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APATITE AND ROCK PHOSPHATE

(FINAL RELEASE)

GOVERNMENT OF INDIA
MINISTRY OF MINES
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1 Apatite and Rock Phosphate

Apatite is the most abundant crystalline phosphate mineral found as an accessory mineral in practically all kinds of igneous rocks. Sometimes, it is concentrated in pegmatites, metallic veins and magmatic deposits. It also occurs in metamorphic rocks and as a secondary mineral in phosphatic rocks of sedimentary origin. Moon rocks collected by astronauts during the Apollo Programme also contained traces of apatite. Fluor-apatite $Ca_5(PO_4)_3F$ is the most common variety of apatite and also a secondary source of fluorine. Collophane is apparently a cryptocrystalline or amorphous calcium phosphate complex. Rock phosphates or phosphorites are sedimentary phosphatic deposits comprising fine-grained mixture of various calcium phosphates, most important being hydroxyl-apatite, carbonate-apatite, fluor-apatite and their solid solutions. About 80% phosphate production in the world is derived from phosphate rocks (phosphorite) containing one or more phosphatic minerals, usually calcium phosphate of sufficient purity and quantity to permit its use directly or after concentration in manufacturing commercial products.

Phosphate rock is also the source of by-product fluorine. Apatite & rock phosphate containing 3 to 4% CaF_2 are useful for recovery of fluorite. It is recovered as by-product Hydrofluoro-silicic acid obtained from phosphoric acid plants during processing of rock phosphate. Phosphate rocks also contain uranium which are considered as significant and secondary resource of uranium.

RESOURCES

Apatite

The total resources of apatite as per UNFC system as on 1.4.2010 are placed at 24.23 million tonnes. Out of these resources, the reserves are only 2.09 million tonnes and 22.14 million tonnes are remaining resources. Of the total resources, the bulk (57%) are located in West Bengal followed by Jharkhand (30%) and Meghalaya (5%). The remaining 8% resources are available in Rajasthan, Andhra Pradesh, Gujarat and Tamil Nadu. Gradewise, soil reclamation grade accounts for 45% followed by beneficiable grade (31%), low and non-beneficiable grade (18%) and blendable, others and not-known grades (6%). The resources of chemical fertilizer grade are over one percent (Table-1).

Rock Phosphate

The total resources of rock phosphate as per UNFC system as on 1.4.2010 are placed at 296.3 million tonnes. Out of these, the reserves constitute only 34.8 million tonnes. There are 261.5 million tonnes remaining resources. Of the total resources, 36% are in Jharkhand, 30% in Rajasthan, 17% in Madhya Pradesh, 9% in Uttar Pradesh and 8% in Uttarakhand. Meagre resources are located in Gujarat and Meghalaya. Gradewise, low grade account for 39%, followed by beneficiable (29%), soil reclamation (12%), blendable (9%), chemical fertilizer (6%) and unclassified and not-known grades (about 5%) (Table-2).

EXPLORATION & DEVELOPMENT

Exploration activities for apatite and rock phosphate carried out by the Geological Survey of India; DMG, Rajasthan, DMM, West Bengal and RSMML, Rajasthan during 2010-11 are furnished in Table - 3.

PRODUCTION, STOCKS & PRICES

Apatite

The production of apatite at 3,053 tonnes during 2011-12 decreased by 21% as compared to that in the previous year due to less demand.

There were two reporting mines of apatite in both the years. The share of public sector to the total output of apatite was about 4% in 2011-12. The entire production of apatite was of grade 15-20% P_2O_5 (Tables-4 to 6).

Andhra Pradesh continued its leading position in the production of apatite contributing about 96% output and the remaining 4% was reported from West Bengal.

The mine-head stock at the beginning of 2011-12 was 8,067 tonnes as against 7,529 tonnes at the end of the year (Table - 7).

The average daily labour employed in apatite mines during 2011-12 was 171 as against 195 in the previous year.

Table – 1 : Reserves/Resources of Apatite as on 1.4.2010
(By Grades/States)

(In tonnes)

State/Grade	Reserves			Remaining resources						Total Resources (A+B)
	Proved STD111	Probable STD122	Total (A)	Pre-feasibility STD222	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
All India : Total	**2088536**	**1680**	**2090216**	**1225345**	**2281521**	**11481250**	**6132768**	**1017646**	**22138530**	**24228746**
By Grades										
Chemical Fertilizer	36019	1680	37699	–	30000	–	200163	–	230163	267862
Soil reclamation	1560699	–	1560699	–	2233500	6243000	800000	–	9276500	10837199
Low/Non-beneficiable	–	–	–	–	3360	2363000	1350000	666646	4383006	4383006
Beneficiable	491818	–	491818	1225345	12477	1875250	3592605	351000	7056677	7548495
Blendable	–	–	–	–	2184	–	–	–	2184	2184
Unclassified	–	–	–	–	–	1000000	–	–	1000000	1000000
Non-known	–	–	–	–	–	–	190000	–	190000	190000
By States										
Andhra Pradesh	36019	1680	37699	–	–	–	200163	–	200163	237862
Gujarat	–	–	–	–	–	–	–	351000	351000	351000
Jharkhand	–	–	–	–	2110000	1620000	3540000	–	7270000	7270000
Meghalaya	–	–	–	–	–	–	1300000	–	1300000	1300000
Rajasthan	–	–	–	–	51521	1016000	–	–	1067521	1067521
Tamil Nadu	–	–	–	–	–	–	240000	–	240000	240000
West Bengal	2052517	–	2052517	1225345	120000	8845250	852605	666646	11709846	13762363

Figures rounded off.

