WESTERN HEMISPHERE READINESS SERIES

HRS RESILIENCE FOUNDATION

SECTOR READINESS ASSESSMENT 03

Critical Minerals & Strategic Materials

Strategic Dependency, Supply-Chain Resilience and Long-Term Readiness in the Western Hemisphere

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CONTENTS

About this series. This is the eighth publication in the HRS Resilience Foundation's Western Hemisphere Readiness Series. It applies HRS Readiness Cycle and HRS Strategic Exposure Test — introduced in Strategic Report 01 and extended through the Sector Readiness Assessments on Telecommunications & Digital Infrastructure and Data Centers, Cloud & AI Infrastructure, and through Strategic Report 02's investment framework — to the critical-minerals and strategic-materials sector across the Western Hemisphere.

EXECUTIVE SUMMARY

Critical Minerals & Strategic Materials

Critical minerals and strategic materials are becoming a foundational component of economic security, industrial capacity, technological development, infrastructure resilience and national defense.

The strategic question is no longer simply whether a country possesses mineral resources. The more consequential question is whether it can secure access to essential minerals and materials across the complete value chain — from geological knowledge and exploration through extraction, processing, refining, transportation, manufacturing, recycling and recovery.

The U.S. Geological Survey's final 2025 List of Critical Minerals contains 60 minerals, reflecting the breadth of materials considered important to the U.S. economy and vulnerable to supply disruption.[2]

The International Energy Agency's 2026 Global Critical Minerals Outlook identifies Latin America and the Caribbean as a major supplier of critical minerals — including copper, lithium, silver, graphite, molybdenum, tin, niobium and rhenium — and identifies a significant opportunity to expand regional processing and capture more economic value within the region.[3,4]

This creates an important strategic opportunity for the Western Hemisphere. The region does not necessarily need to become completely self-sufficient in every mineral. Instead, hemispheric readiness can be strengthened by developing diversified, transparent, replaceable and recoverable supply chains connecting:

Resources → Production → Processing → Refining → Manufacturing → Logistics → Recycling → Strategic Reserves

CENTRAL HRS CONCLUSION

Mineral security is not determined by geological abundance alone. It is determined by the resilience of the complete supply system.

For the Western Hemisphere, this means that Brazil, Canada, the United States, Chile, Argentina, Peru, Mexico and other resource-producing countries can play complementary roles within a more diversified continental system — while maintaining national ownership, regulatory authority and sovereign decision-making.

SECTION 01

Purpose and Scope

This assessment examines critical minerals and strategic materials as a Western Hemisphere readiness issue. The analysis focuses on strategic dependency, concentration of supply, geological resource security, mining capacity, processing and refining, transportation and logistics, manufacturing, strategic reserves, recycling and recovery, substitutability, infrastructure, institutional coordination, and long-term continuity.

The assessment does not attempt to establish a single universal definition of "critical mineral." Definitions differ among governments because national economic structures, industrial requirements, defense needs and supply vulnerabilities differ.

Brazil's National Mining Agency (ANM) explicitly notes that the concept of critical and strategic minerals varies by country and identifies supply concentration, external dependency, geopolitical instability and technological limitations as potential sources of supply risk.[7,8]

The HRS approach therefore focuses less on labels and more on readiness characteristics.

SECTION 02

Why Critical Minerals Matter

Critical minerals are inputs into systems that increasingly determine national economic and technological capacity. They may support electrical grids, telecommunications, semiconductors, batteries, transportation, aerospace, defense systems, advanced manufacturing, data centers, artificial intelligence infrastructure, energy generation and storage, medical technologies, industrial equipment, agricultural inputs, construction and scientific instrumentation.

The strategic importance of a mineral therefore depends not only on its geological scarcity. A material becomes strategically significant when:

Demand is important + Substitution is difficult + Supply is concentrated + Recovery is slow

Geological abundance does not automatically equal strategic security. A country may possess substantial deposits while remaining dependent on foreign processing, foreign refining, specialized machinery, imported chemical inputs, foreign technology, overseas transportation, external financing, foreign manufacturing or concentrated downstream markets.

The critical vulnerability may therefore exist after extraction.

