STRATEGIC & FERTILIZER MINERALS GROUP

STRATEGIC minerals may be defined as those which are highly essential for the defence of a country and in which the indigenous resources are presently insufficient to meet the domestic demands. With the present knowledge of resources and reserves position, more than two dozen minerals have been included as strategic for India. Of these tungsten ores, and molybdenite are dealt with in detail.

(1) TUNGSTEN ORES (WOLFRAMITE AND SCHEELITE)

India possesses meagre reserves of tungsten minerals wolframite (ferberite-huabnerite) and scheelite which are tungstates of Fe, Mn and Ca. Wolfram mineralisation is known to occur in the States of Rajasthan, Maharastra, West Bengal, Andhra Pradesh, Bihar, Karnataka, Tamil Nadu and Gujarat; of which the first three bear deposits of commercial and economic importance.

Wolfram is of much commercial and strategic importance both during war as well as in peace times, owing to its remarkable ability to withstand heat, and imparting of toughness when alloyed with steels etc.

Reserves, Specifications and Uses

Wolfram minerals occur in the following localities :

Andhra Pradesh	—	East Godavari and Khammam
Bihar	—	Gaya and Singhbhum
Gujarat	—	Panch Mahals (Jher)
Maharastra	—	Nagpur (Agargaon deposits)
Karnataka	—	Kolar (Kolar Gold Fields—Scheelite) Raichur (Hutti gold fields)
Tamil Nadu	—	Tiruchirapalli (Kadvur)
Rajasthan	—	Nagaur (Degana deposits-Rewat Hills)
West Bengal	—	Bankura (Chandapathar and Porapahar deposits)

The Degana deposits of Rajasthan, Chandapathar deposits of West Bengal and Agargaon deposits of Maharastra have been evaluated to some extent of their reserves and grade of the mineral etc.

Rajasthan Degana deposits (IBM estimate)

(a) Vein Mass	—	52,500 tonnes of 0.54% WO_3
(b) Stock work	—	2,674,200 tonnes of 0.025% WO_3
(c) Eluvial	—	3,303,800 tonnes of 0.04% WO_3

The total quantity of 60% WO_3 in this area comes to 3,800 tonnes.

Maharastra Agargaon deposits (GSI estimate)— 1.34 million tons of 0.21% WO_3 ore. (Equivalent to 4,690 tonnes of wolframite with 60% WO_3 ore.)

West Bengal Chandapathar deposits — 12,000 tonnes of ore with 0.03% WO_3 for a vertical depth of 120 metres.

A total of 20,490 tonnes of ore with 60% WO_3 is expected to be available from these three deposits.

The most important use of tungsten metal with other alloying metals like Cr, Mo, V, etc. is in the production of high speed alloy steels employed in the fabrication of drill bits, dies, cutting tools etc. Tungsten carbide bits are used for cutting tool industry. Tungsten steel is used in defence equipment manufacture such as armour plates, guns, armour-piercing projectiles and jet engines. Tungsten metal and alloys are also used in the electrical and electronic industries (bulb filamants, radio, x-ray and T-V tubes etc) and in space research. Tungsten compounds are used in paints, ceramics, chemicals and textiles.

Tungsten ores or concentrates are to conform to some specifications, to be used for further metallurgical and other uses. The standard commercial grade of wolframite concentrate is 60% WO_3,low in P and Cu, with minimum of S As, Bi or Sn. Concentrate for ferro-tungsten making should contain above 60% WO_3 and less than 0.5% each of S, As, Sn, Cu and P, although for chemical manufacture much lower grades are permitted with penalties. The U.S. National Stockpile specification for tungsten concentrate for consumption in chemical-type plants is given in Table 1.65. India's production, and iomport and export figures of wolfram minerals are given in Table 1.66.

Demand Projections and Future Outlook

All the domestic production of the wolframite concentrate as well as the imports of the ore/concentrate are necessary for internal consumption in the fields of defence and drilling and cutting tool industry, in electrical, electronic, radio and television and automobile industries. The present annual requirements of wolframite concentrate in the country are about 400 tonnes of which hardly 8% is met from indigenous resources, which may go upto 950 tonnes per year by the end of the V Plan period. But our production is not likely to improve to that extent to meet the requirements with the present exploration effort and the known limited resources. Since our domestic known reserves are limited at 20,490 tonnes and will be exhausted by the next two decades or so if our entire needs are to be met from internal resources. As such, if the present policy of imports is continued as at present, substantial domestic reserves will be in the ground by the end of this century.