Table – 2 : Reserves/Resources of Rock Phosphate as on 1.4.2010
(By Grades/States)

(In tonnes)

Grade/State	Reserves				Remaining resources							Total resources (A+B)
	Proved STD111	Probable		Total (A)	Feasibilty STD211	Pre-feasibility		Measured STD331	Indicated STD332	Inferred STD333	Total (B)	
		STD121	STD122			STD221	STD222					
All India : Total	**20697294**	**3352994**	**10728362**	**34778650**	**26826747**	**21273335**	**24226125**	**2912633**	**3549750**	**182717111**	**261505701**	**296284351**
By Grades												
Chemical fertilizer	8140800	-	1399542	9540342	-	6889000	-	-	-	1081200	7970200	17510542
Blendable	3361723	1589807	4643763	9595293	3063503	-	1734370	13333	-	13942513	18753719	28349012
Soil reclamation	3382381	1763187	3715763	8861331	622561	251437	7406169	732800	10000	16887166	25910133	34771464
Beneficiable	5812390	-	969294	6781684	23140683	14132898	15085586	2166500	2799750	21863615	79189032	85970716
Low grade	-	-	-	-	-	-	-	-	-	115271844	115271844	115271844
Unclassified	-	-	-	-	-	-	-	-	740000	10095773	10835773	10835773
Not-known	-	-	-	-	-	-	-	-	-	3575000	3575000	3575000
By States												
Gujarat	-	-	-	-	-	-	-	-	-	314820	314820	314820
Jharkhand	-	-	-	-	-	-	-	-	-	107370000	107370000	107370000
Madhya Pradesh	6589894	1763187	9787162	18140243	3131683	13700000	5990814	-	2730000	5725000	31277497	49417740
Meghalaya	-	-	-	-	-	-	-	-	-	1311035	1311035	1311035
Rajasthan	14107400	1589807	941200	16638407	20631561	7140437	13382355	152633	79750	29893783	71280519	87918926
Uttar Pradesh	-	-	-	-	-	432898	3118586	-	740000	21481960	25773444	25773444
Uttarakhand	-	-	-	-	3063503	-	1734340	2760000	-	16620513	24178386	24178386

Figures rounded off.

Table – 3 : Details of Exploration Activities for Apatite & Rock Phosphate during 2011-12

Agency/ State/District	Location	Mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	No. of boreholes	Meterage	No.	Reserves/Resources estimated
Apatite							
GSI							
West Bengal Purulia	Panrkidih area	-	-	7	30	-	Apatite-magnetite veins up to 30 m vertical depth was persisted . About 150 m strike length and average 1 m width on the surface, do not persist up to the depth. Analytical results of bedrock samples and channel samples show average 24% P_2O_5 and 23% P_2O_5, respectively. Exploration has been completed.
Rock Phoshate	Piploda & Dhanpura-						
GSI							
Madhya Pradesh Jhabua	Khatamba Block	-	-	-	-	-	Reconnaissance stage investigation was carried out for phosphorite in this area. Object was to locate & assess phsophoritic bands associated with dolomitic limestone & chert sequence. A zone of 340 m strike length in Piploda Block and 130 m strike length in Khatamba Block for phosphorite have been delineated. The stromatolytic dolomite limestone, cherty dolomite and brecciated chert of Kelkua Formation are the host rocks of phospherite in this area and the bands are with NE-SSW trend. A tentative resource of 279,625 tonnes of phosphorite with average 16.44% P_2O_5 has been estimated in Piploda Block. Analytical results of Khatamba Block and Kachaldora - Kalikhet Block are awaited.
- do - Chhatarpur & Sagar	Lukri-Akrotha-Raipura-Surajpura area	-	-	-	-	-	The main object of explortion was to assess the extent & grade of phosphorite. Phosphorite is associated with ferruginous sandstone and ferruginous shale as irregular bands and lenses varying in thickness from 3 m to 20 m chemical analysis indicate P_2O_5% value ranging from 10.15% to 33.15% in Surajpura Block. 19.32% to 30.50% in Raipura-Akrotha Block and 20.75% in Lukri Block.

(Contd.)

Table 3 (Concld.)

Agency/ State/District	Location	Mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	No. of boreholes	Meterage	No.	Reserves/Resources estimated
Rock Phosphate							
GSI							
Rajasthan Banswara	Kalinjara, East of Sallupat	-	-	-	-	-	Reconnaissance stage investigation has been carried out for low grade phospharite occurrences and to delineate, locate new areas of phospharite bearing dolomitic limestone. To the north of Rupgarh dolomite band is exposed intermittently for about 5 km while its width varies between 20 m and 500 m within this band stringers patches and lamellae of brecciated stramatolite and lenses at chert the thickness at brecciate stromatolite unit varies between 2 cm and 20 cm.
MECL							
Rajasthan Udaipur	Dhol-ki-Pati,	-	1.0	19	1784.90	-	The general strike of rocks in Dhol-ki-pati in NNE-SSW with steep dips on either side. The phosphorite bands have been tightly compressed to produce a series of isoclinally folded low plunging antiforms and synforms. The axial plane of these folds trend N30° E-S30° W and the axis plunges 10° due S 30° W. Sampling and chemical analysis of 1364 Nos. of primary +check and 137 Nos. of trench/pit samples for P_2O_5 Fe_2O_3, CaO, SiO_2, Al_2O_3, and MgO & 17 no for spectroscopic studies was carried out. 20 samples for petrological studies, 18 samples for minerological studies and 38 no. for specific gravity determinations was undertaken.
RSMML							
Rajasthan Udaipur	A Extn. & G - Block Jhamarkotra mine (25 km SE from Udaipur)	-	-	-	-	-	Exploratory mining in A- Extension and G Block has been carried out over 1370 ha area. The strike length is 2.00 km with deep varying from sub vertical to about 30 degree structurally folded and undulating ore bed dipping towards the centre of Jhamarkotra basin. As on 31.03.2012, about 46.44 million tonnes resources were estimated.

