THE CHOKEPOINT ECONOMY

Critical Minerals, Export Controls and the New Architecture of Industrial Security

THESIS

The strategic contest over critical minerals has moved beyond access to ore. The decisive risks now sit at processing chokepoints, trade controls, qualification standards, finance and industrial capacity. Governments and companies that measure security only by mine supply will misdiagnose the problem.

Ragunauth Ramsaroop

Independent global thought leadership on resources, industrial policy, economic security and responsible development.

Executive Summary

The critical-minerals debate has entered a new phase. Supply concentration is still high, but concentration alone no longer describes the risk. Export controls, quotas, licensing regimes, industrial-policy conditions and qualification bottlenecks now determine whether physical material becomes usable industrial supply.

The International Energy Agency reports that refining concentration across key energy minerals reached a new high in 2025. The average share held by the leading refining country rose to 70%, and to 72% when rare earths are excluded. For gallium, graphite, manganese and rare earths, the leading refiner, China, accounts for more than 90% of global supply. The IEA also reports that investment in critical-mineral development fell 9% in 2025 after several years of growth.

The OECD's 2026 inventory shows a parallel change in trade policy. Export restrictions on critical raw materials are five times higher than in 2009. Across 2022-2024, about 16% of global trade in monitored critical raw materials faced at least one export restriction. Exposure reached about 67% for cobalt, 66% for manganese, 47% for natural graphite and 45% for rare earth elements.

The policy response is becoming more interventionist. The European Union is using strategic-project designation and a Raw Materials Mechanism to connect buyers, suppliers, finance and storage. The United States has directed greater domestic and allied sourcing for defence supply chains and has expanded authorities linked to critical-material security. Producer countries are also using quotas, licensing and other restrictions to retain more value at home.

This paper argues that the next stage of mineral security should be governed through a five-part framework: Source, Process, Route, Qualify and Recycle. A secure mine without secure processing is incomplete. A processed material without reliable trade routes is exposed. A new source that cannot pass technical qualification remains commercially stranded. Recycling without scalable collection and refining is only latent supply.

The central policy proposition is a shift from mineral self-sufficiency to system resilience. Full national self-sufficiency is economically unrealistic for most countries. Resilience comes from diversified production, processing redundancy, allied sourcing, transparent trade rules, faster qualification, strategic inventories, circular supply and investable long-term demand.

The SPRQR Framework

Layer	Core question	Failure mode
Source	Where is the mineral mined, and how concentrated is production?	Mine disruption, permitting delay, political risk
Process	Where is ore converted into usable material?	Refining chokepoint, technology dependence
Route	Under what trade, logistics and legal conditions does material move?	Export control, quota, sanctions, shipping disruption
Qualify	Is the material approved for the intended industrial use?	Testing delay, standards mismatch, supplier lock-in
Recycle	How much secondary supply is recoverable at scale?	Collection gaps, poor economics, insufficient processing

1. The Risk Has Moved Downstream

For much of the last decade, critical-mineral strategy focused on geological access. That was necessary, but it is no longer sufficient. The most consequential vulnerabilities increasingly sit between the mine and the factory.

The IEA's 2026 outlook records higher refining concentration in 2025 than in 2023. Indonesia dominates nickel refining, while China is the leading refiner for most other major energy minerals. The top refining country averaged 70% of supply in 2025. Excluding rare earths, the figure was 72%. In gallium, graphite, manganese and rare earths, China accounts for more than 90% of refined supply.

This matters because a mine does not automatically create industrial independence. Ore must be separated, purified, converted into chemicals, metals or components, certified against technical specifications, transported under stable trade rules and integrated into manufacturing systems. Each step creates a possible chokepoint.

The United States made the same distinction explicit in its January 2026 action on processed critical minerals and derivative products. The policy finding stated that domestic mining does not secure supply when downstream processing remains dependent on foreign capacity. That is a useful analytical principle even outside the US policy context.

Verified fact

IEA data show refining concentration reached new highs in 2025, while investment in critical-mineral development fell 9% in the same year.

Author analysis

The strategic unit of analysis should shift from the mine to the complete industrial chain. Mineral security is a systems problem.

2. Export Controls Have Become an Industrial Variable

Trade policy now changes mineral availability almost as quickly as geology. The OECD reports that export restrictions on critical raw materials increased fivefold between 2009 and 2024. Across 2022-2024, about 16% of global trade in the monitored materials faced at least one restriction, up from 12.4% in 2009-2011.

The exposure is concentrated in materials with high strategic value. OECD data place cobalt at about 67% of global exports affected, manganese at 66%, natural graphite at 47%, rare earth elements at 45% and tin at 41% over 2022-2024.