(2) GRAPHITE

Graphite mineral is one of the three allotropic forms of elemental carbon occurring in nature and has got varied uses right from its simplest form for the manufacture of an ordinary pencil used for writing purposes to its more critical uses such as a moderator in certain atomic reactors. It has emerged as in indispensable material for various metallurgical and other industries due to its resistance to high temperature and chemical

TABLE 1.65—U. S. NATIONAL STOCKPILE SPECIFICATION FOR TUNGSTEN CONCENTRATE

Constituents	Percent by weight (dry basis)			
	Type A, B or C—ferberite, huebnerite or wolframite ores *and* concentrates		Type D-natural scheelite and concentrates	Type E-Synthetic scheelite precipitates
	For carbide powder	Pure metal		
*WO_3- (min.)	65.0	65.0	65.0	65.0
Sn (max.)	1.5	1.5	0.10	0.05
Cu (max.)	0.5	0.5	0.10	0.05
As (max.)	0.2**	0.2**	0.10	0.05
Bi (max.)	0.5	0.5	0.25	0.25
Sb (max.)	0.05	0.05	0.10	0.05
Mo (max.)	0.10	0.025	0.10	0.10
P (max.)	0.05	0.05	0.05	0.05
S (max.)	0.50	0.50	0.50	0.50
Pb (max.)	1.00	1.00	0.10	0.10
Zn (max.)	1.00	1.00	0.10	0.10
Ca (max.)	0.20	0.20	—	—
Mn + Fe (max.)	—	—	2.0	0.50

*Corrected for Nb and Ta, if present.
**Maximum, 0.1% As for processed Government owned material returned under benefication contracts.

action, and high electrical and thermal conductivity. It is largely used as refractory material for the manufacture of metallurgical crucibles for melting non-ferrous metals, stoppers, stirrers, nozzles etc., employed in furnacing operations, as foundry facing material for moulds, as bricks for furnace linings, refractory cements, as lubricant, polishing, in rubber industry, as electrodes in electrical industries and finally as moderator in some nuclear reactors. It is a prescribed substance under the Atomic Energy Act 1962 due to its strategic importance and as such the stastistical details of its production etc. cannot be made available to the public.

Occurrences, Reserves, Specificatiions and Uses

Graphite occurs in nature as three distinct varieties namely flaky, crystalline and amorphous in metamorphic as well as in igneous and sedimentary rocks. Flaky variety is usually disseminated as thin laminae in the associated gneisses and schists, while crystalline graphite forms aggregates in more or less well-defined veins, lenses or pockets; and amorphous graphite is often found uniformly dispersed as fine particles in the country rock.

Graphite occurs in most of the States in India with varied extent and grade. It is found in Andhra Pradesh, Gujarat, Kerala, Karnataka, Jammu & Kashmir, Orissa, Madhya Pradesh, Haryana, Bihar, Himachal Pradesh, West Bengal, Rajasthan and Tamil Nadu. The datails of the occurences, reserves and grades are given in Table No. 1.67, which are available of certain deposits as given by G.S.I. and State Directorates of Mining & Geology.

Of the various graphite deposits in the above list, several have been worked in the past and abandoned due to poor grade of the ore. As these deposits are mostly in private hands, widely scattered, no proper estimates of reserves etc. are available. G.S.I. has recently located a promising deposit in Palamau district in Bihar. Working deposits currently are present in Andhra Pradesh, Orissa and Bihar from where the indigenous production is reported.

The specifications of graphite of commercial value vary with the use to which it is put to in the various industries and depends upon three factors namely (i) its crystalline, amorphous or flaky nature, (ii) its grade (fixed carbon %), and (iii) its physical characteristics. The various industries in which graphite is used are crucible and refractory industry, lubricant, dry cell industry, pencil industry, foundry facings and carbon brushes, paints and pigments, as 'moderator' in the nuclear power reactors, and in electrical industry as heating elements, electrodes, electrical plungers etc. Small vanres to stand temperature upto 2700°C in rockets and space research, and nozzles for turbo-jets working at high temperature are also made of graphite.

Specifications of graphite to be used in important industries are given as follows:

(i) *Crucible Manufacture and Refractory Industry*

High grade flaky graphite with 90% carbon minimum (85% lower limit of graphitic carbon) and ranging in size from —20+90 mesh material.

TABLE 1.66—INDIA'S PRODUCTION AND IMPORT AND EXPORT OF WOLFRAM MINERALS AND METAL

Year	Production (in Kgs.)	Import of concentrate (in tons)	Imports of metal (in tons)	Export of metal (in tons)
1967	28,411	188	7,055	5.0
1968	39,103	207	7,244	Nil
1969	40,519	172	6,490	4.0
1970	34,900	263	7,130	1.0
1971	29,563	333	14,428	2.0
1972	32,382	339	11,992	4 Kg
1973	21,445	276	10,346	18 Kg
1974	23,363	255	11,621	16 Kg
1975	37,538			

TABLE 1.67—RESERVES OF GRAPHITE IN INDIA (GSI)

