CHAPTER VII

MINING

I. Mining Before Independence

Perhaps the earliest use of minerals during pre-historic times by mankind was in the form of primitive implements made of agate, flint and pitchstone. From that stage, man has steadily advanced to the art of employing minerals for innumerable uses. In fact, today we have become so much dependent on mineral products that the very existence of civilization without them may be considered impossible, for they provide us with the materials for building humble dwellings or sky-scrapers, domestic appliances, agricultural implements, for the manufacture of mineral fertilizers vital to agriculture, lighting and power, means of transport on land, sea and air, and a large variety of implements, tools and machines used both in peace and war, besides serving as a medium of exchange of singular importance in international credit and national stability.

Even before the industrial era the lure of minerals and the craving for precious metals had profoundly affected the trend of history by encouraging exploration, inciting conquests and promoting spread of civilization. India is said to have been one of the most important centres of trading for diamonds, gold, emeralds and sapphires. The export trade of these precious commodities attracted the attention of the West and created an irresistible lure to acquire such interests. Columbus, while attempting to find a sea-route to India, discovered America. Thus minerals have played an ever-increasing role in world affairs, and today a fervent search is being made all over the world for uranium and other atomic minerals to manufacture nuclear weapons for war purposes and to utilize atomic energy in peace.

History of Mining in India: India has a long tradition in mining and smelting of gold, copper, lead, zinc and iron ores and mining and cutting of diamonds. Until 1886, the entire diamond wealth of the world had its origin in India. As far back as 300 B.C., Kautilya wrote, "Mines are the sources of treasury". Gold, copper, lead, silver and zinc were mined long before iron ore is known to have been worked in India, for the last 3,000 years or more. It is said that the famous "Damascus" swords of medieval age were made of iron imported from India. There was commerce between India on one hand and Egypt, Africa, Arabia, Persia, the Near East, and several other countries on the other before the dawn of the Christian-era. That Indian steel was of great antiquity is borne out by the fact that it was thought worthy of a king's present. King Poros is said to have presented 13.63 kg. of Indian steel to Alexander the Great (326 B.C.). The famous pillar near Qutub Minar, Delhi, is of solid wrought iron of excellent quality produced in India by indigenous small furnaces, and has stood the ravages of weather without showing signs of rust.

Although there is enormous evidence of the ingenuity, skill and industry of ancient miners of India in mining gold, silver, and diamond and smelting of ores, or even when the first tonne of Indian coal was struck in the Raniganj coal-fields as far back as 1775, or even when in 1843 the first Joint Stock Coal Co. was registered, systematic mining on an appreciable scale had been attempted only towards the close of the 19th century.

Mineral Industry from 1905 to 1946: The development of industries in India before independence, though steady, had been rather slow; therefore, mineral development which had necessarily to keep pace with the growth of other industries requiring the use of mineral raw materials was also very slow. The total value of mineral production of the former Indian Empire (including Burma & Pakistan) in the year 1905 was about Rs. 100 million. Only 15 minerals of economic importance were mined. There were 650 mines (301 coal and 349 non-coal) which employed nearly 110,000 persons. The mines were mostly working near the outcrops and the method of mining in many cases was primitive. Out of 301 coal mines 271 were located in Raniganj and Jharia coal-fields. The production of coal was 8.57 million tonnes. In order of value, the minerals produced were: gold, coal, manganese ore, petroleum, salt, saltpetre, mica, ruby, spinel-sapphire, lode stone, graphite, iron ore, tin ore, chromite, diamonds and magnesite.

The production of manganese from mines near Vijayanagaram which were started in 1891-92 had reached 64,300 tonnes in 1905 and over 112,200 tonnes in 1906. The production of manganese ore from the world-famous deposits of the Central Provinces (now forming parts of Madhya Pradesh and Maharashtra) in the new fields was over 154,000 tonnes in 1905 and rose to some 359,000 tonnes in 1906. Elsewhere in India, considerable activity followed the quest for this mineral with the result that by 1906, work was in progress in Sandur, Singhbhum, Panch Mahals and Mysore (Karnataka), so it can be said that by that year, principal Indian manganese deposits were in production with the output reaching 591,000 tonnes out of the world total production of 1,474,000 tonnes.

The factors responsible for the growth and expansion of the mining industry in India were the domestic need for coal, petroleum, iron and steel, gold and salt and the foreign demand for manganese ore and mica. With progressive industrialization, gold which was in the lead, yielded the first place to coal for good since 1907 and second to petroleum from 1919 to 1931. On the separation of Burma with nearly 70 per cent of the total petroleum output, it regained its second place.

Mining of lead, silver and wolfram commenced in 1909 in Burma, while exploitation and export of monazite from Kerala started in 1911. Thorium extracted from monazite is used for the manufacture of gas mantles. With the establishment of the Tata Iron and Steel Company the mining of iron ore was considerably stepped up and steel production added to the domestic industry in 1912. This also strengthened the demand for coking coal, and the price of coal which had fallen to the lowest yet on record in 1911, improved in 1912 with increasing momentum which continued till the outbreak of World War I in 1914.

During the First World War period from 1914-18 the output of certain minerals and metals like lead, silver, wolfram and tin of Burma, coal, salt, chromite and saltpetre was stimulated. The low demand for manganese ore reduced the output of this mineral, but the increase in price marked the reduction in output. Gold showed a decline in output as well as in value which led to the closure of certain mines. Zinc concentrates from Burma and copper ore mainly from the Singhbhum area were other additions to the list of minerals produced. Ferro-manganese was manufactured in the country from 1917.

The entire demand for refractories other than fire-clay refractories was being met by imports. The First World War provided the Indian refractories industry an opportunity to expand. In 1915-16, Bird & Co. Ltd., added a Silica Works at Kumardhubi; in 1917-18, the Reliance Firebrick & Pottery Co. Ltd. came into being at Chanch; a little later the Behar Firebricks & Potteries Ltd., and the Bengal Firebrick Co. Ltd., and two other small concerns started manufacturing fire refractories. At the end of the war, Burn & Co. too added a Silica Section to their Raniganj factory. The expansion of the refractories industry gave a fillip to the mining of fire clay, China clay, silica, bauxite, felspar, kyanite, siliminite, chromite, magnesite and dolomite. The number of mines (coal and non-coal) rose from 781 in 1910 to 1718 in 1920, which means that the activities of the mining industry were more than doubled during that period of 10 years; the total value of minerals produced rose from Rs. 12 crores to nearly Rs. 18 crores. Due to difficulties of procurement, the value of imports of minerals and metals, which were mineral oil, salt, copper, iron and steel, declined from nearly Rs. 29.25 crores in 1914 to nearly Rs. 17.7 crores in 1918. The effect was wholesome to India which made her self-supporting in iron and steel and led to the establishment of several industries including a small charcoal blast furnace at Bhadravati (Karnataka) in 1923. A steady increase in the value of mineral production was coninued till 1924 when it reached a figure of nearly Rs. 28 crores excluding petroleum. India became the largest producer of ilmenite since 1927. The production of copper from Rakha mines was short-lived and the mines were closed in 1924.

Trained Personnel for the Mining Industry: No industry can develop on sound lines unless trained and experienced technical persons are continuously available to it. Although the mining industry of India progressed rapidly during the first two decades of the present century, the availability of trained personnel was unsatisfactory. The country had to look up to Britain to meet its entire demand of experienced and qualified mining engineers, as there was no college or institution in India for training of mining engineers.

The Indian National Congress recognized the need for such a college as early as 1901, and adopted the following Resolution at its Calcutta Session in 1901.

"Resolved that this Congress notices with satisfaction the rapid progress of the mining industry of India and in consideration of the fact that the mineral resources of this country are vast and the facilities for acquiring a thorough knowledge of mining engineering in this country are almost nothing and in view of the fact that the tendency of recent legislation on mining namely Act VIII of 1901, is that all Indian mines must be kept under the supervision of mining experts, this Congress is of the opinion that a Government College of Mining Engineering be established in some suitable place in India after the model of the Royal School of Mines in England and the Mining Colleges of Japan and the Continent."

It was only on September 11, 1920 that the long awaited decision of the Government of India was announced. An all-India institution, financed by the Central Government providing high grade specialized instruction in mining engineering and geology and in other subsidiary and allied branches of science and engineering was to be established at Dhanbad.

Dr. D. Penman was appointed Principal of the new Institution in 1921. He submitted his scheme in 1922, which was accepted by the Government of India. But it was subsequently pruned as the Government of India slashed the estimates from Rs. 22 lakhs to Rs. 14 lakhs. Due to various impediments, it took nearly four years for the Institution to start functioning in December 1926.

Following the pattern and terminology adopted in naming the Royal School of Mines, London, the Institution was named Indian School of Mines.

The Indian School of Mines, Dhanbad, has been doing excellent work in maintaining a very high standard of training. Thus we find that most of the top and senior positions in Government departments, public sector undertakings, mineral industry and a host of other technical organizations requiring mining or geological qualifications, are held by the alumini of this Institution.

The Banaras Hindu University was a pioneer in starting courses in mining and metallurgy of the degree standard. The first batch graduated in 1927; since then it has been making a very useful contribution to the mineral industry of India by way of supplying trained mining engineers and metallurgists.

The Indian mining industry experienced a great depression in 1930. Production declined considerably and the value of the production (excluding petroleum) which had touched Rs. 28 crores in 1924, fell rapidly to Rs. 14.70 crores in 1932. The quantity and value of production of coal, mica, manganese, chromite and iron ore fell steeply. The output of gold which had also gone down was arrested in 1931, when Britain went off the Gold Standard. Most of the manganese mines were closed down with almost complete cessation of work in the Central Provinces (Madhya Pradesh) in 1932. With the opening up of Mosabani Mines and the setting of copper smelter at Monbhandar near Ghatsila in 1927, steady production of copper was started.

The recovery of the Indian mining industry slowly started from the latter part of 1933 and a definite rising trend was visible in 1934. The industry has since shown a continuous increase in output. Production of coal, iron ore, mica and manganese reached a respectable figure. The value of mineral production in 1938 increased from Rs. 14.79 crores in 1932 to Rs. 33.81 crores. The output of coal reached 25.275 million tonnes in 1937 and the average price of Bengal Coal which was around Rs. 3.25 in 1936 slowly moved up to Rs. 3.94 per tonne in 1937.

A very important event which took place in the history of Indian Mining was the ban on employment of women below surface. It came into force from October 1, 1937.

Arising out of the Indian Coal Mining Committee's recommendations (1937), increased Government control was exercised over the mining for safety including compulsory stowing where necessary. On May 27, 1939, the Coal Mines Safety (Stowing) Act, 1939, was brought into force and a Stowing Board was constituted the following month.

On the separation of Burma, the value of mineral production in India fell from Rs. 33.81 crores before separation to Rs. 21.55 in 1939. The drop was the result of the loss of nearly 70 per cent of petroleum, the entire production of tin, wolfram, nickel-speiss, ruby, lead and zinc ores and the loss of a large part of copper and silver.

The Second World War (1939-45): Difficulties of availability of labour were experienced in the mining industry, as people could get employment elsewhere during the war-period. This was a signal for a fall in output.

Although the output of coal, gold, mica and copper had fallen, the price was, however, continuously on the rise since 1939, so that the effect of the decline in production was more than offset by the increase in the prices of commodities, particularly of coal, gold and mica. The value of mineral production in 1943 was registered at Rs. 32.36 crores. From 1946, practically all the minerals showed an increase in output, and the value of production exceeded a little over Rs. 49.23 crores in that year.

With the outbreak of war the value of imported minerals and mineral products continued to rise and in 1941, it touched Rs. 41.07 crores. There was a fall in 1942, but it shot up to Rs. 91.58 crores in 1944 and to Rs. 116.71 crores in 1945. The most stimulating effect of the war was the unprecedented rise in the production of iron and steel. The production of pig iron was attained to the full installed capacity of 2.32 million tonnes and that of steel to 1.086 million tonnes in 1941. India exported about 0.508 million tonne of pig iron to Japan, U.S.A., and U.K. The output of iron ore rose to over 3.048 million tonnes.

Aluminium metal was produced from imported alumina in 1943 and from Indian bauxite in 1944. Lead-zinc and emerald mining was started in Rajasthan. Mica mining in Rajasthan also received a stimulus during the war.

