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(Part- III : MINERAL REVIEWS)

57th Edition

APATITE AND ROCK PHOSPHATE

(ADVANCE RELEASE)

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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 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 Apatite production was 'nil' in last two years, i.e. 2017-18 and 2016-17. However, production was reported in 2015-16 at 110 tonnes (Tables -3 to 5).

The mine-head closing stocks at the end of 2017-18 was 6521 tonnes as against 6641 tonnes in 2016-17 (Table-6). The average daily labour employed in apatite mines during 2017-18 was 45 as against 58 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 (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	**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 : Producers of Apatite, 2017-18

Name and address of producer	Location of mine	
	State	District
Andhra Phospate (P) Ltd, 45-58-17/5,Narasimha Nagar, Visakhapatanam-530 024.	Andhra Pradesh	Visakhapatanam
West Bengal Mineral Development & Trading Corporation Ltd, 13th Nellie Sengupta Sarani, Kolkata-700 087.	West Bengal	Purulia

Table – 4 : Production of Apatite, 2015-16 to 2017-18 (By States)

(Quantity in tonnes; Value in ₹'000)

State	2015-16		2016-17		2017-18 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	110	387	-	-	-	-
Andhra Pradesh	110	387	-	-	-	-

Table – 5 : Production of Apatite, 2016-17 and 2017-18 (By Sectors/States/Districts/Grades)

(Quantity in tonnes; Value in ₹'000)

State/District	2016-17			2017-18 (P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
India	**2***	**-**	**-**	**2***	**-**	**-**
Public sector	1*	-	-	1*	-	-
Private sector	1*	-	-	1*	-	-
Andhra Pradesh	**1***	**-**	**-**	**1***	**-**	**-**
Visakhapatnam	1*	-	-	1*	-	-
West Bengal	**1***	**-**	**-**	**1***	**-**	**-**
Purulia	1*	-	-	1*	-	-

** Only labour reported.*

Table – 6 : Mine-head Closing Stocks of Apatite, 2016-17 & 2017-18 (By States/Grades)

(In tonnes)

State	2016-17	2017-18 (P)
India	**6641**	**6521**
Andhra Pradesh	335	215
West Bengal	6306	6306

Phosphorite/Rock Phosphate

The total production of phosphorite/rock phosphate at 1,534 thousand tonnes in 2017-18 increased by 36% as compared to that in the previous year (Tables - 7 to 9).

There were 6 reporting mines in both the years. Rajasthan continued to be the principal producing state, contributing 93% of the total production and the remaining 7% was contributed by Madhya Pradesh.

The mine-head closing stocks of Phosphorite/ Rock Phosphate in year 2017-18 were 2,736 thousand tonnes as compared to 2,491 thousand tonnes in 2016-17 (Table-10).

The average daily labour employed in phosphorite/ rock phosphate mines in 2017-18 was 1192 as against 1,222 in the previous year.

Table – 7 : Principal Producers of Phosphorite/Rock Phosphate, 2017-18

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
Madhya Pradesh State Mining Corp. Ltd, Prayas Bhavan, Block No. 1 A, 2nd Floor, Jail Road, Arera Hills, Bhopal-462 011 Madhya Pradesh.	Madhya Pradesh	Chhatarpur Jhabua Sagar
Khajuraho Stones (India) Pvt. Ltd, Sagar Road Dhadari, Chhatarpur-471 001, Madhya Pradesh.	Madhya Pradesh	Chhatarpur

Table – 8 : Production of Phosphorite/Rock Phosphate, 2015-16 to 2017-18 (By States)

(Quantity in tonnes; Value in ₹'000)

State	2015-16		2016-17		2017-18 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**1571863**	**3763823**	**1124440**	**2996711**	**1534269**	**3771584**
Madhya Pradesh	66260	55602	149700	129033	113303	98920
Rajasthan	1505603	3708221	974740	2867678	1420966	3672664

Table – 9 : Production of Phosphorite, 2016-17 and 2017-18 (By Sectors/States/Districts/Grades)

(Quantity in tonnes; Value in ₹'000)