State	District	Locality	Reserve	Grade Fixed carbon %
Andhra Pradesh	Visakhapatnam Srikakulam Khanmam West Godavari		159.720 tons	15+0.88%
Arunachal Pradesh (Preliminary resource estimates)	Siang (Preliminary estimates)		10.35 m. tons (Preliminary estimates)	Low grade graphite schist
	Lohit (Preliminary estimates)		71.0 m. tons (Preliminary estimates)	,,
Bihar	Palamau	Around Daltanganj	0.16 m. tons	Flaky graphite
Gujarat	Panchmahal	Narukot	0.8 m. tons (graphite bearing plyllites)	9%
		Jh-ab-Redhana	2.5 m.tons	8.26%
Jammu & Kashmir (Preliminary estimates)	Barumula	Between Khadyanar &	16.7 m. tons	—
		Islamabad & Dhansoriyidan	48.25 m. tons (Preliminary estimates)	0.45-14.9%
Karnataka	Kolar	Ganacharapara	0.050 m. tons	10-12%
M.P.	Betul	Tikari-Gothan	0.85 m. tons	9.20%
		Chiklar		
Kerala	Idikki	Parulimattam	0.067 m. tons	5-25%
		Manakad	0.199 m. tons	5-29%
	Ernakulam	Paralimattam 'A' Block	0.035 m. tons	9-26%
		Perungala	0.036 m. tons	11-23%
	Quilon	Karuppanthodu	0.035 m. tons	15%
	Trivendrum	Chenga	0.0030 m. tons	75%
Orissa	Dhonkalan, Sambalpur, Kalahandi, Koraput	Reserve not estimated		—
Rajasthan	Banswara	Mahi Dum Bloese	0.5 m. tons	13.32-14.47%
Tamil Nadu	Madurai	Tirumangulam	17500 tons	7-10%
	Ramanathupusam	Kamalipatt-Puvandi area	0.25 m. tons	10-23%
	Worth Arcot	Pudupalaiyam	2800 tonnes	
Sikkim	West Sikkim	Chitra	8000 tonnes	—
		Daroli	(Possible reserve of recoverable graphite)	

ISI Draft Proposal

a. Chemical composition

Carbon content	...	90.0 % Min.
Iron oxide (Fe_2O_3)	...	1.2 % Max.
TiO_2	...	0.5 % Max.
CaO	...	0.02% Max.
Sulphur	...	0.5 % Max.
Volatiles	...	1.5 % Max.

A minimum of 80% carbon is acceptable if the balance of impurities is aluminous or sillimanite.

b. Physical requirements

(a) Graphite should be crystalline and flaky in nature.
(b) Graphite should be reasonably free from micas.
(c) The oxidising temperature should be approx. 750°C.
(d) Particle size should be preferably between —14 and +90 mesh size

(ii) *Lubricant, Paint and Dry Cell Industry*

Second grade flaky graphite with 75% to 90% carbon is used as a lubricant, and in the manufacture of paints and dry cells. Beneficiated concentrates can be accepted provided the ash content does not exceed 5%, and free from abrasive impurities for lubricant and dry cells manufacture.

(iii) *Pencil Industry*

Amorphous graphite of —300 mesh size with less than 50% ash content in it is used for ordinary pencils. The better quality and more

expensive varieties require relatively high grade graphite free from impurities.

(iv) *Foundry Facings*

All types of finely pulverised amorphous and crystalline graphite are used for foundry facings.

(v) *Carbon Brushes*

Special grade with 97-98% graphitic carbon is used for carbon brushes manufacture.

The Indian Standards Institution has formulated specifications for graphite to be used (i) as foundry facing material IS : 1305-1958, (ii) in paints IS : 62-1950 and (iii) as lubricants IS : 495-1954 given in Tables 1.68, 1.69 & 1.70 respectively.

TABLE 1.68—GRAPHITE AS FOUNDRY FACING MATERIAL—IS : 1305-1958

Characteristics	Requirement	
	Grade I	Grade II
Moisture % maximum	1.0	1.0
Volatiles matter % maximum	3.0	3.0
Ash % maximum	20.0	30.0
Fixed carbon %	Remainder	Remainder

TABLE 1.69—GRAPHITE USED IN PAINTS IS : 62-1950

Characteristics	Requirement
Volatile matter	2% Max.
Oil absorption	With in 5 of the approved sample
Colour	Close match to the approved sample
Staining Power	Not inferior to the approved sample
Tone	Equal to the approved sample
Matter soluble in water	1% Max.
Ash	40% Max.

TABLE 1.70—GRAPHITE USED AS LUBRICANTS—IS : 495-1954

Characteristics	Requirement
Loss on heating	1.25% Max.
Petroleum other soluble %	0.5% Max.
Water soluble matter	1.25% Max.
Ash	6.0% Max.
Non-graphite carbon	3.0% Max.

Production, Domestic Consumption, Import and Export

Domestic production, though not available in full, is reported to be nearly 7,792 tonnes and 10,000 tonnes respectively for 1969 and 1970. The production in 1973 is 15,098 tonnes, in 1974 26,456 tonnes and in 1975 it is 18,891 tonnes. The major consumption of graphite is in the foundry industry followed by paints, crucible, battery and pencil manufacture. Imports and exports are given in Table 1.71.

Demand Projections and Future Outlook

India's estimated reserves in Andhra Pradesh, Gujarat and Karnataka come to 3.51 million tonnes. But many deposits in many other states are yet to be proved and established to a large extent. India's export of graphite to other countries is very nominal.

