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CRITICAL MINERALS: THE BLIND SPOT OF THE ENERGY TRANSITION?

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Abstract
The energy transition is not dematerialization—it shifts dependency from fossil fuels to critical minerals, reproducing social, environmental, and epistemic injustices in the Global South. Ethical sourcing alone is insufficient; demand must be addressed.

The recent collapse, in November 2025, of a makeshift bridge at an artisanal copper-cobalt site in Lualaba Province, Democratic Republic of the Congo (DRC), which killed dozens of miners, strongly exposes the human cost of the critical mineral supply chains. Far from being an isolated tragedy, the incident reflects a broader system in which informality, economic desperation, and also militarization converge, externalizing damages onto the most vulnerable actors/spaces in the global value chain.

Such realities challenge the energy transition narrative as one of dematerialization. While public debates frame decarbonization through the cornerstone of energy flow—from fossil fuels to renewables—, this decarbonization narrative hides a less visible transformation, that is one of a massive reorganization of material stocks. Batteries, grids, turbines and digital infrastructure work rely on critical minerals like copper, lithium, cobalt, nickel, rare earths, and others, whose extraction, processing and trade are deeply embedded in the global political economy.

The significant demand increase acknowledged by international institutions signals, in economic terms, not a marginal adjustment but a structural shift in the extractive sector. In this logic are revenues and strategic attention also shifting from fossil-fuel basins to mineral frontiers. It therefore means that supply chains are reconfigured, and with them, new forms of dependency and price volatility arise. In short, the low-carbon economy is highly concentrated on material bases, far from being weightless. However, the dominant economic framing surrounding this shift remains focused on supply: how to secure access, diversify imports, accelerate permitting, certify "ethical" sourcing… It shapes minerals as technical inputs put into an otherwise unproblematic transition pathway. What it often overlooks are the social, environmental and epistemic dynamics accompanying the expansion of mineral extraction—especially in the regions characterized by fragile governance or asymmetrical bargaining power. While the transition's material dimension is marked by its geological features, its footprint is thus also distributive and political.

Using the paradigmatic example of high-volume extraction in the DRC, this article is aimed at unveiling the consequences of massively using critical minerals—not because their importance is unknown, but rather because the debate often abstracts them from the power structures, inequalities and demand assumptions that shape how they are extracted and used. It therefore explores how the energy transition seeking to correct the environmental failures of fossil capitalism risks reproducing the very inequalities and externalities it seeks to overcome.
Reconnecting the macroeconomics of decarbonization (I) with sociological realities of mineral frontiers (II), this article will also focus on the limits of the currently prevailing structural response (III).

I. Decarbonization is material: why the energy transition hinges on critical minerals

Decarbonization is a process that is fundamentally material and implies a wholesale reorganization of the material foundations upon which modern economies operate.

A. From energy flows to material stocks

Although most climate debates focus on flows of greenhouse gases, the low-carbon transition is equally about a massive reconfiguration of stocks of matter. In order to build clear energy systems, the initial material bill is high, as large upfront investments of metals and minerals to build turbines, solar panels, batteries and grids are necessary to reach an economy operating with far lower ongoing fuel extraction.

In quantitative terms, net-zero pathways imply a skyrocketing demand for energy transition minerals. The International Energy Agency (IEA) and the United Nations Environment Programme (UNEP) project that achieving global climate goals will require a four- to six-fold increase in demand for energy transition minerals by 2040-2050. This demand is especially dynamic for some materials: in IEA scenarios, lithium demand grows by more than forty times, cobalt's and nickel's by around twenty times, graphite by a similar magnitude, and rare earths demand for permanent magnets increases sharply as wind and EV deployment accelerates (IEA, 2021).

This expected increase in demand is the reflection of the higher material intensity of low-carbon technologies per unit of installed capacity or service delivered. For instance, a typical combustion engine vehicle requires only a few dozen kilograms of metal—largely steel and some copper, versus over 200 kilograms of transition minerals in the motor, battery and power electronics in an electric vehicle—notably, copper, lithium, nickel, manganese, cobalt and graphite. Likewise, roughly nine times more minerals per megawatt are used by onshore wind turbines, compared to gas-fired plants; offshore wind is even more demanding. Finally, solar PV models increase the demand for silicon, silver and other metals, while large quantities of copper and aluminium are called by the expansion and reinforcement of electricity grids (IEA, 2021).

