

GRAPHITE



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GRAPHITE

(FINAL RELEASE)

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

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25 Graphite

Graphite, also known as plumbago or blacklead or mineral carbon, is a stable form of naturally occurring carbon. Structurally, graphite is known to crystallise in hexagonal system and occurs in layered & lamellar form with grey-to-black metallic lustre and a greasy feel. Natural graphite is categorised into two commercial varieties (i) crystalline (flaky) graphite and (ii) amorphous graphite. Both flaky and amorphous varieties of graphite are produced in India. The quality of graphite depends upon its physical qualities and carbon content. Besides natural graphite, there is synthetic or artificial graphite which is manufactured on a large-scale in electric furnaces, using anthracite or petroleum coke as raw feed.

RESERVES/RESOURCES

Graphite occurrences are reported from various States but the deposits of economic importance are located in Chhattisgarh, Jharkhand, Odisha and Tamil Nadu.

As per NMI database, based on the UNFC system, the total resources of graphite as on 1.4.2015 have been placed at about 194.89 million tonnes, out of which 7.96 million tonnes are in the Reserves category and 186.92 million tonnes are placed under Remaining Resources category. Resources containing +40% fixed carbon constitute about 2.91 million tonnes and resources analysing 10-40% fixed carbon constitute 40.65 million tonnes. The balance 151.31 million tonnes fall under 'Others', 'Unclassified' and 'Not-known' grades. Arunachal Pradesh accounts for 37% of the total resources which is followed by Jammu & Kashmir (32%), Odisha (9.7%), Jharkhand (9%) and Tamil Nadu (4%).

However, in terms of reserves, Jharkhand has the leading share of about (52%) followed by Tamil Nadu (42%) and Odisha (6%) (Table-1).

EXPLORATION & DEVELOPMENT

During 2015-16, GSI carried out G3 stage exploration in Tai area, Siang district, Arunachal Pradesh and undertook detailed mapping of a total area of 0.76 sq km. Graphite resources identified are of amorphous nature, schistose and mixed with carbonaceous phyllite. The schistose bands of graphite are 1-3 cm thick. Graphite is also observed as flakes of 2 to 5 mm in length within quartz mica schist. The strike length of graphite schist is 5.5 km with average width of 30 m in the Tai area. Analyses of sample is awaited.

During the same period, GSI has carried out G2 stage exploration in Tikar-Chiklar-Gauthana area in Betul district of Madhya Pradesh. A total of 12 boreholes were drilled in parts of southern and central graphite band, covering 1.25 km of strike length. The total graphite resources in both the bands is 10.94 million tonnes of 332 category and 10.90 million tonnes in 333 category and fixed carbon percentage ranged from 8.79 to 11.15. Analytical results of core samples are awaited.

In Tamil Nadu, a G3 stage investigation for depth persistence of graphite mineralisation was carried out by drilling 12 boreholes in Arasanur block in Sivagangai district. Pitting and trenching of 100 cu m were also carried out. Occurrence of graphite mineralisation at 60 m depth has been proved. About 700 core samples and 49 pit/trench samples were collected. Analytical result is awaited.