The policy instruments are also becoming stricter. Export taxes and licensing remain common, but prohibitions and quotas have become more prominent. The OECD reports that highly restrictive measures accounted for more than one-third of new measures in 2024. Stated policy motives increasingly include revenue, domestic supply protection, processing and local value addition.

The IEA's 2026 outlook shows how quickly controls move from policy to industrial consequence. It reports that Chinese controls introduced in April 2025 on seven heavy rare earth elements affected downstream industries and led some automakers to reduce utilisation or temporarily stop production. The IEA estimates that full implementation of expanded controls could place about US$6.5 trillion of annual downstream production outside China at risk. This is an IEA scenario estimate, not an observed loss.

3. The SPRQR Framework

Source
Measure mining concentration, ownership, permitting risk, water and power dependence, social licence, fiscal stability and project maturity. A resource estimate is not equivalent to dependable supply.

Process
Map refining, separation, precursor, metal and component capacity. Identify proprietary technology, reagent, equipment and skilled-labour dependencies. Processing is often more concentrated than extraction.

Route
Map export licences, quotas, tariffs, sanctions exposure, customs routes, shipping nodes and bilateral agreements. The route layer converts policy decisions into physical availability.

Qualify
Measure the time and technical burden required for a new source to enter aerospace, defence, automotive, semiconductor, battery or grid applications. A diversified supplier base on paper is not resilient if buyers have not qualified the alternatives.

Recycle
Measure collection rates, scrap access, recovery yields, economics, refining capacity and product standards. Secondary material becomes strategic supply only after a functioning reverse chain exists.

4. Three Policy Models Are Emerging

Model A: Strategic autonomy

Model B: Domestic and allied security

Model C: Resource-based industrialisation

Policy tension
Consumer economies want open, diversified supply. Producer economies want greater domestic value capture. Durable mineral partnerships need to reconcile both objectives through investment, infrastructure, skills, technology transfer, transparent fiscal terms and credible long-term offtake.

5. Why Diversification Is Harder Than Announcing a New Mine

New mining capacity faces long development timelines, but the less visible constraint is qualification. Industrial buyers cannot substitute critical inputs instantly. Chemical purity, particle size, magnetic performance, thermal behaviour, reliability, traceability and manufacturing compatibility all matter.

The IEA's 2026 outlook highlights limited substitution options for several high-risk materials and notes that many are co-products or by-products. Gallium, for example, is mainly recovered alongside aluminium and zinc-related production. Tellurium is linked to copper and lead processing. Germanium is linked to zinc and coal. Supply therefore does not always respond cleanly to higher prices.

This creates a policy trap. Governments often announce diversification targets in tonnes, while manufacturers experience security in qualified, specification-compliant material. The difference between the two is industrial readiness.

6. Finance Is Now Part of Security Policy

Critical-mineral projects compete against incumbent supply chains with established infrastructure, customer relationships and cost advantages. Price volatility weakens investment signals. The IEA reports that critical-mineral investment fell 9% in 2025, ending several years of growth.

Public policy is responding through strategic-project status, concessional finance, guarantees, demand aggregation, stockpiles and procurement preferences. These tools address a real market failure: private investors hesitate to fund high-cost alternative capacity when dominant suppliers can expand rapidly or when prices fall before projects reach production.

The discipline required is to avoid converting security policy into permanent protection for uncompetitive assets. Support should be tied to measurable resilience outcomes, cost decline, technical qualification, environmental and social standards, and time-bound review.

7. Corporate Strategy: From Procurement to Board Risk

Critical-mineral exposure should sit on board risk registers for companies in automotive, energy, electronics, aerospace, defence, data infrastructure and advanced manufacturing. Procurement teams alone do not control the relevant risks.

Boards should require visibility beyond tier-one suppliers. They should know which minerals and processed materials create single-country, single-refiner, single-route or single-technology dependencies. They should also know the time required to qualify an alternative.

Long-term offtake, supplier finance, inventory buffers, recycling partnerships and joint qualification programmes are strategic tools. They carry costs. Those costs should be compared with the value at risk from production interruption, not only with spot-market prices.

8. Policy Recommendations

1. Measure chokepoints, not only reserves. Publish supply-chain maps across mining, refining, trade routes, qualification and recycling. Geological abundance should not be used as a proxy for security.

2. Build qualification capacity into industrial policy. Fund testing laboratories, standards alignment, certification and accelerated buyer qualification alongside new mining and refining projects.

3. Use public finance to crowd in resilience. Tie guarantees, loans and strategic-project support to clear milestones, private capital participation, cost discipline and environmental and social performance.

