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 $Ca_5(PO_4)_3F$ 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 rock also contains significant amount of uranium. Phosphate rocks are considered as the most important secondary resource of uranium.

RESOURCES

Apatite

The total resources of apatite as per UNFC system as on 1.4.2010 are placed at 24.2 million tonnes. Out of these resources, the reserves are only 2.1 million tonnes and 22.1 million tonnes are remaining resources. Out of the total resources, the bulk (56.8%) are located in West Bengal followed by Jharkhand (30%) and Meghalaya (5.4%). The remaining 7.8% 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 resources, the reserves are only 34.8 million tonnes. There are 261.5 million tonnes remaining resources. Out of the total resources, 36% are in Jharkhand, 29.7% in Rajasthan, 16.7% in Madhya Pradesh, 8.7% in Uttar Pradesh and 8.2% in Uttarakhand. The remaining meagre resources are located in Gujarat and Meghalaya. Gradewise, low grade account for 38.9%, followed by beneficiable (29%), soil reclamation (11.7%), blendable (9.6%), chemical fertilizer (5.9%) and unclassified and not-known grades (4.9%) (Table-2).

EXPLORATION & DEVELOPMENT

Exploration activities for apatite and rock phosphate carried out by the Geological Survey of India; DMM, West Bengal and RSMML, Rajasthan during 2009-10 are furnished in Table - 3.

PRODUCTION, STOCKS & PRICES

Apatite

The production of apatite at 5,398 tonnes during 2009-10 decreased by 16% 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 39% in 2009-10. The entire production of apatite was of grade 15-20% P_2O_5 (Tables - 4 to 6).

The mine-head stock at the beginning of 2009-10 was 11,117 tonnes as against 9,378 tonnes at the end of the year (Table - 7).

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

(In tonnes)

State/Grade	Reserves			Remaining resources						Total Resources
	Proved STD111	Probable STD122	Total (A)	Pre-feasibility STD222	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	(A+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
Unclassfied	–	–	–	–	–	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 as on 1.4.2010 (P) : Rock Phosphate
(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 Rock Phosphate during 2009-10

Agency/ State/District	Location	Mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	No. of boreholes	Meterage		Reserves/Resources estimated
GSI							
Chhattisgarh Durg	Kharenadih-Bhargao Sambalpur area	–	–	–	–	NA	Channel samples from bank of Kharkharanala showed 4.5% and certain zones showed P_2O_5 ranging from 18 to 19%. Area of 30 sq. km. extending on both side of canal has been taken up & Phosphatic clay band samples collected by putting auger drill up to a depth of 30m.
Gujarat							
Dahod	Bombela-Tanda area	–	–	–	–	252	Reconnaissance (G-4) stage investigation completed, 184 samples showed positive results.
Jharkhand & West Bengal							
Dhanbad & Purulia	Cholwari & adjoin-ing areas	–	–	–	–	–	Samples of apatite-magnetite rocks in Cholwari area showed 7.46% P_2O_5 whereas channel samples showed 6.77% P_2O_5. In Bhelaidih block apatite-magnetite body was established up to a depth of 30m and P_2O_5 values ranges between 22.13 to 23.67%.
RSMML							
Rajasthan							
Banswara	NV/Kaya, Dhol ki Pati	1:50,000	150.0	–	–	–	Resources will be estimated after receipt of complete chemical analysis results.
	Jhar, Khuntana	1:10,000	1.5	–	–	–	
	Ram ka Munna, etc.	1:2,000	1.5	–	–	–	
Udaipur	A Extn & G - Block Jhamarkotra mine (25 km SE from Udaipur)	–	–	–	–	–	Strike length 2.0 km, folded & undulating ore beds dipping sub-vertical to 30 deg. towards centre of Jhamarkotra basin. Total resources at 115,826 tonnes were estimated during the year. Ongoing exploratory mining is expected to continue till March 2011.
DMM, West Bengal							
Purulia	Kutni village, PS Boro	1:500 –	9102 sq. m.	–	–	25	Resources will be estimated after completion of drilling.