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

Grade/State	Reserves				Remaining Resources				Total Resources (A+B)				
	Proved STD111	Probable STD121	Total (A)	Feasibility STD211	Pre-feasibility STD221	Measured STD331	Indicated STD332	Inferred STD333		Reconnaissance STD334	Total (B)		
												STD122	STD222
All India : Total	4229675	1204423	2526694	7960793	9571933	3825575	3593404	741377	7368340	22361229	139464128	186925987	194886779
By Grades													
+ 40% F.C.	178846	1121513	502465	1802824	-	188968	79358	338686	263391	242528	-	1112931	2915755
10-40% F.C.	3621958	82910	1732350	5437219	9004058	3327566	3138724	353765	2703478	13586597	3106244	35220432	40657651
Others	258346	-	57000	315346	92188	117148	68752	-	3323906	3451194	-	7053188	7368534
Unclassified	170525	-	234879	405404	444415	191893	301706	9090	7253	3856995	63439569	68250921	68656325
Not-known	-	-	-	-	31272	-	4864	39836	1070312	1223915	72918315	75288514	75288514
By States													
Andhra Pradesh	-	-	-	-	-	1195	1135	-	1122	697575	-	701027	701027
Arunachal Pradesh	-	-	-	-	-	-	-	-	-	-	-	72758257	72758257
Chhattisgarh	6111	-	-	6111	1230	-	-	-	-	-	-	1230	7341
Gujarat	-	-	-	-	-	-	-	-	2520805	835000	-	3355805	3355805
Jammu & Kashmir	-	-	-	-	-	-	-	-	-	1059520	61681035	62740555	62740555
Jharkhand	1518581	1204423	1450550	4173555	39262	445703	1959747	5520	1856563	6639828	2440208	13386831	17560386
Karnataka	-	-	-	-	140827	18750	48821	-	41605	149403	-	399406	399406
Kerala	-	-	16518	16518	-	8376	-	-	1088550	322606	-	1419532	1436050
Madhya Pradesh	-	-	-	-	-	-	-	-	-	3456660	2280000	5736660	5736660
Maharashtra	-	-	-	-	-	-	-	-	-	1160000	-	1160000	1160000
Odisha	209795	-	249176	458971	9314306	3312065	1415295	696021	838559	2628394	304628	18509268	18968239
Rajasthan	-	-	-	-	47600	-	165920	-	250000	1450034	-	1913554	1913554
Tamil Nadu	2495188	-	810450	3305638	28708	39486	2486	29136	647500	38666390	-	4613707	7919345
Telangana	-	-	-	-	-	-	-	-	123636	95818	-	219455	219455
Uttarakhand	-	-	-	-	-	-	-	10700	-	-	-	10700	10700

Figures rounded off.

PRODUCTION, STOCKS & PRICES

Production of graphite at about 135 thousand tonnes in 2015-16 increased by 15% as compared to that of the preceding year. The output of graphite is mostly reported in terms of run-of-mine (r.o.m.) which contains varying carbon content.

In all, there were 11 reporting mines in 2015-16 as against 10 in the previous year. Three principal producers accounted for 94% of the total output during the year. The share of the Public Sector in the total output was 67% in 2015-16 as compared to 61% in the previous year.

About 94% of the total production in 2015-16 was produced from three mines, each reported more than 5,000 tonnes of annual production, while 6% was contributed by two mines, in the production range of 1,001 to 5,000 tonnes per annum. Marginal production was reported by 6 mines that produced below 1000 tonnes annually.

Tamil Nadu was the leading producing State that contributed a major share of about 67% to the total output during 2015-16 followed by Jharkhand (27%). The remaining six percent was contributed by Odisha and Kerala (Tables - 2 to 5).

Mine-head closing stock for the year 2015-16 was 140 thousand tonnes as against 116 thousand tonnes in the previous year (Table - 6).

The average daily employment of labour during 2015-16 was 202 against 231 in the preceding year.

Domestic prices of graphite are furnished in the General review on 'Prices'.

MINING & MARKETING

Graphite mines, barring a few underground

mines are mostly small and opencast.

Active mining centres of graphite are in Palamu district in Jharkhand; Nuapada & Balangir districts in Odisha; and Madurai & Sivagangai districts in Tamil Nadu. Disseminated deposit of flaky graphite containing 5 to 20% Fixed Carbon (F.C.) are found in Palamu district of Jharkhand. In Odisha, areas in and around Balangir are the chief mining centres where several graphite grades are produced. At Balangir, a few opencast workings are deeper than 45 m from surface and the r.o.m. from such mines generally contains 10 to 20% F.C. Sargipalli underground mine in Sambalpur district, operated by M/s T.P. Mineral Industries (TPMI), produced graphite that analysed up to 40% F.C. in the past. Water seepage beyond 6 m depth is the main problem faced by almost all mine owners in Odisha.

Graphite of Balangir district is utilised mostly by the Graphite Crucible Industry. The technological changes in recent years have considerably reduced the use of graphite as a lubricant. However, recycled graphite is still used in production of clay-bonded graphite crucibles.

