

# 44 Graphite

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**G**raphite, also known as plumbago or black lead, is a variety of naturally occurring carbon. It crystallises in hexagonal system and has a lamellar form, a grey- to-black metallic lustre and greasy feel. Natural graphite is divisible into two commercial varieties: (i) crystalline graphite and (ii) amorphous graphite. Both flaky and amorphous varieties of graphite are produced in the country. The quality of graphite is dependent upon its physical qualities as well as carbon content. In addition to natural graphite, synthetic or artificial graphite is manufactured on a large-scale in electric furnaces, using anthracite or petroleum coke as raw feed. The latter is known as Calcined Petroleum Coke (CPC).

## RESOURCES

Graphite occurrences are reported from various states but the deposits of economic importance are located in Andhra Pradesh, Jharkhand, Karnataka, Kerala, Orissa, Rajasthan and Tamil Nadu.

As per the UNFC system, the total resources of graphite as on 1.4.2005 are placed at about 168.77 million tonnes, comprising 10.75 million tonnes in the reserves category and 158.02 million tonnes under remaining resources category. Resources containing +40% fixed carbon constitute about 1.11 million tonnes and resources analysing 10-40% fixed carbon 21.23 million tonnes. Balance resources of 146.43 million tonnes fall under 'others', 'unclassified' and 'not known' grades. Out of total resources, Arunachal Pradesh accounts for 43% followed by Jammu & Kashmir (37%), Jharkhand (6%), Tamil Nadu (5%) and Orissa (3%). However, in terms of reserves, Tamil Nadu has leading share of about 37% followed by Jharkhand (30%) and Orissa (29%) (Table-1).

## EXPLORATION & DEVELOPMENT

GSI continued exploration for graphite in Puvandi-Arasanur and Usilampatti area in Sivaganga district, Tamil Nadu. In Arasanur block, presence of graphite mineralisation has been proved for a strike length of 1 km. The average width of the zone is about 12 m. and overall average grade is 14% F.C. A resources of 0.76 million tonnes of graphite (average grade of 13% FC)

has been estimated in 2006-07. In the western extension of Arasanur block, a new block named Kiranur block, was investigated and the results were found to be not encouraging. The west of the Kiranur block, 135 m east of a mine of M/s. V. Thiruvanavukasasu, a trench (KT-1) across graphite gneiss exposed three bands of graphite having 1.90 m, 2.5m and 1.6m widths.

In 2007-08, Directorate of Geology, Jharkhand, carried out exploration in Mukta Tabar and Nawadh area of Palamau district. About 1.05 sq km area was mapped on 1:2000 scale, collecting 155 samples and 56 cu m pitting/trenching. As a result, one million tonnes graphite resources of possible category were estimated with fixed carbon content of 5.95 to 23.47%.

## PRODUCTION STOCKS & PRICES

Production of graphite at 116 thousand tonnes in 2007-08 decreased by 29% as compared to that of the preceding year due to less demand and temporary closure of mines. The output of graphite is reported in terms of run-of-mine (r.o.m..) which contains varying carbon content.

In all, there were 28 reporting mines in 2007-08 as against 33 in the previous year. Ten principal producers accounted for 93% of the total output during the year. The share of public sector in the total output was 43% in 2007-08 as compared to 47% in the previous year.

About 70% of the total production in 2007-08 was accrued from five mines, each producing more than 5,000 tonnes annually, while 22% was contributed by seven mines, each in the production range of 2,000 to 5,000 tonnes per annum. The remaining output of 8 percent was reported by 16 mines, each producing below 2,000 tonnes annually.

Orissa was the leading position contributing a major share of about 44% of the total output during 2007-08, followed by Tamil Nadu 43% and Jharkhand by 13% (Tables - 2 to 5).

Mine-head stock at the end of the year 2007-08 was 45 thousand tonnes as against 72 thousand tonnes in the beginning of the year (Table - 6).

The average daily employment of labour during 2007-08 was 331 as against 490 in the preceding year. Domestic prices of graphite are furnished in Table - 7.