The average daily labour strength employed in apatite mines during 2009-10 was 194 as against 272 in the previous year.

Phosphorite/Rock Phosphate

The total production of phosphorite/rock phosphate at 1,547 thousand tonnes in 2009-10 decreased by about 14% as compared to that in the previous year due to less lifting of ore at crushing plant of Jhamarkotra mine of RSMML, Rajasthan.

There were 8 reporting mines in 2009-10. Rajasthan continued to be the principal producing state, contributing 88% of the total production followed by Madhya Pradesh with 12%.

About 39% of the total production of phosphorite/rock phosphate was of grade 30-35% P_2O_5, 2% of grade 25-30% P_2O_5, 3% of grade 20-25% P_2O_5 and 56% of grade 15-20% P_2O_5 (Tables - 8 to 10).

The mine-head stocks at the end of the year 2009-10 was 437 thousand tonnes as compared to 355 thousand tonnes in the beginning of the year (Table-11).

The average daily labour employed in phosphorite mines in 2009-10 was 1,396 as against 1,229 in the previous year. The domestic prices of apatite and phosphorite/rock phosphate are furnished in Table-12.

Table – 4 : Producers of Apatite, 2009-10

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

Table – 5 : Production of Apatite, 2007-08 to 2009-10
(By States)

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

State	2007-08		2008-09		2009-10 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**6691**	**22115**	**6415**	**13025**	**5398**	**10417**
Andhra Pradesh	3853	7868	3902	8620	3288	6718
West Bengal	2838	14247	2513	4405	2110	3699

Table – 6 : Production of Apatite, 2008-09 and 2009-10
(By Sectors/States/Districts/Grade)

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

State/District	2008-09			2009-10 (P)		
	No. of mines	Quantity 15-20% P_2O_5	Value	No. of mines	Quantity 15-20% P_2O_5	Value
India	**2**	**6415**	**13025**	**2**	**5398**	**10417**
Public sector	1	2513	4405	1	2110	3699
Private sector	1	3902	8620	1	3288	6718
Andhra Pradesh	**1**	**3902**	**8620**	**1**	**3288**	**6718**
Visakhapatnam	1	3902	8620	1	3288	6718
West Bengal	**1**	**2513**	**4405**	**1**	**2110**	**3699**
Purulia	1	2513	4405	1	2110	3699

Table – 7 : Mine-head Stocks of Apatite, 2009-10 (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	**11117**	**9378**
Andhra Pradesh	345	117
West Bengal	10772	9261

Table – 8 : Producers of Phosphorite/Rock Phosphate, 2009-10

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	Sagar

Table – 9 : Production of Phosphorite/Rock Phosphate, 2007-08 to 2009-10 (By States)

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

State	2007-08		2008-09		2009-10(P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**1849188**	**2125681**	**1803954**	**3087617**	**1546742**	**3120117**
Madhya Pradesh	108578	90593	250556	157198	180869	105068
Rajasthan	1740610	2035088	1553398	2930419	1365873	3015049

Table – 10 : Production of Phosphorite, 2008-09 and 2009-10(P) (By Sectors/States/Districts/Grades)

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

State/ district	2008-09							2009-10(P)						
	No.of Mines	Grade content P_2O_5				Total		No. of Mines	Grade content P_2O_5				Total	
		30-35%	25-30%	20-25%	15-20%	Qty	Value		30-35%	25-30%	20-25%	15-20%	Qty	Value
India	**7**	**705517**	**79957**	**37022**	**981458**	**1803954**	**3087617**	**8**	**598099**	**35392**	**50306**	**862945**	**1546742**	**3120117**
Public Sector	7	705517	79957	37022	981458	1803954	3087617	8	598099	35392	50306	862945	1546742	3120117
Madhya Pradesh	**5**	**–**	**79957**	**37022**	**103577**	**250556**	**157198**	**5**	**674**	**35392**	**50306**	**94497**	**180869**	**105068**
Chhatarpur	1	–	21507	–	8300	29807	23360	1	160	9481	1403	7625	18669	13855
Jhabua	3	–	14581	37022	81115	132718	77820	3	–	6969	43227	47166	97362	56277
Sagar	1	–	43869	–	44162	88031	56018	1	514	18942	5676	39706	64838	34936
Rajasthan	**2**	**705517**	**–**	**–**	**847881**	**1553398**	**2930419**	**3**	**597425**	**–**	**–**	**768448**	**1365873**	**3015049**
Udaipur	2	705517	–	–	847881	1553398	2930419	3	597425	–	–	768448	1365873	3015049

