

38 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; and is rivalled in colour range only by quartz. The rich purple colour is by far the most famous and popular colour. It easily competes with the beautiful purple of amethyst. 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 scarce. At the global level, the country has less production. Production of fluorite in the country is reported from the states of Gujarat, Maharashtra and Rajasthan.

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 1.4.2005 are estimated at 20.17 million tonnes. Out of these, 9.21 million tonnes are placed under reserves

category and 10.95 million tonnes under remaining resources category. The reserves are further classified into 8.58 million tonnes under proved category and 0.63 million tonnes under probable category.

By States, Gujarat accounts for 69% of the total resources having 13.93 million tonnes, followed by Rajasthan with 5.24 million tonnes (26%), Chhattisgarh 0.55 million tonnes (3%) and Maharashtra 0.45 million tonnes (2%). The resources are further classified into marketable grade which accounted for (82%) of the total resources, low grade (16%) and unclassified grade (2%) (Table-1).

PRODUCTION, STOCKS & PRICES

The production of fluorite (total) at 13,782 tonnes in 2009-10 increased considerably by 38% as compared to 9,990 tonnes in the previous year. The production of fluorite (graded) was 4,996 tonnes and that of fluorite (concentrates) 8,786 tonnes during the year under review.

There were three reporting mines in 2009-10. The entire output was reported from public sector. Fluorite (graded) was reported from Maharashtra & Rajasthan and concentrate from Gujarat only (Tables - 2 to 4).

The mine-head stock of fluorite at the end of the year 2009-10 were 3,855 tonnes as against 1,334 tonnes at the beginning of the year (Table - 5).

The average daily labour employed in fluorite mines in 2009-10 was 106 as against 102 in the previous year. The domestic prices of fluorite are furnished in the General Review on 'Prices'.

**Table – 1 : Reserves/Resources of Fluorite as on 1.4.2005
(By Grades/States)**

(In tonnes)

Grade/State	Reserves			Remaining resources					Total resources (A+B)	
	Proved STD111	Probable STD121 STD122	Total (A)	Feasibility STD211	Pre-feasibility STD221 STD222	Measured STD331	Indicated STD332	Inferred STD333		Reconnaissance STD334
All India : Total	8585124	165222 463485 9213831	65889 450168 6224178 1713833 495061 1857527 145183 10951838 20165669							
By Grades										
Low	-	- - -	-	-	3790	9680 1710348	445660	1000003	-	3169481
Marketable	8585124	9702 307965 8902791	65889 446378 6214498	-	33650	832524	145183	7738122	16640913	
Unclassified	-	155520 155520 311040	-	-	3485	15751	25000	44236	355276	
By States										
Chhattisgarh	-	- - -	65889 153132 9288 185485	5573	126088	545455	-	545455		
Gujarat	7663840	- 200160 7864000	-	- 5723360	-	337920	-	6061280	13925280	
Maharashtra	287975	- 64100 352075	-	-	-	100000	-	100000	452075	
Rajasthan	633309	165222 199225 997756	- 297036 491530 1528348	489488	1293519	145183	4245103	5242859		

Figures rounded off.

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Table – 2 : Producers of Fluorite, 2009-10

Name and address of producer	Location of mine	
	State	District
Gujarat Mineral Development Corporation Ltd, Khanij Bhawan, 132Ft. Ring Road, Vastrapur, Ahmedabad, Gujarat.	Gujarat	Vadodara
Maharashtra State Mining Corporation Ltd, Plot No. 7, Ajni Chowk, Wardha Road, Nagpur - 440 015, Dist. Nagpur, Maharashtra.	Maharashtra	Chandrapur
Rajasthan State Mines and Minerals Ltd, C-89-90, Janpath, Lal Kothi, Jaipur - 313 001. Dist. Jaipur, Rajasthan.	Rajasthan	Jalore

**Table – 3 : Production of Fluorite (Graded and Concentrates)
2007-08 to 2009-10
(By States)**

(Quantity in tonnes; value in Rs. '000)

