

Refining of Minerals - A missing link in India's mineral mission

Mains: *GS III - Mobilization of Resources.*

Why in News?

In recent years, the Mines and Minerals (Development and Regulation) Act has been amended to support domestic mining through exploration licences, national auctions, mining-associated minerals, and a national mineral exchange.

What are the recent developments and issues in mining sector?

- **Rare earth magnet scheme** - The Union Cabinet's new ₹7,280 crore rare-earth magnet scheme acknowledges a simple truth: digging without processing is just exporting prosperity.
- **Importance of refining** - The new G-20 framework on critical minerals also makes value creation through refining and manufacturing its centrepiece.
- **Indian scenario** - India, which has reformed its mining laws but still lacks large-scale processing, this is a timely reminder.
- Every solar panel, electric vehicle, and wind turbine begins not on an assembly line but in a refinery, where ores are turned into battery-grade graphite, magnet-ready rare earths, or ultra-pure polysilicon.
- Yet, almost all this processing happens outside India, increasing the vulnerability of domestic supply chains.
- **Gaps in Legal reforms** - In recent years, the Mines and Minerals (Development and Regulation) Act has been amended to support domestic mining through exploration licences, national auctions, mining-associated minerals, and a national mineral exchange.
- These reforms help us dig, but they do not help us refine.
- India still imports almost all its lithium, nickel, and cobalt and the stakes extend far beyond clean energy.
- High-purity materials are also vital for semiconductors, telecommunications, automobiles, pharmaceuticals, and defence systems.
- Processing gaps, therefore, expose not just our energy transition but the entire economy.
- The midstream segment of the critical minerals value chain—processing and refining—remains a global chokepoint.
- **Domination of China** - China controls over 90% of rare earth and graphite refining, nearly 80% of cobalt, and 70% of lithium chemicals.

- In October 2025, Beijing briefly weaponised these supply chains, imposing controls on rare earth magnets, lithium-ion batteries, graphite anodes, and processing technologies.
- **US strategy** - The recently inked *U.S.-Japan and U.S.-Australia critical minerals frameworks* now tie financing directly to local refining.
- India must do the same by, scaling up its processing and refining capacity, beginning with the minerals it already produces or recycles.
- The recently approved ₹1,500 crore critical minerals recycling scheme is a promising start.
- **Recent study** - The Council on Energy, Environment and Water (CEEW) shows India mines and processes seven critical minerals relevant for clean energy and defence: copper, graphite, silicon, tin, titanium, rare earths, and zirconium.
- Yet, in each case, refining lags behind in either scale or quality. Domestic graphite reaches 92-99% purity, while batteries need 99.95% spherical graphite.
- Rare earths are processed into oxides but not separated into the metals required for magnets.
- And India's tin production meets barely 1% of demand.

What are the measures India can take to develop critical mineral processing in India?

- **Turn Centres of Excellence into innovation engines** - The nine Centres of Excellence (CoEs) under the National Critical Mineral Mission (NCMM) must drive applied research for producing high-purity compounds and materials aligned to downstream industry needs.
- In the short term, their priority should be developing processing technologies ready for commercial use (technology readiness level 7-8), with clear metrics on purity, recovery, cost, and waste.
- IITs, NITs, industry, and think tanks are already part of this ecosystem and must accelerate life-cycle modelling and cost-benefit analysis through collaborative projects that move innovations swiftly from lab to market.
- **Unlock secondary resources to recover critical minerals** - India generates over 250 million tonnes of coal fly ash annually, containing both light and heavy rare earths.
- Red mud from aluminium plants holds gallium; zinc residues contain cobalt; steel slag carries vanadium.
- Pilot projects at CSIR and IITs show recovery is possible.
- Embedding recovery units in proposed Critical Minerals Processing Parks could scale these efforts, provided they are backed by incentives for mine tailings and residues and co-funded with PSUs and state utilities.
- The Environment Ministry should streamline clearances so such secondary resources can be utilised efficiently.
- **Training and upskilling** - A new generation of process metallurgists and technicians should be trained.
- India's metallurgical workforce is largely trained for bulk metals using pyrometallurgy.
- Critical minerals, found in low-grade ores, require specialised hydrometallurgical and advanced refining techniques.
- The ₹100 crore NCMM allocation for skilling should fund train-the-trainer

programmes, diploma courses, and new curricula at academic and CSIR labs, developed with industry input.

- Apprenticeships at Hindustan Copper, Hindalco, Vedanta, and other refiners can provide hands-on experience.
- This could create thousands of skilled jobs in states like Odisha, Gujarat, and Jharkhand, where mineral reserves and processing hubs are concentrated.
- **De-risk investment** – It should be done through demand assurance and financing tools.
- Global mineral markets are distorted by artificially low prices that deter new entrants.
- The U.S. Department of Defence's deal with the U.S.-based MP Materials, offering offtake commitments and price guarantees, is instructive.
- India could adapt this by turning its planned mineral stockpile into an active market-maker, buying from domestic producers during downturns and releasing during demand surges.
- A dedicated window under the Ministry of Mines could manage this mechanism through long-term contracts.
- **Encouraging key sectors** – Key sectors such as defence, pharmaceuticals, and electronics should be encouraged to source part of their inputs domestically.
- While processors should be encouraged to meet stringent quality and reliability standards, anchoring demand and attracting private investment.
- **Link mineral diplomacy to processing capacity** – India's overseas acquisitions, such as *the five lithium blocks in Argentina through Khanij Bidesh India Limited and exploration rights in Zambia*, are significant but focus mainly on raw ores.
- Real leverage lies in processing strength.
- If India can demonstrate consistent high-purity refining across the seven minerals it already handles, it can shift global partnerships from buyer-seller deals to co-investment alliances.
- A template emerged at the Johannesburg summit with the announcement of the *Australia-Canada-India Technology and Innovation Partnership*.
- By explicitly including critical mineral supply chains in this trilateral agenda, India has opened the door to co-develop processing technologies with major resource holders.
- The concept of critical minerals parks under the NCMM could become a platform for such partnerships.
- The Ministry of Commerce and Industry, along with the Ministry of Mines, should also integrate the processing of critical minerals, along with trade and investment opportunities, into bilateral and multilateral economic dialogues such as G-20, BRICS and IPEF.

What lies ahead?

- China's recent restrictions on minerals and technology are a reminder that control over processing equals control over power.
- For India, the question is no longer whether we have enough mines but whether we can master the stage that turns ores into usable materials. Processing is the missing link that will decide whether we remain suppliers of raw material or become builders of resilient industries.
- True strategic autonomy lies not in the mine, but in the refinery.

Reference

[The Hindu| Missing Link in India's Mineral Mission](#)

