CHAPTER 1

Minerals and Mining in India and its Environmental Implications

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Introduction

Exploration, extraction and utilization of minerals are important for the economic growth and development of a country. The products of the mining and metallurgical sector (including metallic and non-metallic minerals, construction materials or fertilizers) are not only essential for construction activities and many industrial processes, but are also often a valuable source of foreign exchange earnings. However, mining operations frequently involve a high degree of environmental disturbance which can extend well beyond the extent of mineralized areas. Large scale denudation of forest cover, conversion of green landscapes into barren lands, transformation of agricultural lands into wastelands, and pollution of air, water and soil are some of the common consequences of mining. The terrestrial and aquatic ecosystems adjoining the mines become adversely contaminated leading to loss of biodiversity and depletion of other natural resources. All such environmental perturbations exert tremendous pressure on human health and socio-economic fabric of the society. These in turn, have multifaceted repercussion at local, regional and global levels.

Minerals and Mining in India

India is endowed with significant mineral resources distributed all over the country, including the sea beds. India produces 89 minerals out of which 4 are fuel minerals, 11 metallic, 52 non-metallic and 22 minor minerals. India with diverse and significant mineral resources is the leading producer of some of the minerals. For example, India is the largest producer of mica blocks and mica splittings; ranks third in the production of coal and lignite, barytes and chromite; 4th in iron ore, 6th in bauxite and manganese ore, 10th in aluminium and 11th in crude steel (Ministry of Mines, Govt. of India). An account of reserve and exploitation of important minerals in India is given in Table 1.

The total value of mineral production (excluding atomic minerals was Rs. 404768 million in 1998–99. Limestone, magnesite, dolomite, barytes, kaolin, gypsum, apatite and phosphorite, steatite and fluorite account for 92 percent of the value of non-metallic minerals. Whereas, iron ore, copper ore, chromite, zinc concentrates, gold, manganese ore, bauxite, lead concentrates, and silver account for the entire metallic production. India has an estimated 85 billion tonnes of mineral reserves remaining to be exploited. Besides coal, oil and gas reserves, the mineral inventory in India includes 13,000 deposits/prospects of 61 non-fuel minerals.

Mining Policy of India

The Mines and Minerals (Regulation and Development) Act (MMDR Act), 1957 lays down the legal frame-work for the regulation of mines and development of all minerals other than petroleum and natural gas in India. The Central Government has framed the Mineral Concession Rules 1960 for regulating grant of prospecting licenses and mining leases in respect of all minerals other than atomic minerals and minor minerals. The State Governments have framed the rules in regard to minor minerals. The Central Government has also framed the Mineral Conservation and Development Rules, 1988 for

Table 1: Reserve and extraction of important minerals in India

Sl. No.	Mineral/Ore/Metal	Recoverable reserves as on 1.1.1985 (m. tonnes)	Depletion during 1985–97 (m. tonnes)	Recoverable reserves as on 1.1.1997 (m. tonnes)	Projeced production during 1996–97 (m. tonnes)	Balance life at 1996–97 level of production (years)
1.	Crude oil (as on 1.1.91)	993.00	230.00	763.00	50.00	15
2.	Natural Gas (b.cu.mt.) (as on 1.4.90)	858.00	161.00	697.00	30.00	23
3.	Coal (as on 1.1.91) (i) Coking	8507.00	201.00	8306.00	39.00	213
	(ii) Non Coking	60346.00	1397.00	58949.00	269.00	219
4.	Bauxite	2333.00	80.00	2253.00	8.00	282
5.	Copper metal (as on 31.3.88)	3.95	0.43	3.52	0.06	64
6.	Lead metal (as on 1.1.89)	1.93	0.56	1.37	0.10	14
7.	Zinc metal (as on 1.1.89)	7.00	1.10	5.90	0.15	38
8.	Gold (as on 1.1.89)	103000.00	16727.00	86273.00	1850.00	47
9.	Iron ore	10440.00	686.00	9754.00	72.00	135
10.	Chromite Ore	139.00	15.00	124.00	2.40	52
11.	Magnesite	222.00	6.70	215.30	0.73	295
12.	Manganese Ore	83.17	17.65	65.52	1.80	36
13.	Limestone	69353.00	876.00	68477.00	101.00	678
14.	Rock Phosphate High grade	14.78	8.79	5.99	0.72	8
15.	Sillimanite (i) Masslve	0.50	0.35	54.25	0.017	3191
	(ii) Beach sand	54.10				
16.	Kyanite	1.55	0.51	1.04	0.06	19
17.	Dolomite (Usable Grade)	4608.00	32.00	4576.00	3.20	1430

