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Why we need a New Mineral Exploration Policy for National Mineral Security

Summary

Continuous exploration to locate new mineral deposits with regularity is the key to mineral resource security. Mineral concession systems *must* start by optimizing this end of the process. Exploration constitutes a high-risk activity given the apparent randomness of mineral occurrences and the uncertainties in locating minerals hidden beneath the earth’s surface. Exploration success depends on the use of the latest technologies to generate and use multidisciplinary datasets, and calls for specialization and expertise. As is the case internationally, the private sector should be incentivized to be the main source of funding of exploration, given the high risks involved particularly in the case of deep exploration. Needless to say, there are intrinsic difficulties in discharging accountability for judiciously using substantial public funds over long periods in such high-risk situations. The model of incentivizing “Junior” exploration companies funded by venture capital has worked well in advanced mining jurisdictions, such as Canada and Australia. The amendments made in 2015 to the Mines and Minerals (Development and Regulation) Act make auctions the only method of allocation of mineral concessions at prospecting and mining stages and it is left mainly to State Agencies to conduct the preliminary exploration. Auctioning of mineral concessions, while removing arbitrariness and “discretion”, also removes the incentives for the private sector to spend huge sums to conduct exploration since they will not get the mining rights in case of success. As the Supreme Court in its Opinion dated September 27, 2012, on a Reference by the President of India under Article 143(1) of the Constitution has opined, auction is not the only (or even the best) way of discharging a public trust in alienating natural resources, and in the case of minerals, “a fortiori, besides legal logic, mandatory auction may be contrary to economic logic as well”.

More and more exploration, to continuously locate more minerals, at greater depths, is necessary for ensuring India's mineral security. Minerals security has many dimensions, including commercial, economic, and strategic dimensions. A pragmatic system for grant of mineral concessions is necessary which can incentivize private sector investments in exploration while also ensuring best value for the extracted mineral resources. The Conclusion to this Paper gives a possible solution.

Introduction

The Ministry of Mines strategy paper '**Unlocking the Potential of the Indian Minerals Sector**', published in 2011, highlights India's relatively low position in the global mining sector. The paper trenchantly states:

"As the relevance of the mining sector grows globally, the Indian mining sector is lagging behind, with just 1.2 per cent contribution to GDP over the last decade (as opposed to 5 to 6 per cent in major mining economies) and very low exploration spend per square kilometre (USD 9 [₹400] compared to USD 124 [₹5,580] for Australia and USD 118 [₹5,310] for Canada).

India has initiated several progressive policy measures, putting itself in a good starting position to undertake the transformation of the mining sector. Unlocking the potential of the mining sector in India could add around USD 210 billion to USD 250 billion (₹945 to 1,125 thousand crore) or 6 to 7 percent to the GDP and create 13 to 15 million jobs through direct and indirect contribution by 2025.

To achieve this, action is required on six key priorities, including enhancing resource and reserve base through exploration and international acquisition; reducing permit delays; putting in place core enablers (infrastructure, human capital, technology); ensuring sustainable mining and sustainable development around mining; creating an information, education, and communication strategy; and undertaking measures to ensure implementation."

India has significant potential for further exploration as the Indian continental landmass and its offshore consist of several Cratons (crustal masses) going back to the oldest geological periods. India is blessed with ample resources of a number of minerals and has the geological environment for many others. The National Mineral Policy 2008 (NMP 2008) spells out in detail the direction that the mineral development of this country should take in order to discover and exploit these resources. It is based on a review of the successes and failures of the earlier National Mineral Policy 1993 (announced soon after economic liberalization in 1991) analysed in the

report of the high-level Committee (also known as the Hoda Committee), constituted for the purpose.

One of the main thrusts of the Policy, based on the Hoda Committee recommendations, is that to exploit the country's geological potential for the sustainable development of the country, it is important to carry out scientific and detailed prospecting in search of its mineral resources. In particular, it needs to be ensured that regional and detailed exploration is carried out systematically in the entire geologically conducive mineral-bearing area of the country using state-of-the-art techniques in a time-bound manner.

As a major resource for development, the extraction and management of minerals has to be integrated into the overall strategy of the country's economic development. In this context, there is a need to invest significantly in detailed prospecting. As has been detailed in the Ministry of Mines Strategy paper 'Unlocking the Potential of the Indian Minerals Sector' referred to earlier, investment for exploration needs to be heavily boosted as India's past investments have been almost negligible (see Figure 1). The exploration for minerals has to be guided by long-term national goals and perspectives. Just as these goals and perspectives are dynamic and responsive to the changing global economic scenario, the application of the national mineral policy and consequent strategies has to be equally robust taking into

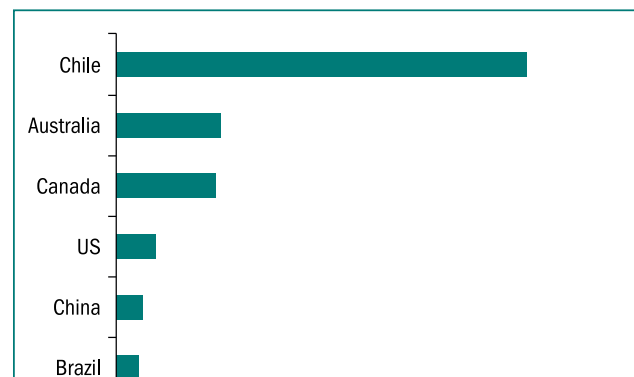


Figure 1: Investment in exploration by select countries

Source: Ministry of Mines, 2011. 'Unlocking the Potential of the Indian Minerals Sector', Strategy Paper for Ministry of Mines

the changing needs of industry in the context of the domestic and global economic environment.

Table 1 provides an overview of the current comparative exploration allocations across the globe according to S&P Global Market Intelligence Data. As a pattern it reflects both the country's prospectivity for minerals as well as the attractiveness of the country's mineral laws for inviting investments. While Canada and Australia have been leaders in exploration for a long time, the emergence of Latin American countries, as hubs of exploration, is directly related to the reforms they have undertaken post 2000 to promote exploration through ease of grant of concessions and stability and predictability of their mineral laws which are translating into higher returns on investment.

Table 1: Country share in global exploration budget 2017	
Country	Percentage share in the global exploration budget
Canada	14 %
Australia	13%
United States	7%
Mexico	6%
Peru	6%
Chile	6%
Other Latin America	6%
Brazil	4%
Europe	5%
West Africa	5%
East Africa	2%
DR Congo	2%
South Africa	4%
Russia	5%
China	6%
Pacific/South East Asia	5%
Former Soviet Union (FSU)	1%
Others	3%

Worldwide Mining Exploration Trends 2017, S&P Market Intelligence Data

The pattern and size of global budgets for exploration has a close relationship with commodity trends in the various metals, and is also a pointer to future uptrends since it takes several years for exploration investments to yield tangible results and still more time for it to translate into mineral production. Currently, the largest proportion of exploration spends are in gold, diamonds, and base metals. Given its geological make-up, India is highly prospective for all three, and as such the low proportion of global exploration investment coming to India cannot be said to be due to the low geological potential or low mineral prospectivity.