Table – 4 : Producers of Apatite, 2011-12

Name and address of producer	Location of mine	
	State	District
Andhra Phosphate (Pvt.) Ltd, D.No.45-58-17/15, Narasimha Nagar, Visakhapatnam-530 024, Andhra Pradesh.	Andhra Pradesh	Visakhapatnam
West Bengal Mineral Development & Trading Corp. Ltd, 2nd -Floor, 13, Nellie Sengupta Sarani, Lindsay Street, Kolkata-700 087, West Bengal.	West Bengal	Purulia

Table – 5 : Production of Apatite, 2009-10 to 2011-12
(By States)

(Quantity in tonnes; value in ₹ '000)

State	2009-10		2010-11		2011-12 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**5992**	**12911**	**3846**	**8345**	**3053**	**6401**
Andhra Pradesh	3882	9212	2585	6134	2917	6163
West Bengal	2110	3699	1261	2211	136	238

Table – 6 : Production of Apatite, 2010-11 and 2011-12
(By Sectors/States/Districts/Grades)

(Quantity in tonnes; value in ₹ '000)

State/District	2010-11			2011-12 (P)		
	No. of mines	Quantity 15-20% P_2O_5	Value	No. of mines	Quantity 15-20% P_2O_5	Value
India	**2**	**3846**	**8345**	**2**	**3053**	**6401**
Public sector	1	1261	2211	1	136	238
Private sector	1	2585	6134	1	2917	6163
Andhra Pradesh	**1**	2585	6134	**1**	2917	6163
Visakhapatnam	1	2585	6134	1	2917	6163
West Bengal	**1**	**1261**	**2211**	**1**	**136**	**238**
Purulia	1	1261	2211	1	136	238

Table – 7 : Mine-head Stocks of Apatite, 2011-12 (P)
(By States/Grades)

(In tonnes)

State	At the beginning of the year 15-20% P_2O_5	At the end of the year 15-20% P_2O_5
India	**8067**	**7529**
Andhra Pradesh	74	111
West Bengal	7993	7418

Phosphorite/Rock Phosphate

The total production of phosphorite/rock phosphate at 2,327 thousand tonnes in 2011-12 increased by about 11% as compared to that in the previous year due to more lifting of ore at crushing plant of Jhamarkotra mine of RSMML, Rajasthan.

There were 5 reporting mines during the year as against 7 in previous year, Rajasthan continued to be the principal producing state, contributing 90% of the total production followed by Madhya Pradesh with 10%.

About 52% of the total production of phosphorite/rock phosphate was of grade 30-35% P_2O_5 grade, 6% of 25-30% P_2O_5 grade, 1% of 20-25% P_2O_5 grade and 41% of 15-20% P_2O_5 grade (Tables - 8 to 10).

The mine-head stocks at the end of the year 2011-12 was 684 thousand tonnes as compared to 705 thousand tonnes at the beginning of the year (Table-11).

The average daily labour employed in phosphorite mines in 2011-12 was 1,517 as against 1,554 in the previous year.

The domestic prices of apatite and phosphorite/rock phosphate are furnished in the General Review on 'Prices'.

Table – 8 : Producers of Phosphorite/Rock Phosphate, 2011-12

Name and address of producer	Location of mine	
	State	District
Rajasthan State Mines & Minerals Ltd, C-89/90, Janapath, Lal Kothi Scheme, Jaipur-302 004, Rajasthan.	Rajasthan	Udaipur
The Madhya Pradesh State Mining Corp. Ltd, Block A,2nd Floor, Paryawas Bhavan,Jail Road,Arera Hills Madhya Pradesh.	Madhya Pradesh	Jhabua Chhatarpur Sagar
Hindustan Zinc Ltd, Yashad Bhavan,Near Swoop Sagar, (Chetak Circle) Udaipur-313 004, Rajasthan.	Rajasthan	Udaipur

Table – 9 : Production of Phosphorite/Rock Phosphate, 2009-10 to 2011-12
(By States)

(Quantity in tonnes; value in ₹ '000)

State	2009-10		2010-11		2011-12 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**1605489**	**3103095**	**2097490**	**5014699**	**2326876**	**6429734**
Madhya Pradesh	212168	122007	133378	76946	243960	151284
Rajasthan	1393321	2981088	1964112	4937753	2082916	6278450

Table – 10 : Production of Phosphorite, 2010-11and 2011-12 (P)
(By Sectors/States/Districts/Grades)

(Quantity in tonnes; value in ₹ '000)

State/ District	2010-11 No.of mines	Grade : P_2O_5 content 30-35%	25-30%	20-25%	15-20%	Total Qty	Total Value	2011-12(P) No. of mines	Grade : P_2O_5 content 30-35%	25-30%	20-25%	15-20%	Total Qty	Total Value
India	**7**	**922587**	**139390**	**21815**	**1013698**	**2097490**	**5014699**	**5**	**1212147**	**128568**	**31241**	**954920**	**2326876**	**6429734**
Public Sector	7	922587	139390	21815	1013698	2097490	5014699	5	1212147	128568	31241	954920	2326876	6429734
Madhya Pradesh	**5**	**-**	**17053**	**21815**	**94510**	**133378**	**76946**	**3**	**-**	**3860**	**-**	**240100**	**243960**	**151284**
Chhatarpur	1	-	5146	-	17674	22820	12137	1	-	1151	-	69989	71140	33390
Jhabua	3	–	3578	20124	36433	60135	40191	1	-	-	-	109819	109819	87206
Sagar	1	–	8329	1691	40403	50423	24618	1	-	2709	-	60292	63001	30688
Rajasthan	**2**	**922587**	**122337**	**-**	**919188**	**1964112**	**4937753**	**2**	**1212147**	**124708**	**31241**	**714820**	**2082916**	**6278450**
Udaipur	2	922587	122337	-	919188	1964112	4937753	2	1212147	124708	31241	714820	2082916	6278450

Table – 11 : Mine-head Stocks of Phosphorite/Rock Phosphate, 2011-12 (P)
(By States/Grades)

(In tonnes)

State	At the beginning of the year Grade : P_2O_5 content 30-35%	25-30%	20-25%	15-20%	Total	At the end of the year Grade : P_2O_5 content 30-35%	25-30%	20-25%	15-20%	Total
India	**49682**	**124412**	**21664**	**508965**	**704723**	**158612**	**55054**	**45802**	**424810**	**684278**
Madhya Pradesh	130	-	21664	16098	37892	–	404	7799	35298	43501
Rajasthan	49552	124412	-	492867	666831	158612	54650	38003	389512	640777

MINING AND MARKETING

Apatite mining is confined to Visakhapatanam district, Andhra Pradesh and in Purulia district, West Bengal. In apatite mine of Andhra Phosphate (Pvt.) Ltd, manual mining was carried out by putting inclined shafts, following the dip of ore body, and by lateral developments of levels along the strike. A mineral treatment plant at Srungavarapukota, about 20 km from the apatite mine consists of two disintegration units of 15 hp and 50 hp located in two separate sheds. Apatite after disintegration is screened to 40 mesh, 60 mesh and 100 mesh. The screened material of right size is packed for sale in polythene-lined gunny bags weighing 50 kg each and despatched to buyers through Srungavarapukota railway station.