In the last one decade domestic consumption of graphite has almost doubled from 11,000 tonnes in 1960 to nearly 20,000 tonnes in 1970, including 11,500 tonnes natural graphite and 8,500 tonnes synthetic graphite (used mainly for electrodes, batteries and rubber manufacture). Some high grade graphite has to be imported from Ceylon for some specific uses.

Synthetic graphite plants at Durgapur and Barauni are producing a total of 3,500 tonnes annually. Projections for the years 1978-79 and 1983-84 of natural and synthetic graphite may be stated in Table 1.72.

Most of the domestic requirements of natural graphite could be met with from the domestic reserves. The production of synthetic graphite can also be increased by augmenting the production capacity of the existing plants and setting

TABLE 1.71—GRAPHITE IMPORT AND EXPORT (IN TONNES)

Year	Import	Export
1967	1,248	14
1968	972	160
1969	1,088	158
1970	1,244	Negligible
1971	855	86
1972	1,703	199
1973	1,074	150
1974	780	176

TABLE 1.72—FUTURE PROJECTIONS OF GRAPHITE

Years	Natural graphite in tonnes					Synthetic graphite in ton	Total in tonnes
	Refractory	Pencil	Steel	Foundry	Lubricant		
1978-79	5,500	950	1,800	3,300	2,800	30,000	43,550
1983-84	7,000	1,000	1,000	4,200	3,500	37,000	53,700

up some new plants in public sector which are under contemplation in Rajasthan, Karnataka and Bihar.

(3) MOLYBDENITE MoS_2

Molybdenite is the most important mineral of molybdenum metal found in nature, and generally is associated with the basemetal sulphide ores with chalcopyrite, sphalerite, galena etc. and in pegmatite rocks. Molybdenum is widely used as an alloying element with steel as well as with non-ferrous metals. It is also used in electrical, electronic and wireless industries. Molybdenum compunds are used as fertilizers, in pigments, lubricants and ceramic industry.

Reserves, Occurrences, Specifications, Uses

Occurrences of molybdenite have been reported from various States in India. However, no workable deposits have so far been located. Workable grade of molybdenum is considered at 0.07% to 0.1% Mo.

Lesser contents deposits may be workable in case they are associated with other commercially economic minerals link Cu, Pb, Zn etc. In recent times some recoverable quantities of molybdenite deposits have been located in the Rakha Copper Ore deposits and Jaduguda Uranium ore deposits of Singhbhum district in Bihar and Karadikuttam in Palani of Madurai district in Tamil Nadu. The various occurrences in India are given as follows :

(1) Andhra Pradesh — East Godavari, Nizamabad, Mahaboobnagar, Karimnagar and Medak district.
(2) Assam — Khasi hills.
(3) Bihar — Singhbhum and Hazaribagh districts (Rakha, Jaduguda and Chhotihajpur.)
(4) Kerala — Mangamalai and Quilon.
(5) Madhya Pradesh — Prattapur in Chhatarpur district.
(6) Rajasthan — Kishangarh in Ajmer district and Rewa in Nagaur district.
(7) Tamil Nadu — Karadikuttam, Neykkarapatti and Chattrapatti in Madurai district and Aurmanallur in Kanyakumari district.

In all the above occurrences molybdenite is present as very fine disseminations.

Specifications for molybdenite concentrate after beneficiation is generally on the basis of 95% MoS_2. The chemical specification as per U.S. National Stockpile specifications for molybdenite concentrate are MoS_2 = 90% min; Cu = 0.45% Cu max; Pb = 0.15% max; P = 0.04% max; and Sn + As = 0.15% max.

Molybdenum metal is chiefly used as an alloying element with steel (as ferro-molybdenum) and some non-ferrous metals. It is also used in chemical, electrical, electronics and telecommunication industries.

Production, Domestic Consumption and Import

There is no indigenous production of molybdenite and all the domestic requirements of molybdenum metal and ferromolybdenum are met with by imports. The import and production figures of molybdenum metal and ferro-molybdenum are given in Table No. 1.73.

Future Outlook

Molybdenum metal is indispensable mainly for alloying purposes. As such the recovery of molybdenite from the existing deposits of Rakha and Jaduguda deposits in Bihar where exploitation of the mineral along with other associated

minerals is underway gains much importance to minimise the imports. The new finds of Tamil Nadu in particular have to be taken up for exploitation and concentration of the mineral by proper ore-beneficiation techniques.

TABLE 1.73—IMPORT AND PRODUCTION OF MOLYBDENUM AND FERRO-MOLYBDENUM (IN TONNES)

Year	Molybdenum (Import)	Ferro-Molybdenum	
		Import	Production
1967	17		
1968	16		
1969	22	51	34.08
1970	32	194	145.00
1971	18	196	250.675
1972	13	108	237.584
1973	16	2	92.885
1974	67	80	209.072
1975			197.667

Fertilizer Minerals Group

Apatite and rock phosphate (Phosphorite rock) constitute the mineral raw materials for the production of phosphatic fertilizers. Pyrite is used as potential source of sulphur for obtaining sulphuric acid which is utilised in the manufacture of sulphate fertilizers.