Exploration as part of the larger strategy of mineral development

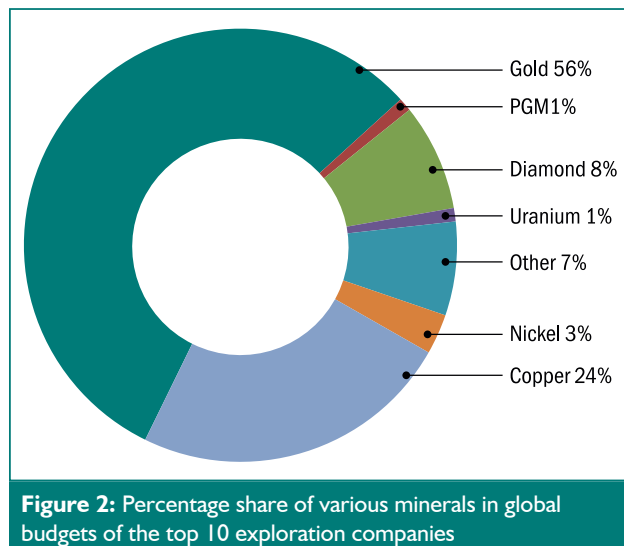
As laid out in the National Mineral Policy, the strategy for development of any mineral should naturally keep in view its ultimate end uses in terms of demand and supply in the short, medium, and long term. Considerations of "inter-generational equity" should be addressed "positively" through exploration to further enhance the current potential resources rather than thorough abstinence from consumption or preservation for use in the distant future. Given its geological evolution, the fact that India is highly prospective for minerals must be leveraged through the discovery of new mineral resources on a continuous basis through the latest technologies. Historical evidence in advanced mining jurisdictions shows that in the case of common minerals of widespread use, such as iron ore and limestone, exploration more than replaces the stock of resources consumed through mining. A case in point is Australia whose iron ore resources have increased a hundred fold in 40 years through a process of increased exploration and beneficiation, as cited in the Hoda Committee Report 2006.

As the National Mineral Policy rightly says, conservation of minerals should be viewed as a positive concept leading to the augmentation of the reserve base through improvement in mining methods, beneficiation, and utilization of low-grade ore and rejects the recovery of associated minerals. Over time, the grades may go down and extraction costs may rise as accessibility becomes more expensive, but since the process occurs in a globally networked context, preserving high grades for the future and denying oneself access to resources that are critical for current growth may

be counterproductive, particularly at moments when growth momentum needs to be built up to a level where it can become self-sustaining.

Global exploration trends

With vast resources lying unexplored, survey and exploration is the first step towards developing domestically available minerals for internal utilization in infrastructure, capital goods, and basic industries. Globally, economies with a large mining base or potential resources have projected significant spends (public and private) for exploration; however, Indian exploration budgets are still limited. It also needs to be noted that while the global investments in exploration have been rising in many countries, particularly after a reform process, a similar trend is not visible in the Indian subcontinent. A study on the Corporate Exploration Strategies (CES) of global companies by S&P Global Market Intelligence for the year 2016 highlights that the 20 companies with the largest non-ferrous exploration budgets in 2016 accounted for 31% of the global exploration of around \$7 billion. The report also highlights that the top 10 companies accounted for \$1 out of every \$5 that was being spent on exploration globally. Copper, gold, and diamonds accounted for 88% of the total exploration budgets of the top 10 companies (see Figure 2).



International exploration budgets are allocated based on the attractiveness of destinations. According to Fraser Institute Annual Survey of Mining Companies 2016, Asia has the least attractive policy environment in the world. The Fraser Annual Survey undertakes a

survey of countries globally to analyse their investment attractiveness and policy environment. The survey looks at various policy areas, such as mineral administration, enforcement of regulations, environmental regulations, legal and taxation regime, land, infrastructure, socioeconomic issues, political and security concerns, trade issues, etc., for analysis. India has been ranked 88 in the Policy Perception Index, 94 in the Best Practices Mineral Potential Index, and 97 amongst 104 jurisdictions for Investment Attractiveness Index which is a composite index that combines both the Policy Perception Index and results from the Best Practices Mineral Potential Index (see box).

Fraser Annual Mining Survey 2016

The Fraser Institute is a Canadian think tank that publishes the Annual Mining Survey and other publications on exploration and mining every year. The Fraser Annual Mining Survey of 2016 covered 104 mining jurisdictions (States/Provinces or Countries) across the globe and ranks their mineral potential and mineral policy framework. The survey highlights where each jurisdiction stands in overall investment attractiveness.

The top jurisdiction in the world for investment based on the Investment Attractiveness Index for 2016 is Saskatchewan (Canada) and Manitoba (Canada) moved up to the second place this year after ranking 19th in the previous year. Western Australia was third and the others were Nevada (USA), Finland, Quebec (Canada), Arizona (USA), Sweden, the Republic of Ireland, and Queensland (Australia).

The Argentinian province of Jujuy ranks as the least-attractive jurisdiction in the world for investment. Also in the bottom 10 are 4 other Argentinian provinces as well as Venezuela, Afghanistan, India, Zimbabwe, and Mozambique.

The emerging scenario clearly implies a major challenge for enhancing investment in mineral exploration and also highlights an urgent need to undertake major transformation in the mineral sector from both policy as well as implementation-related perspectives.

National Mineral Policy 2008: Changes to the enabling environment

One of the main reasons why the National Mineral Policy 2008 (NMP 2008) replaced the National Mineral Policy of 1993 was because it had failed, inter alia, to bring in the expected investments in exploration. The announcement of NMP 2008 led to a large number of legislative as well as non-legislative actions for sector reform and reorienting of priorities. Of these, the restructuring of the Geological Survey of India (GSI)

in 2009 in the form of 5 Missions is perhaps the most significant non-legislative action completed (the other major non-legislative initiative, still underway, is the creation of an on-line GIS-based Mining Tenement System by the Indian Bureau of Mines). The reform is intended to ensure that the GSI is well able to discharge its responsibility as the principal agency for geological mapping and regional mineral resources assessment of the country. The GSI needs to ensure that its regional surveys for baseline data collection cover all major geo-scientific datasets, including geology, magnetics, electromagnetics, spectral, gravity, geochemistry, etc. and is in line with best international practices. It also needs to undertake measures to publish all pre-competitive data, including spatial data in the Geographical Information System (GIS) environment to facilitate entrepreneurs to take investment decisions for exploration and when making applications for grant mineral concessions. Many of these datasets, though requiring high investment of funds and manpower, give very high returns through the discovery of new mineral deposits. GSI also needs to look at capacity issues in terms of experienced geoscientists and state-of-the-art equipment, both crucial constraints that need to be overcome in order to ensure availability of geochemical and geophysical regional baseline maps as per the current best practice, that is, on 1:50,000 scale. It is well known that the upsurge of exploration and mining in China was a consequence of their systematic geochemical mapping in the previous decade and there is no reason why such an upsurge should not happen in India as well.

