

29 Diamond

India is known for its diamond cutting and polishing business especially for small size diamonds. Most of the world's business come to India, particularly to Surat in Gujarat. Indian diamond industry handles 80% of the global polished diamond market. India depends largely on imports of rough gem diamonds for its cutting and polishing industry as there is only one producer in Madhya Pradesh and the production is negligible to meet the cutting and polishing industry's requirements. The cut and polished diamonds are re-exported. Diamond has been the most valuable among gems for more than 2,000 years. Being the hardest natural substance known, industrial variety diamonds are used in grinding, drilling, cutting and as polishing tool. In addition, diamond exhibits highest thermal conductivity amongst minerals and has high electrical resistivity making it suitable for application in semiconductors. The prices of gem diamonds depend upon their rarity, weight, quality, shape and flawlessness.

Diamond has a high refractive index and strong dispersion which gives it exciting brilliance when cut as a faceted stone. Gem diamonds are transparent and colourless or show faint shades of different colours. The transparent water-clear diamonds are known as "of first water" or "blue-white". When yellowish or honey colour tinge is present, they are termed as off-colour stones. The industrial diamonds are dark brown in colour. Diamonds with green, blue or red shades are rare and attract higher price than the common varieties.

Flawless stones of good colour are employed in gem trade while off-colour, flawed & defective stones, chips & cuttings as well as small grains & dust are used in industry. Industrial grade diamond, i.e., diamond that does not meet gem quality standards in terms of colour, clarity, size or shape and those that are produced as a by-product of mining for gem diamonds continue to be used principally as abrasives in many applications despite their initial cost. Although diamond is more expensive than the other abrasive materials, it is more cost-effective in numerous industrial processes because it lasts longer than any other material.

Broadly, industrial diamonds have three varieties viz, 'ballas' which is mass of minute diamond crystals difficult to cleave, 'bort' is grey to black and massive, flawed or irregular in shape and 'carbonado' is black, opaque and without cleavage.

RESOURCES

Diamond occurrences are reported since pre-historic times in the country. Presently, diamond fields of India are grouped into four regions:

- 1) South Indian tract of Andhra Pradesh, comprising parts of Anantapur, Cuddapah, Guntur, Krishna, Mahaboobnagar and Kurnool districts;
- 2) Central Indian tract of Madhya Pradesh, comprising Panna belt;
- 3) Behradin-Kodawali area in Raipur district and Tokapal, Dugapal, etc. areas in Bastar district of Chhattisgarh; and
- 4) Eastern Indian tract mostly of Odisha, lying between Mahanadi and Godavari valleys.

As per the UNFC system as on 1.4.2005 all India resources of diamond are placed at around 4.582 million carats. Out of these, 1.206 million carats are placed under reserves category and 3.376 million carats under remaining resources category. By grades, about 17% resources are of gem variety, 18% of industrial variety and bulk of the resources (65%) are placed under unclassified category. By states, Andhra Pradesh accounts for about 40% resources followed by Madhya Pradesh (32%) and Chhattisgarh (28%) (Table - 1).

EXPLORATION & DEVELOPMENT

GSI continued exploration activities for search of kimberlite, the source rock of diamond, in Andhra Pradesh and Karnataka. Directorate of Geology, Odisha, explored areas in Nuapada district. Details of exploration activities by GSI and State DG, Odisha are furnished in Table -2.

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

State/Grade	Reserves				Remaining resources				Total Resources (A+B)	
	Proved STD111	Probable STD122	Total (A)	Pre-feasibility STD221	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334		Total (B)
All India : Total	605577	600000	1205577	1240	298638	1523077	1549359	4022	3376336	4581913
By Grades										
Gem	-	-	-	1017	234148	-	521600	-	756765	756765
Industrial	-	-	-	223	58200	-	782400	-	840823	840823
Unclassified	605577	600000	1205577	-	6290	1523077	245359	4022	1778748	2984325
By States										
Andhra Pradesh	-	-	-	1240	298638	1523077	-	-	1822955	1822955
Chhattisgarh	-	-	-	-	-	-	1304000	-	1304000	1304000
Madhya Pradesh	605577	600000	1205577	-	-	-	245359	4022	249381	1454958

