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Critical Minerals and the Nuclear-Regulatory Interface in Brazil: A Framing Analysis of *Observatório da Mineração*

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1. Introduction

Critical minerals have become central to debates on energy transition, industrial policy, and national security. Supply vulnerability is shaped not only by geological availability but also by the concentration of capabilities in separation, refining, and advanced manufacturing [1], [2], [3], [4]. Rare earth elements (REEs) are essential to permanent magnets, electronics, defense systems, and low-carbon technologies, and mineral criticality is increasingly understood as a value-chain-wide issue involving technological capability, environmental performance, and international dependence [1], [5], [6].

Brazil combines substantial geological potential with renewed investment in critical-mineral projects. However, investment and supply diversification coexist with concerns about foreign control, limited domestic processing, territorial rights, and environmental licensing. Critical-minerals discourse may therefore support industrial-policy initiatives while also legitimizing accelerated extraction or the displacement of socio-environmental burdens [2], [7], [8]. The rare-earth–nuclear interface adds a distinct governance dimension. REE deposits and processing streams may contain naturally occurring uranium and thorium, raising questions about radiological characterization, waste, and regulatory responsibilities [9]. The public significance of these issues also depends on how they are framed by specialized journalism, which selects problems, attributes causes, and makes particular responses more salient [10].

The study asks: how does *Observatório da Mineração* frame the Brazilian debate on critical minerals, particularly rare earths, and what perspectives on value chains, sovereignty, socio-environmental impacts, and nuclear regulation emerge from its coverage? Its objective is to identify and critically interpret the dominant frames through which this outlet communicates opportunities, risks, conflicts, and institutional responsibilities. The analytical scope is explicitly delimited to this specialized outlet, and results are not extrapolated to the broader Brazilian public or journalistic debate.

2. Methodology

An exploratory and descriptive design combined qualitative content analysis with framing analysis. The publication was the primary unit of analysis. The corpus was identified through the outlet's critical-minerals section archive and a complementary site-wide search. The search used the following Portuguese-language terms and combinations applied to the outlet's archive and internal search engine: "minerais críticos", "minerais estratégicos", "minerais de transição energética", "terras raras", "cadeia de valor", "política industrial", "dependência tecnológica", "competição geopolítica", "direitos territoriais", "impactos socioambientais", "licenciamento ambiental", "regulação nuclear" and "urânio" and "tório" combined with "Brasil" when the query returned an unmanageable number of results. All editorial formats published between the earliest eligible item (March 25, 2021) and July 27, 2026, were screened.

Items were included when critical or strategic minerals constituted the central topic or a substantive analytical component connected to Brazil. Items were excluded when the topic was incidental, the geographic focus lacked an analytical connection to Brazil, or the item duplicated a previously identified publication. Full-text screening reduced 65 candidates to 61 publications: two items were excluded for insufficient connection to the Brazilian case and two translated versions were excluded as duplicates. The analytical structure comprised the general corpus (n = 61), a rare-earth subcorpus (n = 16), and a nuclear-regulatory core comprising a limited subcorpus of two publications (n = 2), explicitly emphasizing the exploratory scope of this finding.

A deductive-inductive codebook covered value-chain stages, industrial policy, technological sovereignty, geopolitics, socio-environmental impacts, territorial rights, and nuclear-regulatory interfaces. Multiple thematic codes were permitted per publication. Each publication was then assigned a single dominant frame from five categories: unconditioned economic opportunity, threatened sovereignty, territorial and socio-environmental conflict, regulatory fragility, or conditioned opportunity. Following Entman [10], framing analysis examined problem definition, causal attribution, moral evaluation, and implied response. Dominance was operationalized by identifying the primary problem defined in the headline and lead paragraph, the principal causal attribution, the prevailing moral evaluation, and the most salient implied response in the body of the text. When more than one frame was substantively present, the frame whose four dimensions received the greatest combined emphasis was selected as dominant. A purposive six-item pilot was used to calibrate these decision rules, refine category boundaries, and resolve ambiguities before full-corpus application.

