ways in which China received help. China in fact received a diverse aid in diverse ways, from material aid to technical advice (Hucker, 2026). However, it is misleading to assume that the plan was fully influenced by the Soviet Union.

In connection to the chapter 4.1.1., this part will start by presenting the academic cooperation projects between Soviet universities and Chinese universities. In 1956, the Chinese Academy of Sciences sent Chinese personnel to study computing technology in the Soviet Union, besides receiving documents on computing technology and components for the production of computers, such as the Soviet computer M-2 and M-3 (Zhang and Zhang, 2019). Using these documents, China manufactured a small-scale digital electronic computer Model 103 and a large-scale electronic computer Model 104 (Zhang and Zhang, 2019). Besides that, China established the Institute of Computing Technology and computer research institutions and specialized computer departments (Zhang and Zhang, 2019). China also used Soviet models for developing missiles, copying the Soviet P-2 and naming it as “Dongfeng-1” (Zhang and Zhang, 2019).

In fact, the Soviet Union provided equipment and technical aid for industrial projects often, not being restricted to the computing case nor to the initiatives under the Long-Term Plan for the Development of Science and Technology (Hucker, 2026). Besides equipment and technical aid, the Soviet Union also provided significant loans to China, including $300 million in credit in the 1950s and other smaller developmental loans for China to conclude its plans (Hucker, 2026).

Although, by the time of the development of the plan, China was trying to create an independent state and to become a great power, it still had influence from the Soviet Union. This influence was not regular, having moments when it was stronger and others marked by conflicts and weakness, notable by the weakening during the Korean War. On the Chinese side, China used it for its development goals, as exemplified by the technical partnership and loans obtained. On the Soviet side, it was marked by a way of spreading its ideology and trying to limitate the areas of technical cooperation. In this sense, the Soviet Union had denied its contribution for the development of a nuclear bomb in China (Hucker, 2026). However, it constantly sent texts and propaganda materials over China, trying to always maintain a close ideology and political influence (Hucker, 2026).

4.5. Principles / Focus

Although the concept of principles can sound abstract on an occident perspective, they have a strong importance in China and were repeated many times in the literature on the plan. In a Daoist philosophy, the principles are the paths to be followed (Hansen, 2025). In the context of the plan, the principles are described in fact as a path to be followed in order to better reach development and have a short term and a long term perspective. In other words, the principles were the different focus of the plan, and they divided the industry and the academia in their influence on the plan, because each group was responsible for taking over a different focus.

There were two key principles for formulating the plan: **"Make it based on tasks and on disciplines, with tasks driving disciplines"** (Zhang and Zhang, 2019), so the principle of discipline could supplement the principle of tasks. By tasks, the plan means straight-foward actions and projects, based on national economic development needs and industry needs (Zhang and Zhang, 2019). By disciplines, it means academic disciplines aiming to cover a medium/long-term scenario (Zhang and Zhang, 2019).

In the development of the plan, scientists considered that the task-based approach only covered a short-term need and weakened theoretical research (Zhang and Zhang, 2019). Therefore, Premier Zhou Enlai suggested the disciplinary approach and the necessity to look at long-term needs and theories focused on scientific research, fundamental progress and innovation in technology (Zhang and Zhang, 2019), which was indeed the final design of the plan that included both tasks and disciplines. Therefore, at the end, the plan was based to cover the short-term needs (tasks) and long term general aspects (disciplinary approach). It set detailed measures and goals for the next stage of industrialization (Wang, 2015).

4.6. System

As introduced in the Actors chapter, the government had strong influence on the plan, and a "top down" system was established with a highly centralized government apparatus (Hucker, 2026), after understanding how the government coordinated the specific focus of each sector, it is important to understand how it looked like in the plan. In this sense, the plan functioned as a guide for the development of science and technology (Hucker, 2026), through a systematic plans system based on subjects.

For formulating the plan, the industrial sectors were in charge of creating plans in different areas and major research topics (Zhang and Zhang, 2019), representing the tasks mentioned in chapter 4.5. Meanwhile, the Ministry of Higher Education was focusing on developing training plans for scientific personnel and recommending research topics for the scientists (Zhang and Zhang, 2019), represented by the subjects presented in chapter 4.5.

There were 55 subjects considered as Important National Scientific and Technological fields to be covered by the plan, they ranged from natural resources, mining and metallurgy, fuels and energy, machinery building, chemical industries, construction transportation and communication, defense, agriculture, medicine and health (Wang, 2015). The most important category was the "New Technologies", which included Rare Earth related goals, such as establishment of semiconductors, computing, electrical and supersonic technologies, besides expanding their applications (Wang, 2015).

Among all the goals set during the development of the plan, the 12 priority projects included 3 directly related to Rare Earth Elements: 1. Ultra-high-frequency technology, semiconductor technology, electronic computers, remote control technology, electronic instrument, and telecontrol in electronics; 2. Exploration of petroleum and other critically scarce resources, and the search for and identification of mineral resource bases; 3. Establishment of an alloy system tailored to China's resource conditions and the development of new metallurgical processes (Zhang and Zhang, 2019)

In conclusion, the plan gathered efforts from the industrial sector, the government and the scientific community. In this sense, it had a system of defining actions that used both short-term tasks based on industrial needs and a long-term approach based on scientific research, allowing the plan to address urgent actions and forecast long-term issues. Besides that, it clearly defined priority projects, which were directly and indirectly related to Rare Earth Elements.

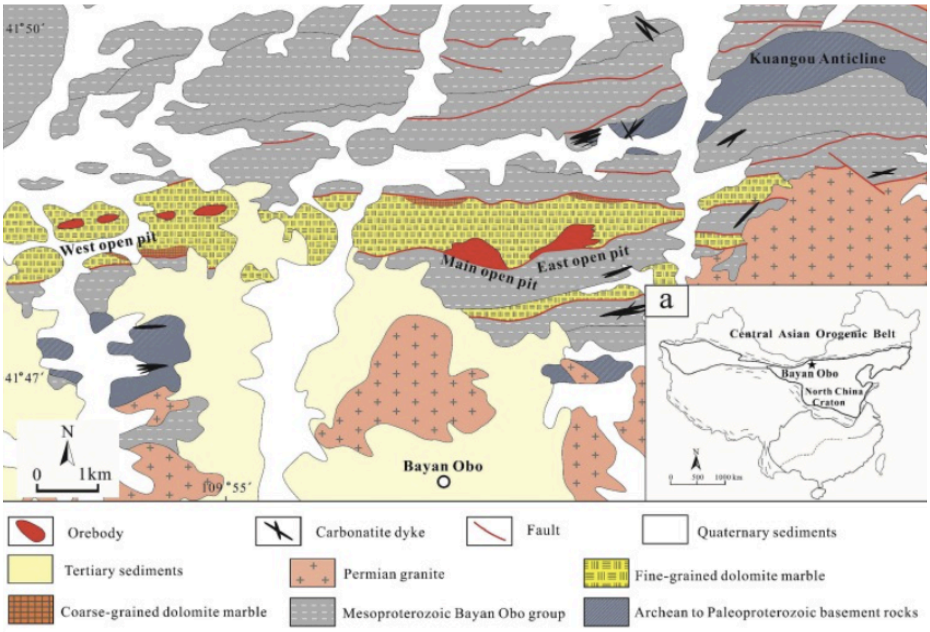
4.7. Realization of the Plan

The realization of the plan is represented by the Phase I, which is considered by the literature to be the period from 1949 to 1985, marked by the planning itself in addition to key breakthroughs in resource exploration and the enabling of large-scale REs production. The realization of the plan can be noticed already during its development, known as the "First Five-Year Plan" period. During that period, test actions were taken and technological programs were systematically organized in order to be included on the plan, as was the case of the Baiyunebu Mine.

