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APATITE AND ROCK PHOSPHATE

(FINAL RELEASE)

GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

Indira Bhavan, Civil Lines,
NAGPUR – 440 001

PHONE/FAX NO. (0712) 2565471
PBX : (0712) 2562649, 2560544, 2560648
E-MAIL : cme@ibm.gov.in
Website: www.ibm.gov.in

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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.Fluorapatite $Ca_5(PO_4)_3F$ is the most common variety of apatite and also a secondary source of fluorine.Collophane ($Ca_3P_2O_8$) 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, fluorapatite 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. Hydrofluoro-silicic acid is recovered as by-product from phosphoric acid plants during processing of rock phosphate. Phosphate rocks are also considered as a significant and secondary resource of uranium.

India is deficient in Apatite & Rock Phosphate's availability. In case of apatite the country is fully dependent upon imports while the Rock Phosphate production is only from two states namely Rajasthan and Madhya Pradesh.

RESOURCES

Apatite

The total resources of apatite as per UNFC system as on 1.4.2013 are placed at 22.66 million tonnes. Out of these resources, the Reserves are placed at 0.03 million tonnes while 22.63 million tonnes are placed under Remaining Resources category. Of the total resources, West Bengal accounts for the bulk of 54%, followed by Jharkhand (32%) and Meghalaya (6%). The remaining 8% resources are located in Rajasthan, Andhra Pradesh, Gujarat and Tamil Nadu. Gradewise, soil reclamation grade accounts for 50% followed by beneficiable grade (24%), Low, Non-beneficiable grade (19%) and remaining blendable, unclassified & 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 1.4.2013 are placed at 314.51 million tonnes. Out of these, the reserves constitute only 65.39 million tonnes while 249.12 million tonnes are under Remaining Resources category. Of the total resources, 34% are in Jharkhand, 31% in Rajasthan, 18% in Madhya Pradesh, 8% in Uttar Pradesh & Uttarakhand each, respectively. Meagre quantities of resources are also located in Gujarat and Meghalaya. Gradewise, low-grade account for 38%, followed by beneficiable (27%), soil reclamation & blendable (11% each), chemical fertilizer (7%) and remaining unclassified and not-known grades (about 5%) (Table-2).

EXPLORATION & DEVELOPMENT

Exploration activities for apatite and phosphorite/rock phosphate carried out by the DGM West Bengal, MPSMC Madhya Pradesh and RSMML, Rajasthan during 2014-15 are furnished in Table - 3.

PRODUCTION, STOCKS & PRICES

Apatite

The production of apatite at 930 tonnes during 2014-15 decreased by 28% as compared to that in the previous year. In both the years, production is reported by single private sector mine from Andhra Pradesh (Tables - 4,5 & 6).

The mine-head closing stock of apatite for the year 2014-15 was 7,059 tonnes as against 7,409 tonnes in the previous year (Table- 7). The domestic prices of apatite are furnished in the General Review on 'Prices'.

The average daily labour strength employed in apatite mines during 2014-15 was 108 as against 126 in the previous year.

Table – 1 : Reserves/Resources of Apatite as on 1.4.2013
(By Grades/States)

(In tonnes)

State/Grade	Reserves				Remaining Resources								Total Resources (A+B)
	Proved		Probable	Total	Feasibility	Pre-feasibility		Measured	Indicated	Inferred	Reconnaissance	Total	
	STD111	STD121	STD122	(A)	STD211	STD221	STD222	STD331	STD332	STD333	STD334	(B)	
All India : Total	**29112**	**-**	**1680**	**30792**	**-**	**491818**	**1225345**	**2281521**	**11481250**	**6132768**	**1017646**	**22630348**	**22661140**
By Grades													
Chemical Fertilizer	29112	-	1680	30792	-	-	-	30000	-	200163	-	230163	260955
Soil Reclamation	-	-	-	-	-	491818	1225345	2233500	6243000	1131430	-	11325093	11325093
Low/Non-beneficiable	-	-	-	-	-	-	-	3360	2363000	1350000	666646	4383006	4383006
Beneficiable	-	-	-	-	-	-	-	12477	1875250	3261175	351000	5499902	5499902
Blendable	-	-	-	-	-	-	-	2184	-	-	-	2184	2184
Unclassified	-	-	-	-	-	-	-	-	1000000	-	-	1000000	1000000
Non-known	-	-	-	-	-	-	-	-	-	190000	-	190000	190000
By States													
Andhra Pradesh	29112	-	1680	30792	-	-	-	-	-	200163	-	200163	230955
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	-	-	-	-	-	491818	1225345	120000	8845250	852605	666646	12201664	12201664

Figures rounded off.