GSI's progress in geoscientific survey and mapping (on 1:50,000 scale) has been substantial but not adequate:

- Geological mapping: 95% completed
- Geophysical mapping: 20% completed
- Geochemical mapping (for 68 elements including rare earth elements): 16% completed
- Aerogeophysical mapping: systematic programme commencing in three phases in 2017
- Geomorphological mapping (including lineaments): completed in 2010
- Hyperspectral mapping: completed in 2009

GSI has also revamped its Portal and rolled out the Online Core Integrated System (OCBIS) application which enables display of spatial data from regional mapping as well as large-scale maps from the field investigations; the

application enables the integration of third-party data such as that obtained from reconnaissance surveys by concessionaires.

National Mineral Policy 2008: Changes to the legislative framework for exploration

On the legislative side, the Mines and Minerals (Development and Regulation) Act 1957 (MMDR Act) was amended in 2015 (and Rules were notified thereunder) with the intention of removing discretion and introducing more transparency in the allocation process. The Hoda Committee had advocated the auction of “fully prospected” mineral deposits and encouragement of exploration under a risk-reward system incentivizing the use of high technology for locating deeper mineral occurrences. The National Mineral Policy 2008 generally adopted the direction advocated by the Hoda Committee. The amendments to the MMDR Act, 1957, made in January 2015, however, provide that mineral concessions will be granted only on the basis of bidding, for the prospecting stage or mining stage as the case may be (Section 10B(2) and 11(2), respectively). The Mineral (Auction) Rules 2015 notified under the MMDR Act specifies the auction procedures. The Mineral (Evidence and Mineral Contents) Rules 2015 also notified under the MMDR Act specifies that for the prospecting stage, the data needs to comply with the United Nations Framework Classification (UNFC) standard of G3 (Preliminary Exploration); for mining it needs to comply with the G2 (General Exploration) standard. These standards lay down the extent to which geological, technical, and economic parameters have to be investigated, including drilling, sampling, and mineralogical analysis.

The amendment to the MMDR Act in January 2015, replaces the earlier process of granting Reconnaissance Permits on a first-come-first-served basis with a system of Non-Exclusive Reconnaissance Permits (NERP) (Section 10C, MMDR Act). The Mineral (Non-Exclusive Reconnaissance Permit) Rules 2015 issued under the Act specify the procedures. Section 10 C of the Act, which provides for the grant of the Permit, also states that a NERP holder shall have no right to claim for a prospecting licence or a mining lease on the basis of his reconnaissance. The intention is that the data discovered

in an NERP will be used to conduct further exploration by the government agencies so as to auction a mineral find. The NERP Rules 2015 states in Rule 4 (1) that the NERP holder can submit his data and ask the government to auction the find.

The Hoda Committee, too, had recommended introduction of non-exclusive reconnaissance permits under an “open sky policy” so as to quickly complete a preliminary survey of the country’s landmass for evidence of mineralization. The Hoda Committee had recommended the “Large Area Prospecting Licence” (LAPL) as a key element of its strategy to speed up exploration and induct high technology for the purpose along with private investment. The NERP instrument devised through the newly added Section 10 C, however, is not an adequate incentive for anyone to expend funds on reconnaissance in what is internationally perceived as a high-risk high-reward game, and large investments from the private sector generally and foreign investments in particular (which bring in special expertise and high technology as well) in this area may not be likely. The Hoda Committee analysis of the key role of venture-capital based specialized exploration, including exploration through “Junior” exploration companies, has many implications which can be ignored only at the cost of undiscovered mineral wealth. The Junior Exploration Companies are funded by venture capital raised on the Toronto Venture Capital exchange and other similar institutional innovations, and such capital will be available only if the mineral discoveries made using the funds can be quickly monetized by acquiring the mining rights or selling the data to companies who can do so. Introduction of an auction system will disrupt this process. The fact that Section 8A(2) of the Act now mandates that the mining lease would be a non-renewable 50-year, lease places a general cap on the exploration spend for a large world-class prospect, assuming that the other conditions mentioned above did not operate as a disincentive.

The fact that NERP Rule 4(2) enables the State Government to seek further information from the NERP holder, and proviso to Section 10B(6) of the Act read with Rule 6(3) and 6(4) of the Mineral (Auction) Rules 2015 which enables the State Government to reserve a mine (at mining lease stage) for a particular end use while seeking bids in an auction, only increases the difficulty in monetizing an exploration find. The last straw may be the eligibility conditions required under

the Mineral (Auction) Rules 2015, which require a first-stage bidder (the entity incorporated in India) to have a net worth equal to 4% in case of a mining lease-stage bid (1% in the case of a prospect-stage bid) of the value of the estimated resources. This clearly rules out the “Juniors” in relation to even a moderate-size mineral find.

The amendments made to the MMDR Act in 2015 provide for the creation of the National Mineral Exploration Trust (NMET) under Section 9C of the Act. The Trust is funded by a 2% cess on the royalty and assuming an annual royalty flow of ₹20,000 to ₹30,000 crore (including coal royalty) the funds accruing to the Trust will be of the order of ₹600 crore per annum (or \$100 million per annum). While this is much higher than the current spending level in the region of \$5 million a year (mostly on coal exploration), this is clearly a drop in the ocean compared to the exploration expenditures in countries such as Australia (US\$ 900 million p.a.) and Latin America (US \$1200 million p.a.). It would appear that the Trust can cover only some of the huge expenditure that is entailed in stepping up the pace of exploration and may not be able to adequately capture the spirit of the high-risk high-reward paradigm (see the section on the National Mineral Exploration Policy below).

The Trust funds are currently used to fund detailed exploration activities of the GSI and Central PSUs, including MECL. There is a danger that the Trust funds may take GSI away from its primary work of baseline surveys from geology, geophysics, and geochemistry into the quicksand of detailed exploration for minerals. There is also a distinct possibility that GSI, which post restructuring is inducting expert manpower, may not be able to muster the scientific personnel to conduct a detailed exploration on a mass scale with the requisite expertise (as well as the experience), particularly for deeper deposits of base metals, noble metals, and gemstones. The entire strategy for exploration may actually need to be analysed further from the point of view of ensuring that GSI’s work of baseline data collection is not disrupted on the one hand, and funds and expert resources for exploration flow are unhindered on the other.

National Mineral Exploration Policy (NMEP) 2016

A National Mineral Exploration Policy (NMEP) has been brought out by the government in 2016 to give

further momentum to exploration efforts. The Policy purports to:

- Permit the engagement of private agencies to carry out exploration work in identified blocks/areas with the right to a certain share in the revenue (by way of a certain percentage of royalty/premium) accruing to State Government throughout the lease period, with transferable rights. The Policy states that this percentage/amount will be paid by the successful bidder to the concerned exploring agency and will be determined when mineral blocks on the basis of successful exploration are put on e-auction;
- Promote revenue sharing, which could be either in the form of a percentage of royalty/premium for the concession period (of 50 years) or a lump sum amount, to be calculated on the basis of the net present value of that share of royalty/premium to be accrued during the lease period. The Policy also indicates that these exploration agencies will be allowed to participate in e-auctioning when mineral blocks after successful exploration are put on auction; and
- Move towards working out normative cost of exploration for different kinds of minerals so that the exploration agencies could be compensated, in case they do not discover any mineable reserves in their respective areas. This is seen to be an added incentive for exploration agencies to mitigate their risk.