When the plan was being developed, China's government organized the Baiyunebu Survey Team to explore and research the first known RE mine in China, the Baiyunebu Mine (Huafu, 2024), located in the west of Inner Mongolia. The mine was discovered as a Fe deposit in 1927, but only later recognized as a REE and Nb deposit (Yun-Xiang Zhan et al., 2023). Already during the First Five-Year Plan period, the government designated the comprehensive utilization of the Baiyunebu Mine as a national key scientific research project (Huafu, 2024), allowing scientists to extract mineral samples and make chemical tests. Since the beginning of the plan, the development of Rare Earth Elements combined research with practical actions.

In the XXI century, The Baiyunebu Mine is also known as Bayan Obo Mine and is the largest REE resource in the world (Yun-Xiang Zhan et al., 2023). The literature recognizes it as a major LREE producer that has been producing it for a long time (Yun-Xiang Zhan et al., 2023). Besides that, it is currently the object of studies for the development of HREE, the rarest type of REE. Recently four types of HREE-rich minerals were identified, fergusonite, samarskite, aeschynite and an unknown Pb-rich mineral (Yun-Xiang Zhan et al., 2023), indicating the potential of expanding further the production capacity of the mine. The success of the Baiyunebu Mine is a reflection of the actions taken under the Long-Term Plan for the Development of Science and Technology in the XX century, when they started the comprehensive utilization of it. The map below shows the mine and its three mining pits: the Main Pit, the East Pit and the West Pit.

Map 2 - Geology of Baiyunebu Mine



Source: Yun-Xiang Zhan et al., 2023 "The Occurrence and Genesis of HREE-Rich Minerals from the Giant Bayan Obo Deposit, China,"

In 1956, China's government issued the Outline of the Long-Term Plan for the Development of Science and Technology, in which item 16 addressed RE research and exploring new applications (Huafu, 2024). This item reinforced the work that was being made in the Baiyunebu Mine and made it a priority project for the government. In the period from 1956 to 1967, the research and development projects enabled technological breakthroughs in REE pyrometallurgical technology (Huafu, 2024), those developments of the pyromentallurgical industry were essential technologies used for the extracting process of REE. That finding was key to enable large-scale production and industry growth in the following years. In this sense, the development pyrometallurgical industry for RE is also a reflection of the plan.

However, this progress had a cost, especially due to the amount of foreign technology imported from third countries. In order to be able to further develop its national industry, China purchased equipment and technology from the international market. For it, it was necessary to adopt the strategy of exporting foreign exchange in the 1980s (Zhou and al., 2020), when it exported agricultural goods in exchange of foreign exchange, mainly to Hong Kong.

In 1886, the development of the international RE industry began with the United States, Japan, France, the United Kingdom, Germany, Austria, Canada and the Soviet Union engaging in RE separation and processing (Huafu, 2024). Their operations started around 30 years after China, motivated by the technological sector. However, China introduced measures to maintain its RE competitive, which led the other countries to buy from China instead of developing their RE industries. Examples of measures to foment REE industry was to establish an export tax rebate policy, implementing incentives for selling RE abroad (Zhou, Huang, Shao and Yang, 2020). That measure had an intense impact together with the development of the global semiconductor industry, because the world needed REs to produce semiconductors. From 1991 to 2004, China's exports increased from 8,2t to 53,3t (Zhou et al., 2020). Besides that, China's consumption also increased in order to produce semiconductors domestically, from 8,3t to 33,4t. Therefore, RE production increased from 48t to 95t and China's RE reserves decreased from 43 million tons in 1995 to 27 million tons in 2002 (Zhou et al., 2020). It was possible for China to establish competitive prices on its REE because its industry was already developed and it is an indirect consequence from the Long-Term plan.

After 1985, China's actions were influenced by international competition and by internal factors, functioning as an adaptation period. The literature labels the period from 1985 to 2004 as a period of encouraging RE exports and standardizing mining procedures (Zhou et al., 2020). Besides that, it is possible to analyse that the measures taken in that period were already influenced by the international RE demands and competition. In comparison to the previous period of the plan, now the actions are directed to adapt to the trading patterns instead of just focusing on the national interests, as it was the case before. In this period it is clear that China enjoyed a privileged position of having a more consolidated industry in comparison to other countries, which was just possible because of the achievements through the plan. Besides that, its actions of facilitating exports slowed the production of RE abroad.

Besides addressing the international competition, this period also addresses the illegal and irregular mining behaviors that increased during the 1990s motivated by the big amount of revenues generated by the industry. Therefore, the government introduced standardizing mining and utilization procedures and protection to the ionic RE resources (Zhou et al., 2020). By establishing a stand procedure on how to mine RE, the government centralizes the know-how and facilitates the fiscalization of the mining sites.

In the 1990's China officially joined the WTO in order to increase its foreign exchange reserves. The new member attracted intense attention from third countries to the research and development of RE functional materials in China, increasing the international competition (Zhou et al., 2020). China started to strive for national interests in foreign trade in terms of export pricing power and the government took measures on RE industry concentration and export tax rebates (Zhou et al., 2020), keeping its REE prices competitive.

4.8. Overall Evaluation of the Plan

The literature has an overall consensus about the positive results of the plan, including its completion ahead of the schedule and the way it narrowed down the gap with the world's standards and developing China's science and technology, national defense, economy and society (Zhang and Zhang, 2019). In this sense, this chapter will present the key evaluations of the plan and the key areas that it was considered successful, in order to highlight the results and the successful initiatives.

The literature points to the period of 1953-57 as the beginning of China's rapid and successful industrialization (Hucker, 2026), showing the impact of the mobilization of the sectors already in the beginning stage. In this sense, the central government's strategies were seen as key to channel scarce resources mainly into development of heavy industry (Hucker, 2026). The ability of the central government to generate progress in the industrial and technological area reflected in the production of key goods that were considered China's goal, such as the computers Model 103 and 104 and the "Two Bombs", including the beginning of China's nuclear program (Zhang and Zhang, 2019).

Another key contribution of the plan was the institucionalization of research groups and technological working groups, improving the scientific field in China. In this sense, the State Science and Technology Commission was established, the leading institution for technology of the government (Hucker, 2026). Besides that, many institutes were created under the Chinese Academy of Science, as already presented.

Besides the material results, the overall public impression was of a stronger China and a positive impact of the plan (Hucker, 2026). In addition, the plan is pointed as a key way to provide income and to motivate the labor force in the state sector (Hucker, 2026). Overall, it is possible to see a positive impression of the plan in many areas of China, from the civil society to the government. Besides that, it provided clear material results aligned to the goals established.