State	2007-08		2008-09		2009-10(P)	
	Quantity	Value	Quantity	Value	Quantity	Value
<u>Fluorite (Total)</u>						
India	7764	65183	9990	104341	13782	148182
Gujarat	3794	45554	6814	88715	8786	126412
Maharashtra	3970	19629	3176	15626	4932	21561
Rajasthan	–	–	–	–	64	209
<u>Fluorite (Graded)</u>						
India	3970	19629	3176	15626	4996	21770
Maharashtra	3970	19629	3176	15626	4932	21561
Rajasthan	–	–	–	–	64	209
<u>Fluorite (Concentrates)</u>						
India	3794	45554	6814	88715	8786	126412
Gujarat	3794	45554	6814	88715	8786	126412

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**Table – 4 : Production of Fluorite (Graded and Concentrates)
2008-09 and 2009-10
(By Sector/States/Districts)**

(Quantity in tonnes; value in Rs. '000)

State/District	2008-09			2009-10(P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
Fluorite (Total)						
India	2	9990	104341	3	13782	148182
Public sector	2	9990	104341	3	13782	148182
Fluorite (Graded)						
India	1	3176	15626	2	4996	21770
Public sector	1	3176	15626	2	4996	21770
Maharashtra	1	3176	15626	1	4932	21561
Chandrapur	1	3176	15626	1	4932	21561
Rajasthan	–	–	–	1	64	209
Jalore	–	–	–	1	64	209
Fluorite (Concentrates)						
India	1	6814	88715	1	8786	126412
Public sector	1	6814	88715	1	8786	126412
Gujarat	1	6814	88715	1	8786	126412
Vadodara	1	6814	88715	1	8786	126412

**Table – 5 : Mine-head Stocks of Fluorite
2009-10 (P)
(By State)**

(In tonnes)

State	At the beginning of the year	At the end of the year
India	1334	3855
Maharashtra	1334	3855

MINING

Ambadungar Fluorspar mine in Gujarat owned by GMDC is the largest fluorite mine in the country. Mining is carried out by opencast method, using heavy earth moving equipment of 0.9 cu m, 0.17 cu m hydraulic excavators with 7 tonnes dumpers.

Maharashtra State Mining Corporation (MSMC) operates Dongargaon fluorite mines manually in Chandrapur district, Maharashtra. The run-of-mine was hand sorted for marketing.

When in operation, RSMML carries out semi-mechanised opencast mining in Karara, Tavidar and Lakhawas areas in Jalore district, Rajasthan. Fluorite of different grade is obtained manually by hand breaking and sorting method.

BENEFICIATION

Low grade fluorite produced is used after beneficiation in the industries. GMDC has a beneficiation plant of 1,82,000 tpy capacity located at Kadipani to produce acid grade and metallurgical grade fluorite, analysing 92.5 to 95.5 % CaF₂ and 86 to 93% CaF₂, respectively. Besides, it has facility to produce MFC powder analysing 65 to 85% CaF₂ starch briquettes (81% CaF₂ min) and silicate briquettes (79% , CaF₂ min).

RSMML has a Pilot Beneficiation Plant located at Village Verdha, about 28 km from Dungarpur to process the mineral rejects (-20% CaF₂) lying in the mine. The plant has 10-15 tpd capacity to produce fluorite powder analysing 80-85% CaF₂. No production was reported in 2009-10.

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 71,700 tonnes in 2009-10. The major consuming industry is the chemical industry which accounted for more than 78% of the total consumption reported. Industrywise consumption of fluorite is given in Table-6.

Table – 6 : Reported Consumption of Fluorite 2007-08 to 2009-10 (By Industries)

Industry	(In tonnes)		
	2007-08	2008-09(R)	2009-10(P)
All Industries	70000	71000	71700
Alloy steel	3000 (12)	3000 (12)	3000 (12)
Aluminium	100 (3)	100 (3)	100 (3)
Cement	7600 (4)	8500 (4)	8900 (4)
Chemical	56000 (4)	56000 (4)	56000 (4)
Electrode	300 (8)	300 (8)	300 (8)
Ferro-alloys	100 (5)	100 (5)	200 (5)
Foundry	300 (8)	200 (8)	200 (8)
Glass	200 (5)	200 (5)	200 (5)
Iron & steel	2400 (6)	2600 (6)	2800 (6)

Figures rounded off.

Data collected on non-statutory basis.