Source: Ministry of Mines, Govt. of India.

conservation and systematic development of minerals. These are applicable to all minerals except coal, atomic minerals and minor minerals.

The different guidelines emphasize the need for conservation and judicious exploitation of finite mineral resources. Recent revisions have incorporated certain new aspects and elements like mineral exploration in the sea-bed, development of proper inventory, proper linkage between exploitation of minerals and development of mineral industry, protection of forest, environment and ecology from the adverse effects of mining, enforcement of mining plan for adoption of proper mining methods and optimum utilization of minerals, export of minerals in value added form and recycling of metallic scrap and mineral waste. To attract private investment (both domestic and foreign) in mining sector the National Mineral Policy was revised in 1994 and permitted for the exploration and exploitation of thirteen minerals namely iron ore, copper, manganese, lead, chrome ore, zinc, sulphur, molybdenum, gold, tungsten ore, diamond, nickel and platinum group of metals by the private companies. The MMDR Act was further amended in 1999 to delegate more powers to the State Governments as well as to bring the provisions for grant of mineral concessions on par with major mineral producing countries of the world. The salient features of the amendments are:

- The concept of reconnaissance operations as a stage of operations distinct from and prior to actual prospecting operations has been introduced.
- Grant of mineral concessions in respect of mineral limestone has been entrusted with the State Governments.
- Renewal (first or subsequent) of mining lease and prospecting licenses has been delegated to State Governments.
- Area restrictions for prospecting license, mining lease, reconnaissance permits have been substantially liberalized by making such restrictions applicable state wise instead of the country as a whole.

- Powers for granting mining lease/prospecting license in certain areas and approving mining plans for certain categories of mines have been delegated to the State Governments.

The Minerals (except fuel and atomic minerals) which require prior concurrence of Central Government for grant of mineral concessions are only 10 which include asbestos, bauxite, zinc, chrome ore, precious stones, copper ore, manganese ore, gold, lead and iron ore.

Ministry of Mines

The Ministry of Mines, Government of India is responsible for the survey and exploration of all minerals, other than natural gas, petroleum, and atomic minerals. The Ministry is also responsible for the mining and metallurgy of non-ferrous metals like aluminum, copper, zinc, lead, gold, nickel, etc., and for the administration of the Mines and Minerals (Development and Regulation) Act, 1957, in respect of all mines and minerals, other than coal, natural gas, petroleum, and atomic minerals. However, the Department of Coal administers the MMDR Act for coal and lignite. Broadly, the following subjects fall under the purview the Ministry of Mines.

1. Legislation for regulation of mines and development of minerals within the territory of India, including mines and minerals underlying the ocean within the territorial waters or the continental shelf, or the Exclusive Economic Zone and other Maritime Zones of India as may be specified from time to time by or under any law made by the Parliament.
2. Regulation of mines and development of minerals other than coal, lignite and sand for stowing and any mineral declared as prescribed substances for the purposes of the Atomic Energy Act, 1962 (33 of 1962) under the control of the Union as declared by law, including questions concerning regulation and development of minerals in various states and the matter connected therewith or incidental thereto.

3. All other metals and minerals not specifically allotted to any other Ministry/Department such as aluminum, zinc, copper, gold, diamond, lead and nickel.
4. Planning, development and control of and assistance to all industries dealt with by the Ministry.
5. Coordination with organizations operating under the Ministry.

The following organizations operate under the jurisdiction of Ministry of Mines for survey, exploration, regulation and conservation purposes:

Geological survey of India (GSI)

The GSI is the principal agency responsible for the assessment of geological and regional mineral resources of the country. GSI was established in 1851 and is one of the India's oldest investigative agencies in the field of earth sciences. Its areas of operation encompass scientific surveys and research, for locating mineral resources. The GSI operates through six regional offices and four specialized wings — marine, coal geophysics, airborne surveys and training.