In Beldih semi-mechanised mine of West Bengal Mineral Development & Trading Corporation (WBMDTC), apatite is mined by opencast method. WBMDTC has adopted semi-mechanised opencast mining method with the deployment of machines/equipment/ vehicles like JCB excavator, jackhammer drills, air compressor, tippers, etc. on single shift basis to develop the mine with a targetted production of about 15,000 tonnes of in situ ore per annum. Half of the low grade ore (10-12% P_2O_5) is blended with available high grade ore (>22%, P_2O_5) manually to produce additional quantity of saleable ore (18-20% P_2O_5). The desired grade (18-20% P_2O_5) of apatite ore is ground to 100 mesh and sold as direct application phosphatic fertilizer in the brand name of "PURULIA PHOS".

The production of phosphorite/rock phosphate was reported from seven mines in public sector. Of these, two were in Madhya Pradesh at Hirapur in Chhattarpur and Sagar districts and three in Jhabua district and two in Rajasthan in Udaipur district.

The Khatamba mine in Jhabua district and Hirapur mine in Chhattarpur and Sagar districts of Madhya Pradesh are opencast, and are operated manually by Madhya Pradesh State Mining Corporation. Compressed-air jackhammers are deployed for drilling. The present run-of-mine capacity of Jhabua mine is 90,000 tonnes. The lumpy ore is crushed by mechanised crushers. Four jaw crushers and a grinding unit (50 hp) have been set up at Meghnagar railway siding, about 22 km from the mine. Despatches are made to manufacturers of phosphatic fertilizers and chemicals.

The run-of-mine ore from Hirapur mine after hand sorting and dressing is transported to the two crushing plants, situated at a distance of 6 km on Hirapur-Damoh road, each having 4 to 8 tonnes per hour capacity. A small pulveriser with 3 to 4 tonnes per hour capacity had also been installed to meet the special demand of material of 30 to 100 mesh.

Jhamarkotra area extends over a length of 16 km, has an average width of phosphate bed of about 15 m and an average inclination of about 55^0 from the vertical. The height of the bench is maintained up to 10 m. Shovels (6.1 cu m) and dumpers (85 tonnes) are used for removing ore and overburden. The mine has an annual rock handling capacity of about 20 million tonnes. The thin and sharply dipping ore body results in long and narrow pits with great depth extension, involves very high stripping ratio (i.e., 1:10) with high lead and lift for waste and mineral. An effective dewatering scheme was implemented to tackle groundwater problem. The working levels are kept dry. The beneficiation plant of RSMML at Jhamarkotra has 9 lakh tpy capacity to treat run-of-mine low grade ore, analysing 16% P_2O_5. Production from Jhamarkotra mine is despatched to many phosphatic fertilizer and chemical manufacturers from Udaipur and Umra railway stations which are located 18 and 25 km, respectively, away from the mine. The 88.10 inch dia drills are used to drill Blastholes. Blasting is carried out mainly with SMS to fragment the rock.

RSMML produces the following products:

(1) **+31.5% P_2O_5 crushed -1/2" size high-grade rock phosphate** (for SSP manufacturing units).

(2) **31.5% P_2O_5 high grade rock phosphate Chips** (for non ssp manufacturing units.

(3) **18-20% P_2O_5 ground low-grade beneficiated rock phosphate (RAJPHOS)** (as fertilizer for direct application to acidic soils).

(4) **31.54% P_2O_5 - BRP Grade**

RSMML could not market its low grade rock phosphate (trade name-Rajphos) till 2005-06 because of its high R_2O_3 content which could neither be blended nor beneficiated. However, during recent years, this grade of rock phosphate was sold to DAP manufacturers.

INDUSTRY

At present, there are 56 large fertilizer units, manufacturing a wide range of nitrogenous, phosphatic and complex fertilizers. Of these, 21 large-size fertilizer units produce DAP and complex fertilizers. Besides, there are 72 small-scale and medium-scale units which produce single superphosphate (SSP). The total installed capacity of phosphatic nutrient as on 31.1.2010 was 56.59 lakh tonnes. The production of phosphate fertilizer in 2011-12 was estimated at 44.32 lakh tonnes compared to 45.32 lakh tonnes in 2010-11. The share of public and co-operative sector during 2011-12 was 16.14 lakh tonnes while that of private sector was 28.17 lakh tonnes.

The major phosphatic fertilizer plants in public sector are Fertilizers and Chemicals (Travancore) Ltd (FACT) at Udyogmandal, and Kochi (Kerala); Rashtriya Chemicals and Fertilizer Ltd (RCF) at Trombay, Mumbai (Maharashtra); Madras Fertlizer Limited at Chennai (Tamil Nadu); HCL at Khetri (Rajasthan); and Paradeep Phosphates Ltd (PPL) at Paradeep (Odisha). The plants in private sector are Gujarat State Fertilizer Company Ltd (GSFC) at Vadodara and Sikka (Gujarat); Coromandal Fertilizer Ltd at Visakhapatnam (Andhra Pradesh) and Ennore (Tamil Nadu); Zuari Agro Chemicals Ltd in Goa; Southern Petro Chemicals Industries Corporation Ltd (SPIC) at Thoothukudi (Tamil Nadu); Mangalore Chemicals and Fertilizer Ltd at Mangalore (Karnataka); Gujarat Narmada Fertilizer Corporation (GNFC) at Bharuch (Gujarat); TCL at Haldia (West Bengal), Deepak Fertilizers & Petrochemicals Corp. Ltd (DFPCL) at Taloja (Maharashtra); EID-Parry at Ennore (Tamil Nadu); Hindustan Industries Ltd at Dahej (Gujarat); Oswal Chemicals & Fertilizers Ltd (OCF) at Paradeep (Odisha); and Godawari Fertilizers & Chemicals Ltd (GFCL) at Kakinada (Andhra Pradesh). The only plant in the co-operative sector to manufacture phosphatic fertilizer is of Indian Farmers Fertilizer Co-operative Ltd (IFFCO) at Kandla (Gujarat).