Table – 2 : Reserves/Resources of Rock Phosphate as on 1.4.2013
(By Grades/States)

(In tonnes)

State/Grade	Reserves				Remaining Resources								Total Resources (A+B)
	Proved		Probable	Total	Feasibility	Pre-feasibility		Measured	Indicated	Inferred	Reconnaissance	Total	
	STD111	STD121	STD122	(A)	STD211	STD221	STD222	STD331	STD332	STD333	STD334	(B)	
All India : Total	**53370665**	**1763187**	**10257699**	**65391551**	**7697147**	**34990335**	**15432125**	**2912633**	**3549750**	**181859734**	**2678275**	**249119999**	**314511549**
By Grades													
Chemical Fertilizer	8522000	-	1393079	9915079	-	11766000	-	-	15000	1081200	-	12862200	22777279
Blendable	13566856	-	4592563	18159419	3602903	-	1734370	13333	-	12081513	-	17432119	35591538
Soil Reclamation	3063129	1763187	3302763	8129079	622561	251437	7819169	732800	10000	16900468	-	26336435	34465514
Beneficiable	25439680	-	969294	26408974	3471683	22972898	5878586	2166500	2784750	22478231	20750	59773398	86182372
Low grade	2779000	-	-	2779000	-	-	-	-	-	115647549	-	115647549	118426549
Unclassified	-	-	-	-	-	-	-	-	740000	10095773	2657525	13493298	13493298
Not-known	-	-	-	-	-	-	-	-	-	3575000	-	3575000	3575000
By States													
Gujarat	-	-	-	-	-	-	-	-	-	314820	-	314820	314820
Jharkhand	-	-	-	-	-	-	-	-	-	107370000	-	107370000	107370000
Madhya Pradesh	12706556	1763187	9780699	24250442	3471683	13700000	5990814	-	2730000	6728622.76	50625	32671745	56922186
Meghalaya	-	-	-	-	-	-	-	-	-	1311035	-	1311035	1311035
Rajasthan	40664109	-	477000	41141109	1161961	20857437	4588355	152633	79750	28032783	2627650	57500569	98641678
Uttar Pradesh	-	-	-	-	-	432898	3118586	-	740000	21481960	-	25773444	25773444
Uttarakhand	-	-	-	-	3063503	-	1734370	2760000	-	16620512.5	-	24178386	24178386

Figures rounded off.

Table – 3 : Details of Exploration Activities for Apatite & Rock Phosphate During 2014-15

Agency/ State/District	Location	Mapping		Drilling		Sampling	Remarks
		Scale	Area (sq km)	No. of boreholes	Meterage	No.	Reserves/Resources estimated
Apatite							
West Bengal							
DGM							
Purulia	Kutni P.S. Boro	-	-	3	158	-	Reserves/resource estimation for the Kutni & P.S. Boro areas is in progress. Extension of strike is 700 m. Further plans for exploration in respect of current investigations depend upon the G-I level database formed at Kutni apatite prospect.
M.P. State Mining Corporation Ltd.							
(A Govt. of M.P. undertaking)							
Rock Phosphate							
Madhya Pradesh							
Jhabua	Kachaldara		37.5	7	282	121	Geologically the area forms the southern extension of the early or middle proterozoic Aravali belt from Rajasthan to western MP. The rocks are old metamorphosed Precambrian dolomitic limestone and quartzite. Phosphate rock occurs characteristically associated with algal stromatelitic structure in chemo-ginic, biogenic metasediments of the proterozoic Aravali super group. The deposit occurs between Amilyamal in North and Kachaldara in south over a strike length of 12 km. Phosphate ore body with greater than 10% P_2O_5 occurs over a strike length 4.5 km between Amilyamal and Khatamba. Resources were not estimated.
RSMML							
Rock Phosphate							
Rajasthan							
Udaipur	A Ext & C Blocks at Jhamarkotra mine	-	1370.369	14	1629	-	The objective of exploration was to establish the continuity of phosphate ore at depth and strike for mine planning. The strike length is about 12.06 km with dip varying from sub vertical to about 30 degree. Structurally folded and undulating ore bed dipping towards the centre of Jhamarkotra basin. As on 1.4.2015 total resources were estimated at 48.05 million tonnes (Reserves-27.39 million tonnes Resources- 20.66 million tonnes).