Indian Mining Industry on the eve of Independence: The Second World War showed that the establishment of a healthy and sound mining industry was the backbone of all major industries. It required a change in the attitude of the Government towards the industry which had so far been almost neglected. There was no definite policy for the development and utilization of minerals. The minerals were worked in an unscientific manner. Interest had been shown only in the high grade and easily accessible and mineable minerals and ores to feed as raw materials for foreign industries without any consideration for the conservation or proper utilization of the mineral wealth of the country. Low and marginal grades of ore were dumped along with mine spoils and in several cases even good grades of iron and manganese ores were used as road metal.

Problems of waste, fire, flood, explosions, sound mining practices were lost sight of during exploitation of mines.

Mining leases were granted for any length of time and for any area in disregard to the capacity, technical ability or financial resources of a lessee or to the present or future requirements of the country. The rates of royalty also varied from lessee to lessee. None of these conditions were conducive to scientific development of minerals in the country. Thus minerals which are the real wealth of a nation, and cannot be replenished by human efforts, were allowed to be indiscriminately worked and depleted.

No attempt was made to beneficiate or upgrade low grade ores to marketable or usable standards though nature had endowed India with the largest reserves of iron ore of good quality in the world. It has small reserves of coking coal (metallurgical quality); yet no thought was given to conserve as far as possible coking coal and use it only for metallurgical purposes. It was freely used for steam raising in locos and in brick kilns. No serious attempt was ever made to locate fresh workable deposits and assess the potentialities of known deposits of minerals in which there was a big gap between the production and existing and future demands of the country. There was no restriction on exports of minerals in short supply. Technical services pertaining to the mineral industry were ruthlessly cut down during the World Depression of 1930.

In short, there was no attempt to develop a self-reliant and self-sustained economy for minerals which could hold out a promise of starting mineral based industries, which would provide to the people a continually rising standard of living, more opportunities for gainful employment and a sense of security and self-sufficiency both in peace and war.

II. Problems and Policies since Independence

National Mineral Policy: The foremost task for the new Government of India was to have a determined National Mineral Policy and to shift the emphasis from the whole-sale export of high grade minerals to the local manufacture, where possible, of finished goods, restricting exports of minerals in short supply and thereby conserving them. The plan was to effect a greater measure of Government control to achieve the desired objectives.

Mineral exploration programmes were now to be directed towards developing the potential mineral wealth of the country to the maximum extent possible, to provide the necessary mineral raw material base for industrialization and to make significant contributions to the national economy through foreign exchange savings and earnings. Thus in relation to this larger objective, scientific, systematic and integrated programme of exploration have become of far greater consequence than a random search for buried treasure.

Problem of Nationalization and Public Sector Undertakings: There are many generally accepted arguments in favour of or against nationalization; but greater need and urge is felt for nationalization in under-developed rather than in industrially advanced countries. Also increasing Government control of private investments, particularly that of foreign capital, is usually justified on account of the general cost benefit consideration, fixation of priorities, its effect on the country's balance of payments, its control over the development of key or strategic minerals and the need for planned economic development, so that there is a balanced growth of economy, most efficient utilization of capital resources and avoiding duplication or overlapping of efforts. The fear of sudden nationalization hampers the growth and efficient working of the private sector, therefore, if the private sector has to play any part in the industrial activities of the nation and there is no reason why it should not help in the task of nation building, then it is necessary for the State Government to enunciate its policy clearly.

Broadly the principles governing this policy are that the development of the minerals which cannot very well be carried out by the private sector for various reasons, should of course be given priority in the programmes of the public sector undertakings to form a well integrated development plan. Development of minerals of marginal grade which has been neglected by the private sector and development of minerals of strategic importance and mining projects requiring large investments must necessarily be taken up by public sector undertakings. It is also true that policies of any State cannot remain stagnant for a long period; in cases where compelling circumstances necessitate nationalization of any particular industrial unit, the law of the land should provide for payment of reasonable compensation determined by impartial authorities. The State must also reserve its right to bring about such changes in the degree of control of any unit in the public interest as may be considered necessary from time to time.

Regulation of Production: Regulation of production by the State through legislative controls is inevitable to achieve planned economic development. The need for regulation of production may also arise from strategic considerations, lack of adequate known resources of particular minerals, need for conservation of mineral resources for future use and to balance output of a particular type or quality of minerals according to their consumption in certain selected industries etc. For example, in India, known resources of coking coal are very limited compared to those of iron ore; therefore, a need has been felt to peg the production of coking coal to the requirements of the existing metallurgical plants. Similarly, minerals of strategic importance of limited known reserves may be subject to production controls, all the more so when they are likely to be required in substantial quantities in the near future for indigenous industries.

Conservation of Mineral Resources: Mineral resources are wasting assets and yet modern civilization is making more and more use of minerals necessitating a continuous increase in their production. Therefore, enforcement of conservation measures are essential not only in the interest of a particular nation but that of the whole world. These conservation measures may provide for the systematic exploration, prospecting, mining, milling, concentration, beneficiation, etc., by scientific and efficient methods, obtaining the maximum possible recovery of the subsidiary associated minerals, blending of ore, substitution of some high grade minerals by other synthetic products or lower grade minerals for certain purposes, grant of subsidies and allowances to make fruitful use of the minerals in general. Although selective mining of high grade minerals alone, may yield spectacularly high profits but generally it leads to lowering of valuable reserves and hence may not be beneficial from an overall national point of view. Valuable by-products, although economically recoverable, may not be recovered by mine owners either because of their inability or unwillingness to invest additional capital or because of the possible resultant decrease in rates of profits even though they may be quite just or proper. Thus to conserve the country's mineral resources by elimination of avoidable waste during mining, processing and utilization is considered absolutely essential.

Mineral Beneficiation and Ore Dressing: Some of the vital technical fields have remained unattended for a long time in India, though there has always been a pressing necessity of developing them. Ore dressing is unquestionably one of them having strong bearing on the mineral development of the country; without proper utilization of the so-called low grade ores the mineral industry can never be put on a firm economic footing. This is especially true when we consider that hardly, if at all, the high grade ore could be mined as such, without at the same time, producing a large quantity of low grade or marginal grade of ore. In all foreign countries the case of progress of ore dressing has always proceeded parallel with the mining activities.

India has vast deposits of low grade ore lying untapped, which could be utilized if proper benificiation techniques are employed; and in this respect special attention needs to be paid to manganese ores, coal, mica, chromite, ilmenite, asbestos, kyanite, and atomic minerals.

Grading and Marketing: Mineral resources may be developed either to meet local indigenous demands or for export with or without any treatment, concentration etc., or for both. Production of finished, or semi-finished products from minerals permits the full benefit such as employment opportunities, development of subsidiary industries, considerable enhancement of value and steady market demands etc. In an under-developed country like India which is on the threshold of economic and industrial progress, the capacity to earn foreign exchange by export of finished products is small and the need to import capital goods is great. In order to maintain a proper balance of foreign currency earnings and payments, this gap can only be filled by export of raw minerals judiciously selected for the purpose, keeping the present and future local needs in view. Strict quality control is essential to ensure that substandard minerals are not supplied either for the internal market thereby lowering the efficiency of production units and the quality of their products or for export.

Export-Import Policies: Export-import policy in minerals is deeply related to the foreign exchange situation and other economic considerations, mineral conservation policies, strategic considerations, and known resources of minerals etc., all of which are liable to change from time to time. Therefore, this policy has to be formulated only for short periods. The main object is to encourage development of indigenous industries either for export promotion or for import substitution by, if necessary, protecting them from competition with imported material particularly during the initial stages or giving them assistance by way of reduction in railway freight, royalties and export duty or cesses and payment of subsidies to become competitive in price and quality in any or all foreign markets. Such policies have been framed from time to time by the Ministry of Foreign Trade in consultation with the Department of Mines and Metals.

Safety and Welfare of Workers: Both from the management as well as from the workers' point of view the safety and welfare of workers is very important. O.M.S. (Output per man shift) in India is very low, hardly 0.5 and in many cases just over 0.4. It can certainly be improved by better mining conditions underground, better lighting, adequate ventilation, by providing fatigue removing implements, adequate medical facilities, elementary training in principles and methods of mining, better wages and incentive bonus, better housing, recreation clubs, canteens, pit-head baths, creches etc.

If India has to build and develop the mining industry, there should be no outside political interference or influence on miners' unions. Such influence leads to proliferation of trade unions in the industry. Each mine should have its own labour councils manned by repersentatives of management and workers, where problems concerning the safety and welfare of workers, their wages and bonus, problems of better O.M.S and problems of reducing production costs should be discussed and solutions found for them.

Mineral Policy: A Mineral Policy Conference was held at the beginning of 1947. It unanimously agreed upon the advisability of formulating a well co-ordinated national mineral policy to ensure planned development of the mineral resources of the country and to establish a complete technical organization to maintain close liaison among the various ministries and departments of the Government of India as well as to advise them on all matters concerning minerals. As a result of this Conference, the Indian Bureau of Mines was constituted in 1948.

During the first two years of its life, the Bureau functioned as an advisory body. With the passing of the Mines and Minerals (Regulation and Development) Act, 1948, the Bureau was assigned the following functions:

1. Advising the Central and State Governments on all matters relating to the grant of mineral concessions and on the exploration and utilization of the country's mineral resources.
2. Periodic inspection of mines for effecting systematic development of mineral deposits, elimination of waste and promotion of improved methods of mining.
3. Conducting research on the beneficiation of low grade ore and industrial utilization of minerals and mineral products as well as on mining problems in collaboration with other research organizations.
4. Conducting analyses of ore and minerals.
5. Collection and publication of statistics of mineral production, world mineral trade, foreign mining rules and other matters.
6. Assisting the mineral trade in the marketing of minerals.
7. Detailed prospecting of mineral deposits by means of drilling and exploratory mining.

Expansion of Technical Departments: The Geological Survey of India (G.S.I.) which began with a strength of 400 in 1947 was 8,400 strong in 1971. The National Metallurgical Laboratory, the Fuel Research Institute, a chain of other national laboratories and the Atomic Energy Department were established in rapid succession. The Mines Department, now named Directorate of Mines Safety, was suitably expanded to deal with safety of workers in mines.

Minerals being the basic raw materials for industrial development, mining of coal and lignite, mineral oils, iron ore, manganese ore, chrome ore, gypsum, sulphur, gold and diamonds, mining and processing of copper, lead, zinc, tin, molybdenum and wolfram and minerals specified in the Schedule to the Atomic Energy (Control of Production and Use) Order, 1953, were placed in the category of industries whose future development would be the exclusive responsibility of the State under the Industrial Policy Resolution of 1955.

To meet the requirements arising out of the changed conditions after independence several Acts have been passed and rules framed thereunder. Some of the important Acts and Rules are:

1. Mines and Minerals (Regulation and Development) Act, 1948,

substituted by Act 67 of 1957:
- (i) Mineral Concession Rules, 1949.
- (ii) Mineral Concession Rules, 1960.
- (iii) Mineral Conservation & Development Rules, 1958.

2. Mines Act, 1952:
   - (i) Mines Rules, 1955.
   - (ii) Mines (Posting up of Abstracts) Rules, 1954.
   - (iii) Indian Coal Mines Regulation, 1957.
   - (iv) Indian Metalliferous Mines Regulation, 1961.
3. Coal Mines (Conservation and Safety) Act, 1952:
   - (i) Coal Mines (Conservation and Safety) Rules, 1954.
4. Coal Mines Labour Welfare Fund Act, 1947:
   - (i) Coal Mines Labour Welfare Fund Rules, 1949.
   - (ii) Coal Mines Labour Welfare Office Establishment (Contributory Provident Fund) Rules, 1951.
5. Mica Mines Labour Welfare Fund Act, 1946:
   - (i) Mica Mines Labour Welfare Fund Rules, 1948.
   - (ii) Mica Mines Labour Welfare Office Establishment (Contributory Provident Fund) Rules, 1950.
6. Iron Ore Mines Labour Welfare Fund Act, 1960.
7. Iron Ore Mines Labour Welfare Cess Act, 1961.

Mineral Development and Mineral Exploration: Revolutionary changes have taken place in the purpose, scope, tempo and nature of mineral exploration in India after 1947 when the country became independent.