M/s. RSMML has a beneficiation plant in Jhamarkotra in Rajasthan. M/s. Krishna Phoschem Ltd has also set up a 600 tpd rock phosphate beneficiation plant at Meghnagar in Jhabua district of Madhya Pradesh. The company has long term tie-up with M.P. State Mining Corporation Ltd.

Only about 35-40% requirement of raw material for phosphate fertilizer production is met through indigenous sources. The remaining requirement is met through import in the form of rock phosphate, phosphoric acid and direct fertilizers.

In India, most of the existing phosphatic fertilizer and phosphoric acid plants have been designed for high grade imported rock phosphate, mainly from Morocco and Jordon. The Indian deposits are relatively of low grade. Therefore, the fertilizer and phosphoric acid plants that may be set up as replacement to the existing plants will have to be designed to accept indigenous ores as a feed.

Coimbatore Pioneer Fertilizer Ltd and Rashtriya Chemicals & Fertilizers Ltd, Mumbai were the domestic plants which recover by-product fluorine from rock phosphate in the form of hydrofluorosilicic acid, sodium silico-fluoride, and aluminium fluoride. Department of Atomic Energy has issued sanctions for establishment of 2 units for recovery of uranium from rock phosphatic sources, these are: Rashtriya Chemicals & Fertilizers, Mumbai in association with Heavy Water Board (HWB); and SPIC, Thoothukudi in association with IREL.

RCF is also setting up a rapidwall plant for manufacture of unique building material using phospho-gypsum as a raw material which is the by-product of phosphoric acid plant. The project is estimated to cost ₹ 75 crore.

Red phosphorus is manufactured mainly by Star Chemicals (Bombay) Pvt Ltd and United Phophorus Ltd. Red phosphorus is consumed in matches industry. It also has applications as fumigant in agriculture industry and as flame retardant.

Joint Ventures Abroad

Due to total dependence on imported raw materials for production of phosphatic fertilizers, the Government has been encouraging Indian Companies to establish joint ventures in other countries which have rich reserves of natural gas and rock phosphate. Important joint ventures abroad by Indian Companies for phosphatic fertilizers are as follows:

(1) The Government of India (GoI), Indian Farmers Fertilizers Cooperative Ltd (IFFCO) and Southern Petrochemicals Industries Corporation Ltd (SPIC) had earlier set up a joint venture company named, Industries Chimiques du Senegal (ICS) in Senegal. However, SPIC withdrew from the project later on. The company has a capacity to produce 6.6 lakh tpy phosphoric acid and finished phosphate fertilizers in its Senegalese plants. A major portion of phosphoric acid to the tune of 5.5 lakh tonnes against an installed capacity of 6.6 lakh tpy is being utilised by IFFCO through long-term buy back arrangement. The company had suffered financial losses and with the active support of Government of India was restructured to improve its performance. The restructuring plan was approved by the Regional High Court of Dakar (Senegal) and the company is in operation.

Overseas Joint Ventures

(1) Gujarat State Fertilizers & Chemicals Ltd (GSFC) and Coromandel Fertilizers Ltd (CFL) along with 'Groupe Chimique Tunisien' (GCT) and 'Compagnie Des Phosphates De Gafsa' (CPG) are setting up a joint venture project in Tunisia for production of 3.6 lakh tpy phosphoric acid. The entire production of phosphoric acid is for off-take by GSFC and CIL.

(2) IFFCO and Jordan Phosphate Mining Company (JPMC) have agreed to set up a phosphoric acid plant in Jordan with installed capacity of 0.5 million tpy of P_2O_5 (1,500 tonnes per day of phosphoric acid) under a joint venture company, Jordan India Fertilizer Company (JIFCO). The equity holdings in the project is 52 : 48 between IFFCO and JPMC, respectively.

(3) IMACID, joint venture between Office Cherifien Des Phosphates (OCP), Morocco and Chambal Fertilizers & Chemicals Ltd (CFCL) to produce 3.60 lakh tonnes phosphoric acid per annum was commissioned in October 1999. After subsequent joining of Tata Chemicals Ltd (TCL), capacity of the plant has been increased to 4.30 lakh tonnes per annum.

(4) SPIC, Jordan Phosphate Mines Company Ltd (JPMC) and Arab Investment Company (AIC) set up a joint venture project, Indo-Jordan Chemicals Ltd (IJC) in Jordan in May 1997 with a capacity of 2.24 lakh tonnes of phosphoric acid production per annum. Phosphoric acid produced by IJC is off-taken by SPIC and other fertilizer units in India.

ENVIRONMENTAL CONCERNS

Phospho-gypsum, is formed as a by-product during manufacturing of phosphoric acid. It contains about 1% P_2O_5, 1% F and 10-30 times more radon, none of which is desirable. Environment Protection Agency (EPA) of USA stipulated in 1989 that phospho-gypsum is unsuitable for sale as common gypsum. Production of each tonne of P_2O_5 yields about five tonnes phospho-gypsum. EPA has prescribed stringent measures for storage, transport and disposal of phospho-gypsum. In India, however, by-product phospho-gypsum is used widely in cement manufacture.

The use of phosphate also falls under scrutiny. Much attention has been paid to its role in stimulating the growth of algae and other organisms in surface water, the process known as eutrophication. This process is deleterious because it causes blooms of algae which consume dissolved oxygen in lakes and even observed in shallow, isolated arms of the ocean. Phosphate fertilizers are probably not the only cause of phosphate-induced eutrophication. Fertilizer phosphate does not leach readily from soil. One of the best ways to remove this phosphate is through the addition of lime which causes precipitation of apatite. However, this procedure, being relatively costly, has not been applied

widely. Instead, the use of phosphate in detergents has been discouraged.

USES

Phosphate rock is used primarily as a plant nutrient, either by direct application to the soil as a powdered product or in the manufacture of superphosphate, triple superphosphate, or diammonium phosphate (DAP) fertilizers. Elemental phosphorus and phosphoric chemicals derived from phosphate rock are also used in detergents, insecticides, matches, fireworks, military smoke screens, incendiary bombs. Apatite is occassionally used as a gemstone. Blue & green varieties in finely divided form are also used in pigments.

