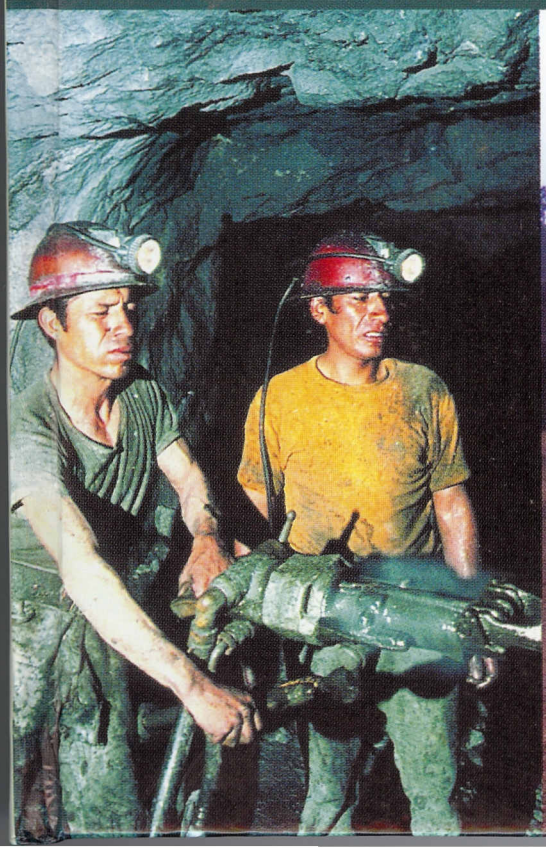
MINING ENVIRONMENT

Problems & Remedies

Editor
O.P. Singh



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Editor

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Regency Publications
New Delhi

ISBN 81-89233-16-5

Published by Regency Publications, 20/36-G, Old Market, West Patel Nagar, New Delhi 110 008 and printed at Radiant Printers, New Delhi, Phones: 2588 4571, 5248 4101; Telefax: 2588 4571.

Email: regency@satyam.net.in • www.regency-books.com

Preface

India, endowed with rich mineral resources, produces 89 different minerals comprising of 4 fuel, 11 metallic, 52 non-metallic and 22 minor minerals. The country is the largest producer of mica, third largest producer of coal and lignite, fourth in iron production, sixth in bauxite and manganese, and tenth in aluminum production in the world. The metallic production of the country is mostly contributed by iron-ore, copper-ore, chromite and/or zinc concentrates, manganese ore, bauxite, lead concentrates, gold and silver. Amongst the non-metallic minerals, 92 percent of the aggregate value is shared by limestone, magnesite, dolomite, barytes, kaolin, gypsum, apatite and phosphorite, steatite and fluorite. In 1999–2000, total mineral production from over 3100 mines accounted for 550 million tones worth more than Rs. 452.3 billion.

During recent past, India has witnessed a spurt of mining activity to meet the growing industrial and commercial demands of minerals and metals. The extractive nature of mining activities creates a variety of impacts on the environment before, during and after mining operations. Large scale denudation of forest cover, scarcity of water, pollution of air, water and soil, and degradation of agricultural lands are some of the conspicuous environmental implications of the mining operation. In addition, mining leaves physically disfigured landscape due to haphazard dumping of overburden, caving in of the ground and subsidence of land.

The extent and nature of impacts can range from minimal to significant depending on a range of factors associated with each mining activity. The environmental impacts of mining, although significant, are generally confined to adjoining areas. The terrestrial and aquatic ecosystems surrounding mines become severely contaminated leading to adverse impacts on human health, agricultural and other socio-economic activities of the local people. Mining on forest land leads to deforestation and loss of biodiversity.

In India, a vast area of land is affected every year by mining and mining-related activities. Restoration of mining affected environment has been a challenging task and very little progress has been made considering the magnitude of the problem. In order to mitigate the adverse impacts of mining activities and rehabilitate the mining affected areas, it is important to understand various problems of mining environment and their management. Assessment and stock taking of the prevailing environmental problems of the mining areas are prerequisites for initiating necessary remedial actions. Experience sharing of actions already initiated is equally important in formulating strategies for ecorestoration of mining degraded areas. To address these issues, a National Symposium on 'Ecorestoration of Mining Affected Areas' was organized at Shillong in 2003. The Symposium, sponsored by North Eastern Council (NEC), Shillong, North-Eastern Hill University (NEHU), Shillong and Indian National Science Academy (INSA), New Delhi was attended by about 50 participants. The participants deliberated on various aspects of mining environment and its management. The financial assistance provided by NEC, NEHU and INSA, and moral and physical support rendered by the organizing committee members, particularly Prof. B.K. Tiwari, Dr. V.T. Darlong and Dr. S.K. Barik are gratefully acknowledged.

The organizers of the Symposium decided to compile and publish selected papers in the form of a book for the benefit of students, researchers, policy makers and all concerned for ecorestoration of mining affected environment. The present volume on 'Mining Environment — Problems and Remedies' is the out come of this effort. The book comprising of five

Sections includes a total of 18 Chapters. The Section- I includes two Chapters on Status of Minerals and Mining in India. Eight Chapters pertaining to Environmental Problems of Mining have been included in Section-II. The Section-III comprising of three Chapters deals with Ecorestoration of Mining Affected Areas. Section-IV of the book, devoted to Mining Policies, Regulations and Environmental Impact Assessment includes three Chapters. Finally, Section-V incorporates Notification issued by Ministry of Environment and Forests, Government of India on Environmental Impact Assessment and a Glossary of terms related to mining environment.

The chapters included in this book are contributed by researchers renowned in their respective areas. I gratefully acknowledge their valuable contributions. I also would like to thank Shri Arun K. Verma of Regency Publications for expeditious publication of this book.

Shillong O.P. Singh

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Abbreviations/Acronyms

AAS	Atomic Absorption Spectroscope
Al	Aluminum
AMD	Acid Mine Drainage
As	Arsenic
Au	Gold
Bi	Bismuth
BNHS	Bombay Natural History Society
BOD	Biochemical Oxygen Demand
BR	Biosphere Reserve
$Ca(OH)_2$	Hydrated lime
$CaCO_3$	Limestone
CaO	Pebble quicklime
CBA	Coal Bearing Area
CO	Carbon monoxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
Cu	Copper
Cu_2S	Chalcosite
$CuFeS_2$	Chalcopyrite
DGM	Directorate of Geology and Mining
DGMS	Director General of Mines Safety
DMR	Directorate of Mineral Resources
DO	Dissolve Oxygen
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FCA	Forest (Conservation) Act

Fe	Iron
$Fe(OH)_3$	Ferric hydroxide
Fe_2+	Ferrous ion
Fe_2O_3	Hematite
$Fe_3(OH)_4$	Ferrihydrite
Fe_3^+	Ferric ion
$Fe_8O_8(OH)_6SO_4$	Schwertmannite
FeAsS	Arsenopyrite
FeOOH	Goethite
FeS	Pyrrhotite
FeS_2	Iron disulfide (Pyrite)
FeS_2	Marcasite
FeS_2	Marcasite
FRI	Forest Research Institute (Dehradun)
G & M	Geology and Mining
GGS	Group Gathering Station
GSI	Geological Survey of India
H^+	Hydrogen ions
H_2O	Water
HgS	Cinnabar
IBM	Indian Bureau of Mines
MCR	Mineral Concession Rules
MECL	Mining Exploration Corporation Limited
MMDR Act	Mines and Minerals (Development and Regulation) Act
Mn	Manganese
Mo	Molybdenum
MoEF	Ministry of Environment and Forests
Na_2CO_3	Soda ash
NaOH	Caustic soda
NEERI	National Environmental Engineering Research Institute (Nagpur)
NGO	Non-Governmental Organization
NH	National Highway
NH_3	Ammonia
Ni	Nickel
NiS	Millerite
NOx	Nitrogen oxides

