Indian Minerals Yearbook 2015

(Part- III : MINERAL REVIEWS)

54th Edition

FLUORITE

(ADVANCE RELEASE)

GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

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December, 2016

21 Fluorite

Fluorite or fluorspar is the common name of the mineral having chemical composition calcium fluoride (CaF_2). It is a mineral with veritable bouquet of brilliant colours from hallmark colour purple to blue, green, yellow, colourless, brown, pink, black and reddish orange. The rich purple colour is by far the most famous and popular colour. It is an important commercial source of fluorine. Fluorite plays a vital role in the manufacture of aluminium, gasoline, insulating foams, refrigerants, steel and uranium fuel.

Mainly two grades of fluorite are involved in consumption and trade, namely, the acid grade containing more than 97% CaF_2 and the sub-acid grade analysing 97% or less CaF_2. The sub-acid grade includes metallurgical and ceramic grades and is commonly known as metallurgical grade. Fluorite production in the country is meagre when compared with the world production. Production of fluorite in the country is reported from the state of Maharashtra in 2013-14 and 2014-15.

In addition to the natural fluorite production, synthetic fluorite is recovered as by-product during uranium processing, petroleum alkylation and stainless pickling. The by-product, fluorosilicic acid, obtained from phosphoric acid plants while processing phosphate rock also supplements fluorite as a source of fluorine.

RESOURCES

As per the UNFC system, the total resources of fluorite in the country as on 1.4.2013 are estimated at 18.19 million tonnes. Out of these, 4.57 million tonnes are placed under reserves category (further classified into 4.5 million tonnes under proved category and 0.06 million tonnes under probable category). Remaining resources comprise 13.6 million tonnes.

By States, Gujarat accounts for 66% of the total resources having 12 million tonnes, followed by Rajasthan with 5.24 million tonnes (29%), Chhattisgarh 0.55 million tonnes (3%) and Maharashtra 0.39 million tonnes (2%). Gradewise, the resources are classified into marketable grade which accounted for 81% of the total resources, low grade (17%) and unclassified grade (2%) (Table-1).

EXPLORATION & DEVELOPMENT

Department of Mining and Geology, Rajasthan carried out exploration in Sirohi district of Rajasthan and occurrence of fluorite was observed at about 2 km NW of village Andoor. The strike length of fluorite vein is more than 100 m with width up to 10 cm showing whitish, purple and yellow in colour and crystalline in form filled in open vug/open fractures. Another isolated hillock, north of village Sardarpura, a fluorite occurrences found within the thin veins. The fluorite here is whitish, purple and yellow in colour.

PRODUCTION, STOCKS & PRICES

The production of fluorite (graded) at 2,947 tonnes in 2014-15 increased by 19% as compared to that in the previous year.

There was only one reporting mines in 2014-15 as against 2 mines 2013-14. The entire output was reported from a public sector mine located in Chandrapur district of Maharashtra owned by Maharashtra State Mining Corporation Ltd (Tables - 2 to 4).

The mine-head closing stock of fluorite (graded) for the year 2014-15 was 94,461 tonnes as against 91,570 tonnes in the previous year (Table-5).

The average daily labour employed in fluorite mines in 2014-15 was 43 as against 62 in the previous year.The domestic price of fluorite are furnished in the General Review on 'Prices'.

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

(In tonnes)

Grade / State	Reserves				Remaining resources								Total resources (A+B)
	Proved STD111	Probable		Total (A)	Feasibility STD211	Pre-feasibility		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	
		STD121	STD122			STD221	STD222						
All India : Total	**4509488**	**63860**	**0**	**4573348**	**697519**	**745390**	**571311**	**1713833**	**6218421**	**3522537**	**145183**	**13614193**	**18187541**
By Grades													
Marketable	4509488	63860	0	4573348	697519	586080	406111	-	5757010	2497534	145183	10089437	14662784
Low	-	-	-	-	-	3790	9680	1710348	445660	1000003	-	3169481	3169481
Unclassified	-	-	-	-	-	155520	155520	3485	15751	25000	-	355276	355276
By States													
Chhattisgarh	-	-	-	-	65889	153132	9288	185485	5573	126088	-	545455	545455
Gujarat	4279230	-	-	4279230	-	-	-	-	5723360	2001920	-	7725280	12004509.7
Maharashtra	230258	63860	-	294118	-	-	-	-	-	100000	-	100000	394118
Rajasthan	-	-	-	-	631630	592258	562023	1528348	489488	1294529	145183	5243458	5243458

Figures rounded off.