Table – 4 : Producers of Apatite, 2014-15

Name and address of producer	Location of mine	
	State	District
Andhra Phosphate (Pvt.) Ltd, 45-58-17/5, Narasimha Nagar, Visakhapatnam-530 024, Andhra Pradesh.	Andhra Pradesh	Visakhapatnam

Table – 5 : Production of Apatite, 2012-13 to 2014-15
(By States)

(Quantity in tonnes; Value in ₹'000)

State	2012-13		2013-14		2014-15 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India/Andhra Pradesh	**572**	**1208**	**1300**	**2768**	**930**	**2021**

Table – 6 : Production of Apatite, 2013-14 and 2014-15
(By Sectors/States/Districts/Grades)

(Quantity in tonnes; Value in ₹'000)

State/District	2013-14			2014-15 (P)		
	No. of mines	Quantity 15-20% P_2O_5	Value	No. of mines	Quantity 15-20% P_2O_5	Value
India	**2**	**1300**	**2768**	**2**	**930**	**2021**
Public sector	1*	-	-	1*	-	-
Private sector	1	1300	2768	1	930	2021
Andhra Pradesh	**1**	**1300**	**2768**	**1**	**930**	**2021**
Visakhapatnam	1	1300	2768	1	930	2021
West Bengal	**1***	**-**	**-**	**1***	**-**	**-**
Purulia	1*	-	-	1*	-	-

** Only labour reported.*

Table – 7 : Mine-head Closing Stocks of Apatite, 2013-14 & 2014-15 (By States/Grades)

(In tonnes)

State	2013-14	2014-15 (P)
	15-20% P_2O_5	15-20% P_2O_5
India	**7409**	**7059**
Andhra Pradesh	548	754
West Bengal	6861	6305

Phosphorite/Rock Phosphate

The total production of phosphorite/ rock phosphate at 1,580 thousand tonnes in 2014-15 increased by about 9% as compared to that in the previous year.

There were 5 reporting mines in both the years. Rajasthan continued to be the principal producing state, contributing 95% of the total production and the remaining 5% was contributed by Madhya Pradesh.

About 60% of the total production of phosphorite/ rock phosphate was of grade 15-20% P_2O_5, while that of 30-35% P_2O_5 grade was 31%, 25-30% P_2O_5 grade was 7% and 20-25% P_2O_5 grade was 2% (Tables- 8 to 10).

The mine-head closing stocks of Phosphorite/ Rock Phosphate in year 2014-15 were 1,739 thousand tonnes as compared to 1,802 thousand tonnes in 2013-14 (Table-11). Domestic prices are furnished in the General Review on 'Prices'.

The average daily labour employed in phosphorite/ rock phosphate mines in 2014-15 was 1,366 as against 1,079 in the previous year.

Table – 8 : Principal Producers of Phosphorite/Rock Phosphate, 2014-15

Name and address of producer	Location of mine	
	State	District
Rajasthan State Mines & Minerals Ltd, C-89/90, Janpath, Lal Kothi Scheme, Jaipur-302 004, Rajasthan.	Rajasthan	Udaipur
Hindustan Zinc Ltd, Yashad Bhavan, Udaipur-313 004, Rajasthan.	Rajasthan	Udaipur
The Madhya Pradesh State Mining Corp. Ltd, Block 1(A), 2nd Floor, Paryawas Bhavan, Jail Road, Arera Hills, Bhopal - 462 011, Madhya Pradesh.	Madhya Pradesh	Chhatarpur Jhabua Sagar

Table – 9 : Production of Phosphorite/Rock Phosphate, 2012-13 to 2014-15 (By States)

(Quantity in tonnes; Value in ₹'000)

State	2012-13		2013-14		2014-15 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**1941158**	**6807233**	**1453580**	**4754755**	**1579561**	**3905087**
Madhya Pradesh	248352	226616	131465	145137	77565	65991
Rajasthan	1692806	6580617	1322115	4609618	1501996	3839096

Table – 10 : Production of Phosphorite, 2013-14 and 2014-15 (By Sectors/States/Districts/Grades)

(Quantity in tonnes; Value in ₹'000)

State/ District	2013-14							2014-15(P)						
	No.of mines	Grade : P_2O_5 content				Total		No. of mines	Grade : P_2O_5 content				Total	
		30-35%	25-30%	20-25%	15-20%	Qty	Value		30-35%	25-30%	20-25%	15-20%	Qty	Value
India	**5**	**460864**	**115976**	**64018**	**812722**	**1453580**	**4754755**	**5**	**484312**	**118277**	**25218**	**951754**	**1579561**	**3905087**
Public Sector	4	460864	-	-	812722	1273586	4251189	4	484312	1922	-	951754	1437988	3536189
Private Sector	1	-	115976	64018	-	179994	503566	1	-	116355	25218	-	141573	368898
Madhya Pradesh	**3**	**-**	**-**	**-**	**131465**	**131465**	**145137**	**3**	**-**	**1922**	**-**	**75643**	**77565**	**65991**
Chhatarpur	1*	-	-	-	-	-	-	1	-	1752	-	24328	26080	20415
Jhabua	2	-	-	-	131465	131465	145137	1	-	-	-	19598	19598	21636
Sagar	-	-	-	-	-	-	-	1	-	170	-	31717	31887	23940
Rajasthan/ Udaipur	**2**	**460864**	**115976**	**64018**	**681257**	**1322115**	**4609618**	**2**	**484312**	**116355**	**25218**	**876111**	**1501996**	**3839096**