NWAP	National Wildlife Action Plan
O_2	Oxygen
OB	Over burden
OCP	Open cast Mining Practice
Pb	Lead
PbS	Galena
PM_{10}	Particulate matter of diameter less than 10 micron
$PM_{2.5}$	Particulate matter of diameter less than 2.5 micron
RC-NAEB	Regional Centre-National Afforestation and Eco-development Board
RSPM	Respirable Suspended Particulate Matter
S	Sulfur
SAIL	Steel Authority of India Ltd
Se	Selenium
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment
SO_2	Sulfur dioxide
SO_4^{2-}	Sulfate ion
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
TDS	Total Dissolve Solid
TERI	Tata Energy Research Institute
WII	Wildlife Institute of India
Zn	Zinc
ZnS	Sphalerite

Section I

Minerals and Mining

CHAPTER 1

Minerals and Mining in India and its Environmental Implications

O.P. Singh

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	14.78	8.79	5.99	0.72	8
	High grade					
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.

Section V

Appendices

Appendix I

Notification on Environmental Impact Assessment of Development Projects

Ministry of Environment & Forest, Government of India, New Delhi

No. Z-12013/4/89-IA-I Dated: the 27th January, 1994

1. S.O.60(E) Whereas a notification under clause (a) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986 inviting objections from the public within sixty days from the date of publication of the said notification, against the intention of the Central Government to impose restrictions and prohibitions on the expansion and modernisation of any activity or new projects being undertaken in any part of India unless environmental clearance has been accorded by the Central Government or the State Government in accordance with the procedure specified in that notification was published as S.O.No. 80(E) dated 28th January, 1993;

   And whereas all objections received have been duly considered;

   Now, therefore, in exercise of the powers conferred by sub-section (1) and clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) read with clause (d) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986, the Central Government hereby directs that on and from the date of publication of this notification in the Official Gazette expansion or

modernisation of any activity (if pollution load is to exceed the existing one) or a new project listed in Schedule I of this notification shall not be undertaken in any part of India unless it has been accorded environmental clearance by the Central Government in accordance with the procedure hereinafter specified in this notification.

2. Requirements and procedure for seeking environmental clearance of projects:

I. (a) Any person who desires to undertake any new project or the expansion or modernisation of any existing industry or project listed in Schedule I shall submit an application to the Secretary, Ministry of Environment and Forests, New Delhi.
The application shall be made in the proforma specified in Schedule II of this notification and shall be accompanied by a project report which shall, inter alia, include an Environmental Impact Assessment Report/ Environment Management Plan and details of public hearing as specified in Schedule IV prepared in accordance with the guidelines issued by the Central Government in the Ministry of Environment and Forests from time to time.

(b) Cases rejected due to submission of insufficient or inadequate data and plans may be reviewed as and when submitted with complete data and plans. Submission of incomplete data or plans for the second time would itself be a sufficient reason for the Impact Assessment Agency to reject the case summarily.

II. In case of the following site specific projects:

(a) mining;
(b) pit-head thermal power stations;
(c) hydro-power, major irrigation projects and/or their combination including flood control;
(d) ports and harbours (excluding minor ports);
(e) prospecting and exploration of major minerals in areas above 500 ha.,

The project authorities will intimate the location of the project site to the Central Government in the Ministry of

Environment and Forests while initiating any investigation and surveys. The Central Government in the Ministry of Environment and Forests will convey a decision regarding suitability or otherwise of the proposed site within a maximum period of thirty days. The said site clearance shall be granted for a sanctioned capacity and shall be valid for a period of five years for commencing the construction, operation or mining.

III. (a) The reports submitted with the application shall be evaluated and assessed by the Impact Assessment Agency and if deemed necessary it may consult a Committee of Experts, having a composition as specified in Schedule-III of this Notification. The Impact Assessment Agency (IAA) would be the Union Ministry of Environment and Forests. The Committee of Experts mentioned above shall be constituted by the IAA or such other body under the Central Government authorised by the IAA in this regard.

(b) The said Committee of Experts shall have full right of entry and inspection of the site or, as the case may be, factory premises at any time prior to, during or after the commencement of the operations relating to the project.

(c) The Impact Assessment Agency shall prepare a set of recommendations based on the technical assessment of documents and data furnished by the project authorities and supplemented by data collected during visits of sites of factories, if undertaken and details of public hearing.
The assessment shall be completed within a period of ninety days from receipt of the requisite documents and data from the project authorities and completion of public hearing and decision conveyed within thirty days thereafter.
The clearance granted shall be valid for a period of five years from commencement of the construction or operation of the project.
No construction work, preliminary or otherwise, relating to the setting up of the project may be

undertaken till the environmental and/or site clearance is obtained.

IV. In order to enable the Impact Assessment Agency to monitor effectively the implementation of the recommendations and conditions subject to which the environmental clearance has been given, the project authorities concerned shall submit a half-yearly report to the Impact Assessment Agency. Subject to the public interest, the Impact Assessment Agency, shall make compliance reports publicly available.

V. If no comments from the Impact Assessment Agency are received within the time limit, the project would be deemed to have been approved as proposed by project authorities.

3. Nothing contained in this Notification shall apply to:

   (a) any item falling under entry nos. 3, 18 and 20 of the Schedule-I to be located or proposed to be located in the areas covered by the Notifications S.O. No.102(E) dated 1st February, 1989; S.O. 114(E) dated 20th February, 1991 S.O. No. 416(E) dated 20th June, 1991 and S.O. No.319(E) dated 7th May, 1992.

   (b) any item falling under entry Nos. 1, 2, 3, 4, 5, 7, 9, 10, 12, 13, 14, 16, 17, 19, 21, 25 and 27 of Schedule-I if the investment is less that Rs.50 crores.

   (c) Any item reserved for Small Scale Industrial sector with investments less than Rs.1 crore.

4. Concealing factual data or submission of false, misleading data/reports, decisions or recommendations would lead to the project being rejected. Approval, if granted earlier on the basis of false data would also be revoked. Misleading and wrong information will cover the following:

   - False information.
   - False data.
   - Engineered reports.
   - Concealing of factual data.
   - False recommendations or decisions.

R. Rajamani, Secy.

Schedule-I

(See paras 1 and 2)

List of projects requiring environmental clearance from the central government

1. Nuclear Power and related projects such as Heavy Water Plants, nuclear fuel complex, rare earth.
2. River Valley projects including hydel power, major irrigation and their combination including flood control.
3. Ports, Harbours, Airports (except minor ports and harbours).
4. Petroleum Refineries including crude and product pipelines.
5. Chemical Fertilisers (Nitrogenous and Phosphatic other than single superphosphate).
6. Pesticides (Technical).
7. Petrochemical complexes (Both Olefinic and Aromatic) and Petro-chemical intermediates such as DMT, Caprolactam, LAB etc. and production of basic plastics such as LDPE, HDPE, PP, PVC.
8. Bulk drugs and pharmaceuticals.
9. Exploration for oil and gas and their production, transportation and storage.
10. Synthetic Rubber.
11. Asbestos and Asbestos products.
12. Hydrocyanic acid and its derivatives.
13. (a) Primary metallurgical industries(such as production of Iron and Steel, Aluminium, Copper, Zinc, Lead and Ferro Alloys).
    (b) Electric arc furnaces (Mini Steel Plants).
14. Chlor-alkali industry.
15. Integrated paint complex including manufacture of resins and basic raw materials required in the manufacture of paints.
16. Viscose Staple fibre and filament yarn.
17. Storage batteries integrated with manufacture of oxides of lead and lead antimony alloy.