State/ District	2016-17							2017-18 (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**	**584820**	**9898**	**66798**	**462924**	**1124440**	**2996711**	**6**	**769896**	**25928**	**6642**	**731803**	**1534269**	**3771584**
Public Sector	4	584820	-	-	449924	1034744	2905471	4	769896	23448	-	692915	1486259	3732060
Private Sector	2	-	**9898**	**66798**	13000	89696	91240	2	-	2480	6642	38888	48010	39524
Madhya Pradesh	**4**	**-**	**1100**	**66798**	**81802**	**149700**	**129033**	**4**	**-**	**2480**	**6642**	**104181**	**113303**	**98920**
Chhatarpur	2	-	1100	66798	39279	107177	92509	2	-	2480	6642	49210	58332	48121
Jhabua	1	-	-	-	2523	2523	3204	1	-	-	-	38420	38420	36097
Sagar	1	-	-	-	40000	40000	33320	1	-	-	-	16551	16551	14702
Rajasthan/	**2**	**584820**	**8798**	**-**	**381122**	**974740**	**2867678**	**2**	**769896**	**23448**	**-**	**627622**	**1420966**	**3672664**
Udaipur	2	584820	8798	-	381122	974740	2867678	2	769896	23448	-	627622	1420966	3672664

** Only labour reported.*

Table –10: Mine-head Closing Stocks of Phosphorite/Rock Phosphate, 2016-17 & 2017-18 (By States/Grades)

(In tonnes)

State	2016-17					2017-18 (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	**895433**	**4310**	**146243**	**1444601**	**2490587**	**754956**	**262786**	**113186**	**1605056**	**2735984**
Madhya Pradesh	-	1981	27006	58392	87379	-	1377	10306	93778	105461
Rajasthan	895433	2329	119237	1386209	2403208	754956	261409	102880	1511278	2630523

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 (1820%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 & 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 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 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 55^0 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 fertilizers scenario 2017, presently, there are about 30 large size UREA, 32 DAP and complex, 105 SSP and 2 ammonium sulphate plants.

Among the major fertilizer products, the estimated production of urea during the year 2017-18 was 24.25 million tonnes (6.97 million tonnes from Public Sector, 6.40 million tonnes from Cooperative Sector and 10.88 million tonnes from Private Sector), Diammonium Phosphate (DAP) and complex fertilizer 5.03 million tonnes (1.98 million tonnes from Cooperative Sector and 3.05 million tonnes from Private Sector), complex fertilizers) 9.038 million tonnes (1.31 million tonnes from Public Sector, 2.06 million tonnes from Cooperative Sector and 5.66 million tonnes from Private Sector) during 2017-18 (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 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, 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 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. The Department of Fertilizer has undertaken joint ventures abroad with 5 countries in the previous years. Although during the year 2016-17, no joint venture with any country was signed by this Department but a number of major develpments took place with the following countires.

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, Algerian side shared a draft MoU which has considerable changes as compared to the MoU prepared by Indian side. The same is under examination.

Malaysia: The Malaysian Prime Minister presented a proposal for the setting up of a urea and ammonia manufactuing 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. Later, the MoU has been 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.

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

RESEARCH AND DEVELOPMENT

RSMML has developed the organic fertilizer called Phosphate Rich Organic Manure (PROM) by using high grade rock phosphate with farm yard 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 marked 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 utilization 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 year

to increase agronomic efficacy of secondary ore which is being produced as intermediate product and presently not used. The quantity is about 50 lakhs 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.

3. Company has developed the low cost organic fertilizer "PROM".

4. Two patents have been filed and approved by the Company jointly with MLS University, Udaipur under the title i) "process for making slow release phosphate fertiliser". ii) "An eco-friendly process for making EPSOM and Gypsum".

5. Company has introduced 30% crushed Rock phosphate replacing 31.5% CRP.

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 $CO_2\% : P_2O_5\%$	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 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:

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 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 70 billion tonnes, located mainly in Morocco & Western Sahara (71%), Algeria (3%), China (5%), and other countries which contribute the remaining 18% (Table-11).

The world production of phosphate rock slightly decreased to 253 million tonnes in 2017 from 271 million tonnes in 2016. China (49%), Morocco (13%), USA (11%), Russia (5%) and Jordan (3%) have been the major producers (Table-12).