SPECIFICATIONS

Elemental Phosphorus and Phosphoric acid

BIS (IS:11224-1985, reaffirmed 2010) has prescribed the following specifications of rock phosphate required for the manufacture of elemental phosphorus (Type-I) and phosphoric acid (Type-II).

Sl. No.	Characteristics	Requirement	
		Type I	Type II
1.	Total Phosphate (as P_2O_5) by mass (min)	30.0	32.0
2.	Silica (as SiO_2) % by mass (min)	10.0	5.0
3.	CO_2 % by mass (max)	2.0	3.0
4.	Fluoride (F) % by mass (max)	2.0	4.0
5.	Mixed Aluminium and iron oxide (Al_2O_3 and Fe_2O_3) % by mass (max)	3.0	3.5
6.	Moisture % by mass (max)	1.5	1.5
7.	Magnesium oxide (MgO) % by mass (max)	0.5	0.5
8.	Chloride (Cl) % by mass (max)	0.015	0.05
9.	Organic Matter and combined water % by mass (max)	2.0	1.5

Single Superphosphate

The P_2O_5 content in rock phosphate for manufacturing single superphosphate should be minimum 31%. Silica up to 8% can be tolerated. Iron and alumina; i.e., R_2O_3 should not be more than 3.5%. Higher R_2O_3 may tend reversion of available P_2O_5 (water soluble P_2O_5). Carbonate up to 5% will improve the reactivity of rock phosphate by increasing the reaction temperature and making the mass porous.

Direct Application of Rock Phosphate as Fertilizer

In India, the finely-ground rock phosphate containing 16% P_2O_5 is used directly on the soil for soil amendment and is suited most for pastures and forage crops and for acidic soils. The following specifications are considered for utilising any rock phosphate as phosphatic fertilizer for direct application in acidic soils.

1.	Absolute citrate solubility index	7% max
2.	Apatite to carbonate ratio $CO_2\% : P_2O_5\%$	0.035
3.	Origin of rock phosphate	Sedimentary
4.	Mesh size	100
5.	Hydroxyl ion in crystal lattice is higher indicating substitution of OH for PO_4:H_2O	2
6.	Grade of rock phosphate powder citrate soluble fraction	16% P_2O_5
7.	Iron as Fe_2O_3	5%
8.	CaO to P_2O_5 ratio	1:8

The use of rock phosphate for direct application as fertilizer depends on its level of solubility in acidic soil.

CONSUMPTION

The consumption of apatite and rock phosphate in 2011-12 was about 3.96 million tonnes against 3.55 million tonnes in 2010-11, increasing about 10%. Fertilizer industry alone accounted for about 80% consumption followed by chemical (20%). The consumption in glass,

sugar and iron & steel industry was meagre (Table - 12).

Table – 12 : Reported Consumption@ of Apatite and Rock Phosphate, 2009-10 to 2011-12 (By Industries)

(In tonnes)

Industry	2009-10	2010-11 (R)	2011-12 (P)
All Industries	**3145600**	**3552700**	**3955100**
Chemical	818100(7)	787200(6)	787500(6)
Fertilizer	2327100(24)	2765100(25)	3167200(26)
Others (glass, sugar, iron & steel)	400(4)	400(9)	400(9)

Figures rounded off. Figures in parentheses denote the number of units in organised sector reporting consumption.*

*(*Includes actual reported consumption and/or estimates made wherever required).*

@ Consumption for organised sector, excluding small scale units. Besides rock phosphate, imported phosphoric acid is also consumed for manufacturing phosphatic fertilizers. Apatite and rock phosphate in ground form are also used directly in acidic soil. Data relates only to those units who have actually responded to the questionnaire sent by IBM.

POLICY

Imports of natural calcium phosphates (including apatite), natural aluminium-calcium phosphates and phosphatic chalk are allowed freely under heading no. 2510 as per the Foreign Trade Policy 2009-2014. All chemical fertilizers except urea continue to be decontrolled. The Government of India has been implementing a scheme of concession fixing indicative maximum retail price (MRP) for enabling sales of decontrolled phosphatic and potassic fertilizers at reasonable prices.

In case of phosphate fertilizer industry, the paucity of domestic raw material constrains the attainment of self-sufficiency in the country. Indigenous rock phosphate supplies meet only 5-10% requirement of P_2O_5. A policy has, therefore, been adopted which involves following three options:

i) domestic production based on indigenous imported rock phosphate and imported sulphur.

ii) domestic production based on imported intermediates; viz, phosphoric acid.

iii) imports of finished fertilizers.

WORLD REVIEW

The world reserves of phosphate rock are about 67 billion tonnes, located mainly in Morocco & Western Sahara (75%), Iraq (7%), China (6%), Algeria (3%) and South Africa, Jordan, United States of America and Russia (2% each). Large deposits have also been identified on the continental shelves and on seamounts in the Atlantic Ocean and Pacific Ocean. World resources of phosphate rock are more than 300 billion tonnes (Table - 13).

The world production of phosphate rock increased to 203 million tonnes in 2011 from 182 million tonnes in 2010. China (40%), Morocco & USA (14%) each , Russia (5%) and Jordan (4%) were the major producers. Almost 90% of the rock phosphate production was consumed for the chemical fertilizer products (Table - 14).

Australia

Minemakers Ltd continued development of the Wonarah Rock Phosphate Project in the Northern Territory. The company changed the business plan of the project from producing phosphate rock for export to upgrading the rock into phosphoric acid or fertilizer for export. In November 2011, a study commissioned by Minemakers was completed. The study proposed to either produce wet process phosphoric acid and DAP/MAP or to produce superphosphoric acid via the improved hard process (IHP), a thermal processing technology developed by JDC Phosphate Inc. (JDC). Minemakers were waiting for JDC to complete a demonstration plant before it committed to using the IHP. Minemakers planned to start mining in 2014 with an initial capacity of 1.5 million metric tons per year (Mt/year).

Canada

Agrium signed a long-term contract with OCP Group of Morocco to supply phosphate rock to its Alberta phosphate facility beginning in late 2013 when the company's Kapuskasing, Ontario, mine was projected to be depleted.

Arianne Resources Inc. began development of the Lac-a-Paul Project in northern Quebec. A prefeasibility study was completed in November 2011 that demonstrated measured and indicated resources of 348 Mt of apatite with an average grade of 6.5% P_2O_5 that could be upgraded to a 39% P_2O_5 concentrate. The company has plans to commence mining in 2014.

