Strengthening India’s Critical Mineral Supply Chain

This editorial is based on “India's critical mineral challenge threatens its 2030 economic goals ” which was published in Business Standard on 02/06/2025. The article brings into picture the risks of India’s import dependence for critical minerals, as China’s rare earth export curbs threaten EV supply chains.

For Prelims: **Critical mineral**, **Lithium reserves in Jammu & Kashmir**, **Rare earth imports**, **Atmanirbhar Bharat**, **India’s $10 billion semiconductor initiative**, **Mineral Security Partnership** , **IndiaAI Mission**, **Semiconductor Mission**, **World Economic Forum**.

For Mains: Significance of Critical Minerals, Key Issues Associated with India's Critical Mineral Supply Chain.

China's recent restrictions on rare earth magnet exports have created supply concerns for **India's growing EV sector**, revealing the country's significant **reliance on imports for critical minerals.** While India possesses considerable reserves of important minerals like cobalt and rare earth elements, the nation has historically focused less on exploration and processing infrastructure development. This import dependency extends to other **essential minerals including lithium, graphite, and emerging resources like natural hydrogen and thorium**. As India works toward becoming the **world's third-largest economy**, developing domestic mining and processing capabilities will be essential for securing **mineral supply chains and reducing import dependence.**

Economic importance	Supply risk
• Disruption potential • Substitutability index (EI) • GVA multiplier score • Cross-cutting index (CCI)	• Governance-weighted mineral concentration • End-of-life recycling rates (EOL-RR) • Import reliance (IR) and self sufficiency (SS) • Substitutability index (SR)

What Role does Critical Minerals Play in India's Growth Story?

- **Driving Renewable Energy Expansion:** Critical minerals like **silicon, tellurium, and rare earth elements** are indispensable for **solar panels and wind turbines,** forming the foundation of India's clean energy goals.
  - **India's renewable capacity** aims for **50% non-fossil power by 2030,** relying heavily on these minerals.
  - For instance, India's solar capacity reached 64 GW in 2024, with wind set to grow from 42 GW to 140 GW by 2030. This creates massive demand for these minerals to meet climate targets.
- **Powering Electric Mobility Revolution: Lithium, cobalt, and nickel** are essential for lithium-ion batteries, which are the heart of **India's electric vehicle (EV) ambitions.**
  - Currently, **India imports 100% of its lithium and cobalt,** with China supplying over 70% of lithium imports. This supply is critical to sustain India's EV industry growth.
- **Strengthening Electronics and Semiconductor Manufacturing: Gallium, germanium, and indium** serve as core inputs for semiconductors and advanced electronics **(IndiaAI Mission and Semiconductor Mission)**, crucial for India's goal of self-reliance in high-tech manufacturing.
  - India is almost fully **import-dependent on these minerals, primarily from China.**
  - Recent strategic partnerships, including joining the **Minerals Security Partnership,** aim to secure these inputs and boost domestic manufacturing capabilities.
- **Enhancing National Security and Defence Capability: Titanium, rare earth elements, and nickel** are critical for **aerospace, defense electronics, and strategic equipment manufacturing.**

    - India’s defence sector depends heavily on imports, with **over 50% reliance on titanium and significant dependence on rare earths.**
    - The government’s centralized auction system for critical minerals enhances control over these vital resources for national security.
- **Fueling Economic Growth and Employment:** Domestic mining and processing of critical minerals can catalyze industrial development and job creation in mineral-rich regions.
    - The **National Critical Mineral Mission** aims to train 10,000 skilled workers and initiate **1,200 exploration projects by 2031**.
    - Auctions involving companies like Vedanta and Ola Electric demonstrate growing private sector participation, boosting local economies and reducing import bills.

What are the Key Issues Associated with India's Critical Mineral Supply Chain?