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Table – 2 : Details of Exploration Activities for Diamond, 2009-10

Agency/ State/ District	Location	Mapping		Drilling		Sampling (No.)	Remarks and reserves/Resource estimated
		Scale	Area (sq km)	No. of borehole	Meterage		
GSI Andhra Pradesh Mahaboob- nagar	Buthpur & Achampet block	–	–	–	–	N.A.	Systematic stream sediment samples were collected from suitable trap sites from 4 th & 5 th order streams. Heavy minerals identified include magnetite, epidote, garnet, tourmaline, zircon, sphene, amphibole, ilmenite, hematite, cassiterite rutile and iron hydroxide.
Mahabbob- nagar	Kalwakurthi and Charakunda block	–	–	–	–	–	Samples collected from suitable trap sites from 4 th & 5 th order streams. The major heavy minerals observed are, magnetite, epidote, garnet, tourmaline, zircon, sphene, etc. The investigation will be completed during FS 2009-10.
Karnataka Raichur	Gunjehalli			Reconnaissance stage			Analytical result of samples are awaited.
	Turkandoni			Indicator mineral Survey, geological traverse and pitting			Mapping of the area revealed a suspected ultramafic body. Two kimberlite bodies were discovered about 300 m south of Turkandoni through indicator mineral survey, geological traverse and pitting.
Directorate of Geology Odisha Nuapada	Arkholi	1:50,000	20.00	–	–	120 tonnes bulk samples	Trial excavation 100 cu.m. Resources were not estimated because no incidence of diamond was noticed.
	Kalmidadar	–	–	24 core & non core	501.45m	Core-500 Rock-27 Loam-03 Total:530	Bulk sample processing inferred that Kalmidadar lamproit body is diamond bearing with good recovery of diamonds.

PRODUCTION & STOCKS

Production of diamond at 16810 carats in 2009-10 as against 536 carats in the previous year showed a steep rise of 31 times over the previous year, because the ban on Majhgaon diamond mine, Panna of NMDC was lifted by Madhya Pradesh State Pollution Controll Board and mine started on 20.6.2009. There were two operating mines, both in public sector located in Panna district of Madhya Pradesh. Of these, the one is operated by National Mineral Development Corporation (NMDC) Ltd contributed the almost

entire production of diamond and a very small quantity of production was reported by the Department of Geology and Mining, Government of Madhya Pradesh.

Out of the total output, gem variety constituted 33% and the remaining 67% was of off-colour and dark brown varieties of industrial grade (Tables 3 to 5).

The average daily employment of labour during 2009-10 was 163 as against 197 in the previous year.

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Table – 3 : Producer of Diamond, 2009-10

Name & address of producer	Location of Mine	
	State	District
NMDC Ltd 10-3-311-/A, Castle Hills, Masab Tank, Hyderabad-500 028, Andhra Pradesh.	Madhya Pradesh	Panna
Director of Geology & Mining, Government of Madhya Pradesh, Khanij Bhavan, 29-A, Arera Hill, Bhopal - 462 016, Madhya Pradesh.	Madhya Pradesh	Panna

**Table – 4 : Production of Diamond, 2007-08 to 2009-10
(By State)**

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

State	2007-08		2008-09		2009-10(P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	586	5701	536	4537	16810	115949
Madhya Pradesh	586	5701	536	4537	16810	115949

**Table – 5 : Production of Diamond, 2008-09 and 2009-10
(By Sectors/State/District/Grades)**

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

State/District	No. of mines	2008-09			Value	No. of mines	2009-10(P)			Value
		Quantity					Quantity			
		Gem (rough & uncut)	Industrial*	Total			Gem (rough & uncut)	Industrial*	Total	
India										
Public sector	2	216	320	536	4537	2	5556	11254	16810	115949
Madhya Pradesh										
Panna	2	216	320	536	4537	2	5556	11254	16810	115949

* Includes off-colour and dark-brown varieties of diamond.

