

APATITE AND ROCK PHOSPHATE



Indian Minerals Yearbook 2017

(Part- III : Mineral Reviews)

56th Edition

APATITE AND ROCK PHOSPHATE

(FINAL RELEASE)

**GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES**

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March, 2018

1 Apatite and Rock Phosphate

Apatite is a group of phosphate minerals and named by German Geologist Abraham Werner in 1786. It 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. It is a group of phosphate minerals, usually referring to hydroxylapatite, fluorapatite and chlorapatite. Fluorapatite $\text{Ca}_5(\text{PO}_4)_3\text{F}$ is the most common variety of apatite and also a secondary source of fluorine. Collophane ($\text{Ca}_3\text{P}_2\text{O}_8$) 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 hydroxylapatite, carbonateapatite, 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 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 Reserves/Resources of apatite as per NMI data, based on UNFC system as on 1.4.2015 have been placed at 24.05 million tonnes. Out of these resources, the Reserves are placed at 0.03 million tonnes, while 24.02 million tonnes are placed under Remaining Resources category. Of the total reserves/

resources, West Bengal accounts for the bulk of 57%, followed by Jharkhand (30%) and Meghalaya (5%). The remaining 8% resources are located in Rajasthan, Andhra Pradesh, Gujarat and Tamil Nadu. Gradewise, soil reclamation grade accounts for 53% followed by beneficiable grade (28%), Low, Non-beneficiable grade (13%) and remaining blendable, unclassified & not-known grades (6%). The resources of chemical fertilizer grade are over one percent (Table-1).

Rock Phosphate

The total reserves/resources of rock phosphate as per NMI data, based on UNFC system as on 1.4.2015 have been placed at 312.67 million tonnes. Out of these, the reserves constitute only 45.80 million tonnes while 266.87 million tonnes are under Remaining Resources category. Of the total reserves/resources, 34% are in Jharkhand, 31% in Rajasthan, 19% 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 37%, followed by beneficiable (29%), blendable (11%), chemical fertilizer & soil reclamation (8% each) and remaining unclassified and not-known grades (about 7%) (Table-2).

EXPLORATION & DEVELOPMENT

Exploration and development details, if any, are given in the review on "Exploration & Development" in "General Reviews".

PRODUCTION & STOCKS

Apatite

The production of apatite was nil during 2016-17 as compared to 110 tonnes production reported in 2015-16. In previous year production was reported by single private sector mine from Andhra Pradesh (Tables - 3 & 4).

The mine-head closing stocks of apatite for the year 2016-17 were 6,641 tonnes as against 6,691 tonnes in 2015-16 (Table- 5).

The average daily labour employed in apatite mines during 2016-17 was 47 as against 95 in the previous year.

APATITE AND ROCK PHOSPHATE

**Table – 1 : Reserves/Resources of Apatite as on 1.4.2015
(By Grades/States)**

(In tonnes)

State/Grade	Reserves				Remaining Resources						Total Resources (A+B)	
	Proved STD111	Probable STD121	Total (A)	Feasibility STD211	Pre-feasibility STD221	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)		
All India : Total	27715	1680	29395	1385734	491818	1225345	2281521	11481250	6132768	1017646	24016082	24045477
By Grades												
Chemical Fertilizer	27715	1680	29395	-	-	-	30000	-	200163	-	230163	259558
Soil Reclamation	-	-	-	1385734	491818	1225345	2233500	6243000	1131430	-	12710827	12710827
Low/Non-beneficial	-	-	-	-	-	-	3360	2363000	50000	666646	3083006	3083006
Beneficial	-	-	-	-	-	-	12477	1875250	4561175	351000	6799902	6799902
Blendable	-	-	-	-	-	-	2184	-	-	-	2184	2184
Unclassified	-	-	-	-	-	-	-	1000000	-	-	1000000	1000000
Non-known	-	-	-	-	-	-	-	-	190000	-	190000	190000
By States												
Andhra Pradesh	27715	1680	29395	-	-	-	-	-	200163	-	200163	229558
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	-	-	-	1385734	491818	1225345	120000	8845250	852605	666646	13587398	13587398

Figures rounded off.