The intention of the Policy is that the preliminary work will be done by public agencies (and their private nominees) so that the data gathered can be used to auction any mineral occurrences, and thus maximize revenues. The National Mineral Exploration Policy in paragraph 15.1 states that: *“State Governments have a key role to play in building up a steady stream of auctionable mineral prospects. They will have to take up mineral exploration reports prepared by the GSI or other agencies and build on them to complete G3 or G2 level of exploration. States also need to build up the exploration capabilities of their staff. The Central Government will have to provide suitable incentives to expedite this process. Capacity building of States will be supported by the NMET.”*

Ensuring that mineral finds are explored to G3 or, better still, G2 levels require substantial ground-level work and expenditure, with the attendant risk of infructuous expenditure, in case the find is not

really exploitable for technical or commercial reasons. Currently, the capacity of these public agencies is severely limited in terms of geoscientific and technical resources. Substantial investments (including financial equity in the case of PSUs and budget support in other cases) will have to be made to build up capacity to conduct detailed exploration and efficiently use modern technology to locate concealed mineral deposits. Mineral exploration for concealed or deep-seated minerals also requires substantial multidisciplinary expertise that can only be built up over time.

Though the Policy is still in the process of being rolled out and “Expressions of Interest” from private agencies have been invited, there are clearly several issues that need deeper consideration:

- The exploration work of the private agencies is not covered by the current legislative framework which provides for an NERP. Presumably the agencies will be notified under the second proviso to Section 4 of the MMDR Act, which, for the purpose of an exploration licence, earlier exempted the Geological Survey of India, the Indian Bureau of Mines (IBM), the Atomic Minerals Directorate (AMD) of the Department of Atomic Energy of the Central Government, the Directorates of Mining and Geology of the State Governments, and the Mineral Exploration Corporation Limited (MECL), and has been amended in 2015 so as to exempt any other “entity” notified for the purpose. However, this may imply that the agencies will not be subject to the direct regulatory control of the IBM in terms of the Mineral Concession Rules 1960 and the Mineral Conservation and Development Rules 2017 (replacing the earlier Rules of 1988), as would be the case with a concessionaire.
- The agency is sought to be compensated in two ways; a normative cost will be worked out and the agencies compensated (presumably out of the Trust funds) in case they do not make a find. In case they do make a find, they will share part of the revenue accruing to the State Government from the auction. In fact their selection as a partner would be on the basis of their bid in this respect. This is clearly a very substantial incentive, and may incentivize “Juniors” in case the block for exploration is large enough to make it worth their while.
- The provision that such agencies may also bid in the auction itself, however, raises many issues,

including that of a level-playing field, as well as the true competitiveness of their bid for a revenue share which is the basis of their selection. The possibility that they may not share all the data in order to enjoy an advantage cannot be discounted.

- As already stated, the annual accrual into the National Mineral Exploration Trust is of the order of ₹600 crore (\$100 million); a significant proportion will be reserved for bringing prospects to G3 or G2 level through the GSI, Central Mine Planning and Design Institute (CMPDI), MECL, and State Directorates of Mining and Geology. Capacity building of the States will also need to be undertaken out of Trust funds as mentioned in paragraph 15.1 of the NMEP. The amount available to fund private exploration from the Trust funds for exploration under the NMEP is, therefore, likely to be limited. Thus, though the NMEP in paragraph 11.2 advocates the development of a mechanism by IBM to periodically fix national priorities for exploration, it is difficult to see a major expansion in exploration for deep-seated and concealed mineral deposits or for identified strategic or other minerals identified on the basis of a prioritization process.

As the mining sector takes off, the country will need more and more mining engineers, geologists, geophysicists, geochemists, and geo-informatists. A comprehensive review of the sector's manpower was undertaken through a study by the Confederation of Indian Industry (CII) in 2011 in the form of *The Skill Mapping Report* commissioned for the Ministry of Mines. Based on that, the strategy paper for the Ministry of Mines titled "Unlocking the Potential of the Indian Minerals Sector", has estimated that in the period up to 2025, there will be a need to produce some 3,000 geoscientists and 40,000 mining engineers *over and above the normal supply*. The MMDR Act's current emphasis on exploration predominantly by government agencies adds to the urgency of ensuring the availability of appropriate human resources in a sector where experience is as important as expertise.

Transparency in exploration

The amendments made in the MMDR Act in 2015 were mainly actuated by the desire to reduce undue discretion and arbitrariness in the allocation of concessions which are a source of potential corruption and to increase

the revenue from the alienation of a public resource in favour of a private party. Price discovery through auctions has been incorporated into the law both to reduce arbitrariness (and provide equal opportunity as provided in Article 14 of the Constitution) and to enable a transparent price discovery. However, as the Supreme Court in its Opinion dated September 27, 2012, on a Reference by the President of India has stated, (Special Reference No.1 of 2012 under Article 143(1) of the Constitution of India), auction is not the only way of discharging a public trust while alienating natural resources. As the Court has stated: "*Therefore, in conclusion, the submission that the mandate of Article 14 is that any disposal of a natural resource for commercial use must be for revenue maximization, and thus by auction, is based neither on law nor on logic... besides legal logic, mandatory auction may be contrary to economic logic as well. Different resources may require different treatment. Very often, exploration and exploitation contracts are bundled together due to the requirement of heavy capital in the discovery of natural resources. A concern would risk undertaking such exploration and incur heavy costs only if it was assured utilization of the resource discovered; a prudent business venture, would not like to incur the high costs involved in exploration activities and then compete for that resource in an open auction.*"

As has been brought out in this Paper, and in fact anticipated by the Court as is evident from the extract above, auctions have resulted in the potential for exploration investments being seriously impacted. While it may be argued that auctions at least enable independent and fair price discovery, the fact is that till exploration processes become transparent in their own right, the valuation for auction purposes will always be subjective and prone to error, and as such the price discovery may be seriously flawed, with the "winners curse" on the one hand and the "windfall profit" on the other becoming the Scylla and Charybdis of the sector.

Currently Rule 9 of the Mineral (Auction) Rules 2015 refers to "mineral resources" as a bidding parameter and to the Geological Report as the information base for bidding for mining leases, and Rule 17 has a similar provision with respect to bidding for prospecting (composite) licences. The framework for estimation of the mineral resources for bidding for mining stage and prospecting (composite) stage are given in the Minerals (Evidence of Mineral Contents) Rules 2015 and is called the UNFC Framework (see box).

The requirement in the Minerals (Evidence of Mineral Contents) Rules 2015 is that for a mining lease, at least General Exploration (G2) should have been completed to establish the Indicated Mineral Resource (332); for prospecting (composite) licence, the requirement is that Preliminary Exploration (G3) should be completed to

establish the Inferred Mineral Resource (333). As is clear, the E and F axes are not required under the provision to be “2” or “1”, implying that beyond the geological report, there is no requirement for a pre-feasibility study and estimation of potentially economic resources (much less a feasibility study).