SECTION 03

The HRS Sector Readiness Framework

The HRS Readiness Cycle, introduced in Strategic Report 01, applies directly to the critical-minerals sector: Detect → Assess → Decide → Coordinate → Deploy → Sustain → Learn.

FUNCTION	APPLIED TO CRITICAL MINERALS
Detect	Identify strategic minerals; supply concentration; critical infrastructure; processing dependencies; transportation bottlenecks; foreign and technological dependencies; strategic stock levels.
Assess	Determine concentration, substitutability, recovery time, domestic and regional capacity, infrastructure constraints and market exposure.
Decide	Prioritize minerals, projects, infrastructure, processing capacity, strategic reserves and diversification initiatives.
Coordinate	Connect governments, geological services, mining companies, processors, manufacturers, financial institutions, logistics operators, research institutions and allied partners.
Deploy	Translate readiness assessments into infrastructure, capacity, contracts, stockpiles, processing, transportation, workforce and recovery mechanisms.
Sustain	Maintain production, processing, skilled workforce, infrastructure, reserves and information systems.
Learn	Use market disruptions, supply interruptions, exercises, project experience and technological change to continuously update readiness.

SECTION 04

The Critical Minerals Value Chain

Mineral security should be evaluated as an integrated system, not a single extraction event.

STAGE	DESCRIPTION
1. Geological knowledge	Geological mapping; resource identification; exploration data; mineral reserves; resource modeling.
2. Exploration	Prospecting; drilling; feasibility studies; project development.
3. Extraction	Mining; concentration; beneficiation; transportation from mine sites.
4. Processing	Chemical processing; concentration; separation; intermediate materials.
5. Refining	Production of higher-purity materials; metallurgical processing; specialized refining.
6. Manufacturing	Components; alloys; cathode/anode materials; magnets; electronic materials; industrial products.
7. Logistics	Roads; rail; ports; waterways; pipelines where applicable; storage; customs systems.
8. Recycling	Recovery; reprocessing; secondary supply; material substitution.

A disruption at any point can reduce the strategic value of the entire chain.

SECTION 05

Geological Resources and Strategic Production

The Western Hemisphere has an unusually diverse mineral base. Latin America and the Caribbean hold important shares of global resources of lithium, copper, silver and graphite, and important reserves of molybdenum and tin, alongside established production of niobium and rhenium, while Canada and the United States possess significant geological resources, mining capabilities, technological capacity, capital markets and industrial infrastructure.[3]

The IEA estimates that Latin America and the Caribbean accounted for around 40% of global copper mine output and around one-quarter of global lithium supply in 2025.[4] This creates strategic potential — but mineral resources should not be treated as a strategic asset until the country can reliably transform geological potential into usable capacity.

HRS Resource-to-Readiness Test

Resource → Production → Processing → Refining → Manufacturing → Logistics → Market

A missing link can create strategic dependency.

SECTION 06

Processing and Refining Capacity

One of the most important findings for the Western Hemisphere is the difference between mining capacity and processing capacity. The IEA reports that Latin America and the Caribbean refined only around one-fifth of the key energy minerals they mined in 2025, excluding lithium.[3]

Who controls the transformation of the resource into usable material? Extraction without processing can leave countries dependent on external industrial capacity. Processing capacity therefore deserves the same strategic attention traditionally given to mining.

HRS Processing Readiness Questions

- Where is the mineral extracted?
- Where is it concentrated?
- Where is it chemically processed?
- Where is it refined?
- Where are intermediate products manufactured?
- How many alternative facilities exist?
- How quickly could another facility replace a disrupted one?
- Are transportation routes independent?
- Are critical processing technologies replaceable?

SECTION 07

Strategic Dependency and Concentration

Critical mineral vulnerability is strongly influenced by concentration, which may occur in one country, one mine, one processing facility, one refining technology, one logistics corridor, one manufacturer, one financial source or one downstream market.

The HRS framework does not treat foreign participation as inherently problematic.

DEPENDENCY TYPE	MANAGEABILITY CONDITION
Foreign dependency	May be manageable if it is transparent + governed + replaceable + recoverable.
Domestic dependency	Can also be strategically significant if it is concentrated + difficult to replace + infrastructure-dependent + slow to recover.

This distinction is central to HRS analysis.