About two dozen "energy transition minerals" are central. Among them are particularly accounted copper, lithium, cobalt, nickel, manganese, graphite, rare earths, platinum-group metals, aluminium (UNEP, 2024). As critical inputs into renewable generation, storage and transmission, this bundle of minerals is projected to bring a profound shift in the structure of the global extractive economy. As a consequence, revenue from transition minerals is therefore set to overtake coal revenues, and that well before 2040, suggesting that capital and state attention will increasingly transition from fossil-fuel basins to mineral frontiers (IEA, 2021).

Nevertheless, energy transition critical materials differ from fossil fuels in economically important ways. First, mining is a long process: long lead times—often 15-16 years from discovery to production—bring about supply struggles to follow demand curves, therefore creating structural risks and price volatility (IEA, 2021). Likewise, many critical minerals are by-products (e.g. with copper/nickel), which means that their supply is constrained by investments decided in other markets rather than their own price signals in isolation. Third, ore grades for certain key metals—notably copper—have fallen over time (UNEP, 2024). They therefore require more rock movement, more energy and water consumption, and larger tailings volumes management for every tonne of metal recovered.

These characteristics make mineral supply as capital-intensive as fragile. Tight, inelastic supply already drives boom-bust price cycles (e.g. lithium's eight-fold spike and -80% collapse on the 2020-2024 period), which affects technology costs (e.g., EV costs), competitiveness and adoption curves, and are projected to recur as decarbonisation accelerates (IEA, 2025).

In short, far from dematerializing the energy system, transition from fossil fuels re-materializes it around a different bundle of resources with new geological, economic and also geopolitical characteristics.

B. Concentration, dependency, and strategic value chains

This new material basis of the energy systems is organized through highly concentrated and hierarchical value chains.

Data shows that the steps of extraction and processing of energy transition critical minerals are highly concentrated in a small number of countries and firms, bringing about new dependencies and bargaining positions.

The extraction side is dominated by the DRC, Chile, Argentina, Australia, Indonesia, China, and a handful of other states:

- About half of global cobalt comes from the DRC;
- About four-fifths of lithium comes from Australia, Chile, and Argentina;
- Large shares of manganese originate from South Africa, China and Australia;
- Nearly 90% of rare earths are extracted in China (IEA, 2021).

In parallel, some countries are progressing towards joining these major extractors: Indonesia and the Philippines in this respect jointly account for a rapidly growing share of nickel output.

On the processing side, concentration is even stronger. Indeed, China refines a majority of the world's rare earths, cobalt, and lithium. It also produces an overwhelming share of some intermediate chemicals. In this regard can be cited high-purity manganese sulphate or purified phosphoric acid (IEA, 2025). Furthermore, the concentrated structure of the refining market for many strategic minerals has been strengthened in recent years.

This highly concentrated structure has important economic consequences, creating what is referred to as the new "strategic checkpoints" by the IEA. They correspond to nodes in the supply chain, without easy substitutes, controlled by a small number of countries and companies. As a consequence, clean-energy deployment is more susceptible to be disrupted by trade disputes, export restrictions, infrastructure failures or domestic crises. Vulnerability to physical shocks such as extreme weather is also amplified: climate-induced floods' or droughts' effects on copper or lithium processing located in a limited region can quickly translate into global price spikes.

As a response, this vulnerability is often approached by importing regions like the European Union (EU) in terms of "security of supply" and diversification (IEA, 2025). Conversely, in exporting regions—particularly in the Global South—this same situation is framed in terms of sovereignty and value capture—through local processing, export taxes or restrictions, and industrial policies (UN SG Panel on Critical Transition Minerals, 2024).

This tension lies at the core of the "decarbonisation divide" (Berthet et al., 2024): wealthy regions externalize the most damaging stages of the supply chain—mining, beneficiation, smelting—while importing "clean" technologies whose environmental and social footprints are effectively offshored. In this respect, studies show that while the EU has the ability to cover a majority of its own extraction footprint for some materials, the mineral processing footprint for many critical minerals is largely located in South America, Africa and the Asia-Pacific region, an externalisation projected to intensify. Policies merely focusing on the diversification of suppliers or on the substitution of one chemistry by another therefore risk leaving this basic pattern intact.

This geography is also entrenched by the role of corporate power. Leading firms in the automotive, technology, and mining sectors shape sourcing, investment, and standards. Thereby, they often lock producing regions into enclave models in which mines are physically integrated in local territories while being economically and politically oriented outward. Meanwhile, "junior" mining companies handle early exploration and community contact. However, they lack the capital and incentives necessary for robust engagement (S&P Global Ratings, 2025).