** Only labour reported.*

Table – 11 : Mine-head Stocks of Phosphorite/Rock Phosphate, 2013-14 & 2014-15 (By States/Grades)

(In tonnes)

State	2013-14					2014-15 (P)				
	Grade : P_2O_5 content					Grade : P_2O_5 content				
	30-35%	25-30%	20-25%	15-20%	Total	30-35%	25-30%	20-25%	15-20%	Total
India	**574360**	**96785**	**99112**	**1031251**	**1801508**	**741442**	**156034**	**113280**	**727969**	**1738725**
Madhya Pradesh	-	224	191	16708	17123	-	146	-	5659	5805
Rajasthan	574360	96561	98921	1014543	1784385	741442	155888	113280	722310	1732920

MINING AND MARKETING

Apatite mining is confined to Visakhapatnam district, Andhra Pradesh and in Purulia district, West Bengal. In apatite mine of Andhra Phosphate (Pvt.) Ltd, manual mining was carried out by developing benches manually along the strike length, 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 has two disintegration units of 15 hp and 50 hp that operate from two separate sheds. Apatite after disintegration is screened to 40 mesh, 60 mesh and 100 mesh. The screened material of right size is packed in quantities of 50 kg each in polythene-lined gunny bags and are despatched for sale to buyers through Srungavarapukota railway station.

West Bengal Mineral Development & Trading Corporation (WBMDTC) operates the only apatite mine in West Bengal which is located at Beldih. The mine is operated by using opencast mining method with the deployment of HEMM like JCB excavator, jackhammer drills, air compressor, tippers, etc. The mine has a production capacity 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 in the local market for direct application in the name of "PURULIA PHOS". However, no production was reported for the year 2014-15.

In the case of rock phosphate, the production of phosphorite/rock phosphate in India was reported from four State Public Sector mines. Of these, Chhatarpur, Sagar and Jhabua districts of Madhya Pradesh have one mine each while Udaipur district of Rajasthan has the fourth mine. The one mine under the Private Sector is also located at Udaipur district in Rajasthan.

The Meghnagar mine in Jhabua district and Hirapur mine in Chhatarpur and Sagar districts of Madhya Pradesh are worked by opencast method and both the mines are operated by Madhya Pradesh State Mining Corporation Ltd. Compressed-air jack hammers are deployed for drilling. The present run-of-mine capacity of Jhabua mine is 1,50,000 tonnes per year. The entire ore produced from this mine is directly sold to private beneficiation companies namely, AP India Biotech Ltd and M/s. Krishna Posphochem Ltd, whose plants are located about 22 km from the mine. The BRP plant at Hirapur mine is operated by Madhya Bharat Agro Industries Ltd. The processed ore from the plant is predominantly sold to manufacturers of phosphatic fertilizers and chemicals. Some parts of the ore are also internally consumed for fertilizer production.

In Rajasthan, the ore body at Jhamarkotra mine extends over a strike length of 10 km and the average width of phosphate bed is about 15 m with 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 removal of 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 which leads to very high stripping ratio (about 1:10) with high lead distance and lift for waste and mineral. An effective dewatering scheme was implemented to tackle ground water problem. The beneficiation plant of RSMML at Jhamarkotra has 9 lakh tpy capacity to treat run-of-mine low-grade ore, with an average 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 at 18 and 25 km, respectively, away from the mine.

RSMML produces the following products:

(1) (+)30% 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% P_2O_5 ground low-grade beneficiated rock phosphate (RAJPHOS) (direct application to acidic soils).

(4) 31.54% P_2O_5 - BRP Grade (for SSP & DCP Manufacturing units,PROM etc.)

M/s. RSMML was unable to 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 has found takers especially, fertilizer manufacturers.

INDUSTRY

Presently, there are about 30 large size UREA, 21 DAP and complex, 97 SSP plants.Total capacity of Nitrogen (N) increased marginally from 12.77 million tonnes to 13.26 million tonnes. Similarly, the capacity of Phosphatic Nutrient (P), increased from 6.21 million tonnes to 7.06 million tonnes during the period. The production of N increased marginally from 12.41 million tonnes during 2013-14 to 12.43 million tonnes during 2014-15.The production of P_2O_5 increased from 3.97 million tonnes during 2013-14 to 4.11 million tonnes during 2014-15.