SECTION 08

Logistics and Infrastructure

Mining projects are infrastructure systems. Strategic mineral production depends upon roads, railways, ports, electricity, water, telecommunications, storage, specialized equipment and skilled personnel.

A mine without reliable logistics may have limited strategic value. A refinery without reliable electricity may not provide resilient capacity. A processing facility dependent on one transportation corridor may possess only nominal redundancy.

The assessment therefore treats mining infrastructure as part of the strategic supply chain rather than as a separate issue.

SECTION 09

Manufacturing and Downstream Capacity

The strategic value of minerals increases substantially when countries can convert raw materials into higher-value products:

Ore → Concentrate → Refined Material → Intermediate Product → Component → Finished Product

Each step can generate industrial capability, employment, technological knowledge, supply-chain control, export capacity and strategic flexibility.

The IEA estimates that greater local processing could substantially increase the economic value captured within Latin America and the Caribbean.[3]

This suggests the strategic objective should not simply be to increase extraction; it should be to build resilient value chains.

SECTION 10

Strategic Reserves and Stockpiles

Not every mineral requires a permanent national stockpile. However, certain materials may justify strategic reserves when disruption consequences are severe, substitution is limited, replacement capacity takes years, production is geographically concentrated, or defense or infrastructure applications are involved.

Stockpile Priority

$$\textit{Criticality} \times \textit{Disruption Probability} \times \textit{Recovery Time} \times \textit{Substitutability}$$

A reserve without a replenishment strategy can become obsolete. A modern strategic reserve should therefore include quantity, quality, storage, rotation, replenishment, ownership, release authority and emergency logistics.

SECTION 11

Substitutability and Recovery

The existence of another mineral does not necessarily mean it is an operational substitute. Substitution must consider technical performance, cost, availability, manufacturing compatibility, qualification requirements and time to deployment.

TERM	DEFINITION
Nominal substitute	A theoretically available alternative.
Effective substitute	An alternative that can be deployed within an operationally acceptable period.

This distinction is essential for long-term readiness.

SECTION 12

Western Hemisphere Mineral Architecture

The Western Hemisphere does not need every country to possess every capability. A more resilient architecture can emerge through complementarity.

United States

Potential strategic strengths include advanced manufacturing, defense industrial capacity, technology, research, capital markets, downstream demand, processing and recycling capabilities.

Canada

Canada possesses substantial mineral resources and has established a national strategy covering exploration, production, processing, manufacturing and recycling.[5] Its current 2026–27 plans emphasize critical-mineral supply chains, strategic stockpiling, infrastructure and partnerships with allies.[6]

Brazil

Brazil possesses a highly diverse geological base and is developing policies intended to increase knowledge, production, processing and international integration of critical minerals. Brazil's 2026 National Mining Plan 2050 identifies critical minerals as an important component of long-term national mineral policy.[9,10]

Chile, Argentina, Peru, Mexico, Bolivia and Other Producers

Chile is strategically important for copper, lithium, mining expertise, processing potential and Pacific logistics. Argentina is strategically important for lithium, copper potential, expanding mineral production and regional integration. Peru is strategically important for copper, zinc, silver, mining infrastructure and Pacific logistics. Mexico is strategically important because of geographic proximity to the United States, industrial manufacturing, automotive supply chains and North American logistics integration. Bolivia is strategically important particularly because of lithium resources and a potential future role in regional battery-material supply chains. Ecuador, Colombia, Guyana, the Dominican Republic and Jamaica may contribute to specific mineral, industrial or logistical chains depending upon resource development and infrastructure.

> *These roles are analytical, not policy assignments. Each sovereign government retains authority over its own resources, regulations, investment decisions and industrial policy.*

SECTION 13

Country-Level Strategic Roles

COUNTRY / REGION	POTENTIAL STRATEGIC ROLE
United States	Technology, manufacturing, defense, capital, processing, recycling
Canada	Mining, processing, advanced materials, stockpiles, allied supply
Brazil	Diversified mineral resources, niobium, graphite, lithium, nickel, copper and downstream potential
Chile	Copper, lithium and Pacific logistics
Argentina	Lithium, copper and mineral expansion
Peru	Copper, zinc, silver and Pacific logistics
Mexico	Mining + North American manufacturing integration
Bolivia	Lithium and future battery-material capacity
Other Latin America	Specialized minerals, logistics, industrial inputs and diversification

SECTION 14

Institutional Coordination

Mineral security crosses institutional boundaries. A national readiness architecture may require coordination among geological services, mining authorities, energy agencies, transportation authorities, industry ministries, defense institutions, foreign affairs institutions, customs, environmental authorities, financial institutions, private industry and research organizations.