For strategic interpretation, the authors developed a heuristic informed by capability- and dependency-oriented approaches [1], [2], [3], [4]. Leverage represents assets that strengthen Brazil's position; defense, capacities that reduce risks; overcoming, capabilities required to address bottlenecks; and containment, conditions that reinforce dependence or liabilities. This heuristic is explicitly defined as a qualitative, second-level interpretive matrix to structure findings, and is not presented as an empirically validated model, explanatory framework, or predictive quantitative variable. Three reviewers jointly examined the selection criteria, coding protocol, and pilot sample. Following the pilot, coding responsibilities were distributed across the three reviewers, who coded independently and then resolved all discrepancies through consensus discussion supported by documentary evidence recorded for each coding decision. The audit compared the assigned codes and frames with the supporting evidence. Because independent parallel coding of the full corpus was not conducted, no formal inter-rater reliability coefficient (e.g., Krippendorff’s alpha or Cohen’s kappa) is reported; this is acknowledged as a methodological limitation in Section 4. Absolute frequencies and proportions are strictly interpreted as indicators of thematic presence and media visibility within the analyzed corpus. They do not constitute direct measures of productive capacity, industrial scale, economic magnitude, regulatory enforcement, or actual physical prevalence in the Brazilian mineral sector.

3. Results and Discussion

Coverage was predominantly critical. Territorial and socio-environmental conflict led (n = 21; 34.4%), followed by conditioned opportunity (n = 16; 26.2%), threatened sovereignty (n = 14; 23.0%), regulatory fragility (n = 9; 14.8%), and unconditioned economic opportunity (n = 1; 1.6%). Thus, 60 of 61 publications framed mineral development through conflicts, conditions, or regulatory limits (Table I).

Table I: Dominant frames in the analyzed corpus.

Dominant frame	n	%
Territorial and socio-environmental conflict	21	34.4
Conditioned opportunity	16	26.2
Threatened sovereignty	14	23.0
Regulatory fragility	9	14.8
Economic opportunity	1	1.6

Source: Own elaboration

Table II demonstrates that extraction dominated thematic visibility (n = 46; 75.4%), whereas downstream stages remained marginal (beneficiation: 2; separation: 3; industrial applications: 4; refining: 0). This quantitative imbalance explicitly reflects media agenda-setting and thematic emphasis within the selected outlet, rather than Brazil's objective productive architecture, industrial scale, or technological capabilities.

Nevertheless, it shows public debate focusing on extraction rather than value addition. Geological endowment alone does not ensure supply security or industrial autonomy.

International cases reinforce this distinction. China's dominance reflects long-term value-chain integration and state coordination [4]; Japan built resilience through diversification, stockpiling, and recycling [3]; Australia combined extraction with downstream processing support. These experiences show that resource ownership and technological sovereignty are distinct, and friend-shoring may reproduce dependencies without local learning and safeguards [2].

Table II: Frequency of thematic categories in the analyzed corpus.

Thematic category	n (%)	Thematic category	n (%)
Extraction	46 (75.4)	Territories and rights	30 (49.2)
Environmental impacts	26 (42.6)	Institutional coordination	26 (42.6)
Geopolitical competition	21 (34.4)	Financing	15 (24.6)
Foreign control	13 (21.3)	Prospecting and reserves	12 (19.7)
Productive autonomy	10 (16.4)	Technological dependence	6 (9.8)
Productive verticalization	5 (8.2)	Industrial applications	4 (6.6)
Separation and purification	3 (4.9)	Uranium and thorium	3 (4.9)
Beneficiation	2 (3.3)	Radiological risk	2 (3.3)
Regulatory competence	2 (3.3)	Waste and liabilities	1 (1.6)
Refining and metallurgy	0 (0.0)		

Source: Own elaboration

Note: Multiple thematic categories could be assigned to the same publication; therefore, frequencies and percentages are not mutually exclusive and do not sum to 61 or 100%.