Table – 11 : Mine-head Stocks of Phosphorite/Rock Phosphate, 2009-10 (P) (By States/Grades)

(In tonnes)

State	At the beginning of the year					At the end of the year				
	Grade content P_2O_5					Grade content P_2O_5				
	30-35%	25-30%	20-25%	15-20%	Total	30-35%	25-30%	20-25%	15-20%	Total
India	**68777**	**10219**	**38420**	**237354**	**354770**	**285773**	**48011**	**48562**	**55153**	**437499**
Madhya Pradesh	–	10219	37945	6506	54670	–	2676	48562	7594	58832
Rajasthan	68777	–	475	230848	300100	285773	45335	–	47559	378667

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 targeted production of about 15,000 tonnes of insitu 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 eight mines in public sector. Of these, two were in Madhya Pradesh at Hirapur in Chhattarpur and Sagar districts and three in Jhabua district and three 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 (30 hp, 40 hp and two 20 hp each) 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 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.

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^o 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, copper and coal sector. 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 with high lead and lift for waste and mineral. 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 (trade name-Rajphos) till 2005-06 because of its high R_2O_3 content which could neither be blended nor beneficiated. However, during 2008-09 and 2009-10, approximately 95,000 and 80,000 tonnes, respectively, of this grade of rock phosphate were 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 31.1.2009 was 56.59 lakh tonnes whereas estimated productions in 2008-09 and 2009-10 were 34.65 and 43.52 lakh tonnes of phosphates, respectively. The production of phosphatic fertilizer (DAP) was less than installed capacity due to constraints in availability of raw materials/intermediates which are substantially imported.

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 Tuticorin (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 already 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.

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.

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 was proposed to be supplied by RSMML and ammonia by RCF. Dialogue was going on with HZL for supply of sulphuric acid. However, due to reduction in import prices of DAP, the project was not found to be viable and it was decided to defer the investment decision for the time being.

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, Tuticorin in association with IREL.

RCF is putting up a plant in Rajasthan in joint venture with RSMML to produce 850 tpd diammonium phosphate (DAP). Accordingly, joint venture company has been formed and investment decision will be taken by the JV.

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 Rs. 75 crore.

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 venture for phosphatic fertilizers is as follows:

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 produced is being utilised by IFFCO through long-term buy back arrangement. However, the company suffered financial losses and with the active support of Government of India is under restructuring to improve its performance. The restructuring plan was approved by the Regional High Court of Dakar (Senegal).

Overseas Joint Ventures Under Implementation/Consideration

(1) Indian Farmers Fertilizer Cooperative Ltd. (IFFCO) has entered into a 'Principles of Offtake Agreement' with Legend International Holdings of Australia to undertake joint mining of Rock Phosphate in Lady Annie mines (Georgina Basins in Queensland) along with an assured 3 million tonnes annual offtake. A total of US $800 million investment has been envisaged for undertaking rock phosphate mining in Australia. IFFCO will receive 30 million options in Legend International Holdings. IFFCO would provide both technical and financial facilitation to Legend International Holdings in the development of its phosphate mining and shipment of its product to India.

(2) Gujarat State Fertilizers & Chemicals Ltd (GSFC) and Coromandel International Ltd (CIL) along with 'Groupe Chimique Tunisien' (GCT) and 'Compagnie Des Phosphates De Gafsa' (CPG) are setting up a joint tpy venture project in Tunisia for production of 3.6 lakh tpy phosphoric acid. The entire production of phosphoric acid would for off-take by GSFC and CIL. The plant was expected to be commissioned during 2010.