MINING & PROCESSING

Majhgawan in Madhya Pradesh is a fully mechanised mine operated by NMDC. It is worked by opencast method in tuff rock by deploying 4.1 cu m hydraulic shovel and 40-tonne dumpers in combination. The mine benches have been designed with a height of about 10 m. Few benches are of 4-5 m height too. Drilling is done

by 4-inch diameter drills and charged with slurry explosives, and about 40-50 holes are blasted at a time with delay pattern. The capacity of the mine is about 30,000 carats per year. Diamonds are also recovered from conglomerate and gravel beds at shallow depths by small operations on the basis of annual permits granted by Diamond Officer, Government of Madhya Pradesh.

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At Majhgawan, kimberlite rock after mining is stock piled for weathering action and then is fed to crushing plant. It is processed through Heavy Media Separation System in processing plant for recovery of diamond. Recently, X-ray diamond sorter has been installed for sorting of diamonds from ore by which recovery of raw diamonds has increased to 98%.

Diamond Mining Factors

Grade: Grade is the weight of diamond expressed as carats per tonne (ct/t) of ore. It varies widely from one mine to another but generally falls somewhere between 0.3 and 1.3 ct/t. One carat is equivalent to 0.2 gram.

Size (weight) of rough diamonds in deposit: Individually, rough diamonds can range from microweight to stones weighing more than 1,000 carats. Depending on the mine, the average size of rough diamonds recovered can weigh from 0.01 ct (about 1 mm) to more than 0.7 ct. Many mines in the world show on an average about 0.4 to 0.5 ct per stone. It is interesting to note that the number of stones larger than 2 ct (0.4 g) produced at mines are very small (about 400,000 stones per year)

INDUSTRY

Indian diamond industry enjoys respect and credibility in the world market, particularly for small diamonds used in jewellery. Indian diamond manufacturing standards are reckoned as the best in the world. Indian artisans can polish small diamonds economically and efficiently. India may become a Trading Centre for rough and polished diamonds in near future. Surat in Gujarat is the main centre of the cutting and polishing industry.

There are over 10,000 diamond processing units in Surat. Most of them now use computerised cutting machines.

India is maintaining its leading position in the world market because of the combination of pragmatic policies of the Government and sustained efforts of exporters. Policy changes, such as, creation of Special Economic Zones (SEZ) will help boost the export performance further. Several diamond polishing companies have

already established offices in India for trading in rough and polished diamonds. India obtains rough diamonds from Belgium, UK, Hong Kong, UAE, Israel, etc. Indian diamond traders seek opportunities to establish direct trade ties with mining countries and companies. The Indian diamond industry is looking for more supply of rough diamonds at competitive rates directly from the producers to maintain its lead in the world market.

CONSUMPTION

Industrial diamonds are mostly consumed by manufacturers of drill bits, grinding tools and stone cutting and polishing machines. Though many small-scale sector units operate in cutting and polishing trade, it is difficult to get a reliable data on consumption of industrial diamonds. Demand of industrial diamonds is mostly met by imports.

SUBSTITUTE

Synthetic Diamond

Today, market for industrial diamond is dominated by synthetic stones, first developed in 1950s. Synthetic diamonds manufactured using high pressure and high temperature methods compete as an abrasive mineral with natural industrial diamonds and also with manufactured materials like silicon carbide (SiC), alumina (Al₂O₃), tungsten carbide (WC) and carbide boron nitrate (CBN). Synthetic diamonds being marketed are mostly 0.6 - 0.8 mm and smaller in size. Synthetic Diamond Abrasives (SDA) are used for sawing, drilling or milling hard stones, concrete aggregate, refractory materials, masonry and asphalt. In general, large crystals are used for cutting softer materials and smaller crystals for tougher jobs. Synthetic diamonds now account for bulk supply of industrial diamonds and are preferred over natural diamonds because their quality can be controlled to suit customer requirements.

Synthetic diamonds were produced earlier by using graphite with a metal catalyst under very high pressure & temperature.

A process which needs relatively low pressure for production of synthetic diamonds is chemical vapour deposition (CVD). This process involves depositing tiny crystals of diamond on a

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film which can be built in complicated shapes and used at desired places or instruments such as machine part, heat conductors in micro circuit, shortwave UV, microwave sources and radiation detectors. In future, CVD can be a substitute for silicon in computer industry. In 2009, in USA, developments were made in CVD method of growing 100% pure diamond using microwave plasma technology to make this method more economical, as also to grow larger crystals.