APATITE AND ROCK PHOSPHATE

**Table – 2 : Reserves/Resources of Rock Phosphate as on 1.4.2015
(By Grades/States)**

(In tonnes)

State/Grade	Reserves				Remaining Resources								Total Resources (A+B)
	Proved STD111	Probable STD121	Total STD122	Total (A)	Feasibility STD211	Pre-feasibility STD221	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)		
All India : Total	43832936	5179	1969370	45807485	10679080	36271671	25008353	29126633	3549750	185771368	2678275	266871130	312678615
By Grades													
Chemical Fertilizer	8612446	5179	439204	9056829	-	12936677	1682389	-	15000	2284379	-	16918245	25975074
Blendable	10446537	-	477000	10923537	6394650	-	5849933	13333	-	12092513	-	24350429	35273966
Soil Reclamation	-	-	-	-	705867	251437	7672812	732800	10000	16887166	-	26260082	26260082
Beneficial	24773953	-	1053166	25827119	3578563	23083757	6976076	2166500	2784750	25288989	20750	63899385	89726504
Low grade	-	-	-	-	-	-	-	-	-	115547549	-	115547549	115547549
Unclassified	-	-	-	-	-	-	2827143	-	740000	10095773	2657525	16320441	16320441
Not-known	-	-	-	-	-	-	-	-	-	3575000	-	3575000	3575000
By States													
Gujarat	-	-	-	-	-	-	-	-	-	314820	-	314820	314820
Jharkhand	-	-	-	-	-	-	-	-	-	107370000	-	107370000	107370000
Madhya Pradesh	5999399	5179	1492370	7496948	6460616	14981336	15702042	-	2730000	10629258	50625	50553877	58050825
Meghalaya	-	-	-	-	-	-	-	-	-	1311035	-	1311035	1311035
Rajasthan	37833537	-	477000	38310537	1154961	20857437	4453355	152633	79750	28043783	2627650	57369569	95680106
Uttar Pradesh	-	-	-	-	-	432898	3118586	-	740000	21481960	-	25773444	25773444
Uttarakhand	-	-	-	-	3063503	-	1734370	2760000	-	16620513	-	24178386	24178386

Figures rounded off.

APATITE AND ROCK PHOSPHATE

**Table – 3 : Production of Apatite, 2014-15 to 2016-17
(By States)**

(Quantity in tonnes; Value in `'000)

State	2014-15		2015-16		2016-17 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India/Andhra Pradesh	930	2065	110	387	-	-

**Table – 4 : Production of Apatite, 2015-16 and 2016-17
(By Sectors/States/Districts/Grades)**

(Quantity in tonnes; Value in `'000)

State/District	No. of mines	2015-16		No. of mines	2016-17 (P)	
		Quantity	Value		Quantity	Value
India	2	110	387	2 *	-	-
Public sector	1*	-	-	1*	-	-
Private sector	1	110	387	1 *	-	-
Andhra Pradesh	1	110	387	1 *	-	-
Visakhapatnam	1	110	387	1 *	-	-
West Bengal	1*	-	-	1 *	-	-
Purulia	1 *	-	-	1 *	-	-

* Only labour reported.

**Table – 5 : Mine-head Closing Stocks of Apatite, 2015-16 & 2016-17
(By States/Grades)**

(In tonnes)

State	2015-16	2016-17 (P)
India	6691	6641
Andhra Pradesh	385	335
West Bengal	6306	6306

Phosphorite/Rock Phosphate

The total production of phosphorite/rock phosphate at 1,181 thousand tonnes in 2016-17 decreased by 25% as compared to that in the previous year (Tables - 6 to 8).