(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 P_2O_5 (1,500 tpd of phosphoric acid) under a joint venture company, Jordan India Fertilizer Company (JIFCO). The plant was expected to be commissioned in 2010.

(4) RCF and IDC/FOSKOR of South Africa are exploring the possibility to set up a phosphatic and ammonia-urea fertilizer project near Maputo Port, the capital city of Mozambique. The project proposes to source rock phosphate from new mines of FOSKOR in Phalaborwa, South Africa. Raw materials such as ammonia and sulphur can be imported from Maputo for production of phosphatic fertilizers. In this context, an MoU has been signed between RCF & IDC/FOSKOR.

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 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, 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 screens, 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_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 2009-10 was about 3.13 million tonnes against 3.42 million tonnes in 2008-09, decreasing about 9%. Fertilizer industry alone accounted for about 74% consumption followed by chemical (26%). The consumption in glass, sugar and iron & steel industry was meagre (Table - 13).

Table – 13 : Reported Consumption of Apatite and Rock Phosphate, 2007-08 to 2009-10 (By Industries)

(In tonnes)

Industry	2007-08	2008-09 (R)	2009-10 (P)
All Industries	**3527400**	**3423800**	**3129100**
Chemical	837800(10)	847900(10)	818100(10)
Fertilizer	2689000(29)	2575300(29)	2310400(30)
Others (glass, sugar, iron & steel)	600(4)	600 (4)	600(4)

Figures rounded off. Data collected on non-statutory basis. 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 and 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 is about 160 billion tonnes, located mainly in Morocco & Western Sahara (36%), China (23%), South Africa and Jordan (10% each), United States of America (7%), Brazil (2%) and Russia (1%). The world reserves are immense. Large deposits have also been identified on the continental shelves and on seamounts in the Atlantic Ocean and Pacific Ocean but can not be mined economically with the present technology (Table - 14).

The world production of phosphate rock decreased to 159 million tonnes in 2009 from 165 million tonnes in 2008. China (38%), USA (17%), Morocco (12%), Russia (6%) and Tunisia (5%) were the major producers. Almost 90% of the rock phosphate production was consumed for the chemical fertilizer products (Table - 15).

China

China is now the leading producer of rock phosphate, phosphoric acid and DAP. The major mining centres are in Yunnan, Guizhou and Hubai provinces. Production in China was likely higher than the official figure, which did not include production from numerous small independent mines. Most of the Chinese production supplies the growing demand for fertilizer within the country. China raised the export tariffs on phosphate rock and fertilizer products in 2008 to ensure its domestic requirements.

Australia

Minemakers Ltd progressed in the development of its Wonarah Phosphate rock mine in the Northern Territory of Australia. The deposit has an inferred resource of 1,100 million tonnes with an average grade of 18% P_2O_5. The firm plans to ship the phosphate rock from the Port of Darwin to destinations in Asia and New Zealand.

Mali

Oklo Uranium Ltd of Australia was developing the Tatteul deposit in northeastern Mali. The company expected to start production in 2012. Great Quest Metals Ltd of Canada began exploration of the Tin Hina deposit in the Tilemsi Valley in northeastern Mali near the border with

Niger. The firm claims potential resources of more than 50 million tonnes of phosphate rock.

Morocco

OCP Group, the Moroccan phosphate rock producer, announced plans to expand its phosphate rock production capacity from 28 million tonnes per year to 54 million tonnes per year by 2015. The company plans to develop three new mines and build a slurry pipeline to transport ore from the mines to the processing plant.

Namibia

Minemakers Ltd and Tungeni Investments CC, a Namibian firm planned to develop Sandpiper/ Meob offshore phosphate deposit. The phosphate deposits were about 100 km off the coast of Namibia and contained an estimated indicated resources of 47.6 million tonnes grading 21.4% P_2O_5 and estimated inferred resources of 1.41 billion metric tonnes grading 18.8% P_2O_5 according to Minemakers.