United Nations Framework Classification (UNFC)

The classification system used in the Minerals (Evidence of Mineral Contents) Rules 2015 (and also described therein) is the United Nations Framework Classification (UNFC), which classifies mineral finds on a 3-digit code (E, F,G) where E is the *Economic* axis; F is the *Feasibility* axis, and G is the *Geological* axis. The exploration for any mineral deposit involves four stages on the geology axis, namely, Reconnaissance Survey (G4), Preliminary Exploration (G3), General Exploration (G2), and Detailed Exploration (G1). These stages of exploration lead to four resource categories, namely, Reconnaissance Mineral Resource, Inferred Mineral Resource, Indicated Mineral Resource, and Measured Mineral Resource, respectively reflecting the degree of geological assurance. An Intrinsically economic (E3) and feasible (F3) rating is available through a Geological Study. Depending on the extent of exploration, and based on a geological study, a mineral find would be classified in a three-digit code, (3, 3, 4), (3, 3, 3), (3, 3, 2), or (3, 3, 1) as the case may be (the change from “4” to “3” to “2” and to “1” in the third digit reflecting the increased exploration). Prefeasibility (F2) or feasibility (F1) study must be conducted to establish potentially economic (E2) and economic (E1) quantities and convert the relevant portions of the “Mineral Resources” to “Mineral Reserves” which is the economically mineable part of the Mineral Resource. This conversion through modifying factors include issues relating to mining, processing, end use, cut off grade, threshold value, metallurgical, infrastructure, economic, marketing, legal, environmental, social, and governmental factors.

[note: The three digit code (E,F,G) may also be expressed without the commas, as (EFG);for example “(3,3,2)” as “(332)”.]

When adequate exploration has been done (that is, at least general exploration or G2) and some feasibility study has been conducted to estimate the economic or potentially economic nature of the find and its practical extractability, the resource (or reserve in case economics of extraction have been established), the mineral find can be classified into one of the following :

- *Probable Mineral Reserve* (121 and 122) is the economically mineable part of an Indicated, and in some circumstances, a Measured Mineral Resource. The confidence in the Modifying Factors applying to a Probable Mineral Reserve is lower than that applying to a Proved Mineral Reserve. (The *modifying factors* relate to mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social, and governmental factors, which impact technical and economic feasibility.)
- *Proved Mineral Reserve* (111) is the economically mineable part of a Measured Mineral Resource. A Proved Mineral Reserve implies a high degree of confidence in the Modifying Factors.
- *Feasibility Mineral Resource* (211) A ‘Feasibility Mineral Resource’ is that part of a Measured Mineral Resource which is not economically mineable as defined by studies at the feasibility level. This material is identified as being possibly economically viable subject to changes in technological, economic, and environmental and/or other relevant conditions.
- *Pre-Feasibility Mineral Resource* (221 and 222) A ‘Prefeasibility Mineral Resource’ is that part of an Indicated, and in some circumstances, Measured Mineral Resource, that has been found by studies at the Pre-feasibility level, as not economically viable. This material is identified as being possibly economically viable subject to changes in technological, economic, and environmental and/or other relevant conditions.

The Mineral (Evidence of Mineral Contents) Rules incorporate the provision for a pre-feasibility report in Part V of the Schedule to the Rules and states in Rule 4 that a legacy concession holder of a prospecting licence, in order to claim a mining lease under the earlier provisions, must have carried out at least General Exploration (G2 level) over the area to establish Indicated Mineral Resource (332); and prepared at least a pre-feasibility study (F2) report to establish a probable mineral reserve (121 and 122) conforming to Part V of the Schedule. However, the same standard has not been applied for the auction of leases and what are being auctioned are

likely to be “resources” whose potential for economic extraction has not been established with any substantial degree of confidence rather than “reserves” which may be economically mineable or potentially mineable under favourable price conditions.

There are other classification systems, such as the Australian JORC Code or its counterpart the Canadian National Instrument 43.101. The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (‘the JORC Code’) is a professional code of practice that sets minimum standards for public reporting of mineral Exploration Results, Mineral Resources and

Ore Reserves. The JORC Code provides a mandatory system for the classification of mineral Exploration Results, Mineral Resources and Ore Reserves according to the levels of confidence in geological knowledge and technical and economic considerations and for their reporting in Public Reports. Public Reports prepared in accordance with the JORC Code are for the purpose of informing investors or potential investors and their advisors. They include annual and quarterly company reports, press releases, information memoranda, technical papers, website postings, and public presentations of Exploration Results, Mineral Resources and Ore Reserves estimates. The Australian Securities Exchange and the New Zealand Stock Exchange both require publication of reports in accordance with the JORC Code for all solid minerals, including diamonds, other gemstones, industrial minerals, and coal.

In the JORC Code, a Public Report is the responsibility of the company acting through its Board of Directors. Documentation must be prepared by, or under the direction of, and signed by a Competent Person. A 'Competent Person' is a minerals industry professional who is a Member or Fellow of The Australasian Institute of Mining and Metallurgy, or of the Australian Institute of Geoscientists, or of a 'Recognized Professional Organization' (RPO). A Competent Person must have a minimum of five years relevant experience in the style of mineralization or type of deposit under consideration and in the activity which that person is undertaking. If the Competent Person is preparing documentation on Exploration Results, the relevant experience must be in exploration. If the Competent Person is estimating, or supervising the estimation of Mineral Resources, the relevant experience must be in the estimation, assessment, and evaluation of mineral resources. If the Competent Person is estimating, or supervising the estimation of Ore Reserves, the relevant experience must be in the estimation, assessment, evaluation, and economic extraction of ore reserves.

The JORC Code has a checklist or reference for use by those preparing Public Reports on Exploration Results, Mineral Resources, and Ore Reserves. It is the responsibility of the Competent Person to consider the criteria listed in the checklist and any additional criteria that should apply to the study of a particular project or operation.

As in the case of the UNFC, in JORC, Exploration Results are translated into "resources" based on

the extent of geological knowledge and thence into "reserves" based on modifying factors relating to mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social, and governmental factors, which pertain to technical and economic feasibility.

While in principle, the system is not too different from the UNFC system described earlier, the JORC framework provides for a regular process of public reporting of the exploration progress and the results prepared by independent third-party professionals which imparts a high degree of transparency and credibility to the Exploration Results and estimation of resources and reserves. The use of the JORC Code and the processes embedded therein can impart a high degree of confidence to valuations for the purposes of Mergers and Acquisitions (M&A), and in fact is used for such purposes internationally and is recognized by the Stock Exchanges, Financial Institutions, and M&A Advisors.

The current system of auctions of "mineral resources" under the MMDR Act based on G2-level data for mining leases and G3-level data for Composite licenses (which corresponds to [332] and [333], respectively as per UNFC classification) has several potential problems arising out of the uncertainty of the estimations. As mentioned in paragraph 15.1 of the NMEP, the aim is to build a steady stream of auctionable prospects by funding State Governments through the NMET to produce G3- or G2-level reports. The estimations are being done by agencies of the same entity (that is, the government), which stands to benefit from the auction and an "arms-length" principle does not seem to be in place, and the data is not subject to any third-party check or verification. Additionally, as has already been mentioned, 332- and 333-level exploration is not enough to quantify an economically mineable or a potentially economically mineable reserve, and expert knowledge based on all the available evidence needs to be brought to bear to make a valuation for auction purposes, specifying the assumptions and projections. A prefeasibility report is essential in such circumstances, and in the interest of a level-playing field, the standard applied to the auction of mining leases should not be lower than that required for transiting from prospecting to mining under the old (non-auction) provisions of the MMDR Act.