In the field of mineral exploration, the role of the Geological Survey of India relates to the preparation of basic geological maps and the regional investigation of mineralized districts. In addition to conventional geological methods, photo-geological, geo-chemical and geo-physical methods are employed. Ground mapping and aerial photographs in a number of mineralized districts such as the Zawar lead-zinc district, the Khetri and Dariba copper districts and the Singhbhum copper belt have been carried out. The geo-physical surveys, employing seismic, gravimetric, magnetic and electrical methods have been carried out to locate favourable structures for oil as well as in connection with exploration of concealed deposits in a variety of minerals including copper, lead, graphite, pyrites, diamonds, etc.

The activities of the Indian Bureau of Mines (I.B.M.) which came into existence in 1948 are widespread including the introduction of scientific methods of prospecting, exploring, mining and utilizing minerals through systematic and regular inspection of mines, detailed exploratory and proving operations to convert prospects into working mines, research investigations in mineral beneficiation and mineral technology; and the collection, compilation and interpretation of statistical data relating to all aspects of India's mineral industry, such as production, consumption, marketing, import, export, reserves, grade, and utilization.

A few of the important results of detailed exploratory and proving operations carried out by the Indian Bureau of Mines are given below:

	Mineral	*Reserves proved*
(a)	Coal	4940.29 million tonnes
(b)	Iron ore	959.0 million tonnes
(c)	Limestone & dolomite	88.0 million tonnes 10.2 million tonnes
(d)	Copper ore	100 million tonnes average grade 1% Cu.
(e)	Copper-lead-zinc	0.36 million tonnes, Total metal content 6.24%
(f)	Pyrites	76.2 million tonnes, sulphur content 40% Indicated reserve — 313.9 million tonnes
(g)	Magnesite	12.19 million tonnes, containing about 41 to 46% magnesia.

A separate Oil and Natural Gas Commission has been set up to carry out oil exploration on a major scale in the country. In addition to the conventional methods, the latest methods are employed by the Commission including aeromagnetic surveys, geo-physical surveys and photo-geological surveys. Notable success has already been achieved in the Cambay and other areas in Gujarat.

The Department of Atomic Energy is carrying out extensive radio-metric surveys, both on the ground and by air, in their search for deposits of radio-active minerals.

In order to beneficiate any given ore, it is first necessary to undertake systematic research on a representative sample of the ore to evolve a suitable process. It has been rightly said that no two ores are identical in their amenability to beneficiation. These studies should be supplemented by tests on a pilot plant scale to work out the proper flow-sheet and collect all the relevant data which are very necessary for designing a suitable beneficiation plant.

Exploitation of Minerals by the State: In order to exploit deposits of coal, iron ore, copper, diamonds, pyrites, proved by the Indian Bureau of Mines and the Geological Survey of India, the Government of India have set up a number of Corporations in the Public sector. These are:

1. The National Coal Development Corporation (N.C.D.C.) for working coal.

2. The National Mineral Development Corporation (N.M.D.C.) for working minerals other than coal.
3. The Pyrites & Chemical Development Corporation to work pyrites at Amjor (Bihar) and at Saladipura (Rajasthan) for sulphur.
4. The Metal Corporation of India was taken over by the Government of India in 1965 and a new undertaking, Hindustan Zinc Ltd., was set up to run mines and smelters.
5. Copper has been transferred from N.M.D.C. to Hindustan Copper.
6. The Uranium Corporation of India is in-charge of the deposits at Jaduguda Mines in Bihar.
7. The Neyveli Lignite Corporation is now owned and run by the State of Tamil Nadu to mine the lignite deposits at Neyveli.
8. For trading in minerals and metals the Minerals and Metals Trading Corporation (M.M.T.C.) has been established.

A long awaited decision of the Government regarding the conservation of fast depleting resources of coking coal as compared to vast reserves of high grade iron ore in the country, was announced on October 17, 1971, taking over 214 coking coal mines. Bharat Coking Coal Corporation has been formed to work these mines. Non-coking coal mines have also been nationalized and are now worked by the Coal Mining Authority.

III. Survey of Mining Industries

Coal: The workable coal measures of India belong to the Upper Palaeozoic and the Lower Tertiary. Workable coal seams are confined to Lower Gondwanas in the case of the former and in the case of Tertiary the workable seams occur in the Eocene. The Gondwana coals are of bituminous and sub-bituminous quality while the Eocene coals are generally lignite. In the Himalayan mountain area, however, higher rank coals are occasionally met with, the process of maturity having been accelerated by the abnormally high tectonic pressures which accompanied the growth of Himalayas.

The Gondwana coal-fields are spread over Assam, West Bengal, Bihar, Orissa, Madhya Pradesh, Maharashtra and Andhra Pradesh, while Tertiary coal-fields occur in Assam, Gujarat, Jammu and Kashmir, Rajasthan, Pondicherry and Tamil Nadu.

The earlier history of Indian coal mines is somewhat obscure; but the claims that the use of coal is entirely a western fuel introduced into India is untenable in the face of indigenous place names of localities like Damodar, Barakar and Kali Pahari which are still amongst the most important centres of coal mining. All these show that the existence of coal and its use in the area was known long before Summer and Heatly applied for their concession in August 1774, in Raniganj (Bengal).

Coal mining started in 1862 in the Central Provinces (Madhya Pradesh), and in the former Rewa State in 1884. The Singareni collieries went into production in 1887. Coal mines in Upper Assam were opened in 1881, while the Jharia coal-field was opened in 1893. Development of the Jharia coal-field was so rapid that in 1906 production exceeded that of the Raniganj field and India produced over 8.13 million tonnes of coal.

In the absence of railway facilities, expansion of the coal industry was slow for many years. By 1860, the annual output of coal had reached only 37,750 tonnes. Mining methods were primitive and only the outcrop coal was worked to shallow depths. Gins were used for lowering and raising buckets of coal and water. Miners used picks and carried baskets of coal on their heads.

Trends in use of machinery in Coal Mines: The Pulsometer type steam pump was perhaps the first mechanical plant used in Indian mines. A 10 h.p. steam engine was employed in 1852 to raise coal replacing manual labour. From 1900 onwards, simple mining machinery like rope haulages and pumps were introduced. In 1906 the first colliery power station of 400 KVA (kilovolt ampere) was installed by the Bengal Coal Co. at Sodepur. The advent of electricity in the mines was a great technological stride towards mine mechanization. In 1925 out of 810 mines, 108 were using electric power. In 1950, out of 848 working mines, 345 were electrified and had installed electric machinery of the order of 372,000 h.p. In 1966, 661 collieries were using electric energy of the aggregate horse power of 610,006.

The use of mining machinery has steadily increased. In 1925, there were 125 coal-cutting machines in use, in 1950 there were 399 coal-cutting machines employed by 120 mines and in 1955, 151 coal mines were cutting coal with 527 coal-cutting machines. In 1960, 199 collieries produced 14 million tonnes of coal by machines i.e. 27% of the total output. The number of coal-cutting machines further rose to 738 in April 1963, and 1,588,939 tonnes of coal was cut by them. While in 1966 the number of coal-cutting machines worked by electricity was 951. The number of mechanical loaders rose from 7 in 1951 to 23 in December 1960, and those of coal conveyors rose from 23 in 1951 to 106 in March 1961, and to 162 in April 1963. In 1960, more than 481,000 tonnes of coal was conveyed by coal conveyors. During 1969 more than 200 conveyors were in operation. Another important feature in mines in India has been the use of more and more of electric safety lamps in place of *mug batties*. By 1966, the number of safety lamps rose to 254,853 out of which 240,647 were of electrical type.

Size of Mine and Pattern of Production: The average annual output of coal per mine in 1925 was 25,000 tonnes. A number of small mines were closed during the general depression in the thirties and the average output increased to 41,000 tonnes. During World War II, as the demand for coal shot up, many small mines sprouted again and the average output per mine registered a fall and was only 27,550 tonnes in 1945. Since 1950, there has been a steady rise in the average output per mine and it has increased from 36,700 tonnes in 1950 to 61,000 tonnes in 1960. Still only 18% of the mines produced more than 10,000 tonnes a month while 32% produced less than 100 tonnes a day or 2,500 tonnes a month and another 18% produced less than 600 tonnes of coal per month. But there are 40 collieries producing more than 25,000 tonnes of coal per month and four of these produce more than 75,000 tonnes per month.

A definite change in the pattern of production is noticeable, as until 1958 only 13% of the total production came from open cast workings while 87% was accounted from underground. But there is a steady rise in the production from open cast workings due to the opening up of new large-scale quarries in the public sector by N.C.D.C. During the next decade or so several other open cast mines will be opened by the public sector to meet the increased production targets. At present, upto 1:3 (coal to overburden ratio) is planned for open cast workings, but this ratio is likely to go upto 1:5. Thus large-scale quarrying may become a permanent feature in Indian coal mining. Now the N.C.D.C. produces over 9 million tonnes of coal annually from its open cast mines. They are semi or fully mechanized, employing power shovels, draglines and dumpers. The dragline employed at Bisrampur open cast mine has a bucket capacity of nearly 30 cubic metres.

Deep shafts are also being sunk for mining coal from deeper horizons and a number of coal mines will be operating at depths of nearly 186 metres in the near future.

Coal and Five Year Plans: Coal being classed as a schedule 'A' mineral, its future development will have to be carried out by the State. The idea of having a master plan for coal mining development in India was prepared by the Chief Mining Engineer, Railway Board ,in 1950 showing the actual and potential capacities of different coal-fields and also the estimated requirements of the country. The estimated increased demand of coal during the First Plan period was of the order of only about six million tonnes, which was considered to be met with in the normal production capacity of the industry.

With the Second Plan the position changed considerably as more emphasis was laid on industrialization and to meet its fuel requirements the production of coal had to be increased from 38 million tonnes to 60 million tonnes. To achieve the required additional production of

22 million tonnes, within a period of five years was a stupendous task. The private sector as a whole could not raise 60 million tonnes. The Government had to step in to open out new areas and establish new mines. The additional production was shared between the private sector and the public sector — 12.3 million tonnes and 10.5 million tonnes respectively. An autonomous Government undertaking the National Coal Development Corporation with the eleven old railway collieries as its nucleus was established on October 1, 1956 to accomplish this task. The N.C.D.C. is now operating 52 collieries.

Unrestricted access to under-developed coal bearing areas had to be given to Government and for the purpose of speeding acquisition of coal bearing areas, the Coal Bearing Areas (Acquisition and Development) Act, 1957, was enacted.

Opening out of new mines or for extending the working of existing mines to virgin areas require considerable data regarding the behaviour, attitude, geological disturbances, overburden, thickness, strike and dip of the coal seams, reserves, grade and washing characteristic of coal for planning their opening. Co-operation and assistance was taken of existing technical organizations, the G.S.I. and the I.B.M. The I.B.M. put in all its resources for detailed prospecting of Korba, Kathara, Bisrampur, Jhilimili, Giddi, Talchir, Ramgarh, Kargali, Bokaro and Satpura fields, and supplied N.C.D.C. all the data including the ratio of overburden to coal, and floor contour. To supplement the work of the I.B.M. and G.S.I., the N.C.D.C. also organized a prospecting section. During the Second Five Year Plan, the N.C.D.C. opened 11 more collieries and achieved an annual producton rate of 10 million tonnes. Production from the 11 old collieries was also expanded from 2.9 million tonnes to 3.6 million tonnes.

The private sector did its share and the output of coal reached 56 million tonnes in 1961; the share of N.C.D.C. and Singareni collieries was 10.3 million tonnes.

In the Third Five Year Plan, the target of coal production was fixed at 97 million tonnes, the share of public sector and private being fixed at 37 million and 60 million tonnes respectively. The I.B.M., the N.C.D.C. and G.S.I. have continued detailed prospecting by drilling during the Third Five Year Plan in selected blocks in various coal-fields in Bihar, West Bengal, Madhya Pradesh, Maharashtra and Jammu and Kashmir. As a result of drilling, the I.B.M. has discovered a deposit of coking coal in Chano Rikba area of North Karanpura coal-fields and more than 58 million tonnes of reserves of coal have been proved. The G.S.I. has proved a thick coal seam in Singrauli coal-field. These new discoveries are a valuable addition to the coal resources of the country. The G.S.I. and N.C.D.C. are carrying out exploratory operation for coal in the different coal-fields of Bihar, West

Bengal, Madhya Pradesh, Orissa, Jammu and Kashmir, Assam and Andhra Pradesh to enable the producing organizations to achieve and sustain the production targets for coal envisaged in the Fourth Plan and subsequent plans.