Thus, moving from fossil fuels to minerals brings about a strong reorganization of power and value at multiple scales: between exporting and importing countries, between upstream and downstream segments of supply chains, between local communities and transnational corporations (Park et al., 2024). Critical-minerals value chains are not neutral conduits; they are a structured system of dependency and power shaping which countries/communities gain or lose from the energy transition.

II. Mineral frontiers and the reproduction of injustice

Behind the macroeconomic logic of the mineral supply chain lies a more uncomfortable reality of externalities reproducing social injustice, as local communities bear the cost of a transition that does not benefit them.

A. Social and distributive injustice

On the social side, the risks of the transition are concentrated in places that capture relatively very little of its gains. Large shares of the workers producing critical minerals operate in countries where modern slavery, weak labour inspection, and limited social protection are more likely to happen, making workers more vulnerable.

Estimates have therefore shown that about a quarter of the relevant mining workforce for the European energy system is located in states associated with elevated modern-slavery risk scores, data that particularly affects cobalt, but that is also visible in parts of the copper, manganese, and nickel chains (Berthet et al., 2024). For instance, cobalt extraction is embedded within broader political and geopolitical dynamics: patterns of illegal mining, land dispossession, corruption, and broken development promises are described by reports on Chinese mining operations in Central and West Africa. Chinese firms have been accused of operating hundreds of illegal mines, evading taxes and failing to deliver promised infrastructure (schools, hospitals) in the DRC (Babatunde et al., 2025). These kinds of dynamics are reinforcing perceptions of neo-extractive relationships, in which African states and communities are to bear the social and environmental costs of extraction although value is captured elsewhere. At the same time, the recent reporting on U.S.-backed diplomatic initiatives linking peace agreements to access to Congolese minerals underlines how cobalt is increasingly considered as a strategic security asset. This raises concerns that justice and accountability be subordinated to geopolitical and market interests.

This "livelihood paradox"—a notion describing the phenomenon of communities located in resource-rich areas experiencing a decline in their quality of life—is particularly well explained by the case of artisanal and small-scale mining (ASM) where the geographical of the DRC is central, as it supplies over 70 percent of the world's cobalt (Reuters, 2025), placing Congolese communities at the core of the energy transition. Tens of thousands of "creuseurs" rely on ASM cobalt for income exceeding those of local opportunities, encouraging them to accept the high cost of extreme hazard. Indeed, the precarity of their conditions make them highly exposed to danger: work with rudimentary tools, absence of formal contracts, or of safety equipment, risks of tunnel collapses, exposure to toxic dust, or to violence. The University of Nottingham's Right Lab's report is particularly revealing: 1,400 surveys conducted on artisanal and small-scale miners in southeastern DRC allowed the study to find that more than one-third of respondents were in situations of forced labor, including widespread child labor, debt bondage and trafficking. Studies also reveal low incomes, miners earning on average just over three dollars per day, which is paired with no written contracts and no access to trade unions (Kara, 2025). These facts thus directly go against corporate claims that cobalt supply chains are responsibly audited and ethically managed, which reveals the discrepancy between downstream sustainability narratives and upstream labor realities. Both ASM and industrial mining economic benefits are thinly spread among local workers and communities, in comparison with the value captured downstream in battery manufacturing, automotive production and technology firms (Murray, 2022).

On a larger scale, the same structure applies to many mineral-rich states that remain stuck at the bottom of global value chains. This phenomenon is due to revenue flows from royalties and taxes often leaking through corruption, transfer mispricing or opaque fiscal regimes. However, even in places where these flows reach public budgets, their translation into improvements in infrastructure, education or health, is not automatic. This “enclave” pattern is precisely what is criticized by the UNEP papers and the UN Secretary-General’s panel: while countries detaining critical minerals act as primary commodity suppliers, processing, high-value manufacturing and intellectual property rents are accrued elsewhere. This structure, when combined with the volatility of mineral prices and the long, capital-intensive nature of projects, can result in a reinforcement of boom-bust cycles and macroeconomic fragility—instead of the stable development it is aimed for.

This distributive injustice between companies and communities can also be noticed within producing societies. In this case, women tend to be under-represented in formal mining employment, over-represented in low-paid, informal or unpaid activities. They are disproportionately exposed to secondary impacts as well, such as increased gender-based violence and the loss of subsistence agriculture as land is converted to mining. Meanwhile, children, if not directly subject to hazardous work, bear health costs from pollution.

