

14 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. Fluor-apatite ($\text{Ca}_5(\text{PO}_4)_3\text{F}$) 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.

RESOURCES

Apatite

The total resources of apatite as per UNFC system as on 1.4.2005 are placed at 26.9 million tonnes. Out of these resources, the reserves are only 6.2 million tonnes and 20.7 million tonnes are remaining resources. Out of the total resources, the bulk (61%) are located in West Bengal followed by Jharkhand (27%) and Meghalaya (5%). The remaining 7% resources are available in Rajasthan, Andhra Pradesh, Gujarat and Tamil Nadu. Gradewise, soil reclamation grade accounts for 44% followed by beneficiable grade

(27%), low and non-beneficiable grade (23%) and blendable, others and not-known grades (5%). 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 1.4.2005 are placed at 305.3 million tonnes. Out of these resources, the reserves are only 52.7 million tonnes. There are 252.6 million tonnes remaining resources. Out of total resources, 35% are in Jharkhand, 31% in Rajasthan, 17% in Madhya Pradesh, 9% in Uttar Pradesh and 8% in Uttarakhand. Gradewise, low grade account for 38%, followed by beneficiable (30%), soil reclamation (12%), blendable (9%), chemical fertilizer (7%) and unclassified and not-known grades (5%) (Table-2).

EXPLORATION & DEVELOPMENT

Details of exploration activities conducted by GSI and State DMG and RSMML during 2006-07 and 2007-08 are furnished in Table - 3.

PRODUCTION, STOCKS & PRICES

Apatite

The production of apatite at 6,691 tonnes during 2007-08 decreased by 29% as compared to that in the preceding 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 42% in 2007-08. The entire production of apatite was of grade 15-20% P_2O_5 (Tables - 4 to 6).

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**Table - 1: Reserves/Resources as on 1.4.2005 : Apatite
(By Grades/States)**

State/Grade	Reserves			Remaining resources					Total resources (A+B)
	Proved STD111	Probable STD122	Total (A)	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
All India : Total	6125946	19629	6145575	2281521	11481250	5938716	1017646	20719133	26864708
By Grades									
Chemical Fertilizer	-	19629	19629	30000	-	337541	-	367541	387170
Soil reclamation	1560699	-	1560699	2233500	6243000	1760000	-	10236500	11797199
Low/Non-beneficiable	-	-	-	3360	2363000	3130000	666646	6163006	6163006
Beneficiable	4565247	-	4565247	12477	1875250	521175	351000	2759902	7325149
Blendable	-	-	-	2184	-	-	-	2184	2184
Others	-	-	-	-	1000000	-	-	1000000	1000000
Not-known	-	-	-	-	-	190000	-	190000	190000
By States									
Andhra Pradesh	-	19629	19629	-	-	337541	-	337541	357170
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	6125946	-	6125946	120000	8845250	521175	666646	10153071	16279017

Figures rounded off.

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**Table - 2 : Reserves/Resources as on 1.4.2005 : Rock Phosphate
(By Grades/States)**

Grade/State	(In tonnes)											
	Reserves					Remaining resources					Total resources (A+B)	
	Proved STD111	Probable STD121	STD122	Total (A)	Feasibility STD211	Pre-feasibility STD221	STD222	Measured STD331	Indicated STD332	Inferred STD333		Total (B)
All India : Total	33090127	3892392	15740973	52723492	23798683	28974156	19118001	3036903	4428773	173228568	252585084	305308576
By Grades												
Chemical fertilizer	11741881	-	1399542	13141423	-	6900000	-	-	-	1081200	7981200	21122623
Blendable	6289368	1589807	6378133	14257308	-	-	13333	-	-	13942513	13955846	28213154
Soil reclamation	4921970	1763187	3835668	10520825	-	8374156	6878001	732800	900000	8178166	25063123	35583948
Beneficial	10136908	539398	4127630	14803936	23798683	13700000	12240000	2170000	2760000	21233615	75902298	90706234
Low grade	-	-	-	-	-	-	-	120770	-	115151074	115271844	115271844
Unclassified	-	-	-	-	-	-	-	-	768773	10067000	10835773	10835773
Not-known	-	-	-	-	-	-	-	-	-	3575000	3575000	3575000
By States												
Gujarat	-	-	-	-	-	-	-	-	-	314820	314820	314820
Jharkhand	-	-	-	-	-	-	-	-	-	107370000	107370000	107370000
Madhya Pradesh	7605864	1763187	9787162	19156213	3131683	13700000	5990814	-	2730000	5725000	31277497	50433710
Meghalaya	-	-	-	-	-	-	-	-	-	1311035	1311035	1311035
Rajasthan	22420760	1696307	1100855	25217922	20667000	15274156	13127187	276903	68773	21295240	70709259	95927181
Uttar Pradesh	-	432898	3118586	3551484	-	-	-	-	740000	21481960	22221960	25773444
Uttarakhand	3063503	-	1734370	4797873	-	-	-	2760000	890000	15730513	19380513	24178386