Reserves: Reserves of all grades of coal in seams of 1.4 metres and over in thickness are estimated to be of the order of 43,000 million tonnes within a depth of 609 metres. Inferred reserves are placed at an additional 80,000 million tonnes. Thus the total resources of coal inclusive of proved, estimated and inferred are placed at 123,000 million tonnes. Detailed exploration has shown that the overall position of coal resources in the country is considerably larger. Talchir coal-field alone may contain coal reserves of the order of 90,000 million tonnes.

Though in terms of quantity, coal resources appear to be large, the reserves of selected and grade I coal are limited. This is all the more so in case of metallurgical coal (coking coal). India is endowed with very large reserves of high grade iron ore (above 60% Fe.) whereas the reserves of coking coal suitable for metallurgical purposes have been assessed as 4,600 million tonnes upto a depth of 600 metres and are restricted to the Jharia coal-field in Bihar.

Consequently on shortfalls in the industrial complex of the country there was a setback in the coal production programme, in the Third Five Year Plan. The demand for coal slackened and production in 1965-66 was a little over 70 million tonnes against a target of 97 million tonnes. By the end of the Fourth Five Year Plan period, the requirements of coking coal by the steel plants alone, was expected to be of the order of 23 million tonnes, and 1.2 million tonnes of blendable coal; besides this quantity, another 3.6 million tonnes of coking coal was required for other cokeries. This involved a considerable increase from the current production of about 17 million tonnes. This situation, therefore, called for focussing attention on a measure of conservation of metallurgical coal by pegging the production of coking coal and using it only for metallurgical purposes, scanning the country for other deposits of coking coal, investigating the possibility of producing iron and steel by using non-coking, or coals of lower coking index and washing of low grade coking coal to reduce the percentage of ash.

The Government has, therefore, taken over 214 coking coal mines placing them under a Government undertaking named as Bharat Coking Coal Co. High priority has been assigned to the coking coal programme for the future Plans. In addition to the various coking coal mines already in production, N.C.D.C. will contribute 2 million tonnes each from its two new mines, Sudamdih and Moridih. The non-coking coal mines have also been nationalized and placed under the control of the Coal Mining Authority. To achieve the target of production of 97 million tonnes both the Coal Mining Authority and the N.C.D.C. are going ahead with their development and production plans. Prior to nationalization the private owned collieries were granted a loan of 35 million dollars by the World Bank for meeting their foreign exchange requirements.

The N.C.D.C. has launched its major schemes with the assistance and collaboration of Poland, France, West Germany, U.S.S.R. and the U.S.A. The British National Coal Board is willing to develop three gassy mines near Bokaro for 3 to 4 lakhs tonnes of coking coal annually. Umrer colliery in Maharashtra and a colliery in Talchir have been opened by N.C.D.C. for an annual production of 1 million tonnes of coal each.

Collieries in Satpura basin near Betul have been developed to supply coal for a super thermal power station near Ghora Dongri in Betul district.

The output of coal during 1970 was 72.51 million tonnes as against 74.21 million tonnes in 1969.

The requirements of coal in 1974-75 have been estimated at 95 million tonnes comprising 26 million tonnes of coking coal and 69 million tonnes of non-coking and blendable coal.

Washing of Coal: Good quality coking coals have been largely exhausted in the Jharia fields and the poorer quality of coals with high percentage of ash have to take their place. Therefore, washing of such coals has become a necessity. Four washeries in the private sector at Lodhna, West Bokaro, Jamadoba and Nowrozabad and five coal washeries in public sector at Kargali, Bogda, Patherdih, Bhojudih and Durgapur have been completed and two more new washeries at Kathara and Bhurkunda will be set up in the public sector. The existing washing capacity and that of the new plant is estimated to be 13.7 million tonnes of clean coal.

The problems facing the washeries in India are the distribution of ash in the segregation form in the coaly matter and the disposal of middlings. Unless power stations using middlings are set up near the washeries to improve the economics of clean coal, the cost of washing may become prohibitive when the percentage of clean coal is low in many cases. Again, the capital cost in setting up washeries to meet the entire requirements of coal for the steel plants may run into staggering sum of money in terms of foreign exchange unless the entire plant is designed and manufactured indigenously.

Lignite: Deposits of lignite at Palana in Rajasthan have been worked for several years now and the lignite is in use in the thermal station at Bikaner. The reserves are of the order of 22 million tonnes.

The Indian Bureau of Mines has completed detailed proving operations at Nichahoma in Jammu and Kashmir, and there is a scheme to exploit this deposit.

Neyveli lignite deposits in the South Arcot district of Tamil Nadu are the largest so far discovered. Exploration has revealed reserves of about 2,000 million tonnes of lignite over an area of 259 sq. km. A seam of lignite varying in the thickness from 0 metre to 27 metres occurs at depths of 54 to 75 metres. Under the lignite bed there is an artesian aquifer exerting a pressure of 6 to 8 tonnes per square foot (0.09 sq. m.). A pilot quarry 183 x 183 metres was excavated during 1953-54 and a pumping test was conducted which has revealed that, to control this pressure it would be necessary to pump out 2,05,000 litres of water per minute.

An integrated Lignite Project comprising the open cast mines, thermal power stations of 250 MW to be expanded to 400 MW, a Briquetting and Carbonization Plant with a capacity to produce 380,000 tonnes of carbonized briquettes per annum, besides a number of by-products like chardust, middle oil, phenols and kerosene, etc., a fertilizer plant with capacity to produce 152,000 tonnes of urea fertilizer, using about 0.5 million tonnes of lignite and a clay washing plant has been planned. Regular mining of lignite has been started, overburden is stripped by conventional earth moving machinery consisting of a shovel and loaders and specialized machinery consisting of bucket-wheel excavators and slewable spreaders. Two of the bucket-wheel excavators have bucket capacity of 350 litres; while the other two have bucket capacity of 700 litres. The output of 350 litres bucket-wheel excavators is 611.6 cubic metres of overburden per hour and that of 700 litres bucket-wheel excavators is 1529 cubic metres per hour. The disposal of burden from the mine to the spoil heap is done by belt conveyors and bottom dumpers, and the material is distributed on the spoil heap by slewable spreaders. For excavation of lignite alone, bucket-wheel excavators and belt conveyors are used. The mine is planned for an output of 3.5 million tonnes of lignite per annum (about 13,000 tonnes per day) which is expected to be raised to 4.8 million tonnes per annum when the thermal power station is expanded to produce 400 MW.

The output of lignite in 1963 from Neyveli was 987,174 tonnes, as against 174,805 tonnes in 1962, which rose to 2.56 million tonnes by 1966. The production in 1970 was 3.5 million tonnes. The entire quantity was from Neyveli open cast mine using bucket-wheel excavators. The production of lignite is expected to be enhanced to 6 million tonnes to meet the requirements of the increased capacity of the power station from 400 MW to 600 MW.

Iron Ore: The manufacture of iron from its ore in India can be traced to pre-historic times. It had markets in the Middle East, Egypt and East Africa even before the Christian era. The famous Damascus swords of medieval age were manufactured from the steel imported from India. It is known that at the time of Alexander's invasion (326

B.C.), Indians were as familiar with use of iron and steel in the battle field as the Greeks themselves.

The famous wrought iron pillar at Mehrauli near Delhi bearing an inscription in Sanskrit of king Chandra (identified with, Chandra Gupta II, 5th cen. A.D.) has stood the weathering effect for centuries without showing any sign of rust or corrosion. It testifies to the high quality of wrought iron produced in this country.

Until the close of the 18th century the indigenous iron industry flourished throughout India except in the alluvial plains. Iron was manufactured in local iron smelting furnaces, built of sun-dried bricks plastered with a mixture of earth and cowdung. The capacity of such a furnace in Alwar (Rajasthan) was 250 kg. of iron ore and 210 kg. of charcoal. The yield of iron from one charge varied from 120 to 130 kg. Cadell wrote in 1873 that there were thirty such iron smelting furnaces at work in former Alwar State and they produced nearly 540 tonnes of iron per year. The indigenous industry could not compete with imported iron and steel and eventually died.

Modern Trends: The production of iron on a large scale could not be attained till the beginning of this century, though numerous attempts were made to graft European methods on the local process and to smelt iron ores. The establishment of the Tata Iron & Steel Co. Ltd. (T.I.S. CO.) and the commissioning of the blast furnaces in 1911 and 1912 at Jamshedpur, the inauguration of the Indian Iron & Steel Co. (I.I.S. CO.) furnaces at Burnpur near Asansol in 1922, the completion of the then Mysore Government scheme of manufacturing iron by charcoal at Bhadravati in 1933, and the amalgamation of the Bengal Iron Co. Ltd., with works at Kulti near Asansol and the Indian Iron & Steel Co. in 1936, are important landmarks in the history of iron and steel production in India.

These units, however, did not expand appreciably till independence and the formulation of Five-Year Plans. Apart from the modernization and expansion of the existing steel plants, and doubling of their capacities, three new steel plants at Rourkela, Bhilai and Durgapur were set up in the public sector during Second Plan period. Another steel plant has been constructed at Bokaro in addition to the expansion of the existing public sector units. A capacity target of 10.2 million tonnes of mild steel ingots, 1.5 million tonnes of pig iron and 20,000 tonnes of alloy tool and special steel has been fixed. The requirement for iron ore for the above production targets will be of the order of 20 million tonnes. The output of iron ore was 13.36 million tonnes and 14.92 million tonnes in 1962 and 1963 respectively. Although the Bokaro Steel Plant which was programmed to go into commission during the Third Five Year Plan could not materialize, and the target production of 10.2 million tonnes of steel ingots could not be achieved, yet the production of iron ore reached a figure of 20.065 million tonnes; Goa produced 6.718 million tonnes of iron ore. It is expected that by the end of 1975, the domestic demand for finished steel and pig iron will be of the order of 8 million tonnes and 2 million tonnes respectively. It has, therefore, been programmed to step up the production of Bhilai steel plant from 2.5 million tonnes to 3.2 million tonnes and complete the first stage of Bokaro for an output of 1.7 million tonnes. In the private sector I.I.S.C.O. is expected to increase its production from 1.0 million tonnes to 1.3 million tonnes. Exports have been envisaged at a level of 1 million tonnes of finished steel and 1.5 million tonnes of pig iron. On the basis of this expansion programme, the capacity of 12 million tonnes of ingot will be reached.

Resources of Iron Ore: The world resources of iron ore are estimated at about 83,000 million tonnes. Actually the resources may be higher in view of the fact that data for U.S.S.R. are meagre, and no substantial work for the estimation of reserves has been done in the under-developed countries.

The reserves of iron ore in India are estimated at 21,000 million tonnes and it falls under three categories — hematite, magnetite and limonite. Detailed exploration undertaken during the Second Plan period on a few deposits has revealed that earlier estimates have been highly conservative. In view of this, the reserve figures indicated above may shoot up, if detailed exploration is carried out of the deposits for reliable assessment.

Extensive deposits of hematite ore occur in the Singhbhum district of Bihar; Keonjhar, Mayurbhanj and Sundergarh districts of Orissa; Drug, Bastar and Jabalpur districts of Madhya Pradesh; Ramagiri and Chanda districts of Maharashtra; Hyderabad and Kurnool districts of Andhra Pradesh; Jaipur, Jhunjhunu and Sikar districts of Rajasthan; Mysore, Bellary and Dharwar districts of Karnataka and Mohindergarh district of Haryana.

The Indian ores are generally of high grade containing more than 60 per cent iron. The ores of Singhbhum-Keonjhar-Bonai area and Bailadila and Rawghat areas are mostly of very high grade containing on an average, more than 65 per cent iron. Redi and Shimoga-Chitaldrug—Tumkur areas, though contain some high grade ore, the proportion of low grade ore is more. Dharwar and Narnaul (Haryana) produce ores of still poorer quality, iron content being 45 to 60 per cent. The poorest ore is from Tamil Nadu (Salem) containing 35 to 45 per cent iron contents. The ore of Rajasthan contains high percentage of iron but it also contains certain proportion of magnetite. The percentage of phosphorus is usually less than 0.77 per cent in most of the areas, though in some cases it goes upto 0.1 per cent or even more. The ores of Haryana (Narnaul) especially contain higher percentage of phosphorous going upto 0.43 sometimes.

The Indian ores are also usually low in sulphur content, being less than 0.03 per cent, though in a few cases it goes upto 0.05 per cent. Only certain ores of Karnataka and Haryana contain sulphur upto 0.24 per cent. Similarly, silica percentage is usually within 4 per cent, being less than 1.5 per cent in Bihar-Orissa ores. Silica is higher in the Dharwar and Bellary regions of Karnataka and the Narnaul region of Haryana.