To give a generalised view of the development in various countries the country-wise description is sourced from latest available publication of Mineral 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 – 11: World Reserves of Phosphate Rock (By Principal Countries)

(In '000 tonnes)

Country	Reserves
World: Total (rounded)	**70000000**
Algeria	2200000
Australia	1100000
Brazil	1700000
China	3200000
Egypt	1300000
Finland	1000000
India*	46000
Israel	67000
Jordan	1000000
Kazakhstan	260000
Mexico	30000
Morocco & Western Sahara	50000000
Peru	400000
Russia	600000
Saudi Arabia	1400000
Senegal	50000
South Africa	1500000
Syria	1800000
Togo	30000
Tunisia	100000
Vietnam	30000
USA	1000000
Uzbekistan	100000
Other countries	770000

Source: Mineral Commodity Summaries, February 2019.

**India's total reserves/resources as on 1.5.2015 is 312.67 m.t.*

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

(In '000 tonnes)

Country	2015	2016	2017
World: Total (rounded)	**264000**	**271000**	**253000**
Algeria	1289	1274	1300[e]
Australia	1028	1037	942
Brazil[b]	6100	6500	5500
China	142039	144398	123132
Egypt	3427	3000[e]	3000[e]
India*	1572	1124	1534
Israel	3427	3591	2637
Jordan	8336	7991	8688
Kazakhstan[e]	1830	1830	1830
Mexico	1929	3294	2307
Morocco	26264	26900	32800
Peru	11162	10561	8450
Russia	11500	12300	12500
Saudi Arabia	2002	5400	5670
Senegal	1062	1609	1385
South Africa	1852	1697	2079
Togo	1150	850	733
Tunisia	3228	3664	4422
USA	27400	27100	27700
Vietnam	2923	3143	3239
Other countries	4494	4014	3458

Source : *World Mineral Production, 2013-17, BGS*

b: Including beneficiated and directly shipped material.

**India's production was 1.57,1.12 and 1.53 million tonnes respectively during 2015-16, 2016-17 and 2017-18.*

FOREIGN TRADE

Exports

In 2017-18, exports of rock phosphate decreased drastically to 395 tonnes from 5915 tonnes achieved in the previous year. Exports of phosphatic fertilizers at 8762 tonnes in 2017-18 decreased drastically from 24181 tonnes recorded in the preceding year. The exports of phosphoric acid increased drastically to 569 tonnes from 227 tonnes. Export of elemental phosphorus remained constant in both the years. Rock phosphate was exported mainly to Bangladesh (98%). Elemental phosphorus was mainly exported to USA (26%) . In 2017-18, exports of phosphatic fertilizers was mainly to Malaysia (84%) and Sri Lanka (9%) while phosphoric acid was mainly exported to Egypt (71%) (Tables- 13 to 18).

Imports

Imports of rock phosphate decreased slightly to 7.7 million tonnes in 2017-18 from 7.51 million tonnes in the previous year. Imports were mainly from Jordan (40%), Egypt (24%) and Morocco (21%). Imports of elemental phosphorus increased marginally to 30,639 tonnes in 2017-18 from 28,356 tonnes in the previous year. The imports of elemental phosphorus were mainly from Vietnam (81%). During 2017-18, 123 tonnes of phosphatic fertilizers were imported mainly from Spain (40%). Imports of phosphoric acid increased marginally to 2.96 million tonnes in 2017-18 from 2.49 million tonnes in the previous year. Imports were mainly from Morocco (30%), Senegal (26%) and Jordan (23%) (Tables- 19 to 24).

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All countries	**5915**	**8615**	**395**	**598**
Bangladesh	508	335	382	265
Nepal	5214	5576	4	162
UAE	-	-	9	144
Sri Lanka	-	-	++	18
Malaysia	112	890	++	8
Saudi Arabia	-	-	++	1
Pakistan	19	683	-	-
Israel	9	42	-	-
Germany	++	6	-	-
Other countries	53	1083	-	-

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**2793**	**4898**	**4**	**189**
Nepal	2652	3229	4	162
Sri Lanka	-	-	++	18
Malaysia	112	890	++	8
Saudi Arabia	-	-	++	1
Congo Dem. Rep.	++	35	-	-
Israel	9	42	-	-
Germany	++	6	-	-
China	1	13	-	-
Pakistan	19	683	-	-

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**3122**	**3717**	**391**	**409**
Bangladesh	508	335	382	265
UAE	-	-	9	144
Bahrain	52	1035	-	-
Nepal	2562	2347	-	-