Table – 2 : Producer of Fluorite, 2014-15

Name and address of producer	Location of mine	
	State	District
Maharashtra State Mining Corporation Ltd Plot No. 7, Ajni square, Wardha Road, Nagpur-440 015, Maharashtra.	Maharashtra	Chandrapur

Table – 3 : Production of Fluorite (Graded), 2012-13 to 2014-15 (By States)

(Qty in tonnes;value in ₹'000)

State	2012-13		2013-14		2014-15(P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	**3092**	**13818**	**2487**	**11402**	**2947**	**13849**
Maharashtra	3092	13818	2487	11402	2947	13849

Table – 4 : Production of Fluorite (Graded), 2013-14 & 2014-15 (By Sector/States/Districts)

(Qty in tonnes; value in ₹'000)

State/District	2013-14			2014-15(P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
India	**2**	**2487**	**11402**	**1**	**2947**	**13849**
Public Sector	2	2487	11402	1	2947	13849
Gujarat	**1***	**-**	**-**	**-**	**-**	**-**
Vadodara	1*	-	-	-	-	-
Maharashtra	**1**	**2487**	**11402**	**1**	**2947**	**13849**
Chandrapur	1	2487	11402	1	2947	13849

*****: *Only labour reported.*

Table – 5 : Mine-head Stocks of Fluorite, 2013-14 & 2014-15 (By State)

(In tonnes)

State	2013-14	2014-15(P)
India	**91570**	**94461**
Maharashtra	91570	94461

MINING

Maharashtra State Mining Corporation (MSMC) operates Dongargaon fluorite mines in District Chandrapur, Maharashtra. Mining is carried out by semi-mechanised opencast method. The run-of-mine is hand sorted for marketing.

BENEFICIATION

Fluorspar is beneficiated by hand sorting followed by gravity concentration methods such as heavy media, jigs and tables in order to separate calcite and silicate mineral impurities. Low grade fluorite produced is used after beneficiation in the industries. GMDC has a beneficiation plant of 500 tpd capacity located at Kadipani to produce acid grade (96% CaF_2) and metallurgical grade (90% CaF_2) fluorite upgrading the low grade fluorspar ore from 23-25% CaF_2 by flotation method. Besides, it has facility to produce MFC & MET grade powder analysing 75 to 85% CaF_2 & 85 to 92.5% CaF_2 respectively, starch briquettes (81% CaF_2 min) and silicate briquettes (79% CaF_2 min). The Government of Gujarat has accorded approval for setting up beneficiation plant at Kadipani, district Vadodara in joint venture with M/s Gujarat Fluoro Chemicals Ltd, Noida and M/s Navin Fluorine International, Mumbai. They are developing process of beneficiation with new reagents, modification in the plant.

The hand-picked high grade ore from Dongargaon mine of MSMC is beneficiated in a beneficiation plant of M/s SANBRO Corporation Ltd, situated at Waregaon, Koradi, Nagpur district, to produce fluorite concentrate.

CONSUMPTION

Fluorite consumption was 62,600 tonnes in 2014-15. The major consuming industry is the chemical industry which accounted for more than 85% of the total consumption. Industrywise consumption of fluorite is given in Table-6.