Russia

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.

FOREIGN TRADE

Exports

In 2009-10, exports of rock phosphate sharply decreased to 924 tonnes from 5,408 tonnes in the previous year. Similarly, in 2009-10, exports of phosphatic fertilizers also decreased to 1,458 tonnes from 15,017 tonnes in the preceding year. However, the export of phosphoric acid was significantly increased to 143,195 tonnes from 61,193 tonnes and elemental phosphorus to 407 tonnes from 368 tonnes in the previous year. Rock phosphate was exported mainly to Nepal (21%), Thailand (16%), Bangladesh (13%) and UAE (12%). Elemental phosphorus was mainly exported to USA (63%). In 2009-10, exports of phosphatic fertilizers were mainly to UAE (32%), Nepal (21%) and Sri Lanka (15%) while those of phosphoric acid were to Indonesia (39%), Bangladesh (33%) and Chinese Taipei/Taiwan (15%) (Tables - 16 to 19).

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

(In '000 tonnes)

Country	Reserves
World: Total (rounded)	**16000000**
Australia	82000
Brazil	260000
Canada	15000
China	3700000
Egypt	100000
Israel	180000
Jordan	1500000
Morocco and Western Sahara	5700000
Russia	200000
Senegal	80000
South Africa	1500000
Syria	100000
Togo	60000
Tunisia	100000
USA	1100000
Other countries	950000

Source: *Mineral Commodity Summaries, 2010.*

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

(In '000 tonnes)

Country	2007	2008	2009
World: Total	**159000**	**165000**	**159000**
Australia	2131	2157	1963
Brazil	6185	6730	5600
China	45417	50741	60209
Egypt	2504	3179	3708
Israel	3069	3088	2697
Jordan	5552	6266	5281
Morrocco	27834	24861	18307
Russia	10936	9810	9538
South Africa	2556	2287	2237
Syria	3678	3221	2466
Tunisia	8002	7692	7409
USA	29700	30200	27200[e]
Other countries	11436	14768	12385

Source: *World Mineral Production, 2005-2009.*

Imports

Imports of rock phosphate increased marginally to 5.68 million tonnes in 2009-10 from 5.01 million tonnes in the previous year. Imports were mainly from Jordan (44%), Morocco and Egypt (15% each). Imports of elemental phosphorus also increased to 15,911 tonnes from 13,842 tonnes in the previous year. The imports of elemental phosphorus were mainy from China (56%) and Vietnam (44%). In 2009-10, 72,805 tonnes of phosphatic fertilizers was imported almost entirely from China (99%). Imports of phosphoric acid increased to 2.69 million tonnes in 2009-10 from 1.64 million tonnes in the previous year. Imports were mainly from Morocco (47%), South Africa and Senegal (12% each) and Tunisia (11%) (Tables - 20 to 23).

Table – 16 : Exports of Rock Phosphate (By Countries)

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	**5408**	**27205**	**924**	**10138**
Thailand	–	–	150	2921
Germany	200	1552	100	1343
Nepal	414	978	192	1188
Bangladesh	33	742	118	999
Nigeria	30	491	30	893
USA	83	783	50	717
UAE	138	542	112	677
Kenya	479	5362	5	36
Madagascar	40	1119	–	–
Malaysia	3351	12988	–	–
Other countries	640	2648	167	1364

Table – 17 : Exports of Phosphorus (Elemental) (By Countries)

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	**368**	**95366**	**407**	**80789**
USA	135	35772	255	25201
Iran	23	6486	15	11208
Canada	29	14331	28	9103
Egypt	–	–	33	8553
Peru	–	–	14	4523
Sri Lanka	57	12180	8	4200
South Africa	14	1243	11	4141
UAE	2	1016	7	4128
Philippines	25	11609	11	3381
Indonesia	76	10727	13	2958
Other countries	7	2002	12	3393

