The Critical Minerals Emerge as Strategic Resources Driving Energy Security, Industrial Competitiveness and National Economic Sovereignty

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Recent Developments:

- **Critical Minerals** have emerged as a major strategic concern amid intensifying global competition over mineral supply chains, with countries prioritising **resource security**, **processing capacity**, and **resilient value chains**.
- The **International Energy Agency (IEA)** in its **Global Critical Minerals Outlook 2026** highlighted rising **supply concentration**, **declining investments**, and **export restrictions**, increasing global vulnerabilities in mineral supply chains.
- **China's** tightening control over **Rare Earth Elements (REEs)** and export licensing measures has accelerated efforts by major economies to diversify mineral sourcing and reduce strategic dependence.
- Against this backdrop, **India** is accelerating implementation of the **National Critical Mineral Mission (NCMM)**, strengthening overseas acquisitions, expanding domestic processing, and deepening strategic partnerships to secure critical mineral supplies.

Summary:

- **Critical Minerals** have become the foundation of the **clean energy transition**, **advanced manufacturing**, **digital technologies**, and **national security**, making them central to geopolitical competition.
- India is adopting a comprehensive **Mine-to-Market Strategy** through **domestic exploration**, **international partnerships**, **processing infrastructure**, **recycling**, and **strategic stockpiling** to achieve **Net Zero** and **Viksit Bharat 2047** objectives.

What are Critical Minerals?

Meaning and Characteristics:

- **Critical Minerals** are **non-fuel metallic** or **non-metallic minerals** that are indispensable for modern technologies, industrial production, and strategic sectors.
- There is **no universally accepted definition** of Critical Minerals, as every country identifies them based on **economic importance**, **supply risk**, **import dependence**, and **availability of substitutes**.
- They are termed **critical** because any disruption in their supply can significantly affect a country's **economic growth**, **industrial production**, **energy transition**, **technological leadership**, and **national security**.

Critical Minerals Identified by India:

- The **Ministry of Mines** has identified **30 Critical Minerals** for India through an Expert Committee.
- Major minerals include **Lithium**, **Cobalt**, **Nickel**, **Copper**, **Graphite**, **Rare Earth Elements (REEs)**, **Molybdenum**, **Niobium**, **Vanadium**, **Titanium**, **Tin**, **Tungsten**, and **Silicon**.

Strategic Importance of Critical Minerals:

Foundation of Clean Energy Transition:

- **Critical Minerals** constitute the backbone of **Electric Vehicles (EVs)**, **Battery Energy Storage Systems (BESS)**, **Solar Power**, **Wind Energy**, **Green Hydrogen**, and modern electricity grids.
- The transition towards **low-carbon economies** under the **Paris Agreement (2015)** and national **Net Zero** commitments has substantially increased global demand for these minerals.

Role in Renewable Energy Technologies:

- **Lithium**, **Nickel**, **Cobalt**, and **Graphite** are essential for manufacturing **Lithium-ion Batteries** used in EVs and grid-scale energy storage.
- **Silicon**, **Tellurium**, **Gallium**, and **Indium** are widely used in **Photovoltaic (Solar) Cells**.
- **Neodymium** and **Dysprosium** are indispensable for **Permanent Magnets** used in high-efficiency **Wind Turbines** and electric motors.
- **Copper** remains the most important conductor for **electricity transmission**, renewable energy infrastructure, and charging networks.

Supporting India's Energy Transition:

- **NITI Aayog** estimates that India's cumulative requirement of **Critical Energy Transition Minerals (CETMs)** could reach nearly **169 million tonnes** by **2070**, around **51%** higher than the Current Policy Scenario.
- Availability of these minerals will determine the pace of India's **renewable energy expansion**, **electric mobility**, and **energy security**.

Driving Emerging Technologies:

- Critical Minerals are indispensable for **Semiconductors**, **Artificial Intelligence (AI)**, **Quantum Computing** , **Advanced Electronics**, **Telecommunications**, **Space Technologies**, and **Robotics**.
- They support manufacturing of **high-performance chips**, **data centres**, **5G infrastructure**, and next-generation electronic devices.

National Security and Defence:

- Modern defence systems require specialised alloys and rare earth magnets for **fighter aircraft**, **missiles**, **radars**, **satellites**, **precision-guided weapons**, and **electronic warfare systems**.
- Secure mineral supplies are therefore essential for **strategic autonomy**, **defence preparedness**, and **technological sovereignty**.