Figures rounded off.

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Table - 3 : Details of Exploration Activities for Rock Phosphate in 2006-07 and 2007-08

Agency/ State/District	Location	Mapping		Drilling		Sampling	Remarks Reserves/Resources estimated
		Scale	Area (sq km)	No. of boreholes	Meterage		
2006-07							
GSI							
Madhya Pradesh							
Sidhi	Baskadi Paniha area	-	-	-	-	-	A ferruginised chert breccia band which is at places phosphatic in nature was traced for about 3 km from Baskati to Paniha. Analytical results showed P ₂ O ₅ content varying from 7.5 to 13% in Paniha area and 2 to 6% in Baskati area. Investigation is continued.
DMG							
Rajasthan							
Banswara	N/v Lorda, Kushalgarh, etc.	1:50,000 1:10,000	150 10	-	-	60	Deposits of dolomite with Phosphatic stromatolite were identified.
RSMML							
Rajasthan							
Udaipur	A Extn & G - Block Jhamarkotra mine	1:1,000	124.84	-	-	-	Work in progress
2007-08							
GSI							
Madhya Pradesh							
Sidhi	Baskati-Paniha area	-	-	-	-	-	In Paniha area, length of band ranges from 25 to 400 m and in thickness from <1 to 15 m. In Baskati area, the length of lensoid band demarcated is about 300 m.
Rajasthan							
Pali	Khivandi area	-	-	-	-	-	Grab samples indicated presence of phosphorite.
Uttarakhand							
Tehri-Garhwal	Dhalwala-Singtali area	-	-	-	-	-	Mineralisation occurs as discontinuous small lenticular bodies. The analytical results showed P ₂ O ₅ content ranging from 3.2 to 11.35%.

Table - 4 : Producers of Apatite, 2007-08

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, 13, Nelile Sengupta Sarani, Lindsay Street, II-Floor, Kolkata-700 087, West Bengal.	West Bengal	Purulia

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**Table – 5 : Production of Apatite, 2005-06 to 2007-08
(By States)**

(Quantity in tonnes; value in Rs. '000)

State	2005-06		2006-07		2007-08 (p)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	9053	17942	9464	18359	6691	12799
Andhra Pradesh	3899	8149	3720	8307	3853	7832
West Bengal	5154	9793	5744	10052	2838	4967

**Table – 6 : Production of Apatite, 2006-07 and 2007-08
(By Sectors/States/Districts/Grade)**

(Quantity in tonnes; value in Rs. '000)

State/District	2006-07			2007-08 (p)		
	No. of mines	Quantity 15-20% P ₂ O ₅	Value	No. of mines	Quantity 15-20% P ₂ O ₅	Value
India	2	9464	18359	2	6691	12799
Public sector	1	5744	10052	1	2838	4967
Private sector	1	3720	8307	1	3853	7832
Andhra Pradesh						
Visakhapatnam	1	3720	8307	1	3853	7832
West Bengal						
Purulia	1	5744	10052	1	2838	4967

The mine-head stocks at the beginning of 2007-08 was 15,032 tonnes as against 13,055 tonnes at the end of the year (Table - 7).

The average daily labour employed in apatite mines during 2007-08 was 178 as against 233 in the previous year.

Phosphorite/Rock phosphate

The total production of phosphorite/rock phosphate at 1.86 million tonnes in 2007-08 increased by about 17% 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 4 reporting mines in 2007-08. Rajasthan continued to be the principal

producing State, contributing 94% of the total production followed by Madhya Pradesh with 6%. About 43% of the total production of phosphorite/rock phosphate was of grade 30-35% P₂O₅, 4% of grade 25-30% P₂O₅ and 53% of grade 15-20% P₂O₅ (Tables - 8 to 10).

