TITLE:

DILEMMAS OF NATURAL RESOURCE-BASED DEVELOPMENT: THE CASE OF RARE EARTHS IN BRAZIL

Thomas J. Trebat

Abstract:

Secure access to rare earth elements (REEs) has gained great strategic importance because of their importance to low-carbon energy systems and advanced manufacturing. The global concern about secure supply chains creates an opportunity for Brazil to leverage its resource wealth in ways that promote domestic industrialization. This paper looks at the question of whether and under what circumstances REEs can serve not merely as a revenue-generating export opportunity for Brazil, but also as a basis for sustainable development. Drawing upon a neo-structuralist perspective, the paper argues that the developmental significance of REEs depends less on resource endowments alone than on the capacity of industrial policy to convert mineral wealth into productive diversification, technological learning, and stronger domestic linkages. It concludes with a call for Brazil to leverage its advantage in its rare earth wealth to pursue indispensable global alliances that both foster domestic development and contribute to secure global supply chains.

Keywords: rare earths, energy transition, innovation, green industrialization

JEL Classification Codes: O14, O25, Q38

Latin America's natural resources, renewable energy, human capital, and geopolitical position give it an important role in decarbonization. This third

paper in a series on the region's energy transition examines rare earths in Brazil, following studies of biofuels and critical mineral extraction and processing (Trebat 2025, 2026).

Structuralist and Neo-Structuralist Foundations

These papers draw on Latin American structuralism (Prebisch 1950; Cardoso and Faletto 1979) and contemporary neo-structuralism (ECLAC 2024). Structuralists rejected reliance on natural resource extraction, arguing that it reproduced colonial patterns of unequal exchange, marginalized local communities, limited technological learning and industrialization, and exposed export earnings to volatile commodity prices.

Neo-structuralist thinking has updated this original framework to validate natural resource-based development to the extent that it leads to sustainable industrialization, as well as to a more equal North-South power relationship within the global economy. (ECLAC 2024) However, this literature points to the critical challenge. How can resource-rich countries capture a greater share of the value added in global supply chains if the capabilities (technology, capital, skilled labor, etc.) remain concentrated in a small number of industrial powers?

The industrial powers do have a strong incentive to cooperate with resource-rich countries and promote domestic economic development in the South. Rare earth elements (REEs) are most coveted by the US and its Western allies to prevent supply chain disruptions and to achieve secure, non-Chinese access.

At the same time, international cooperation can give way to coercion and force. The resource-rich countries remain wary of the risks of “resource imperialism”, e.g., great power threats to invade Greenland, and the 2026 overthrow of the Venezuelan government to gain access to its mineral resources.

This paper applies the neo-structural analysis by looking at an actual case of rare earth development in the case of Brazil. The key question is the possibility of a truly mutually beneficial relationship between a nation rich in rare earths and the global industrial powers.

Rare Earths and Their Global Importance

Rare earths are 17 chemically similar metallic elements. They are widespread in the Earth's crust, but commercially exploitable concentrations are uncommon. Once niche manufacturing inputs, they now figure prominently in geopolitical competition.

The global marketplace for the most strategic of the rare earths is one of contrasting demand-side and supply-side dynamics.

Demand. The strategically important rare earths include those used in high-performance NdFeB permanent magnets. These enable precise electric motor control, miniaturization, and energy efficiency (IEA 2026b), with applications in wind turbines, EVs, generators, sensors, and defense systems.

The IEA reports that global demand for these most strategic rare earth elements (neodymium, praseodymium, dysprosium, terbium) doubled between 2015 and 2025. Furthermore, demand could increase by an additional 45% by 2030, driven primarily by EVs and wind energy. (IEA 2026b). Demand for strategic rare earths is expected to grow beyond 2030 driven by industrial advances in automation, robotics, and digital technologies.

Supply. The supply-side dynamics are what make secure access to REEs a source of great power rivalry. While rare earth deposits are abundant “upstream”, a technologically complex processing and downstream

capacity needed to refine, process, and manufacture permanent magnet products is almost totally concentrated in China.

The “mine to magnet” supply chain goes well beyond mining to include highly demanding capital- and energy-intensive activities which are closely intertwined via vertical integration. These phases account for most of the value-added in the finished product and include:

- Extraction and initial beneficiation
- Separation of the concentrated elements
- Refining to produce individual oxides
- Manufacture of metals and alloys
- Permanent magnet production
- Recycling
- Manufacturing for specific industrial applications

The concentration of all of these phases of magnet production in China is astounding. Again according to the IEA, this makes the REE supply chain “among the most geographically concentrated of all energy-transition minerals”. [1]

It begins with China providing 60% of global production of mined rare earths.