The adoption of a robust and more transparent exploration reporting, such as the JORC Code or

its equivalent, is thus an urgent necessity to make the auction process in India more reliable, credible, transparent, equitable, and investment friendly. This is particularly important if private agencies are engaged, as proposed under the NMEP, to explore prospects using NMET funds, and all the more so if they are to share the revenue stream and even participate in the auction itself. The JORC process would involve regular public reporting of Exploration Results and the estimation and valuations by “Competent Persons” who will be independent third parties.

Regulation of exploration activity

Exploration, as in the case of mining, requires regulation. The IBM and the State Directorates need to be strengthened with manpower, equipment, and skillsets in order to be able to discharge their regulatory responsibilities. They need to ensure that exploration takes place in accordance with the terms and conditions of the licence and in the larger interest of promoting discovery and exploitation. The regulatory systems need to be provided with the necessary teeth through the legislative framework to make the sector more conducive to investment and technology flows. The amendment to the MMDR Act has increased the range and scope of work of the IBM and the State Directorates (by making auctions as the only mode of granting mineral concessions), particularly with regard to ensuring accuracy of mineral resource estimations and mineral reserve valuations, which are specialized activities requiring the development of credible and multi-disciplinary expertise. Capacity building for this purpose has to be a high priority if the intention behind adopting the auction route is to be realized.

The National Mineral Policy actually takes a wide-angle view of regulation and speaks of an arm’s-length between State Agencies that mine (and indeed explore as well) and agencies that regulate. While the IBM has no exploratory function, the State Directorates may have and the arm’s-length principle has to be systemically and transparently incorporated. Given the complex and widespread nature of regulatory deficit generally in the mining sector, perhaps the time has come to create independent Mining Regulatory Authorities for oversight at State level to restore investor confidence and to ensure that the primary regulatory mechanisms for exploration (as well as mining plans and closure plans)

operate transparently and reliably to internationally recognized technical standards. These authorities must also ensure that data generated from regional exploration is adequately integrated with national spatial datasets maintained with the GSI and resource estimations from detailed exploration is adequately and reliably reflected in the data of reserves and resources. The NMEP in paragraph 8 mentions the need for a National Geoscience Data Repository and Drill Core libraries; however, these need to be statutorily created so that data inflow, management, and use are all properly regulated.

“Exploring in India” for “Making in India”

As the country develops and industry and manufacturing grows impelled by the “Make in India” policy, assured availability and proximity of mineral resources will play an important role in giving a competitive edge to the Indian industry in general and manufacturing in particular. The IBM, while determining the national priorities for exploration, as contemplated in paragraph 11.2 of the NMEP, needs to make assessments with regard to India’s long-term mineral security. In particular, emphasis needs to be given to the co-production of by-product metals from base metal ores through process R&D so that the country’s needs of the so-called Technology Metals and Energy-Critical Metals are effectively met. Needless to say, this will provide raw material security on the one hand and a competitive edge on the other for the country’s manufacturing sector. Exploration should not only increase revenues, but should also improve India’s mineral security and competitive edge.

As the National Mineral Policy 2008 rightly recognizes, it is necessary to attract investments attached with high technology so that base metal, noble metal, and other deeper mineral occurrences can be detected and assessed for commercial exploitation. These are issues not merely of mineral exploration but of resource security with respect to widely used industrial metals, such as Copper, Lead, and Zinc; fertilizer minerals, such as Phosphates; the Platinum group of elements, and now, in the context of sophisticated applications, including renewable and non-fossil energy applications, the Technology Metals, that is, Molybdenum (Mo), Rhenium (Re), Tellurium (Te), Selenium (Se), Germanium (Ge), Cadmium (Cd), Indium (In), Gallium (Ga), Vanadium(V), Scandium (Sc), and Energy-Critical Metals, such as

Gallium (Ga), Germanium (Ge), Selenium (Se), Indium (In), and Tellurium (Te); and of course the Rare Earth Metals and Atomic Metals.

A study by The Council for Energy, Environment and Water (CEEW) titled “Critical Non-Fuel Mineral Resources for India’s Manufacturing Sector: A Vision for 2030” states as follows:

“A clear understanding at the national level, of India’s mineral resource base, is a prerequisite for any kind of strategic planning for resource security. Currently, less than 10% of India’s total landmass has been geo-scientifically surveyed for an assessment of the underlying mineral wealth. This is a big deterrent for private exploration agencies to invest, as they require good base line data to justify risky investments. Further, the recently amended MMDR Act, 2015 advocates for a transparent regime for the grant of mining leases, but certain provisions such as the non-exclusive reconnaissance permit act as deterrents to private investment. The expectation of returns when risk capital is employed is also high and provisions of royalty to RP holder (from the subsequent miner) are not seen as lucrative.

*As recognised by the NMEP (2016), a prioritisation of exploratory activities is essential to make best use of the limited amount of resources available with the government. The study (i.e the CEEW study) proposes a useful decision-tree analysis, overlaid with indicators of criticality of specific mineral, which then provides a priority order for exploration efforts. This is not a definitive approach but also identifies interventions at other levels – trade, recycling or finding technical substitutes. The study also highlights minerals with low or no reserves in India, and the ones, which are available only as an associated, or by-product from other mineral processing. These include **bismuth, cadmium, gallium, germanium, indium, molybdenum, rhenium, selenium and tin**, and all require specific attention at the national level.”*

Clearly the paradigm for mineral resource security in India is one where exploration priorities are determined keeping in view the medium-term requirement for minerals and development of processes through R&D to ensure optimum extraction of those minerals and metals which are identified in the prefeasibility studies as requiring process R&D for their economic extraction.

R&D to take exploration results forward

Efforts will need to be directed towards the development

of new technologies and processes for improving the feasibility of conversion of the existing mineral resources into viable economic resources and reserves. In many cases, the technology or the knowledge needs to be sourced from advanced mineral jurisdictions (and locally customized), perhaps as part of FDI. As advocated by the NMP 2008, attention needs to be given to beneficiation and agglomeration techniques to bring lower grades and finer particle-size material into use. Research organizations, including the Mineral Processing Laboratories of the IBM will need to be strengthened for the development of regional-level processes for beneficiation and mineral and elemental analysis of ores and ore-dressing products. While CSIR labs and IBM can do “public good” process R&D based on regional samples, deposit-specific process R&D needs to be done by the concessionaire on a commercial basis (though CSIR labs and IBM can do such work for the concessionaire on a job basis).

In the intermediate R&D space, where the feasibility of the deposit is the question, process R&D to establish feasibility constitutes a high-risk high-reward situation and the creation of a venture-capital-funded process R&D set up is clearly required if the concept of zero-waste mining is to be taken to its logical conclusion. Fiscal as well as non-fiscal incentives need to be structured through a well-thought out policy after a detailed study of how the system works in other countries, such as Australia and Canada, especially the Australia’s Cooperative Research Centre (CRC) mechanism which supports end-user driven research collaboration. In this connection, the importance of prefeasibility studies to get the best value from the auction of mineral resources under the MMDR Act cannot be overemphasized in relation not only to the beneficiation of low grades, but also (as mentioned earlier) the co-production of minor metals, many of them of strategic value, as by-products.