5. KEY TAKEAWAYS FROM CHINA'S REE SUPPLY CHAIN DEVELOPMENT

Although the plan had an unique context, it is important to extract its essence and the key measures that made it successful, which can be applicable to other contexts, such as the Brazilian case. Based on what was exposed before, main ideas from the planning can be considered as key for China to develop its Rare Earth Elements industry, such as the alignment of the scientific and industry sectors, the technological partnerships and the use of long-term plans.

It is possible to conclude from the Realization chapter (4.7.) that the study and development of mining activities in the Baiyunebu Mine and the development of the pyromentallurgical industry were the key actions that allowed China to produce in large scale and to set a competitive price of its REE, enabling the development of the sector despite of a rise in the international competition. In this sense, it is important to connect those two factors with the Long-Term Plan for the Development of Science and Technology and the activities that led to these achievements in order to understand how they became possible.

First, the development of mining activities in the Baiyunebu Mine was possible because the government chose to focus on a specific mine and assign a research team specifically for that project, understanding its complexity and mapping the region. This action is addressed by the plan as a key priority and a national research project. By being addressed in the plan, it becomes an object of combined work between the industrial sector and the scientific sector. From a technical REE perspective, it makes sense for China to elect one mine and to focus the studies on that specific mine, because the literature recognizes the complexity of the extraction of REE and how different this process can be depending on the mine and the exact type of mineral. Therefore, knowing exactly how the mine works and which minerals are reachable and how to extract them makes sense from a strategic perspective.

The second key progress was the development of the pyromentallurgical industry, which allowed REE to be produced in large-scale. This development was only possible because the industrial sector was working closely with the scientific sector, so the breakthroughs of the research sector were combined with the findings of the scientific sector. As mentioned in the chapter on the development of the plan, the needs of the industrial sector were addressed by research groups, enabling technological development through R&D.

Another key action considered relevant by the literature is making technological partnerships with other countries. This action was present both in the academic and industrial sector and counted with the exchange of personnel and the purchase of equipment from third countries, with the highlight for the Soviet Union due to the high amount of cooperation projects. An evidence of its relevance on a national level is the economic reorganization of China in order to obtain foreign exchange to buy equipment, which represented a big national project. Besides that, an evidence of its success was the amount of products that resulted from the cooperation projects, such as computers and bombs.

Finally, the projects had the goal of making China a great power and they were developed based on national interests. The chapter on the context of the plan shows the motivations of the PRC and their long-term plans for China, which were reflected in the plan. From a theoretical perspective, the way that PRC prioritized China's economic and technological development are aligned with all the theories mentioned before.

From a World System Theory perspective, China can clearly be seen as a country trying to leave the Periphery and reach the Core. It is evidenced by PRC's discourse of making China a great power compared to other countries. Besides that, the World System theory has the technology as the main object representative of power, which was also the focus of the PRC and China's development plans. It is clear the equation of developing technology in order to be a Core country, exactly as described by the theory.

From a Dependency Theory point of view, it is possible to see China as a dependent country in relation to the Soviet Union at the beginning of the XX century. China's struggle to become independent is explained by the theory as the way it focused on developing its technology and avoiding the role of supplier of low-aggregated value goods to third countries. China looked for the ownership of technology to become independent from the Soviet Union, instead of depending on its technology. Complimentary, the Novo Desenvolvimento Theory addresses the role of the State in coordinating the actions. Which, in the case of China, was key to delegate the actions for the industrial and scientific sector. Therefore, the importance of long-term planning in the way China did it can be explained by the theories presented.

6. LESSONS FROM CHINA THAT CAN BE APPLIED TO BRAZIL

1. Focus on the development of mining in one specific mine, Baiyunebu Mine in the case of China;
2. Have a long-term plan coordinated by the government having the national interest as the main goal. The Long-Term Plan for the Development of Science and Technology developed by the PRC is an example from China's case;
3. Have the Industrial sector working closely with the scientific sector in order to have relevant technological development. The pyrometallurgical industry was the biggest technological breakthrough in this sense;
4. Make technological partnerships to complement the national technological developments. In the case of China, importing mine technology from the Soviet Union and Japan, in addition to other computing technologies from the U.S..

6.1. Focus on the Development of Mining in one specific Mine

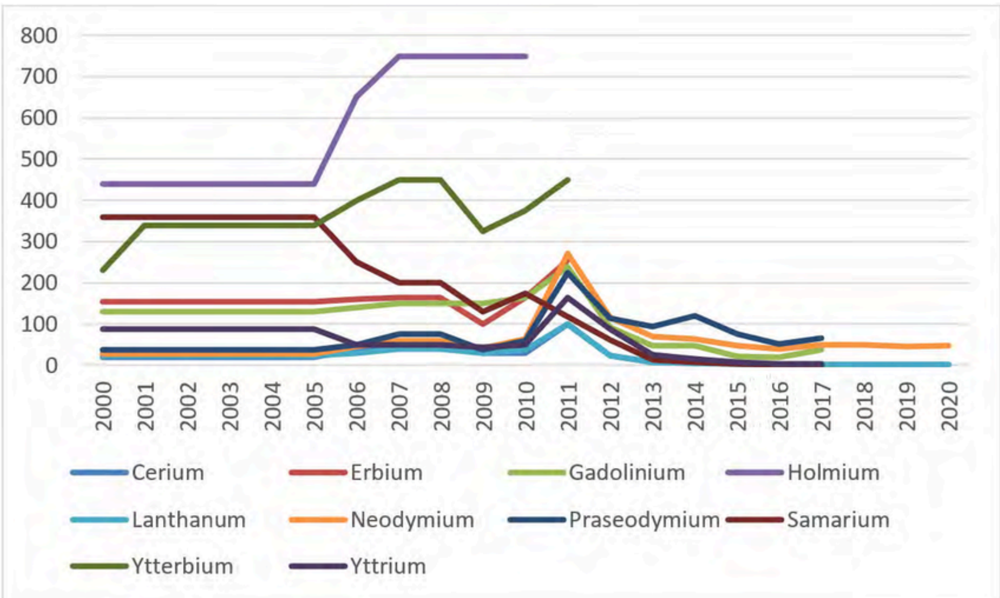
In the case of China, the Baiyunebu Mine was the chosen mine to focus on, because it was the only big mine where REE was found. The Baiyunebu Mine was already a known deposit of iron and, after conducting research and experimental exploration they found Rare Earth Elements. Therefore, it was possible to use an already existing infrastructure of transport and mining in the Baiyunebu Mine. Besides that, it proved to contain a diverse range of types of REE.

From a RE mining perspective, it makes sense to focus on one specific mine and to develop a mining technology for that one mine, given that the extraction of REE is a highly complex process and it changes from different types of RE and the way they are located in the deposit.

For example HREEs usually have harder extraction than LREEs. Therefore, developing a system that works specifically for that mine and for specific REE can be more efficient than trying to extract REE from a wide range of mines, especially given the costs of R&D and buying foreign technology, as China did. Besides that, one mine can produce large enough output and income to be relevant for the whole economy, as was the case of the Baiyunebu Mine in China.