Thereafter, Chinese firms, many with links to the Chinese government, provide 90% of separation and refining globally and 90% of magnet production. China has the advantages stemming from its significant headstart based upon scientific and engineering foresight and a robust Chinese domestic demand for products made with REEs.

The resulting “mine anywhere, manufacture in China” model leaves global manufacturing vulnerable to Chinese supply decisions. Beijing imposed

[1] IEA 2026b, p. 8

export controls on seven heavy rare earths and magnets in April 2025, extending them to five more elements that October.

While these Chinese controls were suspended late in 2025, it was not before significant disruption had occurred in the worldwide supply chains of vitally important industries, including automotive, aviation, and defense. The IEA has estimated that a reimposition of Chinese export controls could result in downstream economic losses on the order of *$6.5 trillion per year* in the United States, Europe, Japan, and elsewhere. (IEA 2026b)

Dependence also extends to intermediate products: China's market power influences their location and cost of production, limiting the profitability of manufacturers elsewhere.

This stark dependence on Chinese supplies of rare earths has set off a political reaction in its rival economic powers. The US has an ambitious, multi-agency effort to build non-Chinese supply chains for rare earths.[2] The U.S. strategy seeks secure access to raw materials from non-Chinese sources (including Brazil, Australia, and Greenland) while also seeking technological support for R&D, processing, and downstream manufacturing through cooperation with Japan and the European Union.

The central question for the developing nation producers is whether this effort to diversify global supply chains also provides relief from their own dependence on the advanced economies to process and capture value added from their resources.

Can Participation in a Global Rare Earth Supply Chain Support Sustainable Development?

[2] U.S. policy is in the process of being codified into legislation, e.g., the "Dominance" Act passed by the House of Representatives in June 2026.

While REE-endowed producer nations would seem to have a great deal to gain in theory, the actual experience is that developing countries face practical obstacles to moving into the more technology- and capital-intensive stages of the supply chain.

Their firms remain largely absent from higher-value midstream and downstream operations, still concentrated in China (CEBRI 2026).

Sustaining the profitability of any domestic supply chain over a long period of time requires access to financing, offtake agreements with long-term price guarantees, and a robust domestic demand from sectors producing electric vehicles, wind energy, defense needs, and so on. Even Australia still lacks a developed value-added capability in rare earths, and in critical minerals more generally, despite years of effort. (IEA 2026a)

If moving beyond rare earth mining really is unlikely in developing countries, a dilemma arises. Should this natural resource wealth be a focus of policy at all? The World Bank has recently warned about the risks: "Without deliberate efforts to build processing, manufacturing, and technological capabilities, mineral wealth is likely to reproduce enclave-style specialization rather than sustained industrialization, quality employment, and technology absorption." (World Bank 2023)

How then to move forward? The case study (below) of rare earths in Brazil can shed light on how producer nations are dealing with this dilemma. In the case of Brazil, it appears to be choosing a pathway that involves developing selected midstream capabilities rather than to create the complete mine-to-magnet supply chain.

Case Study: Rare Earths and Industrial Development Dilemmas in Brazil

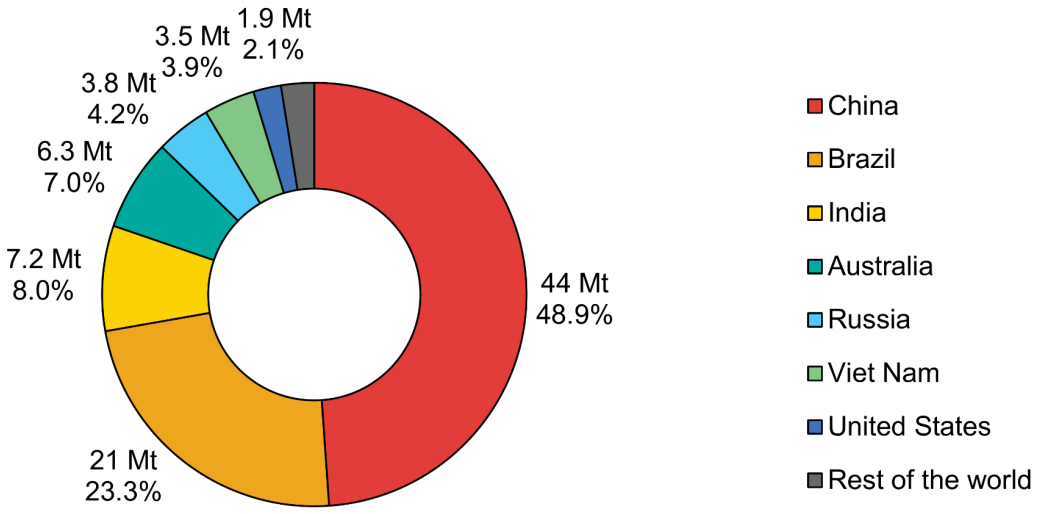
Two characteristics of the rare earth industry in Brazil illustrate why it is emerging as a sought-after partner in production alliances designed to build non-Chinese supply chains..

