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Non-Fuel Minerals and Mining: Enhancing Mineral Exploration in India

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India's mineral exploration legacy

India has a landmass of 3.2 million km^2 with a multitude of geological - tectonic domains, which evolved through the entire course of geological past and developed varied mineral potential. India also has a significant legacy of mining from pre-historic times which continues to this day. For centuries India produced iron ore, copper, zinc, lead, gold, silver, diamonds, and other precious gemstones and fascinating facing and building stones which are visible in our historical architecture. While the British colonial times had the mining of precious metals and stones, as well as mining of coal (and petroleum) as its twin focus, it also laid the foundations of modern geological studies in India through the establishment of the Geological Survey of India (GSI) and institutions like the Presidency College of Calcutta, which housed India's first geology departments. Large iron ore deposits were discovered by the pioneering GSI geologists in eastern, central, and southern India towards the beginning of the 20th century and entrepreneurs like Jamshed Ji Tata accepted the challenge of setting up the foundations of India's steel industry. The British also started the great geodetic survey of the South Asian region, while the GSI started the geological mapping of the entire sub-continent.

This spectacular legacy of geological mapping and survey continued post-independence, as India embarked on the path of rapid industrial growth and development. India's bulk mineral commodities like iron ore, coal, manganese, limestone and later, bauxite contributed to India's infrastructural development. Most of the major minerals in the country were produced by India's public sector units (PSUs). GSI, Mineral Exploration Corporation Limited (MECL), and later, Coal Mine Planning and Development Institute (CMPDI), a subsidiary of Coal India Limited (CIL), took up the cudgels of mineral exploration in the country. Together, GSI and CMPDI carried out significant explorations in defining the coal resources of India. However, much of the bulk commodities were either dispensed as Mining Leases (ML) to PSUs or allocated to the private sector with minimal exploration data. Very limited mineral exploration was carried out for bulk commodities by the ML holders in the last 70 years, which unfortunately resulted in a significant gap towards the conversion of Geological Resources to Mineable Reserves. Even the GSI carried out very limited exploration for bulk commodities once large areas were dispensed for ML in any of the mineral districts. Thus, many Greenfield areas are yet to be explored even for bulk commodities. For non-bulk commodities, there had been focussed exploration in some of the mineral districts like the Aravallis and Singbhum Sheared Zone (for base-metals), the Dharwar Craton for gold, and others. These led to the discovery of many medium to small mineral deposits, only a few of which were converted to mines. However, India remained grossly under-explored for both bulk and non-bulk commodities compared to the rest of the world. Exploration spending in India remained less than 100 million US$ annually, while the top exploration domains in the world like Canada, Australia, Southern America, China, Western Africa, SE Asia received hundreds of millions of dollars of exploration investments annually. A general estimation is that India had detailed exploration in less than 10% of the total Obvious Geological Potential area.

The liberalisation of India's economy in 1991 progressively opened India's major minerals sector to private sector investments. PSUs like Hindustan Zinc Limited (HZL) and Bharat Aluminium Company Limited (BALCO) were disinvested through private sector investments and many coal blocks were allocated for private sector captive development. India made significant changes to the Mines and Minerals Development and Regulation (MMDR), 1957 Act to align the same with the minerals code of the best-known minerals jurisdictions, which allowed private sector investments for mineral exploration in India on assets dispensed on First Come First Serve (FCFS) basis. In about 13 years of exploration, in different phases in different parts of India, since MMDR 1993 and its modified versions were implemented, few large and some of the junior Indian and international companies including Rio Tinto, De Beers, BHP Billiton, Anglo American, Phelps Dodge, Geomysore India Limited established their exploration units in India and carried out limited but high quality modern integrated exploration including airborne and ground geophysics, sophisticated remote sensing, geochemistry, and detailed drilling programs. Rio Tinto and De Beers were the most successful in making many discoveries of kimberlites – the source rocks for diamonds. Rio Tinto's Bunder Diamond discovery is hailed as one of the largest clusters of diamond deposits found in the last two decades, globally. Additionally, few gold and base metal deposits were also discovered. HZL, which was disinvested to Vedanta Group, added more than 200 million tonnes of additional lead and zinc Geological Resource in Rampura Agucha to make it the world's largest zinc – lead deposit. HZL also discovered brownfield resources at Sindesar Khurd, making it a world-class deposit.