In the case of Brazil, two options of already existing projects can be chosen: 1. The extraction process using beach sand or; 2. One of the already existing mines. This thesis considered suggesting recovering the processes of removing Monazite from the beaches, which were common and profitable in the 1960's. However, the process used was to remove the REEs chemically from the sand, which is highly pollutant due to the nuclear waste from the process (Costa and Rochedo, 2005). Besides that, the type of minerals obtained in this process are lanthanum, cerium and neodymium, the three are LREE, usually the cheapest REEs. The graph below presents the cheapest types of REE elements and it is possible to see lanthanum cerium and neodymium among the six cheaper ones, all with values below 300 US$/kg during all the historical period analysed.

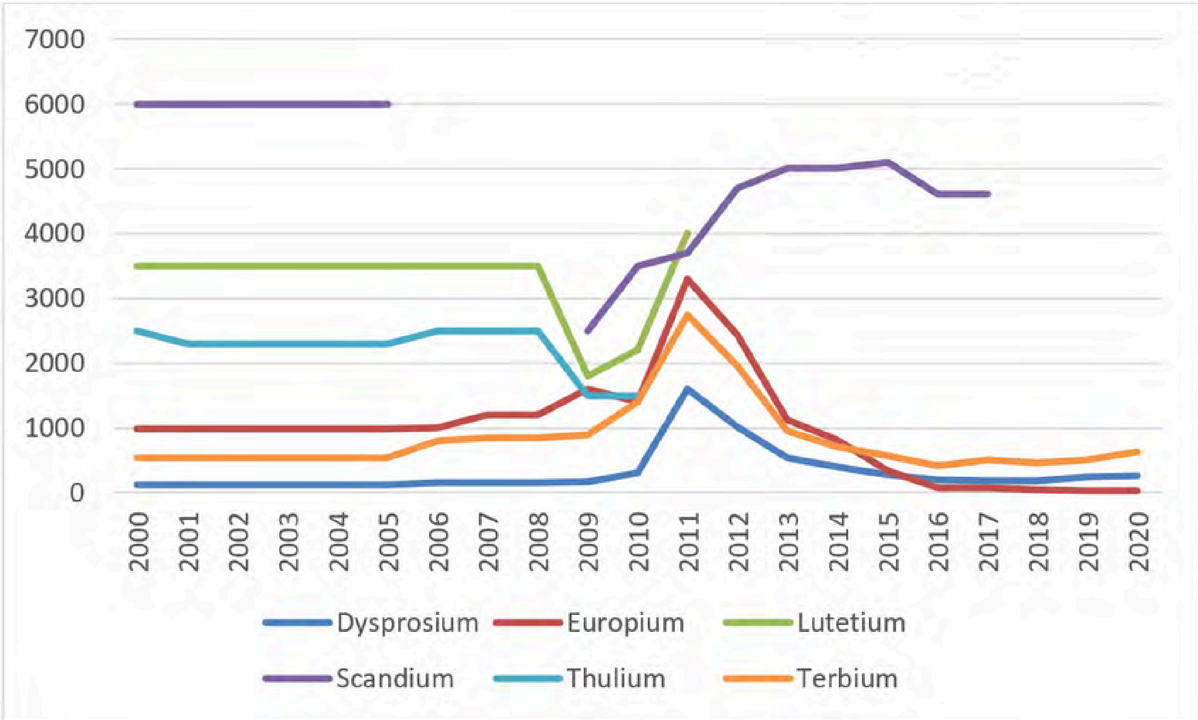
Graph 2 - Cheapest REE (US$/kg)



Source: Filho and Thauan. (2022). Energy Security Transition: clean energy, critical minerals, and new dependencies. Ambiente & Sociedade

Due to the high pollution and costs related to the process, in addition to the low aggregated value related to it, it is possible to understand why the Brazilian government took the decision to stop the extraction process from the beach sand. Therefore, it is more adequate to pick one of the mines that contain REE, focusing especially on those with high-aggregated value, as indicated in the table below.

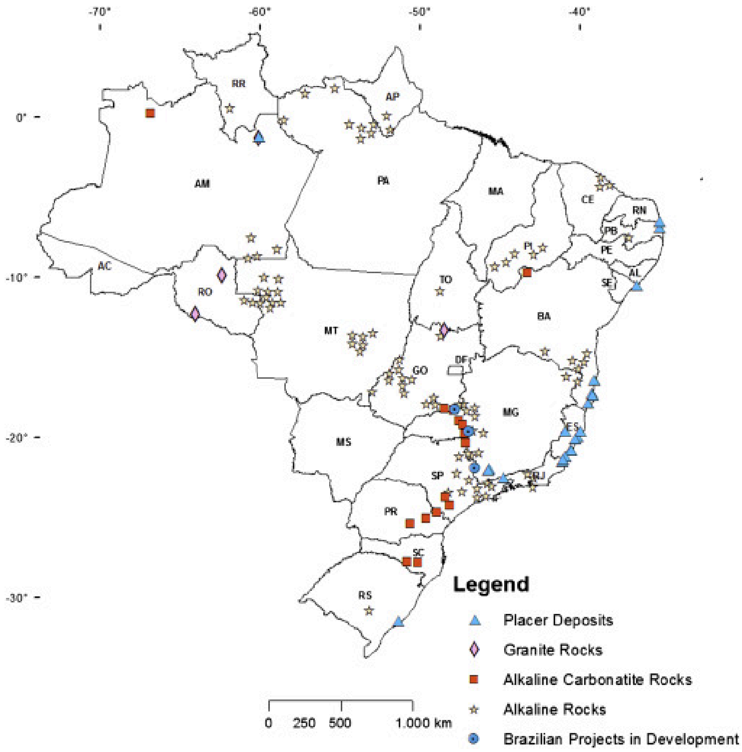
Graph 2 - The Most Expensive REE (US$/kg)



Source: Filho and Thauan. (2022). Energy Security Transition: clean energy, critical minerals, and new dependencies. Ambiente & Sociedade

Although Brazil has a huge amount of REE reserves, not many of them are being mined. Among the mines, almost all of them contain LREE, the cheapest kind of REE, except by Pela Ema and Pitinga. Besides that, both of the HREE mines are owned by foreign companies, a factor that will be addressed in the following subchapters. The map below presents the REE projects in development and the type of minerals found in each project.

Map 3 - Rare Earth Elements Projects in Development



Source: Ismar Borges De Lima and Walter Leal Filho, "Rare Earths Industry : Technological, Economic, and Environmental Implications," 2016.

In terms of LREE, it was found in Catalão I, Araxá and Morro dos Seis lagos mainly Monazite, which can be used for the production of cerium and neodymium (Lima and Leal, 2016). In Poços de Caldas, an abundant amount of bastanese is found, a source of cerium, neodymium and lanthanum (Lima and Leal, 2016). These three REE represent cheap types of REE. The project carried out in Araxá is the most advanced one, and it is led by the Brazilian Metallurgy and Mining Company (Lima and Leal, 2016).

