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(Part-III: Mineral Reviews)

58th Edition

APATITE & ROCK PHOSPHATE

(FINAL RELEASE)

GOVERNMENT OF INDIA
MINISTRY OF MINES
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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 $Ca_5(PO_4)_3F$ 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 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.

RESERVES/RESOURCES

Apatite

The total Reserves/Resources of apatite as per NMI data, based on UNFC system as on 1.4.2015 has 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 has 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% each in Uttar Pradesh & Uttarakhand, 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 covered in the Review on "Exploration & Development" under "General Reviews".

PRODUCTION & STOCKS

Apatite

The Apatite production was 'nil' in 2018-19 as well in previous year(Table -3).

The mine-head closing stocks at the end of 2018-19 was 6,521 tonnes same as in 2017-18 (Table-4). The average daily labour employed in apatite mines during 2018-19 was nil as against 45 in the previous year.

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	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	**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-beneficiable	-	-	-	-	-	-	-	3360	2363000	50000	666646	3083006	3083006
Beneficiable	-	-	-	-	-	-	-	12477	1875250	4561175	351000	6799902	6799902
Blendable	-	-	-	-	-	-	-	2184	-	-	-	2184	2184
Unclassified	-	-	-	-	-	-	-	-	1000000	-	-	1000000	1000000
Not-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.

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

(In tonnes)

State/Grade	Reserves				Remaining Resources								Total Resources
	Proved	Probable		Total	Feasibility	Pre-feasibility		Measured	Indicated	Inferred	Reconnaissance	Total	
	STD111	STD121	STD122	(A)	STD211	STD221	STD222	STD331	STD332	STD333	STD334	(B)	(A+B)
All India : Total	**43832936**	**5179**	**1969370**	**45807485**	**10679080**	**36271671**	**25008353**	**2912633**	**3549750**	**185771368**	**2678275**	**266871130**	**312678615**
By Grades													
Chemical Fertilizer	8612446	5179	439204	9056829	-	12936477	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
Beneficiable	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.

Table – 3 : Production of Apatite, 2017-18 and 2018-19
(By Sectors/States/Districts/Grades)

(Quantity in tonnes; Value in `'000)

State/District	2017-18			2018-19 (P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
India	**2***	-	-	-	-	-
Public sector	1*	-	-	-	-	-
Private sector	1*	-	-	-	-	-
Andhra Pradesh	**1***	-	-	-	-	-
Visakhapatnam	1*	-	-	-	-	-
West Bengal	**1***	-	-	-	-	-
Purulia	1*	-	-	-	-	-

** Only labour reported.*

Table – 4 : Mine-head Closing Stocks of Apatite, 2017-18 & 2018-19
(By States/Grades)

(In tonnes)

State	2017-18	2018-19 (P)
India	**6521**	**6521**
Andhra Pradesh	215	215
West Bengal	6306	6306

Phosphorite/Rock Phosphate

The total production of phosphorite/rock phosphate at 1,285 thousand tonnes in 2018-19 decreased by 15% as compared to that in the previous year (Tables - 5 to 7).

There were 6 reporting mines in both the years. Rajasthan continued to be the principal producing State contributing 92% of the total production and the remaining 8% share was contributed by Madhya Pradesh.

The mine-head closing stocks of phosphorite/ rock phosphate in the year 2018-19 were 2,245 thousand tonnes as compared to 2,735 thousand tonnes in 2017-18 (Table-8).

The average daily labour employed in phosphorite/ rock phosphate mines in 2018-19 was 1,096 as against 1,279 in the previous year.