The first is Brazil's geology.

Brazil's geological diversity is consistent with many types of REE deposits scattered widely across the country. Brazil ranks second globally (after China) in terms of its REE deposits, accounting for almost one-quarter of global rare earth reserves. (See Figure 1).

Figure 1. Geographical Distribution of Rare Earth Reserves, 2026

Geographical distribution of rare earth reserves, 2026



IEA. CC BY 4.0.

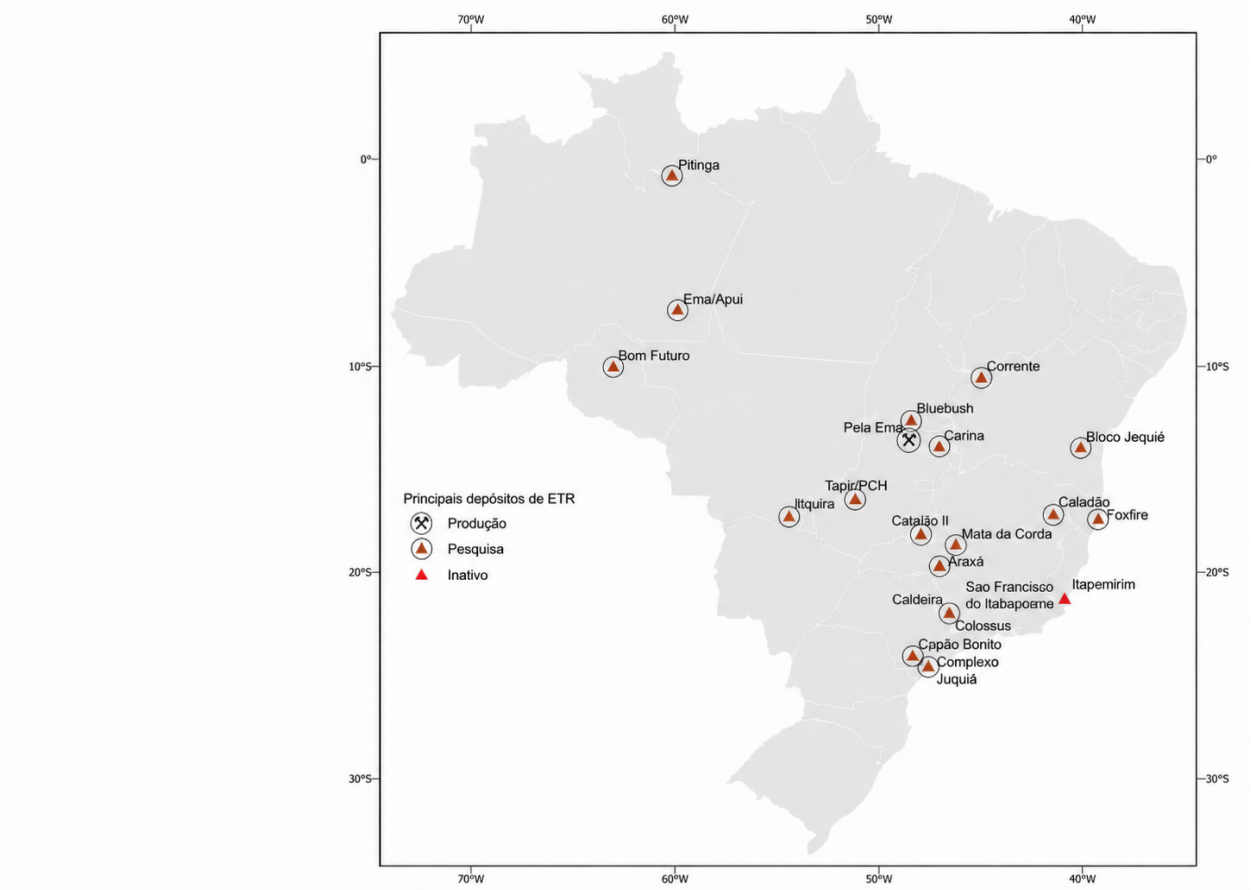
Notes: The figures are estimated in terms of rare earth oxides equivalent and include all rare earth elements. The shares are based on the volume of the reserves that could be economically extracted at the time of determination. Myanmar is excluded from the chart due to lack of reliable data on reserves, but the country is one of the largest mined producers of medium and heavy rare earths.