The mine-head stocks at the end of the year 2007-08 was 527 thousand tonnes as compared to 1,111 thousand tonnes in the beginning of the year (Table-11).

The average daily labour employed in phosphorite mines in 2007-08 was 1,431 as against 1,302 in the previous year. Domestic prices of apatite and phosphorite/rock phosphate are furnished in Table - 12.

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Table - 7 : Mine-head Stocks of Apatite, 2007-08(p)
(By States/Grades)

(In tonnes)

State	At the beginning of the year	At the end of the year
	15-20% P ₂ O ₅	15-20% P ₂ O ₅
India	15032	13055
Andhra Pradesh	570	1013
West Bengal	14462	12042

Table - 8 : Producers of Phosphorite/Rock phosphate, 2007-08

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
Madhya Pradesh State Mining Corp. Ltd, E-5/14, Arera Colony, Bhopal-462 016, Madhya Pradesh.	Madhya Pradesh	Chhattarpur Jhabua

Table - 9 : Production of Phosphorite/Rock Phosphate, 2005-06 to 2007-08
(By States)

(Quantity in tonnes ; value in Rs.'000)

State	2005-06		2006-07		2007-08 (p)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	2049277	2942798	1586843	2184561	1859851	3090409
Madhya Pradesh	178117	64321	193213	80995	119500	55370
Rajasthan	1871160	2878477	1393630	2103566	1740351	3035039

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**Table - 10 : Production of Phosphorite/Rock Phosphate, 2006-07 & 2007-08
(By Sectors/States/Districts/Grades)**

(Quantity in tonnes; value in Rs.'000)

State/ District	No. of mines	2006-07						2007-08(p)						
		Grade content P ₂ O ₅				Total		Grade content P ₂ O ₅				Total		
		30 - 35%	25 - 30%	20 - 25%	15 - 20%	Qty.	Value	30 - 35%	25 - 30%	20 - 25%	15 - 20%	Qty.	Value	
India	5	304991	26806	10938	1244108	1586843	2184561	4	795866	73670	-	990315	1859851	3090409
Public sector	5	304991	26806	10938	1244108	1586843	2184561	4	795866	73670	-	990315	1859851	3090409
Madhya Pradesh	3	-	26806	10938	155469	193213	80995	3	-	73670	-	45830	119500	55370
Chhatarpur	1	-	-	-	38549	38549	14456	1	-	26291	-	1869	28160	13330
Jhabua	1	-	5022	10938	79892	95852	47315	1	-	-	-	36689	36689	17427
Sagar	1	-	21784	-	37028	58812	19224	1	-	47379	-	7272	54651	24613
Rajasthan	2	304991	-	-	1088639	1393630	2103566	1	795866	-	-	944485	1740351	3035039
Udaipur	2	304991	-	-	1088639	1393630	2103566	1	795866	-	-	944485	1740351	3035039

**Table - 11 : Mine-head Stocks of Phosphorite/Rock phosphate, 2007-08 (p)
(By States/Grades)**

(In tonnes)

State	At the beginning of the year					At the end of the year				
	Grade content P ₂ O ₅					Grade content P ₂ O ₅				
	30-35%	25-30%	20-25%	15-20%	Total	30-35%	25-30%	20-25%	15-20%	Total
India	318086	3525	9241	780048	1110900	66945	1	475	459641	527062
Madhya Pradesh	-	3525	8766	84634	96925	-	1	-	4824	4825
Rajasthan	318086	-	475	695414	1013975	66945	-	475	454817	522237

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**Table - 12 : Prices of Apatite and Phosphorite/Rock phosphate, 2005-06 to 2007-08
(Domestic Markets)**

(In Rs. per tonne)