Important magnetite deposits have been located in the Guntur and Nellore districts of Andhra Pradesh; Salem and Tiruchirappalli districts of Tamil Nadu; Mandi district of Himachal Pradesh; Shimoga, Hasan and Bangalore districts of Karnataka and Palamau district of Bihar. Of all the magnetite deposits in the country, the Palamau deposits of Bihar are of high grade.

There are good deposits of titaniferous magnetite containing appreciable amount of vanadium in Karnataka, Tamil Nadu, and parts of Singhbhum district of Bihar and Mayurbhanj district of Orissa. The presence of titanium renders the ore unfit for normal steel making except for making special types of titanium steel. Limonite or spathic iron ores are found in the barren measures of lower Gondawana in West Bengal.

Nature has endowed India with the richest deposits of iron ore, production of which has risen from 3.6 million tonnes in 1951 to 4.8 million tonnes in 1956, 10.6 million tonnes in 1960, 28.6 million tonnes in 1969, and to 30.78 million tonnes in 1970. The increase has been due to heavy internal and external demands. Commensurate with the anticipated tempo of industrial development and export trade, the production of 54 million tonnes of iron ore is envisaged to increase to 54 million tonnes, out of which, 22 million tonnes will meet domestic demands and the rest will be exported.

Export Trade: The export of iron ore has received considerable impetus during the last decade. The export of ore which was only 197,005 tonnes in 1951 increased to 1.98 million tonnes in 1956, to 3.2 million tonnes valued at 17 crores of rupees in 1960, 3,390,000 tonnes in 1962 and 7,914,000 tonnes in 1963 (including exports from Goa since April 1963) valued at Rs. 31.5 crores. 15 million tonnes valued at Rs. 87.5 crores in 1969 and 21.23 million tonnes in 1970 and thereby earned foreign exchange amounting to Rs. 118.72 crores.

Japan, the East European and the West European countries are having ambitious programmes of steel expansion. They are turning to India for the supply of ore. The export trade of iron ore is handled by M.M.T.C.

Development Trends: To meet the increased external and internal demands, the general development trend is to establish large mines and to mechanize them.

The National Mineral Development Corporation has developed an open cast mine at Kiriburu, where the Indian Bureau of Mines had proved iron ore reserves, for annual production of two million tonnes of iron ore for export to Japan through the Visakhapatnam port. This mine has been mechanized right from the mine face to the rail-head loading point. The Table below shows the pattern of development and mine mechanization in some of important iron ore mines.

Name of Mine	*Location*	*Owner*	*Remarks*
Noamundi	Bihar	T.I.S.CO.	At present 50% of the production is realized from mechanized mining. This mine will give 6,000 tonnes of production per day after complete mechanization. This mine has been further developed for an annual production of 2 million tonnes.
Rajhara	Madhya Pradesh	Hindustan Steel Ltd.	The mine is being completely mechanized to produce 7,000 tonnes ore per day.
Kemmangundi	Karnataka	Mysore Iron & Steel Works	Feeding Mysore Iron and Steel Works.
Barsus	Orissa	Hindustan Steel Ltd.	Being mechanized to produce 3 million tonnes of iron ore for Rourkela Steel Plant.
Kiriburu	Orissa	N.M.D.C.	This mine will produce nearly 2 million tonnes of ore for export to Japan.
Bolani	Orissa	Bolani Iron Ore Pvt. Ltd.	Will be meeting the requirements of Durgapur Steel Plant.
Bailadila	Madhya Pradesh	N.M.D.C.	Planned to produce 4 to 6 million tonnes of ore for export to Japan from 1966. The mine will be fully mechanized.

The supply of iron ore to Japan from Kiriburu at the rate of 2 million tonnes per annum started from 1966. It is proposed to increase the current capacity of 2 million tonnes to a level of 4.5 million tonnes during the Fourth Plan. The prospecting of deposits No. 10, 5 and 14 at Bailadila has been completed and a project report to mine 4 million tonnes from this area has been prepared by N.M.D.C. The Bailadila project has commenced supplying ore to Japan. The Kiriburu ore will consequently be diverted to the Bokaro plant after its construction. The export commitment of Kiriburu will then be transferred to Bailadila. The N.M.D.C. is expected to contribute about 14 million tonnes out of the target of 51 million tonnes of iron ore for the Fourth Plan period. The Mysore Board of Mineral Development proposes to raise about a million tonne of ore from the Bellary-Hospet area for export through Mangalore port. The incidence of a good quantity of high and low grade ores in that area provides prospects of even exporting low grade ore in which some of the European countries are interested.

Beneficiation Trends: In iron ore mining, about 30 per cent of total production may go as rejects. This means that on an average about 10 million tonnes of iron ore fines would be produced every year, for mining 32 million tonnes of iron ore. This calls for the beneficiation of iron ore rejects by pelletizing, modulizing and sintering. Apart from this aspect, the high limit of 65% iron in the specifications, imposed by the foreign markets, necessitates beneficiation of iron ore to a certain extent. The common impurities in iron ore are silica and alumina which have to be eliminated to meet the blast furnace requirements. The Tata Iron and Steel Co. has installed a washing plant at Noamundi in Bihar to reduce the alumina content. The Company has also installed a sintering plant for treating iron ore fines. The sintered products would be more uniform as regards the composition and size. More sintering plants will come into being when the increased mining of iron ore begins. Hindustan Steel has already set up sintering plants at Rourkela and Bhilai. Almost all the steel plants in India have sintering plants. Their total capacity is about 5 million tonnes. There is only one pelletization plant in the country located in Goa with a capacitv of 0.6 million tonnes.

T.I.S.CO. is setting up a pelletization plant at Noamundi with one million tonne capacity to start with; it will utilize iron ore fines and blue dust produced at Noamundi mine.

IV. Petroleum In India

During the present jet and supersonic age the importance of petroleum to a country cannot be over emphasized. It is indispensable to meet the requirements of energy and power needed for defence equipment. India does not appear to have plentiful resources of oil although the search for petroleum in India is almost as old as in most of the advanced countries. The first bore hole drilled for oil in India was in November 1866, by a Calcutta firm at Nohar Pung near Burhi Dhing river in Upper Assam; but it was not until 1889 when Mr. Willie Leova Lake struck oil at depth of 201.68 metres in his very first hole at Makum near Margherita. By 1899, 14 wells were drilled north of Makum in the Digboi area which led to the formation of the Assam Oil Co (A.O.C.) This company maintained its existence for over 20 years during which 80 wells ranging in depth to 609.6 metres were drilled. In January 1921, the Burmah Oil Company took over the management of the A.O.C. providing it much needed financial assistance, technical know-how and refining facilities. In about ten years, production was raised from 70,000 litres a day to 9,00,000 litres. A total of 998 wells had been drilled upto the end of 1962, out of which 400 wells are still producing. The deepest well in this field is No. 898 which has gone down to 2,786 metres. The Digboi oil-field is showing signs of exhaustion and there is no further exploration.

Since 1906, this field has produced nearly 10 million tonnes of crude oil; the production during 1962 was 182,667 tonnes. Till 1954, the Assam Oil Co. was the only concern in India producing oil. With the separation of Burma from India in 1937, India's deficiency in petroleum became apparent and following the partition in 1947, the oil-fields of Potwar went to Pakistan. India was left with the aging Digboi oil-fields whose reserves were gradually depleting.

Origin of Petroleum: It is generally accepted that the formation of oil has taken place due to decay of low forms of animals and plants in the marine sedimentary formations especially clay or mud. Sediments of recent ages *viz.*, teritiary formations are considered more favourable for preservation of petroleum than other older sediments which are more tectonically disturbed and have gone under several geological strains and stresses.

The water, oil or gas accumulated in clayey beds during the course of compression have moved upward into the porous rocks such as sandstone, limestone, etc., which are called reservoir rocks. In the reservoir rocks, the oil or gas tends to move upward till some obstruction is met due to some change in lithology or faulting. Anticlinal folds or domes are the most suitable homes for oil accumulation. Within these reservoirs, accumulation is governed by the buoyancy of the fluids, the lighter ones moving upward, the heavier ones gravitating to the lower levels. Thus, generally in all oil wells, water is found at the bottom, oil in the middle, and gas at the top.

In India, nearly 10,36,000 sq. km. are covered by marine sediments of recent origin besides off-shore coastal tracts which can be called the potential home of petroleum. This has to be proved by intensive geological, geophysical surveys and by wild cat drilling. The recent surveys have shown that suitable oil reservoirs exist at a depth of over 3,000 m. in the Assam valley. To find oil at such great depths requires a great deal of surface work in deciphering the geological structures suitable for accumulation of oil.

Setting up of Oil and Natural Gas Commission: A delegation headed by the then Minister for Mines and Fuel, K. D. Malviya, visited in 1955, oil fields in the U.S.S.R., Netherlands and Rumania to study the organizational methods and techniques in oil exploration, exploitation and oil refining. Oil industry being capital intensive, its operations are complicated and in this respect it is different from a normal industrial organization in India or abroad. It was with this background and also with a view to intensifying the search for mineral oil, that the delegation recommended to the Government of India the establishment of a separate commission for exploration of oil in India. A separate department for the exploration of oil and natural gas was established in 1955, with headquarters at Dehradun. In 1958, it became a Commission and then an autonomous body.

Discovery of Oil in Gujarat: Three oil structures have been discovered by the Commission in the Lunej (Cambay) area, Hazat (Ankleshwar) and Sertha (Kalol) in 1958, 1959 and 1961 respectively.

The Lunej structure initially located by geophysical investigations in Cambay is approximately 20.7 sq. km. in extent. The first site for drilling was selected in the south-western area. After necessary preparations drilling operations started in 1958 with a Russian Ural-mash — 3 D turbo drill. The well was drilled to a depth of 2,191 metres in 91 days. In the course of drilling, several horizons of oil and gas sands were encountered at varying depths, between 1,310 and 1,710 metres. The oil was accompanied by gas under high pressure. In the second well which was drilled about one and a half kilometre to the east, the presence of oil and gas was confined in various horizons at and below 1,500 metres. The seismic work has shown that the total area of the Cambay field, is about 53 sq. km.

Attention was next directed to a larger structure covering more than 32 sq. km. near a gas show nearly 134 kilometres south of Cambay at Ankleshwar. The first well was spudded in 1959 and drilled to a depth of 1,960 metres. Oil and gas shows were observed in May during production testing.

In 1960, survey was begun of the Kalol area, some 24 km. north of Ahmadabad. Kalol well No. 1 was drilled by an Indian team assisted by Soviet experts. The well reached a depth of 1,800 metres. A perforation test was carried out in June 1961, and oil flowed freely from the well.

The total number of deep wells drilled till the end of 1962 in Gujarat is given below:

Area	*Oil*	*Gas*	*Dry*	*On test*	*Com-pleted*	*Under Drilling*	*Total*	*Metres Drilled*
(1) Ahmadabad a) Kalol	3	—	—	2	3	1	6	9,515
b) Sanand	—	—	—	1	1	—	1	1,850
c) Wavel	—	—	—	2	2	—	2	3,847
(2) Ankleshwar (including Kosamba).	50	—	4	2	56	3	59	80,522
(3) Cambay	3	14	9	6	32	—	32	66,504
(4) Olpad	—	—	—	1	1	—	1	2,054
Total Gujarat	56	14	13	14	95	4	101	164,292

The Oil and Natural Gas Commission (O.N.G.C.) has drilled 200 wells in

Ankleshwar oil-field upto 1969; of these 170 are oil producing, 12 gas producing and the rest are dry.

Firm estimates of oil reserves in the oil-fields of Gujarat which have been drilled by O.N.G.C. have now been made upto the end of 1966. The estimated reserves in the three fields are 68.80 million tonnes which are sufficient to feed a 3-million tonne refinery set up at Koyali near Baroda. The reserves of natural gas are estimated at 67.25 thousand million cubic metres.

The commercial production of oil from the Ankleshwar field started in 1962 and has now attained an annual rate of production of 7,30,000 tonnes. The crude goes by rail to the Bombay refineries, but when the Koyali refinery is completed, it is expected to raise the production to 2 million tonnes to feed that refinery. The production was stepped up to 9,500 tonnes per day in 1968-69 and to 10,000 tonnes per day in 1969-70.