Conclusion

The preceding discussion reveals the following:

- The system of Non-Exclusive Reconnaissance Permits (NERP) (Section 10C, MMDR Act), but with no rights to proceed to prospecting or mining in case of evidence of mineralization, is not an adequate incentive for private players to expend funds on reconnaissance in what is internationally perceived as a high risk-high reward game. Large investments from the private sector generally and foreign investments in particular (which bring in special expertise and high technology as well) are unlikely.
- Specialized venture capital-based exploration companies, including the “Juniors”, need to be incentivized to conduct deep exploration using advanced technologies. Introducing an “auctions only” system will disrupt this process.
- NERP Rule 4(2) enables the State Government to seek further information from the NERP holder, and proviso to Section 10B(6) of the MMDR Act read with Rule 6(3) and 6(4) of the Mineral (Auction) Rules 2015 enables the State Government to reserve a mine for a particular end use while seeking bids in an auction, thereby increasing the difficulty in monetizing an exploration find.
- The eligibility conditions required under the Mineral (Auction) Rules 2015 require a first-stage bidder (the entity incorporated in India) to have a net worth equal to 4% in case of a mining lease-stage bid (1% in the case of a prospect-stage bid) of the value of the estimated resources. This clearly rules out the “Juniors” in relation to even a moderate-size mineral find.
- Once the prospects which have already been worked upon is exhausted, supply of new mines and prospects for auction will be significantly constrained by the pace of exploration, and deep-seated deposits or non-bulk deposits including base metals may not come up for auction for quite some time.
- The annual funding by the National Mineral Exploration Trust of Government agencies (and private agencies selected by them) will be of the order of ₹600 crore per annum (or \$100 million per annum) which is miniscule compared to annual global exploration budgets of the order of \$7 billion (the maximum was \$12 billion), and may be able to pay for only some of the huge expenditure that is entailed in stepping up the pace of exploration. It will not be able to adequately capture the spirit of the high-risk high-reward paradigm.
- As the Supreme Court has stated in its Opinion dated February 27, 2012, auction is not the only way of discharging a public trust in alienating natural resources. As the Court has stated: *“A fortiori, besides legal logic, mandatory auction may be contrary to economic logic as well. Different resources may require different treatment. Very often, exploration and exploitation contracts are bundled together due to the requirement of heavy capital in the discovery of natural resources. A concern would risk undertaking such exploration and incur heavy costs only if it was assured utilization of the resource discovered; a prudent business venture, would not like to incur the high costs involved in exploration activities and then compete for that resource in an open auction.”*
- The absence of a requirement in the Minerals (Evidence of Mineral Contents) Rules 2015 for a pre-feasibility study and the estimation of potentially economic resources (much less a feasibility study) and valuations based thereon, even for the auction of a mining lease, is likely to create a high degree of uncertainty in the auction process.
- The NMET will be funding government agencies (and private agencies selected by them) to produce G3- or G2-level reports. The estimations are being done by agencies of the same entity (that is, the government), which stands to benefit from the auction and an “arm’s-length” principle does not seem to be in place. The data is also not subject to any third-party check or verification.
- There are other classification systems, such as the Australian JORC code or its equivalent, the Canadian National Instrument 43.101, which require a regular process of public reporting of exploration progress and results and preparation of reports signed by an independent third-party professional (“Competent Person”) and which imparts a high degree of transparency and credibility to the exploration results and estimation of resources and reserves. The use of the JORC Code and the embedded processes can impart a high degree of confidence to valuations for auctions as well as M&A.

- “Exploring in India” for “Making in India”: The determination by IBM of national priorities for exploration, as contemplated in paragraph 11.2 of the NMEP, needs to include assessments with regard to India’s medium-term mineral security. In particular, emphasis needs to be given to the co-production of by-product metals from the base metal ores through process R&D so that the country’s needs of so-called Technology Metals and Energy-Critical Metals are effectively met. Needless to say, this will provide raw material security on the one hand and competitive edge for the country’s manufacturing sector on the other. Creation of a venture capital-funded process R&D set up is clearly required to extract metals of strategic value which occur in small concentrations.

Continuous exploration to locate new mineral deposits with regularity is the key to mineral resource security, and mineral concession systems *must* start by optimizing this end of the process. The Hoda Committee report elaborately envisioned the contours of a National Mineral Policy, pointing out the need for technological impetus, adoption of best practices in mining regulation, and R&D. The Committee (in paragraph 1.32) had recommended that in respect of ore bodies prospected by State Agencies at public expense, or with respect to the data deposited by a private concessionaire where the lock-in period was over, auction may be undertaken (based on the adequacy of data). Importantly, the Committee also recommended that the private sector must be the main source of funding of exploration in future, given the high risks involved, particularly in the case of deep exploration. The Committee accordingly recommended the Canadian model of incentivizing “Junior” exploration companies funded by venture capital and recommended; the “Large Area Prospecting Licence” (LAPL) as a concession with this in mind. In the context of the amendments made in 2015 to the MMDR Act, mandating auctions as the only method of allocation of mineral concessions at the prospecting stage and depending on State Agencies to conduct the preliminary exploration may be suboptimal with reference to ensuring India’s mineral security.

Introduction of the “Large Area Prospecting Licence (LAPL)”, specifically for minerals other than iron ore, bauxite, limestone, etc. (bulk or surficial minerals) and for deep exploration, and providing a separate channel that allows the LAPL concessionaire to claim assured and

direct mining rights (including transferability thereof) is clearly, necessary to discover the minerals we need.

This alone will ensure that the private sector investments flow into exploration along with new and advanced technology to locate deep and concealed minerals vital for India’s economic growth and development, and for its long-term minerals security. To ensure that the government gets the best value for its known natural resources, the provision of “reservation” of areas, already available in the MMDR Act, can be used to keep out of the purview of the private sector areas that are sought to be taken up, say in the next 5 to 10 years for a detailed exploration with a view to auction. The remaining areas may be left open to exploration investment by the private sector with assured rights of mining as is the best international practice.

Appendix

Glossary of Terms

Beneficiation: Beneficiation is the processing of minerals or ores for the purpose of (i) regulating the size of a desired mineral produce; (ii) removing unwanted constituents; and (iii) improving quality, purity, or assay grade of the desired mineral produce (MCDR).

“Bulk” and near-surface minerals: Minerals occur through a variety of processes. Some minerals are formed by sedimentary processes and are deposited in basins which occur in the earth’s surface. These include limestone and some kinds of iron ore deposits. Some minerals, such as Bauxite, are formed by weathering processes. Such minerals generally occupy large surface areas and are often called “bulk” minerals. Very often they are available at or near the surface. Other minerals are concentrated at depth, and are formed under high pressure and temperature, and in many cases, through the chemical action of hot mineralizing fluids (hydrothermal action) associated with volcanism or tectonism. These minerals, including base metals such as copper, and noble metals such as gold, and special cases such as diamonds can occur at depths.

Concealed, deep-seated, or deep-located deposits: Mineralization often occurs at depth, with no apparent surface shows. In other cases, mineralization, even if extensive, is hidden by subsequent sedimentary layers (“cover sediments”), or concealed by lava flows

as in the case of the Deccan Trap areas.