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**Table - 1 : Reserves/Resources of Graphite as on 1.4.2005  
(By Grades/Stages)**

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						
<b>All India : Total</b>	<b>5163505</b>	<b>1021869</b>	<b>4564534</b>	<b>10749908</b>	<b>12000</b>	<b>78386</b>	<b>930118</b>	<b>51326</b>	<b>5956595</b>	<b>16506673</b>	<b>134489932</b>	<b>158025030</b>	<b>168774938</b>
<b>By Grades</b>													
+ 40% F.C.	413639	77132	342807	833578	-	37000	80	-	951	238500	-	276531	1110109
10-40% F.C.	4733667	937943	3943249	9614859	12000	41386	930038	8740	1596449	8952091	73897	11614601	21229460
Others	15574	6794	210952	233320	-	-	-	-	3283001	2330151	-	5613152	5846472
Unclassified	-	-	67526	67526	-	-	-	2750	5882	3127538	61497720	64633890	64701416
Not known	625	-	-	625	-	-	-	39836	1070312	1858393	72918315	75886856	75887481
<b>By States</b>													
Andhra Pradesh	-	-	1135	1135	-	-	-	-	124758	301306	-	426064	427199
Arunachal Pradesh	-	-	-	-	-	-	-	-	-	-	72758257	72758257	72758257
Gujarat	-	-	-	-	-	-	-	-	2520805	835000	-	3355805	3355805
Jammu & Kashmir	-	-	-	-	-	-	-	-	-	1059520	61681035	62740555	62740555
Jharkhand	442537	670448	2163106	3276091	-	-	720000	2750	1143701	5180124	24350	7070925	10347016
Karnataka	1308	6794	188812	196914	-	-	-	-	18200	52500	-	70700	267614
Kerala	-	8300	17762	26062	-	-	35600	-	1148350	240418	-	1424368	1450430
Madhya Pradesh	-	-	-	-	-	-	-	-	-	1006660	-	1006660	1006660
Maharashtra	-	-	-	-	-	-	-	-	-	1160000	-	1160000	1160000
Orissa	1553293	336327	1217349	3106969	12000	38900	172032	8740	103281	1954721	26290	2315964	5422933
Rajasthan	47600	-	165920	213520	-	-	-	-	250000	1450034	-	1700034	1913554
Tamil Nadu	3118767	-	810450	3929217	-	39486	2486	29136	647500	3266390	-	3984998	7914215
Uttarakhand	-	-	-	-	-	-	-	10700	-	-	-	10700	10700

Figures rounded off.

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**Table – 2 : Principal Producers of Graphite  
2007-08**

Name & address of producer	Location of mine	
	State	District
Tamil Nadu Minerals Ltd, 31, Kamarajar Salai, Chepauk, Chennai – 600 005, Tamil Nadu.	Tamil Nadu	Sivaganga
Natwar Lal Agarwal P.O. Balibanda Distt. Sambalpur, Orissa	Orissa	Bolangir
Pramod Kumar Agrawal, Patnaikpara, Dist. Sambalpur, Orissa.	Orissa	Bolangir Nuapada
K. K. Poddar, Poddar Niket, Bariaju Road, Ranchi, Jharkhand.	Jharkhand	Palamau
Girdharilal Agrawal, Khetrajpur, Dist. Sambalpur, Orissa.	Orissa	Bolangir Nuapada

Table - 2 (Concl.)

Name & address of producer	Location of mine	
	State	District
Prabhas Chandra Agrawal, Shakti Kunj, Farm Road, Modipara, Sambalpur, Orissa.	Orissa	Bargarh Bolangir
Ramesh Kumar Agrawal, Khetrajpur, Dist. Sambalpur, Orissa.	Orissa	Bolangir
Shri Sunandan Pradhan (Pradhan Industries), Telanga Bazar, PO - Cuttack, Orissa.	Orissa	Rayagada
Diamond Graphite Industries Pvt. Ltd, Alishan Complex, Kantabanji, Dist. Bolangir, Orissa.	Orissa	Bolangir
Orissa Manganese & Minerals (P) Ltd, 9, Esplande Mansion Kolkata West Bengal	Jharkhand	Palamu

(Contd.)