18. All tourism projects between 200 m–500 meters of High Tide Line or at locations with an elevation of more than 1000 meters with investment of more than Rs. 5 crores.
19. Thermal Power plants.
20. Mining projects (major minerals) with leases more than 5 hectares.
21. Highway Projects except projects relating to improvement work including widening and strengthening of roads with marginal land acquisition along the existing alignments provided it does not pass through ecologically sensitive areas such as National Parks, Sanctuaries, Tiger reserves, Reserve forests.
22. Tarred Roads in Himalayas and/or Forest areas.
23. Distilleries.
24. Raw Skins and Hides.
25. Pulp, paper and newsprint.
26. Dyes.
27. Cement.
28. Foundries (individual).
29. Electroplating.

Schedule-II

(See Sub-para 1(a) of Para 2)

Application form

1. (a) Name and Address of the project proposed
   (b) Location of the project
   Name of the place
   District, Tehsil
   Latitude/Longitude
   Nearest Airport/Railway Station
   (c) Alternate sites examined and the reasons for selecting the proposed site
   (d) Does the site conform to stipulated land use as per local land use plan
2. Objectives of the project
3. (a) Land Requirement
   Agriculture Land:

Forest land and Density of regetation:
Other (specify):
(b) (i) Land use in the Catchment/ within 10 kms. radius of the proposed site:
(ii) Topography of the area indicating gradient, aspects and altitude:
(iii) Erodability classification of the proposed land:
(c) Pollution sources existing in 10 km. Radius and their impact on quality of air, water and land
(d) Distance of the nearest National Park/Sanctuary Biosphere Reserve/Monuments/heritage site/Reserve Forest
(e) Rehabilitation plan for quarries/borrow areas
(f) Green belt plan
(g) Compensatory afforestation plan

4. Climate and Air Quality
   (a) Windrose at site
   (b) Max./Min./Mean annual temperature
   (c) Frequency of inversion
   (d) Frequency of cyclones/tornadoes/cloud burst
   (e) Ambient air quality data
   (f) Nature and concentration of emission of SPM, Gas (CO, CO_2, Nox,CHn etc.) from the project
5. Water balance
   (a) Water balance at site
   (b) Lean season water availability
   (c) Source to be tapped with competing users (River, Lake, Ground, Public supply)
   (d) Water quality
   (e) Changes observed in quality and quantity of ground water in the last 15 years and present charging and extraction details
   (f) (i) Quantum of waste water to be released with treatment details
   (ii) Quantum of quality of water in the receiving body before and after disposal of solid waste
   (iii) Quantum of waste water to be released on land and type of land

(g) (i) Details of reservoir water quality with necessary Catchment Treatment Plan
(ii) Command Area Development Plan

6. Solid wastes
   (a) Nature and quantity of solid wastes generated
   (b) Solid waste disposal method
7. Noise and Vibrations
   (a) Sources of noise and vibrations
   (b) Ambient noise level
   (c) Noise and Vibration control measures proposed
   (c) Subsidence problem if any with control measures
8. Power requirement indicating source of supply
   Complete environmental details to be furnished separately, if captive power unit proposed
9. Peak labour force to be deployed giving details of
   - Endemic health problems in the area due to waste water/air/soil borne diseases
   - Health care system existing and proposed
10. (a) Number of village and population to be displaced
    (b) Rehabilitation Master Plan:
11. Risk Assessment Report and Disaster Management Plan
12. (a) Environmental Impact Assessment
    (b) Environment Management Plan
    (c) Detailed Feasibility Report
    (d) Duly filled in questionnaire

    } Report prepared as per guidelines of MOEF issued from time to time
13. Details of Environmental Management Cell

I hereby give an undertaking that the data and information given above are true to the best of my knowledge and belief and I am aware that if any part of the data/information submitted is found to be false or misleading at any stage, the project be rejected and the clearance given, if any, to the project is likely to be revoked at our risk and cost.

Date: Signature of the applicant with
Place: name and full address

Given under the seal of organisation on behalf of whom the applicant is signing.

In respect to item for which data are not required or is not available as per the declaration of project preponent, the project would be considered on that basis.

Schedule-III

(See Sub-para III(a) of Para 2)

Composition of the expert committees for environmental impact assessment

1. The Committees will consist of experts in the following disciplines:
   (i) Eco-System Management
   (ii) Air/Water Pollution Control
   (iii) Water Resource Management
   (iv) Flora/Fauna Conservation and Management
   (v) Land Use Planning
   (vi) Social Sciences/Rehabilitation
   (vii) Project Appraisal
   (viii) Ecology
   (ix) Environmental Health
   (x) Subject Area Specialists
   (xi) Representatives of NGOs/Persons Concerned With Environmental Issues.
2. The Chairman will be an outstanding and experienced ecologist or environmentalist or technical professional with wide managerial experience.
3. The representative of IAA will act as Member-Secretary.
4. Chairman and members will serve in their individual capacities except those specifically nominated as representatives.
5. The membership of a Committee shall not exceed 15.

Schedule-IV

(See Sub-para I of Para 2)

Procedure for public hearing

1. Process of Public Hearing

Whoever apply for environmental clearance of projects, shall submit to the concerned State Pollution Control Board twenty sets of the following documents namely:

(i) An executive summary containing the salient features of the project both in English as well as local language.
(ii) Form XIII prescribed under Water (Prevention and Control of Pollution) Rules, 1975 where discharge of sewage, trade effluents, treatment of water in any form, is required.
(iii) Form I prescribed under Air (Prevention and Control of Pollution) Union Territory Rules, 1983 where discharge of emissions are involved in any process, operation or industry.
(iv) Any other information or document which is necessary in the opinion of the Board for their final disposal of the application.

2. Notice of Public Hearing

(i) The State Pollution Control Board shall cause a notice for environmental public hearing which shall be published in at least two newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality concerned. State Pollution Control Board shall mention the date, time and place of public hearing. Suggestions, views, comments and objections of the public shall be invited within thirty days from the date of publication of the notification.
(ii) All persons including bona fide residents, environmental groups and others located at the project site/sites of displacement/sites likely to be affected can participate in the public hearing. They can also make oral/written suggestions to the State Pollution Control Board.

Explanation

For the purpose of the paragraph person means:

(a) any person who is likely to be affected by the grant of environmental clearance;
(b) any person who owns or has control over the project with respect to which an application has been submitted for environmental clearance;
(c) any association of persons whether incorporated or not likely to be affected by the project and/or functioning in the field of environment;
(d) any local authority within any part of whose local limits is within the neighbourhood, wherein the project is proposed to be located.

3. Composition of public hearing panel

The composition of Public Hearing Panel may consist of the following namely:

(i) Representative of State Pollution Control Board;
(ii) District Collector or his nominee;
(iii) Representative of State Government dealing with the subject;
(iv) Representative of Department of the State Government dealing with Environment;
(v) Not more than three representatives of the local bodies such as Municipalities or panchayats;
(vi) Not more than three senior citizens of the area nominated by the District Collector.

4. Access to the Executive Summary

The concerned persons shall be provided access to the Executive Summary of the Project at the following places namely:

(i) District Collector Office;
(ii) District Industry Centre;

(iii) In the Office of the Chief Executive Officers of Zila Parishad or Commissioner of the Municipal Corporation/Local body as the case may be;
(iv) In the head office of the concerned State Pollution Control Board and its concerned Regional Office;
(v) In the concerned Department of the State Government dealing with the subject of environment.

[No.Z-12013/4/89-IA.I] R.H.Khwaja, Jt.Secy.