Grade	Market	2005-06	2006-07	2007-08 (p)
Apatite				
r.o.m. (Unsize)	Ex-factory S.Kota (Andhra Pradesh)	2300	2300	2300
100 mesh powder	Ex-factory S.Kota (Andhra Pradesh)	2800	2800	2800
r.o.m. 14-15% P ₂ O ₅	Ex-Beldih (West Bengal)	1600	1600	1600
r.o.m. 18-20% P ₂ O ₅	Ex-Beldih (West Bengal)	1900	1900	1900
Phosphorite/Rock phosphate				
1st 'A' Grade r.o.m. 25-27% P ₂ O ₅	Ex-Meghnagar (Madhya Pradesh)	823	860	-
1st 'B',Grade r.o.m. 22-24% P ₂ O ₅	Ex-Meghnagar (Madhya Pradesh)	660	697	-
Low Grade r.o.m. 18-20% P ₂ O ₅	Ex-Meghnagar (Madhya Pradesh)	300	365	481
1st 'A' Grade r.o.m. + 29% P ₂ O ₅	Ex-Mine Hirapur (Madhya Pradesh)	617	642	1047
1st 'B' Grade r.o.m. 27-29% P ₂ O ₅	Ex-Mine Hirapur (Madhya Pradesh)	543	568	-
1st 'C' Grade r.o.m. 25-27% P ₂ O ₅	Ex-Mine Hirapur (Madhya Pradesh)	414	439	623
Powdered rock phosphate 18-20% P ₂ O ₅	Ex-factory Rangadih (West Bengal)	1900	NA	-
HGO	Ex-mine Jhamarkotra (Rajasthan)	2085	2198	2637
Cr. RP DAP 34%	Ex-mine Jhamarkotra (Rajasthan)	2403	2576	2741
34% Beneficiated	Ex-mine Jhamarkotra (Rajasthan)	2223	2239	3126
Rajphos	Ex-mine Jhamarkotra (Rajasthan)	569	254	1111
LGO 22-24%	Ex-mine Jhamarkotra (Rajasthan)	1180	1306	-

MINING AND MARKETING

Apatite mining is confined to Visakhapatnam district, Andhra Pradesh and in Purulia district, West Bengal. In apatite mine of Andhra Phosphates 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, jack hammer drills, air compressor, tippers, etc. on single shift basis to develop the mine with a targeted production of about 15,000 tonnes of in-situ ore per annum. Half of the low

grade ore (10-12% P₂O₅) is blended with available high grade ore (>22% P₂O₅) manually to produce additional quantity of saleable ore (18-20% P₂O₅). The desired grade (18-20% P₂O₅) 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 was reported from 4 mines in public sector. Of these, three were in Madhya Pradesh at Hirapur in Chhattarpur and Sagar districts and Khatamba in Jhabua district; and one in Rajasthan in Udaipur district. Maton mine of HZL remained closed. Mines of Rajasthan State Mines & Minerals Ltd (RSMML) faced closure by Pollution Control Board.

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 soft mineral mined (6 mm) is sold as such. The lumpy ore is crushed by mechanised crushers. Four jaw crushers (30 hp, 40 hp and two 20 hp each) and a grinding unit (50 hp) have been set up at

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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 crushing plant, situated at a distance of 6 km on Hirapur-Damoh Road. There are two jaw crushers, 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. The crushed material is despatched by trucks.

Maton mine of HZL, Kanpur, Badgaon, Kharbaria-ka-Guda, Dakankotra and Eklingpur mines, of RSMML (earlier of RSMDC), were opencast and mechanised. Jhamarkota area extends over a length of 16 km, has average width of phosphate bed of about 15 m and average inclination of about 55° from the vertical. The height of the bench is maintained up to 10 m. Shovels and dumpers are used for removing ore and overburden. Jhamarkotra is probably the largest opencast mine in India outside the iron ore, bauxite and coal sector. The mine has an annual rock handling capacity of about 197 million tonnes. In Jhamarkotra, the problem of groundwater had affected the mining operations. Therefore, an effective dewatering scheme was implemented. The working levels are kept dry. The pumping of groundwater is continued through tube wells constructed on periphery of the pit limit. The beneficiation plant of RSMML at Jhamarkotra has 9 lakh tpy capacity to treat run-of-mine ore, analysing 18% 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.

RSMML produces the following products:

- (1) **31.5% P_2O_5 crushed -1/2" size high-grade rock phosphate** (for SSP manufacturing units).
- (2) **34% P_2O_5 crushed -1/2" size high-grade rock phosphate** (for DAP/nitrophosphate manufacturing units).