Economic and Industrial Importance:

- Critical Minerals strengthen **manufacturing competitiveness**, **industrial diversification**, **high-value exports**, and **global supply chain integration**.
- Reliable mineral supplies reduce external vulnerabilities while supporting **Make in India**, **Atmanirbhar Bharat**, and advanced manufacturing ecosystems.

Contribution to Sustainable Development Goals (SDGs):

- Critical Minerals directly support:
- **SDG 7** – Affordable and Clean Energy.
- **SDG 9** – Industry, Innovation and Infrastructure.
- **SDG 12** – Responsible Consumption and Production.

- **SDG 13** – Climate Action.
- However, mineral extraction must follow **environmentally sustainable**, **socially responsible**, and **resource-efficient** mining practices.

Growing Geopolitical Importance:

- Export restrictions, resource nationalism, trade controls, and concentrated processing capacity have transformed Critical Minerals into strategic geopolitical assets often described as the **"New Oil"** of the clean energy era.
- The **IEA Global Critical Minerals Outlook 2026** notes that mineral security is now central to **energy security**, **economic security**, and **industrial resilience**.

Major Critical Minerals and Their Availability in India:

Critical Mineral	Major Reserves / Occurrence in India
Lithium	Karnataka, Jamm& Kashmir
Cobalt & Nickel	Odisha, Jharkhand, generally associated with copper ores
Rare Earth Elements (REEs)	Andhra Pradesh, Karnataka, Odisha, Kerala, Gujarat, Rajasthan
Graphite	Arunachal Pradesh, Jharkhand, Tamil Nadu
Copper	Rajasthan, Madhya Pradesh, Jharkhand

How Geopolitics is Reshaping Critical Mineral Supply Chains:

Weaponisation of Mineral Supply Chains:

- Countries possessing dominant control over mining or refining are increasingly using **Critical Minerals** as instruments of **geoeconomic influence**.
- China's export licensing requirements for **Rare Earth Elements** highlighted the strategic vulnerability of countries dependent on a few suppliers.

Supply Chain Concentration:

- According to the **IEA Global Critical Minerals Outlook 2026**, refining of many critical minerals remains concentrated in a few countries, increasing risks associated with geopolitical tensions, trade restrictions, and supply disruptions.
- China continues to dominate global refining of **Rare Earth Elements**, **Graphite**, **Lithium Chemicals**, and **Cobalt**, creating significant supply vulnerabilities.

Rise of Friendshoring and Alliance Economy:

- Major economies are shifting towards **Friendshoring**, under which mineral supply chains are developed among trusted strategic partners rather than depending upon a single dominant supplier.
- Initiatives such as the **Minerals Security Partnership (MSP)**, **EU Critical Raw Materials Act**, **US-Australia Compact**, and **Quad Critical Minerals Initiative** reflect this emerging strategy.

Traditional Geopolitical Conflicts Affecting Energy Transition:

- Critical mineral supply chains are increasingly exposed to **maritime chokepoints**, **regional conflicts**, and **trade disruptions**.
- The **IEA** noted that disruptions in sulphur supplies and export restrictions increased refining costs, highlighting growing vulnerabilities in global mineral processing.

Shift Towards Supply Chain Diversification:

- Countries are adopting **China+1 Strategies** by expanding domestic mining, investing in overseas mineral assets, promoting recycling, and building diversified supply chains with trusted partners.
- Mineral security is increasingly viewed as a prerequisite for **energy transition**, **industrial competitiveness**, and **economic resilience**.
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Global Approaches to Critical Mineral Security:

Country / Bloc

Approach

China

Dominates mining, refining, processing, exports, and uses mineral supply chains as an instrument of geoeconomic influence.

United States

Promotes **Friendshoring**, strategic alliances, domestic processing, overseas investments, and diversified supply chains.

European Union

Focuses on strategic autonomy through domestic extraction, recycling, refining, and reducing dependence on single suppliers.

Australia

Utilises abundant reserves while expanding downstream processing and partnerships with trusted economies.

Japan

Secures overseas mining assets, long-term contracts, strategic stockpiles, and resource diplomacy.

India

Pursues an integrated **Mine-to-Market Strategy** through domestic exploration, overseas acquisitions, value addition, recycling, and resilient international partnerships.