Table – 5 : Principal Producers of Phosphorite/Rock Phosphate, 2018-19

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
Khajuraho Stones (India) Pvt. Ltd, Sagar Road Dhadari, Chhatarpur-471 001, Madhya Pradesh.	Madhya Pradesh	Chhatarpur

Table – 6 : Production of Phosphorite/Rock Phosphate, 2016-17 to 2018-19 (By States)

(Quantity in tonnes; Value in `'000)

State	2016-17		2017-18		2018-19 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**1124440**	**2996711**	**1515645**	**366826**	**1284580**	**3547584**
Madhya Pradesh	149700	129033	113947	108783	98600	79296
Rajasthan	974740	2867678	1401698	3559484	1185980	3468288

Table – 7 : Production of Phosphorite, 2017-18 and 2018-19 (By Sectors/States/Districts/Grades)

(Quantity in tonnes; Value in `'000)

State/ District	2017-18							2018-19 (P)						
	No.of mines	Grade: P_2O_5 content				Total		No. of mines	Grade: P_2O_5 content				Total	
		Above 30%	Above 25-30%	Above 20-25%	Up to 20%	Qty	Value		Above 30%	Above 25-30%	Above 20-25%	Up to 20%	Qty	Value
India	**6**	**299199**	**496906**	**8216**	**711324**	**1515645**	**3668267**	**6**	**313464**	**420158**	**-**	**550958**	**1284580**	**3547584**
Public Sector	4	299199	494426	-	673367	1466992	3624113	4	313464	420158	-	452358	1185980	3468288
Private Sector	2	-	2480	8216	37957	48653	44154	2	-	-	-	98600	98600	79296
Madhya Pradesh	**4**	**-**	**2480**	**8216**	**103251**	**113947**	**108783**	**4**	**-**	**-**	**-**	**98600**	**98600**	**79296**
Chhatarpur	2	-	2480	8216	48279	58975	52907	2	-	-	-	98600	98600	79296
Jhabua	1	-	-	-	38420	38420	41839	1	-	-	-	-	-	-
Sagar	1	-	-	-	16552	16552	14037	1	-	-	-	-	-	-
Rajasthan/	**2**	**299199**	**494426**	**-**	**608073**	**1401698**	**3559484**	**2**	**313464**	**420158**	**-**	**452358**	**1185980**	**3468288**
Udaipur	2	299199	494426	-	608073	1401698	3559484	2	313464	420158	-	452358	1185980	3468288

** Only labour reported.*

Table –8: Mine-head Closing Stocks of Phosphorite/Rock Phosphate, 2017-18 & 2018-19

(In tonnes)

State	2017-18					2018-19 (P)				
	Grade: P_2O_5 content					Grade: P_2O_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	**761640**	**255927**	**113186**	**1604006**	**2734759**	**623682**	**92880**	**78696**	**1449626**	**2244884**
Madhya Pradesh	-	1377	10306	93781	105464	-	1377	3304	58498	63179
Rajasthan	761640	254550	102880	1510225	2629295	623682	91503	75392	1391128	2181705

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% 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 2017-18 & 2018-19.

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 in Udaipur district, 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 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 55^0 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 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% 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 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% 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 DAP/Phos Acid 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.)

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

As per Ministry of Chemicals and Fertilizers Annual Report 2018-19, presently, there are about 32 large size urea, 21 DAP and complex, 110 SSP and 2 ammonium sulphate plants.

Among the major fertilizer products, the estimated production of urea during the year 2018-19 was 24.00 million tonnes (7.01 million tonnes from Public Sector, 6.90 million tonnes from Cooperative Sector and 10.08 million tonnes from Private Sector), Diammonium Phosphate (DAP) 3.90 million tonnes (1.42 million tonnes from Cooperative Sector and 2.48 million tonnes from Private Sector), complex fertilizers 8.99 million tonnes (1.22 million tonnes from Public Sector, 2.15 million tonnes from Cooperative Sector and 2.48 million tonnes from Private Sector).

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 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) at Bardala (Uttar Pradesh); Kanpur Fertilizer and Cements Ltd (KFCL) at Kanpur (Uttar Pradesh); Indo-Gulf Fertilizers Limited at Jagdishpur Uttar Pradesh, etc.

The plants in the Co-operative Sector that 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, RSMML has a beneficiation plant in Jhamarkotra in Rajasthan, while 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 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 also has 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 countries which are rich in fertilizer resources with arrangements to buy back and to enter into long-term agreement for supplying fertilizer to India. The Department of Fertilizers has undertaken joint ventures abroad with 5 countries in the previous years. Although during the year 2017-18, no joint venture with any country was signed, a number of major developments that took place with the following countries were reported.