Sources: US Geological Survey (2026), Mineral Commodity Summaries; Government of India (2026), India's Rare Earth Strategy: Manufacturing, Corridors, and Global Integration.

While Brazil's rare earth reserves were long thought to be those of lesser strategic and commercial value, this view is changing. More recent surveys have found significant amounts of those REEs most useful for permanent magnet production, particularly the elements dysprosium (Dy), terbium (Tb) and neodymium (Nd). The most important source for these strategic rare earths is the Serra Verde project which is the first Brazilian mine in operation. Other HREE-rich deposits in Goias and Minas Gerais are nearing operational status.

Figure 2 below shows the geographic breadth of Brazil's resource base as well as the concentration of the more advanced HREE projects in the Center West of the country. (See Figure 2 below.)

Figure 2. Location of Principal Rare Earth Deposits in Brazil



Fonte: CEBRI/Vallya, 2026

Brazil's second advantage is a decades-long industrial policy ambition to move beyond extraction. Its “verticalization” strategy seeks domestic midstream and downstream activities, from concentrates and oxides to metals, alloys, and permanent magnets (CGEE 2025).

While Brazil has long planned for rare earth industrialization, little progress has been made toward connecting Brazil’s natural resource base and its scientific knowledge with a domestic industrial capacity capable of

producing finished magnets at scale. The factors that raise the risk of rare earth investments in Brazil include: inadequate financing, an ill-prepared domestic industrial base, a shortage of engineering know-how, the difficulty of finding long-dated "offtake" agreements with accompanying price guarantees, and weak domestic demand for finished products.

The policy conundrum is whether or not Brazil can leverage its geological wealth in exchange for some of these "missing" factors that would permit industrialization beyond mere extraction. Its leverage is clearly enhanced by the projected demand trends for REEs. This leverage is especially relevant given the strategic interests of the U.S. (and other Western economies) to gain secure access to rare earths at predictable pricing and costs not affected by supply chain volatility in China. .

The case study can illustrate the central policy dilemmas: Can and should Brazil seek to evolve as a globally competitive producer of the most highly valued rare earths? If so, can it develop in Brazil at least some of the midstream and downstream value-added activities?

Attention is now turned to a case study of REE development in Brazil focused on the Serra Verde/Pela Ema project in Goiás.

A Case Study of Brazil's Serra Verde Project

The Serra Verde (SV) project, located in Goiás in the Center-West of Brazil, is presently the only commercial rare earth mine operating in Brazil, although other promising deposits are advancing through pre-operational stages. (See Figure 2)

The ionic-clay deposits at the SV site (known as Pela Ema) are noteworthy for concentrations of light magnetic rare earths neodymium (Nd) and praseodymium (Pr) and also for heavy rare earths (Dy and Tb). These four elements are the most strategic for the final production of permanent magnets and their applications. Serra Verde/Pela Ema is currently the only

operating mine outside of China able to supply at scale all four of these rare earths.

Hence, the SV project has attracted significant geopolitical attention from the United States, beginning during the Biden administration (2021–2025) and intensifying under the second Trump administration (2025–).[3] Although the U.S. government does not directly own or control Serra Verde, it has become deeply involved in financing and supporting the project and its private sector owner. This U.S. involvement includes a US$565 million financing facility from the U.S. International Development Finance Corporation (DFC) and a long-term (15 years) offtake arrangement under which a special purpose vehicle is committed to purchase essentially all of Serra Verde's Phase I production on behalf of the U.S. Department of Defense.

Thus, Serra Verde illustrates the central dilemma for Brazilian rare earth industrial policy. On the one hand, it is an attractive project. SV is commercially viable as a mining operation with some initial physical and chemical beneficiation taking place on site. The foreign investment behind it generates export revenues, local employment, infrastructure and other benefits.

