Indian Minerals Yearbook 2016

(Part- III : Mineral Reviews)

55th Edition

GARNET

(FINAL RELEASE)

GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

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February, 2018

23 Garnet

Garnet is the collective name for a group of minerals which crystalise in cubic system with different chemical composition. The principal members of the Garnet group are Almendine (Fe-Al) , Pyrope (Mg-Al), Spessartite (Mn-Al), Grossularite (Ca-Al), Andradite (Ca-Fe), and Uvarovite (Ca-Cr). Almendine is harder amongst all varieties and is often used for abrasive purpose. Garnet is dense & hard with sharp angular chisel-edged fracture, containing small amounts of free silica and exhibits high resistance to physical and chemical attacks. It is used both as semi-precious stone and as an abrasive. The hardness of garnet varies from 6.5 to 7.5 on Mohs' scale.

RESERVES/RESOURCES

In India, garnet deposits suitable for use in abrasive industry occur in Andhra Pradesh, Chhattisgarh, Jharkhand, Kerala, Odisha, Rajasthan, Tamil Nadu and Telangana. Gem variety of garnet occurs in Ajmer, Jaipur, Kishangarh, Tonk and Udaipur districts, Rajasthan; Krishna and Nellore, Andhra Pradesh; Warangal district, Telangana and Coimbatore, Nilgiri, Tirunelveli, Kanyakumari, Madurai, Tiruchirappalli, Thoothukudi and Salem districts, Tamil Nadu. Garnet is found to occur in beach sands along with ilmenite, rutile, sillimanite, etc. in the states of Kerala, Odisha and Tamil Nadu.

The total reserves/resources of garnet in India as on 1.4.2015, as per NMI database based on UNFC system are placed at 56.16 million tonnes of which reserves under proved and probable categories together constitute 12.78 million tonnes. Of the total reserves/resources, about 20.90 million tonnes are of abrasive grade, whereas resources of semi-precious grade are mere 5,803 tonnes only. Tamil Nadu alone accounts for about 48% of the total reserves/resources followed by Andhra Pradesh 31% and Odisha 17% and Telangana 3%. The remaining states together shared less than 1% (Table- 1).

EXPLORATION & DEVELOPMENT

During 2015-16, GSI investigated 50 sq km within the territorial waters off north of Bhimunipatnam, (off Santapalle) Andhra Pradesh. About 66 vibro core samples with core length varying from 0.16 to 3.25 m were collected on a grid pattern of 1 km x 1 km within water depths of 12.98 to 21.5 m. Increase in grain size towards bottom is recorded in the area. Heavy minerals are observed in grey fine sand. Detailed studies are in progress.

GSI continued investigation in Gopalpur-Sonapurpeta sector in Ganjam district, Odisha in the beach sand and nearshore region (0 to 10 m isobaths) to study the coastal processes with emphasis on heavy mineral concentration. Preliminary studies reveal major constituents of heavy minerals comprising ilmenite, garnet and sillimanite followed by zircon, rutile, monazite suggesting their source from crystalline. The heavy minerals weight percentage is found on an average of 11% in beach sand samples and 6% in the near shore samples.

Indian Rare Earths Ltd carried out drilling in Chatrapur areas in Ganjam district, Odisha. Total 409 boreholes with a total meterage of 3385 meters were drilled. About 202.24 million tonnes of total reserves of beach sand minerals including garnet were proved.

PRODUCTION AND STOCKS

Garnet (Abrasive)

Production of garnet (abrasive) at 81,794 tonnes during 2015-16 decreased by 11% as compared to that in the preceding year. There were 7 reporting mines during 2015-16 as against 6 in the previous year. Besides, production of garnet (abrasive) was reported as an associated mineral by one sillimanite mine in Odisha. Three principal producers accounted for about 99% of the total output during the year. The share of public sector in the total output was about 31% in 2015-16 and 25% in the previous year.

In 2015-16, 68% of the total production was reported from Andhra Pradesh, 18% from Odisha, 13% from Tamil Nadu and the remaining 1% was from Rajasthan (Tables - 2 to 4).

Mine-head closing stocks of Garnet (abrasive) for the year 2015-16 were 65 thousand tonnes as against 64 thousand tonnes in the previous year (Table -5).