- (3) **31.54% P_2O_5 beneficiated rock phosphate concentrate** (for SSP & dicalcium phosphate (DCP) manufacturing units, etc.)
- (4) **18-20% P_2O_5 ground low-grade beneficiated rock phosphate (RAJPHOS)** (as fertilizer for direct application to acidic soils).
- (5) **30-31% P_2O_5 + 1/2" size high grade rock phosphate (Gitti)** (for elemental phosphorus manufacturing units).

RSMML could not market its high grade rock phosphate till 2005-06 because of its high R_2O_3 content which could neither be blended nor beneficiated. However, during 2007-08, approximately 80,000 tonnes of this grade of rock phosphate were sold to DAP manufacturers like GSFC, GNFC and M/s SOLARIS.

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 31.1.2008 was 56.59 lakh tonnes whereas estimated production in 2007-08 was 49.14 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 Fertilizer Limited at Chennai (Tamil Nadu); HCL at Khetri (Rajasthan); and Paradeep Phosphates Ltd. (PPL) at Paradeep (Orissa). 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 Tuticorin (Tamil Nadu); Mangalore Chemicals and Fertilizer Ltd at Mangalore (Karnataka); Gujarat Narmada Fertilizer Corporation (GNFC) at Bharuch

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(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 (Orissa); and Godawari Fertilizers & Chemicals Ltd (GFCL) at Kakinada (Andhra Pradesh). The only plant in the co-operative sector is of Indian Farmers Fertilizer Co-operative Ltd (IFFCO) at Kandla (Gujarat).

Rajasthan State Mines & Minerals Ltd (RSMML) and Rashtriya Chemicals & Fertilizers Ltd (RCF) have signed an MoU for setting up at Kapasan in Chittorgarh district, Rajasthan, a new Joint Venture company namely Rajasthan Rashtriya Chemicals and Fertilizers Ltd for producing DAP. Rock phosphate will be supplied by RSMML and ammonia will be supplied by RCFL. Dialogue is going on with HZL for supply of H_2SO_4 .

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 Jordan. 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.

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 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) have set up a joint venture company named, Industries Chimiques du Senegal (ICS) in Senegal. The company has capacity to produce 6.6 lakh tpy phosphoric acid and finished phosphate fertilizers in its Senegalese plants. A major portion of phosphoric acid produced is being utilised by IFFCO through long-term buy back arrangement. Due to financial difficulties, the performance of the company has been adversely affected. The government is making efforts to restructure the company to improve its performance.

(2) 'Indo Jordan Chemicals Company Limited' is a joint venture between SPIC, Jordan Phosphates Mines Company Ltd (JPMC) and Arab Investment Company (AIC). Its 2.24 lakh tpy phosphoric acid plant was commissioned in May 1997 in Jordan. The phosphoric acid produced by this venture is imported by SPIC and few other fertilizer units.

(3) A Joint Venture IMACID (Indo Maroc Phosphore SA) between Office Cherifien Des Phosphates (OCP), Morocco and Chambal Fertilizers & Chemicals Ltd (CFCL) to produce 3.30 lakh tonnes phosphoric acid per annum was commissioned in October 1999. After completion of first phase of revamp/debottlenecking project during 2004, the capacity had been increased to 3.65 lakh tonnes per annum. Subsequently in 2005, Tata Chemicals Ltd India, became the third equal joint venture partner in IMACID.

Overseas Joint Ventures Under Implementation/Consideration

(1) IFFCO and EI Nasr Mining Co. (ENMC) have formed a Joint Venture Company the 'Indo Egyptian Fertilizers Company' on 15 November 2005 for setting up a phosphoric acid plant in Egypt with 0.5 million tpy P_2O_5 capacity. ENMC which is the largest rock phosphate mining company of Egypt, will supply rock phosphate while IFFCO will buyback the entire phosphoric acid production. The plant is expected to achieve commercial production by 2010.

(2) 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 phosphoric acid. The plant is expected to be commissioned latest by December, 2009 and will have 3.60 lakh tpy capacity. Full production of the joint venture will be sold to both the Indian parties. An MoU was signed in October, 2005 in this regard.

(3) 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 P₂O₅.