**Table – 3 : Production of Graphite, 2005-06 to 2007-08  
(By States)**

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

State	2005-06		2006-07		2007-08 (p)	
	Quantity	Value	Quantity	Value	Quantity	Value
<b>India</b>	<b>125651</b>	<b>43050</b>	<b>162293</b>	<b>59296</b>	<b>116007</b>	<b>47430</b>
Jharkhand	16286	4921	12999	4842	14762	5599
Orissa	50385	24021	88758	35083	50702	25627
Tamil Nadu	58530	14108	60536	19371	50543	16204

**Table – 4 : Production of Graphite, 2006-07 and 2007-08  
(By Sectors/States/Districts)**

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

State/District	2006-07			2007-08(p)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
<b>India</b>	<b>33</b>	<b>162293</b>	<b>59296</b>	<b>28</b>	<b>116007</b>	<b>47430</b>
Public sector	1	58961	18514	1	49308	15532
Private sector	32	103332	40782	27	66699	31898
<b>Jharkhand</b>	<b>9</b>	<b>12999</b>	<b>4842</b>	<b>9</b>	<b>14762</b>	<b>5599</b>
Palamu	8	12695	4751	8	13918	5325
Latehar	1	304	91	1	844	274
<b>Orissa</b>	<b>22</b>	<b>88758</b>	<b>35083</b>	<b>17</b>	<b>50702</b>	<b>25627</b>
Bargarh	4	1605	642	4	7425	3198
Bolangir	15	22847	11312	11	30720	17610
Nuapada	2	12983	5166	1	8486	3394
Rayagada	1	51323	17963	1	4071	1425
<b>Tamil Nadu</b>	<b>2</b>	<b>60536</b>	<b>19371</b>	<b>2</b>	<b>50543</b>	<b>16204</b>
Madurai	1	1575	857	1	1235	672
Sivaganga	1	58961	18514	1	49308	15532

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**Table – 5 : Production of Graphite, 2006-07 and 2007-08  
(By Frequency Groups)**

(Qty. in tonnes)

Production group	No. of mines		Production for the group		Percentage in total production		Cumulative percentage	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
<b>India</b>	<b>33</b>	<b>28</b>	<b>162293</b>	<b>116007</b>	<b>100</b>	<b>100</b>	-	-
Upto 500	16	9	1777	836	1	1	1	1
501-1000	2	3	1438	2774	1	2	2	3
1001-2000	6	4	8506	5662	5	5	7	8
2001-3000	1	2	2677	5292	2	5	9	13
3001-4000	1	2	3540	7288	2	6	11	19
4001-5000	2	3	8825	12936	5	11	16	30
Above 5001	5	5	135530	81219	84	70	100	100

**Table – 6 : Mine - head Stocks of Graphite, 2007-08 (p)  
(By States)**

(In tonnes)

State	At the beginning of the year	At the end of the year
<b>India</b>	<b>71999</b>	<b>45140</b>
Jharkhand	4625	3791
Orissa	44262	17196
Tamil Nadu	23112	24153

**Table - 7 : Prices of Graphite, 2005-06 to 2007-08  
(Domestic Markets)**

(In Rs. per tonne)

Grade	Market	2005-06	2006-07	2007-08(p)
Below 10% F.C.	Ex- factory Ranchi(Jharkhand)	400	400	400
55-60% C (-200 mesh)	Ex-factory Patrapati (Orissa)	9000	-	-
60-65% C (-200 mesh)	Ex-factory Patrapati (Orissa)	10200	13000	15000
70-75% C (-200 mesh)	Ex-factory Patrapati (Orissa)	11500	-	-
80-85% C (-200 mesh)	Ex-factory Patrapati (Orissa)	12800	-	-
60-65% C (-80 mesh)	Ex-factory Patrapati (Orissa)	11000	12000	-
60-65% C (-100 mesh)	Ex-factory Patrapati (Orissa)	-	11500	14000
70-75% C (-100 mesh)	Ex-factory Patrapati (Orissa)	13000	13250	17000
60-65% C (-150 mesh)	Ex-factory Patrapati (Orissa)	9800	12500	13000
70-75% C (-150 mesh)	Ex-factory Patrapati (Orissa)	14000	-	-
80-85% C (-20+50 mesh)	Ex-factory Patrapati (Orissa)	30000	34000	39000
80-85% C (-50+80 mesh)	Ex-factory Patrapati (Orissa)	18800	20500	23000

## MINING & MARKETING

Graphite mines are mostly small and opencast barring a few underground mines. Water seepage beyond 6 m depth is the main problem faced by almost all mine owners in Orissa.