By the end of March 1970, the Commission had produced and despatched a total of 15.13 million tonnes of crude oil from the oil-field of Gujarat. Of this 4.9 million tonnes were supplied to Burmah Shell and Esso Refineries in Bombay and 10.23 million tonnes were supplied to Indian Oil Corporation (I.O.C.) Refinery at Koyali in Gujarat. The Commission at present supplies the entire demand of crude oil of Koyali Refinery in Gujarat. The Commission during 1969-70 produced and sold 3.64 million tonnes of crude, 3.45 million tonnes from Gujarat and 0.19 million tonnes from its fields in Assam, and sold also 333.1 million cubic metres of gas, valued at Rs. 38.58 crores as against 34.80 crores in the previous year.

Exploration for Oil by O.N.G.C.: Detailed deep drilling exploration had been started in 1958 in several areas in Punjab *viz.* Adampur, Hoshiarpur, Janauri and Jawalamukhi. Oil has not so far been struck in any well; only gas came out from one well.

Further exploratory drilling in Punjab is in progress. The O.N.G.C. has entered into an agreement with the French Petroleum Institute for oil exploration in the Jaisalmer area of Rajasthan.

Besides these, detailed geological and geophysical surveys are being carried out in the Kaveri basin in Tamil Nadu, Uttar Pradesh., Bihar, Punjab, West Bengal, etc.

During the Third Plan, about Rs. 202 crores were provided for oil exploration and development by the Oil and Natural Gas Commission; greater emphasis was laid on oil exploration and production.

The O.N.G.C. organized, on an average, 14 geological parties, 11 gravity cum magnetic parties and 20 seismic parties and 8 electrologing parties to intensify their search for oil in area where sedimentary rocks are suspected to occur below the surface. Extensive geological mapping, line-traversing and reconnaissance were carried out in alluvial areas of Jammu and Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, West Bengal, Assam, Orissa, Madhya Pradesh, Rajasthan, Gujarat, Tamil Nadu and the Andaman Islands.

Gravity and magnetic work was carried in almost all the alluvial regions of the country where sedimentary were suspected to be covered with soil. Several thousand Gravity and Magnetic (G.M.) stations were measured.

Seismic work was carried out in Andhra Pradesh, Assam, Bihar, Gujarat, Rajasthan, Uttar Pradesh., West Bengal, Tamil Nadu and Jammu and Kashmir. One seismic party operated in the area of Gujarat. Exploratory and deep drilling was caried out where structures were found favourable for oil. By the end of 1966, the O.N.G.C. had completed 458 oil wells of which 237 were oil bearing, 40 gas bearing, 94 dry, 18 water injection wells and 69 were under test.

Out of 458 wells, 392 were drilled in Gujarat, 47 in Assam (Rudrasagar area), 7 in Punjab, 3 in Uttar Pradesh., 2 in Bihar, 4 in Rajasthan and 3 in Pondicherry.

During the Third Plan O.N.G.C. estimated the reserves of oil in Gujarat and their area in Assam.

Discovery of Oil at Rudrasagar and Sibsagar, Assam: Exploratory drilling operation was started at Rudrasagar and Sibsagar in 1961 where a favourable structure had earlier been established by Seismic Survey. Oil flowed freely from the first well. Out of five wells drilled, four at Rudrasagar encountered oil, while one near Sibsagar was dry. The production from this oil-field started in 1966 when 0.02 million tonnes of crude was produced. The O.N.G.C. produced 0.15 million tonnes of crude oil in 1968-69 and 0.19 million tonnes in 1969-70. The crude produced from this field was supplied to Gauhati and Barauni Refineries of I.O.C.

Exploration of Oil in West Bengal — Indo-Stanvac Petroleum Project: After an aeromagnetic and grounds survey by the Standard-Vacuum Oil Company, in collaboration with the Government of India, a drilling programme was initiated in 1953. After drilling ten test wells (all dry) the project was abandoned.

Discovery of Nahorkatiya Field–Birth of Oil India Ltd: The geophysical work in upper Assam was undertaken by the Assam Oil Company as early as 1925. Seismic work was carried out later, which confirmed that Barail rocks at a depth of about 3,048 metres from which oil is supposed to have migrated into higher Tipam sands in Digboi are also oil bearing in Nahorkatiya and Hugrijan areas. Drilling followed and the first oil producing well was completed in 1953. Oil was found in several sand beds between 2,865 to 3,108 metres. At Moram, about 32 km. further west of Nahorkatiya, the first test well was successfully completed in 1956 and the existence of oil was proved in the same rock formations.

Further extensive drilling in the Nahorkatiya-Hugrijan area where 30 wells were completed by the end of 1957, proved this potential oil-field.

The discovery led to the formation of Oil India Limited (a rupee company) in 1958, on a 50-50 partnership basis between the Government of India and the Assam Oil Company. Taking into consideration the development of the oil-fields, Oil India Limited was entrusted with the job of constructing 1,160 km. long pipeline for carrying crude from these fields to public sector refineries located at Noonmati in Assam and Barauni in Bihar.

Oil India has also acquired the rights to explore an area of 4,947 sq. km. in the north-east of Assam. Till March 1968, Oil India had completed 160 wells in the Nahorkatiya and Moram areas out of which 106 were oil bearing, 8 gas bearing and 16 had proved dry while the rest were awaiting further testing.

Laying of the Pipe Line: The problem of transporting crude oil to a distance of 403 km. from Nahorkatiya to the Noonmati refinery in Gauhati, Assam and to the Barauni refinery in Monghyr, Bihar, a distance of 1,160 km. from Nahorkatiya, crossing many rivers on the way, was completed in February 1962. Crude is supplied to Digboi and the Noonmati refinery, and it will feed the Barauni refinery when it goes into operation. The production will, then, be stepped up to 3 million tonnes of crude a year.

Refineries: There are in all five refineries in production at present, out of which four (2 in Bombay and one each in Vishakhapatnam and Digboi) are in private sector. The fifth refinery at Noonmati in Assam, is the first one in the public sector. The sixth refinery at Barauni on the northern bank of the Ganga in Bihar will go into production shortly. The Government of India has constituted a separate organization 'Indian Refineries' to run these public sector refineries. Another refinery is coming up at Koyali in Gujarat; but this is likely to be looked after by the O.N.G.C. The refinery at Noonmati has been constructed by the Rumanian Government and the Barauni and Koyali plants are being put up with Russian assistance. The three public sector refineries will have a total capacity of 4.5 million tonnes which will be expanded to 7 million tonnes, Gauhati to one million and Barauni and Koyali to 3 million tonnes each.

The Government of India in May 1963, concluded an agreement with the Phillips Petroleum Company of America to set up a refinery in Cochin with a capacity of 2.5 million tonnes. The plant is likely to cost Rs. 35 crores. It will be jointly owned by the Government of India and Phillips Co. It will be located at Ambalamukal on the eastern bank of Chitrapurha river, 16 km. from Cochin port.

Details of the refineries with their present and envisaged capacities are tabulated on next page:

Company	*Location*	*Cost Rs. (crores)*	*Year of Estt.*	*Capacity in million tonnes during 1962*	*Envisaged expansion capacity*
Assam Oil Company	Digboi	NA	1901	6.45	—
Burmah-Shell	Bombay	26	1955	3.50	3.73
ESSO	Bombay	17	1954	2.40	2.50
Caltex	Vishakhapatnam	15	1957	1.05	—
Indian Refinery	Noonmati	17.7	1962	0.75	1.23
,,	Barauni	40	1963	2.00	3.00
O.N.G.C.	Koyali	30	1964—65	2.00	3.00
Phillips	Cochin	35	1965—66	2.50	—

All public sector refineries are to meet the supply of crude oil from the newly opened oil-fields in Assam and Gujarat.

The Government of India have set up another agency, Indian Oil Ltd., for distribution of petrol and petroleum products produced from refineries in the public sector and also to import and market deficit kerosene and middle distillates. This company was formed in 1959, with an authorized capital of Rs. 12 crores. It has already entered into a contract with an export organization of the U.S.S.R. for the import of 1.9 million tonnes of products mainly kerosene and high speed diesel.

Oil in India's Economy: The per capita consumption of petroleum in India during 1962 worked out to 18 litres per annum, as against 3,000 litres in U.S.A., 730 litres in U.K. and 238 litres in Japan. The production from indigenous sources (Digboi, Nahorkatiya, Ankleshwar) contributed only 13 per cent to the total requirements in the country during 1962. Even on the basis of 100 litres per capita consumption, 50 million tonnes crude oil per annum will have to be produced. It is essential, therefore, to intensify exploration in a number of potential areas to meet the widening shortage. At present India is importing the bulk of her petroleum and petroleum products. The potentialities of newly discovered fields so far known are capable of producing about 6 to 7 million tonnes annually which is hardly sufficient to meet even the 40 per cent of her total requirements. Recently oil has been struck during off-shore drilling at Bombay High. The indications are promising although it is too early to predict its potentialities.

Other Oil Possibilities in India: It is now well established that marine sediments of Eocene to Upper Miocene age are the source rock of petroleum. In the newly discovered fields in the Gulf of Cambay, Ankleshwar and Kalol, the oil bearing beds are of Eocene age.

There seem to be two distinct possibilities of oil belts in India, the one running from the Potwar Plateau (Attock oil-fields) through Punjab, Uttar Pradesh, Bihar, Bengal, Assam and veering round to Burma, and the other belt from the Sui Oil Gas belt (in Pakistan) through the Gulf of Kutch to the Gulf of Cambay. As a matter of fact, almost all the areas in the western and eastern coasts where marine transgression has taken place in post Cretaceous age should be searched for petroleum. Such areas are north of Goa on the West Coast, Kerala, Tiruchirappalli and Thanjavur in Cauvery basin in Tamil Nadu, the Pondicherry area, the Godavari delta in Andhra Pradesh and the Orissa coast and the Andaman and Nicobar Islands.

Recently, a geophysical survey conducted in North Bihar with West German collaboration has revealed interesting results, which are now to be confirmed by deep drilling. The entire area consisting of Jaisalmer, Bikaner and Ganganagar in Rajasthan, areas between the Sutlej and Beas rivers in the Punjab and the foot-hills of the Himalayas in Uttar Pradesh, Bihar and the alluvial basin of West Bengal deserve thorough investigation. The O.N.G.C. has entered into an agreement with the French Petroleum Institute for oil exploration in the Jaisalmer area.

An institute of Petroleum Technology has been established in Dehra Dun, which will help solving many problems concerning oil technology.

V. Other Minerals

Antimony: A few occurrences of stibnite (Antimony Sulphide) are known and the most important one is that of Bara Shigri glacier in Lahaul area, Himachal Pradesh. The deposit was leased to a private party at one time. The G.S.I. carried out investigations for stibnite (antimony ore) by detailed mapping and drilling in the Chamboli district of Uttar Pradesh. They drilled 111.78 metres and collected 9,682 tonnes of stellerite. Exploration has been temporarily suspended since December 1966. The Star Metal Refinery Ltd., with its plant at Vikhroli, Bombay, is the only producer of antimony metal from imported antimony ore from Bolivia, Thailand and Australia. The annual requirement of antimony metal which is mainly consumed in the manufacture of antifrication metal, printing and type metal and storage battery plates, etc., is of the order of 850 tonnes. Antimony Trisulphide ($Sb_2 S_3$) is used in the manufacture of safety matches, in cartridge percussion caps and for producing dense white fumes in military manoeuvres. Antimony Penta Sulphide ($Sb_2 S_5$) is used in the manufacture of paints and in vulcanizing rubber. There is no indigenous production. The plant at Vikhroli produces antimony metal from imported Antiomony Sulphide ore after beneficiation and smelting. The installed capacity is 1,000 tonnes per annum which is sufficient to meet the country's requirements.