Among the major fertilizer products, the production of UREA was 22.59 million tonnes, Diamonium Phosphate (DAP) 3.45 million tonnes, (Nitrogen, Phosphorus and Potash) NP/NPK complex fertilizers 7.83 million tonnes and Single superpho-sphate (SSP) 4.17 million tonnes during 2014-15.

Among the major fertilizer products,the consumption of Urea was 30.61 million tonnes, DAP 7.63 million tonnes, NP/NPK complex fertilizers 8.28 million tonnes,SSP 3.99 million tonnes and MOP (for direct application) 2.85 million tonnes during 2014-15.

The major phosphatic fertilizer plants in Public Sector are Fertilizers and Chemicals (Travancore) Ltd (FACT) at Udyogamandal, Kochi (Kerala); Rashtriya Chemicals and Fertilizer Ltd (RCF) at Trombay, Mumbai (Maharashtra); Madras Fertilizer Limited at Chennai (Tamil Nadu) 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 at Chennai (Tamil Nadu); Zuari Agro Chemicals Ltd in Goa; Southern Petro Chemicals Industries Corporation Ltd (SPIC) at Thoothukudi (Tamil Nadu); Mangalore Chemicals and Fertilizers & Chemicals Ltd at Mangaluru (Karnataka); Gujarat Narmada Valley Fertilizers & Chemicals Ltd (GNFC) at Bharuch (Gujarat); TCL at Haldia (West Bengal), Deepak Fertilizers & Petrochemicals Corp. Ltd (DFPCL) at Taloja (Maharashtra); Hindalco India Ltd at Dahej (Gujarat) and Brahmaputra Valley Fertilizers Corporation Ltd (BVFCL) at Namrup (Assam) .

The plants in the Co-operative Sector to manufacture phosphatic fertilizer are Indian Farmers Fertilizer Co-operative Ltd (IFFCO) at Kandla (Gujarat) and Krishak Bharti Cooperative Ltd. (KRIBCHO) at Hazaria (Gujarat)..

Besides, M/s. RSMML has a beneficiation plant in Jhamarkotra in Rajasthan, while M/s. Krishna Phoschem Ltd has 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.

The other associate industries on rock phosphate include Coimbatore Pioneer Fertilizer Ltd and Rashtriya Chemicals & Fertilizers Ltd, Mumbai which have domestic plants that 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 and 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 Phosphorus Ltd. Red phosphorus is consumed in Matches Industry. It has also applications as fumigant in Agriculture Industry and as flame retardant.

Joint Ventures Abroad

India's dependency on import at present is to the extent of 25% of our requirements of Urea, 90% in case of phosphates either as raw material or finished fertilizers (DAP/MAP/TSP) and 100% in case of potash. The Government has been encouraging Indian companies to establish joint venture in those countries which are rich in fertilizer resources with arrangements of production facility and to enter into long term agreement for supplying fertilizer to India. In previous years Department of Fertilizer has undertaken joint ventures abroad with 5 countries. The details of joint venture project are given below:

(1) IFFCO has joint venture with ICS Senegal in Senegal for the production of 5.50 lakh tonnes of phosphoric acid per year. Production has already started.

(2) A joint venture was made betwen Oman Oil Co. (OOC-50%), IFFCO (25%) & KRIBHCO (25%) for 16.52 lakh MT Urea and 2.48 lakh MT Ammonia. Production started in the year 2006.

(3) IFFCO and Jordan Phosphate Mining Company (JPMC) have set up a phosphoric acid plant in Jordan of 4.8 lakh tonnes. Commercial production started in December, 2014.

(4) IMACID, a joint venture between Office Cherifien Des Phosphates (OCP), Morocco, Chambal Fertilizers & Chemicals Ltd (CFCL) & TCL (33% each) to produce 4.25 lakh tonnes phosphoric acid production started in 1997-98.

(5) Gujarat State Fertilizers and Chemicals Ltd (GSFC) and Coromandel Fertilizers Limited (CFL) now Coromandel International Limited (CIL) along with Tunisian company 'Group Chimique Tunisien' (GCT) and 'Compagine Des Phosphates De Gafsa' (CPG) are setting up a joint venture company in the name of Tunisia-India fertilizer company (TIFERT),for production of 3.6 lakh tpy phosphoric acid. The entire production of phosphoric acid is for off take by GSFC and CFL.The production started in April,2014.

Apart from above, the prospects of cooperation with countries like Ghana, Indonesia, Nigeria, Syria, Togo, Canada, etc. too have gained traction.