Active mining centres of graphite are in Latehar and Palamu districts in Jharkhand; Bargarh, Nuapada, Rayagada and Bolangir districts in Orissa and Madurai and Sivaganga districts in Tamil Nadu. In Jharkhand, mining activities are concentrated mostly around Sokara village in Palamu district. It is a disseminated deposit of flaky graphite containing 5 to 20% F.C. In Orissa, areas in and around Bolangir are the chief mining centres where several graphite grades are produced. At Bolangir, 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, analysing up to 40% F.C. in the past.

Dangachacha mine, also owned by TPMI, is a promising opencast mine in which the r.o.m. contains 40% F.C. The ore from the mine is partially beneficiated in a 3,000-tpy plant. The remaining output is sold to other beneficiation plants nearby. Graphite of Bolangir and Sambalpur districts is utilised mostly by the graphite crucible industry while graphite worked earlier from Kalahandi district used to be despatched to foundry units. The technological changes in recent years have considerably reduced the use of graphite as a lubricant. However, recycled graphite is being used in producing clay-bonded graphite crucibles.

## BENEFICIATION

Graphite occurs generally admixed with the country rocks and hence, it often 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.

The r.o.m., on an average, containing 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. Few plant owners claimed to have obtained product containing as high as 95% F.C.

Beneficiation plants in Orissa 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. is also used.

National Metallurgical Laboratory had undertaken study on graphite sample from TP Mineral Industries of Sambalpur district, Orissa to produce high-purity graphite, which can be used as a substitute of imported product. The sample assaying 48.2% F.C., 46.04% ash, 4.58% volatile matter and 0.46% sulphur was subjected to froth flotation in two stages and further subjected to acid leaching under different conditions to reduce ash content. The final graphite concentrate produced (yield 42.6%) assayed 98.16% F.C., 0.98% ash, 0.032% iron and 0.12% sulphur with 90.2% fixed carbon distribution.

Tamil Nadu Minerals Ltd (TAMIN) produced flaky graphite from a mine in Sivaganga area, Sivaganga district in Tamil Nadu. The beneficiation plant located adjacent to the mine site was commenced in November 1994 to produce 9,240 tpy of natural graphite concentrate containing 96% F.C. with 92% recovery from r.o.m. A list of important beneficiation plants in the country is given below:

### Beneficiation Plants in India

#### *Andhra Pradesh*

Srinivasa Graphite Crucible Industries,  
P. O. Amadalavalsa, District Srikakulam.

#### *Jharkhand*

Chhota Nagpur Graphite Industries, Daltonganj.

Carbon and Graphite Products, Daltonganj.

New Chemicals and Metals Products Private Ltd,  
Hazaribag Road, Ranchi.

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Parijat Mining Industries (India) Private Ltd,  
Ranchi.

Carbon and Graphite Industries, Repala,  
District Palamu.

### *Gujarat*

Harikrupa Minerals, Chhota Udepur, District  
Vadodara.

Farmsons Minerals Industries, Devgadhabaria,  
District Panchmahals.

India Minerals, Kellanpur, District Vadodara.

M. S. Patel, Muthai, Jatpur Road, Vadodara.

### *Orissa*

Agrawal Graphite Industries, Sambalpur.

Gandhamardhan Graphite Udyog, Sambalpur.

G. R. Graphite Industries, Sambalpur.

National Carbon Products, Sambalpur.

Lakshminarayan Makhanlal Company, Sambalpur.

Graphite International, Sambalpur.

Laxminaryan Girdharilal, Sambalpur.

G. P. Minerals Industries, Sargipalli, Sambalpur.

T. P. Minerals Private Limited, Sambalpur.

Indesmin Graphite, Titlagarh.

Pioneer Graphite, Titlagarh.

Trinath Pradhan, Patnagarh, District Bolangir.

B. K. Agrawal, Padmapur Diamond Graphite  
Industries, Kartabanji.

Raimata Graphite Industries, Patnagarh, District  
Bolangir.

Misrilal Dharamchand Jain, Bolangir.

Pradhan Industries, Rayagada.

Mangalam Graphite Industries, Bhubaneswar.

### *Tamil Nadu*

Tamil Nadu Minerals Ltd (TAMIN), Sivaganga,  
District Sivaganga.

### Specifications of Graphite

End product	Percentage of graphite used	Quality of the graphite used	
		Fixed Carbon (F. C.)	Size (micron)
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	Amorphous 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
Recarburisation of steel	100	99%	Micronised
Colloidal graphite	100	99.9%	Colloidal

Foundry coatings are used to prevent fusion of liquid metal with the sand at the mould or core face. They are applied as coating by spraying or painting in the form of suspension or by dusting or rubbing as dry powders. Good quality graphite which is one of the materials for this purpose, does not peel off in flakes. On drying, it imparts a smooth surface to the casting.