ENVIRONMENTAL CONCERNS

Phospho-gypsum, is formed as a by-product during manufacturing of phosphoric acid. It contains about 1% P₂O₅, 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 P₂O₅ 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, mainly 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 screen, incendiary bombs, and many other products.

SPECIFICATIONS

Elemental Phosphorus and Phosphoric acid

BIS (IS:11224-1985, reaffirmed 2003) 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 ₂ O ₅) % by mass (min)	30.0	32.0
2.	Silica (as SiO ₂) % by mass (max)	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 ₂ O ₃ and Fe ₂ O 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 P₂O₅ content in rock phosphate for manufacturing single superphosphate should be minimum 31 percent. Silica up to 8% can be tolerated. Iron and alumina; i.e., R₂O₃ should not be more than 3.5 percent. Higher R₂O₃ may tend reversion of available P₂O₅ (water soluble P₂O₅). 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% P₂O₅ 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 ₂ O 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 ₂ O	2
6.	Grade of rock phosphate powder citrate soluble fraction	16% P ₂ O ₅
7.	Iron as Fe ₂ O ₃	5%
8.	CaO to P ₂ O 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 2007-08 was about 3.88 million tonnes against 4.09 million tonnes in 2006-07, decreasing about 5%. Fertilizer industry alone accounted for about 75% consumption followed by chemicals (25%). The consumption in glass, sugar and iron & steel industry was meagre (Table - 13).

Table - 13 : Reported Consumption of Apatite and Rock Phosphate,* 2005-06 to 2007-08 (By Industries)

(In tonnes)			
Industry	2005-06(R)	2006-07	2007-08(p)
All Industries	4081700	4090200	3885000
Chemical	958000(9)	964700(9)	968000(9)
Fertilizer	3123300(29)	3124900(29)	2916400(29)
Others (glass, sugar, iron & steel)	400 (3)	600 (3)	600 (3)

Note: Figures rounded off. Data collected on non-statutory basis. Figures in parentheses denote the number of units in organised sector reporting consumption.

* Besides rock phosphate, imported phosphoric acid is also consumed for manufacturing phosphatic fertilizers. Apatite and rock phosphate in ground forms are also used directly in acidic soil. Data related only to those units who have actually responded to a questionnaire sent by IBM. Consumption for organised sector, excluding small scale units. Consumption may not be exhaustive.

POLICY

Imports of natural calcium phosphates and natural aluminium-calcium phosphates and phosphatic chalk are allowed freely as per the Foreign Trade Policy 2004-2009. 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 P₂O₅. 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.

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During 2008-09, about 90% requirement of phosphatic fertilizers was met through first two options.

WORLD REVIEW

The world reserve base of phosphate rock is about 50 billion tonnes, located mainly in Morocco (42%), China (26%), United States of America (7%), South Africa (5%), Jordan (3%), Australia and Russia (2% each). The world resources are immense. Large deposits have also been identified on the continental shelves and on seamounts in the Atlantic Ocean and Pacific Ocean but cannot be mined economically with present technology (Table - 14).

Table -14 : World Resources of Rock Phosphate (By Principal Countries)

(In '000 tonnes)	
Country	Reserve base
World : Total (rounded)	50000000
Australia	1200000
Brazil	370000
Canada	200000
China	13000000
Egypt	760000
Israel	800000
Jordan	1700000
Morocco and Western Sahara	21000000
Russia	1000000
Senegal	160000
South Africa	2500000
Syria	800000
Togo	60000
Tunisia	600000
USA	3400000
Other countries	2200000

Source: Mineral Commodity Summaries, 2008.

The world production of phosphate rock increased to 159 million tonnes in 2007 from 151 million tonnes in 2006. China (29%), USA (19%), Morocco (17%), Russia (7%) and Tunisia (5%) were the major producers (Table - 15). Almost 90% of the rock phosphate production goes into chemical fertilizer products.

Table - 15 : World Production of Phosphate Rock (By Principal Countries)

(In '000 tonnes)			
Country	2005	2006	2007
World : Total	154000	151000	159000
Australia	1936	2083	2131
Brazil	5631	5932	6185
China	30445	38960	45417
Egypt	3270	2177	2504
Israel	3236	2949	3069
Jordan	6375	5805	5552
Morocco	28788	27097	27638
Russia	11317	10813	10964
South Africa	2577	2629	2556
Syria	3500	3664	3678
Tunisia	8220	7838	8002
USA	36300	30100e	29700
Other countries	12405	10953	11604

Source: World Mineral Production, 2003-2007.