(31%), Botswana (46%), Canada (26%), Congo (36%), Russia (6%), and South Africa (53%). The principal producers were Russia (29%), Congo (18%), Botswana (15%), Angola (11%), Canada & Australia (9% each) and South Africa (5%) (Table-7). Natural diamonds are cut in 52 countries. The major diamond cutting centres in the world are Antwerp in Belgium, Ramatyyan in Israel, New York in USA and Surat in India.

POLICY

Import of diamond under Heading No.7102, whether or not worked, but not mounted or set, fall under 'free' category as per the Export-Import Policy 2009-2014. Foreign Direct Investment (FDI) in diamond mining up to 100% is admissible for automatic approval of Reserve Bank of India.

WORLD REVIEW

The world reserves of industrial diamond are about 580 million carats and are located in Congo (Kinshasa) (26%), Botswana (22%), Australia (17%), South Africa (12%) and Russia (7%). The world reserves of diamond are given in Table-6.

**Table – 6 : World Reserves of Diamond
(Industrial)
(By Principal Countries)**

Country	Reserves
(In million carats)	
World : Total (rounded)	580
Australia	95
Botswana	130
China	10
Congo (Kinshasa)	150
Russia	40
South Africa	70
USA	NA
Other countries	85

Source: Mineral Commodity Summaries, 2010.

The total world production of diamond decreased considerably by 27% from 165 million carats in 2008 to 121 million carats in 2009. Angola increased the output of diamond considerably, while decrease in output was noticed in Australia

**Table – 7 : World Production of Diamond
(By Principal Countries)**

Country	2007	2008	2009
(In '000 Carats)			
World: Total	169900	165200	121300
Russia	38291	36925	34759
Congo, Dem. Peo. Rep.	28452	33402	21298
Botswana	33639	32595	17734
Angola	9702	8907	13828
Canada	17008	14803	10946
Australia	19231	15670	10795
South Africa	15247	12901	6119
Namibia	2266	2435	1192
Zimbabwe	695	797	963
Ghana	839	598	354
Guinea	1019	3098	697
Sierra Leone	604	371	400
Other countries	2907	2698	2210

Source: World Mineral Production, 2005-2009.

Worldwide in 2009, three small mines and two expansion projects started up three mine were in Russia and two were in Guinea.

CANADA

Diamond exploration continued in Canada with several commercial diamond projects. Additional discoveries were made in Alberta, British Columbia, the Northwest Territories, Nunavut, Ontario and Quebec. After Canada's Ekati Diamond Mine and Diavik Diamond Mine, Jericho Diamond Mine is the third diamond mine located in Nunavut. Diavik mine started underground developments in 2009 and first ore was expected in 2010, while full production is

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expected by 2013. The Snap Lake Mine of De Beers' Canada Inc is in the Northwest Territories. It started operations in 2007 and commercial production in 2008. Its capacity is 1.4 million carat per annum and estimated life of 20 years. De Beers' Victor Mine is open pit mine. Opened in 2007, it started production in 2008. At 600,000 carats per annum, its life is estimated to be 12 years.

GUINEA

The Mandala alluvial mine, owned by Stellar Diamonds, is estimated to have 536,000 carats of diamond in 1.41 Mt of resources grading 0.38 carats per tonne.

Bomboko alluvial mine of West Africa Diamonds started production in October 2009 with the capacity of 1500 carats of diamond per month from 35,000 tonnes of ore. 60% of diamond produced was of gem quality and 40% was industrial grade. Diamond reserves were estimated at 750,000 carats at the grade of 0.03 carats per tonne.