Table – 2 : Principal Producers of Graphite, 2015-16

Name & address of producer	Location of mine	
	State	District
Tamil Nadu Minerals Ltd, 31, Kamarajar Salai, Chepauk, Chennai-600 005, Tamil Nadu.	Tamil Nadu	Sivagangai
K.K. Poddar, 3 P, Shree Gopal Complex, Court Road, Ranchi-834 001, Jharkhand.	Jharkhand	Palamu
Shishir Kumar Poddar, 4L, Shree Gopal Complex, Court Road, Ranchi-834 001 Jharkhand.	Jharkhand	Palamu

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**Table – 3 : Production of Graphite, 2013-14 to 2015-16
(By States)**

(Qty in tonnes; Value in ₹'000)

State	2013-14		2014-15		2015-16 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	146390	102471	116712	83996	134568	66197
Chhattisgarh	1403	631	-	-	-	-
Jharkhand	43716	20203	41424	22733	36270	20636
Karnataka	2205	2646	-	-	-	-
Kerala	-	-	250	2000	240	1920
Odisha	10521	5927	2082	1301	7783	4864
Tamil Nadu	88545	73064	72956	57962	90275	38777

**Table – 4 : Production of Graphite, 2014-15 and 2015-16
(By Sectors/States/Districts)**

(Qty in tonnes; Value in ₹ '000)

State/District	2014-15			2015-16 (P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
India	10	116712	83996	11	134568	66197
Public sector	1	71706	57150	1	90275	38777
Private sector	9	45006	26846	10	44293	27420
Chhattisgarh	1*	-	-	1*	-	-
Surguja	1*	-	-	1*	-	-
Jharkhand	3	41424	22733	2	36270	20636
Palamu	3	41424	22733	2	36270	20636
Karnataka	2*	-	-	1*	-	-
Mysuru	2*	-	-	1*	-	-
Kerala	1	250	2000	1	240	1920
Ernakulam	1	250	2000	1	240	1920
Odisha	1	2082	1301	4	7783	4864
Nuapada	1	2082	1301	3	2953	1845
Balangir	-	-	-	1	4830	3019
Tamil Nadu	2	72956	57962	2	90275	38777
Madurai	1	1250	812	1*	-	-
Sivagangai	1	71706	57150	1	90275	38777

* Only labour reported during the year.

**Table – 5 : Production of Graphite, 2014-15 & 2015-16 (P)
(By Frequency Groups)**

(Qty in tonnes)

Production group	No. of mines		Production for the group		Percentage In total production		Cumulative percentage	
	2014-15	2015-16 (P)	2014-15	2015-16 (P)	2014-15	2015-16 (P)	2014-15	2015-16 (P)
India	10	11	116712	134568	100.00	100.00	-	-
Up to 1000	5	6	250	240	0.21	0.18	0.21	0.18
1001-5000	2	2	3332	7783	2.86	5.78	3.07	5.96
Above 5000	3	3	113130	126545	96.93	94.04	100.00	100.00

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**Table – 6 : Mine-head Closing Stocks of Graphite, 2014-15 & 2015-16
(By States)**

(In tonnes)

State	2014-15	2015-16 (P)
India	115526	139622
Chhattisgarh	4281	4079
Jharkhand	7235	7281
Karnataka	8186	8186
Kerala	210	100
Odisha	2502	4846
Tamil Nadu	93112	115130

The Sivagangai graphite is of flaky variety with 14% average Fixed Carbon (F.C.) used in the manufacture of refractory bricks, expanded graphite, crucibles and carbon brushes. It is being mined by opencast mining method. The mined graphite is subjected to size reduction by crushing, grinding, flotation and dewatering to upgrade the graphite concentrate from other gangue minerals.

Mining is considered to be easy and safe in case of graphite deposits, in view of their comparatively soft nature and presence of hard rocks on either side. In order to expose graphite deposit, thickness of 1 to 2 meters of top lateritic soil is dozed out using dozer or removed by excavator and loaded through dumper and transported to separate dump yard located in non-mineralised zone in the lease area. The graphite ore obtained usually is transported to stock yard for blending. In stock yard, both high-grade and low-grade ores are stacked separately. Depending on plant requirements, blending work is carried out and blended ore is despatched to beneficiation plant for consumption.

Tamil Nadu Minerals Limited (TAMIN) has over 600 acres of graphite-bearing areas in Pudupatti, Kumaripatti and Senthudayanathapuram of Sivagangai District, Tamil Nadu.

BENEFICIATION

Graphite occurs generally admixed with country rocks, and hence, it requires beneficiation for obtaining desired grade for various end-uses. Processes for graphite beneficiation depend upon nature and association of gangue minerals present. The common processes adopted are washing, sorting, tabling, acid leaching and froth flotation.

Amongst these, froth flotation process is used widely as it helps in producing a fairly high-grade graphite concentrate. Sometimes, beneficiated concentrate is further enriched by chemical treatment (acid leaching, chlorination, etc.) to obtain a very high-grade concentrate containing 98 to 99% F.C.