The average daily employment of labour during 2015-16 was 1,868 as against 1,864 in the previous year.

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

(In tonnes)

Grade/State	Reserves				Remaining Resources								
	Proved STD111	Probable		Total (A)	Feasibility STD211	Pre-feasibility		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	Total (B)	Total Resources (A+B)
		STD121	STD122			STD221	STD222						
All India : Total	**9917936**	**278493**	**2587427**	**12783856**	**84320**	**1643412**	**3287667**	**121099**	**10247428**	**27992906**	**333**	**43377166**	**56161022**
By Grades													
Gem	39000	362	34	39396	2	81339	-	-	-	109	-	81450	120846
Abrasive	9804483	276468	2586266	12667217	3062	1489600	3194708	106060	19428	3423374	333	8236565	20903782
Semi-precious	18	13	1128	1159	41	115	514	39	1249	2688	-	4645	5803
Others	-	-	-	-	9051	36358	-	-	-	215573	-	260982	260982
Unclassified	74435	1650	-	76085	72164	36000	394	15000	10225996	23968842	-	34318396	34394481
Not-known	-	-	-	-	-	-	92051	-	756	382321	-	475128	475128
By States													
Andhra Pradesh	1183898	4500	568750	1757148	12189	232525	791238	18	8800000	5674011	-	15509981	17267129
Chhattisgarh	-	-	-	-	-	-	-	-	-	28800	-	28800	28800
Jharkhand	-	-	-	-	-	-	88303	-	-	21768	-	110071	110071
Kerala	-	-	45797	45797	-	-	-	100874	-	52190	-	153064	198861
Odisha	8459821	-	585130	9044951	5	-	-	-	-	348000	-	348005	9392956
Rajasthan	33566	35926	5556	75048	3100	26663	29629	5207	21432	123587	333	209952	285000
Tamil Nadu	225554	238067	1382194	1845815	21936	1342191	2378497	15000	1425996	19888574	-	25072194	26918009
Telangana	15097	-	-	15097	47090	42033	-	-	-	1855976	-	1945099	1960196

Figures rounded off.

Table – 2 : Principal Producers of Garnet (Abrasive), 2015-16

Name & address of producer	Location of mine	
	State	District
Trimex Sands Pvt. Ltd, Trimex Towers, No. 1, Subbraya Avenue, C. P. Ramaswamy Road, Alwapet, Chennai-600 018. Tamil Nadu	Andhra Pradesh	Srikakulam
Indian Rare Earths Ltd, Plot No. 1207, Veer Savarkar Marg, Near Siddhivinayak Temple, Prabhadevi, Dadar- 400 028 Mumbai, Maharashtra.	Tamil Nadu Odisha	Kanyakumari Ganjam*
Transworld Garnet India Pvt. Ltd, New No. 34, Old No. 46, M. G. R. Road, Kalakshetra Colony, Besant Nagar, Chennai- 600 090, Tamil Nadu.	Andhra Pradesh	Srikakulam

**Producing as an associated mineral with Sillimanite.*

Table – 3 : Production of Garnet (Abrasive) 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	**483559**	**1113231**	**91394**	**800998**	**81794**	**685899**
Andhra Pradesh	108409	831543	68275	645124	55583	513370
Odisha	19091	106012	11999	73218	14767	92701
Rajasthan	715	807	725	993	751	1342
Tamil Nadu	355344	174869	10395	81663	10693	78486

Table – 4 : Production of Garnet (Abrasive), 2014-15 & 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	**6(1)**	**91394**	**800998**	**7(1)**	**81794**	**685899**
Public sector	2(1)	22394	154881	2(1)	25460	171187
Private sector	4	69000	646117	5	56334	514712
Andhra Pradesh	**2**	**68275**	**645124**	**2**	**55583**	**513370**
Srikakulam	2	68275	645124	2	55583	513370
Odisha	**(1)**	**11999**	**73218**	**(1)**	**14767**	**92701**
Ganjam	(1)	11999	73218	(1)	14767	92701
Rajasthan	**2**	**725**	**993**	**3**	**751**	**1342**
Ajmer	1*	-	-	1*	-	-
Bhilwara	1	725	993	2	751	1342
Tamil Nadu	**2**	**10395**	**81663**	**2**	**10693**	**78486**
Kanyakumari	2	10395	81633	2	10693	78486