Algeria: An Algerian Government owned mining company and other mining companies like ASMIDAL visited India. During their interaction, the delegation invited Indian companies for undertaking feasibility studies for cooperation in the Fertilizer Sector. Subesquently, the Algerian side shared a draft MoU

which has considerable changes as compared to the MoU prepared by Indian side. The comments received have been incorporated in the draft Framework Agreement and the same has been shared with MEA for further sharing with Algerian side.

Malaysia: The Malaysian Prime Minister presented a proposal for the setting up of a urea and ammonia manufacturing plant in Melaka, Malaysia with production capacity of 2.4 million tonnes of urea and 1.35 million tonnes for ammonia per annum at an estimated investment for USS 2.1 billion with a assured G2G buy-back arrangement between India and Malaysia. Subsequently, an MoU was signed between India and Malaysia on 01.04.2017. Commercial Negotiation Committee has already had a round of discussion with the Malaysian side and further correspondances with them are on. There has been general agreement on various terms and conditions factoring the formula for determining prices. A revised proposal has been sent to Malaysian side recently in this regard. Their response is awaited.

Iran: The RCF-GSFC delegation visited Tehran from 6-9 November, 2016 to discuss setting up of Urea-Ammonia plant in Chabahar Free Trade Zone. The delegation had a meeting with five potential JV partners. Among five parties, at prima facie, only two parties, i.e., M/s Tadbir Energy Development Company and M/s Pasargad Energy Development Company (PEDC) was found interested in proposed JV. A decision on the project is on hold owing to geo-political tensions in the region. The RCF/GSFC would update DOF on the developments once MEA clarifies their stand on Iran, including possibility of funding the project. Further, a meeting under Chairpersonship of Secretary (F) had been held on 03.05.17, after it has been decided that: a) PDIL would provide global scenario of demand & supply of urea and also finalise long-term offtake agreement. b) RFC & GSFC would explore possibilities of engaging ICICI or ILFS for loan syndication. c) Advice of MEA has been sought on whether to go for JV or not.

Gabon: An invitation letter was received from Govt. of Gabon inviting Govt. of India to establish a Urea-Ammonia Joint Venture Company in the Gabon Fertilizer Project. Rashtriya Chemicals and Fertilizers, a Public Sector Organisation, has recently completed a due diligence of the project.

Apart from above, talks are also being held with countries like Belarus, Saudi Arabia, Qatar etc., regarding Joint Venture Possibilities and Long-term Offtake Agreement.

RESEARCH AND DEVELOPMENT

RSMML has developed the organic fertilizer called Phosphate Rich Organic Manure (PROM) by using high-grade rock phosphate with farmyard waste and other organic matter. The field trials conducted through different agricultural unversities in the country have shown that the agronomic efficacy of this new P-fertilizer is higher than that of the complex phosphatic fertilizers available in the market today. 'PROM' is suitable to neutral and alkaline soils, which will prove to be a boon to the Indian farmers. In the long run, this product will be a winner as it has significant price advantage vis-a-vis the other chemical fertiizers. Commercialisation of the PROM technology will help utilisation of waste and also help in conservation of the mineral rock phosphate as PROM shows good residual effect.

1. R&D efforts in the following areas strengthened the Company's operation through technology absorption, adaptations & innovation:
   a) A research project has been awarded to MPUA&T, Udaipur for `11,62,500/- for three years to increase agronomic efficacy of secondary ore which is being produced as intermediate product and presently not used. The quantity is about 50 lakh tonnes.
   b) Productivity studies of HEMM at Jhamarkotra Mines.
   c) Beneficiation of secondary rock phosphate.
2. Benefits derived as a result of the above R&D:
   a) Strengthening of market share.
   b) Converting waste into useful product.
   c) Conservation of Mineral.
   d) Futrue plan of action-Energy efficient process.
3. The Company has developed the low cost organic fertilizer "PROM".
4. Two patents have been filed by the Company jointly with MLS University, Udaipur which got approved under the title i) "process for making slow release phosphate fertiliser". ii) "An eco-friendly process for making EPSOM and Gypsum".
5. The Company has introduced 30% crushed Rock phosphate replacing 31.5% CRP, which has improved mineral conservation.