In the corpus, sovereignty extended beyond deposit ownership. Technological dependence (n = 6), foreign control (n = 13), productive autonomy (n = 10), and geopolitical competition (n = 21) questioned whether policy would foster domestic processing or reinforce extractive export roles. Specialized journalism thus connects value-chain position with ownership, capability, and benefit distribution.

Read through this qualitative interpretive matrix (and explicitly not as an empirically validated predictive model), geological potential and policy attention function as leverage but require defensive safeguards for territories, environment, and radiological control. Overcoming centers on downstream learning, while foreign control, financing constraints, and disputed regulation act as containment.

Territories and rights (n = 30; 49.2%), environmental impacts (n = 26; 42.6%), and institutional coordination (n = 26; 42.6%) linked mineral expansion to Indigenous territories, consultation, water, and biodiversity. This challenges an automatic equivalence between critical-mineral extraction and energy transition, showing that criticality discourse can mobilize climate urgency for extractive interests unless safeguards are specified [7], [8].

The nuclear-regulatory interface is explicitly classified as a quantitatively limited, strictly exploratory finding. Two publications formed the nuclear-regulatory core (n = 2), while uranium/thorium associations appeared in three, radiological risk in two, waste in one, and regulatory competence in two. REE processing routes may generate uranium- or thorium-bearing streams requiring characterization and management [6], [9]. Uncertainty becomes salient when agencies, companies, and communities dispute competence and risk. Given n = 2, these observations represent preliminary governance signals rather than confirmed or generalizable sectoral patterns, requiring broader empirical confirmation.

4. Conclusions

Observatório da Mineração framed critical minerals primarily as a contested governance issue rather than an unqualified economic opportunity. Its coverage emphasized extraction, territorial and environmental effects, conditionalities, sovereignty, and regulatory capacity, while downstream technological stages received limited visibility. Within this corpus, sovereignty meant the capacity to govern investment, master processing, retain value, protect rights, and exercise regulatory authority — not merely to possess

mineral resources. The nuclear-regulatory interface constitutes a strictly exploratory result based on a minimal core (n = 2), highlighting emerging disputes over radiological risk, waste, and jurisdictional boundaries in rare-earth projects; it is presented explicitly as a preliminary indication requiring further empirical investigation rather than a confirmed pattern.

The study contributes the integrated identification of value-chain, sovereignty, territorial, environmental, and nuclear-regulatory frames in Brazilian specialized journalism. Three formal methodological limitations must be explicitly emphasized. First, all findings and conclusions are strictly confined to *Observatório da Mineração*, a specialized outlet with an investigative and socio-environmental orientation; results cannot be generalized to the broader Brazilian media landscape, public debate, or mining sector as a whole. Second, coding was conducted through structured consensus discussion rather than independent parallel coding of the full corpus, which explicitly constitutes a methodological limitation due to the absence of a formal inter-rater reliability statistic. Third, corpus frequencies explicitly measure media visibility within this specific outlet, and must not be interpreted as direct measures of productive capacity, economic magnitude, regulatory enforcement, or industrial reality in the Brazilian mineral sector; moreover, the partial 2026 period is not directly comparable with complete annual cycles.

To advance this line of inquiry without overextending conclusions beyond the evidence produced, future research should pursue three complementary directions. First, comparative studies should expand the empirical base beyond a single specialized outlet to include mainstream journalistic sources, government policy documents, corporate sustainability and annual reports, peer-reviewed scientific literature, records of public consultations, and semi-structured interviews with sectoral experts. Second, future analyses should disaggregate different critical minerals — particularly rare earths, lithium, graphite, niobium, and uranium — because their value chains, geopolitical conditions, technological requirements, environmental implications, and regulatory interfaces differ substantially. Third, longitudinal designs should examine whether and how media frames change in response to industrial policies, large-scale investments, territorial conflicts, regulatory reforms, or geopolitical events, thereby linking framing dynamics to specific policy and market triggers.

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