## SPECIFICATIONS

Traditional uses are in crucibles, foundries, pencils, etc. Now, more sophisticated applications of graphite have emerged. Examples of such uses are in refractories, expanded graphite-based sealing, gasket, graphitised grease, braid, brushes, brake lining, etc. Graphite is used in bulk for producing certain products. It is also used in a minor amounts as a vital additive for producing other products. The specifications of graphite for some possible uses are as follows :

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BIS has prescribed IS-1305-1984 for graphite for use in foundry coating. The specifications are given for natural (three grades) and synthetic graphite (one grade).

The specification for natural graphite lays down 1% moisture (max) and 3% volatile matter (max). Ash content should be 12% (max) for Grade I material, 20% (max) for Grade II and 30% (max) for Grade III. Non-graphitic carbon content should be 0.5% (max) for Grade I and 2.5% (max) for Grade II and III. Fixed carbon content is the balance by difference. Specification for synthetic graphite is : moisture 1% (max), volatile matter 2% (max), ash 3% (max), non-graphitic carbon 3.5% (max) and fixed carbon by difference. Both the material should pass through 75 micron sieve (75% min) and 150 micron sieve (100%).

## INDUSTRY

### Graphite Crucibles

#### *Clay-bonded graphite crucibles*

The clay-bonded graphite crucible usually comprises 60 - 65% flaky graphite, 25 - 30% clay, 5% silicon carbide and 5% borax. The graphite crucible industry is concentrated in Rajahmundry-Samalkot area in East Godavari district, Andhra Pradesh. This area has about 70 small-scale crucible manufacturing units out of 90 such units in the country. Many of them manufacture clay-bonded graphite crucibles. Other centres in the country are Titlagarh and Sambalpur, Orissa; Padur, Gugai, Salem and Chennai, Tamil Nadu; Ranchi, Jharkhand; Wapi, Gujarat; Varanasi, Uttar Pradesh; Mumbai, Maharashtra and Kolkata, West Bengal. Only good quality flaky graphite is preferred in the manufacture of crucibles. The proportion of flakes of the desired size in the total graphite content must not be below 25%. Crucibles are made by mixing various ingredients like graphite with clay and borax. The ingredients are mixed in proportion with water and are heated for a day or two and then subjected to thorough mixing in pug mill several times. The bonded material so obtained is then shaped into crucibles through moulds of different sizes. Green crucibles are dried and finally baked in a muffle or down-draught kiln at a temperature of about 1300°C in a reduced condition. Graphite crucibles are designated by numbers which denote the capacity in kilogram of molten metal (copper as standard) that can be handled at a time. Crucibles up to 1000 size are made in India, of which crucibles of size

1 to 200 are commonly manufactured. Graphite crucibles are used for melting both non-ferrous and ferrous metals.

#### *Silicon carbide-graphite crucibles*

The silicon carbide-graphite crucibles use isostatic pressing technology, require flaky graphite having only about half the size of those needed in clay-bonded graphite crucibles. The carbon content of graphite should be around 80%. Such crucibles consist of 25-40% flaky graphite and 40-60% silicon carbide besides some other ingredients. However, the use of silicon carbide-graphite crucibles is restrictive. There are three small-scale units and two large-scale units in organised sector in the country. The large-scale units are located at Mehsana in Gujarat and Walunj near Aurangabad in Maharashtra.

#### *Synthetic graphite and other carbon products*

Calcined Petroleum Coke (CPC) is the raw material for manufacturing synthetic graphite. Synthetic graphite is manufactured by heating petroleum coke bound with pitch to about 2500°C under pressure.

India is self-sufficient in the requirement of petroleum coke, a by-product of petroleum refineries of Indian Oil Corporation (Guwahati, Digboi and Barauni) and Reliance Industries Ltd, (Jamnagar). Production of petroleum coke from crude oil refining in India was 3.78 million tonnes and 4.13 million tonnes in 2006-07 and 2007-08, respectively. The sales/consumption during the same period was 5.44 million tonnes and 4.34 million tonnes, respectively. Calcined petroleum coke manufacturing units are Indian Carbon Limited at Noonmati and Guwahati in Assam and Budge-Budge in West Bengal; Indian Oil Corporation at Barauni in Bihar; Petro-carbon and Chemicals Co. at Haldia in West Bengal and Goa Carbon Limited at Margao in Goa.