6. Benefits derived as a result of the above efforts are product imporvement, cost reduction, product development, import substitution, etc.

Above efforts helped in satisfying the consumer needs as well as business requirements by intorducing new products.

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

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 0.035 CO_2% : P_2O_5%
3. Origin of rock phosphate Sedimentary
4. Mesh size 100
5. Hydroxyl ion in crystal lattice 2 is higher indicating substitution of OH for PO_4:H_2O
6. Grade of rock phosphate powder 16% P_2O_5 citrate soluble fraction
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 apparent consumption of apatite and rock phosphate in 2017-18 was about 9.23 million tonnes.

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:

1. domestic production based on indigenous imported rock phosphate and imported sulphur.
2. domestic production based on imported intermediates, viz, phosphoric acid.
3. imports of finished fertilizers.

Government of India notified new Urea Policy extended for the period 01.6.2015 to 31.3.2019 for existing gas-based urea manufacturing units.

WORLD REVIEW

The world reserves of phosphate rock are about 69 billion tonnes, located mainly in Morocco & Western Sahara (72%), China (5%) and Syria & Algeria (3% each). The remaining 17% is located in other countries (Table - 9).

The world production of phosphate rock decreased slightly by 9% to 232 million tonnes in 2018 from 255 million tonnes in 2017. China (42%), Morocco (16%), USA (12%), Russia (6%) and Jordan (3%) have been the major producers (Table- 10).

To give a generalised view of the development in various countries, the country wise description is sourced from latest available publication of Minerals Yearbook 'USGS' 2016 is furnished below:

Morocco

OCP Group continued with an expansion programme that was to increase its mine capacity from 30.1 Mt/yr to 52.1 Mt/yr during the next decade. In 2016, construction was ongoing at the Khouribga and Gantour mining areas. A 10 Mt/yr expansion at Khouribga was completed in 2016. OCP planned to open new mines at Meskala deposit in the Essaouisa 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 mine was part of the Wa'ad Al Shammal phosphate project joint venture among MPC (60%), Mosaic (25%) and Saudi Basic Industries Corp. (15%). The project included 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 – 9: World Reserves of Phosphate Rock (By Principal Countries)

(In '000 tonnes)

Country	Reserves
World: Total (rounded)	**69000000**
Algeria	2200000
Australia	1200000[5]
Brazil	1700000
China	3200000
Egypt	1300000
Finland	1000000
India	46000
Israel	62000
Jordan	1000000
Kazakhstan	260000
Mexico	30000
Morocco & Western Sahara	50000000
Peru	210000
Russia	600000
Saudi Arabia	1400000
Senegal	50000
South Africa	1400000
Syria	1800000
Togo	30000
Tunisia	100000
USA	1000000
Uzbekistan	100000
Vietnam	30000
Other countries	770000

Source: USGS, Mineral Commodity Summaries, February 2020.

[5]For Australia, Joint Ore Reserves Committee compliant reserves were 81 million tons.

Table – 10 : World Production of Phosphate Rock (By Principal Countries)

(In '000 tonnes)

Country	2016	2017	2018
World: Total (rounded off)	**271000**	**255000**	**232000**
China	144398	123132	96326
Morocco	26900	32800	37600
USA	27100	27900	27000*
Russia	12300	13200	13600
Peru	10561	8450	10308
Jordan	7991	8688	8022
Saudi Arabia	5400	5800	6090
Vietnam	3143	4588	5424
Brazil(d)	6500	5345	5098
Israel	3591	2637	3029
Tunisia	3664	4422	2802
Egypt(e)	2556	2500*	2500*
South Africa	1697	2079	2058
Kazakhstan	1830*	1830*	1830*
Senegal	1609	1385	1782
India(f)	1124	1534	1250
Algeria	1274	1112	1204
Finland	940	979	989
Togo	850	733	931
Australia(e)	1037	942	851
Other countries	6386	4796	2854

Source : *BGS, World Mineral Production, 2014-18.*
**:Estimate*
d: Including beneficiated and directly shipped material.
e:Years ended 30 June of that stated.
f: Years ended 31 March following that stated.