India's Initiatives to Strengthen Critical Mineral Security:

National Critical Mineral Mission (NCMM):

- The **National Critical Mineral Mission (NCMM)** was launched in **2025** and is being implemented from **FY 2024–25 to FY 2030–31** to develop the complete **Mine-to-Market Value Chain** for Critical Minerals.
- The Mission focuses on **exploration**, **mining**, **beneficiation**, **processing**, **recycling**, **research & development (R&D)**, **human resource development**, **strategic stockpiling**, and **global partnerships**, thereby reducing India's long-term import dependence.

MMDR Act Amendment, 2023:

- The **Mines and Minerals (Development and Regulation) Amendment Act, 2023** empowered the **Central Government** to auction **24** of the **30 identified Critical Minerals**, accelerating private participation, exploration, and domestic production.
- The amendment aims to improve **ease of doing business**, attract investment, and strengthen India's mineral security.

International Cooperation:

- India signed the **India–US Critical Minerals and Rare Earths Framework (2026)** to strengthen **secure**, **trusted**, and **diversified** Critical Mineral supply chains.
- India is also expanding bilateral cooperation with **Australia**, **Argentina**, **Chile**, **Namibia**, **Brazil**, and several **African countries** for exploration, mining, processing, and technology transfer.

KABIL (Khanij Bidesh India Limited):

- **KABIL** is a joint venture of **National Aluminium Company Limited (NALCO)**, **Hindustan Copper Limited (HCL)**, and **Mineral Exploration and Consultancy Limited (MECL)**.
- It secures overseas Critical Mineral assets through **exploration**, **acquisition**, **joint ventures**, and **long-term supply agreements**, thereby reducing India's dependence on imported raw materials.

Pax Silica Initiative (2026):

- India joined the **US-led Pax Silica Initiative** to strengthen trusted supply chains for **Critical Minerals**, **Semiconductors**, **Artificial Intelligence (AI)**, and **Advanced Manufacturing**.
- The initiative promotes resilient value chains while reducing dependence on highly concentrated suppliers.

Quad Critical Minerals Initiative (2025):

- The **Quad Critical Minerals Initiative** brings together **India**, **Australia**, **Japan**, and the **United States** to build secure and diversified Critical Mineral supply chains.

- The initiative proposes mobilisation of nearly **USD 20 billion** for **mining**, **processing**, **recycling**, and **technology development**.

Rare Earth Corridors:

- The **Union Budget 2026–27** proposed **Rare Earth Corridors** in **Odisha**, **Kerala**, **Andhra Pradesh**, and **Tamil Nadu** to strengthen domestic **processing**, **value addition**, and downstream manufacturing.
- These corridors aim to reduce dependence on imported **Rare Earth Magnets** and strengthen indigenous industrial capabilities.

Recycling and Circular Economy:

- India is promoting **urban mining**, **battery recycling**, **electronic waste recovery**, and **resource efficiency** to recover valuable Critical Minerals from end-of-life products.
- Recycling is expected to become a major secondary source of Critical Minerals while reducing environmental impacts.

Challenges to India's Critical Mineral Security:

High Import Dependence:

- India remains heavily dependent on imports for several Critical Minerals, making supply chains vulnerable to **geopolitical tensions**, **trade restrictions**, and **price volatility**.
- **Lithium** is almost entirely imported, **Cobalt** is largely sourced from the **Democratic Republic of the Congo (DRC)**, **Nickel** mainly from **Indonesia**, while **Rare Earth Magnets** are predominantly imported from **China** .

Limited Domestic Processing Capacity:

- Despite possessing mineral resources, India has limited capacity for **battery-grade lithium chemicals**, **high-purity graphite**, **rare earth separation**, **advanced smelting**, and **chemical refining**.
- Nearly **70–90%** of global value addition occurs at the processing stage, making domestic capability essential for strategic autonomy.

China's Midstream Dominance:

- China refines more than **90%** of global **Rare Earth Elements** and **Graphite**, around **75%** of **Cobalt**, and nearly **70%** of **Lithium Chemicals**.
- This concentration enables China to exercise significant influence over global Critical Mineral supply chains through export restrictions and processing controls.

Inadequate Exploration:

- Mineral exploration in India remains largely **reconnaissance-based** and relatively shallow, whereas Critical Minerals generally occur in **deep-seated geological formations**.
- Advanced technologies such as **airborne geophysical surveys**, **hyperspectral imaging**, **3D geological modelling**, and **Artificial Intelligence (AI)** require wider adoption.

Environmental and Social Concerns:

- Mining activities may result in **deforestation**, **water pollution**, **land degradation**, **loss of biodiversity**, and **community displacement** if not managed sustainably.
- Balancing **mineral security** with **environmental conservation** and **social justice** remains a major policy challenge.