The quantity of antimony metal produced from the imported Antimony Sulphide ore during 1960-1970 is given below:

Year	1960	1966	1967	1968	1969	1970
Import of Antimony Sulphide ore (in tonnes)	1,214	2,110	1,528	1,733	1,636	699
Production of antimony metal (in tonnes)	821	854	901	812	637	526

Apatite and Phosphate Rocks: Apatite is used in the manufacture of high phosphorous pig iron. Apatite and other phosphates are the chief raw materials for the manufacture of superphosphates. Apatite mines are worked in Singhbhum (Bihar) near Ghatsila. In the Kasipatnam area of Andhra Pradesh, apatite occurs in thin veins. Only one mine is working in this State while three mines are working in Singhbhum (Bihar). Small quantities of phosphate nodules are also produced sometimes from Tiruchirapalli, Tamil Nadu. All apatite mines are worked manually by open cast mining at Ghatsila mine in Singhbhum district. Apatite occurs in lenses and each lense is worked as a separate quarry. In 1966, a new mine at Kasipatnam was opened by the Fertilizer Corporation of India. The indigenous production is hardly 10% of the requirements, which have to be met through imports from Jordan, Tunisia, Morocco and Egypt. In 1962 production was 29,018 tonnes while imports were 287,609 tonnes. The production in 1963 declined and was only 13,127 tonnes. The production in the years 1966-70 was as below:

Production	1966	1967	1968	1969	1970	*Year*
	16,275	11,631	6,695	9,316	15,768	*Tonnes*

Asbestos: Deposits of asbestos are worked in Andhra Pradesh, Bihar, Karnataka and Rajasthan. Except asbestos produced from Pulivendla a taluk of Cuddapah, Andhra Pradesh, which is of a very high chrysotile variety, others are of tremolite variety which has lower tensile strength and is brittle.

Asbestos is used in the manufacture of asbestos cement sheets, fire proof cloth, mineral filler, boiler lagging, etc. India imports large quantity of asbestos to meet her requirements. During 1962, 22,376 tonnes of raw asbestos valued at Rs. 23.33 million was imported from Canada and Rhodesia. Indigenous production reached the peak of 2,712 tonnes in 1963. The production of asbestos was only 82 tonnes in 1948, 719 tonnes in 1953, and 1,181 tonnes in 1958. Asbestos mines in Pulivendla are worked by inclined adits and long wall fill back system. There is one underground mine in Rajasthan which is worked by board and

and pillar system. All the other mines are worked by the open cast method and are manually worked. The details of production and imports between 1966-70 are as below:

Production	1966	1967	1968	1969	1970	*Year*
	6,979	7,014	9,073	9,550	9,834	*Tonnes*
Imports	—	—	25,924	33,609	39,766	*Tonnes*

In some cases pneumatic rock drills are employed for drilling. A few mine owners sort out the fibre and wash the material while others adopt crushing to powder the material.

By the end of Fourth Plan 1973-74 the demand for asbestos is estimated to be of the order of 80,000 tonnes whereas the indigenous production was expected to reach 12,000 tonnes. Rajasthan is the leading producer. The balance had to be met by imports. During 1970, 39,766 tonnes of asbestos valued at Rs. 71.25 million was imported as against 33,609 tonnes valued at Rs. 56.5 million in 1969. Imports are canalized through S.T.C.

Barytes: The Sulphate of Barium also known as heavy spar occurs in veins and fissure veins. Cuddapah, Anantapur and Kurnool districts of Andhra Pradesh and Alwar district of Rajasthan are the important mining centres of barytes. It is also mined in Bihar near Ranchi. In India, barytes is mainly used in the manufacture of paint (Lithophone) and as filler in paper, textile and linoleum industries. Off-colour barytes is used in drilling mud. Barytes is used in the manufacture of barium chemicals.

A total of 37,312 tonnes of barytes was produced and 9,193 tonnes valued at Rs 817,000 was exported during 1963. It is expected that the domestic requirements of barytes by 1975 will be of the order of 75,000 tonnes. The production of barytes in 1969 was 58,722 tonnes which rose to 71,923 tonnes. This shows that production is likely to keep with the demand.

Bauxite: Deposits of bauxite in India are usually found as capping on flat hill tops. Good deposits are found in Ranchi and Palaman districts of Bihar; Sarguja, Raigarh, Jabalpur, Shahdol, Bilaspur, Durg, Balaghat and Mandla districts of Madhya Pradesh; Kolhapur and Kolaba districts in Maharashtra; Belgaum in Karnataka; Salem in Tamil Nadu; Sambalpur and Koraput in Orissa and Saurashtra in Gujarat. Chemical grade having ferric oxide less than 2% and alumina contents 60% is limited to the coastal tracts of Gujarat.

Bauxite is the ore of aluminium metal; it is also used in the manufacture of refractories and abrasives for refining kerosene and lubricating oils, for the manufacture of alum and in the cement industry.

During 1966 four companies were producing aluminium metal. Indian Aluminium Co. Ltd., Aluminium Corporation of India Ltd., Hindustan Aluminium Corporation Ltd., and Madras Aluminium Company have installed capacities of 36,170 tonnes, 7,500 tonnes, 40,000 tonnes and 10,000 tonnes respectively. The Indian aluminium industry consumed 155,108 tonnes of bauxite during 1962 and manufactured 53,004 tonnes of alumina, besides 17,607 tonnes of alumina was imported to produce 35,209 tonnes of aluminium ingots. The licensed capacity of aluminium metal during the Third Five Year Plan had been revised to 150,000 tonnes. During 1966 the production of bauxite was 749,948 tonnes against 706,649 tonnes in 1965, while in 1969 and 1970, 1,085,000 tonnes and 1,360,000 tonnes were produced respectively.

There has been a considerable upward trend in the production of bauxite during the years 1965-70, due to rapid expansion of the aluminium industry in India and the increased overseas demand as indicated below:

Year	1965	1966	1967	1968	1969	1970
Output of bauxite in tonnes	706,649	749,948	789,000	939,000	1,085,000	1,360,000
Production of aluminium metal in tonnes	68,968	83,759	96,223	120,000	132,577	161,081

Japan, Italy, West Germany and Australia are the principal buyers of Indian bauxite.

Although the production of aluminium ore and aluminium metal has substantially increased during the recent years, still the output of aluminium is far below the increasing requirements, which are met by imports. During 1969, 2,091 tonnes of aluminium metal had to be imported at a cost of Rs. 1.27 crores. The foreign exchange earned during the same period by exporting bauxite was Rs. 33.5 lakhs. The rapid increase in the requirements of aluminium is due to its substitution for copper and zinc particularly in electric cables and wires.

The production of aluminium is expected to be stepped up to 220,000 tonnes by 1973-74. Establishment of two smelters with alumina production facilities at Korba and Kona are under constructions. In view of substantial deposits of good grade bauxite occurring in Kutch and Saurashtra an export oriented alumina plant has been proposed in the area.

Chromite: The important deposits of chromite are located in the Singhbhum district of Bihar, Keonjhar and Cuttack districts of Orissa, Hasan and Mysore districts of Karnataka, and in the Bhandara and Ratnagiri districts of Maharashtra. A proper assessment of reserves has not been made but reserves at present are placed at 4.9 million tonnes. Most of the mines are worked by open cast method except Jojohatu in Singhbhum (Bihar) and Sinduali and Tallur in Karnataka which are worked by underground mining method. Chromite is mainly consumed in the manufacture of chrome steel, stainless steel and production of chromium metal which finds extensive use in electro-plating. Due to its high resistance to corrosion and its ability to stand high temperature it finds extensive use as refractory material for lining steel furnaces. Chrome bricks or chrome magnesia bricks are manufactured for this purpose. In the chemical industry, chromite is used for the manufacture of chromates and bichrome which are required in the tanning, dyeing, ceramic, glass and other industries.

The chromite mining industry also largely depends upon export markets, although there has been some improvement in domestic consumption by the refractory and chemical industries. The bulk of the high grade chromite *i.e.* 48% and above $Cr_2 O_3$ is exported and only medium and low grade are utilized for indigenous requirements. The production of chromite in 1969 and 1970 was 226,568 tonnes and 270,879 tonnes respectively, valued at Rs. 1.20 crores and Rs. 1.44 crores respectively. During the same period 111,620 tonnes of chromite valued at Rs. 2.06 crores and 153,402 tonnes valued at Rs. 3.18 crores respectively were exported. Internal consumption by 1973-74 is expected to be of the order of 100,000 tonnes.

Copper Ore: The Indian Copper Corporation Ltd. mines copper ore from its mines in Mosaboni area of Singhbhum copper belt, Bihar. The Corporation is operating three mines namely Mosaboni, Surda and Patharghora. Mining in all three mines is being done by underground methods by breast stopping with pillar and timber support and scraper mucking. Rocker shovels and electric battery locos are also employed to speed up tramming. The ore is smelted at Corporation's smelter at Monbhandar near Ghatsila, with an annual production capacity of about 9,000 tonnes of fire refined copper. The Corporation has been busy in installing an electrolytic copper refinery of an annual capacity of 8400 tonnes to be initially fed by imported blister copper. The refinery has been commissioned since August 1965. The production of copper in the country is far below the demand, which is rapidly increasing due to industrial development. It hardly meets 10 per cent of the requirements. The production of copper during 1970 was 9,311 tonnes against a requirement of 85,000 tonnes. The demand for this metal is expected to go up to 124,000 tonnes by 1973-74. The Indian Copper Corporation is installing a Flash Smelter thereby increasing its production capacity from 9,960 tonnes to 16,500 tonnes by 1973-74. The requirements of copper may rise to about 300,000 tonnes in the next 10 years or so. Import of 71,730 tonnes was made at a cost of Rs. 23.77 crores during 1962. All-out efforts are being made by the Indian Bureau of Mines and the Geological Survey of India to explore the possibilities of developing new copper deposits in the country. At Khetri, the Indian

Bureau of Mines has proved about 100 million tonnes of 1% copper ore, by deep drilling and the National Mineral Development Corporation has been entrusted with the exploitation of copper deposits at Khetri and Dariba (Rajasthan).

Plans for exploitation and extraction of copper at a rate of 21,000 tonnes of electrolytic copper per annum have been prepared by Western Knapp Engineering Co., U.S.A. who are consultants to the National Mineral Development Corporation. It was decided that instead of going in for the conventional smelter as recommended by Western Knapp, Flash Smelter shall be installed, for which agreement has been signed with OUTOKUMPO of Finland. The proposed capacity of the smelter will be 31,000 tonnes per annum and is likely to go into operation in 1974-75. The Hindustan Copper Ltd. (H.C.L.) proposes to develop Rakha mines in Bihar for an anticipated copper production of 20,000 tonnes by 1978-79.

Manganese Ore: India is endowed with rich deposits of manganese ore. Deposits are located in the Nagpur, Bhandara and Ratnagiri districts of Maharashtra; the Panch Mahal district of Gujarat, the Balaghat and Chindwara districts of Madhya Pradesh; the Singhbum district of Bihar; the Keonjhar, Bolangir, Sundergarh, and Koraput districts of Orissa; the Shimoga, Chikmagalur, Chitaldurg, Belgaum, North Kanara, Bellary and Tumkur districts of Karnataka, the Banswara and Udaipur districts of Rajasthan and the Srikakulam district of Andhra Pradesh.

In India, almost the entire quantity of manganese is mined by open cast method except at Balaghat, Shivrajpur and Gowardhna mines where, to work deeper horizons, underground mining has been adopted. In the Balaghat mine, square set timbering system to support weak ground has been introduced, while the fill back stoping system of mining is being carried out in Shivrajpur mines. Earth moving equipment is employed in Kandri mines of Manganese Ore India Ltd. and at Dongribusurg mine of the Central Provinces Manganese Ore Co. (C.P.M.O.). Women labour is employed in hand cobbing and dressing of manganese ore. For upgrading low grade ores, hand operated jigs are used. At Dongribusurg heavy media separation plant is being operated by C.P.M.O. for beneficiating low grade ore from old dumps.

With the setting up of new steel plants and the expansion of old steel mills and the setting up of 6 ferro-manganese plants, 160,020 tonnes of ferro-manganese was produced during 1972. The internal demand for manganese ore has increased; 497,000 tonnes of manganese ore was consumed in the country in 1962 while 698,000 tonnes was exported. The indigenous demand for manganese ore by 1973-74 was expected to be of the order of 688,800 tonnes of low grade for the production of pig iron and 181,440 tonnes of ferro-manganese for the production of ingot steel.

During the past few years the export of manganese ore has dropped considerably. The slump in the market has been marked by a downward trend in the price. Free on Board price of 46-48% manganese ore at Calcutta port dropped from Rs. 160 per tonne in 1958 to Rs. 120 per tonne in 1962. India produced 1.226 milllion tonnes and 1.075 million tonnes of manganese ore during 1962 and 1963 respectively; whereas 1.629 million tonnes of manganese ore was produced during 1972 and 862,000 tonnes valued at Rs. 92.43 milllons was exported.