Gypsum and anhydrite are used in the manufacture of ammonium sulphate in fertilizer industry (nitrogenous fertilizers), as well as source of sulphur for sulphuric acid manufacture.

Limited reserves of apatite are present in India in the States of Andhra Pradesh, Bihar and West Bengal while rock-phosphate deposits occur extensively in Rajasthan, Madhya Pradesh and Uttar Pradesh and phosphatic nodoules in Tamil Nadu. Pyrite occurs as two main deposits in Bihar and Rajasthan, whose reserves are very extensive and considered to be sufficient for the needs of the country. Gypsum occurs in Rajasthan, Gujarat, Jammu & Kashmir and Uttar Pradesh and the reserves are adequate for future consumption.

Most of the above deposits are of low grade variety and can be used only after beneficiation.

(1) APATITE-FLUOR-APATITE $CaF.Ca_4(PO_4)_3$ and CHLOR-APATITE—$CaCl.Ca_4(PO_4)_3$

Apatite is calcium phosphate with calcium fluoride or calcium chloride or containing both fluorine and chlorine in chemical combination with it. Fluor-apatite is much more common than Chlor-apatite. Apatite is a widely distributed mineral, occurring in rocks of various kinds and ages, but is most common in metamorphic crystalline rocks like limestone, gneisses, schists etc. It is one of the important mineral raw materials used for the production of commercial phosphatic fertilizers needed in agriculture as a major plant nutrient.

Reserves

Workable deposits of commercial importance are present only in two States namely Andhra Pradesh and Bihar. The apatite deposits of Sitaramapuram areas, Vizianagaram taluk in Visakhapatnam district of Andhra Pradesh occur as parallel veins and are of high grade with more than 35% P_2O_5 but the reserve is very small.

The deposits in Singhbhum district of Bihar are present as thin veins and lenses in patches extending over a distance of 60 KM from Itagarh (West of Tatanagar) to Khejurdhari south of Mosaboni with a grade ranging from 11% to 20% P_2O_5 and of limited reserves estimated to be about 1 million tonnes. Some deposits have been located in Palamau and Hazaribagh districts of Bihar but are not of much economic significance. The estimated reserves of Andhra Pradesh, Bihar and West Bengal are given in Table 1.74. Phosphatic nodules with 24 to 27% P_2O_5 are present in Tiruchirapalli district of Tamil Nadu.

(2) ROCK PHOSPHATE—PHOSPHORITE

The phosphate deposits of marine sedimentary origin with apatite known as "Collophane" mineral (amorphous) are referred to as Phosphorites or rock phosphate deposits. Many new deposits have been found in recent times by the intensive search programme of G.S.I., O.N.G.C. and State Geology Departments, in several areas in the States of Rajasthan, Uttar Pradesh, Himachal Pradesh, M.P., Jammu & Kashmir, Assam and Gujarat. Besides, type of deposits formed due

TABLE 1.74—APATITE RESERVES IN ANDHRA PRADESH AND BIHAR (IN MILLION TONNES)

State	District	Reserves	Mineral	Grade P_2O_5%
Andhra Pradesh	Visakhapatnam	1.68 (GSI)	Apatite	42%
Bihar	Singhbhum	1.094	Apatite	15.48%
West Bengal	Purulia	0.05 m. ton	Apatite	—

(*Source :* GSI & IBM)

to accumulation of organic remains and enriched in phosphate (P_2O_5% = 5.0) are restricted to Laccadiv and Amnidiv Islands and coastal areas.

Almost all the indigenous rock-phosphate deposits cannot be directly used as ready raw material for fertilizer industry as they are, in most cases, low grade and need beneficiation.

Reserves

Extensive deposits of rock-phosphate have been recently found out in Rajasthan, Uttar Pradesh and M.P. The details of the reserves and their grades are given in Table 1.75. The total reserves of all the grades (except gauno deposits) come to nearly 60 million tonnes ranging from 10 to 36% P_2O_5. Some areas have recently been proved to contain the same type of deposits as that of Jhamarkotra of Rajasthan in the Jhabua district of Madhya Pradesh. Exploration works in Bastar and Raipur districts of the same State are also encouraging and are likely to prove in big deposits.

Uses and Specifications

The chief use of apatite and rock phosphate is mainly for the manufacture of phosphatic fertilizers containing the phosphate in a soluble form, followed by iron and steel and chemical industries The Indian fertilizer producers generally prefer acid grade rock phosphate to be used in wet

TABLE 1.75—RESERVES OF ROCK-PHOSPHATE IN INDIA (GSI)