Figures in parentheses indicate associated mine of sillimanite.
** Only Labour Reported.*

Table – 5 : Mine-head Closing Stocks of Garnet (Abrasive) 2014-15 & 2015-16 (By States)

(In tonnes)

State	2014-15	2015-16 (P)
India	**63608**	**64612**
Andhra Pradesh	7409	7783
Odisha	515	1037
Rajasthan	405	451
Tamil Nadu	55279	55341

Garnet (Gem)

No production of garnet (gem) was reported during 2015-16.

MINING & MARKETING

Garnet is obtained generally by digging small shallow pits barring a few places in Tamil Nadu where it is recovered from sea shore. Mining is done manually with the help of pick axes and spades. Drilling and blasting are not required as garnet is excavated from soft weathered rocks. Fine abrasive garnet is recovered from processing of beach sands. The mining of beach sand is done by dry and wet dredging. In Heavy Upgradation Plant and Mineral Separation Plant, individual minerals including garnet are separated. Sands with 26% of contained garnet is upgraded to 80-88% garnet rich concentrate at TGI Plan, which is further upgraded to 98-99% pure product. The production from mines is graded into two varieties- abrasive and gem, depending on the clarity of crystals. After cutting and polishing, clear, flawless and rich-colour crystals of garnet are sold as semi-precious stones.

USES & CONSUMPTION

The most important industrial use of garnet in the form of garnet sand is as an abrasive. About 90% production of abrasive garnet is used for manufacturing of garnet-coated papers, clothes and discs. Garnet-coated abrasives are used in the form of belts, covers for drums, discs or as small sheets. It is used for cleaning spark plugs, paints, polishing and grinding of plate-glass. The remaining 10% output is used in the form of loose grains for surfacing and polishing soft stones (marble, slate, soapstone, etc.). Clear, flawless and rich-coloured crystals of garnet are used as semi-precious stones. The principal variety among them are pyrope, deep-crimson almandine, orange-yellow grossularite, etc. Other uses are in electronic and television industry for polishing glass and TV tubes. Garnet granules are used in 'abrasive blasting' commonly called 'sand blasting' in order to smoothen, clean and remove oxidation products from metals, stone and other material. MMTC laid down specifications of garnet sand used for sand blasting\jet cutting/other uses are as follows: Al_2O_3: 20.8 to 21.2%, Bulk density; 2.17 kg\m^3, Hardness in Moh's scale should be7.5 to 8.

Water jet cutting machines generally use finely ground 80-120 mesh size garnet as cutting medium with high pressure water. Owing to its inertness to a wide range of chemicals and relatively high specific gravity, it is used as filter medium for water and other liquids.

WORLD REVIEW

Garnet group of minerals are found through out the world in metamorphic, igneous and sedimentary rocks.

World reserves of garnet are moderate to large and occur in a wide variety of rocks like gneisses, schists in crystalline limestone, pegmatites, serpentinites, vein deposits, etc. In addition, alluvial garnet also occurs in heavy minerals sand deposits throughout the world. Major garnet deposits are found in USA, Australia, China and India. Deposits of garnets are also located in Canada, Chile, Czech Republic, Pakistan, South Africa, Spain, Thailand and Ukraine.

In 2015, India produced about 47% of total global production, followed by China 31% and Australia 15% and remaining 7% was contributed by USA and other countries. Russia and Turkey are also mining garnet for domestic markets. Garnet is also mined in Canada, Chile, Czech Republic, Pakistan, South Africa, Spain, Thailand and Ukraine.

Worldwide the end uses of garnet and market shares are: abrasive blasting media 30%, abrasive grains for waterjet cutting 35%, water filtration 20%, abrasive powder 10% and other end uses 5 per cent.

The world reserves and production of industrial garnet are furnished in Tables- 6 and 7.