Table- 6: Consumption* of Fluorite 2012-13 to 2014-15 (By Industries)

(In tonnes)

Industry	2012-13	2013-14(R)	2014-15(P)
All Industries	**62900**	**62500**	**62600**
Alloy steel	1300(7)	1300(7)	1400(7)
Cement	4100(2)	4100(2)	4100(2)
Chemical	53300(6)	53300(6)	53300(6)
Electrode	1500(13)	1600(13)	1600(13)
Ferro-alloys	200(3)	200(3)	200(3)
Iron & steel	2200(9)	1700(8)	1800(8)
Others (aluminium, foundry glass, Refractories)	300(9)	300(9)	300(9)

Figures rounded off.
Figures in parentheses denote the number of units in organised sector.
** Paucity of data, hence consumption may not be complete.*

SPECIFICATIONS

BIS has prescribed IS: 8587-1993 (First Revision, reaffirmed 2011) for acid grade fluorite for use in chemical industries, and IS: 4574-1989 (Second Revision, reaffirmed 2008) for fluorite in metallurgical industries.

USES

Acid grade fluorite is used as a feedstock in the manufacture of hydrofluoric acid (HF) and to produce aluminium fluoride (AlF_3). The major use of HF is for the production of a wide range of fluorocarbon chemicals, including hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), and fluoropolymers. But, owing to environmental concerns, part of chlorofluorocarbons (CFCs) are replaced by HCFCs. HF is used in the manufacture of uranium tetrafluoride required to make nuclear fuel and fission explosives. It is also used in stainless pickling, petroleum alkylation, glass etching, oil & gas well treatment and as etcher/cleaner in electronic industry.

HF is used in the manufacture of a host of fluorine chemicals used in dielectrics, metallurgy, wood preservatives, herbicides, mouthwashes, decay-preventing dentifrices, plastics and water fluoridation.

AlF_3 manufactured from acid grade fluorite is used as a flux in electrolytic recovery of aluminium. On an average, worldwide consumption of fluorides is about 21 kg for every tonne of aluminium produced. This ranged from 10 to 12 kg per tonne in a modern pre-baked aluminium smelter and about 40 kg in an old Soderberg smelter without scrubber.

Ceramic grade fluorite containing 85 to 95% CaF_2 is used in ceramic industry as a flux and as an opacifier in the production of flat glass, white or opal glass and enamels. The addition of 10-30% ceramic grade fluorspar to glass makes it opaque, white and opalescent. It is also used in the manufacture of magnesium. Some manganese chemicals and welding rod coating.

Metallurgical grade fluorite is used primarily as fluxing agent by steel industry. It is added to slag to make it more reactive through increased fluidity. Fluorite of different grades is used in the manufacture of aluminium, cement and glass fibres. It is also used in the melt shop by foundry industry.

INDUSTRY

Many fluorine-based chemicals like hydrofluoric acid, aluminium fluoride, cryolite, sodium silicofluoride and hydrofluorosilicic acid were produced by chemical and fertilizer industries in the country.

In addition to material produced indigenously, substantial quantity of high grade fluorite was also imported to meet the demand of the fluorine-based chemical industries.

The Tanfac Industries Ltd is a joint sector company of TIDCO and Aditya Birla Group at Cuddalore, Tamil Nadu. It is engaged in the manufacture of fluorine chemicals, such as, aluminium fluoride, anhydrous hydrofluoric acid, sodium silico fluoride, ammonium bifluoride, potassium fluoride, and various other fluorine-based chemicals. The company has an annual installed capacity of 16,500 tonnes each of aluminium fluoride and anhydrous hydrogen fluoride, 67,200 tonnes of sulphuric acid, 14,000 tonnes of hydrofluoric acid and 3,400 tonnes of speciality fluorides. Company has strategically reduced the production of hydrofluoric acid and stiff competition from China in aluminium fluorides segment have led to lower sales volume & higher interest outgo.

Navin Fluorine Industries Ltd, Surat, Gujarat, has an installed capacity of about 22,000 tpy of hydrofluoric acid. The Company produces a number of fluorine chemicals, namely, hydrofluoric acid, cryolite, aluminium fluoride and various other organic and inorganic fluorine-based chemicals.