Prominent beneficiation plants for graphite in India are Chota Nagpur Graphite Industries and Carbon & Graphite Products, Daltonganj; Agrawal Graphite Industries, Gandhamardhan Graphite Udyog and T. P. Minerals Private Limited, Sambalpur; Tamil Nadu Minerals Ltd (TAMIN), Sivagangai, etc.

The r.o.m., containing an average of about 10% F.C. has to be invariably beneficiated before marketing. Indigenously fabricated equipment is used generally to upgrade the r.o.m. to produce marketable grade graphite which contains normally 70 to 80% F.C. About 92% F.C. product has been obtained by many producers after repeated cycles of beneficiation. A few plant owners have claimed to have obtained product containing as high as 95% F.C.

Beneficiation plants in Odisha seem to have been designed for treating +10% F.C. graphite (r.o.m.). In practice, it is seen that lower grade graphite having +5% F.C. is blended with higher grades to meet the requirements of beneficiation plant, i.e., +10% F.C. Thus, low-grade ore analysing +5% F.C. also gets used.

Tamil Nadu Minerals Ltd (TAMIN) produces flaky graphite from a mine in Sivagangai district in Tamil Nadu. The beneficiation plant located adjacent to the mine site is designed to produce 8,400 tpy of natural graphite concentrate containing 96% F.C. with 92% recovery from r.o.m.

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USES & SPECIFICATIONS

Traditional uses of graphite are in crucibles, foundries, pencils, etc. More sophisticated applications of graphite are in refractories that are used in the manufacture of steel, cement and glass, expanded graphite-based sealing gaskets, graphitised grease, braid, brushes, brake lining, etc. It is also used for speciality applications such as in the Nuclear Industry, soil conditioners and graphite foils, which is used for sealing in the Chemical and Petrochemical industries as well as in the Energy, Engineering and Automotive industries. It is also used in minor amounts as a vital additive for producing foundry coatings to prevent fusion of liquid metal with sand at the mould or core face. Such coatings are either applied by spraying or painting in the form of suspension or by dusting or by rubbing as dry powders. Graphite used for coating is of high quality which does not peel off as flakes on drying and imparts a smooth surface to the casting. Graphite, a major additive to many coating systems, is known for its multifarious functions, such as, refractory, lubricant, thermal conductor, electrical conductor, UV shield, electromagnetic pulse shield, corrosion shield and pigment. It is also used as moderator in nuclear reactors and in Lithium-ion (Li-ion) batteries which is used in the electric vehicles, that require high purity flake graphite in their anode material.

The BIS has prescribed the following specifications of graphite for use in various industries:

IS: 1132-1985 (Reaffirmed 2008) - graphite for use in Graphite Crucible Industry;

IS:1305-1984 (Reaffirmed 2012) - graphite for use in foundry coatings;

IS: 14852-2000 (Reaffirmed 2010) - flaky graphite for Refractory Industry;

IS: 495-1967 (First Revision, Reaffirmed 2007) - graphite flakes for lubricants;

IS: 62-2006 (First Revision, Reaffirmed 2011) - graphite for paints; and

IS: 2079-1982 (First Revision, Reaffirmed 2010) - graphite for pencil slips.

The specifications of graphite adopted for various industrial purposes are detailed as below:

Specifications of Graphite

End product (F.C.)	Percentage of graphite used	Quality of the graphite used	
		Fixed Carbon (micron)	Size
Mag-Carb refractories	12	87-90%	150-710
Alumina-Carb (graphitised) alumina refractories	8-10	85% min.	150-500
Clay-bonded crucibles	60-65	+80% -20 to +100 mesh	
Silicon carbide crucibles	35	80-89%	+150
Expanded (or flexible) graphite foils and products based thereon (e.g. sealing gaskets in refineries, fuel pumps, automobiles)	100	90% min. (preferably +99%)	250-1800
Pencils	50-60	+95-98%	50 max.
Brake-linings	1-15	98% min.	75 max.
Foundry	–	40-70%	53-75
Batteries			
a) Dry cells	–	88% min.	75 max.
b) Alkaline	–	98% min.	5-75
Brushes	–	Usually 99%	Usually less than 53
Lubricants	–	98-99%	53-106
Sintered products (e.g. clog wheels)	–	98-99%	5
Paint	Up to 75	50-55% 75% min.	Amorph- ous powder flake
Braid used for sealing (e.g. in ship)	40-50	95% min.	–
Graphitised grease (used in seamless steel tube manufacturing)	–	+99%	38 max.
Colloidal graphite	100	99.9%	Colloidal