At the same time, and as presently configured, the SV project envisions no substantial links to the higher-value midstream and downstream activities in a prospective non-Chinese mine-to-magnet supply chain. These more technology-intensive activities are to take place outside of Brazil, partly at a magnet plant in Oklahoma, but also at manufacturing sites in Europe and Japan.

Summing up, SV is a major step forward for the Brazilian rare earth industry with benefits that include:

[3] In September 2026, Serra Verde was acquired by USA Rare Earth, Inc. , a publicly traded U.S. company, which now owns the Pela Ema mine and processing operation. The US government, through the U.S. Department of Commerce, holds a 10% equity interest in USA Rare Earth.

- Participation in a pioneering, non-Chinese supply chain
- Financing to permit commercial operation of a promising deposit
- Long-term purchase commitments to remove demand risk
- Price floors for its rare earths to reduce market risk
- Local economic development

Nevertheless, Serra Verde does little to achieve Brazil's goal of domestic midstream and downstream development. Its strategic minerals primarily support industrial policies in the U.S. and Europe, while Brazil remains dependent on processing abroad.

Pathways to Industrialization

After decades of study, the rare earth industry in Brazil is emerging. Geological knowledge of rare earth deposits in Brazil continues to expand and mining licenses are being extended to other promising rare earth deposits. It is possible that these new projects, together with a strong increase in global demand, can move Brazil closer to the vision of a technology-infused domestic rare earth supply chain in line with the neo-structuralist vision.

Recent developments on the public policy front inside Brazil do point in the direction of moving beyond mining and early-stage processing.

First, Brazilian policymakers have become increasingly focused on avoiding the limitations associated with enclave-style development of the country's rare earth industry. This concern is reflected in the recently enacted National Policy on Critical and Strategic Minerals (PNMCE), established by Law No. 15,506 of September 16, 2026. The new policy seeks to increase domestic value addition by encouraging beneficiation, mineral transformation, and industrialization within Brazil, while also promoting technology absorption, research, and innovation. Among other instruments, the law provides preferential treatment for projects that internalize important stages of the mineral value chain and authorizes

requirements or incentives linked to the degree of domestic processing (Brazil 2026).

Second, the Brazilian private sector involved in mining, public development banks, and civil society organizations are coming together to promote higher value-added rare earth activities. Specifically, CEBRI, a leading Brazilian international affairs thinktank, has produced a detailed feasibility study with this objective in mind. (CEBRI and Vallya 2026)

Their study advocates incremental integration rather than immediate construction of a complete supply chain. It prioritizes domestic separation and refining of strategic rare earths into higher-purity intermediate products.

Over time, these “next-step” capabilities could provide the foundation for Brazil industrial expansion into metals, alloys, magnetic materials, and eventually permanent magnets.

A particularly important contribution of the CEBRI/Vallya study is its financial modeling of a domestic rare-earth separation and refining industry. Preliminary results suggest that Brazil could become internationally competitive in separation and refining under plausible assumptions regarding prices, operating costs, investment requirements, domestic industrial policy, and international partnerships .

Brazilian competitiveness in the midstream would arise from a combination of natural advantages—abundant domestic feedstock, strategically valuable rare earth deposits, and relatively favorable energy conditions - with deliberate industrial policies that reduce financing costs, stabilize domestic demand, reduce taxes, and encourage interindustry linkages. (CEBRI and Vallya 2026)

The model estimates a 16.5% equity IRR for a Brazilian separation plant, rising to above 30% with international offtake agreements, price floors, and

cheaper financing. These attractive returns remain conditional on the model's assumptions (CEBRI and Vallya 2026).[4]

With this caveat in mind, the significance of this conclusion is that Brazil could promote domestic development and be internationally competitive in rare earth supply chains via selective investments in early midstream processing stages. Brazil would not need to replicate the entire Chinese strategy of integrated mine-to-magnet supply chain.

Conclusion: Toward A Global Rare Earth Alliance

With all of its advantages, the Brazil case also underlines that "going it alone" is not a realistic policy. Brazil needs development-fostering international alliances and partnerships that go beyond standard mineral extraction to encompass financing, technology transfer, domestic procurement, guaranteed prices, and offtake agreements.

The U.S.-based Council on Foreign Relations in a recent report has called for just such cooperation in rare earths to co-develop, finance, implement new technologies, share R&D, and coordinate procurement. (Crebo-Rediker and Kahn 2026)

Brazil's potential partners in building secure non-Chinese supply chains have the industrial experience and access to capability that Brazil lacks; Brazil has the resource wealth and secure access that they all need. These motivated international partners include the U.S., of course, but also the EU, Japan, Canada, and still others.