Sterlite Industries (India) Ltd, a Vedanta Group Company, was planning to set up a high bulk density and low bulk density aluminium fluoride plant of 13,000 tpy capacity at or near Thoothukudi, Tamil Nadu as a joint venture with Maya Rasayan Ltd. The plant will produce aluminium fluoride through hydro-fluorosilicic acid route.

Apatite and rock phosphate containing 3 to 4% CaF_2 was another useful source for recovery of fluorine. Coimbatore Pioneer Fertilizer Ltd has reported production of sodium silicofluoride in the past. Hydrofluorosilicic acid producing units were Rashtriya Chemicals & Fertilizer Ltd, Mumbai, whereas Dharamsi Morarji Chemical Co. Ltd, Ambernath, Maharashtra no longer report production of fluorine chemicals. Aluminium fluoride was being produced by Southern Petrochemical Industries Corporation Ltd, Thoothukudi, Tamil Nadu with an installed capacity of 2,560 tpy.

SUBSTITUTES

Olivine or dolomitic limestone was used as substitute for fluorite in Iron & Steel industry. The by-product fluorosilicic acid from phosphoric acid production was used as a substitute in aluminium fluoride production.

ENVIRONMENT

Fluorine attracts environmental concern. Use of fluorine in drinking water has begun to wane. Fluorine is toxic in high concentration but beneficial in low concentration. Although fluorine has been under attack ever since its use in water in 1949, the only significant health problem with which it has been linked was 'Fluorosis', a disease that involves health defects and bone lesions. This problem is caused by concentration of fluoride that is much higher than the permissible levels in municipal water supplies. As per Indian Standards, the permissible limit of fluoride in the drinking water is 1.5 mg/l. "Defluoridisation by adsorption" is a common economical and efficient method for removal of excess fluoride from drinking water. Electrolytic precipitation based on use of aluminium salts and by electrochemical route, etc. are the other few methods used for defluoridisation.

Fluorine is at the centre of controversy over chlorofluorocarbons (CFCs), which causes depletion of atmospheric ozone layer that protects the earth from ultraviolet radiation, a major cause of skin cancer. The hydrofluorocarbon (HFC) and hydrochlorofluorocarbon (HCFC) compounds, which have been developed as an alternative to CFC, require more hydrofluoric acid than CFC and are expected to boost fluorite consumption. These greenhouse gases are being phased out in stages. It is reported that even if CFC emission is stopped, the present level of these gases may take up to ten years to reach the upper atmosphere where they could persist for a century or more.

According to United Nations Environment Programme (UNEP) ,an international agreement to curtail illegal trade in CFC and other ozone depleting chemicals came into effect on 10 November 1999. The agreement, which was authorised through an amendment to the Montreal Protocol in 1997, requires nations to create licensing system for international sales of ozone depleting chemicals. Further, as a part of the Montreal Protocol, 129 nations agreed on a three-year funding package to enable developing countries to continue their efforts to phase out CFC and other ozone depleting chemicals, and accordingly, the Fund's Executive Committee approved major agreements with China and India to finance the shutdown of CFC production facilities in the two countries during the next ten years.

The United Nations Environment Programme (UNEP) has prepared a Montreal Protocol Handbook that provides additional detail and explanation of the provisions. CIESIN's Thematic Guide on Ozone Depletion and Global Environmental Change presents an in-depth look at causes, human and environmental effects, and policy responses to stratospheric ozone depletion.

WORLD REVIEW

World total reserves of fluorite were 240 million tonnes. World reserves are concentrated mainly in South Africa (17%), Mexico (18%) followed by China (10%) and Mongolia (9%) (Table- 7).

World production of fluorite in 2014 decreased slightly to 6.1 million tonnes from 7.52 million tonnes during the year 2014. China (58%), Mexico (18%) and Mongolia (5%) were the principal producing countries (Table - 8).