- **Overdependence on Chinese Imports:** India’s critical mineral supply chain is perilously dependent on China, creating a geopolitical chokehold that threatens national security and economic growth.
    - Minerals like **lithium (82% import share), bismuth (85.6%), and silicon (76%)** are overwhelmingly sourced from China, exposing India to supply manipulation amid rising bilateral tensions.
    - The **recent rare earth export restrictions by China** spotlight the fragility of this dependency.
- **Bottlenecks in Domestic Exploration and Auctioning:** Despite substantial mineral reserves, India’s domestic extraction suffers from **bureaucratic delays and unattractive auction designs,** deterring private investment.
    - Since 2023, **over 100 critical mineral blocks have been auctioned but many remain unsold**—14 out of 18 auctions in June 2024 were annulled for lack of technical bids—highlighting industry scepticism.
    - Complex mineralogy, like **lithium in clay form in Jammu & Kashmir,** demands high upfront risk capital, further discouraging exploration.
- **Underdevelopment of Mineral Processing and Refining Ecosystem:** India’s value chain bottleneck lies in its negligible processing capabilities, compelling it to **export raw ores and import costly refined materials.**
    - China commands over **87% of rare earth processing and 58% of lithium refining,** enabling supply chain dominance.
    - India’s IREL, with **a capacity of 600,000 tons/year,** struggles to meet the growing demand for battery-grade minerals, delaying indigenous EV and semiconductor manufacturing ambitions.
        - This processing gap erodes domestic value addition.
- **Environmental and Socio-Political Challenges:** Mining operations face growing scrutiny over **ecological degradation, pollution, and displacement of indigenous communities,** intensifying project delays.
    - Many critical mineral deposits lie in **ecologically fragile or tribal regions**, where environmental clearances are arduous.
    - **Rajasthan’s rare earth projects have stalled amid such issues.** Without stringent **ESG frameworks and community engagement**, opposition risks escalating, jeopardizing mining licenses and supply security.
- **Volatile Global Market Prices and Investment Risks:** The fluctuating and unpredictable prices of critical minerals create uncertainty for policymakers and manufacturers.
    - For example, the **price of lithium fell 75% in 2023 after spiking over 400%** in 2022, and **cobalt has lost two-thirds of its value from its peak in 2022**. **(World Economic Forum)**
    - Supply disruptions, driven by geopolitical tensions and export controls, magnify **price swings.**
        - Such volatility **inflates green tech project costs**, complicates budgeting, and deters long-term investments necessary for India’s ambitious renewable and EV targets.
- **Technological Deficiency and Human Capital Gaps:** Advanced mining and beneficiation

technologies are critical for exploiting deep and complex deposits, but India lacks **both technology and skilled manpower at scale.**
    - The **National Critical Mineral Mission's plan to train 10,000 workers addresses this,** but current shortfalls slow project timelines.
    - Extraction o**f lithium from clay in Reasi** requires sophisticated **hydrometallurgical expertise** absent domestically, prolonging import reliance and delaying strategic autonomy
- **Nascent Circular Economy and Recycling Infrastructure:** India's recycling framework for critical minerals is underdeveloped, limiting recovery from **e-waste and spent batteries,** which could mitigate import dependence and environmental impact.
    - Although **India plans ₹1,500 crore incentives to recycle 24 critical minerals like lithium & cobalt,** current infrastructure is sparse and inefficient.
    - Furthermore, **export bans by China and Europe on battery scrap ('black mass')** restrict secondary raw material access, stalling India's transition to a sustainable circular mineral economy.

What Measures can India Adopt to Strengthen its Critical Mineral Supply Chain?