Investment and Technology Constraints:

- Critical Mineral projects involve **high exploration risks**, **long gestation periods**, **capital-intensive processing facilities**, and **technology-intensive refining**, limiting private sector participation.

Way Forward:

Strengthen Domestic Exploration:

- Accelerate **deep-seated mineral exploration** through **Artificial Intelligence (AI)**, **airborne geophysical surveys**, **hyperspectral mapping**, **3D geological modelling**, and advanced mineral exploration technologies.
- Expand geological surveys under the **National Critical Mineral Mission (NCMM)** while improving accessibility of geological data.

Develop Processing and Refining Ecosystem:

- Establish domestic facilities for **battery-grade lithium**, **nickel**, **cobalt**, and **rare earth refining** through fiscal incentives, **Production Linked Incentive (PLI)** support, and **Public-Private Partnerships (PPPs)**.
- Develop integrated **Mine-to-Market Value Chains** to maximise domestic value addition.

Diversify Overseas Mineral Sources:

- Secure long-term mineral supplies through **KABIL**, strategic investments, and joint ventures in resource-rich countries such as **Australia**, **Argentina**, **Chile**, **Namibia**, and African nations.
- Reduce dependence on any single supplier by expanding diversified sourcing strategies.

Promote Circular Economy:

- Scale up **battery recycling**, **electronic waste management**, **urban mining**, and **resource recovery** to reduce primary mineral demand and strengthen supply resilience.
- Encourage research on **substitute materials** and **resource-efficient technologies**.

Improve Ease of Mining:

- Streamline **environmental** and **forest clearances**, strengthen risk-sharing mechanisms, improve logistics, and create a stable regulatory environment to attract private investment.
- Strengthen collaboration among **government**, **industry**, **research institutions**, and **international partners**.

Strengthen Strategic Stockpiles and Partnerships:

- Develop national stockpiles of strategically important minerals to manage short-term supply disruptions.
- Expand cooperation through the **Quad**, **India–US Framework**, **Minerals Security Partnership (MSP)**, and other trusted international platforms.

Conclusion:

- **Critical Minerals** have become central to the global transition towards **clean energy**, **advanced manufacturing**, and **strategic technologies**, making secure supply chains an important component of economic and national security.
- India's long-term mineral security will depend upon successfully integrating **domestic exploration**, **processing capacity**, **technology development**, **international resource partnerships**, **recycling**, and **sustainable mining practices**.

- Transitioning from a supplier of **raw ores** to a global hub for **high-value mineral processing**, **advanced materials**, and **circular resource management** will strengthen **Atmanirbhar Bharat**, support **Net Zero** commitments, and accelerate the journey towards **Viksit Bharat 2047**.

Value Addition for UPSC:

Important Facts:

- **Ministry Responsible: Ministry of Mines**.
- **Critical Minerals identified by India: 30**.
- **National Critical Mineral Mission (NCMM): 2025**.
- **Implementation Period: FY 2024–25 to FY 2030–31**.
- **MMDR Amendment: 2023**.
- **KABIL Full Form: Khanij Bidesh India Limited**.
- **Quad Members: India**, **Australia**, **Japan**, **United States**.
- **IEA Outlook 2026:** Highlights increasing **supply concentration**, **processing dominance**, and **geopolitical vulnerabilities** in Critical Mineral supply chains.

Prelims Focus:

- **Lithium:** Electric vehicle batteries, energy storage.
- **Cobalt:** Lithium-ion battery cathodes, aerospace alloys.
- **Nickel:** Battery manufacturing, stainless steel.
- **Copper:** Electrical transmission, renewable energy infrastructure.
- **Graphite:** Battery anodes, refractories.
- **Rare Earth Elements (REEs):** Permanent magnets, electronics, defence equipment, wind turbines.

Mains Enrichment:

- **Critical Minerals** are increasingly recognised as the **"New Oil"** because control over their extraction, processing, and supply chains is becoming as strategically important as control over fossil fuels was during the twentieth century.
- India's strategy must shift from **"Mine-to-Export"** towards **"Mine-to-Market"**, integrating **exploration**, **processing**, **manufacturing**, **innovation**, and **recycling** to build resilient and globally competitive Critical Mineral value chains.

Sustainable mineral security should combine **resource efficiency**, **environmentally responsible mining**, **community participation**, **technological innovation**, and **international cooperation** to ensure long-term economic resilience and strategic autonomy