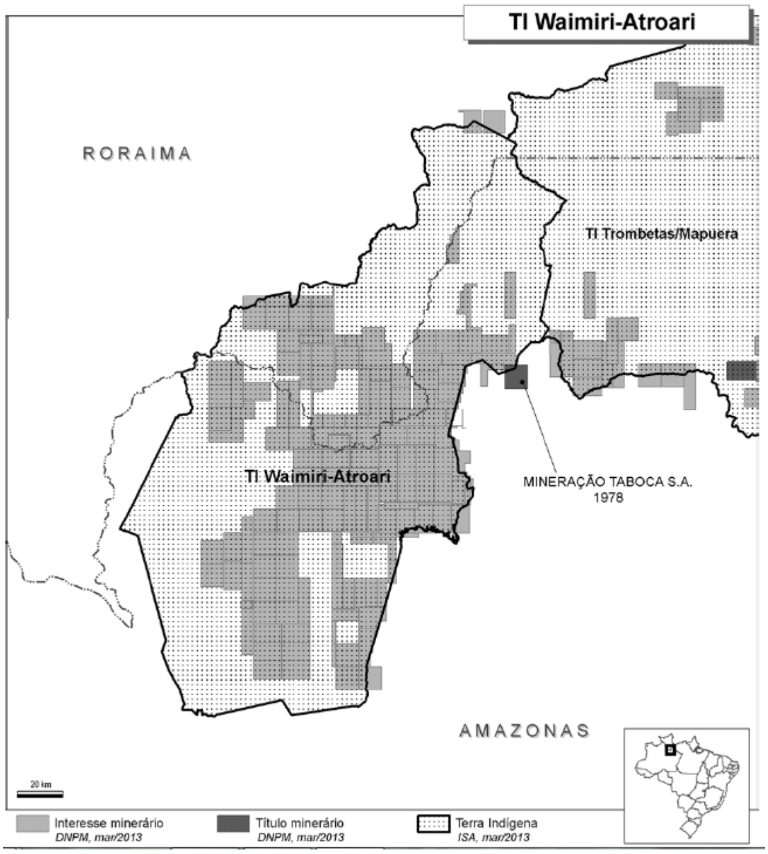
In terms of HREEs, Brazil has a huge potential for developing its supply chain, as the presence of them is already estimated (Lima and Leal, 2016). There are mining plants in Pitinga (Amazonas) and in Pela Ema (Goiás), both regions with big HREE reserves (Lima and Leal, 2016). The mine in Pitinga is currently producing Niobium and other types of minerals, with research projects to mine Ytrium, a HREE (Lima and Leal, 2016). The Pela Ema mine is the most well-developed REE mine in Brazil, it produces HREE already in commercial scale.

Pela Ema mine is operated by the Serra Verde mining company and it produces Neidymium and Praseodymium (LREE), besides Dysprosium and Terbium (HREE). The company has strategically chosen to develop the mining process for these four REEs because they together are used for manufacturing permanent magnets for aerospace, defence, automotive, electronic and energy applications (Serra Verde, 2025). The presence of those REE necessary for aerospace reveals a huge potential for integration of the supply chain with the Embraer industry.

Taking in account that the HREEs are the type of REEs with the highest value, the rarest type in the international market and one of the most important for a wide range of industries, it is essential to select a mine that can produce HREE, thinking in a long-term utility and price of the mineral. The high value related to HREE takes into account both its high price due to the complexity of its extraction, but also the high profits related to it, as it has a low supply in the international market, triggering a high market price.

Therefore, the chosen mine has to be either Pela Ema or Pitinga. The first one has its mining actions already developed with a combination of both LREEs and HREEs that are essential for producing magnets, meanwhile the second one is still in the early stages of development. In addition to the stage of the development, the location of the mines become a key decisive point, because Pitinga is located in the middle of the Amazon rainforest, between indigenous territories and other protected lands, as it is shown in the picture below.

Map 4 - Location of Pitinga Mine ("Mineração Taboca S.A.")



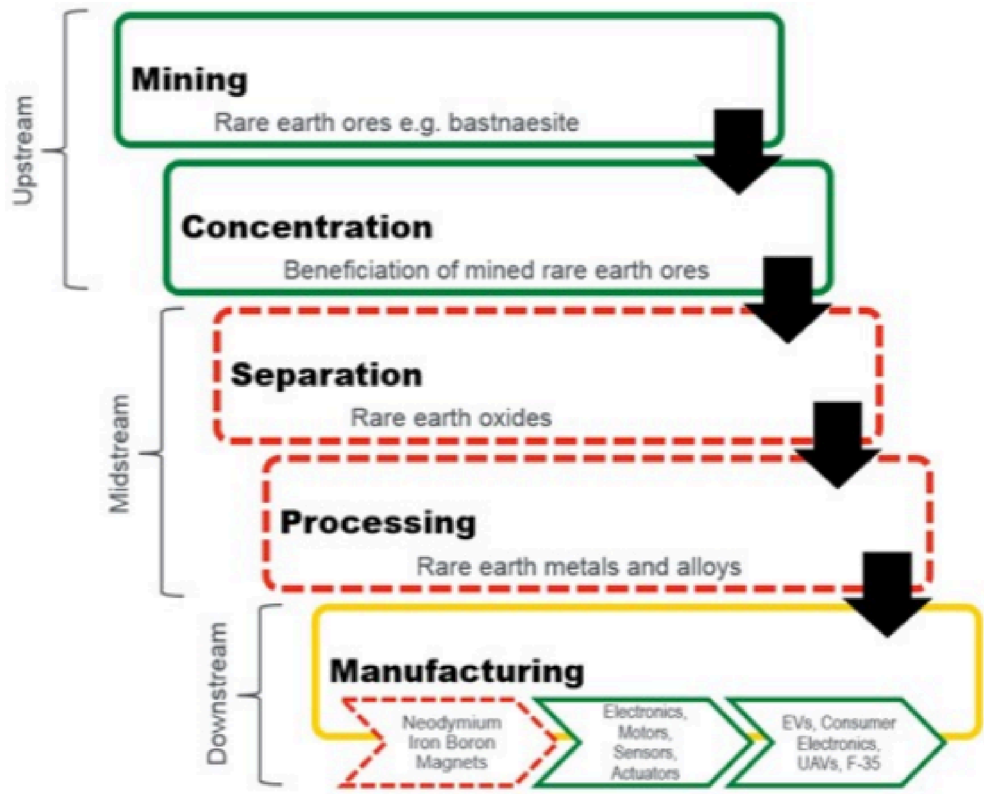
Source: Global Atlas of Environmental Justice. “Pitinga Cassiterite Mine.” Ej Atlas, 2025.

In fact, Pitinga mine has been facing long-term legal disputes due to its negative environmental and human right impacts, being reported for visible deforestation, surface water pollution, mine tailing spills, displacement of local community, lack of work security, violations of human rights, land dispossession and loss of livelihood (Global Atlas of Environmental Justice, 2025). Besides that, the company Mineração Taboca S.A., bought by a Chinese company, already lost some disputes, having to provide compensations (Global Atlas of Environmental Justice, 2025).

The financial costs of social and environmental compensation, plus the reputation cost of investing in the Pitinga mine are high weaknesses of that mine. Besides that, it goes directly against the goal of promoting social welfare and sustainable development. Therefore, the chosen mine for focusing on is Pela Ema, due to its advanced status of the installations, the high value related to their REEs, its geographical location and its sustainability friendly operations.