There were 5 reporting mines in both the years. Rajasthan continued to be the principal producing state, contributing 94% of the total

production and the remaining 6% was contributed by Madhya Pradesh.

The mine-head closing stocks of Phosphorite/Rock Phosphate in year 2016-17 were 2,460 thousand tonnes as compared to 2,568 thousand tonnes in 2015-16 (Table-9).

The average daily labour employed in phosphorite/rock phosphate mines in 2016-17 was 818 as against 1,129 in the previous year.

APATITE AND ROCK PHOSPHATE

Table – 6 : Principal Producers of Phosphorite/Rock Phosphate, 2016-17

Name and address of producer	Location of mine	
	State	District
Rajasthan State Mines & Minerals Ltd, C-89/90, Janpath, Lal Kothi Scheme, Jaipur-302 015, Rajasthan.	Rajasthan	Udaipur
Hindustan Zinc Ltd, Yashad Bhavan, Udaipur-313 004, Rajasthan.	Rajasthan	Udaipur
Madhya Pradesh State Mining Corp. Ltd, Block A, 2 nd Floor, Paryawas Bhavan, Jail Road, Arera Hills, Bhopal - 462 011, Madhya Pradesh.	Madhya Pradesh	Chhatarpur Sagar Jhabua

**Table – 7 : Production of Phosphorite/Rock Phosphate, 2014-15 to 2016-17
(By States)**

(Quantity in tonnes; Value in `'000)

State	2014-15		2015-16		2016-17 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	1607215	3759071	1571863	3763823	1181307	3894738
Madhya Pradesh	79264	67263	66260	55602	68803	58240
Rajasthan	1527951	3691808	1505603	3708221	1112504	3836498

**Table – 8 : Production of Phosphorite, 2015-16 and 2016-17
(By Sectors/States/Districts/Grades)**

(Quantity in tonnes; Value in `'000)

State/ District	No. of mines	2015-16				2016-17 (P)				Total				
		Grade: P ₂ O ₅ content				Grade: P ₂ O ₅ content								
		Above 30%	Above 25- 30%	Above 20- 25%	Up to 20%	Qty	Value	No. of mines	Above 30%	Above 25- 30%	Above 20- 25%	Up to 20%	Qty	Value
India	5	593939	25943	30875	921106	1571863	3763823	5	705588	8798	-	466921	1181307	3894738
Public														
Sector	4	593939	288	-	921106	1515333	3678190	4	705588	-	-	466921	1172509	3872688
Private														
Sector	1	-	25655	30875	-	56530	85633	1	-	8798	-	-	8798	22050
Madhya Pradesh	3	-	288	-	65972	66260	55602	3	-	-	-	68803	68803	58240
Chhatarpur	1	-	238	-	26026	26264	22252	1	-	-	-	26281	26281	21892
Jhabua	1*	-	-	-	-	-	-	1	-	-	-	2523	2523	3028
Sagar	1	-	50	-	39946	39996	33350	1	-	-	-	39999	39999	33320
Rajasthan/	2	593939	25655	30875	855134	1505603	3708221	2	705588	8798	-	398118	1112504	3836498
Udaipur	2	593939	25655	30875	855134	1505603	3708221	2	705588	8798	-	398118	1112504	3836498

* Only labour reported.

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**Table – 9: Mine-head Closing Stocks of Phosphorite/Rock Phosphate, 2015-16 & 2016-17
(By States/Grades)**

(In tonnes)

State	2015-16					2016-17 (P)				
	Grade: P ₂ O ₅ content					Grade: P ₂ O ₅ content				
	Above 30%	Above 25-30%	Above 20-25%	Up to 20%	Total	Above 30%	Above 25-30%	Above 20-25%	Up to 20%	Total
India	714410	55288	141803	1656203	2567704	904659	2442	119237	1433242	2459580
Madhya Pradesh	-	114	-	31512	31626	-	114	-	45346	45460
Rajasthan	714410	55174	141803	1624691	2536078	904659	2328	119237	1387896	2414120

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 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% 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 in the local market for direct application in the name of "PURULIA PHOS". However, no production was reported for the year 2014-15 & 2015-16.