Iraq

A recent evaluation of the seven major phosphate deposits in Iraq was conducted by the Iraq Geological Survey. Of the seven, only the Akashat deposit has been mined. It has been in operation since 1983 and has reserves of 430 Mt, with an average grade of 21.5% P_2O_5. Total phosphate rock resources in Iraq are 9.5 billion metric tons, which is 3% of estimated world resources.

Namibia

Namibia Marine Phosphate (pty) Ltd, (NMP) [a joint venture between Minemakers, UCL Resources Ltd (Australia), and Tungeni Investments cc (Namibia)], continued development of its Sandpiper project 60 kilometers (km) off the coast of Namibia. NMP plans to dredge marine sediments containing 18% to 20% P_2O_5 at a depth of 225 meters. A feasibility study completed in early 2012 demonstrated the viability of a 3 Mt/yr production facility producing a concentrate of 28% P_2O_5 for export beginning in 2013 and expanding to 3 Mt/year by 2016, depending on market conditions.

Morocco

OPC Group began work on expanding its mines and production facilities. As announced in 2010, OCP planned to increase phosphate rock production capacity from 30 Mt/yr to 50 Mt/yr by 2018. Phosphate rock beneficiation capacity would also be increased from 9 Mt/year to 38 Mt/year and DAP/MAP capacity from 3 Mt/year to 9 Mt/year. The processing expansion would be accomplished through the construction of four new plants at the Jorf Lasfar complex, which would be served by a 44-Mt/year slurry pipeline from the mines.

New Zealand

Chatham Rock Phosphate Ltd proceeded with development of a shallow undersea mining operation 450 km off the east coast of New Zealand. The company has an offshore mining permit for 4,276 square kilometers with an estimated resource of 100 Mt of phosphate rock. The company signed an agreement with a dredging company in 2011 and planned to begin comprehensive ore sampling and assessment.

Peru

Output from the Vale SA Miski Mayo Mine near Bayovar increased production to 2.5 Mt in 2011. Vale planned to increase production capacity from 3.9 Mt/yr to 5.8 Mt/year by 2016 and develop a second deposit at Bayovar, which would add 1.9 Mt/year production capacity by 2017.

Russia

JSC Acron, through its North-Western Phosphorus Co. subsidiary was to commence mining at the Oleniy Ruchey deposit in the Murmansk region.

The mine is expected to have a production capacity of 1 Mt/year and further increase to 2 Mt/year in 2017.

Saudi Arabia

Ma'aden Phosphate Co. began mining and processing phosphate rock at its Al-Jalamid complex in 2011. The phosphate concentrate was used to produce DAP at Ras Al Khair. Ma'aden planned to build a new phosphate complex at Umm Wu'al to mine the Al-Khabra deposit. The new mine would have a production capacity of 5 Mt/year.

Table – 13 : World Reserves of Phosphate Rock (By Principal Countries)

(In '000 tonnes)

Country	Reserves
World: Total (rounded)	**67000000**
Algeria	2200000
Australia	490000
Brazil	270000
Canada	2000
China	3700000
Egypt	100000
India	6100
Iraq	460000
Israel	180000
Jordan	1500000
Mexico	30000
Morocco and Western Sahara	50000000
Peru	820000
Russia	1300000
Saudi Arabia	750000
Senegal	180000
South Africa	1500000
Syria	1800000
Togo	60000
Tunisia	100000
USA	1400000
Other countries	390000

Source: *Mineral Commodity Summaries, 2013.*

Table – 14 : World Production of Phosphate Rock (By Principal Countries)

(In '000 tonnes)

Country	2009	2010	2011
World: Total	**162000**	**182000**	**203000**
Australia	1963	2136	2388
Brazil	6100	6300	6634
China	60209	68070	81223
Egypt	6227	3021	1393
India	1605	2152	2297
Israel	2697	2777	3022
Jordan	5281	6529	7643
Kazakhastan	1205	1755	2213
Morocco	18307	26603	28052
Russia	9538	10843	10850
South Africa	2237	2494	2565
Syria	2466	3765	3542
Tunisia	7409	8148	2479
USA	26400	25800	28400
Vietnam	2047	2324	2563
Other countries	8309	9283	17741

Source: *World Mineral Production, 2007-2011.*

FOREIGN TRADE

Exports

In 2011-12, exports of rock phosphate were 248 tonnes compared to 712 tonnes in the previous year. Similarly, exports of phosphatic fertilizers were 827 tonnes in 2011-12 compared to 1,205 tonnes in the preceding year. The export of phosphoric acid increased drastically to 18,674 tonnes from 6508 tonnes and that of elemental phosphorus to 429 tonnes from 337 tonnes in the previous year. Rock phosphate was exported mainly to UAE (23%), USA & Nigeria (20% each) and Egypt (11%). Elemental phosphorus was mainly exported to USA (34%) and South Africa (8%). In 2011-12, exports of phosphatic fertilizers were mainly to Kenya (61%), Saudi Arabia (36%) and Oman (2%) while those of phosphoric acid were mainly to Indonesia (99%) (Tables - 15 to 18).

Imports

Imports of rock phosphate increased significantly to 973 million tonnes in 2011-12 from 5.19 million tonnes in the previous year. Imports were mainly from Jordan (48%), Morocco (14%). and Egypt (12%). Imports of elemental phosphorus increased marginally to 22,630 tonnes from 19,949 tonnes in the previous year. The imports of elemental phosphorus were mainly from China (49%) and Vietnam (40%). In 2011-12, 110,644 tonnes of phosphatic fertilizers were imported mainly from China (99%). Imports of phosphoric acid increased considerably to 2.32 million tonnes in 2011-12 from 2 million tonnes in the previous year. Imports were mainly from Morocco (47%), Senegal (17%) and USA (14%) (Tables - 19 to 22).