China

China is the world's largest producer, contributing about 29% of world production. The major mining centres are in Yunnan, Guizhou and Hubai provinces.

Egypt

IFFCO (a major Indian phosphate fertilizer producer), announced a new joint venture project to build phosphoric acid unit in Egypt using local resources in conjunction with El Nasr Mining Co. The phosphoric acid plant is expected to go on stream by 2010 and would require 1.6 million tonnes production additionally.

Jordan

Production of phosphate rock at Jordan Phosphate Mining Company Limited (JPMC) was increased by 2.5%.

Morocco

Morocco contains the largest phosphate rock reserve in the world. Mining by the state-owned operating company, Office Cherifien des Phosphates (OCP) attained new record level of 28.8 million tonnes. OCP was to build a new phosphoric acid unit at Jorf-Lasfar scheduled for completion in early 2007, which had to feed the phosphoric acid requirement of Fauji of Pakistan's DAP unit. With Bunge of Brazil, OCP has made a phosphate rock and phosphate fertilizer supply agreement. In early 2005, OCP announced that the Tata Chemicals (Indian company) was to buy an equal share of existing joint venture

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phosphoric acid unit at Jorf Lasfar, established some years ago with Zuari/Chambal group of India.

Peru

The Government awarded the exploration rights of Bayovar phosphate resources to CVRD of Brazil which is expected to develop a 3.3 million tpy mine and processing plant, 1000 km north of Lima near the coast. One million tpy production is envisaged by 2010 and full capacity by 2014.

Russia

In Russia, two major producers of rock phosphate; are Phosagro and Eurochem. High-grade apatite rock production came from Kola, Kovdor and Kingisepp mines. Fertilizer producer JSC Acron is developing a new 6 million tpy ore mine at Oleny Ruchei reserve, equivalent to 1.5-2 million tpy of concentrate. The mine is likely to go into production with 300,000 tpy concentrate by 2011-12.

South Africa

Foskor (a major phosphoric acid exporter) of South Africa entered into agreement with Coromandel Fertilizers Ltd (CFL) of India by which CFL will initially invest Rs. 300 million to acquire 2.5% share in Foskor and which can later be increased to 16.5% under an option agreement.

USA

United States is now second in the world in terms of phosphate rock production accounting 19% of global output.

FOREIGN TRADE

Exports

In 2007-08, exports of rock phosphate increased to 3,182 tonnes from 1,181 tonnes in the previous year. Similarly, in 2007-08, exports of elemental phosphorus also increased to 603 tonnes from 415 tonnes, phosphatic fertilizers to 9,895 tonnes from 7,420 tonnes and phosphoric acid to 59,358 tonnes from 10,234 tonnes in the previous year. Rock phosphate was exported mainly to Malaysia (58%), Oman (19%) and Kenya (9%). Elemental phosphorus was exported mainly to Hong Kong (33%), USA (24%) and Rep. of Korea (8%). In 2007-08, exports of phosphatic fertilizers were mainly to Nepal (88%) and UAE (8%) while those of phosphoric acid were to Bangladesh (66%), Turkey (17%) and Indonesia (16%) (Tables - 16 to 19).

Imports

Imports of rock phosphate increased to 5.02 million tonnes in 2007-08 from 5.01 million tonnes in the previous year. Imports were mainly from Jordan (50%), Morocco (20%), Algeria (11%) and Togo (6%). Imports of elemental phosphorus increased to 16,672 tonnes from 12,316 tonnes in the previous year. More than 90% imports of elemental phosphorus were from China. In 2007-08, only 184 tonnes of phosphatic fertilizers was imported mostly from Jordan and Italy. Imports of phosphoric acid decreased to 2.05 million tonnes in 2007-08 from 2.23 million tonnes in the previous year. Imports were mainly from Morocco (43%), South Africa (21%), Senegal (11%), Tunisia (10%), USA (8%) and Jordan (5%) (Tables - 20 to 23).