Both Pitinga and Pela Ema are owned by foreign companies, the second one by a Chinese group and the second one by Serra Verde Mineração, a company that was bought by USA Rare Earths group. In this sense, the government can't mine directly using Serra Verde's operations, but it has a wide range of actions that can be taken in order to integrate the mine to research programs and to other national industries. The picture below shows the supply chain of a Rare Earth Element.

Pícture 1 - Rare Earth Elements Supply Chain



Source: Atwell, Cabe. "Rare Earth Metals Supply Chain Caught up in Global Politics." EE Times Asia, 2021

Serra Verde produces a mineral concentrate containing high value REEs, Nd and Pr (LREE) and Dy and Tb (HREE), which means that its product is located after the Concentration process illustrated in the picture. The company has the full Upstream part of the supply chain developed. However, from Midstream to Downstream, the processes are done outside Brazil, due to the lack of companies in national territory that are able to do it. Serra Verde's production has been under Chinese and American dispute (Assis, 2026), without a domestic market that could make the Midstream process.

Therefore, one of the main recommendations of how to engage with Pela Ema mine is to invest in the development of the next steps of the supply chain, Separation and Processing, enabling the minerals to acquire higher aggregated-value and generating more jobs and development in Brazil's industry. In terms of the nature of the industry, it can be developed both by public initiative and/or private initiative, both requiring an intense partnership with the scientific sector, as it will be explored in subchapter 6.3. Besides that, the next subchapter will address legislative initiatives that can foment the integration of the mine with national industries, in order to transform the revenue generated into social welfare.

In a further step of the supply chain, but that could be researched simultaneously with the Midstream development, is the development of the manufacturing process, which would fully integrate the REE supply chain to the domestic industries, this is possible due to the nature of the REE produced in Pela Ema and by the nature of the industries present in Brazil, in the automotive and aviation field. Pela Ema is the only mine outside Asia to produce Neidymium, Praseodymium, Dysprosium and Terbium in commercial scale (Assis, 2026). These minerals have the potential of integrating the REE supply chain with other national industries, because they are materials needed for producing electric cars and airplanes, both industries already present in the country, creating a verticalized supply chain that will allow jobs to be generated in national territory.

The Pela Ema mine could not only benefit research and development on a public level, but also benefit the private sector by supplying critical minerals and generating jobs to the national population. Serra Verde started its production in 2024, when it started supplying REE to the international market. In terms of numbers, Serra Verde produced 60 tons of REE in 2024, generating US$ 2,2 millions and, in 2025, 678 tons, generating US$ 12 millions (ComexStat, 2026). This growth from one year to another represents the potential of the mine to expand what is already in the company's plans.

Secondly, the government could interact with Serra Verde by creating research programs in the specific field of REE, requiring the company to employ a number of scientists in a mutually beneficial relation with research institutions. The scientists would bring the knowledge developed in the laboratories to the mine and they would get practical experience and samples from the mine. The subchapter 6.3. will deeper address the cooperation between the scientific and the industrial/mining sector.

6.2. Have a long-term plan coordinated by the government

The Long-Term Plan for the Development of Science and Technology was the successful long-term plan coordinated by China's government. In this sense, the government was responsible for aligning the trends in the scientific and technological sector with national development needs and coordinating the actions. Besides that, the government had the goal of developing its own industries in order to have a connected supply chain. The goals mentioned in the plan were:

- the development of ultra-high-frequency technology, semiconductor technology, electronic computers, remote control technology, electronic instrument, and telecontrol in electronics;
- the search for and identification of mineral resource bases;
- the establishment of an alloy system tailored to China's resource conditions and the development of new metallurgical processes.

In Brazil, the matter of having a Long-Term Plan can be complicated, because the country's politics and projects are marked by a lack of continuity, especially on a federal level. Some examples of projects seeking social development are the Transnordestina Railway, created in 1960s and never finished due to ministerial changes (Moura and al., 2019), many projects from the Rio 2016 Olympics that also have never been completed and are related to corruption cases. The Ferrogão Railway is a symbolic example of how development projects are affected by opposite ideology governments, this project was advanced under Bolsonaro's administration in 2010, but stopped under Lula's government in 2021 due to environmental reasons. The list of examples is extensive and present during Brazilian history.

An example of discontinuity in the field of Rare Earth Elements is the Monazite extraction, mentioned in previous chapters. It was a project from the University of São Paulo and the private sector. Despite the positive development of the technologies, after two decades Brazil lost its technological edge (Mindreau, 2025). Therefore, it is highly indicated that the long-term plans are related to relatively independent national institutions and more than one national institution, making it decentralized and avoiding its discontinuity, as the successful case of Embrapa that will be addressed further in chapter 6.3.

In addition, the creation of laws that protect and regulate the mining of REEs has been a demand from the industrial sector since the beginning of the XXI century and it can guarantee a long-term protection of the resources and assist translating them into national development. For example by enforcing that a part of the revenue generated with them will stay in the country for industrial and technological development. Exchange rate projects can also be conducted by the Central Bank in order to protect the minerals, as Singer and Furtado defend.

In general, it is ideal for the government to create and coordinate an environment where private companies can develop technologies and the industry can thrive. Besides that and mostly related to this thesis, the government should assist in translating the revenue from the extraction of REE to social welfare and development. Therefore, the legislation should guide the achievement of this goal, regardless of governmental continuity. It is still interesting for the government to do as China's government and set goals of development for specific technologies, in order for the legislative sector to establish laws in that sense and to connect the existing mining programs to a REE supply chain. For example, by giving tax benefits to magnet companies, it would help verticalize the supply chain in Brazil's territory, as the REE wouldn't need to leave the country. Another key industry already in the country is the airplane industry Embraer, which could benefit by having a supplier of technological airplane parts made by the REE extracted in the country, taking in account that many parts of the airplane need REE.

By suggesting legislative and economic actions, the government not only helps create welfare and verticalize the supply chain, but also involve other federal institutions, avoiding lack of continuity. Brazil has to avoid its historical colony position, of only supplying raw material without having social development. Brazil was historically responsible for supplying raw material to Portugal and therefore was directed towards exporting materials of lower aggregate and technological value. Portugal didn't allow the production of manufactured goods in Brazil until 1808 (Fausto, 2015). In the sense of Rare Earths, even before their price escalation and their current geopolitical situation, they were already exploited in Brazil by a colonialist system. They were removed from the beaches in Bahia for free and taken to Europe under the company E. Johnston & Co, which would sell them in Austria and Germany for producing lightning, based on Carl Auer von Welsbach's discoveries ("Auerlights"). It is estimated that E. Johnston & Co received, from 1885 to 1897, an income of 750.000 francs from Vienna's Lightening Company, obtained from selling 1300 tons of Monazite extracted in Brazil (Sousa, 2014).

In this sense, the legislative actions have to be in the sense of protecting the supply chain, for example by classifying it as national strategic minerals, which would limit the foreign participation, or, as China does, to require that an amount of REE be processed in national territory. It is also highly recommended to create benefits for attracting companies to process REE in Brazil, for example by reducing taxes for REE-related companies in regions close to Pela Ema mine. Besides that, a legislation that requires a number of workers to be Brazilian, in order to generate jobs and train the local workers.