4. Pair producer-country value addition with infrastructure. Domestic-processing goals need reliable power, water, transport, skills, finance and customer access. Export restrictions without these conditions risk reducing investment rather than building industry.

5. Create reciprocal mineral partnerships. Consumer economies should offer bankable offtake, finance, technology and skills. Producer economies should offer transparent rules, stable access and credible project execution.

6. Treat recycling as industrial capacity. Move beyond recycling targets. Build collection systems, processing capacity, product standards and offtake for secondary materials.

7. Stress-test corporate supply chains. Boards should test scenarios involving export controls, sanctions, shipping disruption, dominant-refiner outages and delayed qualification of alternative suppliers.

8. Protect openness where possible. Strategic security and open trade are not mutually exclusive. Transparency, predictable licensing and narrower measures reduce the risk that resilience policy fragments markets further.

9. Implementation Logic: A 12-Month Resilience Review

Period	Action	Output
0-90 days	Map SPRQR dependencies for priority minerals.	Verified chokepoint register
90-180 days	Quantify disruption exposure and qualification lead times.	Materiality and scenario model
180-270 days	Design sourcing, inventory, finance, recycling and qualification responses.	Funded resilience portfolio
270-365 days	Contract alternatives, test suppliers, set board metrics and publish governance principles.	Operational resilience programme

10. Factual Boundaries

Verified facts

Historical data, policy dates, concentration measures, trade-restriction shares and institutional actions come from the cited IEA, OECD, European Commission and US government sources.

Projections

The IEA's estimate of downstream economic activity exposed under full implementation of certain export controls is a scenario estimate. It is not reported as realised economic loss.

Attributed claims

Assessments of supply risk, market concentration and policy effects are attributed to the institutions that published them.

Author propositions

The SPRQR Framework, board-risk approach, reciprocal mineral partnership model and 12-month resilience review are the author's analytical proposals.

Scope limit

This paper addresses global industrial and economic-security architecture. It does not assess any individual company's confidential supply chain, any specific investment security, or the legal validity of a particular trade measure.

11. Scrutiny Audit

IEA concentration figures were checked against the Global Critical Minerals Outlook 2026 executive summary, market overview and outlook sections.

OECD trade-restriction figures were checked against the 2026 Inventory of Export Restrictions on Critical Raw Materials, published 28 April 2026.

The OECD dataset covers measures through the end of 2024. Later policy examples are sourced separately and are not presented as part of the OECD 2024 inventory.

The IEA's US$6.5 trillion figure is labelled as an estimate of annual downstream production outside China exposed under full implementation of expanded rare-earth controls. It is not described as a forecast loss.

The EU Raw Materials Mechanism launch date, purpose and 17-material scope were checked against European Commission material published in April 2026.

The US July 2026 defence-supply-chain action is described by its operative sourcing, mapping and qualification provisions. Political promotional language from the source is excluded.

No claim is made that export restrictions are uniformly harmful. The paper distinguishes producer-country development objectives from execution and market-fragmentation risks.

No claim is made that national self-sufficiency is necessary or economically optimal. The paper argues for system resilience through diversification and redundancy.

All monetary figures use the currency stated in the source. No currency conversion is required for the core analysis.

12. References

1. International Energy Agency. Global Critical Minerals Outlook 2026. Executive Summary, Market Overview and Outlook. 2026. https://www.iea.org/reports/global-critical-minerals-outlook-2026

2. OECD. OECD Inventory of Export Restrictions on Critical Raw Materials 2026: Monitoring the Use of Export Restrictions Amidst Growing Market and Policy Tensions. 28 April 2026. DOI: 10.1787/d5ca8f62-en.

3. European Commission. Commission launches platform to aggregate demand of raw materials and strengthen diversification. 13 April 2026.

4. European Commission. Raw Materials Mechanism, first Diversification Round. 2026.

5. European Commission. Strategic Projects under the Critical Raw Materials Act. Current implementation page, accessed September 2026.

6. The White House. Adjusting Imports of Processed Critical Minerals and Their Derivative Products into the United States. January 2026.

7. The White House. Executive Order 14415, Securing America's Defense Supply Chains and Ensuring Domestic Acquisition of Critical Materials. 20 July 2026.

8. The White House. Presidential Determination on recoverable critical minerals and materials under the Defense Production Act. 30 July 2026.

Closing Proposition

The next mineral shock will not be explained by geology alone. Industrial security now depends on whether economies control, diversify or credibly access the chain between ore and finished product. The countries and companies that map that chain first will make better decisions before disruption forces them to.