Carbon electrodes used in electric arc furnaces and various other electrolytic processes are made from synthetic graphite. Graphite India Ltd has two plants, one at Durgapur in West Bengal and the other in Bangalore. Hindustan Electro-Graphite Ltd and Carbon Corporation Ltd have a plant each in Mandideep near Bhopal, Madhya Pradesh and Nasik, Maharashtra, respectively. The production of graphite electrodes and anodes in 2006-07 and 2007-08 was 94,550 tonnes and 112,854 tonnes, respectively. Production of carbon black during the same period was 423,020 tonnes and 428,802 tonnes, respectively.

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### CONSUMPTION

Reliable consumption data on beneficiated graphite concentrates are not available. As per the information received from various graphite consuming units and estimates, the consumption of various grades of graphite during 2005-06 to 2007-08 ranged from 13,800 tonnes to 14,100 tonnes. Out of total consumption in 2007-08, the refractory industry accounted for 6,300 tonnes (44.7%), crucible industry 4,600 tonnes (32.6%) and foundry industry 1,000 tonnes (7.1%). Industrywise consumption data are given in Table - 8.

**Table - 8 : Reported Consumption of Graphite  
2005-06 to 2007-08  
(By Industries)**

Industry	2005-06(R)	2006-07	2007-08(p)
<b>All Industries</b>	<b>13800</b>	<b>14000</b>	<b>14100</b>
Dry cell battery	400(2)	400(2)	400(2)
Electrode	600 (5)	600 (5)	600 (5)
Foundry(e)	1000 (4)	1000 (4)	1000 (4)
Graphite products (Crucible)(e)*	4500(3)	4500(3)	4600(3)
Graphite products (pencil)(e)*	500 (1)	500 (1)	500 (1)
Refractory	6100 (23)	6300 (23)	6300 (23)
Others (asbestos products, chemicals, paint, paper, pesticide, pharmaceuticals and rubber)	700 (20)	700 (20)	700 (20)

*Figures rounded off. Data collected on non-statutory basis. Figures in parentheses denote the number of units in organised sector reporting consumption.*

*(e) Estimatead consumption taken from Market Survey conducted by IBM.*

*(e)\* - Based on the information supplied by The All India Graphite Crucible Manufacturers Association, Rajahmundry (Andhra Pradesh) and field survey to Samalkot/Rajahmundry area by M.E. Division, IBM in March, 2007.*

*Consumption of graphite for beneficiation purposes is estimated at 14,000 tonnes*

### WORLD REVIEW

The world resources of graphite are believed to be quite extensive. However, rough estimate of the reserve base of graphite has been placed at 210 million tonnes of which China alone holds 140 million tonnes; i.e., over 67% (Table-9).

World production of graphite was 2.1 million tonnes in 2007. China continued to be the leading producer, having a share of about 86%, followed by India (6%) second largest producer, and Brazil (4%) (Table-10).

**Table - 9 : World Resources of Graphite (Natural)  
(By Principal Countries)**

Country	Reserve base
<b>World : Total (rounded)</b>	<b>210000</b>
Brazil	1000
China	140000
Czech Republic	14000
India*	3800
Madagascar	960
Mexico	3100
USA	1000
Other countries	44000

*Source: Mineral Commodity Summaries, 2008.*

*Figures for Canada, Germany, North Korea, Norway, Sri Lanka, Turkey, Ukraine and Zimbabwe are included in other countries.*

*\* India's resources of graphite as per UNFC system are placed at 168.77 million tonnes*

**Table - 10 : World Production of Graphite (Natural)  
(By Principal Countries)**

Country	2005	2006	2007
<b>World : Total</b>	<b>2000</b>	<b>2039</b>	<b>2100</b>
Brazil@	76	76	77
Canada	17 <sup>(e)</sup>	15	15
China#	1650	1730	1800
India*	126	124	116
Korea, Dem.E			
People's Rep. of	30 <sup>(e)</sup>	30 <sup>(e)</sup>	30 <sup>(e)</sup>
Mexico	12	12	10
Russia	14 <sup>(e)</sup>	14 <sup>(e)</sup>	14 <sup>(e)</sup>
Ukraine	10	6	NA
Zimbabwe	4	7	7 <sup>(e)</sup>
Other countries	61	25	31