Foot Note: The Principal notification was published vide No. S. O. 60(E) dated 27th January, 1994 and subsequently amended vide No. S. O. 356(E) dated 4th May, 1994.

Explanatory note Regarding the Impact Assessement Notification Dated 27th January, 1994

1. Expansion and modernisation of existing projects
A project proponent is required to seek environmental clearance for a proposed expansion/modernisation activity if the resultant pollution load is to exceed the existing levels. The words "pollution Load" will in this context cover emissions, liquid effluents and solid or semi-solid wastes generated. A project proponent may approach the concerned State Pollution Control Board (SPCB) for certifying whether the proposed modernisation/expansion activity as listed in Schedule-I to the notification is likely to exceed the existing pollution load or not. If it is certified that no increase is likely to occur in the existing pollution load due to the proposed expansion or modernisation, the project proponent will not be required to seek environmental clearance, but a copy of such certificate issued by the SPCB will have to be submitted to the Impact Assessment Agency(IAA) for information. The IAA will however, reserve the right to review such cases in the public interest if material facts justifying the need for such review come to light.

2. Availability of summary feasibility report, EIA/EMP report etc. to concerned parties or groups
The project proponent will have to submit an executive summary incorporating in brief the essence of project details

and findings of environmental impact assessment study which could be made available to concerned parties or environmental groups on request.

3. Clarification about concerned parties or environmental groups
The concerned parties or environmental groups will be the bonafide residents located at or around the project site or site of displacement or site of alleged adverse environmental impact.

4. Public hearing
Public hearings could be called for in case of projects involving largedisplacement or having severe environmental ramifications.

5. Requisite information required for site clearance/project clearance
(a) Site Clearance: Site clearance will be given for site specific projects as mentioned in para-2(ii) of the notification. Project proponents will be required to furnish information according to the environmental appraisal questionnaires for site clearance, as may be prescribed by the IAA from time to time. Additional information whenever required by the IAA will be communicated immediately to the project proponents who will then be required to furnish the same within the time frame specified.
(b) Project clearance: In addition to the application form as mentioned in Schedule II to the notification, project proponents are required to furnish the following information for environmental appraisal:

(i) EIA/EMP report (20 copies);
(ii) Risk Analysis report (20 copies): however, such reports if normally not required for a particular category of project, project proponents can state so accordingly, but the IAA's decision in this regard will be final;
(iii) NOC from the State Pollution Control Board;
(iv) Commitment regarding availability of water and electricity from the competent authority;
(v) Summary of Project report/feasibility report (one copy);

(vi) Filled in questionnaire (as prescribed by the IAA from time to time) for environmental appraisal of the project;
(vii) Comprehensive rehabilitation plan, if more than 1000 people are likely to be displaced, otherwise a summary plan would be adequate.

As a Comprehensive EIA report will normally take at least one year for its preparation, project proponents may furnish Rapid EIA report to the IAA based on one season data (other than monsoon), for examination of the project. Comprehensive EIA report may be submitted later, if so asked for by the IAA.

The requirement of EIA can be dispensed with by the IAA, in case of project which are unlikely to cause significant impacts on the environment. In such cases, project proponent will have to furnish full justification for such exemption, for submission of EIA. Where such exemption is granted, project proponents may be asked to furnish such additional information as may be required.

6. Submission of insufficient or inadequate data

Regarding cases liable to be rejected due to inadequacy of data, it is clarified that the IAA will make such rejection within 30 days from the date of submission of the proposal. While rejecting a proposal due to insufficient or inadequate data after the first evaluation, the IAA may also stipulate additional requirement of information/clarification for impact assessment purposes if deemed essential due to the specific nature of location of the proposed project whose data as prescribed is not available, the IAA can examine the project on the basis of available data.

7. Application form

(i) In order to remove any hardship to the project proponent in providing any information, the project proponent may, where some information is not available or would cause inordinate delay, mention this in their application form. The IAA may consider the project proposal based on the information available.
(ii) Quality and quantity of ground water.

(iii) If 15 years data on the quantity and quality variation of ground water is not available with the concerned Department or Authorities, the project proponent may mention this accordingly in the application form prescribed in Schedule-II to the notification. Further, in case of projects, where ground water is not to be used, and effluents are not to be discharged on the land, the requirement of ground water variation data for the previous 15 years will be dispensed with.
(iv) A project proponent may write the words "Not Applicable" while filling the application form as mentioned in Schedule-II to the notification in respect of items which are not relevant for the purposes of the proposed project.

8. Exemption for projects already initiated

For projects listed in Schedule-I to the notification in respect of which the required land has been acquired and all relevant clearances of the State Government including NOC from the respective State Pollution Control Boards have been obtained before 27th January, 1994, a project proponent will not be required to seek environmental clearance from the IAA. However those units who have not as yet commenced production will inform the IAA.

CIRCULAR No. Z-12013/14/98 IA-I Dated April 22, 1998 of Ministry of Environment and Forests, Government of India

Sub: Prospecting and Exploration of Major Minerals in the areas above 500 ha.- Site clearance under EIA notification No. S.O.60(E) dated 27th January, 1994 as amended on4th May, 1994 and 10th April, 1997 — Clarifications reg.

The question of site clearence for projects involving aerial reconnaissance/aerial surveys for prospection or reconnaissance operations undertaken for preliminary prospecting has been examined. It was noted that these operation do not include pitting, trenching, drilling or sub surface excavation involving disturbance to earth.

It is hereby clarified that for aerial prospection surevys / aerial reconnaissance, which do not include pitting, trenching, drilling or subsurface excavation involving disturbance to

earth, no prior site clearance is required under EIA Notification dated 27th January, 1994 (as amended from time to time). However, site clearance has to be obtained before undertaking ground operations like pitting, trenching, drilling, road construction etc. leading to disturbance to earth in specific areas for exploration of minerals. In this respect the normal procedure in force will mutatis mutandis apply.

(R.H. Khwaja)
Joint Secretary to the Government of India

To All Concerned

CIRCULAR No. Z-12013/14/98 IA Dated October 27, 1998 of Ministry of Environment and Forests, Government of India

Sub: Prospecting and Exploration of Major Minerals in the areas above 500 ha.- Site clearance under EIA notification No. S.O.60(E) dated 27th January 1994 as amended on 2.5.94 and 10.4.87. -Clarifications reg.

The question of sale clearence for mining projects involving surveys for prospecting or reconnaissance operations undertaken for preliminary prospecting has been noted that test drilling exercise for confirmation of mineralization in the already identified anomalies involves on an average one bore hole in a block approximately 100 square kilometers (10000 ha.).

It is hereby clarified that for test drilling on a scale not exceeding one bore hole hundred square kilometers, no prior site clearence including public hearing is needed under the provision of the EIA notification of January, 1994 as amended from time to time. However, necessary approval under the Forest(Conservation) Act, 1980 has to be obtained in case of involvement of forestland.

Site clearence, however, has to be obtained before undertaking prospecting and exploration exercise. In this respect, the normal procedure in force will mutatis mutandis apply.

(V. Rajagopalan)
Joint Secretary to the Government of India

To All Concerned

CIRCULAR No.Z-12013/14/98-IA Dated March 16, 1999 of Ministry of Environment & Forests, Government of India

Sub: Prospecting and Exploration of Major Minerals in the areas above 500 ha. Site clearance under EIA notification No. S.O. 60(E) dated 27th January, 1994 as amended on 4-5-94 and 10-4-97 – Clarification reg.

Attention is invited to this Ministry's Circular of even no Dated 27th October '98 on the above subject regarding test drilling and site clearance.