Table – 15 : Exports of Rock Phosphate (By Countries)

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**712**	**5031**	**248**	**5810**
Nigeria	123	1410	50	2399
Nepal	503	1555	6	1609
USA	10	1298	50	698
UAE	-	-	56	405
South Africa	67	332	11	188
Indonesia	-	-	25	173
Bangladesh	-	-	2	67
Canada	++	2	1	65
UK	-	-	2	65
Egypt	-	-	27	62
Other countries	9	434	18	79

Table – 16 : Exports of Phosphorus (Elemental) (By Countries)

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**337**	**80004**	**429**	**116081**
USA	161	31514	144	31154
South Africa	27	9639	36	14479
Iran	26	10609	31	13680
Indonesia	23	5636	29	9478
Korea, Rep. of	10	3907	23	9348
Egypt	14	3198	28	7173
Brazil	-	-	20	6110
Philippines	16	4288	17	5134
Sweden	-	-	14	4103
Canada	-	-	14	3542
Other countries	60	11213	73	11880

Table – 17 : Exports of Phosphatic Fertilizers (By Countries)

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1205**	**30469**	**827**	**10271**
Kenya	-	-	504	4998
Saudi Arabia	-	-	300	3123
Germany	-	-	2	1316
Ecuador	2	143	++	267
Oman	30	293	20	155
USA	++	6	++	150
Nepal	66	910	++	139
Malaysia	557	20395	1	121
Korea Rep. of	-	-	++	2
Other countries	550	8722	-	-

Table – 18 : Exports of Phosphoric Acid (By Countries)

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**6508**	**281168**	**18674**	**416685**
Indonesia	5392	139037	18411	392011
Nepal	6	374	86	8660
Japan	-	-	7	3183
UAE	24	4512	23	2446
Mozambique	36	3201	20	2225
Chinese Taipei/ Taiwan	9	860	16	1698
Nigeria	1	22	40	1524
Sudan	-	-	10	1520
Sri Lanka	19	1449	10	1103
Bangladesh	5	249	13	883
Other countries	1016	131464	38	1432

Table – 19 : Imports of Rock Phosphate (By Countries)

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**5194203**	**32110281**	**9729592**	**83149873**
Jordan	2401648	15992302	4715511	43171872
Morocco	622658	4024469	1326165	12090739
Egypt	872185	4075579	1149317	7494789
Togo	437906	3202460	491397	5234650
Peru	22	101	346574	2574712
Vietnam	310183	1309815	477112	2571982
Israel	303448	2011248	189319	1794836
USA	++	26	188449	1696692
Algeria	35364	202404	143754	1256321
China	145	2796	98828	868442
Other countries	210644	1289081	603166	4394838

Table – 20 : Imports of Phosphorus(Elemental) (By Countries)

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**19949**	**2685267**	**22630**	**3509486**
China	7932	1117177	11111	1845868
Vietnam	11967	1559588	8999	1291434
Italy	-	-	230	39249
Netherlands	-	-	249	37762
France	-	-	269	36871
Germany	-	-	225	36043
Malaysia	-	-	192	25509
Other countries	50	8501	1355	196750

Table – 21 : Imports of Phosphoric Acid (By Countries)

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**2008376**	**63786633**	**2324532**	**99320356**
Morocco	860313	24855382	1084630	43982039
Senegal	212676	7778297	392742	17091452
USA	235231	8335642	323771	14913046
South Africa	353897	10527759	208469	10048734
Tunisia	227292	7966524	98371	4445115
Israel	31322	1108442	66330	3484547
Indonesia	-	-	46929	1349019
Malaysia	549	26320	34632	975317
Ghana	-	-	14957	805251
China	9173	404022	12074	572800
Other countries	77923	2784245	41627	1653036

Table – 22 : Imports of Phosphoric Fertilizers (By Countries)

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**82582**	**1553711**	**110644**	**2902686**
China	79654	1454832	109704	2886314
Netherlands	880	10850	720	9352
UAE	1977	81410	208	5371
Italy	46	6300	4	1057
Australia	1	28	3	334
USA	-	-	5	258
Other countries	24	291	-	-

FUTURE OUTLOOK

There is no substitute for phosphorus in agriculture. The country is deficient in all fertilizer minerals. The reserves of chemical and fertilizer grades apatite and rock phosphate in India are very limited. Therefore, detailed exploration is necessary for conversion of remaining resources into reserves. Secondly, the search for apatite and rock posphate may have to be itensified in Andhra Pradesh, Rajasthan, Madhya Pradesh, Jharkhand, Tamil Nadu, Meghalaya, Gujarat, Uttar Pradesh, Uttarakhand, West Bengal, etc. Till the domestic resources of these two minerals are improved, the country has no alternative but to depend on their imports.Concentrated effort should be made by making consortium of public private companies to acquire assets abroad specifically in countries like Uzbekistan, Jordan, etc. Strengthening ties with mineral rich countries and provinces with functional and specific MoUs and utilisation of IMG mechanism to align domestic stakeholders with MoUs is required. Only about 21% requirement of raw material for phosphate fertilizer production is met through indigenous sources. The remaining requirement is met through import in the form of rock phosphate, phosphoric acid and direct fertilizers. Private sector participation in rock phosphate mining needs to be promoted in order to make available the above two minerals to reduce import dependence for promotion of fertilizers for agricultural sector.

As per the Report of the Working Group for 12th Plan period (2012-17), the apparent demand of apatite and rock phosphate was 7.23 million tonnes in 2009-10. The apparent consumption of apatite and rock phosphate is estimated at 8.59 million tonnes by 2011-12 and at 13.22 million tonnes by 2016-17 at 9% growth rate. Demand of phosphatic fetilizer will continue to rise due to growth in population and corresponding increase in food requirements.

In India, most of the existing phosphatic fertilizer and phosphoric acid plants have been designed for high grade imported rock phosphate, mainly from Morocco and Jordan. The Indian deposits are of low grade. Therefore, the fertilizer and phosphoric acid plants that may be set up as replacement of the existing plants will have to be designed to accept indigenous ores as a feed. Beneficiation of domestic low grade ores would be a step in the right direction and should be promoted indigenously.

The Working Group has recommended that: (i) Mining of rock phosphate may be opened for private sector, (ii) Cluster mining may be resorted to reduce the mining loss and degradation of environment to the extent possible, (iii) Environmental issues may be sought amicably to start mining operations in Aravali areas, (iv) Technology for extraction of low grade ores may be adopted and (v) Further exploration is needed in various parts of the country.