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 fully mechanised mine under the Private Sector (Hindustan Zinc Limited) is also located at Udaipur district in Rajasthan. The strike of the mine is in NE-SW direction and reserves as on 1.4.2017 are 3.56 million tonnes.

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 production of Meghnagar Mine is used in Single Super phosphate, Fertilizer Industries and Phosphorus Industries. 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 of M/S RSMML 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° 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 working levels are kept dry by continuous pumping of ground water 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 low-grade ore, with an average 16% P₂O₅. Production from Jhamarkotra mine is despatched to many phosphatic fertilizer and chemical manufacturers from Udaipur and Umra railway stations which are located at 18 km and 25 km, respectively, away from the mine. RSMML has put up a beneficiation plant for processing of 9 lakh MT of low-grade phosphate ore per annum.

RSMML produces the following products:

- (1) (+) 30% P₂O₅ crushed -1/2" size high-grade rock phosphate (for SSP manufacturing units).
- (2) 31.5% P₂O₅ high-grade rock phosphate Chips (for DAP/Phos Acid manufacturing units).
- (3) 18% P₂O₅ ground low-grade beneficiated rock phosphate (RAJPHOS) (direct application to acidic soils).
- (4) 31.54% P₂O₅ - 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 R₂O₃ 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, 32 DAP and complex, 104 SSP and 2 ammonium sulphate plants.

Among the major fertilizer products, the production of urea was 24.33 million tonnes (7.16 million

tonnes from Public Sector, 6.60 million tonnes from Cooperative Sector and 10.57 million tonnes from Private Sector), Diammonium Phosphate (DAP) 4.25 million tonnes (1.72 million tonnes from Cooperative Sector and 2.53 million tonnes from Private Sector), Nitrogen, Phosphorus and Potash (NP/NPK complex fertilizers) 8.57 million tonnes (1.27 million tonnes from Public Sector, 2.38 million tonnes from Cooperative Sector and 4.92 million tonnes from Private Sector) during 2016-17 (Estimated).

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), Brahmaputra Valley Fertilizers Corporation Ltd (BVFCL) at Namrup (Assam), National Fertilizers Ltd (NFL) at Noida (U.P.), FCI Aravalli Gypsum and Minerals India Ltd (FAGMIL) at Jodhpur (Rajasthan), Projects and Development India Limited (PDIL) at Noida (U.P.), Fertilizer Corporation of India Limited (FCIL) in New Delhi and Hindustan Fertilizer Corporation Ltd (HFCL) in New Delhi.

The plants in Private Sector are Gujarat State Fertilizer Company Ltd (GSFC) at Vadodara (Gujarat); Zuari Agro Chemicals Ltd in Goa; Mangalore Chemicals and Fertilizers & Chemicals Ltd at Mangaluru (Karnataka); Gujarat Narmada Valley Fertilizers & Chemicals Ltd (GNFC) at Bharuch (Gujarat); Nagarjuna Fertilizer and Chemicals Ltd (NFCL) at Kakinada (Hyderabad), Chambal Fertilizers and Chemicals (CFCL) at Gadepan (Rajasthan); Tata Chemicals Ltd (TCL) Bardala (Uttar Pradesh); Kanpur Fertilizer and Cements Ltd (KFCL) at Kanpur (Uttar Pradesh); Indo-Gulf Fertilizers Limited Jagdishpur Uttar Pradesh, etc.

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 Surat (Gujarat). The 2 plants of IFFCO are in Gujarat (Kalol and Kandla), 2 in Uttar Pradesh (Phulpur and Aonla) and one in Odisha (Paradeep).