- **Streamline Regulatory Framework and Simplify Mineral Auction Processes:** India must overhaul and modernize its mining laws to enable faster grant of exploration and mining leases, reducing bureaucratic delays and enhancing transparency.
    - Introducing **single-window clearances and digitized land and environmental approvals** can accelerate project execution.
    - Flexible auction models, **such as exploration-cum-mining rights,** should incentivize private investment by allowing firms to mine discovered deposits. This will attract risk capital and catalyze domestic production.
- **Integrated Mineral Processing Parks:** Develop dedicated mineral processing hubs equipped with advanced beneficiation and refining technologies to **create value-added products domestically.**
    - These parks should facilitate **co-location of mining, processing, and manufacturing units,** improving logistics and reducing costs.
    - **Public-private partnerships and technology transfer agreements** can accelerate capacity building. This integration will enhance supply chain resilience and reduce dependency on imported refined minerals.
- **Invest Heavily in R&D for Alternative Materials:** Focus on research to develop **substitutes for critical minerals and eco-friendly extraction techniques** tailored for India's unique geology.
    - Collaborations between academia, industry, and government research institutions can foster innovation in low-cost, sustainable mining and recycling technologies.
    - Prioritizing technology to extract minerals from complex sources, such as **lithium from clay, will unlock untapped domestic reserves.** This will reduce import reliance and environmental impact.
- **Strategic Mineral Stockpiling and Supply Chain Diversification:** Create and maintain strategic reserves of critical minerals to buffer against global supply shocks and price volatility.
    - Simultaneously, **diversify import sources by strengthening bilateral and multilateral partnerships** with multiple resource-rich countries beyond China.
    - **Institutionalize long-term off-take agreements and joint ventures** to secure stable supplies. This dual approach ensures uninterrupted availability while mitigating geopolitical risks.
- **Scale Up Skill Development and Specialized Training Programs:** Launch comprehensive capacity-building initiatives to develop a skilled workforce proficient in advanced mining, mineral processing, and environmental management.
    - Incorporate emerging technologies like **AI and IoT for precision mining into training curricula.**
    - Collaborate with global centers of excellence to upgrade local expertise rapidly. A robust talent pipeline is critical to operational excellence and scaling domestic critical mineral industries.

- **Promote Circular Economy with Incentivized Recycling:** Formulate policies that incentivize recovery of critical minerals from **e-waste, battery scrap, and mining tailings through financial subsidies and regulatory support.**
    - Establish certified recycling infrastructure and streamline waste collection mechanisms nationwide.
    - **Foster innovation in urban mining technologies** and mandate minimum recycled content standards in manufacturing. This will reduce virgin mineral demand and environmental footprint.
- **Leverage Digital Technologies for Transparent and Efficient Supply Chain Management:** Adopt blockchain and **AI-driven platforms to track mineral provenance, quality, and movement across the supply chain,** enhancing transparency and reducing illicit mining and trade.
    - Real-time data analytics can optimize inventory management and forecast supply-demand imbalances.
    - Digitalization enables swift regulatory compliance, enhances investor confidence, and strengthens India's global credibility in responsible sourcing.

Conclusion:

Securing India's critical mineral supply chain is vital for its clean energy ambitions, economic growth, and national security. Holistic measures—**ranging from regulatory reforms and advanced processing to strategic diversification and circular economy initiatives**—are essential to reduce import dependence and build resilience. A proactive, integrated approach will position **India as a self-reliant leader in the critical minerals ecosystem**

Drishti Mains Question:

Examine the challenges faced by India's critical mineral supply chain and suggest comprehensive measures to achieve self-reliance in this sector.

UPSC Civil Services Examination Previous Year Question (PYQ)

Prelims:

Q. With reference to the management of minor minerals in India, consider the following statements: (2019)

1. Sand is a 'minor mineral' according to the prevailing law in the country
2. State Governments have the power to grant mining leases of minor minerals, but the powers regarding the formation of rules related to the grant of minor minerals lie with the Central Government.
3. State Governments have the power to frame rules to prevent illegal mining of minor minerals.

Which of the statements given above is/are correct?

(a) 1 and 3 only

(b) 2 and 3 only

(c) 3 only

(d) 1, 2 and 3

Ans: (a)

Q. What is/are the purpose/purposes of 'District Mineral Foundations' in India? (2016)

1. Promoting mineral exploration activities in mineral-rich districts
2. Protecting the interests of the persons affected by mining operations
3. Authorizing State Governments to issue licenses for mineral exploration

Select the correct answer using the code given below:

(a) 1 and 2 only

(b) 2 only

(c) 1 and 3 only

(d) 1, 2 and 3

Ans: (b)

Mains

Q. Despite India being one of the countries of Gondwanaland, its mining industry contributes much less to its Gross Domestic Product (GDP) in percentage. Discuss. (2021)

Q. "In spite of adverse environmental impact, coal mining is still inevitable for development". Discuss. (2017)