China

Hunan Nonferrous Metals Corporation Ltd and Hunan Nonferrous Metals Investment Ltd established a joint venture, the Jinshua Fluorite Company, to recover fluorspar from tailings of the Huangshaoing Mine. The company expected to produce 58,000 tonnes per year of acid grade and 38,000 tonnes per year metallurgical grade fluorspar through a two stages flotation process.

Germany

Nickelhutte AUE GmbH commenced production at a new fluorspar mine in the Ore Mountain. The mine is expected to have a capacity of 40,000 tonnes per year of acid grade fluorspar, which is expected to be sold in the domestic market.

Kenya

The Government of Kenya revised the royalties levied of fluorspar products, increasing royalties in increments from 2% of gross sales value through the end of 2015 to 5% of gross sales value by July 2019.

Namibia

Salvay S A announced it was indefinitely suspending operation at the Okorusu Fluorspar Mine due to depletion of higher grade resources. The company has been unable to economically beneficiate the remaining ore owing to technical issues in the separation of gangue material and unavoidable market conditions.

Spain

Arkema S A announced a plan to close its fluorochemical production plant in Zaramillo. The plant manufactures the HFC refrigirants R 32 and R 143a. In making the announcement, Arkema S A cited increased competition from China and the United States in the f-gas industry as well as the impending implementation of new European regulatory requirements in 2015.

United Kingdom

The Peak District National Park Authority granted British Fluorspar Ltd permission to continue mining at the Milldam Mine until 2028. Currently the mine is producing 65,000 tonnes of acid grade fluorspar and 10,000 tonnes of barite annuallly.

Table – 7 : World Reserves of Fluorite (By Principal Countries)

(In '000 tonnes)

Country	Reserves
World: Total (rounded)	**240000**
China	24000
Iran	3400
Kenya	5000
Mexico	32000
Mongolia	22000
Morocco	580
South Africa	41000
Spain	6000
USA	4000
Other countries	110000

Source: *Mineral Commodity Summaries, 2016.*

Table – 8 : World Production of Fluorite (By Principal Countries)

(In '000 tonnes)

Country	2012	2013	2014
World: Total	**9308**	**7527**	**6170**
Argentina	35	35	35*
Brazil@	24	28	25(e)
Bulgaria	70	82	83
China	6550	5000(e)	3600(e)
Germany	54	49	35
Iran	60	70	70(e)
Kazakhstan(e)	66	66	66
Kenya	91	72	97
Mexico	1237	1210	1110
Morocco	79	81(e)	80
Mongolia	429	337	338
Namibia	91	63	57(e)
Russia(e)	130	56	56
South Africa(e)	225	175	230
Spain	114	129	135
Other countries	53	74	153

Source: *World Mineral Production, 2010-2014.*
@ Including beneficiated and directly shipped material.

FOREIGN TRADE

Exports

Exports of fluorite decreased substantially to 561 tonnes in 2014-15 from 876 tonnes in the previous year. Exports were mainly to Indonesia (34%) and Kuwait (25%). Exports of aluminium fluoride also decreased slightly to 2,831 tonnes in 2014-15 as compared to 3,658 tonnes in the previous year. Exports were mainly to UAE (87%), Brazil (7%) and Japan (5%). Exports of hydrofluoric acid in 2014-15 were 2,291 tonnes against 1,415 tonnes in the previous year. No exports of sodium fluoride were reported during last three years i.e. 2012-13, 2013-14 & 2014-15 (Tables- 9 to 11).

Imports

Imports of fluorite increased considerably to 1.55 lakh tonnes in 2014-15 as compared to 1.17 lakh tonnes in the previous year. Imports were mainly from China (48%), Thailand (22%), Kenya (18%) & South Africa (7%). Imports of aluminium fluoride slightly increased to 30,120 tonnes in 2014-15 from 24,542 tonnes in the previous year. Imports were mainly from China (72%) and Italy (18%). On the other hand, imports of hydrofluoric acid increased marginally to 2,156 tonnes in 2014-15 from 1,372 tonnes in the previous year. Imports were mainly from China (90%) and Chinese Taipei/Taiwan (9%) (Tables- 12 to 14).