Figures in parentheses denote the number of units in organised sector reporting consumption.*

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

SPECIFICATIONS

BIS has prescribed IS: 8587 - 1993 (First Revision, reaffirmed 1999) for acid grade fluorite for use in chemical industries, and IS: 4574 - 1989 (Second Revision, reaffirmed 2003) 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 (AlF₃). The major use of HF is for the production of a wide range of fluorocarbon chemicals, including hydrofluoro-

carbons (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.

AlF₃ manufactured from acid grade fluorite is used in electrolytic recovery of aluminium. On an average, world wide 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% CaF₂ is used in ceramic industry as a flux and as an opacifier in the production of flat glass, white or opal glass and enamels.

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 inorganic fluorine-based chemicals, such as, aluminium fluoride, anhydrous hydrofluoric acid, sodium silico fluoride, ammonium bifluoride, potassium fluoride, cryolite and various other fluorine-based chemicals. The company has an annual installed capacity of 16,500 tonnes of aluminium fluoride, 66,000 tonnes of sulphuric acid, 14,000 tonnes of hydrofluoric acid and 3,500 tonnes of speciality fluorines.

The 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. The plant will produce aluminium fluoride through hydro-fluorosilicic acid route.

Triveni Chemicals is engaged in manufacture of fluorides, fluoroborate, silico fluoride, etc. Similarly, Tarun Fluo-Chem Pvt Ltd, manufactures fluoroborates, fluorides, dilute hydrofluoric acid, fluoroboric acid, fluorotitanic acid, etc.

Apatite and rock phosphate containing 3 to 4% CaF_2 was another useful source for recovery of fluorine. Coimbatore Pioneer Fertilizer Ltd, was the only fertilizer plant which produced sodium silicofluoride in the past. Hydrofluorosilicic acid producing units were Rashtriya Chemicals & Fertilizer Ltd, Mumbai and Dharamsi Morarji Chemical Co. Ltd, Ambarnath, Maharashtra. 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 in chlorofluorocarbons (CFCs), which cause 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 gases being greenhouse gases are being phased out. 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, 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

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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 230 million tonnes. South Africa and Mexico possess 18% and 14% of the world reserves, respectively.

World production of fluorite in 2009 decreased to 5.8 million tonnes from 6.0 million tonnes in 2008. China remained the leading producer of fluorite with 3.2 million tonnes. The production is still dominated by Chejiang Province. There has also been significant output from Fujian, Hunan, Anhui, Guizhou, Hubei, Henan and Jiangxi. Mexico is the world's second largest producer after China, producing more than a million tonnes of fluorspar in 2008. The Coahuila and San Luis Potosi were the principal producing states. Other principal producing countries were Mongolia, South Africa, Russia, Spain, Namibia and Kenya. The world reserves and production of fluorite are given in Tables 7 and 8, respectively.

Mexico

Mexichem SAB opened an AlF_3 plant at Matamoros, Tamaulipas as part of downstream expansion. The export oriented plant has a 60,000 tpy capacity.

South Africa

Sephaku Holdings Ltd completed a feasibility study of proposed Nokeng Fluorspar Mine in the Gauteng Province. As per the study, two separate deposits (Outwash Fan and Plattekop deposits) would be developed as a mine complex

which would include an open pit mine and a 130,000 tpy flotation mill. The ore production is scheduled to begin by early 2012.

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

(In '000 tonnes)	
Country	Reserves
World: Total (rounded)	230000
China	21000
Kenya	2000
Mexico	32000
Mongolia	12000
Morocco	NA
Namibia	3000
Russia	NA
South Africa	41000
Spain	6000
USA	NA
Other countries	110000

Source: Mineral Commodity Summaries, 2010.

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

(In '000 tonnes)			
Country	2007	2008	2009
World: Total	5700	6000	5800
Brazil	66	64	60 ^(e)
China	3200	3250	3200
Iran	68	62	62 ^(e)
Kenya@	85	130	5
Mexico	933	1058	1046
Morocco	79	57	66
Mongolia	355	335	460
Namibia	119	119 ^(e)	118 ^(e)
Russia	180 ^(e)	269 ^(e)	210 ^(e)
South Africa	285	299 ^(e)	180 ^(e)
Spain	156	149	122
Other countries	174	208	271

Source: World Mineral Production, 2005-2009.

@ : Exports.