*Source: World Mineral Production, 2003-2007.*

*@ Including beneficiated and directly shipped material  
# Including flake graphite.*

*\* Production of graphite in India in 2005-06, 2006-07 and 2007-08 was 125,651 tonnes, 162,293 tonnes and 116,007 tonnes respectively.*

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**FOREIGN TRADE**

**Exports**

In 2007-08, exports of graphite (natural) decreased to 1,420 tonnes from 1,850 tonnes in the previous year. Graphite (natural) was exported mainly to UK (22%), Germany and France (15% each). Exports of graphite (artificial) increased to 14,586 tonnes from 6,877 tonnes in 2006-07. Graphite (artificial) was exported mainly to Germany (51%), Iran (11%), USA (8%) and Poland (7%).

The exports of graphite crucibles increased to 622 tonnes in 2007-08 from 393 tonnes in the previous year while exports of silicon carbide crucibles decreased in 2007-08 to 1,905 tonnes from 2,698 tonnes in the previous year. Exports of graphite bricks and shapes increased to 62 tonnes in 2007-08 from 4 tonnes in the previous year. Graphite bricks and shapes were mainly exported to Nepal. Malaysia, Indonesia, Iran and Bangladesh were the main buyers of graphite crucibles. Silicon carbide crucibles were exported mainly to Iran, Egypt, UAE, Indonesia China, Turkey and Malaysia (Tables - 11 to 15).

**Imports**

Imports of graphite (natural) increased to 11,666 tonnes in 2007-08 from 9,927 tonnes in the previous year. Similarly, imports of graphite (artificial) increased to 18,450 tonnes in 2007-08 from 17,321 tonnes in 2006-07. Graphite (natural) was mainly imported from China (87%). Imports of graphite (artificial) were mainly from China (69%), Norway (14%), and Germany (6%). Imports of graphite bricks and shapes decreased to 159 tonnes in 2007-08 from 333 tonnes in 2006-07. Imports of graphite crucibles increased in 2007-08 to 1,794 tonnes from 749 tonnes in the previous year. Imports were mainly from China (89%) (Tables - 16 to 20).

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

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	<b>1850</b>	<b>50012</b>	<b>1420</b>	<b>44538</b>
UK	262	15785	311	10682
Germany	150	8009	221	9364
France	77	3182	220	7422
Netherlands	3	89	52	4509
Australia	49	2103	34	1193
UAE	37	1929	35	1141
New Zealand	43	1321	23	704
Malaysia	62	1812	4	222
Poland	129	2519	-	-
USA	168	4785	-	-
Other countries	870	8478	520	9301

**Table – 12 : Exports of Graphite (Artificial) (By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	<b>6877</b>	<b>624595</b>	<b>14586</b>	<b>1502775</b>
Germany	2214	227954	7475	790605
Iran	1670	59580	1677	150660
USA	1290	126747	1149	109932
Austria	-	-	517	97510
France	105	21614	247	49296
Netherlands	118	23337	283	48095
Sweden	193	33833	208	37185
UK	197	19868	529	30322
Poland	225	10135	1073	21436
Japan	162	29104	52	8988
Other countries	703	72423	1376	158746

**Table – 13 : Exports of Graphite Bricks & Shapes (By Countries)**

Country	2006-07		2007-08	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	<b>4</b>	<b>57</b>	<b>62</b>	<b>715</b>
Nepal	3	31	33	225
Saudi Arabia	-	-	8	202
Oman	-	-	10	131
USA	-	-	4	62
Ethiopia	-	-	3	51
Canada	-	-	3	32
Kenya	-	-	1	12
Uganda	1	26	-	-

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

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
<b>All Countries</b>	<b>393</b>	<b>22487</b>	<b>622</b>	<b>23840</b>
Malaysia	-	-	170	5212
Indonesia	-	-	115	5135
Iran	15	713	82	3005
Sri Lanka	31	1618	35	2350
Nigeria	48	2733	36	2004
Bangladesh	58	833	62	1630
Chinese Taipei/Taiwan	-	-	50	1610
Philippines	4	297	20	1426
Australia	40	835	-	-
Oman	186	15060	-	-
Other countries	11	398	52	1468