It has been brought to the notice of the Ministry that in large areas more than one anornaly has been noticed and therefore, one bore hole will not give the clear picture in regard to the true potential. Finely the testing of the material obtained from one borehole may not give the correct picture of the grade and the size of the deposit. This may result in deposits with good potential and viable economic size escaping identification. A thorough and systematic scout-drilling program will improve the chances of finding mineral deposits within a realistic timeframe.

In view of the above, it is clarified that test drilling on a scale not exceeding 5 bore holes per 100 square kilometers would require to prior site clearance including public hearing, under and provision of EIA Notification of January '94 as amended from time to time. However necessary approval under Forest Conservation Act, 1989 would have to be obtained in case forest land is involved.

Site clearance has to be obtained before undertaken prospecting and exploration exercises in this respect, the normal procedure in force will mutatis mutandis apply.

(V. Rajagopalan)
Joint Secretary to the Government of India

To All Concerned

Appendix II

Glossary

Acid: Any of a class of substances that liberate hydrogen ions in water are usually sour and corrosive, and have a pH of less than 7.

Acid mine drainage (AMD): Acidic run-off water from mine waste dumps and mill tailings ponds containing sulphide minerals. Also refers to ground water pumped to surface from mines. Such drainage often requires treatment to neutralize acidity before it can be released into the natural environment.

Acid mine water: Mine water that contains free sulfuric acid, mainly due to the weathering of iron pyrites.

Acidic precipitation: Rain or snow that have a low pH, caused by sulphur dioxide and nitric oxide gases from industrial activity released into the atmosphere.

Acidic rocks: Usually refers to an igneous rock carrying a high (greater than 65%) proportion of silica.

Acid rain: The precipitation of dilute solutions of strong mineral acids, formed by the mixing in the atmosphere of various industrial pollutants — primarily sulfur dioxide and nitrogen oxides with naturally occurring oxygen and water vapour.

Act: In the legislative sense, a bill or regulation passed by the Parliament; a law.

Active mine: A mine is active if it has an owner and mining activities are carried out on the site.

Aerosol: A suspension of small liquid or solid particles in gas.

Agglomeration: A method of concentrating valuable minerals based on their adhesion properties.

Airborne survey: A survey made from an air craft to obtain photographs, or measure magnetic properties, radioactivity, etc.

Air pollution: Toxic or radioactive gases or particulate matter introduced into the atmosphereusually as a result of human activity.

Alluvial, alluvium: Relatively recent deposits of sedimentary material laid down in river beds, flood plains, lakes, or at the base of mountain slopes.

Amendment: A change or addition to an existing law or rule.

Anthracite: see Ranks of coal

Aquaculture: The controlled rearing of fish or shellfish by people or corporations who own the harvestable product, often involving the capture of the eggs or young of a species from wild sources, followed by rearing more intensively than possible in nature.

Aquifer: Underground source of water.

Ash: Incombustible residue left over after incineration or other thermal processes.

Asthma: A condition marked by labored breathing, constriction of the chest, coughing and gasping usually brought on by allergies.

Atmosphere: the 500 km thick layer of air surrounding the earth which supports the existence of all flora and fauna

Back: The roof or upper part in any underground mining cavity.

Backfill: Mine waste or rock used to support the roof after coal removal.

Barren: Said of rock or vein material containing no minerals of value, and of strata without coal, or containing coal in seams too thin to be workable.

Basalt: An extrusive volcanic rock composed primarily of plagioclase, pyroxene and minor olivine.

Base: Any compound that will combine with an acid and neutralize it, forming a salt; also bottom or support for any structure.

Beneficiation: The treatment of mined material, making it more concentrated or richer.

Biodegradable: Waste material composed primarily of naturally-occurring constituent parts, able to be broken down and absorbed into the ecosystem. Wood, for example, is biodegradable, for example, while plastics are not.

Biodiversity: Variability among living organisms viz., animals, plants, fungi, and microorganisms. It exists at three levels i.e., Genetic diversity, Species diversity and Habitat/ Ecosystem diversity.

Biomass: (1) The amount of living matter in an area, including plants, large animals and insects; (2) plant materials and animal waste used as fuel.

Biosphere: (1) The part of the earth and its atmosphere in which living organisms exist or that is capable of supporting life; (2) the living organisms and their environment composing the biosphere.

Biosphere Reserve (BR): A part of an international network of preserved areas designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Biosphere Reserves are vital centers of biodiversity where research and monitoring activities are conducted, with the participation of local communities, to protect and preserve healthy natural systems threatened by development. There are 13 BRs in India designated by Ministry of Environment and Forest, Government of India.

Biotic: Of or relating to life.

Birth defects: Unhealthy defects found in newborns, often caused by the mother's exposure to environmental hazards or the intake of drugs or alcohol during pregnancy.

Bituminous: see Ranks of coal.

Calcareous: Like limestone or calcium carbonate, or composed of same.

Calcine: Name given to concentrate that is ready for smelting (i.e., the sulphur has been driven off by oxidation).

Calorie: Heat required to raise the temperature of 1 gram of water by 1 degree Centigrade.

Calorific value: The quantity of heat that can be liberated from one pound of coal or oil measured in BTU's.

Cancer: Unregulated growth of changed cells; a group of changed, growing cells (tumor).

Carbon dioxide (CO_2): A naturally occurring greenhouse gas in the atmosphere, concentrations of which have increased (from 280 parts per million in pre-industrial times to over 350 parts per million today) as a result of humans' burning of coal, oil, natural gas and organic matter (e.g., wood and crop wastes).

Carcinogens: Substances that cause cancer.

Clean coal technologies: A number of innovative, new technologies designed to use coal in a more efficient and cost-effective manner while enhancing environmental protection. Several promising technologies include: fluidized-bed combustion, integrated gasification combined cycle, limestone injection multi-stage burner, enhanced flue gas desulfurization (or "scrubbing"), coal liquefaction and coal gasification.

Chlorofluorocarbons (CFCs): Stable, artificially-created chemical compounds containing carbon, chlorine, fluorine and sometimes hydrogen. Chlorofluorocarbons, used primarily to facilitate cooling in refrigerators and air conditioners, have been found to damage the stratospheric ozone layer which protects the earth and its inhabitants from excessive ultraviolet radiation.

Closed mine: A mine is closed if licensed mining activities are finished for the mine or when there is no ongoing mining activity.

Coal: A solid, brittle, more or less distinctly stratified combustible carbonaceous rock, formed by partial to complete decomposition of vegetation; varies in color from dark brown to black; not fusible without decomposition and very insoluble.

Coal dust: Particles of coal that can pass a No. 20 sieve.

Coal Gasification: The conversion of coal into a gaseous fuel.

Coal mine: An area of land and all structures, facilities, machinery, tools, equipment, shafts, slopes, tunnels, excavations, and other property, real or personal, placed upon, under, or above the surface of such land by any person, used in extracting coal from its natural deposits in

the earth by any means or method, and the work of preparing the coal so extracted, including coal preparation facilities; "Colliery".

Coal reserves: Measured tonnages of coal that have been calculated to occur in a coal seam within a particular property.

Coal washing: The process of separating undesirable materials from coal based on differences in densities. Pyritic sulfur, or sulfur combined with iron, is heavier and sinks in water; coal is lighter and floats.

Coke: A hard, dry carbon substance produced by heating coal to a very high temperature in the absence of air.

Collar : The term applied to the timbering or concrete around the mouth or top of a shaft. The beginning point of a shaft or drill hole at the surface.

Compost: Process whereby organic wastes, including food wastes, paper, and yard wastes, decompose naturally, resulting in a product rich in minerals and ideal for gardening and farming as a soil conditioners, mulch, resurfacing material, or landfill cover.