FOREIGN TRADE

Exports

In 2018-19, exports of rock phosphate increased drastically to 1,652 tonnes from 395 tonnes achieved in the previous year. Exports of phosphatic fertilizers at 6,947 tonnes in 2018-19 decreased by 21% from 8,762 tonnes recorded in the preceding year. The exports of phosphoric acid decreased drastically by 37% to 360 tonnes from 572 tonnes. Export of elemental phosphorus increased to 610 tonnes from 455 tonnes. Rock phosphate was exported mainly to Italy (53%). Elemental phosphorus was also mainly exported to Italy (42%) . In 2018-19, exports of phosphatic fertilizers were mainly to Nepal (77%) and Tanzania (11%) while phosphoric acid was mainly exported to Vietnam (20%) (Tables- 11 to 16).

Imports

Imports of rock phosphate decreased slightly to 7.5 million tonnes in 2018-19 from 7.7 million tonnes in the previous year. Imports were mainly from Jordan (35%), Morocco (28%) and Egypt (17%). Imports of elemental phosphorus increased slightly to 40,081 tonnes in 2018-19 from 30,639 tonnes in the previous year. The imports of elemental phosphorus were mainly from Vietnam (65%) and Russia (24%). During 2018-19, 2,559 tonnes of phosphatic fertilizers were imported mainly from China (92%). Imports of phosphoric acid decreased marginally to 2.77 million tonnes in 2018-19 from 2.96 million tonnes in the previous year. Imports were mainly from Morocco (34%), Senegal (26%) and Jordan (20%) (Tables- 17 to 22).

Table – 11: Exports of Rock Phosphate (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All countries	**395**	**599**	**1652**	**46795**
Iran	-	-	480	35079
Italy	-	-	871	8150
Bhutan	-	-	40	2365
UAE	9	144	46	950
Bangladesh	382	265	200	119
Nepal	4	162	8	112
Tunisia	-	-	6	15
Czech Republic	-	-	1	4
Malaysia	++	8	++	1
Germany	++	++	++	++
Other countries	++	19	++	++

Figures rounded off

Table – 12 : Exports of Rock Phosphate (Ground) (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**4**	**190**	**573**	**36534**
Iran	-	-	480	35079
Italy	-	-	92	1440
Bangladesh	-	-	++	11
Czech Republic	-	-	1	4
Germany	++	++	++	++
Nepal	4	162	-	-
Sri Lanka	++	18	-	-
Malaysia	++	8	-	-
Saudi Arabia	++	1	-	-
Oman	++	++	-	-

Figures rounded off

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

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (``'000)	Qty (t)	Value (``'000)
All Countries	**391**	**409**	**1080**	**10260**
Italy	-	-	779	6710
Bhutan	-	-	40	2365
UAE	9	144	46	950
Nepal	-	-	8	112
Bangladesh	382	265	200	107
Tunisia	-	-	6	15
Malaysia	-	-	++	1

Figures rounded off

Table – 14: Exports of Phosphorus (Elemental) (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (``'000)	Qty (t)	Value (``'000)
All Countries	**455**	**171596**	**610**	**224682**
Italy	-	-	255	85858
USA	118	39673	90	33314
Brazil	58	22204	40	17087
Indonesia	38	14865	38	16167
Philippines	28	10186	29	11909
Canada	14	4881	28	10575
Pakistan	8	2849	27	10015
Chile	49	18402	18	8775
South Africa	14	5747	14	6330
Ukraine	5	1891	15	6048
Other countries	122	50899	57	18602

Figures rounded off

Table – 15: Exports of Phosphatic Fertilizers (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (``'000)	Qty (t)	Value (``'000)
All Countries	**8762**	**68885**	**6947**	**94622**
Nepal	94	2010	5373	57211
Tanzania	-	-	750	11836
Iran	16	1920	51	11151
Kenya	226	5163	390	7231
Zambia	-	-	208	3641
Uganda	25	419	50	1059
Cote D' Ivoire	-	-	50	830
Guinea	25	546	50	811
Maldives	-	-	21	390
Malaysia	7383	49174	1	243
Other countries	993	9652	3	218