When taken together, these patterns reveal a social "cust curve" of the transition that is very steepest for groups with the least bargaining power in local labour markets and political systems.

B. Environmental degradation and sacrifice zones

Environmental impacts at mineral frontiers are not only a matter of local catastrophes, they are also about systemic blind spots in climate policy. The production of lithium and copper is particularly telling in this regard, as the major portion originates from regions under high water stress (IEA, 2025). Indeed, extraction and processing processes—especially brine evaporation for lithium and ore processing for copper—can rapidly consume, or even contaminate, water in a statistically significant way in comparison to local availability. This is exemplified by the legal and political challenges faced by local communities in the Andean "lithium triangle" (Argentina, Bolivia, Chile), regarding the depletion of groundwater and the lack of meaningful consultation about water use. Their main argument was that their livelihoods as well as their cultural practices are being sacrificed for distant energy transitions (S&P Global Ratings, 2025).

Furthermore, ore grades decrease means that more rock must be mined and processed in order to obtain each unit of metal. As a result, energy intensity and greenhouse-gas footprint of mining itself find themselves increased, while the volume of tailings and waste rock must be stored safely for decades. Even though relatively rare in terms of frequency, tailings failures can bring about huge environmental and financial costs when they occur. And even where catastrophic accidents are avoided, chronic contamination of solids and rivers with heavy metals and acid mine drainage can still happen, with dramatic health impacts extending far beyond the active life of a mine (Global Witness, 2024).

These regions are labelled as “sacrifice zones” amongst the sociological literature, standing for places where ecosystems and communities are effectively written off as acceptable collateral damage in order to achieve aggregate emissions abatement. Paradoxically, climate policy, supposed and conceived to protect vulnerable populations from climate consequences, can result in an increase of vulnerability for those living above mineral deposits when degrading local environmental conditions and exposing them to new hazards (UNEP, 2024).

Economically, un-internalized externalities translate themselves later into remediation costs, litigation, loss of productive land; and in some cases proposals for funds arise to address “legacy” sites where operators have departed or gone bankrupt (UN SG’s Panel on Critical Energy Transition Minerals, 2024).

This picture is also fed back by climate risk. Indeed, as mines and processing plants are increasingly exposed to extreme heat, floods and droughts, operations are disrupted, while infrastructure is damaged. In addition, the concentration affecting supply chains increases the potential of fast reverberation of such events through global markets. It thus makes environmental degradation and climate vulnerability not mere ethical issues but also direct threats shadowing upon the reliability and cost of supply that the very decarbonization strategies depend on.

C. Epistemic and procedural injustice

Beyond concerns regarding material harms and benefits distribution, knowledge and voice are unequally distributed along mineral supply chains. In that matter, decision-marking about exploration licenses, mine approvals, and regional development strategies are grounded in technical and economic expertise largely controlled by companies, consultants, and government agencies. Conversely, indigenous and local knowledge (about ecosystems, water cycles, cultural landscapes, long-term environmental change) is often regarded as anecdotal or procedural rather than as a valid form of proof.

This process is the result of two mechanisms. The first, referred to as "testimonial injustice", corresponds to the fact that local residents, indigenous leaders or artisanal miners may have their credibility discounted because of their social profile, occupation, or level of formal education—even in the case of correct and accurate information being provided about environmental impacts or social dynamics. The second one, the "hermeneutical injustice" is about existing legal and technical categories unable to mirror or properly express local experiences (Zhou and Brown, 2024). For example, many legal complaints led by indigenous communities have been disregarded, as spiritual relationships to land or holistic conceptions of territory and water are not a valid motive to present in court, making it difficult for these particular experiences to exert any influence on official assessments and permits. Both these mechanisms highlight that important dimensions of risk and value stay invisible with the models and matrices that lead investment decisions.

In procedural terms, consultation and impact-assessment processes are often led by project proponents or state agencies with limited resources, instead of being designed by independent bodies. Likewise, social and environmental impact assessments may be made available only in technical language, at short notice, or basically in formats that do not allow communities to develop informed counter-expertise, making participation more of a formal requirement than a meaningful opportunity to influence the outcome. The "junior miner" phenomenon further complicates this, as early-stage exploration companies often engage with communities first. However, since they possess little capacity or incentive to establish long-term trust, it often leads them to sell projects to majors, leaving behind distrust as well as unresolved conflicts inherited from the early phase.