Containment pond: Structure for the accumulation of solid, chemical or dangerous substances in order to prevent their dispersal into the environment.

Contamination: Pollution.

Crusher: A machine for crushing rock or other materials. Among the various types of crushers are the ball mill, gyratory crusher, Handsel mill, hammer mill, jaw crusher, rod mill, rolls, stamp mill, and tube mill.

Demonstrated reserves: A collective term for the sum of coal in both measured and indicated resources and reserves.

Deposit: Mineral deposit or ore deposit is used to designate a natural occurrence of a useful mineral, or an ore, in sufficient extent and degree of concentration to invite exploitation.

Dioxin: A man-made chemical by-product formed during the manufacturing of other chemicals and during incineration. Studies show that dioxin is the most potent animal carcinogen ever tested, as well as the cause of severe weight loss, liver problems, kidney problems, birth defects, and death.

Drainage: The process of removing surplus ground or surface water either by artificial means or by gravity flow.

Drilling: Piercing a hole in rock. In exploration, drilling allows for samples of the rock to be taken. In mining, it is used to insert explosives for blasting.

Dump: To unload; specifically, a load of coal or waste; the mechanism for unloading, e.g. a waste dump (also called heap, pile, tip, spoil pike, etc.).

Dump sites: Waste disposal grounds.

Ecosystem: An interconnected and symbiotic grouping of animals, plants, fungi, and Microorganisms in relation to a specific environment.

Endangered species: Species in danger of extinction throughout all or a significant part of its range.

Environmental Impact Assessment (EIA): A written report, compiled prior to a production decision, that examines the effects proposed mining activities will have on the natural surroundings of an exploration property.

Era: A large division of geologic time; the Precambrian era, for example.

Erosion: The breaking down and subsequent removal of either rock or surface material by wind, rain, wave action, freezing and thawing and other processes.

Estuary: A bay or inlet, often at the mouth of a river, in which large quantities of freshwater and seawater mix together. These unique habitats are necessary nursery grounds for many marine fishes and shellfishes.

Excavation: Extraction of solid earth material from the ground for mineral mining.

Exploration: The search for mineral deposits and the work done to prove or establish the extent of a mineral deposit; Prospecting and subsequent evaluation.

Extraction: The process of mining and removal of ore from a mine; separation of desired mineral from ore.

Fault: A break in the Earth's crust caused by tectonic forces which have moved the rock on one side with respect to the other; faults may extend for many kilometres, or be only a few centimetres in length; similarly, the movement or displacement along the fault may vary widely.

Fault zone: A fault, instead of being a single clean fracture, may be a zone hundreds or thousands of feet wide. The fault zone consists of numerous interlacing small faults or a confused zone of gouge, breccia, or mylonite.

Fauna: The total animal population that inhabits an area.

Ferrous: Containing iron.

Fire damp: The combustible gas, methane, CH4. Also, the explosive methane-air mixtures with between 5% and 15% methane. A combustible gas formed in mines by decomposition of coal or other carbonaceous matter, and that consists chiefly of methane.

Fixed carbon: The part of the carbon that remains behind when coal is heated in a closed vessel until all of the volatile matter is driven off.

Flora: The total vegetation assemblage that inhabits an area.

Flotation: A form of concentration of certain minerals from gangue based on their different surface reaction to chemical flocculants. A reagent (chemical flocculants) is used to adhere to the target mineral, which then rises to the top of the flotation cell with injected air, where it can be collected.

Fluidized Bed Combustion: A process with a high degree of ability to remove sulfur from coal during combustion. Crushed coal and limestone are suspended in the bottom of a boiler by an upward stream of hot air. The coal is burned in this bubbling, liquid-like (or "fluidized") mixture. Rather than released as emissions, sulfur from combustion gases combines with the limestone to form a solid compound recovered with the ash.

Fly ash: The finely divided particles of ash suspended in gases resulting from the combustion of fuel. Electrostatic precipitators are used to remove fly ash from the gases prior to the release from a power plant's smokestack.

Formation: Any assemblage of rocks which have some character in common, whether of origin, age, or composition. Often, the word is loosely used to indicate anything that has been formed or brought into its present shape.

Forests: Lands on which trees are the principal plant life, usually conducive to wide biodiversity.

Fossil fuel: A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals; compare to alternative energy.

Fracture: A general term to include any kind of discontinuity in a body of rock if produced by mechanical failure, whether by shear stress or tensile stress. Fractures include faults, shears, joints, and planes of fracture cleavage.

Gangue: Rock surrounding a mineral or precious gem in its natural state.

Gasification: Any of various processes by which coal is turned into low, medium, or high Btu gases.

Geiger counter: An instrument used to measure radioactivity (e.g., that which emanates from certain minerals) by means of a Geiger- Mueller tube. It detects the gamma rays and indicates the frequency or intensity either visually (by dial or flashing light), audibly (by earphones) or both.

Geochemistry: The study of the chemical properties of rocks; The use of a broad spectrum of chemical elements and ratios and their patterns, which are naturally dispersed around ore deposits, to detect concealed ore bodies.

Geologist: One who studies the constitution, structure, and history of the earth's crust, conducting research into the formation and dissolution of rock layers, analyzing fossil and mineral content of layers, and endeavoring to fix historical sequence of development by relating characteristics to known geological influences (historical geology).

Geology: The science concerned with the study of the rocks which compose the Earth.

Geophysical survey: A scientific method of prospecting that measures the physical properties of rock formations. Common properties investigated include magnetism, specific gravity, electrical conductivity and radioactivity.

Geophysicist: A scientist who practices geophysics

Geophysics: The study of the physical properties of rocks and minerals; The use of the physical, magnetic or electrical properties of rock formations, minerals and orebodies to remotely detect new ore deposits, either by ground or airborne surveys.

Geothermal: Pertains to the heat of the Earth's interior.

Global climate change: This term usually refers to the gradual warming of the earth caused by the greenhouse effect. Many believe this is the result of man-made emissions of greenhouse gases such as carbon dioxide, chlorofluorocarbons (CFC) and methane.

Global warming: Increase in the average temperature of the earth's surface.

Grain: In petrology, that factor of the texture of a rock composed of distinct particles or crystals which depends upon their absolute size.

Greenhouse effect: The process that raises the temperature of air in the lower atmosphere due to heat trapped by greenhouse gases, such as carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and ozone.

Greenhouse gas: A gas involved in the greenhouse effect e.g. carbon dioxide, chlorofluorocarbons (CFC), methane etc.

Grinding: Means of reducing ore into very small particles by means of pressure or impact. Different types of grinders are used in the processing plant to obtain the desired dimension.

Groundwater: Water below the earth's surface; the source of water for wells and springs.

Habitat: (1) The natural home of an animal or plant; (2) the sum of the environmental conditions that determine the existence of a community in a specific place.

Hazardous waste: Material that, given its quantity, concentration and composition or its corrosive, inflammable, reactive, toxic, infectious or radioactive characteristics, presents a real or potential danger to human health, safety and public well-being or poses a danger to the environment if it is not stored, treated, transported, eliminated, used or otherwise managed. Mine tailings are not normally hazardous waste.

Hematite: The most common iron ore, it is a natural iron oxide that is reddish or brown in colour.

Hydraulic: Of or pertaining to fluids in motion. Hydraulic jacks lift through the force transmitted to the movable part of the jack by a liquid. Hydraulic control refers to the mechanical control of various parts of machines, such as coal cutters, loaders, etc., through the operation or action of hydraulic cylinders.

Hydrocarbon: A family of chemical compounds containing carbon and hydrogen atoms in various combinations, found especially in fossil fuels, e.g., methane, butane, propane etc.