Figures rounded off

Table – 16: Exports of Phosphoric Acid (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (``'000)	Qty (t)	Value (``'000)
All Countries	**572**	**35081**	**360**	**30931**
Belgium	9	3636	16	4045
Vietnam	++	79	73	3924
Nepal	17	1330	40	3042
Mozambique	54	6170	34	2703
Malaysia	3	657	3	2475
Sri Lanka	7	2579	29	2080
UAE	1	140	38	1993
Bangladesh	8	1090	11	1599
Israel	-	-	26	1354
Fiji Islands	-	-	12	1194
Other countries	473	19401	77	6521

Figures rounded off

Table –17 : Imports of Rock Phosphate (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (``'000)	Qty (t)	Value (``'000)
All Countries	**7702634**	**45457006**	**7519156**	**56379204**
Jordan	3104604	19819918	2644129	21942603
Morocco	1584310	11042030	2075879	18342421
Togo	445021	3210465	834190	6249080
Egypt	1838792	7035823	1270762	5863565
Algeria	156672	777211	238447	1277780
UAE	-	-	230190	1255213
Peru	376040	2234336	122404	755364
Senegal	78206	434824	51657	326867
Cyprus	-	-	47450	274531
UK	23	1380	480	29097
Other countries	118966	90109	3568	62683

Figures rounded off

Table – 18: Imports of Rock Phosphate (Ground) (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (``'000)	Qty (t)	Value (``'000)
All Countries	**3114504**	**18783095**	**3815094**	**29617466**
Morocco	1572127	10958492	2075879	18342421
Togo	303491	2176945	589740	4386790
Egypt	955449	3823439	505265	2520009
Jordan	24600	179441	265000	2192201
UAE	-	-	230190	1255213
Senegal	78206	434824	5165	326849
Cyprus	-	-	42450	274531
Algeria	61672	308485	46869	233088
UK	23	1380	480	29097
Hong Kong	-	-	745	25537
Other countries	118936	900089	1819	31730

Figures rounded off

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

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**4588130**	**26673911**	**3704063**	**26761739**
Jordan	3080004	19640477	2379129	19750402
Egypt	883343	3212384	765497	3343557
Togo	141530	1033521	244450	1862290
Algeria	95000	468726	191578	1044692
Peru	376040	2234336	122404	755364
Iran	-	-	988	5167
China	5	52	17	233
Germany	-	-	-	17
Senegal	-	-	-	17
Morocco	12183	83537	-	-
Other countries	25	878	-	++

Figures rounded off

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

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**30639**	**5407470**	**40081**	**7954161**
Vietnam	27118	4817523	26189	5302952
Russia	-	-	9570	1828333
Latvia	-	-	2659	503461
Kazakhstan	3521	589509	801	154510
UAE	-	-	412	81185
USA	++	208	436	78041
Italy	-	-	14	5097
Japan	++	89	++	480
Netherlands	-	-	++	55
UK	++	59	++	33
Other countries	++	82	++	14

Figures rounded off

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

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**2961670**	**111954691**	**2773555**	**147391854**
Morocco	874284	33259707	934954	49482626
Senegal	777615	30227685	734678	38635314
Jordan	674171	25735672	551058	29786774
USA	187614	7112101	207264	10791915
Tunisia	173708	5729396	143129	7456639
South Africa	106471	3820808	85444	4489732
Vietnam	111786	3907769	73725	4321013
China	5751	406718	7997	594592
UAE	-	-	11506	584653
Taiwan	13415	577207	10600	550863
Other countries	36855	1177628	13200	697733

Figures rounded off

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

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**123**	**20478**	**2559**	**99988**
China	37	11298	2345	78031
Spain	49	6785	153	16586
Malaysia	-	-	15	4819
Thailand	23	270	46	552
Turkey	14	1889	-	-
Austria	++	236	-	-

Figures rounded off

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 imports 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 for phosphatic fetilizer 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.