Besides that, it is essential to launch laws that require the donation of part of the generated resources to universities and research related to REE. The importance of the scholars acting together with the industry is a key lesson from China's case and it can be used in Brazil via laws that encourage research. This measure can prepare the scientific community to contribute to the industry and also to, in a medium-term, start developing government-owned initiatives.

In an economics perspective, Furtado and Singer defend a strong influence in the exchange rate, saying that letting the exchange rate float would trigger the same historical pattern of exploitation..

6.3. Have the Industrial sector working closely with the scientific sector

Encouraging the scientific sector to research on REE is a key way of developing national technologies and enabling the development of new industries owned by national actors, either private companies or the government. In the case of China, the government coordinated the research topics according to the industrial needs, enabling the creation of government-owned initiatives. In the Brazilian case, due to the ownership of all HREE mines by foreign companies, it is a different scenario and the supply chain is not starting from zero as in China.

In the case of Brazil, it is necessary for the government to foment the research in the supply chain of REE, in order to develop its own refining and separation of REE companies. First, it has to update its geological mapping. The research conducted now is based on maps from the 2010's, which are very complete but need to be updated using new findings. Brazil's map institution IBGE should conduct specific research on REE reserves and update its geological mapping.

Secondly, a national research institution should be created in order to coordinate and determine goals for REE, in alignment with the industry. This measure also dialogues with chapter 3.2 that addresses the need for long-term goals and to avoid the lack of continuity by delegating the projects to relatively independent institutions instead of the national government. Besides that, a good way of aligning the industrial and research sectors is by requiring data sharing from national research institutions to national private and public companies, enabling them to use scientific findings for developing their technologies. The funding of the research should necessarily condition the research to industrial needs.

Despite the existence of national institutions indirectly related to the topic, which work with initiatives related to REE, such as the Ministry for Science, Technology and Innovation and the Ministry for Mines and Energy (Costa Santos, 2026), it is necessary to create an institution dedicated specifically for REE, in order to have continuous projects in the field. The REE institution can coordinate the actions and work together with the other ministries, decentralizing and avoiding discontinuity.

A proof that this model can work in Brazil is the Embrapa, an agricultural research institution created in 1974 in Brazil with the goal of making the agriculture sector more technological (Embrapa, 2026) and deeply analysed as a case of success around the world. After many studies to understand its success, the main findings was that the success of the Brazilian agricultural sector cannot be traced to a specific policy, but by the institutional resilience of its system, that emerged by the creation of inclusive and sustainable institutions through fiscal, monetary and political environment (Mueller, 2016). The Embrapa is a public company connected to the Agriculture and Pecuary Ministry with 43 institutions around the country (Embrapa, 2026).

In this sense, by developing its own REE research institution, the government will be able to offer valuable data for private and public companies besides defining goals aligned to the industry and complementing the already-existing REE supply chain, connecting it to the already-existing national industries. This measure would complement the laws suggested in chapter 6.2. that would require an amount of REE to stay in Brazil for the further supply chain processes. In terms of law, according to Art. 20 (9) of the Constitution of Brazil (Constituição Federal, 1988), the underground is owned by the national government, enabling this research institution to conduct research on the mines freely, regardless of the ownership of them.

6.4. Make technological partnerships to complement the national technological developments

This lesson has the basis on identifying the countries considered successful technologically in the field and importing technology through scientific partnership projects and the purchase of technological equipment. In the case of China, it had the Soviet Union and Japan as examples for mining, in addition to the U.S. for computing technologies. Therefore, it established diverse programs seeking technology transferring from these countries.

In the case of Brazil, it already has the presence of a wide range of capital invested in the territory on the matter of REE, so it is necessary to establish the basis of the technological investments programs, in order to ensure the development of the national industry. A lesson learned from China is to make scientific knowledge exchange, sending and receiving scientists from countries with technological ownership to train the local scientists. For that, China can be a key partner, as it is the biggest player in the REE supply chain industry, besides being interested in Brazil's agricultural technology and being a member of BRICS+, a multilateral forum that encourages development partnerships. In fact, many development programs were already developed in a bilateral level between Brazil and China, with highlight to agricultural-focused programs in China that offer scholarships for Brazilian students, besides Chinese centers of research in Brazil for the study of agricultural technologies.

In Brazil there is also the opportunity of collaborating with the countries who already own mines or investments in the REE sector in the country. In fact, the government should require technological partnership in order to allow foreign companies to establish in the strategic mining sector. In this sense, the technological partnership should be established on a similar basis as the ones presented in the previous subchapters. First, by assuring that a representative number of Brazilian workers are employed in the companies. Secondly, by making training and research projects with universities and research centers. Thirdly, by assuring that an amount of the minerals mined are going to stay in Brazil for the further process of their supply chain.

Among the companies not necessary related to REE but with extensive technological assets in the mining sector are the Canadian Itafos; and the Chinese CMOC, CNMC, Baiyan, Hongbridge Holdings and BYD; The first is engaged in the exploration, mining and production of phosphate based fertilizers and has operations in Arraias, Santana and Araxas in Brazil (Itafos, 2026). The second one mines and processes Gold, Niobium and Phosphorus in many regions of Brazil (CMOC, 2026). Besides that, there are many Japanese companies owning equity of companies from Brazil, such as Mitsui & Co that owns 6% of Vale (Mitsui & CO, 2017), ITOCHU Corporation that owns equity from CSN Mineração (ITOCHU, 2026) and the Sumitomo Corporation that owns the joint venture Usiminas Mineração together with Usiminas (Usiminas, 2025). Among the companies directly related to REE in Brazil are the American USA Rare Earths; and the Australian Meteoric. The first one is engaged in HREE and LREE mining and processing in Pela Ema (Serra Verde, 2026). The second one is analysing the viability of start mining in Caldeira (Meteoric, 2026).

7. AVOIDING HISTORICAL PATTERNS

The measures suggested in the previous chapter will make Brazil avoid the repetition of the historical pattern of being a raw material exporter without manufacturing products with aggregated-value. In fact, it was key having theories focusing on developing countries as the basis for the analysis and as inspiration for the measures and adaptations suggested. Besides that, the choice of China as the model for the comparative study was in fact aligned with the theories, because the measures developed by China also had the goal of removing China from the position of periphery country, occupied in the 1960s.

From a World System Theory, Brazil nowadays and China in the 1960s occupy similar positions, as semi-peripheral countries which have a prestigious position regionally but which still struggle with historically systemic issues. China is an example of how it successfully obtained core characteristics for the production of REE, such as the concentration of high-technologies and the high diversification of production, exemplified by the ownership of different parts of the supply chain. These aspects put China closer to a core position, moving away from the low-technology and less diversified production and closer to a dominant position capable of generating industrial development and using the technologies as a political asset.

In the case of Brazil, its position when it comes to REE is still extremely semi-peripheric, because it can negotiate with core countries (core aspect), but it still concentrates the part of the supply chain with low-profit and low-wage, which is the mining production. In fact, even the type of mineral, LREE, owned by Brazilian private industries are the minerals associated with lower-profit, while foreign companies own the mining projects associated with higher-profit, the HREE mines. In this sense, the actions presented in the previous chapter will enable Brazil to move from that semi-peripheral position to a position closer to the core position, by increasing the high-technologies, high-profit and high-wage activities in the national territory and owned by national industries.