Mineral exploration corporation limited (MECL)

The MECL is a public sector company, which undertakes detailed exploration of various minerals/ores by drilling, and exploratory mining. It is also engaged in proving the existence of reserves for their eventual exploitation.

Indian bureau of mines (IBM)

The IBM is the principal government agency responsible for compiling exploration data and mineral maps and for providing access to the latest information in respect of mineral resources in the country. The IBM has both regulatory as well as service functions. IBM offers technical expertise and proven experience in the fields of geology, mine planning and feasibility studies. The geological services of IBM include survey and preparation of mine plans, preparation of geological

plans, preliminary geological appraisal of mineral properties, including the formulation of an initial scheme of detailed exploration with estimate of cost and preliminary reconnaissance, quick survey to determinate potential areas out of large properties, etc. IBM also performs regulatory functions, namely: — enforcement of Mines and Minerals (Regulation and Development) Act, Mineral Concession Rules, Mineral Conservation and Development Rules and compliance with Environmental Protection Act.

Besides, a number of public sector companies such as Bharat Aluminium Company Limited, Bharat Aluminium Company Limited, Hindustan Zinc Limited, Hindustan Copper Limited, National Aluminium Company Limited, Sikkim Mining Corporation and Bharat Gold Mines Limited work under the jurisdiction of the Ministry for Mining and Processing of minerals and metals in the country.

Mining Operation and its Environmental and Social Consequences

Mining operations may be categorized as either surface or underground. Surface mining may be broadly defined to encompass open pit, open cast, quarry, strip, dredging and placer (hydraulic) mining. Underground methods include pillar-and-stope, shrinkage stope, block caving and long wall mining. Primitive method such as "Rat hole" mining is also practiced in some parts of the country. Most mining operations are large scale activities (whether surface or underground) and share a number of common stages or activities such as exploration, removal overburden and waste rocks and its disposal, extraction and processing of ore, transportation of ore and processed mineral, treatment and disposal of tailings and construction and infrastructure development. Each of these mining activities have potentially adverse impacts on the natural environment, social and cultural conditions, or the health and safety of mine workers or communities in the environs of the mine.

The environmental impacts of the mining operation commence with exploration activities, extend through

extraction and processing of minerals, and may continue post-closure of the operation, with the nature and extent of impacts varying throughout the stages in mining operation. Large scale denudation of forest cover and depletion of biodiversity, scarcity of water, pollution of air, water and soil and degradation of agricultural lands are some of the serious environmental implications of the mining. Besides, caving in of the ground and subsidence of land and haphazard dumping of minerals and overburden deteriorate the aesthetic beauty of the landscape and leave scar on the face of the earth. Details of various mining activities and associated environmental and social implications are discussed below:

Exploration of minerals

Exploration activities encompass all actions in the field which precede feasibility studies. This might include initial reconnaissance flights and electromagnetic or geophysical surveys, stream sediment studies, construction of access roads, clearing of test drilling sites, installation of drill pads and drilling rigs, erection of temporary accommodations and power generation for exploratory drilling.

The potential environmental implications of exploration depend on a number of factors including extent and type of mining, proximity of surface waters to mining sites, ecological sensitivity of the affected area, and proximity to and intrusion upon existing settlements or resources utilized by local or indigenous people. The disruption associated with exploration may be controlled by measures such as restricting land clearance to the minimum required, removal or disabling of access infrastructure, or the use of aerial access for personnel and equipment wherever practicable.

Extraction of mineral ore and disposal of overburden

Mineral ore is found embedded in rocks beneath the earth surface. In order to reach the mineral deposit and extract the ore, huge quantity of rocks are removed and piled near the mining site. These overburden and waste rock include

non-mineralized material overlying or interleaving mineralized zones, and low grade ores which can not be viably processed. The key issues to consider in determining the magnitude and significance of environmental impacts include the aerial extent and depth of the mineralized zone, the quantities of material to be disposed of and effects on dump locations and designs, the inherent toxicity of the wastes, and the potential for acid drainage from waste rock dumps etc. Blasting for removal of ore and overburden, vehicular traffic for transportation, associated civil works such as landscaping, road fill or aggregate, tailings dam or bund construction, or clay liners for tailings disposal areas or settlement ponds, and management overburden and slurries (containment, control and disposal) are some other important factors that determine the magnitude of the environmental impacts.