Brazil's ANM has specifically identified the need for coordination among mining, industry, science and technology, environment and foreign affairs institutions when developing national critical-mineral policy.[7]

HRS PRINCIPLE

Strategic readiness is an institutional capability, not merely a mining capability.

SECTION 15

Cascading Failure

Critical mineral disruptions can propagate across sectors:

> *Mineral disruption → Processing shortage → Manufacturing constraint → Component shortage → Infrastructure delay → Technology production constraint → Economic and security consequences*

The same principle applies in reverse. A failure in electricity, water, transportation, telecommunications or financing can disrupt mineral production.

Critical minerals should therefore be analyzed as part of an interconnected infrastructure system.

SECTION 16

The HRS Strategic Dependency Test

First introduced in the HRS Country Readiness Assessment series, the Strategic Dependency Test applies directly to critical minerals through five questions:

1. **Concentration** — How much essential capacity depends on one country, mine, processor, refinery, technology, transportation route or supplier?
2. **Substitutability** — Can the dependency be replaced?
3. **Control** — Does the relevant institution possess sufficient visibility, authority and access?
4. **Recovery** — How quickly can capacity be restored?
5. **Cascading impact** — What other sectors depend upon the affected capability?

SECTION 17

Nominal Redundancy vs. Effective Redundancy

A recurring problem in strategic supply-chain planning is confusing the existence of alternatives with actual resilience.

TERM	DEFINITION
Nominal redundancy	Two or more suppliers appear to exist.
Effective redundancy	Two or more suppliers can independently operate when the primary supplier fails.

- Two mines are not sufficient if both depend on the same processing facility.
- Two processing facilities are not sufficient if both depend on the same imported chemical input.
- Two ports are not sufficient if both depend on the same rail corridor.
- Two suppliers are not sufficient if both ultimately depend on the same upstream source.

More sources do not automatically mean more resilience. Independence matters.

SECTION 18

Sector Readiness Profile

DIMENSION	READINESS QUESTION
Resource	Is the geological base understood?
Production	Can extraction be sustained?
Processing	Can material be processed domestically or regionally?
Refining	Is specialized refining available?
Manufacturing	Can materials enter strategic industrial chains?
Infrastructure	Are power, water and transportation resilient?
Logistics	Are routes diversified?
Reserves	Is emergency capacity available?
Substitutability	Can dependencies be replaced?
Institutional readiness	Can government and industry coordinate under stress?

SECTION 19

Priority Readiness Gaps

1. **Processing concentration** — Mining capacity can exceed regional processing capacity.
2. **Refining dependency** — Specialized refining may remain geographically concentrated.
3. **Infrastructure constraints** — Mining and processing expansion requires power, water and transportation.
4. **Insufficient substitutability** — Some strategic materials cannot be quickly replaced.
5. **Long project cycles** — Major mineral projects often require years of exploration, permitting, financing and construction.
6. **Limited downstream integration** — Exporting raw or minimally processed material can reduce strategic and economic value captured locally.
7. **Information fragmentation** — Governments may lack integrated visibility across resource → production → processing → logistics → manufacturing.
8. **Workforce** — Specialized mining, metallurgical, chemical, engineering and geological expertise requires long-term development.

SECTION 20

HRS Critical Minerals Resilience Improvement Framework

1. Map critical dependencies — Identify strategic minerals and complete value-chain dependencies.
2. Map processing and refining — Identify where transformation capacity exists and where concentration occurs.
3. Classify critical materials — By economic importance, defense relevance, supply concentration, substitutability and recovery time.
4. Test effective redundancy — Determine whether alternative suppliers can actually operate independently.
5. Strengthen processing capacity — Where economically and strategically justified, expand regional processing and refining.
6. Protect logistics — Assess roads, rail, ports, waterways, power and telecommunications.
7. Develop strategic reserves — Where justified, establish stockpile thresholds, replenishment mechanisms and emergency release procedures.
8. Build recycling capacity — Develop secondary sources where technically and economically viable.
9. Develop regional partnerships — Create mechanisms that allow countries to complement rather than duplicate capabilities.
10. Convert lessons into investment — Supply-chain disruptions should change infrastructure, procurement, stockpiles, processing, workforce and recovery planning.