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**455**	**175773**	**455**	**171597**
USA	96	34355	118	39673
Brazil	48	19900	58	22204
Chile	10	4282	49	18402
Indonesia	38	15510	38	14865
Philippines	34	12892	28	10186
Sweden	14	4905	22	7540
Hungary	20	7238	20	7135
Iran	7	4366	8	6851
South Africa	28	11845	14	5747
Egypt	18	7786	14	5031
Other countries	142	52694	86	33963

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**24181**	**131548**	**8762**	**68885**
Malaysia	12855	90413	7383	49174
Sri Lanka	500	4614	812	6295
Kenya	57	2012	226	5163
Kuwait	-	-	14	2193
Nepal	1547	16848	94	2010
Iran	-	-	16	1920
UAE	-	-	140	615
Guinea	-	-	25	546
Yemen Republic	-	-	27	519
Uganda	-	-	25	419
Other countries	9222	17661	++	31

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**227**	**58406**	**569**	**35080**
Egypt	++	35	404	12469
Mozambique	-	-	54	6170
Belgium	16	3714	9	3636
Sri Lanka	8	2326	7	2579
Philippines	1	159	26	1525
Nepal	7	259	17	1330
Turkey	2	222	16	1250
Bangladesh	7	938	8	1090
Singapore	++	20	2	875
Malaysia	45	4582	3	657
Other countries	141	46151	23	3499

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**7511445**	**49513134**	**7702634**	**45457006**
Jordan	2782977	19361379	3104604	19819918
Morocco	1107756	9340944	1584310	11042029
Egypt	2180162	10133979	1838792	7035823
Togo	509295	4499365	445021	3210466
Peru	748905	4948168	376040	2234336
Algeria	48092	316309	156672	777211
South Africa	28100	234569	64570	510192
Senegal	-	-	78206	434824
Mozambique	-	-	24190	184363
Israel	103545	635099	29087	169038
Other countries	2613	43322	1142	38806

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**2737390**	**18646790**	**3114504**	**18783095**
Morocco	1107756	9340944	1572127	10958492
Egypt	1018360	4694792	955449	3823439
Togo	252912	2220935	303491	2176945
South Africa	28100	234569	64570	510192
Senegal	-	-	78206	434824
Algeria	5742	39521	61672	308485
Mozambique	-	-	24190	184363
Jordan	264401	1708055	24600	179441
Israel	58000	371819	29087	169038
China	72	2976	856	28539
Other countries	2047	33179	256	9337

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**4774055**	**30866344**	**4588130**	**26673911**
Jordan	2518576	17653324	3080004	19640477
Egypt	1161802	5439187	883343	3212384
Peru	748905	4948168	376040	2234336
Togo	256383	2278430	141530	1033521
Algeria	42350	276788	95000	468726
Morocco	-	-	12183	83537
Pakistan	169	5677	25	878
China	18	191	5	52
Israel	45545	263280	-	-
Iran	307	1299	-	-

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**28356**	**5285023**	**30639**	**5407470**
Vietnam	24188	4544472	27118	4817523
Kazakhstan	1480	259878	3521	589509
USA	++	63	++	208
Japan	-	-	++	89
China	2688	480524	++	60
UK	++	78	++	59
Germany	++	4	++	19
Belgium	++	4	++	3

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**2490986**	**98873274**	**2961670**	**111954691**
Morocco	898696	36394183	874284	33259707
Senegal	375171	15437595	777615	30227685
Jordan	533299	20543567	674171	25735672
USA	202795	8799644	187614	7112101
Tunisia	136328	4992569	173708	5729396
Vietnam	122375	4361477	111786	3907769
South Africa	86796	3507630	106471	3820808
Chinese Taipei/Taiwan	11621	531829	13415	577207
China	8745	532908	5751	406718
Israel	30370	1234687	10528	405782
Other countries	84790	2537185	26327	771846

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

Country	2016-17		2017-18	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**106**	**6357**	**123**	**20478**
China	55	1087	37	11298
Spain	12	1169	49	6785
Turkey	1	193	14	1889
Thailand	-	-	23	270
Austria	-	-	++	236
Korea, Rep. of	++	28	-	-
USA	3	472	-	-
Mexico	9	2455	-	-
Latvia	26	940	-	-
Switzerland	++	13	-	-

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 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.