Besides, M/s. RSMML has a beneficiation plant in Jhamarkotra in Rajasthan, while M/s. Krishna Foschem 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 Madhya Pradesh 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 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 between 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 capacity. 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

Most of the phosphate rock mined throughout the world is used to produce phosphate fertilizer. 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.

Transparent specimens of apatite with vivid green, blue, yellow or pink colour and excellent clarity are often cut into faceted gemstone. Along with other phosphates apatites are also a proposed host material for storage of nuclear waste.

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 ₂ O 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 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%. Silica up to 8% can be tolerated. Iron and alumina, i.e., R₂O₃ should not be more than 3.5%. 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 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 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 2016-17 was about 1.99 million tonnes as against 4.44 million tonnes in 2015-16. Chemical Industry alone accounted for about 54% consumption followed by Fertilizer Industry (46%) (Table-10). The apparent consumption of rock phosphate for 2016-17 was about 7724170 tonnes or 7.72 million tonnes.

Table-10: Consumption* of Apatite and Rock Phosphate, 2014-15 to 2016-17 (By Industries)

Industry	(In tonnes)		
	2014-15	2015-16 (R)	2016-17 (P)
All Industries	4340500	4441800	1994100
Chemical	792400	1088400	1071100
Fertilizer	3547700	3353000	923000
Others (glass & sugar)	400	400	++

Figures rounded off.

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

* Due to paucity of data, the consumption figures may not be completed.

POLICY

Imports of natural calcium phosphates (including apatite), natural aluminium-calcium phosphates and phosphatic chalk are allowed 'free' under Heading No. 2510 as per the Foreign Trade Policy 2015-2020. 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 scarcity of domestic raw material constrains the attainment of self-sufficiency in the country. 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.

Government of India notified new Urea Policy 2015 for existing gas based urea manufacturing units.

WORLD REVIEW

The world reserves of phosphate rock are about 70 billion tonnes, located mainly in Morocco & Western Sahara (71%), China (5%), Algeria (3%),

and other countries which contribute the remaining 18% (Table - 11).

The world production of phosphate rock increased to 276 million tonnes in 2016 from 268 million tonnes in 2015. China (52%), Morocco (11%), USA (10%) and Peru & Russia (4 % each) have been the major producers (Table- 12).

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.

Morocco

OCP Group continued with an expansion programme that was to increase its mine capacity from 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.

APATITE AND ROCK PHOSPHATE

Table – 11: World Reserves of Phosphate Rock (By Principal Countries)

(In '000 tonnes)

Country	Reserves
World: Total (rounded)	7000000
Algeria	220000
Australia	110000
Brazil	170000
China	330000
Egypt	130000
Finland	100000
India	65000
Israel	74000
Jordan	130000
Kazakhstan	260000
Mexico	30000
Morocco & Western Sahara	5000000
Peru	40000
Russia	70000
Saudi Arabia	140000
Senegal	50000
South Africa	150000
Syria	180000
Togo	30000
Tunisia	100000
Vietnam	30000
USA	100000
Other countries	900000

Source: Mineral Commodity Summaries, January 2018.

FOREIGN TRADE

Exports

In 2016-17, exports of rock phosphate decreased drastically to 5,915 tonnes from 14,242 tonnes achieved in the previous year. Exports of phosphatic fertilizers at 24,181 tonnes in 2016-17 increased drastically from 15,510 tonnes recorded in the preceding year. The exports of phosphoric acid decreased drastically to 227 tonnes from 14,955 tonnes. Elemental phosphorus decreased marginally to 455 tonnes from 486 tonnes in the previous year. Rock phosphate was exported mainly to Nepal (88%). Elemental phosphorus was mainly exported to USA (21%). In 2016-17, exports of phosphatic fertilizers was mainly to Malaysia (53%) and Pakistan (34%) while phosphoric acid was mainly exported to Sudan (36%) (Tables- 13 to 18).