However, India's mineral exploration came to a near-complete halt after 2010, as none of the states issued exploration licences (RP and PL) to any company till the introduction of the new MMDR Act 2015. Meanwhile, the Supreme Court declared the blocks allocated to private sector lease holders for coal as illegal, soon thereafter Shah Commission and Supreme Court stopped much of the mining activities in the state of Karnataka and Goa, while partially halting mining in the states of Odisha and Jharkhand. MMDR 2015 (Amendment) Act was brought in to address the major concerns of Supreme Court in terms of lack of transparency, fairness, and objectivity to mineral asset dispensation process. The minerals code envisaged a rigid framework of Mineral Auctions based on Evidence of Mineral Content (EMC) Rule, which necessitated dispensation of a mineral asset for Composite License (CL) or Mining Lease only if the asset has a defined Geological Resource of (United Nations Framework Classification for Resources) UNFC G3, G2, or a higher category. This

rule instantly split the minerals value chain into two – the exploration to discovery phase of a mineral resource was taken out of the purview of private sector explorers and left to the conventional process of government sponsored exploration; while the resource once discovered by a government sponsored entity was to be auctioned for exploration to develop further confidence on the Geological Resource, followed by development and mining by a Composite License or a Mining Lease. While some bulk commodity assets were auctioned through the new process, the exploration and discoveries of non-bulk commodities, for most part, reduced to a trickle.

India's geological and mineralisation potential

As per Indian Bureau of Mines (IBM), which accounts for the mineral inventory of the country and plays its statutory role in the mine permitting and regulatory process, India currently produces about 95 different mineral commodities. Geological Survey of India, which is accountable for the generation of the baseline geological survey data pertaining to surface geological map, geological structure and tectonics, geochemistry, mineralisation, geomorphology, airborne and ground geophysics, geochronological, exploration, and other datasets, has identified 0.52 million km^2 area as the Obvious Geological Potential area (OGP) for mineralisation. However, if the Himalayan belt, the Deccan Trap, and the broad areas of Peninsular Gneisses and the coastal belts, which have been left out of the OGP are included, as each of the geological domains have significant exploration potential, India's OGP area would increase to about two million km^2 area.

India has over 20 billion tonnes of high-grade iron ore resource established, out of which GSI has explored and established only about 2.5 billion tonnes of resource. India has over 600 million tonnes of manganese Geological Resource reported and over three billion tonnes of bauxite. Each of these commodities have significant likelihood of further resource enhancement that their historical major exploration phase stopped in the early 1980s. Additionally, the bulk commodities also have significant low-grade ore potential, which could become available for commercial extraction in the future with improved mining and processing technologies and lowering of energy costs.

India had very little modern integrated and focussed exploration for non-bulk commodities like base-metals, precious metals, diamonds, chromite, graphite, titanium, tungsten etc. during the last four decades, when many parts of the world saw significant investments in modern exploration. For base-metals and gold, in the past most of exploration was carried out by GSI focused around the historical mine workings. The private sector international exploration during the previous exploration regime discovered over a hundred diamond potential sources in different diamond belts and clusters all over the country including the Bunder Diamond Deposit, which is considered by many as the best diamond discovery for the world in the last two decades. Geological Survey of India considers only about 300,000 km^2 area as diamond potential area in India, while international explorers have considered more than a million km^2 area as diamond potential area of India.

India has excellent mineralisation potential for many tech commodities, which are likely to be highly in demand in the future. Thus, while India has a large content of REE source and ilmenite in the monazite content of beach sand, India also has major alkaline rocks and carbonatite complexes, which are known as the primary source rocks for REE, globally. India has known geological set ups for commodities like lithium, niobium, tantalum, tin, vanadium, titanium, and others. However, India would need to consider the development of the entire value chain of these commodities, from exploration to mining, to extraction, and product development. India has excellent but unexplored or underexplored geological potential for commodities like lateritic nickel, or a Norilsk style nickel deposit, or ultramafic hosted platinum group of elements (PGE).

GSI, which generates a large repository of finest quality geological database would have the responsibility of not only allowing the data to be made freely available in the public domain, but also keep upgrading India's Obvious Geological Potential (OGP) and re-classify the same further, based on commodity classes.