Hydrofluorocarbons: Used as solvents and cleaners in the semiconductor industry, among others; they possess global warming potentials that are thousands of times greater than CO_2.

Igneous rocks: Rocks formed by the solidification of molten material that originated within the Earth.

In situ: In the natural or original position. Applied to a rock, soil, or fossil when occurring in the situation in which it was originally formed or deposited.

Indicated coal resources: Coal for which estimates of the rank, quality, and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections.

Industrial minerals: Non-metallic, non-fuel minerals used in their natural state in the chemical and manufacturing industries; they require some beneficiation. Examples: asbestos, gypsum, salt, graphite, mica, gravel, building stone and talc.

Inferred coal resources: Coal in unexplored extensions of the demonstrated resources for which estimates of the quality and size are based on geologic evidence and projection. Quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repletion of which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence.

Infrastructure: Construction necessary for mining, such as certain buildings, gas pipes, water lines, sewage and water systems, telephone cables and reservoirs. It may also

include roads, railways, airports and bridges, as well as transmission lines, electrical cables, pylons and transformers.

Kaolin: Also known as china clay, kaolin is a white alumina-silicate clay used in porcelain, paper, plastics, rubber, paints and many other products.

Lacustrine deposit: Sediments deposited on the bottom of lakes.

Lakes: Substantial inland bodies of standing water.

Land use: The way in which land is used. Some of the examples of land use are forest, agriculture, wasteland, human settlement.

Laterite: A residual soil developed in tropical countries, out of which the silica has been leached. May form orebodies of iron, nickel, bauxite and manganese.

Leachable: Extractable by chemical solvents.

Leaching: A chemical process for the extraction of valuable minerals from ore; also, a natural process by which ground waters dissolve minerals, thus leaving the rock with a smaller proportion of some of the minerals than it contained originally.

Lignite: refer to Ranks of coal

Liquefaction: The process of converting coal into a synthetic fuel, similar in nature to crude oil and/or refined products, such as gasoline.

Lithology: The character of a rock described in terms of its structure, color, mineral composition, grain size, and arrangement of its component parts; all those visible features that in the aggregate impart individuality of the rock.

Macroscopic: Visible to the unaided eye.

Magmatic ore deposit: Formed by differentiation of mineral in magma.

Magmatic segregation: An ore-forming process whereby valuable minerals are concentrated by settling out of a cooling magma.

Magnetic gradient survey: A geophysical survey using a pair of magnetometers a fixed distance apart, to measure the difference in the magnetic field with height above the ground.

Magnetic separation: A process in which a magnetically susceptible mineral is separated from gangue minerals by applying a strong magnetic field; ores of iron are commonly treated in this way.

Magnetic survey: A geophysical survey that measures the intensity of the Earth's magnetic field.

Magnetite: Magnetic iron ore, being a black iron oxide containing 72.4% iron when pure.

Measured coal resources: Coal for which estimates of the rank, quality, and quantity have been computed from sample analyses and measurements from closely spaced and geologically well-known sample sites, such as outcrops, trenches, mine workings, and drill holes.

Methane: A potentially explosive gas formed naturally from the decay of vegetative matter, similar to that which formed coal. Methane, which is the principal component of natural gas, is frequently encountered in underground coal mining operations and is kept within safe limits through the use of extensive mine ventilation systems.

Methane monitor: An electronic instrument often mounted on a piece of mining equipment, that detects and measures the methane content of mine air.

Mine: A plant built to extract an ore or mineral substance either underground or from the surface. When the ore is extracted underground, the mine needs a system of excavations in the rock to gain access to the ore areas. When the ore is mined from surface, the ore is extracted from one or several pits.

Mineral deposit: Mineralized mass that may be economically valuable, but whose characteristics require more detailed information. An orebody being mined may be called a deposit.

Mine development: The term employed to designate the operations involved in preparing a mine for ore extraction. These operations include tunneling, sinking, cross-cutting, drifting, and raising.

Miner: One who is engaged in the business or occupation of extracting ore, coal, precious substances, or other natural materials from the earth's crust.

Mineral: An inorganic compound occurring naturally in the earth's crust, with a distinctive set of physical properties, and a definite chemical composition.

Mineral processing: Process of extraction and concentration of economic minerals contained in ore. Mineral processing includes various procedures that rely on the mineral's gravimetric and magnetic characteristics, on its colour, and on reagents to make target particles float to the surface (flotation).

Mining: Activity whose purpose is the extraction, concentration, and smelting of economic minerals from a mineral deposit. It includes exploration (in the strict sense), development of mineral deposits, constructing the mine and mining, i.e., extracting and processing the ore or tailings.

Mining activities: The activities of prospecting, extraction and primary in situ processing of minerals.

Mining site: Mining site is the location of mining operation including the area or areas of excavation and adjoining areas or nearby facilities for materials handling, processing and waste disposal.

Mining waste: Any substance or object resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals, which the holder discards or intends or is required to discard.

Native metal: A metal occurring in nature in pure form, uncombined with other elements.

Nitrogen oxides (NOx)- Harmful gases (which contribute to acid rain and global warming) emitted as a byproduct of fossil fuel combustion.

Nodule: A rounded lump or mass of mineral.

Noise pollution: Environmental pollution made up of harmful or annoying noise.

Non:metallic: Containing little or no metal; industrial mineral.

Ore: A natural aggregate of one or more minerals that can be mined and profitably sold under current conditions, or from which one or more minerals can be profitably extracted.

Orebody: Mineralized mass whose characteristics have been determined and deemed to be commercially viable. The term "orebody" is used once the economic limits of the mineralized mass and its grade have been examined.

Ore reserves: The portion of a mineral deposit that can be profitably mined. Use of this term implies both an appropriate detailed knowledge of all the geological, engineering, economic and environmental parameters that might affect the profitability of the operation. For a new mining project or for the mining of new zones in an existing mine, a formal feasibility study is conducted to evaluate all parameters of the project.

Organic maturation: The process of turning peat into coal.

Overburden: Layers of soil and rock covering a coal seam or any other mineral. Overburden is removed prior to surface mining and replaced after the coal is taken from the seam.

Particulate: Of or relating to minute discrete particles; a particulate substance.

Particulate pollution: Pollution made up of small liquid or solid particles suspended in the atmosphere or water supply.

Peat: The partially decayed plant matter found in swamps and bogs, one of the earliest stages of coal formation.

Pegmatite: A coarse-grained, igneous rock, usually irregular in texture and composition, similar to a granite in composition; it usually occurs in dykes or veins and sometimes contains valuable minerals.

Pellet: A marble-sized ball of iron ore bonded by clay and fused for hardness.

Permit: As it pertains to mining, a document issued by a regulatory agency that gives approval for mining operations to take place.

PM10: Particulate matter less than 10 microns in diameter.

Pneumoconiosis: A chronic disease of the lung arising from breathing coal dust.

Pollution prevention: Techniques that eliminate waste prior to treatment, such as by changing ingredients in a chemical reaction.

Population: (1) The whole number of inhabitants in a country, region or area; (2) a set of individuals having a quality or characteristic in common.

Possible reserve: Ore deposits whose continuity has been determined from limited sampling information and reasonable extrapolation. It does not stand alone but is an extension of, or additional to, proven or probable reserves. Possible reserves are excellent targets for increasing a probable reserve and for extending the deposit over a larger and generally deeper area.

Primary crushing: Process of reducing blasted ore into smaller fragments so that it can be transported to the processing plant. In underground mines, the primary crusher is often located underground or at the entrance to the processing plant.