CONSUMPTION

As per the information received from various graphite consuming units and estimates, the consumption of various grades of graphite during 2013-14 to 2015-16 ranged from 49,000 tonnes to 58,000 tonnes. Out of the total consumption in 2015-16, Graphite products (Crucible Industry) accounted for 28,700 tonnes (49%), Chemical Industry 17,800 tonnes (30%), Refractory Industry for 7,700 tonnes (13%) and Foundry Industry 1,300 tonnes (2%). Industry wise consumption data are provided in Table - 7.

**Table - 7 : Consumption* of Graphite
2013-14 to 2015-16
(By Industries)**

Industry	(In tonnes)		
	2013-14	2014-15 (R)	2015-16 (P)
All Industries	49000	61300	58000
Alloy Steel	300	500	500
Chemicals	7800	21300	17800
Dry cell battery	400	400	400
Electrode	600	600	500
Foundry	1000	1100	1300
Graphite products (Crucible)	30800	28700	28700
Graphite products (Pencil)	500	500	500
Refractory	7100	7700	7700
Others (asbestos products, paint, paper, pesticides, pharmaceuticals, and rubber)	500	500	500

Figures rounded off.

*Includes actual reported consumption and/or estimates made wherever required and due to paucity of data, consumption may not be complete.

SUBSTITUTION

In principle, it is possible to substitute graphite by either its synthetic graphite, produced primarily from high carbon precursors such as petroleum coke and coal tar pitch. (e.g. in batteries or for increasing the carbon in steel) or by replacing the product as in the case of pencils or by other compounds as in high temperature applications (e.g. refractories). In the later case, it is difficult to fully substitute graphite as it is tough to replicate the same level of performance that graphite provides.

WORLD REVIEW

The world resources of graphite are believed to exceed 800 million tonnes of recoverable reserves. However, world reserves of graphite have been placed at 250 million tonnes of which Turkey accounts for 36% followed by Brazil 29%, China 22%, Mozambique 5% and India 3% (Table-8).

World production of graphite was 2.17 million tonnes in 2015. China continued to be the leading producer, with a share of about 83% which is followed by India (6%) and Brazil (3%) (Table-9).

Canada was the leading country for natural graphite development with a favourable outlook for new mines. Eight companies reportedly were exploring for graphite.

Brazil was the second leading country providing new natural graphite supply with a new 40,000 tonnes per year mine being considered by Magnesite Refractories SA.

**Table - 8 : World Reserves of Graphite (Natural)
(By Principal Countries)**

(In '000 tonnes)	
Country	Reserves
World : Total (rounded)	250000
Brazil	72000
China	55000
India*	8000
Madagascar	1600
Mexico	3100
Mozambique	13000
Tanzania	5100
Turkey	90000

Source: Mineral Commodity Summaries, 2017.

Reserves in Canada, Korea, Dem P.R., Russia, Norway, Sri Lanka, Ukraine and Zimbabwe are included in the World total.

*India's reserves of graphite as per NMI database, based on UNFC system as on 1.4.2015 have been placed at about 7960 thousand tonnes.

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**Table – 9 : World Production of Graphite (Natural)
(By Principal Countries)**

(In '000 tonnes)			
Country	2013	2014	2015
World : Total	2171	2171	2172
Austria*	17	23	22
Brazil @	92	87	75
Canada ^(e)	20	30	30
China ^{(e) #}	1800	1800	1800
India *	146	117	135
Korea, Dem. P.R. of	10	10	10
Russia ^(e)	14	14	14
Turkey	29	28 ^e	32 ^e
Ukraine ^(e)	7	14	15
Other countries	36	48	39

Source: World Mineral Production, 2011-2015.

@ Including beneficiated and directly shipped material.

Including flake graphite.

* Crude.

India's production of graphite in 2013-14, 2014-15 and 2015-16 was 146 thousand tonnes, 116 thousand tonnes and 135 thousand tonnes, respectively.