SECTION 21

Long-Horizon Readiness

Consistent with the 50-year horizon applied across the HRS Resilience Foundation's Western Hemisphere Readiness Series, critical-mineral infrastructure decisions should be evaluated on a multi-decade timescale, not the timescale of a single administration, market cycle or commodity price. A mine may operate for decades. A processing facility can create industrial dependencies for generations. A railway, port or power connection can influence regional development for fifty years or more.

Critical-mineral policy should not be optimized exclusively for current market conditions.

Long-horizon planning should preserve the ability to change suppliers, change processing technologies, expand production, develop substitutes, recycle materials, redirect logistics and establish new partnerships.

The objective is not permanence. The objective is adaptability.

SECTION 22

Western Hemisphere Perspective

The strategic opportunity for the Western Hemisphere is significant. The region possesses geological diversity, major mineral producers, advanced economies, sophisticated financial systems, large consumer markets, industrial capacity, technological capabilities and Atlantic and Pacific access. The challenge is connecting these assets into resilient supply systems.

Canada's current strategy explicitly seeks to strengthen critical-mineral supply chains through domestic production and processing, infrastructure, stockpiling and international partnerships.[5,6] Brazil is simultaneously developing a long-term national mining strategy and a policy framework for critical and strategic minerals.[9]

This creates a potential basis for greater hemispheric coordination while preserving national sovereignty. The HRS framework does not propose that countries surrender control over mineral resources. It proposes that countries strengthen their ability to choose.

That means having more than one supplier; more than one route; more than one processing option; more than one technological pathway; and more than one strategic partner.

HRS PRINCIPLE

Sovereign choice requires strategic alternatives.

SECTION 23

Conclusion

Critical minerals and strategic materials are increasingly becoming foundational inputs to modern economic, technological, industrial and security systems.

The Western Hemisphere possesses substantial advantages. But resource abundance alone does not guarantee resilience. A mineral becomes strategically useful only when the system surrounding it can identify, extract, process, refine, transport, manufacture, store, recover and substitute.

The principal readiness challenge is therefore not simply increasing production. It is reducing the probability that a disruption at one point in the value chain can compromise essential capabilities elsewhere.

CENTRAL CONCLUSION

The strategic value of critical minerals is determined not only by what a country possesses, but by what it can reliably transform, protect, replace and recover.

For the Western Hemisphere, resilient mineral supply chains can strengthen economic security, industrial capacity, technological resilience, infrastructure continuity, defense readiness and sovereign decision-making. The strategic objective is not to eliminate every external dependency. It is to ensure that no essential dependency becomes irreversible.

Detect → Assess → Decide → Coordinate → Deploy → Sustain → Learn

SECTION 24

Methodology, Research Integrity and Limitations

This report is an original HRS Resilience Foundation synthesis based on publicly available information, including official U.S., Canadian, Brazilian and international sources. Official sources establish factual claims concerning critical-mineral classifications, production, supply chains, government strategies, geological resources, infrastructure and industrial policy.

The HRS Sector Readiness Profile, Strategic Dependency Test, Nominal-versus-Effective Redundancy framework and Critical Minerals Resilience Improvement Framework are original analytical constructs of the HRS Resilience Foundation.

- The report does not claim access to classified intelligence, confidential corporate information or proprietary geological data.
- Where evidence is insufficient to establish a current condition, the report frames the issue as a readiness question rather than a factual allegation.
- No conclusion concerning a specific company, government, supplier, political party or individual should be inferred from sector-level analysis.
- Operational decisions require competent authorities, evidence, applicable law and appropriate due process.

This document is a public-source sector readiness assessment. It is not a security certification, engineering audit, legal opinion, procurement recommendation, investment recommendation or classified threat assessment.

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