The potential environmental implications of these activities include impacts on surface water quality or hydrology, loss of natural habitats, loss of cultural heritage, effects on visual amenity, noise nuisance, degradation and loss of agricultural land or forestry resources including flora and fauna.

Processing of ore

Depending on the type of mine, ore processing may involve beneficiation — where mined ore is either concentrated for further processing (metallic ores) or graded for sale (non-metallic ores) followed by metallurgical processing and refining. For metallic ores, beneficiation consists of preparation by crushing and/or grinding, concentration by gravity or magnetic separation or flotation followed by dewatering and filtration. The outputs from this process are ore concentrate and wastes, in the form of tailings (which may include process chemicals and heavy metals) and dust emissions.

Metallurgical processing typically involves the isolation of a metal from ore concentrates by phytometallurgical, hydrometallurgical or electrometallurgical methods, singly or in combination. Phytometallurgical processes such as roasting and smelting result in atmospheric emissions (of sulfur dioxide, particulates and heavy metals) and slag

containing toxic metals. Hydrometallurgical methods typically retain pollutants in the aqueous phase only, and those which are not recycled are discharged usually to the tailing pond. Wind entrainment of dry tailings can result in indirect airborne pollution. Some of the chemicals used in ore processing (such as cyanide, mercury and strong acids) are inherently hazardous, and their handling, use, storage and disposal pose further environmental problems.

Tailing treatment and disposal

Management of tailings is one of the most significant environmental aspects of mining operations. Failure of tailings containment, treatment or disposal operations can have serious adverse consequences on environment. The options for tailings disposal include backfilling into mined out areas, damming valley areas, construction of a retaining bund (in relatively flat areas) and disposal to river, lake or sea. The latter options are generally resorted to only where land disposal options are seriously constrained.

Infrastructure, access and energy

This encompasses the means of gaining access to the proposed mine, for operating the mine and associated facilities, for accommodating labor, for obtaining power (both during construction and operation) and for exporting finished products. It also includes material handling systems within the mining area (including conveyors, railroads, elevated tramways, pipelines for conveying tailings or mineral concentrates), and construction of railhead or port facilities. The environmental, social, and health impacts of these ancillary activities can be very significant and are influenced by factors such as: proximity of the mine to suitable access infrastructure and energy sources; number of construction and operational staff required; proximity of mine concession to and influence on protected areas and natural habitats; potable water sources and other water bodies; and existing communities or lands used by indigenous peoples.

Construction of worker camps and townships

The demand for labour at industrial mining operations often exceeds local supply, thereby creating a need to 'import' the requisite skills. The impacts of recruiting and providing the necessary infrastructure for large numbers of migrant workers can represent the most significant environmental impacts of mining activity. Where the availability of natural resources or other environmental factors have effectively constrained human settlement, large influxes of mine workers can rapidly degrade environmental resources. For example, mining communities have been linked to degradation of forests (including protected areas), contamination and reduction of water supplies, local extinction of wildlife and trade in endangered species, and transmission of communicable diseases and sexually transmitted diseases.

Post closure plans/decommissioning

At some point, the ore either becomes exhausted or uneconomic to mine, and closure is inevitable. Historically, many mine sites were abandoned without any attempt at reclamation. In principle however, the areas or resources affected by mining should be returned to a safe and productive condition through long term reclamation activities, which may bring back to pre-mining environmental conditions.