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FOREIGN TRADE

Exports

Exports of fluorite rose to 2,024 tonnes in 2009-10 from 203 tonnes in the previous year. Exports were mainly to Italy (76%) and Bangladesh (20%). Exports of aluminium fluoride were 8,128 tonnes in 2009-10 and 8,417 tonnes in the previous year. Exports were mainly to New Zealand (60%), Brazil (17%) and UAE (20%). Exports of hydrofluoric acid in 2009-10 were 770 tonnes against 714 tonnes in the previous year. No exports of sodium fluoride were reported during 2009-10 (Tables 9 to 12).

Imports

Imports of fluorite decreased to 1.47 lakh tonnes in 2009-10 as compared to 1.54 lakh tonnes in the previous year. Imports were mainly from China (54%) and Kenya (31%). Imports of aluminium fluoride increased to 24,140 tonnes in 2009-10 from 23,248 tonnes in the previous year. Imports were mainly from China (95%). Similarly, imports of hydrofluoric acid also increased to 2,692 tonnes in 2009-10 from 716 tonnes in the previous year. No import of sodium fluoride was reported during 2008-09 and 2009-10 (Tables - 13 to 15).

**Table – 9 : Exports of Fluorite
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	203	1730	2024	18121
Italy	–	–	1520	14972
Israel	25	1095	47	1262
Bangladesh	100	319	400	1256
Brazil	–	–	20	327
Nepal	39	23	30	187
Saudi Arabia	–	–	4	92
Kenya	–	–	2	16
UAE	–	–	1	8
China	24	65	–	–
Tanzania	15	228	–	–
Other countries	–	–	++	1

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	8417	719245	8128	477074
New Zealand	3151	272732	4875	303321
UAE	1856	121672	1623	78619
Brazil	–	–	1357	71939
Japan	423	42944	250	21718
Pakistan	–	–	20	1388
Nepal	–	–	1	55
Vietnam	–	–	1	25
Bahrain	1500	138570	–	–
Germany	1	24	–	–
Korea, Rep. of	1485	143264	–	–
Other countries	1	39	1	9

**Table – 11 : Exports of Sodium Fluoride
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	244	5843	–	–
Iran	25	383	–	–
Italy	31	797	–	–
Nepal	3	320	–	–
Netherlands	2	75	–	–
Nigeria	23	496	–	–
Pakistan	25	446	–	–
Saudi Arabia	6	287	–	–
Syria	9	220	–	–
Thailand	20	1401	–	–
Turkey	100	1394	–	–
Other countries	++	24	–	–

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**Table – 12 : Exports of Hydrofluoric Acid
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	714	51557	770	50306
Egypt	–	–	142	11099
Australia	51	5919	89	9338
UAE	52	4131	85	5389
Syria	46	3029	88	5083
Philippines	66	4089	77	4306
Singapore	95	12719	38	3214
USA	161	9008	56	2320
Thailand	34	2655	34	1833
Canada	53	2447	18	709
Pakistan	120	4807	–	–
Other countries	36	2753	143	7015

**Table – 13 : Imports of Fluorite
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	153749	2558710	147138	1971459
China	113953	1992684	79775	1063344
Kenya	34751	500399	45405	807050
Thailand	847	3906	18106	49289
Pakistan	668	7191	1383	13628
Mongolia	350	5293	745	9360
Hong Kong	1874	21649	568	7570
Russia	375	5968	436	5924
UK	8	757	243	4721
Germany	306	7977	160	4331
Spain	153	2775	234	3948
Other countries	464	10111	83	2294

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

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	23248	1424052	24140	1062421
China	21936	1352009	22924	1013783
Indonesia	1298	69752	1214	48262
Belgium	4	547	2	361
UK	-	-	++	11
USA	++	3	++	4
Germany	9	1621	-	-
Netherlands	1	119	-	-
Other countries	++	1	-	-

**Table – 15 : Imports of Hydrofluoric Acid
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
All Countries	716	47260	2692	132679
China	600	32541	2551	118987
Germany	3	160	97	10083
Chinese Taipei/ Taiwan	83	10473	5	1034
Singapore	12	2181	2	760
USA	18	1823	1	315
UK	++	82	2	117
Unspecified	-	-	34	1383

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.