**Table - 15 : Exports of Silicon Carbide Crucibles  
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
<b>All Countries</b>	<b>2698</b>	<b>133199</b>	<b>1905</b>	<b>129802</b>
Iran	366	32494	484	33159
Egypt	97	10608	152	18539
Indonesia	64	6875	106	11846
Turkey	74	6470	84	8610
Korea, Rep. of	96	10323	79	7644
China	73	7237	95	6542
Malaysia	68	8371	81	5940
UAE	50	3920	109	5125
Thailand	69	5818	28	2841
Singapore	1013	8325	9	928
Other countries	728	32758	678	28628

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**Table - 16 : Imports of Graphite (Natural)  
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
<b>All Countries</b>	<b>9927</b>	<b>209100</b>	<b>11666</b>	<b>229768</b>
China	9225	176993	10166	175140
Germany	29	4506	131	10723
Madagascar	40	1271	280	8774
Sri Lanka	417	8656	411	8603
USA	80	5330	130	7532
Italy	7	595	37	2846
Japan	14	4970	20	2456
UK	82	4976	40	2301
Belgium	++	58	11	1282
Unspecified	20	556	220	4062
Other countries	13	1189	220	6049

**Table - 17 : Imports of Graphite (Artificial)  
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
<b>All Countries</b>	<b>17321</b>	<b>1016252</b>	<b>18450</b>	<b>1322611</b>
China	11227	429643	12652	507247
USA	317	98512	718	263415
Germany	490	78747	1155	188464
France	101	48047	368	98771
Norway	3486	92195	2539	77424
Japan	844	137705	413	52123
Netherlands	241	71439	195	46634
UK	68	18637	132	45388
Italy	73	9016	125	22931
Switzerland	23	4314	23	3923
Other countries	451	27997	130	16291

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**Table - 18 : Imports of Graphite Bricks & Shapes  
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
<b>All Countries</b>	<b>333</b>	<b>19074</b>	<b>159</b>	<b>7549</b>
China	261	11871	131	5766
France	52	5668	23	1614
Germany	5	721	-	-
Japan	3	71	3	139
UK	-	-	2	30
USA	12	743	-	-

**Table - 19 : Imports of Graphite Crucibles  
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
<b>All Countries</b>	<b>749</b>	<b>46055</b>	<b>1794</b>	<b>76292</b>
China	675	43799	1594	69468
Hong Kong	-	-	100	4646
USA	-	-	24	840
Germany	30	1202	42	617
Italy	-	-	30	448
Singapore	-	-	3	177
Poland	-	-	1	96
Chinese Taipei/ Taiwan	40	861	-	-
France	4	193	-	-

## FUTURE OUTLOOK

The graphite reserves having +40% fixed carbon are rather limited in the country. Detailed exploration of graphite deposits in Orissa, Jharkhand, Jammu & Kashmir and Kerala should be carried out. Cost-effective beneficiation technologies for low-grade graphite ore need to be developed. Silicon

**Table - 20 : Imports of Silicon Carbide Crucibles  
(By Countries)**

Country	2006-07		2007-08	
	Qty. (t)	Value (Rs. '000)	Qty. (t)	Value (Rs. '000)
<b>All Countries</b>	<b>236</b>	<b>24809</b>	<b>843</b>	<b>33795</b>
Germany	124	9904	216	10158
USA	26	3807	271	9547
UK	44	5902	160	6539
Czech Republic	4	774	96	2387
Switzerland	1	14	30	2111
Italy	12	2651	9	1024
Japan	-	-	41	978
France	-	-	6	568
China	12	742	11	256
UAE	4	644	-	-
Other countries	9	371	3	227

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. Some important higher applications have emerged in exfoliated graphite which are for making sealings, gaskets, braids and brushes. New products of synthetic graphite are graphite fibres/ropes and graphite insulation blankets. Carbon-composite materials are used in very high technology areas, such as aerospace and these advanced materials are produced in Hyderabad in a pilot plant. On world scenario, a potential large-volume end-use for natural graphite has emerged in heat sinks, also called spreader shield, which is a graphite foil material conducting heat only in two directions. It has thermal conductivity above aluminium and almost equal to copper. These are used for carrying away heat in laptop computers, flat-panel displays, wireless phones, digital video cameras, etc. The silicon carbide crucible industry should be encouraged to increase the exports of its products for increased margin of profits.