FOREIGN TRADE

Exports

In 2015-16, exports of graphite (natural) drastically decreased to 286 tonnes as compared to 2,669 tonnes in the previous year. Graphite (natural) was exported mainly to Kuwait (29%), Japan (25%), South Africa (13%), Azerbaijan (9%) and Nepal & Angola (4% each). The exports of graphite (artificial) marginally increased to 17,874 tonnes in 2015-16 from 16,852 tonnes in the previous year. Graphite (artificial) was exported mainly to Germany (28%), Iran (12%), Saudi Arabia (10%), Oman (9%), USA (8%) and France (6%).

The exports of graphite crucibles decreased to 60 tonnes in 2015-16 from 103 tonnes in the preceding year, while those of silicon carbide crucibles decreased marginally to 3,415 tonnes in 2015-16 from 3,478 tonnes in the previous year. Silicon carbide crucibles were exported mainly to Iran (13%), Rep. of Korea (9%), USA & Turkey (8% each) and UK (7%). Exports of graphite Bricks and Shapes also decreased to 219

tonnes in 2015-16 from 304 tonnes in the preceding year. Graphite Bricks and Shapes were mainly exported to South Africa (33%), Saudi Arabia (32%) and UAE (23%) (Tables -10 to 14).

Imports

Imports of graphite (natural) decreased marginally to 26,065 tonnes in 2015-16 from 28,539 tonnes in the preceding year. Imports of graphite (artificial) decreased to 27,696 tonnes in 2015-16 from 29,350 tonnes in the previous year. Graphite (natural) was mainly imported from China (79%). Imports of graphite (artificial) were mainly from China (46%), Poland (22%), Norway & Japan (7% each).

Imports of graphite Bricks and Shapes marginally increased to 155 tonnes in 2015-16 from 126 tonnes in the preceding year. Imports were mainly from China (81%). Imports of graphite crucibles decreased drastically to 58 tonnes in 2015-16 from 1,339 tonnes in the preceding year. China was the main supplier with 86% share. Imports of silicon carbide crucibles decreased marginally to 179 tonnes in 2015-16 from 231 tonnes in the previous year. Imports were mainly from Germany (33%), UK (27%) and USA (23%) (Tables - 15 to 19).

**Table – 10 : Exports of Graphite (Natural)
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	2669	86578	286	17071
Kuwait	-	-	84	4809
Japan	198	10728	72	4027
South Africa	18	993	36	2040
Azerbaijan	-	-	27	1133
Bangladesh	8	909	9	1120
Nepal	39	2421	11	617
Angola	20	1113	11	617
Kenya	19	1008	8	571
Bahrain	1	104	8	385
Ghana	-	-	5	233
Other countries	2366	69302	15	1519

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**Table – 11 : Exports of Graphite (Artificial)
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	16852	1620297	17874	1773017
Germany	5717	765461	5085	651624
Saudi Arabia	159	10938	1795	184362
USA	2101	182124	1455	170913
Iran	1773	75427	2057	86226
France	748	53785	998	71035
UK	1456	79752	901	74930
Belgium	145	51372	244	53966
Oman	1096	44484	1668	64314
Kuwait	124	7634	538	36153
Italy	39	16894	53	30744
Other countries	3494	332426	3080	348750

**Table – 12 : Exports of Graphite Bricks & Shapes
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	304	3833	219	2774
Tanzania	178	1457	-	-
Chile	3	731	-	-
Congo, Dem. Rep.	30	722	-	-
Nepal	70	718	-	-
Ghana	20	180	1	72
Singapore	3	25	-	-
South Africa	-	-	72	1634
Saudi Arabia	-	-	70	593
Nigeria	-	-	25	374
UAE	-	-	51	101

**Table – 13 : Exports of Graphite Crucibles
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	103	3855	60	2532
Bangladesh	82	1793	36	686
Egypt	13	1714	-	-
Indonesia	2	174	-	-
UAE	4	130	1	1
Ethiopia	1	42	-	-
Russia	1	2	-	-
China	-	-	1	1190
Nepal	-	-	21	585
Saudi Arabia	-	-	1	70

**Table – 14 : Exports of Silicon Carbide Crucibles
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	3478	674749	3415	610770
Iran	505	90725	444	73546
Korea, Rep. of	264	66012	295	51042
USA	256	65473	287	69360
Turkey	292	54760	260	46310
South Africa	155	49977	139	44543
Germany	265	49811	234	39626
Egypt	238	49729	181	40061
UK	284	29916	249	27722
UAE	111	22350	219	40265
Thailand	99	21714	108	21832
Other countries	1009	174282	999	156463