Mobilizing this cooperation would demand from Brazil a more integrated industrial and diplomatic policy for rare earths than it has in place at present. Yet Brazil has accumulated considerable expertise in just such international partnerships to support domestic development, e.g., in

[4] See especially pp. 137-159.

aviation and agribusiness. How to adapt these past practices to today's opportunities in rare earths should be high on the economic development agenda.

Disclosure Statement

No potential conflicts of interest were reported by the author.

References

References

Brazil. 2026. *Lei No. 15.506, de 16 de setembro de 2026: Institui a Política Nacional de Minerais Críticos e Estratégicos (PNMCE) e o Conselho Nacional para Industrialização de Minerais Críticos e Estratégicos (CIMCE).* Diário Oficial da União, September 16, 2026.

Cardoso, Fernando Henrique, and Enzo Faletto. 1979. Dependency and Development in Latin America. University of California Press.

Centro Brasileiro de Relações Internacionais (CEBRI) and Vallya. 2026. Apoio à preparação da Estratégia Nacional de Terras Raras: Relatório final. CEBRI. https://www.cebri.org/br/doc/422/relatorio-final-apoio-a-preparacao-da-estrategia-nacional-de-terras-raras.

Centro de Gestão e Estudos Estratégicos (CGEE). 2025. Terras Raras no Brasil: Estado da Arte, Cenários e um Mapa do Caminho Estratégico para 2026–2040.

Crebo-Rediker, Heidi E., and Mahnaz Khan. 2026. Leapfrogging China's Critical Minerals Dominance: How Innovation Can Secure U.S. Supply Chains. Council on Foreign Relations. https://www.cfr.org/reports/leapfrogging-chinas-critical-minerals-dominance.

Economic Commission for Latin America and the Caribbean (ECLAC). 2023. Lithium Extraction and Industrialization: Opportunities and Challenges for Latin America and the Caribbean. United Nations. https://hdl.handle.net/11362/48965.

Economic Commission for Latin America and the Caribbean (ECLAC). 2024. Natural NdFeBOutlook in Latin America and the Caribbean, 2023. United Nations. https://hdl.handle.net/11362/69139.

International Energy Agency (IEA). 2025. Global Critical Minerals Outlook 2025. IEA. https://www.iea.org/reports/global-critical-minerals-outlook-2025.

International Energy Agency (IEA). 2026a. Global Critical Minerals Outlook 2026. IEA. https://www.iea.org/reports/global-critical-minerals-outlook-2026.

International Energy Agency (IEA). 2026b. Rare Earth Elements: Pathways to Secure and Diversified Supply Chains. IEA. https://www.iea.org/reports/rare-earth-elements.

Prebisch, Raúl. 1950. The Economic Development of Latin America and Its Principal Problems. United Nations Economic Commission for Latin America.

Serra Verde. 2026. “Serra Verde garante financiamento de US$ 565 milhões com a Corporação Financeira dos Estados Unidos para o Desenvolvimento Internacional (DFC).” February 5. https://svpm.com.br/br/financiamentodfc/.

Serra Verde Group. 2026. Sustainability Review 2025. https://svpm.com.br/wp-content/uploads/2026/03/SVG_Sustainability-Review-2025.pdf.

Silva, G. F. da, A. D. R. da Silva, and S. M. de S. Gaia, eds. 2024. Panorama do potencial do Brasil para minerais críticos e estratégicos: 2024. Serviço Geológico do Brasil. https://rigeo.sgb.gov.br/bitstreams/d3ed65f7-f6e1-4dfd-bd9d-786e3bade693/download.

Trebat, Thomas J. 2025. “The Role of Biofuels and the Global Biofuels Alliance in the Global Energy Transition.” Journal of Economic Issues 59 (2): 516–525. https://doi.org/10.1080/00213624.2025.2493552.

Trebat, Thomas J. 2026. “From Extraction to Development: Critical Minerals and Inclusive Industrialization in Latin America.” Journal of Economic Issues 60 (2): 577–584. https://doi.org/10.1080/00213624.2026.2657239.

U.S. Geological Survey. 2026. Mineral Commodity Summaries 2026. Version 1.3. U.S. Geological Survey. https://doi.org/10.3133/mcs2026.

World Bank. 2023. From Resource Rich to Resource Smart: Opportunities for Latin America and the Caribbean in the Energy Transition. World Bank. https://openknowledge.worldbank.org/entities/publication/27c02170-0e65-4785-8731-da749f999a30.