Co-production of minor metals: Minor metals are not naturally found in concentration high enough to be profitably mined for their own sake. Many of them also occur in association with other metals which can be commercially mined (primary or major metals, such as lead-zinc-copper or gold or aluminum). Such associated minor metals can be recovered from the “waste” generated during the extraction of the major metals. Many minor metals are finding applications in renewable energy or electronics and though used in small quantities, can be quite critical. ‘Major’ minors include tungsten, cobalt, titanium, magnesium, where several hundred thousand tonnes are produced annually. On the other hand, a ‘Minor’ minor, for example, Hafnium, has an annual production of merely 55 tonnes. Their production requires “process research” so as to put in place an ore-specific combination of physical and chemical processes to separate them from other material. There can be substantial risks and technical- and economic-feasibility questions associated with process research.

Crustal masses and Cratons: The **continental crust** is the layer of igneous, sedimentary, and metamorphic rocks that forms the continents and the adjoining areas of shallow seabed known as continental shelves. **Cratons** are old and stable parts of the crust (and the uppermost mantle), which having survived cycles of merging and rifting of continents, are distinct formations composed of ancient “crystalline basement” rock, often covered by younger sedimentary rocks.

General Exploration involves the initial delineation of an identified mineral deposit. Methods used include surface mapping, widely spaced sampling, trenching, and drilling for preliminary evaluation of mineral quantity and quality (including mineralogical tests on laboratory scale if required), and limited interpolation based on indirect methods of investigation. The objective is to establish the main geological features of a deposit, thereby giving a reasonable indication of continuity and providing an initial estimate of size, shape, structure, and grade. The degree of accuracy should be sufficient for deciding whether a Prefeasibility Study and a Detailed Exploration are warranted (UNFC).

Detailed Exploration involves the detailed three-dimensional delineation of a known mineral deposit through sampling from outcrops, trenches, boreholes, shafts, and tunnels. Sampling grids for drilling are closely spaced such that size, shape, structure, grade, and other

relevant characteristics of the deposit are established with a high degree of accuracy. Processing tests involving bulk sampling may be required (UNFC).

Geoscientific survey and mapping is to be distinguished from “mineral exploration”; while the latter is specifically aimed at finding minerals, geoscientific surveys have a multitude of applications including subsurface water resources, landslides and other hazards, and the nature of rocks and soils; and understanding the topography and climate of the distant past. Very often, mineral exploration ventures use geoscientific surveys as a starting point for the identification of a target area for exploration.

Low-grade ores: The grade of the ore generally refers to the concentration of the mineral of interest in the mineral ore. As the grade drops, the economic viability of a mining enterprise also drops. When the grade of the ore is such that the economic viability is a significant risk, the ore is generally said to be of “low grade”.

Mineral: A mineral is a naturally occurring substance that is solid and inorganic and is representable by a chemical formula. It has an ordered atomic structure. It is different from a rock, which can be an aggregate of minerals or non-minerals and does not have a specific chemical composition. Most but not all minerals are crystalline; also, most but not all minerals have one or more metals as part of the substance.

Mineral resource: A mineral resource is a concentration or occurrence of solid material of economic interest in or on the earth’s crust in such form, grade, or quality and quantity that there are reasonable prospects for eventual economic extraction.

Mineral reserve (or Ore Reserve): A mineral reserve or an ore reserve is the economically mineable part of a mineral resource.

Mineral ore: An ore is a type of rock or rocky material that contains sufficient minerals with important elements including metals that can be economically extracted from the rock through mining operations. An ore body is the assemblage of such a rocky material.

Mineralization: Mineralization is the process of formation of a mineral out of unmineralized material or a concentration of the mineral above its normal abundance due to geological processes involving heat, pressure, chemical action, sedimentation, etc.

Mineral occurrence: This is an indication of mineralization that is worthy of further investigation. The

term “mineral occurrence” only indicates the presence of one or more minerals but does not imply any measure of volume or tonnage, grade or quality and is thus not a part of a mineral resource yet (UNFC).

Mineral deposit: A mineral occurrence of relatively higher concentration.

Mining operation: A mining operation is any operation undertaken for the purpose of winning (that is, recovering) any mineral. It generally includes extracting the ore and then processing it to recover the minerals in the ore (MMDR Act 1957).

Mining lease: A lease granted for the purpose of undertaking mining operations and includes a sublease (MMDR Act 1957).

Mining Tenement System: Such a system depicts the location, extent, nature, and status of current mineral concessions (“tenements”), and often allows for applications to be made for the grant of mineral concessions in areas not already covered. Sometimes the system also shows pending applications as well. The system may also show land ownership (“cadastre”) and other legal information, such as officially notified forests or ecologically sensitive areas, for the benefit of intending applicants.

Prospecting: It means any operation undertaken for the purpose of exploring, locating, or proving a mineral deposit, including geochemical and geophysical surveys, and drilling (MMDR Act 1957).

Prospecting is the systematic process of searching for a mineral deposit by narrowing down areas of promising enhanced mineral potential. The methods utilized are outcrop identification, geological mapping, and indirect methods, such as geophysical and geochemical studies. Limited trenching, drilling, and sampling may be carried

out. The objective is to identify a deposit which will be the target for further exploration. Estimates of quantities are inferred, based on the interpretation of geological, geophysical, and geochemical results (UNFC).

Note: A prospecting licence granted under the MMDR Act permits general exploration as well as detailed exploration.

Prospectivity for minerals: This is a general assessment of the likelihood of finding minerals, based on the geological evolutionary history and geological set up (lithological, structural, and geomorphological) and geophysical, aeromagnetic, gravity, and radiometric imagery data sets.

Reconnaissance: Any operations undertaken for the preliminary prospecting of a mineral through regional, aerial, geophysical, or geochemical surveys and geological mapping, but does not include pitting, trenching, drilling, or sub-surface excavation (MMDR Act 1957).

A reconnaissance study identifies areas of enhanced mineralization on a regional scale based primarily on results of regional geological studies, regional geological mapping, airborne and indirect methods, preliminary field inspection, as well as geological inference and extrapolation. The objective is to identify mineralized areas worthy of further investigation towards mineral deposit identification. Estimates of the quantities should only be made if sufficient data is available (UNFC).

Winner’s Curse: The winner’s curse is a phenomenon that may occur in “highest bid” auctions in conditions of incomplete information. In such an auction, the winner will tend to overpay as he is after all paying what his competitors felt was not worth it since they stopped at a lower bid.

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Abbreviations

CII	:	Confederation of Indian Industries
CMPDI	:	Central Mine Planning and Design Institute
DRDO	:	Defense Research and Development Organization
FDI	:	Foreign Direct Investment
GSI	:	Geological Survey of India
IBM	:	Indian Bureau of Mines
MCDR	:	Mineral Conservation and Development Rules
MECL	:	Mineral Exploration Corporation Limited
ML	:	Mining Lease
MMDR Act	:	Minerals and Mines (Development and Regulation) Act
NERP	:	Non-Exclusive Reconnaissance Permit
NFTDC	:	Non-Ferrous Technology Development Centre
NMET	:	National Mineral Exploration Policy
NMP	:	National Mineral Policy
PL	:	Prospecting License
PSU	:	Public Sector Undertaking
R&D	:	Research and Development
UNFC	:	United Nations Framework Classification (for mineral resources)



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