India's exploration needs in twenty first century

India's mineral mix going forward in the 21st century is predicted to be different from what it was in the post-independence period during the 20th century and in the first two decades of this century. Discovering, mining, and extraction technologies and product development with the extracted metals would be critical for India's growth through the Industry 4.0 era and at subsequent times in the 21st century. The following table (Table 1) shows the likely commodity mix for India's mineral security requirements in this century, classified in terms of its current supply position, with respect to current product demand.

Table 1: India's Minerals Security Needs in the 21st Century

Usage	Raw Materials
Infrastructure	Fe, Al, Mn, V, Cr, Ni, Cu, Pb, Zn, limestone, aggregates
Energy	Coal, hydrocarbons, U, Th
Energy supply	Cu, Al
Energy storage devices	REE, Nb, Ta, Graphite, Li, Ni, Co, Mn
Electric cars	REE, PGE, Sc, Al, Mg, Ti
Water desalination	PGE, Cr, Ti
Telecommunication infrastructure	Cu, Al, Ge
Cellphones	Ta, Nb, Sb
Transport systems	Al, Mg, Ti, Sc, Th, Re, Nb, Ni, Mo, Co, Sm
Paints	Ti, Cr
Moulds	Zr
Fertilizers	Potash, phosphate, boron

*Elements in RED are no Production; elements in GREEN are short supply.

It has been discussed above that India has the right geological set up to host many more critical commodities than the ones that are currently being produced in India. It's important for India to urgently embark on the path of aggressive exploration investments to discover these commodities. Mineral exploration is a highly specialised activity and even the technical specialisation varies from commodity to commodity. Mineral exploration is also a highly risky business with the statistics of less than one in hundred exploration ventures leading to establishment of a mine. However, it has been realised that discovery of additional bulk commodities and critical commodities, which could stand the commercial mining tests, would require intensive and extensive exploration expenditure in India's Obvious Geological Potential areas.

Availability of India's geological survey data

Geological Survey of India (GSI) is India's premier agency carrying out systematic geoscientific data collection from the entire country and from various high priority geological target areas. While most other countries, including some of the finest mineral jurisdictions like Canada and Australia have their baseline geological survey data at 1: 250,000 scale, India on the other hand has the base geological map at a much higher 1: 50,000 resolution for almost 98% of the country. This high-resolution geological map, when seen in the context of India's two to five metre thick regolith / soil profile, gives a significant head start to India in terms of the understanding of the geological set up of the country compared to others like Canada, which has a till thickness of up to 150 m in some parts or like Australia, which has a residual profile of up to 50 m masking the basement geology.

Additionally, GSI has also collected the following critical datasets from large parts of India:

- National Geochemical Database of 64 elements for samples collected from the OGP area (ongoing)
- National Geophysical Mapping with Triaxial gradiometer magnetics and radiometrics at 300 m line spacing and a flying height of 60 m.
- Earlier GSI had also collected significant aeromagnetics, radiometrics and electromagnetics data at different flight specifications covering a large part of the country, and ground geophysical data including gravity, magnetics, radiometrics, and seismic information.
- Geomorphological datasets of India; which is also complimented by high resolution satellite multi-spectral data from India's indigenous satellite IRS / RESOURCESAT.
- Additionally, GSI is also a repository of many geological, geophysical, mineral exploration, specialised research, paleontology, petrology, and geochronology datasets and reports.

GSI is expected to continue updating and upgrading its systematically collected geoscientific datasets to align with the most modern geological surveys of the world. Over the years, GSI has gradually adopted a robust digital data dissemination policy, through their map portal called Bhukosh and their main information dissemination portal. GSI has already uploaded over 28,000 geological and exploration reports for projects it has executed in different parts of India. Additionally, GSI's Publication Division has been publishing scientific research reports through dozens of publications every year. This makes GSI's survey database and publications one of the most exhaustive datasets in the world. Additionally, Indian Bureau of Mines (IBM), Mineral Exploration Corporation Limited (MECL), and the Directorates of Mining and Geology (DMG) of most other state governments now have their own data dissemination portals, which are continually updating their digital mine administration databases.