Table – 18 : Exports of Phosphatic Fertilizers (By Countries)

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	**15017**	**150527**	**1458**	**332253**
Kenya	810	11052	36	317309
Sri Lanka	3640	44872	212	3593
UAE	821	9207	469	3066
Saudi Arabia	–	–	206	3003
Nepal	1575	15122	313	1931
Oman	–	–	100	1581
Malaysia	241	3517	27	639
Mozambique	4174	34624	28	442
Mauritious	61	2140	–	–
South Africa	3435	28263	–	–
Other countries	260	1730	67	689

Table – 19 : Exports of Phosphoric Acid (By Countries)

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	**61193**	**2296686**	**143195**	**1767666**
Indonesia	15	718	56221	677047
Bangladesh	5100	542047	46675	457951
Chinese Taipei/ Taiwan	–	–	21815	263308
Saudi Arabia	8483	227719	8392	241126
Turkey	47137	1507375	10017	120402
UAE	328	9900	23	3635
Mozambique	2	165	18	1678
Sri Lanka	25	1796	3	541
Ethiopia	12	1787	++	5
New Zealand	20	1678	–	–
Other countries	71	3501	31	1973

Table – 20 : Imports of Rock Phosphate (By Countries)

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	**5009662**	**48404898**	**5683654**	**32750208**
Jordan	2033766	22639515	2472464	14712711
Morocco	821623	4195173	863517	5368501
Egypt	339021	2929066	827514	4403793
Togo	327419	4641594	406629	2533772
Israel	117534	934653	393485	2315660
Vietnam	427014	3399860	292403	1074044
Nauru	86791	1238949	120917	741963
Algeria	501209	4561783	121533	603616
Indonesia	41050	315880	61500	304956
China	208383	2780220	23	231
Other countries	105852	768205	123669	690761

Table – 21 : Imports of Phosphorus (Elemental) (By Countries)

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	**13842**	**4296459**	**15911**	**1987340**
China	10680	3354056	8949	1132942
Vietnam	2816	801296	6922	847970
Japan	3	2449	++	312
Switzerland	–	–	1	117
UK	++	5	1	117
Germany	12	5073	–	–
Netherlands	330	133545	–	–
USA	1	35	–	–
Unspecified	–	–	38	5882

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	**1643108**	**112249680**	**2692899**	**67332518**
Morocco	501262	37462540	1273174	28276474
Senegal	137888	8420638	332198	10108641
Tunisia	206002	14108027	298101	8221610
South Africa	508562	30732240	332770	8109751
USA	130885	10007225	222308	6130394
Israel	21842	423901	142757	3897909
Jordan	84676	7620829	48714	1380821
Spain	12618	791003	15126	261509
China	12711	804204	3998	174236
Indonesia	11274	968354	–	–
Other countries	15388	910719	23753	771173

Table – 23 : Imports of Phosphatic Fertilizers (By Countries)

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	**165161**	**5735811**	**72805**	**1083798**
China	112386	4013811	72358	1055926
UAE	–	–	400	20873
Italy	46	6290	46	6901
Germany	–	–	++	77
Netherlands	–	–	1	21
Iran	144	3238	–	–
Israel	33000	1175882	–	–
Sri Lanka	3	191	–	–
UK	1	256	–	–
USA	19581	536143	–	–

FUTURE OUTLOOK

The reserves of chemical and fertilizer grades apatite and rock phosphate in India are very limited. Detailed exploration is, therefore, 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.

In India, most of the existing phosphatic fertilizer and phosphoric acid plants were designed on the basis of high grade imported rock phosphate. The Indian deposits are generally of low grade. Therefore, the future fertilizer plants may have to be designed to accept indigenous mineral or blend of low grade indigenous and imported rock phosphate. Trend indicates that the supplies from world market also show decline in grade. Therefore, the user industries have to orient themselves to allow higher limitations of deletireous constituents. Beneficiation of low grade mineral is another forward looking step for conservation.

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.