ENVIRONMENTAL CONCERNS

There are apparent concerns regarding phospho-gypsum which 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 of 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 in shallow, isolated arms of the ocean. Phosphate fertilizers are probably not the only cause of phosphate-induced eutrophication. Another concern is 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. Other application where the use of phosphate has been discouraged is in manufacturing of detergents.

USES

Phosphate rock is used primarily as a plant nutrient, either by direct application to the soil as a powdered product or in the form of manufactured fertilizer, such as superphosphate, triple superphosphate, diammonium phosphate (DAP), etc. It is also used as animal feed supplements. Elemental phosphorus and phosphoric chemicals derived from phosphate rocks find application in detergents, insecticides, pharmaceutical products, soft drink, tooth paste, glass, photographic films, matches, fire works, military smoke screens, incendiary bombs, etc. Apatite is occasionally used as a gemstone. Blue & green varieties in finely divided form are also used in pigments. There is no natural or synthetic substitute for phosphorus nor is there any economical alternative to phosphate rock as the major source of phosphorus.

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 for direct application to the soil for soil amendment. This application is dependent upon the structure and chemical composition of the rock. Direct application is suited mostly for pastures and forage crops and for acidic soils. According to PPCL 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 2014-15 was about 4.27 million tonnes as against 4.24 million tonnes in 2013-14, showing thereby a increase of about 1%. Fertilizer Industry alone accounted for about 81% consumption followed by Chemical (19%). The consumption of meagre quantities was reported by Glass, Sugar and Iron & Steel Industries as well (Table - 12).

Table-12: Consumption* of Apatite and Rock Phosphate, 2012-13 to 2014-15 (By Industries)

(In tonnes)

Industry	2012-13	2013-14 (R)	2014-15 (P)
All Industries	**4087000**	**4237900**	**4275400**
Chemical	787400(6)	790700(6)	792400(6)
Fertilizer	3299200(27)	3446800(30)	3482600(31)
Others (glass, sugar, iron & steel)	400(6)	400(6)	400(8)

Figures rounded off. Figures in parentheses denote the number of units in Organised Sector. Besides rock phosphate, imported phosphoric acid is also consumed for preparing phosphatic fertilizers. Apatite and rock phosphate in ground form are also used directly in acidic soil. Data relate only to those Units who have actually reported to the questionnaire sent by IBM. Consumption for Organised Sector excludes that of Small Scale Units, consumption may not be exhaustive.

** Paucity of data, hence consumption may not be completed.*

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 the 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 69 billion tonnes, located mainly in Morocco & Western Sahara (73%), China (5%), Algeria & Syria (3% each), and other countries which contribute the remaining 16%. Large deposits have also been identified on the continental shelves and on seamounts in the Atlantic Ocean and Pacific Ocean (Table - 13).

The world production of phosphate rock increased to 245 million tonnes in 2014 from 237 million tonnes in 2013. China (49%), Morocco (13%),USA (11%) and Peru & Russia (5% each) have been the major producers. Almost 90% of the rock phosphate production was consumed for fertilizer products (Table- 14).

Canada

Fertoz limited continued developing the Fernie and Wapiti phosphate rock deposits in British Columbia and conducted exploration activities at the Fernie Project in 2015.

In Quebec, two phosphate rock mines receive mining permits from Provincial authorities in 2015.That will be developed by Investment Quebec (62%) and Yara International ASA (Norway) (38%).The proposed openpit mine would produce between 1.2 and 1.5 million tonnes per year of high grade apatite concentrate for about 30 years.

Arianne Phosphate Inc. received permit for its Laca Paul phosphate project in December 2015 and planned to begin production in 2018.

Morrocco

OCP Group continued with an expansion programme that was to increase its mine capacity fom 32 million tonnes per year to 55 million tonnes per year during next decade. In 2015,construction was ongoing at the Khourigba and Gantour mining areas.A 10 Mt/yr expansion at Khourigba was planned to be completed in 2016. OCP planned to open new mines at Meskala deposit in the Essaouria Region after 2023.

Saudi Arabia

Ma'aden Phosphate Co. (MPC) continued development work at the Umm Wu'al Phosphate Mine on the Al-Khabra deposit. The project was to include the phosphate rock mine and beneficiation plant and production facilities for phosphoric acid, animal feed, purified phosphoric acid, sodium tripolyphosphate and sulphuric acid. Proposals to expand the existing fertilizer plants at Ras Al Khair are also part of the project. The production capacities planned are 5.3 million tpy of phosphate concentrate, 1.5 million tpy of phosphoric acid and 3.5 million tpy of phosphate fertilizers. The project was expected to be completed in 2017.