Finally, despite the growing interest in “responsible” or “ethical” minerals amongst consumers and investors, truly detailed and verifiable information on the origin and conditions of production of specific batches of cobalt, lithium or nickel remains unequal and difficult—especially amid the various competing certification and reporting schemes. This lack of transparency is often described as “unjust ignorance”, since people benefiting from the decarbonisation of energy lack the data necessary to assess the social and environmental footprint it relies on, to express preferences or even exert pressure for change (Zhou and Brown, 2024). Likewise, economic effects are critical, as this opacity disincentives firms to invest in higher standards, precisely because their additional efforts would barely be perceived as credible signals on markets.

In this logic, community resistance and social unrest across cases have to be considered as real indicators of the contradictions of the energy transition—not as obstacles. A Global Witness report documents hundreds of incidents of protest and violence linked to transitional mineral mining around the world. The overwhelming majority is however occurring in low- and middle-income countries. Protestations from DRC communities highlight the limits of a market-driven transition relying on expanding extraction but without addressing structural inequalities, governance failures, or historical patterns of exploitation.

When taken together, these social, environmental and epistemic dynamics show that mineral frontiers, far from merely adding a new sector to the low-carbon economy, risk reproducing the very issues that they are partly aimed at resolving: climate change inequalities.

However, this outcome is not a mandatory component of the decarbonization process itself, but more of the way it is currently framed.

III. The blind spot of the transition: supply-side greenism and demand-side denial

The acknowledgement of injustice has not, however, prompted a fundamental rethinking of the transition model itself; instead, the prevailing response refines its edges through ethical sourcing pledges and certification schemes, leaving its core assumptions—and crucially, the scale of demand driving them—largely untouched.

A. The pledge of ethical sourcing

Facing the concerns raised by mining, the dominant response that characterized the last decade has been the promise of "responsible" or "ethical" mining, translated into better standards, more audits, more certifications. Reports from the IEA, the UN panel on critical energy transition minerals, and UNEP all underline the proliferation of sustainability reports from corporations, voluntary ESG standards, and even supply-chain "clean-up" initiatives in cobalt, lithium, nickel and rare earths. While these efforts are far from being meaningless—since they improved disclosure and eliminated the most important abuses—, they did not fundamentally alter the distribution of risks and bargaining power.

This is first explained by the fact that many schemes are partial and fragmented (Zhou and Brown, 2024). The use of different criteria, scopes and verification methods makes the comparison of performance complicated, as it does for ensuring that higher standards are not merely moving harms from a region/actor to another. This is mainly due to the incomplete traceability within critical minerals supply chains. Indeed, cobalt originating from artisanal sites can still be mixed with industrial production before processing, while refined material becomes essentially fungible in global markets. Ultimately, even in the case of pledges from firms to not work with “high-risk” sources anymore, this can result in pushing informal producers further into illegality instead of improving their working conditions.

The second explanation is more of a structural one, as it responds to an incentive issue. Voluntary standards often rely on companies’ willingness to support extra costs in exchange for better practices—in the hope of reputational gains or access to premium markets. Nevertheless, if buyers do not pay a clear price premium for verified “better” minerals—and as long as they do not have access to detailed and comparable information to guide their consumption—, the firms that actually invest in genuine improvements bear the cost of being undercut by competitors who only meet minimal requirements. In these conditions, only binding due-diligence legislation and standards-based market access—not just voluntary transparency— will foster an ethical behavior-rewarded market.

Third, setting the focus on ethical sourcing at the margin risks shadowing the scale of the challenge. Even in the case of all mines meeting the best environmental and human-rights standards, a six-fold increase in demand still represents a dramatic expansion of land under concession, of water consumption in arid basins, and of tailings volumes worldwide. Supply-side greenism perceives harm as a result of “bad actors” or “bad practices” involvement that can be eliminated, instead of conceiving them as a structural consequence of very large quantities of material being necessitated in a short period without a suitable framework being developed as quickly.

Finally, the political dimension remains predominant. The emphasis on ethical sourcing allows consumers and policymakers from high-income regions to erase guiltiness because they are purchasing and supporting certified green technologies, without further questioning the underlying patterns of consumption and mobility (Zhou and Brown, 2024).