State		District/Locality	Reserve in m. tonnes	Grade P_2O_5%
Rajasthan		**Udaipur Dt.**		
	GSI	Maton	5.40	21-27.3%
	GSI	Kanpur	3.93	11.6%
	GSI	Khabaria-Ka-Gurha	1.34	10-25%
		Dakan Kotra	1.40	15%
		Other areas	3.70 (DGM)	8-25%
		Jhamarkotra	18.14 (DGM)	14-34%
		Jaisalmer Dt.		
	GSI	Birmania	3.50	12.9%
Uttar Pradesh		**Dehradun & Tehri Garhwal Dts.**		
		Maldeota	5.39	19.0%
		Durmala	3.12	22.1%
	GSI	Masrana	2.06	18.5%
	GSI	Paritibba-Chamasari	2.80	18%
		Jalikhal	1.36	21.5%
		Other area	3.32	15-25%
M. P.		**Jhabua Dt.**		
	GSI	Amalmal-Rossori	2.5 to 3 (tentative)	28.6% (av.) at Khatamba & 24.9% at Kehhia block
	GSI	KKelkua area		
	GSI	hatamb block		
		Phosphatic Nadules		
Tamil Nadu		**Tiruchirapalli**		
		NE & NW of Utatur	2 m. tonnes (upto 30 metre depth) (DGM)	21-26.5% P_2O_5

process of fertilizer manufacture with the following specifications :

Size	=	22 mm (Preferably less than 12.5 mm)
P_2O_5	=	31.5% min.
SiO_2	=	4-6%
F	=	4.0% max.
R_2O_3	=	3% max.
CO_2	=	3.9%
Cl	=	0.05% max.

The specifications of M/s. Fertilizers and Chemicals (Travancore) Ltd., are given below :

Free H_2O	=	1-1.5% Max.
Total P_2O_5	=	33-34%
Total CaO	=	51% min.
F & CO_2	=	4.0%
SiO_2	=	1%
Bound H_2O & Organic matter	=	2% max.

Sieve analysis : (1) —6 mm all material
(2) —100 mesh = 20% material

Domestic Production and Import

Prior to the discovery of Rajasthan and Uttar Pradesh deposits before 1966 domestic production of phosphate was a few thousand tonnes and mainly through apatite rock solely from Andhra Pradesh and Bihar only. But later on after the rock-phosphate mining started in Rajasthan it had suddenly jumped to nearly 5 to 10 times in recent years. But due to the growing internal demand of fertilizers to meet the agricultural input of the country heavy tonnages of rock phosphate are to be imported to feed the various industrial units both in public sector and private sector, engaged in the production of super-phosphate, ammonium phosphate and phosphoric acid manufacture. The production and import figures of the rock phosphate are given in Table 1.76.

Demand Projections and Future Outlook

The known reserves of all the phosphate minerals in India at present are put to about 60 million tonnes. With the object of achieving self-sufficiency in food front, a phased increase of fertilizer industry is essential and is to be projected. The production targets of chemical fertilizers in 1978-79 are placed at 7.0 million tonnes of nitrogen 2.5 million tonnes of P_2O_5 and 1.2 million tonnes of potash, against the installed capacity of 1.6 millions of nitrogen and 0.5 million tonnes of phosphate fertilizers (P_2O_5) for which large tonnages of rock phosphate sulphur and potash will be required. Demands of rock phosphate in 1980-81 are assessed at 7.5 million tonnes. As seen from our production and import figures there is a considerable gap between supply and demand. To attain a minimum production target of 2.5 million tonnes of rock phosphate as envisaged for 1980-81 an intensive planning of mining, exploitation and beneficiation of the different grades of ores is needed during the next five years.

TABLE 1.76—DOMESTIC PRODUCTION AND IMPORTS OF APATITE AND ROCK PHOSPHATE (IN TONNES)

Year	Domestic Production			Imports
	Apatite	Rock Phosphate	Total	
1967	11,717	—	11,717	602,930
1968	6,695	—	6,695	860,625
1969	9,316	69,175	78,491	641,749
1970	15,997	156,353	172,350	667,657
1971	11,307	232,170	243,477	813,261
1972	11,614	216,693	228,307	809,476
1973	9,981	135,532	145,513	874,746
1974	12,034	433,438	445,472	1'106,161
1975	24,762	429,109	453,871	

(*Source :* I.B.M.)

(3) PYRITE AND PYRRHOTITE

Both these two minerals are sulphides of iron and important raw materials as alternative source of sulphur used for the manufacture of sulphuric acid to be used in turn for fertilizer production. India possesses extensive deposits of pyrite and pyrrhotite mainly in two states namely Bihar and Rajasthan, besides minor occurrences in Assam, Himachal Pradesh, Tamil Nadu, Jammu & Kashmir, Karnataka, Orissa, Madhya Pradesh, Uttar Pradesh and West Bengal. Detailed exploration and exploitation work is being carried out in the Amjhore pyrite deposits of Shahabad district in Bihar and the Saladipura Pyrite- Pyrrhotite deposits of Sikar district in Rajasthan.

Amjhore deposits are on average of better grade assaying 35-40% S while Saladipura deposits assay 18-25% S. In both cases the ore is to be beneficiated before use.

Reserves, Specifications and Uses

The reserves of the pyrite-pyrrhotite deposits known so far, are given in Table 1.77. The reserves of the two main deposits namely Amjhore and Saladipura have been explored in detail so far. Some more pyrite deposits have been struck recently in the various parts of the country which await detailed exploration work.