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

(In '000 tonnes)

Country	Reserves
World: Total (rounded)	**69000000**
Algeria	2200000
Australia	1030000
Brazil	315000
China	3700000
Egypt	1250000
India*	65000
Iraq	430000
Israel	130000
Jordan	1300000
Kazakhstan	260000
Mexico	30000
Morocco & Western Sahara	50000000
Peru	820000
Russia	1300000
Saudi Arabia	956000
Senegal	50000
South Africa	1500000
Syria	1800000
Togo	30000
Tunisia	100000
USA	1100000
Vietnam	30000
Other countries	380000

Source: *Mineral Commodity Summaries, 2016.*
**India's total reserves/resources of rock phosphate as per UNFC system are placed at 314.51 million tonnes as on 1.4.2013*

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

(In '000 tonnes)

Country	2012	2013	2014
World: Total	**219308**	**237316**	**244916**
Australia	885	2064	1950
Brazil	6740	6715	5998
China	95296	108510	120438
Egypt	6236	5922	6000[e]
India*	1941	1384	1011
Israel	2488	2539	2779
Jordan	6383	5399	6000
Kazakhstan	1868	1832	1830[e]
Morocco	27000	26400	32200
Mexico	1725	2391	1663
Peru	10346	14842	10884
Russia	10017	10500	10500[e]
Saudi Arabia	1534	1820	1911
South Africa	2242	2132	2011
Tunisia	2762	3284	3784
USA	30100	31200	27100[e]
Vietnam	2364	2656	2471
Other countries	9381	7726	6386

Source: *World Mineral Production, 2010-2014.*
**India's production of rock phosphate during 2012-13,13-14 & 14-15 was 1.94 million tonnes, 1.38 million tonnes and 1.01 million tonnes respectively.*

FOREIGN TRADE

Exports

In 2014-15, exports of rock phosphate significantly fell to 437 tonnes from 948 tonnes achieved in the previous year. Exports of phosphatic fertilizers at 2,081 tonnes in 2014-15 increased drastically from 1,269 tonnes recorded in the preceding year. The export of phosphoric acid decreased considerably to 4,014 tonnes from 56,711 tonnes and that of elemental phosphorus to 360 tonnes from 434 tonnes in the previous year. Rock phosphate was exported mainly to UAE (95%). Elemental phosphorus was mainly exported to USA (22%) and Indonesia (13%). In 2014-15, exports of phosphatic fertilizers were almost to Nepal (100%) while phosphoric acid was mainly exported to Rep. of Korea (97%) (Tables- 15 to 20).

Imports

Imports of rock phosphate increased to 8.26 million tonnes in 2014-15 from 7.16 million tonnes in the previous year. Imports were mainly from Jordan (39%), Egypt (21%) and Morocco (16%). Imports of elemental phosphorus also increased marginally to 24,858 tonnes in 2014-15 from 23,464 tonnes in the previous year. The imports of elemental phosphorus were mainly from Vietnam (98%). During 2014-15, 110 tonnes of phosphatic fertilizers were imported mainly from China (91%). Imports of phosphoric acid increased marginally to 1.80 million tonnes in 2014-15 from 1.75 million tonnes in the previous year. Imports were mainly from Morocco (52%), USA (13%) and Tunisia (11%) (Tables- 21 to 26).

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

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**948**	**7005**	**437**	**2916**
UAE	308	2097	417	2231
Congo, D. Rep.	20	806	6	247
Nepal	23	793	6	186
Canada	3	186	2	115
Sri Lanka	-	-	1	108
Kenya	23	131	5	28
Mauritius	-	-	++	1
Other countries	571	2992	-	-

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

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**623**	**2448**	**419**	**2352**
UAE	308	2094	417	2232
Nepal	7	80	2	114
Kenya	2	71	++	6
Other countries	306	203	-	-

Table – 18 : Exports of Phosphorus (Elemental) (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**434**	**371637**	**360**	**129957**
USA	80	24148	78	25056
Indonesia	65	24830	48	18709
South Africa	28	11118	42	16236
Hungary	30	11134	40	14520
Iran	20	12734	31	14328
Chile	8	3125	16	6472
Brazil	45	16450	15	6206
Philippines	16	5884	16	5702
Mexico	7	2439	14	5099
Peru	-	-	15	5039
Other countries	135	259775	45	12590

Table – 17 : Exports of Rock Phosphate (Unground) (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**325**	**4557**	**18**	**564**
Congo, D. Rep.	20	806	6	246
Canada	3	186	2	115
Sri Lanka	-	-	1	108
Nepal	16	713	4	72
Kenya	21	60	5	22
Mauritius	-	-	++	1
Other countries	265	2792	-	-