Table – 12 : World Production of Phosphate Rock (By Principal Countries)

(In '000 tonnes)

Country	2014	2015	2016
World: Total (rounded)	242000	268000	276000
Algeria	1418	1289	1300 ^e
Australia	1950	1028	1037
Brazil ^b	6513	5600	6500
China	120438	142039	144398
Egypt	4831	5500 ^e	5500 ^e
India	1607	1572	1181
Israel	2779	3427	3591
Jordan	7144	8336	7991
Kazakhstan ^e	1830	1830	1830
Mexico	1733	3859	2909
Morocco	27390	26264	30000 ^e
Peru	10884	11162	10561
Russia	10700	11500	11500 ^e
Saudi Arabia	1911	2002	5400
Senegal	806	1062	1609
South Africa	2011	1852	1697
Togo	1086	1150	850
Tunisia	3784	3228	3664
USA	25300	27400	27800 ^e
Vietnam	2471	2923	2849
Other countries	5038	4771	4036

Source:- World Mineral Production, 2012-16, BGS.

b:- Including beneficiated and directly shipped material.

Imports

Imports of rock phosphate decreased slightly to 7.51 million tonnes in 2016-17 from 8.03 million tonnes in the previous year. Imports were mainly from Jordan (37%), Egypt (29%) and Morocco (15%). Imports of elemental phosphorus increased marginally to 28,356 tonnes in 2016-17 from 24,530 tonnes in the previous year. The imports of elemental phosphorus were mainly from Vietnam (85%). During 2016-17, 106 tonnes of phosphatic fertilizers were imported mainly from China (52%). Imports of phosphoric acid increased marginally to 2.49 million tonnes in 2016-17 from 2.19 million tonnes in the previous year. Imports were mainly from Morocco (36%), Jordan (21%) and Senegal (15%) (Tables- 19 to 24).

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**Table – 13: Exports of Rock Phosphate
(By Countries)**

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	14242	69097	5915	8615
Nepal	799	1392	5214	5576
Bahrain	-	-	52	1035
Malaysia	8381	38401	112	890
Pakistan	-	-	19	683
Bangladesh	-	-	508	335
Israel	-	-	9	42
Congo D. Rep.	-	-	++	35
China	-	-	1	13
Germany	++	218	++	6
Bhutan	1856	14936	-	-
Other countries	3206	14150	-	-

**Table – 14 : Exports of Rock Phosphate
(Ground)
(By Countries)**

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	14200	68462	2793	4898
Nepal	758	995	2652	3229
Malaysia	8381	38401	112	890
Pakistan	-	-	19	683
Israel	-	-	9	42
Congo D. Rep.	-	-	++	35
China	-	-	1	13
Germany	-	-	++	6
Bhutan	1856	14936	-	-
UAE	3202	13951	-	-
Tanzania	1	106	-	-
Other countries	2	73	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	42	635	3122	3717
Nepal	41	397	2562	2347
Bahrain	-	-	52	1035
Bangladesh	-	-	508	335
Germany	++	218	-	-
UAE	1	20	-	-

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	486	178267	455	175773
USA	105	34787	96	34355
Canada	42	13926	84	28227
Brazil	31	11890	48	19900
Indonesia	52	21130	38	15510
Philippines	40	14712	34	12892
South Africa	42	17491	28	11845
Egypt	28	11193	18	7786
Hungary	20	7738	20	7238
Turkey	3	1265	17	7160
Sweden	14	4748	14	4905
Other countries	109	39387	58	25955

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	15510	390523	24181	131548
Malaysia	1	160	12855	90413
Nepal	4267	292972	1547	16848
Pakistan	11228	97172	8260	15534
Sri Lanka	-	-	500	4614
Kenya	-	-	57	2012
Chinese Taipei/ Taiwan	-	-	910	1787
USA	-	-	1	109
Greece	++	200	1	105
Saudi Arabia	-	-	50	97
Mauritius	14	19	++	29