RUSSIA

Since 2004 Russia was the world's leading producer of industrial diamonds. The largest mine viz. Lomonosov mine in northwestern Russia was commissioned in 2009. This mine is 95% owned by Alrosa and 5% by the Government of Russia. Lomonosov was estimated to have 27.3 million carat of diamonds contained in 54.8 million tonnes ore grading an estimated 0.5 carat per tonne. The mine has capacity to produce one million tpy ore at present. The Mir underground mine was opened officially in August year and was expected to have a 50 year life. A third new mine owned by Alrosa viz. Aikhal underground mine in Yakutia began commercial production in December 2009. A 25-years mine life has been estimated.

SOUTH AFRICA

In the famous Cullinan mine, where the largest ever diamond was discovered in the last century, a rough diamond weighing over 500 carats was discovered in September 2009 along with three other diamonds weighing 168 carats, 58.5 carats and 53.3 carats. The mine is also a source of blue diamonds.

FOREIGN TRADE

Exports

Value of exports of diamond increased to Rs. 85,942 crore in 2009-10 from Rs. 72,261 crore in the previous year. Diamond (mostly cut) alone accounted for more than 99% exports in terms of value. The share of industrial diamonds and diamond powder was Rs. 106 crore and Rs. 710.6 crore, respectively. Exports were mainly to Hong Kong & UAE (30% each), USA (18%), Belgium (9%) and Israel (4%) (Tables 8 to 11).

Imports

In 2009-10, imports value of diamond decreased marginally to Rs.74,441 crore from Rs.74,886 crore in the previous year. Uncut diamond shared the bulk, i.e., about 99.8 % of imports. Imports of industrial diamond and diamond powder were 2,216 carats and 107,077 carats, respectively, valued at Rs.103.2 crore and Rs.38.6 crore. Imports were mainly from UAE (35%), Belgium (29%), Hong Kong (18%), UK & USA (5% each) and Israel (4%) (Tables 12 to 15).

Table – 8 : Exports Value of Diamond : Total (By Countries)

Country	2008-09	2009-10
	Value (Rs.'000)	Value (Rs.'000)
All Countries	722606545	859420958
Hong Kong	217763531	260518017
UAE	162619138	253989495
USA	127430137	150650963
Belgium	82452750	76503185
Israel	36140073	35283339
Singapore	16021125	16156922
China	21082065	15557667
Thailand	11765711	12543993
Japan	10945508	10327771
Unspecified	7592672	2768303
Other countries	28793835	25121303

Note : Quantity not given due to partial coverage; value figures, however, have full coverage.

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**Table – 9 : Exports of Diamond (Industrial)
(By Countries)**

Country	2008-09		2009-10	
	Qty (Carat)	Value (Rs.'000)	Qty (Carat)	Value (Rs.'000)
All Countries	2484310	1185472	770352	1058591
Hong Kong	127018	225977	46375	478027
UAE	825415	564441	84510	325996
Belgium	973299	252618	558999	241573
South Africa	–	–	2915	6274
USA	69147	33854	25051	2932
China	8763	4188	50000	1357
UK	188878	17126	1000	782
Ireland	130829	7934	–	–
Israel	100594	3504	–	–
Unspecified	50000	70464	295	627
Other countries	10367	5366	1207	1023

**Table – 10 : Exports of Diamond (Mostly Cut)
(By Countries)**

Country	2008-09		2009-10	
	Qty (Carat)	Value (Rs.'000)	Qty (Carat)	Value (Rs.'000)
All Countries	57960232	720920219	66090838	851256380
Hong Kong	19286983	217479104	22202264	258996060
UAE	14904916	161985154	18141623	250839164
USA	6982843	127301027	7708866	150596899
Belgium	6847613	82014838	7917255	73598328
Israel	1331746	36120732	1019436	34964440
Singapore	2334484	16021069	1952764	16156922
China	1553993	21043295	1346982	15493992
Thailand	1049303	11765709	1188321	12541361
Japan	951338	10945304	2599841	10303013
Unspecified	698557	7522208	223565	2753476
Other countries	2018456	28721779	1789921	25012725