Table – 19 : Exports of Phosphatic Fertilizers (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1269**	**40951**	**2081**	**24053**
Nepal	730	11367	2080	22735
Germany	-	-	++	683
Central African Republic	-	-	++	407
Ghana	-	-	++	148
Malaysia	3	516	1	79
Trinidad	-	-	++	1
Other countries	536	29068	-	-

Table – 20 : Exports of Phosphoric Acid (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**56711**	**1105268**	**4014**	**110979**
Korea, Rep. of	5500	108122	3877	88951
Belgium	1	241	19	4928
UAE	27	4411	26	4595
Mozambique	44	5651	22	2821
Nepal	13	1094	35	2656
Sri Lanka	8	1916	11	2580
Yemen Republic	-	-	3	923
Uganda	++	19	7	645
Bangladesh	10	1132	5	597
Malaysia	3	277	1	494
Other countries	51105	982405	8	1789

Table – 21 : Imports of Rock Phosphate (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**7160798**	**55177899**	**8258191**	**61803761**
Jordan	2655089	21036215	3207260	24952331
Egypt	1460964	9422123	1773478	10159535
Morocco	962421	8041825	1281538	10429359
Togo	727773	6824200	805367	7717209
Peru	888496	5999553	849506	5677888
Israel	351194	2788806	171298	1381560
Nauru	22000	296941	53304	619982
Algeria	34850	268281	62615	450441
Senegal	1000	8357	32396	222261
South Africa	40414	358251	21122	185852
Other countries	16597	133347	307	7343

Table – 22 : Imports of Rock Phosphate (Ground) (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**3128190**	**25187860**	**3323457**	**25478189**
Morocco	746872	5990212	1175827	9487032
Egypt	769457	5294573	978799	5700940
Togo	482056	4523030	470154	4572132
Jordon	702129	5853759	452764	3527196
Israel	313960	2473764	171298	1381560
Nauru	22000	296941	53304	619982
South Africa	40414	358251	21122	185852
Pakistan	56	283	189	3450
UK	-	-	++	45
Other countries	51246	397047	-	-

Table – 23 : Imports of Rock Phosphate (Unground) (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**4032608**	**29990039**	**4934734**	**36325572**
Jordan	1952960	15182457	2754496	21425135
Peru	888496	5999553	849506	5677888
Egypt	691507	4127550	794679	4458595
Togo	245717	2301169	335213	3145077
Morocco	215549	2051612	105711	942327
Algeria	-	-	62615	450441
Senegal	1000	8357	32396	222261
China	125	3894	100	3179
France	-	-	18	667
Other countries	37254	315447	++	2

Table – 24 : Imports of Phosphorus (Elemental) (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**23464**	**4959884**	**24858**	**4798763**
Vietnam	16730	3518076	24323	4693280
China	6330	1345916	535	105383
Nertherlands	-	-	++	54
USA	1	186	++	23
UK	-	-	++	13
Germany	-	-	++	10
Other countries	403	95706	-	-

Table – 25 : Imports of Phosphoric Acid (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1751467**	**74648325**	**1798213**	**83022295**
Morocco	1017173	43036974	937614	43137203
USA	294745	12461061	236112	10860028
Tunisia	52087	2319838	192767	8700262
Jordon	-	-	152594	7340491
Senegal	167464	7004822	153799	6940199
Israel	48353	2083624	50207	2382636
South Africa	96230	4137574	25212	1113178
Vietnam	1305	83226	23866	1081525
China	9217	568566	5672	380272
Chinese Taipei/ Taiwan	8532	427216	8791	423023
Other countries	56361	2525424	11579	663478

Table – 26 : Imports of Phosphatic Fertilizers (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**23**	**2195**	**110**	**6369**
China	-	-	100	5068
Turkey	6	1239	7	1230
USA	-	-	3	71
Other countries	17	956	-	-

FUTURE OUTLOOK

There is no substitute for phosphorus in agriculture. The country is deficient in all fertilizer minerals. The reserves/resources 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 phosphate may have to be intensified 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 imports. Concentrated effort should be made by way of constituting consortia 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 10-15% 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.

Demand of phosphatic fetilizer is expected to increase gradually in tandem with the 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 on the other hand, are of low-grade variety. Therefore, the fertilizer and phosphoric acid plants that are likely to be set up as replacement of the existing plants may have to be designed to accept indigenous ores as feed. In addition, beneficiation of domestic low-grade ores would be a step in the right direction and should be promoted persuasively.

The Working Group has made a series of recommendations which included: (i) Mining of rock phosphate be opened for Private Sector, (ii) Cluster mining be encouraged in order to reduce mining loss and degradation of environment to the maximum extent possible, (iii) Environmental issues be sought amicably for commencement of mining operations in Aravali areas, (iv) Technology for extraction of low-grade ores be adopted and (v) Expand exploration to various other parts of the country.