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	14955	412097	227	58406
Sudan	-	-	81	37186
Malaysia	-	-	45	4582
Belgium	12	2772	16	3714
UAE	23	4559	12	2658
Sri Lanka	6	1277	8	2326
Congo P Rep	-	-	15	1398
Zambia	++	5	9	1202
Senegal	++	99	5	955
Bangladesh	9827	265445	7	938
Chinese Taipei/ Taiwan	6	928	3	476
Other countries	5081	137012	26	2971

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	8037745	65290422	7511445	49513134
Jordan	3157242	26448984	2782977	19361379
Egypt	1761293	10215106	2180162	10133979
Morocco	1395306	13818387	1107756	9340944
Peru	889315	6943142	748905	4948168
Togo	461315	5051994	509295	4499365
Israel	98161	715117	103545	635099
Algeria	217900	1619172	48092	316309
South Africa	22000	198165	28100	234569
Pakistan	771	18918	775	25364
UAE	500	4472	1015	7002
Other countries	33942	256965	823	10956

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	3027109	26564903	2737390	18646790
Morocco	1395306	13818387	1107756	9340944
Egypt	672366	4008921	1018360	4694792
Togo	356114	3876138	252912	2220935
Jordan	442908	3632324	264401	1708055
Israel	98161	715117	58000	371819
South Africa	22000	198165	28100	234569
Algeria	5585	42196	5742	39521
Pakistan	579	14003	606	19687
UAE	500	4472	1015	7002
Netherlands	-	-	80	3419
Other countries	33590	255180	418	6047

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

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	5010636	38725519	4774055	30866344
Jordan	2714334	22816660	2518576	17653324
Egypt	1088927	6206185	1161802	5439187
Peru	889315	6943142	748905	4948168
Togo	105201	1175856	256383	2278430
Algeria	212315	1576976	42350	276788
Israel	-	-	45545	263280
Pakistan	192	4915	169	5677
Iran	-	-	307	1299
China	15	179	18	191
France	18	703	-	-
Other countries	319	903	-	-

**Table – 22 : Imports of Phosphorus (Elemental)
(By Countries)**

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	24530	4658200	28356	5285023
Vietnam	21612	4124036	24188	4544472
China	2918	534098	2688	480524
Kazakhstan	-	-	1480	259878
UK	++	17	++	78
USA	++	30	++	63
Belgium	++	15	++	4
Germany	++	4	++	4

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**Table – 23: Imports of Phosphoric Acid
(By Countries)**

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	2192097	109650501	2490986	98873274
Morocco	1034663	52582287	898696	36394183
Jordan	317830	16505037	533299	20543567
Senegal	247142	12812978	375171	15437595
USA	178087	9374620	202795	8799644
Tunisia	127674	6083673	136328	4992569
Vietnam	107163	4769258	122375	4361477
South Africa	61952	2234983	86796	3507630
Israel	60815	3108333	30370	1234687
China	6392	447695	8745	532908
Chinese Taipei/Taiwan	11549	518911	11621	531829
Other countries	38830	1212726	84790	2537185

**Table – 24: Imports of Phosphatic Fertilizers
(By Countries)**

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (` '000)	Qty (t)	Value (` '000)
All Countries	145	8951	106	6357
Mexico	-	-	9	2455
Spain	++	66	12	1169
China	123	6290	55	1087
Latvia	-	-	26	940
USA	-	-	3	472
Turkey	5	1618	1	193
Korea, Rep. of	-	-	++	28
Switzerland	-	-	++	13
Australia	17	842	-	-
France	++	86	-	-
Other countries	++	49	-	-

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. Concerted efforts 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 fertilizer is expected to increase gradually in tandem with the growth in population and corresponding increase in food requirements. The government has been encouraging Indian companies to establish joint venture abroad in countries which are rich in fertilizer resources.

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.