Probable reserve: Ore deposits whose continuity has been confirmed by samplings on a relatively detailed grid. The density of the grid allows for fairly precise determination of tonnage, density and mineral and metal content sufficient to prepare draft preliminary mining plans. Developing a new mine is usually undertaken with probable reserves.

Prospecting: In the broad sense, prospecting refers to exploration. In the strict sense, prospecting describes the search for surface mineralized showings (by prospectors). In the broad sense, prospecting refers to exploration. In the strict sense, prospecting describes the search for surface mineralized showings (by prospectors).

Proven reserve: Ore deposits whose tonnage, density and mineral or metal content are known in detail. This implies that sampling and drilling have been carried out in a regular grid located near mine workings. The term is generally restricted to that part of a reserve that is being developed or mined or for which there is a detailed mining plan.

Pyrite: A hard, heavy, shiny, yellow mineral, FeS_2 or iron disulfide, generally in cubic crystals. Also called iron pyrites, fool's gold, sulfur balls. Iron pyrite is the most common sulfide found in coal mines.

Quarry: Site where stone, rock and construction materials are extracted. Open-pit operation.

Ranks of coal: The classification of coal by degree of hardness, moisture and heat content. "Anthracite" is hard coal, almost pure carbon, used mainly for heating homes. "Bituminous" is soft coal. "Subbituminous" is a coal with a heating value between bituminous and lignite. It has low fixed carbon and high percentages of volatile matter and moisture. "Lignite" is the softest coal and has the highest moisture content. It is used for generating electricity and for conversion into synthetic gas.

Reclamation: The restoration of land and environmental values to a surface mine site after the coal is extracted. Reclamation operations are usually underway as soon as the coal has been removed from a mine site. The process includes restoring the land to its approximate original appearance by restoring topsoil and planting native grasses and ground covers.

Reconnaissance: A preliminary survey of ground.

Recovery: The proportion or percentage of coal or ore mined from the original seam or deposit.

Refining: Extracting and purifying metals and minerals.

Refractory ore: Ore that resists the action of chemical reagents in the normal treatment processes and which may require pressure leaching or other means to effect the full recovery of the valuable minerals.

Rehabilitation: Restoring an old mining site for a new industrial function, recreational use, or to a natural state.

Remediation: Relates to those actions taken to investigate, prevent, minimize or otherwise resolve the effects or potential effects on human health or the environment of a release or threatened release of a hazardous substance.

Reserve: That portion of the identified coal resource that can be economically mined at the time of determination. The reserve is derived by applying a recovery factor to that component of the identified coal resource designated as the reserve base.

Resources: Concentrations of coal in such forms that economic extraction is currently or may become feasible. Coal

resources broken down by identified and undiscovered resources. Identified coal resources are classified as demonstrated and inferred. Demonstrated resources are further broken down as measured and indicated. Undiscovered resources are broken down as hypothetical and speculative.

Run:off: Precipitation that the ground does not absorb and that ultimately reaches rivers, lakes or oceans.

Quartz: Common rock-forming mineral consisting of silicon and oxygen.

Quartzite: A metamorphic rock formed by the transformation of a sandstone rock by heat and pressure.

Sandstone- A sedimentary rock consisting of quartz sand united by some cementing material, such as iron oxide or calcium carbonate.

Scintillation counter: An instrument used to detect and measure radioactivity by detecting gamma rays; more sensitive than a geiger counter.

Scrubber: Any of several forms of chemical/physical devices that remove sulfur compounds formed during coal combustion. These devices, technically know as flue gas desulfurization systems, combine the sulfur in gaseous emissions with another chemical medium to form inert "sludge," which must then be removed for disposal.

Seam: A stratum or bed of coal.

Sedimentation: Formation of sediment. A sediment is a natural deposit created by the action of dynamic external agents such as water, wind and ice.

Settling pond: Basin or pond that allows solid materials in suspension to settle.

Shale: A rock formed by consolidation of clay, mud, or silt, having a laminated structure and composed of minerals essentially unaltered since deposition.

Slag: The waste product of the process of smelting.

Solid waste : Non-liquid, non gaseous category of waste from non-toxic household and commercial sources.

Soot: A fine, sticky powder, comprised mostly of carbon, formed by the burning of fossil fuels.

Stratosphere: The upper portion of the atmosphere (approximately 11 km to 50 km above the surface of the earth).

Strip mining: Mining technique in which the land and vegetation covering the mineral being sought are stripped away by huge machines, usually damaging the land severely and limiting subsequent uses.

Subsidence: The gradual sinking, or sometimes abrupt collapse, of the rock and soil layers into an underground mine. Structures and surface features above the subsidence area can be affected.

Sulphur (S): Element that occurs in a nature state or in compounds such as sulphides.

Sulfur dioxide (SO_2): A heavy, smelly gas which can be condensed into a clear liquid; used to make sulfuric acid, bleaching agents, preservatives and refrigerants; a major source of air pollution in industrial areas.

Surface mine: A mine in which the coal lies near the surface and can be extracted by removing the covering layers of rock and soil.

Surface water: Water located above ground (e.g., rivers, lakes).

Tailings dam: Structure designed to contain mine tailings and waste water.

Tailings pond: A low-lying depression used to confine tailings, the prime function of which is to allow enough time for heavy metals to settle out or for cyanide to be destroyed before water is discharged into the receiving watershed.

Tailings: Sludge, mineral residue and waste water (apart from final effluent) resulting from ore extraction or processing and the slag from pyrometallurgical operations.

Threatened species: Species of flora or fauna likely to become endangered within the foreseeable future.

Toxic: Poisonous.

Toxic emissions: Poisonous chemicals discharged to air, water, or land.

Toxic sites: Land contaminated with toxic pollution, usually unsuitable for human habitation.

Toxic waste: Garbage or waste that can injure, poison, or harm living things, and is sometimes life-threatening.

Tunnel: A horizontal, or near-horizontal, underground passage, entry, or haulage way, that is open to the surface at both ends. A tunnel (as opposed to an audit) must pass completely through a hill or mountain.

Underground mine: Also known as a "deep" mine. Usually located several hundred feet below the earth's surface, an underground mine's coal is removed mechanically and transferred by shuttle car or conveyor to the surface.

Uraninite: A uranium mineral with a high uranium oxide content. Frequently found in pegmatite dykes.

Uranium: A heavy, radioactive, silvery-white metal (atomic number 92) used in the explosion of nuclear weapons (especially one isotope, U-235).

Volatile matter: The gaseous part, mostly hydrocarbons, of coal.

Volcanic rocks: Igneous rocks formed from magma that has flowed out or has been violently ejected from a volcano.

Volcanogenic: A term used to describe the volcanic origin of mineralization.

Water quality: The level of purity of water; the safety or purity of drinking water.

Water table: The underground level at which the ground is saturated with water. The level at which water will stand in an excavation.

Wetland: Land (marshes or swamps) saturated with water constantly or recurrently; conducive to wide biodiversity.

Wildlife: Animals living in the wilderness without human intervention.

Zircon: A durable, crystalline form of zirconium silicate that is commonly found in placer deposits.

Zone: An area of distinct mineralization.

Zone of oxidation: The upper portion of an orebody that has been oxidized.

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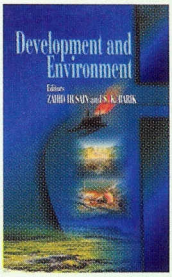

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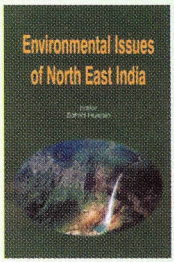

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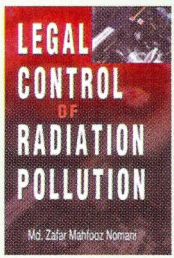

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