Pyrite is used mainly for the production of sulphuric acid and generally marketted on the basis of a sulphur content of 48%. This figure has now-a-days, been relaxed and ranges from 38-44%. The most objectionable impurity is arsenic which should preferably be less than 0.015%. Sulphur resulting from pyrite is used for the manufacture of sulphuric acid, which in turn is used for the production of fertilizer, chemicals, steel, rayon, petroleum and numerous other industries as one of the important raw materials or for processing purposes. Besides, elemental sulphur is used in the manufacture of explosives, matches, insecticides, fungicides and rubber industry. As sulphur dioxide it is used in sugar refining and paper and rayon pulp units.

Domestic Productions of Pyrite Mineral and Import of Sulphur

The domestic production of pyrite and imports of sulphur are given in Table 1.78. Sulphur of 99.5% minimum purity is required for the manufacture of sulphuric acid, and should be free from impurities like arsenic, selenium and tellurium.

Future Outlook

Since there is no indigenous production of sulphur and the domestic production of pyrite is too meagre to meet the increasing industrial requirements large tonnage of sulphur are being imported every year. To minimise the imports of sulphur to a large extent in the coming years the two pyrite deposits of Bihar and Rajasthan which are currently being exploited in a phased development programme, could be in a position to yield ores/concentrates equal to 300,000 tonnes of sulphur equivalent annually at the end of the Fifth plan period, if the exploitation schedule is undertaken on a priority basis.

TABLE 1.78—PYRITE PRODUCTION AND SULPHUR IMPORT (TONNES)

Year	Pyrite Production	Sulphur Imports
1968	13,194	390,390
1969	38,686	294,231
1970	25,643	521,423
1971	40,886	420,607
1972	30,723	559,484
1973	41,507	551,476
1974	35,660	588,113
1975	50,633	

(4) GYPSUM $CaSO_4$ $2H_2O$

The mineral gypsum is a hydrated sulphate of calcium which contains 14-18% sulphur in it and is one of the major sources of sulphur for the manufacture of sulphuric acid next to pyrite to be used as raw material for fertilizer industry for the production of ammonium sulphate (ammonia fertilizer). It is also used in the manufacture of cement, plaster of paris, paint, paper, rubber, textiles, pottery and also as a flux. It is very widely distributed in most of the States but the most important deposits lie in Rajasthan and Tamil Nadu, and smaller deposits in Andhra Pradesh, Uttar Pradesh, Gujarat, Jammu & Kashmir, Karnataka, Himachal Pradesh and Maharastra. Some of them

TABLE 1.77—PYRITE-PYRRHOTITE RESERVES (IN MILLION TONNES)

	State	District	Locality	Reserves	Remarks
(1)	Bihar	Shahbad	Amjhore	391	Pyrite : S = 40% Av.
(2)	Karnataka	Chitaldrug	Ingaldhal	2.03	Pyrite : S = 20-30%
(3)	Rajasthan	Sikar	Saladipura	115.0	Pyrite-Pyrrhotite S = 22%
(4)	Tamil Nadu	North Arcot	Near Polur	0.017	Pyrrhotite : S = 14-20%

are very extensive and of high purity, but some are of low grade and need beneficiation.

Reserves, Specification and Uses

Estimated reserves of gypsum in known deposits after exploration have been put over 1270 million tonnes. Some estimates of the various deposits are given in Table 1.79. It is said that deposits of gypsum in Jammu & Kashmir run over 100 million tonnes. But they are located in interior without proper communication etc, and difficult for exploitation. The big deposit at Nagaur in Rajasthan is of high purity variety and located at a depth of 60 metres from ground level and requires underground mining.

Gypsum is widely used in two industries namely fertilizer and cement. It is also used in smaller tonnages in other industries like ceramics, asbestos products, bricks blocks, insulation boards, plaster of paris, chemical, glass, refractory, paints, rubber, textiles and finally in agriculture as a surface plaster for conserving moisture in soil and for aiding nitrogen absorption (soil conditioner). Pure crystalline variety selenite is used as "gypsum plate" in optical microscopes 'Alabaster' a massive variety of gypsum finds its use in artistic, statuary and ornamental and decorative purposes.

According to the revised specifications of the Indian Standard Institution IS : 1290-1965, gypsum is graded into five grades namely Grade I for surgical plaster industry, Grade II—Ammonium Sulphate Industry, Grade III—Pottery Industry, Grade IV—Cement Industry, and Grade V—for reclamation of soil respectively. Accordingly the material shall be the natural mineral consisting essentially of hydrated calcium sulphate and free from any added impurities. The other constituents, limits and characteristics conforming to each of these five grades are given in Table 1.80.