Mica: India continues to hold the premier position in respect of mica in the world. Brazil is the only country which is gradually coming up. But ruby quality of block mica is nowhere produced except in India.

The chief producing centres of mica in India are the Hazaribagh, Bhagalpur, Gaya and Monghyr districts of Bihar; the Ajmer, Bhilwara, Jaipur, Tonk and Udaipur districts of Rajasthan; the Nellore district of Andhra Pradesh; the Quilon district of Kerala and the Nilgiris district of Tamil Nadu. Mica produced from Kerala is of phlogopite type while the rest is muscovite of high quality.

There has been a considerable improvement in mica mining technique and several mines have installed pumps, air compressors, pneumatic drills, mine hoist, etc. At Bandro Surangi mines of Christeen Mica Industries Ltd., winding machinery with men hoisting cage has been installed.

Mica is a good foreign exchange earner and about Rs. 10 crores worth foreign exchange is secured every year. During 1972, mica valued at Rs. 20.34 crores was exported. The internal consumption is hardly 900 tonnes a year, but it is likely to increase with the development of electrical industries, and the manufacture of heavy electrical machinery.

Lead-Zinc: Known occurrences of lead and zinc ores are located in the Udaipur, Jaipur and Ajmer districts of Rajasthan; Riasi in Jammu; Almora in Uttar Pradesh; and Cuddapah in Andhra Pradesh.

Zawar mine in Udaipur (Rajasthan) is the only working mine at present. The ore mined is treated at the mine. Lead concentrates containing 70-74% Pb. are transported to lead smelter at Tundu near Dhanbad, where lead and silver are recovered. Zinc concentrates containing 52-54% Zn. are exported to Japan for smelting, and zinc metal is received back in the country.

The Metal Corporation of India, a private limited company, was taken over by the Government of India from October 22, 1965, and a new public sector undertaking Hindustan Zinc Ltd. (H.Z.L.) was formed to run the mines and smelters.

The Metal Corporation of India was installing a zinc smelter at Udaipur with an initial capacity of 18,000 tonnes a year. A new shaft is being sunk at Mochia Marga hill to develop the mine at deeper horizons, the capacity of the shaft will be 2,000 tonnes run of mine ore per day.

In 1963, 5,920 tonnes of lead concentrates and 10,627 tonnes of zinc concentrates as against 6,384 tonnes of lead concentrates and 9,837 tonnes of zinc concentrates in 1962 were produced. 4,314 and 3,991 kilograms of silver were recovered in 1962 and 1963 respectively.

Another firm Cominco Binani Ltd. was licensed in 1965 to set up a Zinc Smelter at Alwaye (Kerala) with a capacity of 20,000 tonnes of zinc from imported zinc concentrates. The smelter was commissioned in 1967 and zinc metal was produced for the first time in India. From March 1968, the production of zinc ingots started at Debri Zinc Smelter of H.Z.L. The production of zinc in 1970 was 23,410 tonnes as against 23,051 tonnes in 1969 and 20,699 tonnes in 1968. During 1972, 25,227 tonnes zinc was produced.

Gold: Gold has been produced in India from prehistoric times; some of it has been panned from river beds, while the rest must have been mined, as is evidenced by ancient workings some of which extend to 60 metres. At present there are four mines all located in Karnataka namely, Hutti in Raichur district, Nandi Drug, Champion and Mysore in the Kolar Gold Fields in Kolar district. The Champion mine has gone down to over 3,000 metres, but rich gold bearing rock still persists in Glen ore short. Nandi Drug has enough reserves of low grade ore in the west reef while Mysore mine is almost on its last legs.

The auriferous lodes occur in a narrow strip of hornblende schist known as Kolar schist band of pre-cambrian age surrounded by gneisses and granites. Gold occurs in quartz veins or reefs in the field. This field had been worked since 1880 by John Taylor and Sons, a London firm of mining engineers.

Mines in the Kolar Gold Fields (K.G.F.) are very extensive and have the distinction of being among the deepest mines in the world. The total length of drives, cross cuts and levels driven underground is over 1,040 km. Thus mining methods are most intricate. The choice of a particular method depends on the nature of the ore body, the rock pressure and temperature at various depths and the degree and nature of support required to control ground movements.

The following types of stoping are practised in K.G.F. depending on ore body and the local mining conditions:

(1) Chatty stoping; (2) Ordinary underhand bottom stoping; (3) Cup stoping; (4) Sink stoping; (5) Flat back stoping; (6) Stepped back or staggered back stoping ; and (7) Rill stoping.

There is the problem of rock bursts and high temperatures in these mines. Normal rock temperature at 3048 metres is 65°C. Thus preconditioned air at 3.3°C is forced underground. Auxiliary air conditioning plants are also installed to work at deeper horizons.

Output of gold has been declining over the past several years. Gold mines were nationalized in 1957-58 and worked by Kolar Gold Mining Undertaking (Mysore State Undertaking). The Ministry of Finance, Governmnt of India, took over the administration of the Kolar Gold Mining Undertaking on December 1, 1962. John Taylor and Sons are still the consultants.

The production of gold from K.G.F. and Hutti gold mines in 1961 and 1962 is given below :

Unit in Kg.

Name of the mine	1961	1962
Mysore mine ..	1,048	1,106
Champion reef mine	1,610	1,406
Nandi Drug mine ..	1,537	1,780
Hutti gold mine	673	788
	4,868	5,080

During the year 1969-70, 3,47,000 tonnes of ore were mined at the Kolar Gold Mining Undertaking. There was a yield of 1,979 kg. of gold valued at Rs. 1.67 crores at the International Monetary Fund rate. Production during the first nine months of 1970-71 (for which figures are available) was 1,582 kg. of gold valued at Rs. 1.34 crores. The fall in production during the year was mainly due to a brief strike by workers. The targeted production for the remaining three months of the year was 1,07,000 tonnes with an estimated gold yield of 701 kg. valued at Rs. 0.59 crore.

The ore reserves of the undertakings as at the end of 1969-70 were as follows:

	Payable ore reserves	*Low grade ore reserves*
Quantity (in tonnes) ..	17,58,295	22,85,095
Grade (gm. per tonne) ..	11.368	6.38

Minerals for Atomic Energy: Uranium, radium and thorium are the chief fissionable elements. The most important source of uranium in India are the ancient metamorphic rocks, the grade is low. Beach sands of Tamil Nadu, Kerala and Maharashtra are important sources of thorium occuring in association with monazite. Monazite concentrates also contain 0.3 to 0.35 per cent uranium. A mine is being developed in Bihar for the production of uranium.

Other minerals like beryllium and lithium ores are found in large quantity as beryl and lepidolite (lithium mica) in pegmatites of Bihar and Rajasthan. On the whole, India possesses enough resources of atomic minerals.

Other Minerals: The production of other minerals like gypsum, limestone, dolomite, feldspar, magnesite, steatite, silica, salt and industrial clay has shown a spectacular rise. The expansion in the domestic fertilizer, cement, refractory, chemical, glass and ceramics industries during the Second Five Year Plan, has created large demand for these minerals. Mica, kyanite, ilmenite, sillimanite and barytes still depend almost entirely on the export market. The domestic consumption of sillimanite will, however, increase in view of the installation of a sillimanite refractory plant by the Assam Sillimanite Company Ltd., at Ramgarh in Bihar.

Although India's mineral production has shown a steady rise in recent years, much more remains to be done in the field of exploitation, processing, blending, utilization, beneficiation and manufacture of various products. The mining industry has to be modernized and equipped with the latest machinery. If our mining industry is to survive in this competitive age, we must think in terms of reducing the cost of production and large scale exploitation. On account of lack of capital resources and foreign exchange the Indian mining industry is lagging behind.

Since India has the world's largest reserves of iron ore and is surplus in many other minerals, export of minerals could make a big contribution to foreign exchange earnings.

ANNEXURE I

Trends in the Value of Mineral Production, Mineral Exports and Imports

Year	*Value of total mineral production* (Rs. million)	*Value of mineral exports* (Rs. million)	*Value of mineral imports* (Rs. million)
1948	693	N.A.	N.A.
1949	742	"	"
1950	834	"	"
1951	1,075	351	52
1952	1,080	375	51
1953	1,128	475	57
1954	1,025	357	81
1955	1,070	370	110
1956	1,255	500	97
1957	1,293	641	94
1958	1,383	460	80
1959	1,412	470	102
1960	1,610	674	108
1961	1,772	658	111
1962	2,081	602	149
1963	2,373	691	158 (419)
1964	2,473	805	111 (327)
1965*	2,839	805	205 (307)
1966	3,201	1,121	343 (384)
1967	3,665	1,399	661 (579)
1968	4,077	1,613	655 (N.A.)
1969	4,285	1,690	650 (422)
1970	4,296	2,011	682 (1,024)

Figures in brackets indicate the value of crude petroleum imports.

*From 1965 onwards the value of production includes the value of minerals produced in the Union Territory of Goa, Daman and Diu and also of petroleum and natural gas, but the total value does not include the value of minor minerals and atomic minerals produced in the country.

Trends in Production of Principal Minerals and Metals in India after Independence

Sl. No.	Name of Mineral	Unit of Qty.	Year						Project Demand 1973-74	Number of mines in '69
			1948	1951	1956	1961	1966	1970		
	Minerals									
1.	Apatite	Tonnes	1,114	416	8,785	20,140	16,275	15,768	4,500,000	4
2.	Asbestos	,,	82	518	1,230	1,473	6,979	9,834	80,000	40
3.	Barytes	,,	23,143	10,471	6,315	15,914	52,608	71,923	70,000	57
4.	Bauxite	,,	20,663	67,047	91,225	476,000	750,000	1,360,000	2,600,000	39
5.	Chromite	,,	23,143	16,702	52,386	48,785	77,770	270,879	100,000	7
6.	China Clay	,,	41,000	69,000	155,000	383,000	200,740	202,000	200,000	103
7.	Coal	000 Tonnes	30,120	34,430	39,280	56,060	67,974	72,614	93,500	800
8.	Lignite	000 Tonnes	29.6	30	26	63.765	232	3,545	6,000	1
9.	Copper ore	,,	322	369	386	423	459	518	..	6
10.	Feldspar	Tonnes	987	3,385	3,909	9,860	27,972	29,255	33,000	43
11.	Fire Clay	000 Tonnes	121.7	112.6	139	283	470	509	1,180	87
12.	Gypsum	000 Tonnes	79	204	854	866	1,294	883	1,700	96
13.	Ilmenite	000 Tonnes	229	224	336	174	30.1	—	60	4
14.	Iron ore	000 Tonnes	2,280	3,660	4,900	12,310	20,080	335,455	53,400	200
15.	Kyanite	Tonnes	12,605	42,501	20,135	27,155	63,820	119,000	50,000	9
16.	Magnesite	Tonnes	97,000	117,000	91,700	209,744	232,053	348,962	300,000	8
17.	Manganese ore	000 Tonnes	556	1,292	1,737	1,230	1,622	1,651	2,600	200
18.	Mica	Tonnes	18,100	25,000	28,100	28,340	28,347	22,915	..	477
19.	Pyrites	Tonnes	..	..	..	..	..	26,400	1,670,000	1
20.	Sillimanite	Tonnes	213	4,048	4,637	8,113	10,286	4,562	14,000	5
21.	Zinc concentrates	Tonnes	..	2,110	6,880	5,941	8,900	15,888	...	2
22.	Crude Petroleum	000 Tonnes	257	259	394	510.8	4,650	6,809	..	..
	Metals									
1.	Copper	Tonnes	5,957	7,083	7,623	8,336	9,438	9,311	124,000	..
2.	Lead	Tonnes	542	859	2,497	3,664	2,479	1,862	97,000	..
3.	Zinc	Tonnes	..	..	..	..	..	23,410	142,000	..
4.	Aluminium	Tonnes	3,421	3,849	6,501	8,336	9,438	9,311	230,000	..
5.	Ferro-manganese	Tonnes	..	23,000	24,031	103,995	137,482	173,198	..	..
6.	Finished Steel	000 Tonnes	928	1,070	1,338	2,816.3	4,492	4,350	..	..
7.	Pig Iron (Foundry)	000 Tonnes	356	287	440	1,084	1,381	1,380	..	..
8.	Antimony	Tonnes	..	..	5,696	616	854	526	1,500	
9.	Gold	Kg.	5,113	6,407	5,932	4,868	3,436	3,241	..	..
10.	Silver	Kg.	259	410	2,966	5,941	1,220	1,540	..	..