Reports and news therefore point out corporate accountability as a major area of contestation. Indeed, multiple high-profile legal cases highlight growing efforts to challenge market-driven models of “clean” energy using human rights frameworks. Emblematic of the growing use of human rights frameworks to challenge market-driven models of “clean energy”, lawsuits have been filed in the United States against Apple or Tesla, alleging that these companies have knowingly benefited from cobalt obtained from forced labor, child labor and environmental destruction in the DRC but have marketed their products as ethical and sustainable. In these cases, voluntary audits, supplier codes of conduct, and corporate social responsibility prove insufficient to prevent abuse. Moreover, they might work as tools of greenwashing allowing companies to remain legitimate while continuing to benefit from exploitative extraction (Zhou and Brown, 2024; UN SG Panel, 2024).

In this logic, the illusion is not that better sourcing is possible—because it is—but rather that better sourcing alone can reconcile rapid growth in mineral-intensive consumption with meaningful climate justice.

B. Demand as the missing variable

While supply-side measures dominate current debates, demand-side ones are way underdeveloped. Most projections treat demand for energy services—distance travelled, area heated, devices used—as exogenous, leading the analytical work to look for the cheapest to satisfy demand with low-carbon technologies. Mineral requirements are therefore derived as a consequence of these assumptions, rather than as quantities that could be influenced by policy.

This treatment of demand limits the analytical space. For instance, in transport, long-term scenarios often assume that the existing trend towards car dependence in many regions continues, with internal combustion engines replaced by EVs over time, which translates into high projected demand for battery metals (e.g., lithium, cobalt, nickel).

Conversely, studies incorporating changes in urban form, public transport provision and modal split provide an example of similar mobility outcomes delivered with far fewer vehicles per capital, hence lower aggregate mineral demand, even under the same climate constraints.
A similar point is explored in the literature surrounding circularity and material efficiency. UNEP and the UN panel thus highlight that design choices—product lifetimes, repeatability, reuse, high-quality recycling—deeply change the relation between final energy services and primary material inputs. Scenarios combining efficiency and circularity in high-income economies show that it can significantly moderate growth in primary demand for several critical minerals in comparison with the business-as-usual scenario, without reducing access to energy services. From an economic point of vue, it reframes demand for minerals as partly endogenous to policy and institutional choices, instead of a fixed constraint.

Critiques of the current model therefore emerge, and propositions of alternatives arise. In this respect, the need for mandatory human rights and environmental due diligence, respect for free, prior, and informed consent (FPIC) and shared prosperity models—allowing communities to effectively benefit materially from extraction—are for instance discussed by the Resource Centre's work on just energy transition principles (Business and Human Rights Centre, n.d.). Reports on Africa's position within the global transition mineral value chains are clearly demonstrating that exporting raw cobalt and importing finished technologies deepens dependency while foreclosing development opportunities—while only 2 percent of the continent’s exports of energy transition minerals are sent to other African countries (Publish What You Pay, 2024).

Therefore, considering the “demand as the missing variable” aims at pointing out the gap in many current strategies for critical minerals. Indeed, policies tend to underline expanding and diversifying supply, promoting technological substitution between minerals, and improving ESG at mine sites. However, far fewer interrogate the level and composition of the underlying demand for mineral-intensive goods and infrastructures, nor explore how alternative development pathways might change that demand. Acknowledging this gap is not a simple normative conclusion around the desirable amount of consumption. It is also aimed at reminding that the quantity of minerals required for decarbonization does not solely depend on geology or technology, but is also the result of choices surrounding systems design and service provision that rely on analysis and policy.

To conclude, while decarbonization is often conceived as a technological and financial challenge, this sole frame has shown its shortcomings, as it is also one of a material and political transformation. Critical minerals, as the backbone of the transition to low-carbon economies, create new dependencies, redistribute value, and reshape relations between territories, firms, and states. In this logic, far from a neglect of the transition benefits, it appeals to confront more explicitly its material conditions. Indeed, the legitimacy of this transition might be weakened if it recreates patterns of social exclusion, epistemic marginalization, or environmental degradation. Therefore, even if ethical sourcing and supply diversification remain necessary, they only constitute a part of the answer as long as the scale and structure of demand remain unquestioned.

Ultimately then, the credibility and long-term efficiency of the energy transition will fundamentally depend, not only on carbon pricing or technological innovation, but on whether its material underpinnings are governed in a way that fosters the internalization of their full social and environmental costs, rather than displacing them across borders and generations.

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