Reclamation techniques include: regrading, recontouring, and revegetation of degraded land surfaces; containment of toxic or acid generating wastes through the use of physical (either solid or liquid) or vegetative barriers to prevent erosion or acid drainage; and long term water management measures through recontouring or physical barriers to help contain wastes. Important issues to consider for developing a reclamation plan include: instability of slopes and surface materials; safety issues relating to open pits, shafts, subsidence, toxic, or radiological hazards; the physical characteristics, nutrient status, and inherent toxicity of tailings or waste rock which may constrain revegetation; the potential for acid drainage from abandoned pits and shafts, tailings and waste

rock dumps (as a consequence of oxidation of sulfides contained in the ore or wastes) and the costs of ongoing and post closure reclamation. Besides, the potential environmental and social impacts of mines can be profoundly influenced by the design and location of the mine facilities.

Amelioration of Environmental and Social Impacts of Mining

While the responsibility for managing environmental, social and health programs of industrial mining operations is likely to be placed at several levels (from senior management to mine workers), the manager(s) with the prime responsibility for these issues should be allocated sufficient authority and budget to effectively manage the issues, for example hiring or contracting specialists to develop a reclamation plan. The employment of a community liaison officer to act as the focal point for community issues and concerns is strongly recommended. The interrelated nature of the environmental, social and health impacts of mining should be recognized, and maximum effort should be taken to ensure minimum environmental, social and cultural impacts of mining operations. The following actions are needed in selecting, siting, planning, and designing of mining projects:

1. Preparation of proper environmental impact assessment (EIA) of involved potential impacts in selecting, siting, planning, and designing of mining projects.
2. Preparation and implementation of environmental management plans (EMP) of the mining project in order to reduce air, water and soil pollution, occupational health and safety issues and proper management of tailings, erosion and reclamation.
3. Due consideration for economically viable, environmentally sustainable and socially equitable mining projects.
4. Due to the significance of potential environmental, health and social impacts of mining operations, the effective involvement of stakeholders is essential. This is necessary for the identification of groups likely to be impacted by, or benefited from, mining projects.

5. Protection, maintenance, and rehabilitation of natural habitats by undertaking locally suitable ecorestoration measures including reducing deforestation and promoting afforestation.

Capacity building

Capacity building for improved environmental management involves activities which range from development of appropriate environmental, safety and health standards within the ministries of mining or environment. The principles which guide development of environmental management capacity should include:

1. Development of a regulatory framework and environmental, health and safety standards, should take due account of accepted international practices. Due consideration should also be given on the availability and cost of the associated technological controls and the baseline environmental conditions.
2. Effective environmental regulation is critically dependent of enforcement capacity, the availability of injunctive measures to help enforce compliance, the use of such measures where appropriate, and the ability of the mining sector to finance the costs of compliance.

Monitoring and supervision

In order to implement the suggested measures for mitigation of environmental, social and health impacts, a monitoring plan should be prepared for strict implementation of environmental management plan (EMP). This sets the framework for assessing the acceptability of impacts from ongoing operations and the need for additional mitigation. The plan should define monitoring objectives which clearly identify the questions to be answered by measurement activities. It should include a description of monitoring to be performed and linkages to impacts and mitigation measures identified in the EIA.

Conclusion

India with diverse and significant mineral resources is the leading producer of some of the minerals. Of the 89 minerals produced in the country, 4 are fuel minerals, 11 metallic, 52 non-metallic and 22 minor minerals. Mining and metallurgical operations are important to the development and economic growth of the country as the products of the mining and metallurgical sector (including metallic and non-metallic minerals, construction materials or fertilizers) are not only essential for construction activities and many industrial processes, but are also often a valuable source of foreign exchange earnings. Mining industry directly or indirectly provides employment to thousands of technical and non-technical manpower. However, mining operations frequently involve a high degree of environmental disturbance which can extend well beyond the extent of mineralized areas. The impacts of a mining operation commence with exploration activities, extend through extraction and processing of minerals, and may continue post-closure of the operation, with the nature and extent of impacts varying throughout the stages of project development. In order to avoid or mitigate mining related environmental disturbances, the interrelated nature of the environmental, social and health impacts of mining should be recognized by undertaking thorough environmental impact assessment (EIA)/environmental management plans (EMP) at all levels of mining projects viz. selecting, siting, planning, and designing of mining projects. Simultaneously, strict measures are required for implementation of EMP of the mining project in order to reduce air, water and soil pollution, occupational health and safety issues and proper management of tailings, erosion and reclamation.