**Table - 16 : Exports of Rock Phosphate
(By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	1181	17053	3182	13504
Malaysia	-	-	1837	7515
Oman	240	11226	600	2614
Kenya	154	798	301	1396
Nigeria	78	1256	52	516
Japan	21	349	21	438
USA	4	137	244	267
France	136	799	++	10
Hong Kong	100	699	-	-
UAE	50	999	-	-
UK	75	338	-	-
Other countries	323	452	127	748

**Table - 17 : Exports of Phosphorus (Elemental)
(By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	415	64284	603	60601
USA	150	23577	142	20256
Hong Kong	-	-	200	17856
Philippines	33	6131	35	6021
Egypt	86	13923	30	3949
Sri Lanka	16	4136	10	2308
Peru	-	-	15	2017
Belgium	-	-	10	1910
Korea, Rep. of	12	2199	50	1516
Indonesia	52	8548	-	-
South Africa	35	2765	-	-
Other countries	31	3005	111	4768

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**Table - 18 : Exports of Phosphatic Fertilizers
(By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	7420	53613	9895	150401
Nepal	5648	42976	8733	138728
UAE	1542	6899	788	4747
Sri Lanka	129	1867	309	2613
Korea, Rep. of	-	-	5	1262
New Zealand	-	-	5	931
Japan	10	411	40	578
Spain	-	-	10	574
Saudi Arabia	-	-	2	573
Canada	-	-	3	354
Botswana	86	1372	-	-
Other countries	5	88	++	41

**Table - 19 : Exports of Phosphoric Acid
(By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	10234	107692	59358	820332
Bangladesh	10041	101318	39399	463527
Turkey	5	408	9805	220183
Indonesia	-	-	9287	110541
Italy	2	97	209	7962
UAE	1	66	327	6927
Thailand	20	1074	59	2878
Czech Republic	-	-	104	2493
Spain	-	-	52	1866
Fiji	-	-	35	1274
Australia	41	1927	++	28
Other countries	124	2802	81	2653

**Table - 20 : Imports of Rock Phosphate
(By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	5009214	16136352	5017655	18532414
Jordan	2168102	7412172	2484339	9658111
Morocco	1208526	3310663	997078	2717822
Algeria	368555	1121374	557908	2054672
Togo	539967	2142187	301345	1364360
Egypt	539375	1573039	262121	929037
China	-	-	149878	844813
Vietnam	-	-	130068	496112
Japan	-	-	62550	184244
Australia	44632	176635	-	-
Israel	119757	336822	-	-
Other countries	20300	63460	72368	283243

**Table - 21 : Imports of Phosphorus (Elemental)
(By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	12316	1069411	16672	1451713
China	10763	922048	15158	1311893
Vietnam	953	80969	1047	91993
Netherlands	599	64693	281	25108
Belgium	-	-	131	12363
Japan	1	1641	2	5007
Mexico	-	-	++	41
Germany	-	-	++	8
Italy	++	45	-	-
USA	++	15	-	-
Unspecified	-	-	53	5300

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**Table - 22 : Imports of Phosphoric Acid
(By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	2228835	44048269	2045995	40866828
Morocco	979401	17730115	889030	15178961
South Africa	401126	8427273	421824	9206600
Senegal	122003	2508109	224746	5157226
Tunisia	264586	5479038	209724	4544075
USA	194332	4120457	158992	3591564
Jordan	175913	3732127	106831	2448685
Saudi Arabia	6212	129487	14699	200476
Korea, Rep. of	15266	337031	6326	165657
Israel	52084	1197696	-	-
Lebanon	12011	247941	-	-
Other countries	5901	138995	13823	373584

**Table - 23 : Imports of Phosphatic Fertilizers
(By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	37	7402	184	5994
Italy	15	1911	46	5381
Jordan	-	-	138	613
China	20	5214	-	-
Indonesia	++	5	-	-
Spain	2	249	-	-
Thailand	++	23	-	-

FUTURE OUTLOOK

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. Till the domestic resources of these two minerals are improved, the country has no alternative but to depend on their imports.

Beneficiation of domestic low-grade ores would be a proper step in this regard to counter domestic shortages.

Acquisition of equities in foreign fertilizer companies and setting up of joint ventures abroad with production buyback/sharing agreements is a recent development in right direction which has to be encouraged.