The Fertilizer Corporation of India in their Sindri

TABLE 1.79—RESERVES OF GYPSUM (IN MILLION TONNES)

State	District/Locality	Reserves	Remarks
(1) Andhra Pradesh	Nellore	1.02	G.S.I.
(2) Gujarat	Halar, Bhavnagar, Porbandar & Kutch, Jamnagar	6.7	G.S.I.
(3) Jammu & Kashmir	Doda, Baramulla, Bimbyar-Ijhara-Uri Sector	124.57	G.S.I. & State Government
(4) Himachal Pradesh	Sirmur	1.32	G.S.I.
(5) Karnataka	Gulbarga, Gangurthi, Martimaru	15.67	State Government
(6) Rajasthan	Bikaner	100.35	G.S.I.
	Jaisalmer	1.30	G.S.I.
	Jodhpur	39.10	G.S.I.
	Nagaur	959.00	G.S.I.
	Sriganganagar	3.28	Fertilizer Corporation of India
	Barmer	0.10	
(7) Tamil Nadu	Tiruchirapalli	15.67	G.S.I.
	Coimbatore :		
	Jakkarpalayam South Kattampalli South	0.03	G.S.I.
	East Coimbatore	0.80	Tamil Nadu State Department
(8) Uttar Pradesh	Lachamanjhula	0.10	G.S.I.
	Dehra Dun, Nainital etc.	0.21	G.S.I.

TABLE 1.80—IS : 1290-1965, REQUIREMENTS OF DIFFERENT GRADES OF GYPSUM

Constituent/Characteristics	Requirements for each grade				
	Grade I	Grade II	Grade III	Grade IV	Grade V
(1) Free water % Max.	1.0	—	1.0	—	—
(2) Carbon dioxide CO_2% Max.	1.0	—	3.0	—	—
(3) SiO/ & Other Insolubles % Max.	1.0	6.5	6.5	—	—
(4) Fe & Al oxides % Max.	0.1	1.5	1.0	—	—
(5) MgO % Max.	0.5	1.0	1.5	3.0	—
(6) $CaSO_4.2H_2O$ % Min.	96.0	86.0	85.0	80-85	70-80
(7) Chlorides (as NaCl) % Max.	0.1	0.01	0.10	0.5	—

Plant uses gypsum with the following specifications given in Table 1.81 for the manufacture of ammonium sulphate (nitrogenous) fertilizer. Indian Cement manufacturers prefer gypsum of purity ranging between 75-85% $CaSO_4 .2H_2O$.

TABLE 1.81—SPECIFICATIONS OF GYPSUM USED BY THE SINDRI FERTILIZER PLANT

$CaSO_4.2H_2O$% Min	=	81.78
SiO_2 and other insolubles % Max.	=	6.5-8.5%
Fe & Al (as oxides) % Max.	=	1.5%
MgO % Max.	=	1.0%
Chloride (NaCl) %	=	0.01% Max.

For Paints, Distemper and Pigments

The Indian Standards Institution has formulated specifications IS : 69-1950 for gypsum for use in paint industry as an extender. According to this (1) the material shall be a natural or artificial product consisting essentially of $CaSO_4$ $2H_2O$ (hydrated calcium sulphate), (2) it shall contain not more than 0.5% of free water when heated for 2 hours at 113°F., (3) after drying the material at 45°C (113°F), for 2 hours, the $CaSO_4$, $2H_2O$ content of the material shall not be less than 75%, (4) the material shall be supplied in the form dry powder or in such a condition that it can be reduced to the powder form by crushing without grinding action under a palett knife, (5) microscopic examination shall show that the material consists almost entirely of gypsum grains and (6) when lead-free gypsum is required, it shall contain not more than 0.05% of lead or lead compounds (calculated as metallic lead). Besides the material shall also conform to the requirements are given in Table 1.82.

Production, Import and Export

Domestic production of gypsum comes mainly from Rajasthan and Tamil Nadu. Most of the domestic production is consumed indigenously. The import of gypsum is strictly restricted to "Actual Users engaged in industrial production as alabaster on restricted basis. Exports of gypsum are being allowed 'on merits', and purity basis, in consultation with the Ministry of Foreign Trade and Supply and the Director General of Technical Development. The domestic production, imports and exports are given in Table 1.83.

TABLE 1.82—IS:69-1950 SPECIFICATION FOR GYPSUM FOR PAINTS

Characteristics	Requirement
Residue on sieve	Not more than 0.5%
Oil absorption	Within 5 of the approved sample
Colour	Close match to the approved sample

TABLE 1.83—DOMESTIC PRODUCTION, IMPORT AND EXPORT OF GYPSUM (IN TONNES)

Year	Domestic Production (Gypsum)	IMPORTS		Exports
		Alabaster	Gypsum & Plaster	
1968	1,337,589	43	2	950
1969	1,390,680	60	1	5
1970	925,980	13	5	—
1971	1,088,444	82	5	—
1972	1,104,710	15	2	—
1973	877,750	68	10	—
1974	1,073,441	21		
1975	810,198			

(*Source :* I.B.M.)

The import of gypsum has been very much restricted to "Actual Users" on restricted basis. Exports have been virtually nil in recent years. The domestic production is almost balanced with the demand all these years.

Future Outlook

The country's total reserves of gypsum are comfortably put beyond 1,200 million tonnes, which would be quite sufficient for future consumption. The estimated demand for gypsum by 1978-79 is assessed at 2.06 million tonnes. Present production of gypsum in recent years is around 1 million tonnes per annum which is to be augmented to meet the future demands. The use of gypsum in fertilizer industry is going down due to the use of by-product gypsum.