Changes in India's minerals code

The latest changes in India's minerals code, MMDR 2015 (Amendment) and associated changes thereafter have attempted to remove all discretionary authorities, in accordance with India's Supreme Court's directive to bring in objectivity, fairness, and transparency in the mineral asset allocation process. MMDR 2015 adopted a process of dispensing mineral asset through E-auctions and 2-stage bidding. However, in the process of adapting to the new code, it also added an Evidence of Mineral Content (EMC) Rule, which necessitated having a definite understanding of UNFC G2 or G3 level Geological Resource through a previous exploration of the asset before any bidding. The adaptation of this rule has effectively removed the availability of explorable mineral assets for any private sector exploration and transferred the onus of exploration and discoveries to be channeled entirely through government funded projects. While the government has continued to pump in large sums of money in generating the baseline geoscience data, including the funding from National Mineral Exploration Trust (NMET), the actual investments in the risky mineral exploration in the OGP areas of the country for exploring high priority commodities have been one of the poorest in world. The state governments can ill afford to allocate scarce fiscal resources to extremely risky ventures. In order to meet India's mineral development needs, mineral exploration in India would require risky investments from private sector, which should be orders of greater magnitude than what we are getting today. This also means that India would have to be a competitive world-class exploration and mining destination for the best explorers, mining entrepreneurs, and companies in the world.

Key initiatives towards enhancing mineral exploration investments in India

India needs significant thrust and investments in its mineral exploration to cater to India's minerals security needs in the twenty-first century. India's large land mass has one of the finest geologies, mineralisation, and exploration potentials for both bulk and non-bulk commodities. Vision 2035 for mineral exploration in India envisages the creation of a globally competitive business environment, which would enable the best explorers and mining companies, in India and abroad, to consider high-risk investments in the mineral exploration potential of India.

Some of the key initiatives envisaged towards creating a competitive exploration investment environment and to meet with Vision 2035 for the Mining Sector must include the following:

1. Create a structured, predictable, transparent, fair, and objective permitting process for investors in India's mineral assets for exploration and development.
2. Assure investors of the security of title and tenure of their exploration assets to develop these assets from discovery, to establishing the Geological Resource, mine development, mining, processing, and marketing of ore minerals from these assets.
3. Additionally, the permitting system should not only allow investments in Greenfield exploration targets, but would also encourage brownfield exploration and discoveries around operating mines.
4. Upgrading and training statutory authorities in IBM and state DMGs to cope with the requirements of modernisation, digitalisation, and automation of the statutory process. A unified authority needs to be created - A much needed single regulatory authority has been envisioned in NMP 2019: "A unified authority in the form of an inter-ministerial body under Ministry of Mines, with members like Ministry of Coal, MoEarth Sciences, MoEFCC, Ministry of Tribal Affairs, Ministry of Rural Development, Ministry of Panchayati Raj, Ministry of Steel, including state governments, shall be constituted to institutionalise a mechanism for ensuring sustainable mining with adequate concerns for environment and socio-economic issues in the mining areas, and to advise the Government on rates of royalty, dead rent etc.".
5. Making high-quality geoscientific and other relevant datasets from GSI and other government agencies available in the public domain through their organisational portals, which could be used by commodity specialist exploration teams to carry out their own research and develop a better understanding of the mineral potential in any interest area.
6. Allowing Investors freedom in area selection while opening up large exploration potential blocks for exploration investments. No-go Areas would be clearly identified and marked.
7. Making asset (lease / permit) transfers for profit easier and allowing junior exploration and mining companies to function in harmony with major mining companies
8. India's exploration ecosystem would encourage investments in the exploration and development of both bulk and non-bulk commodities. Exploration of bulk commodities would focus on discovering the structurally hidden deposits and lower grade deposits, which could be optimally developed. Exploration for non-bulk commodities would encourage applying the best of the globally available exploration technologies and tools to not only explore the well-established mineral belts in India, but also to explore and discover in the hitherto underexplored belts of India's OGP for tech and other commodities.
9. India should incentivise risky exploration investments in the Greenfield belts and projects. Incentives shall also be provided for research and development in creation of new tools, systems, and processes in the entire value chain of minerals development – from exploration to mining to extraction to product development. India would strive to become a major technology development hub for the global exploration and mining industry. India would also aim at creating a world-class services and products sector for the exploration and mining industry, for both the Indian and global mining sector.
10. India should encourage the capital market to create an appropriate ecosystem for the exploration entrepreneurs to raise and manage risky exploration funding and report their results transparently through globally recognised reporting systems
11. India should also encourage universities and academic institutions to produce high-quality graduates, managers, and researchers in the field of geology, geophysics, geochemistry, geostatistics, environment, hydrology, hydrogeology, engineering geology, mineral economics, community relations management, mining health and safety, and other relevant domains

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