From a Dependency Theory lens, the most important thing is not to passively integrate to international trade, because by doing so the developing countries will easily reach a position of dependence from core countries. This theory inspired the suggestion for the government to influence the exchange rate in order to avoid passively integration to international trade, which would lead to exploratory consequences (Singer et al. 2023). Besides that, by having an integrated supply chain connected to the national industry, Brazil would avoid depending on third countries for the production of high-technology goods, which was the case of China. In the case of China, it worked closely with the Soviet Union in technological partnerships and buying its technology in order to slowly develop its own processes without depending on foreign assistance, reaching autonomy.

The Novo Desenvolvimento Theory is perhaps the lens that sees the two countries in a more different way, because it addresses the state intervention in order to reach development. In both countries, it is proved the need for a degree of state intervention, indicated by the theory and also by the needs expressed by the industry in both countries. In the case of China, the state intervention is intense by owning the mining companies and by creating long-term plans. In the case of Brazil, the ownership of mining companies proved not to be the best way to proceed, due to the current ownership of the strategic mines by foreign companies. In terms of long term plans, Brazil's political environment has shown a need for the creation of specialized institutions to be in charge of the plan in order to avoid discontinuity. This theory reinforces the necessity of the creation of strategic actions towards the use of natural resources, in order to be able to create welfare and development.

8. CONCLUSION

The thesis provided an extensive review and analysis on China's Long-Term plan for the Development of Science and Technology and its realization, in order to obtain lessons and insights inspired in China's success to apply to Brazil's case. It had the basis of the idea that the natural resources of the country should be used primarily to the development of the country's industry and its welfare, extracted from theories that analyse the systemic challenges that developing countries have to face.

Despite the circumstantial differences between China in the 1950's and Brazil now, China has a wide amount of lessons to teach Brazil in terms of developing the REE and REE industry. In fact, China has proven to be a successful example not only in the numbers of leading production of REE, but also in the process that led to its development. For example, in the alignment of the scientific and the industrial sector, in the long term planning and execution and in the strategic technological partnerships developed during the struggle for technological development.

When analysing the contextual differences between Brazil and China, some things were considered limitations for the full application of China's lessons, which led to adaptations seeking a better suitability and feasibility to Brazil's reality. The main limitations noticed were in terms of:

1. Government ownership in the mining process. While China's context in the 1960's allowed a high governmental ownership of the mining companies, in Brazil it is not the case due to the significant presence of foreign capital and foreign ownership in the sector, especially in the upstream part;

2. Historical tendency of continuity in governmental projects. China's government is able to follow their development projects successfully, Brazil has a historical tendency of discontinuity when it comes to public projects;
3. Opportunities for technological partnership. While China had close ideological and political relations to the Soviet Union and could technologically benefit from it, Brazil will have to build a partnership without that type of proximity. However, a key factor to be taken into account is the amount of foreign companies already established in Brazil, which should facilitate the partnerships.

Taking into account the lessons learnt with China's REE development process and acknowledging the need for adaptation for applying certain lessons in order to enable Brazil to better transform the revenue with REE into industrial and social development, the following set of measures are suggested for Brazil's government:

1. On the creation of institution:

1.1. Create a national institution for REE development, in charge of setting goals and plans for achieving them, coordinating the research and development in the REE field and coordinating technological partnership programs. For that, it is necessary to work together with other institutions such as the legislative sector, the industrial sector, the Ministry for Science, Technology and Innovation and the Ministry for Mines and Energy;

2. On the investment for research and development:

2.1. Invest part of the revenue from REE into research and development of topics that represent the industry's needs;
2.2. Update the geological mapping;
2.3. Focus on the Midstream and Downstream processes, enabling the integration of the already-existing downstream part with the already-existing demand in the national industry;
2.4. Invest in the development of governmental owned technology and industries. The next goal should be to have a REE refining and processing industry;
2.5. Have the projects coordinated by a REE dedicated institution in partnership with other national institutions, avoiding discontinuity;
2.6. Work sharing data with private and public companies, increasing the alignment from the scientific and industrial sector.

3. On technological partnerships with foreign countries:

3.1. Send and receive scientists from China to exchange knowledge on the matter of REEs;

3.2. Make partnerships with the mining companies that are already present in national territory, for example Itafos, CMOC, CNMC, Baiyan, Hongbridge Holdings, BYD, Mitsui & Co, ITOCHU Corporation, Sumitomo Corporation, USA Rare Earth and Meteoric.

4. On the involvement with Pela Ema mine:

4.1. Requiring Serra Verde to host and train a number of researchers from public universities, in a mutually beneficial relation with research institutions, in which the scientists would bring the knowledge developed in the laboratories to the mine and get practical experience from the mine.

5. On the creation of laws:

5.1. Classify REE as strategic minerals, enabling protective measures to be taken;

5.2. Make it mandatory that a part of the revenue generated with REE will be reinvested in the country for industrial and technological development;

5.3. Require an amount of REE to be processed in national territory and create tax benefit programs for REE processing companies;

5.4. Create tax benefits programs for magnet companies and other manufacturing companies that can assist in the integration of the downstream REE sector to the already-existing national industry;

5.5. Require a significant number of Brazilian employers on REE-related foreign companies.

6. On the exchange rate:

6.1. Manage the exchange rate to maintain the competitive industrial equilibrium, where the domestic manufacture can be competitive. It can be done through taxing commodity export revenues, central bank intervention and/or sterilization funds.

These actions will assist Brazil in the development of the REE supply chain by better utilizing its investments and its national resources in a way to benefit national development and general welfare. They will guide the creation of a REE national research institution that will coordinate the sector, provide plans and align the national initiatives related to REE in a strategic way, allowing data sharing and technological development. The revenue generated from REE will be better collected and used for public and developmental matters, maximizing the investments in research and development in a way to enable the development of government-owned industries in the field. Complementarily, the laws created will better use the already-existing mining projects to train and prepare scientists, besides encouraging industries from the midstream and upstream sector to operate in Brazil, fully integrating the supply chain.

The toolkit of measures presented in chapters 6, 7 and 8 represents a multidisciplinary approach on how to address the challenges identified during the conducted study, seeking to maximize the industrial development and welfare generation in Brazil. In this sense, it acknowledges the necessity of developing deeper studies on the feasibility of each suggestion, in order to know how to detail and strategically proceed in each sector to be able to accomplish the given suggestions, especially addressing budgetary and political matters.

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DECLARATION OF AI ASSISTANCE

I hereby declare that I have independently completed this master’s thesis titled “**How can Brazil learn from China on the development of the Rare Earth Elements supply chain?**” In the course of my work, I made use of artificial intelligence (AI) tools—specifically Qwen to

- support my literature review through summarization and clarification of academic content,
- assist with research-related inquiries and technical explanations,
- provide language and style suggestions, including improvements in grammar, sentence structure, and coherence,
- aid in formatting and the refinement of academic writing style.

and DeepL to

- translate documents

All decisions regarding content, structure, analysis, and interpretation were made by me.