Table – 9 : Exports of Fluorite
(By Countries)

Country	2013-14		2014-15(P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**876**	**16549**	**561**	**20763**
Indonesia	211	10386	191	8633
Kuwait	-	-	140	4976
Bangladesh	601	3326	105	2693
Brazil	31	1783	48	2469
Egypt	-	-	24	619
UAE	4	172	37	498
Iran	10	441	10	452
Qatar	-	-	++	130
Bulgaria	-	-	2	99
Kenya	5	170	2	70
Other countries	14	271	2	124

Table – 10 : Exports of Aluminium Fluoride
(By Countries)

Country	2013-14		2014-15(P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**3658**	**257125**	**2831**	**197961**
UAE	3120	209718	2480	171971
Japan	275	29425	150	14045
Brazil	140	8605	200	11892
Nepal	-	-	1	27
Malaysia	-	7	++	18
Maldives	-	-	++	8
Other countries	123	9370	-	-

Table – 11 : Exports of Hydrofluoric Acid (By Countries)

Country	2013-14		2014-15 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1415**	**101403**	**2291**	**162607**
Korea, Rep. of	258	14373	723	37501
Thailand	375	28677	480	35661
Indonesia	332	21890	257	16771
Japan	68	6350	242	22245
Singapore	36	4950	126	18402
Saudi Arabia	29	2687	135	9141
Philippines	44	3686	33	2770
Bangladesh	48	3266	93	5833
Pakistan	66	3135	88	4940
China	23	1507	51	4350
Other countries	136	10882	63	4993

Table – 12 : Imports of Fluorite (By Countries)

Country	2013-14		2014-15(P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**117254**	**2412179**	**155673**	**2967071**
China	72108	1527059	73996	1459578
Thailand	9883	151248	35198	611103
Kenya	15821	314050	29051	537254
South Africa	13054	287885	11998	236548
Norway	1632	37954	2391	54681
UAE	302	6627	550	12822
Turkey	1214	28431	483	11306
Pakistan	1157	16621	585	8611
Spain	294	6151	381	7890
Mongolia	1385	23251	300	6210
Other countries	404	12902	740	21068

Table – 13 : Imports of Hydrofluoric Acid (By Countries)

Country	2013-14		2014-15(P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1372**	**105723**	**2156**	**157766**
China	1103	85972	1950	142297
Chinese Taipei/Taiwan	264	18010	202	13142
UK	++	273	3	1554
Germany	1	946	++	285
Belgium	1	331	1	242
Japan	++	2	++	199
USA	++	41	++	47
Other countries	3	148	-	-

Table – 14 : Imports of Aluminium Fluoride (By Countries)

Country	2013-14		2014-15(P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**24542**	**1738311**	**30120**	**2025904**
China	23422	1663604	21583	1450499
Italy	-	-	5536	375121
Indonesia	1100	73310	3000	200030
USA	-	-	1	254
Other countries	20	1397	-	-

FUTURE OUTLOOK

The resources of fluorite in India are limited and grades of fluorite produced do not meet the specifications of the chemical industry which is the bulk consumer of fluorite. Ambadungar Fluorspar Mine of GMDC is the only domestic source of acid grade fluorite, slightly inferior in quality with high phosphorus content. Hence, to meet the requirements, the domestic chemical industry will have to depend, both qualitatively and quantitatively on imported fluorite in the coming years, both for direct use and for blending with the domestic acid grade fluorite.

As per the Report of the Working Group for 12th plan period (2012-17) the average total consumption of fluorite by all industries has been around 72,000 tonne per annum. The Working Group has estimated the apparent domestic demand of fluorite at 185 thousand tonnes by 2011-12 and at 285 thousand tonnes by 2016-17 at 9% growth rate. The Working Group has recommended that cluster mining approach may be adopted in order to utilise the small deposits for further industrialisation of the mining area in the sector which will improve the workability of small mines. It has also suggested R&D for beneficiation and setting up of facilities to utilise fluorite from other parts of the country in the Chemical Industry.