**Table – 11 : Exports of Diamond Powder
(By Countries)**

Country	2008-09		2009-10	
	Qty (Carat)	Value (Rs.'000)	Qty (Carat)	Value (Rs.'000)
All Countries	8637	500854	16961	7105987
UAE	96	69543	2370	2824335
Belgium	1600	185294	4781	2663284
Hong Kong	830	58450	4797	1043930
Israel	587	15837	1272	318899
China	78	34582	697	62318
USA	3455	95256	1199	51132
UK	382	11037	1058	38731
Japan	6	204	124	24326
Australia	453	4926	4	13075
Ireland	286	8414	385	10203
Other countries	864	17311	274	55754

**Table – 12 : Imports Value of Diamond : Total
(By Countries)**

Country	2008-09	2009-10
	Value (Rs.'000)	Value (Rs.'000)
All Countries	748858813	744408663
UAE	191636107	257281908
Belgium	182708558	215321884
Hong Kong	206817474	137614618
UK	47688626	37566718
USA	36039946	35515405
Israel	27326877	31475499
Russia	3373095	7299794
China	21571147	5252857
Switzerland	3411632	3826897
Unspecified	10897737	826507
Other countries	17387614	12426576

Note : Quantity not given due to partial coverage; value figures, however, have full coverage.

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**Table – 13 : Imports Value of Diamond
(Industrial)
(By Countries)**

Country	2008-09	2009-10
	Value (Rs.'000)	Value (Rs.'000)
All Countries	99064	1031716
Hong Kong	–	861398
UAE	–	67005
Iceland	–	62728
Honduras	–	24514
Singapore	–	7544
UK	–	6664
Namibia	–	755
France	–	660
Belgium	98404	–
South Africa	660	–
Other countries	–	448

Note : Quantity not given due to partial coverage; value figures, however, have full coverage.

**Table – 14 : Imports of Diamond (Mostly Uncut)
(By Countries)**

Country	2008-09		2009-10	
	Qty (Carat)	Value (Rs.'000)	Qty (Carat)	Value (Rs.'000)
All Countries	143464060	748417096	130101282	742991285
UAE	26380076	191636107	28553735	257214320
Belgium	52142986	182594680	60942681	215310767
Hong Kong	26393775	206815973	15196064	136749381
UK	17093722	47686683	12299089	37560054
USA	3442099	36007037	2413370	35483178
Israel	3288667	27326877	3971928	31475499
Russia	1509058	3372674	2210400	7298007
China	3281187	21389181	258218	4992210
Switzerland	1201479	3411438	1373723	3824114
Unspecified	5656712	10880239	62737	819173
Other countries	3074299	17296207	2819337	12264582

**Table – 15 : Imports of Diamond Powder
(By Countries)**

Country	2008-09		2009-10	
	Qty (Carat)	Value (Rs.'000)	Qty (Carat)	Value (Rs.'000)
All Countries	72333	342653	107077	385662
China	55085	181966	91071	260647
Ireland	7917	61803	4149	45582
USA	3849	32909	3794	32227
Korea, Rep. of	1635	13116	1605	13715
Belgium	1189	15474	1149	11117
Hong Kong	84	1501	2503	3839
Germany	785	13707	813	2803
Switzerland	4	194	367	2783
UK	173	1943	–	–
Russia	134	421	–	–
Chinese Taipei/Taiwan	30	680	484	2267
Unspecified	1328	17498	357	7334
Other countries	427	3805	785	3348

FUTURE OUTLOOK

Based on the exploration practices and activities in India new Kimberlites/Lamproites may be discovered. This may result in establishment of new mine and commencement of production by 2015. However, this may only meet a fraction of the industry's requirement. India will have to depend on imports of rough stones for a long time.

The diamond industry in the country currently employs over 7 lakh artisans who are experts in cutting and polishing of small diamonds and are now in a position to process full range of sizes and qualities of gemstones using latest technology.

IBM has identified various thrust areas for modernisation of its testing facilities, one of them is adding one automatic dry up unit and x-ray diamond sorter for characterisation of diamondiferous Kimberlite of Chhattisgarh and Madhya Pradesh region and conducting beneficiation studies for recovery of diamonds.

In view of its superior finishing, the Indian diamonds have a good demand in the international market, especially in USA, Hong Kong, Belgium, Japan, Israel, Thailand, UAE, Switzerland, Australia, New Zealand and Singapore. The exports from India are likely to go up even further.