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**Table – 15 : Imports of Graphite (Natural)
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	28539	1333646	26065	1206070
China	24503	985800	20605	795194
Madagascar	1679	109081	2068	115864
Brazil	1476	116789	1973	140919
Germany	177	41788	167	37073
USA	374	42927	830	76494
Japan	16	5508	23	8314
Sri Lanka	40	4584	27	3840
Mexico	54	5895	87	10563
UK	42	4667	47	4006
Other countries	178	16607	238	13803

**Table – 16 : Imports of Graphite (Artificial)
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	29350	2807319	27696	2818434
China	14396	848717	12609	759915
Poland	4983	541750	6131	651376
Germany	2363	492305	630	318255
France	1173	220435	1470	212031
Norway	3753	210712	2065	120907
Japan	539	160638	2041	396551
USA	315	80254	697	116536
Netherlands	621	75673	571	80884
UK	466	49287	402	38205
Singapore	12	9039	30	26688
Other countries	729	118509	1050	97086

**Table – 17 : Imports of Graphite Bricks & Shapes
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	126	43268	155	66982
China	92	39135	125	63448
USA	8	2557	1	217
Japan	22	796	26	2194
France	1	628	1	785
Italy	1	74	-	-
Germany	1	63	1	325
Belgium	1	15	1	13

**Table – 18 : Imports of Graphite Crucibles
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	1339	74886	58	4879
China	1319	72731	50	2776
USA	10	1318	1	635
Italy	9	713	2	756
Japan	1	124	1	62
France	-	-	3	333
Germany	-	-	1	317

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**Table – 19 : Imports of Silicon Carbide Crucibles
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	231	21467	179	17689
China	195	10069	1	349
USA	15	5456	42	4289
UK	9	2997	48	4968
Italy	4	1240	1	42
Spain	2	546	1	377
Germany	2	460	59	5040
St. Pierce	-	-	8	907
Japan	1	258	17	1571
Thailand	2	426	-	-
Malaysia	-	-	2	146
Other countries	1	15	-	-

FUTURE OUTLOOK

Worldwide demand for combined natural and synthetic graphite is expected to rise along with improvements in the global economic conditions. Demand is also expected to augment further with the development of non-carbon energy applications such as batteries used in electric vehicles, electric devices and energy storage devices that use graphite. The graphite reserves having +40% Fixed Carbon are rather limited in the country. Detailed exploration of graphite deposits in Odisha, Jharkhand, Jammu & Kashmir and Kerala should be carried out. Cost-effective beneficiation technologies for low-grade graphite ore need to be developed. Silicon carbide-graphite crucibles are being diversified and manufactured to improve upon the use of inferior grade material with less quantity and at the same time ensuring longer life of crucible. The domestic demand of graphite r.o.m. was estimated

to touch 2,08,000 tonnes by 2016-17 at 9% growth rate by the Working Group for the 12th Plan, Planning Commission of India.

Of late, a few emerging & important specialised applications of exfoliated graphite have been reported especially in the manufacture of sealings, gaskets, braids and brushes. New products of synthetic graphite, such as, graphite fibres/ropes and graphite insulation blankets have been introduced. In the world scenario there seems to be a rapid diversification in respect of potential large-volume end-use for natural graphite, such as, in heat sinks, also called spreader shield, which is a graphite foil material that conducts heat only in two directions. It has thermal conductivity above aluminium and almost equal to copper. These such as, graphite fibres/ropes and graphite insulation blankets have been introduced. In the world scenario there seems to be a rapid diversification in respect of potential large-volume end-use for natural graphite, such as, in heat sinks, also called spreader shield,

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which is a graphite foil material that conducts heat only in two directions. It has thermal conductivity above aluminium and almost equal to copper. These are used for dissipating heat in laptop computers, flat-panel displays, wireless phones, digital video cameras, etc. Such emerging & high growth applications of graphite are certainly causing noticeable impacts on the demand & consumption patterns within the country & globally as well.

Global demand for natural graphite has been forecasted to increase by 37% by 2020. Demand for graphite in lithium-ion batteries for application in electric/hybrid vehicles, laptops, smartphones, home/business applications and traditional uses for expanded graphite foils, are the potential areas that are expected to be major drivers in the market. It represents 23% of global flake graphite demand. Battery demand for graphite is forecasted to double in the next six years.