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

(In 000' tonnes)

Country	Reserves
World: Total (rounded)	**Moderate to Large**
Australia	Moderate to large
China	Moderate to large
India*	19000
USA	5000
Other countries	6500

***Source**:Mineral Commodity Summaries, 2017.*
** India's total UNFC resources of garnet as on 1.4.2015 are estimated at 56.16 million tonnes.*

Table – 7 : World Production of Garnet (Industrial) (By Principal Countries)

(In tonnes)

Country	2013	2014	2015
World: Total	**1660000**	**1660000**	**1690000**
Australia	263000	263000	260000
China	510000	520000	520000
India*	800000	800000	800000
USA	33900	32200	55600
Other countries	50000	50000	50000

Source:Mineral Commodity Summaries- 2016 & 2017
Note : Figures are rounded off.
** India's production of garnet (abrasive) during 2013-14, 2014-15 and 2015-16 was 0.48 million tonnes, 0. 91 million tonnes and 0.82 million tonnes, respectively.*

FOREIGN TRADE

Exports

Exports of abrasive garnet increased by 7.1% to 4,80,408 tonnes in 2015-16 from 4,48,559 tonnes in 2014-15. Exports were mainly to USA (21%), UAE (15%), Saudi Arabia (6%), Germany (5%) and Kuwait (4%). Exports value of garnet (cut & uncut) decreased in 2015-16 to ` 2.54 crore from ` 3.11 crore in the previous year. Out of total cut and uncut garnet, about 99% exports earnings were from cut garnet. Exports of cut variety were mainly to Czech Republic (5%), Hong Kong (11%), USA (31%), Thailand (9%) and UK (32%) (Tables- 8 to 11).

Imports

In 2015-16, imports of abrasive garnet increased by 36% to 883 tonnes from 647 tonnes in the previous year. Imports value of cut and uncut garnet decreased in 2015-16 to ` 626 lakh from ` 687 lakh in 2014-15. In terms of value imports were mainly from Hong Kong (31%), Kenya (20%) and South Africa (15%) . Out of the total imports in terms of value in 2015-16, uncut garnet accounted for 95% and the remaining 5% was accounted for by cut garnet (Tables-12 to 15).

Table – 8 : Exports of Garnet (Abrasive) (By Countries)

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (``'000)	Qty (t)	Value (``'000)
All Countries	**448559**	**5673827**	**480408**	**5950865**
USA	85057	986186	102722	1181674
UAE	64003	840193	72322	994253
Saudi Arabia	26374	361999	26709	351755
Germany	27095	338476	22305	256067
Kuwait	18900	245464	18368	231852
Italy	16071	192302	17305	200529
Malaysia	16946	196578	17094	195244
Korea, Rep. of	13413	162181	15265	194197
Australia	12745	178004	12998	181006
Thailand	15326	215114	12484	180027
Other countries	152629	1957330	162836	1984261

Table – 9 : Value of Exports of Garnet (Cut & Uncut) (By Countries)

Country	2014-15	2015-16 (P)
	Value (``'000)	Value (``'000)
All Countries	**31070**	**25404**
Czech Republic	8964	6788
Hong Kong	2925	5981
USA	7125	5605
Thailand	6928	3250
Italy	354	1855
UK	2115	1436
Japan	1643	347
UAE	-	93
Germany	111	38
Baharain	-	6
Other countries	905	5

Table- 10: Exports of Garnet (Cut) (By Countries)

Country	2014-15		2015-16 (P)	
	Qty ('000 Carats)	Value (``'000)	Qty ('000 Carats)	Value (``'000)
All Countries	**1009**	**28200**	**1062**	**25131**
Czech Republic	76	8964	53	6788
Hong Kong	37	789	112	5754
USA	15	7035	325	5605
Thailand	254	6892	94	3241
Italy	5	354	6	1855
UK	411	1898	343	1436
Japan	96	1643	125	347
UAE	-	--	4	93
Baharain	-	-	++	6
Greece	++	42	++	4
Other countries	115	583	++	2

Table- 11: Exports of Garnet (Uncut) (By Countries)

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (``'000)	Qty (t)	Value (``'000)
All Countries	**++**	**2870**	**++**	**273**
Hong Kong	++	2136	++	227
Germany	-	-	++	38
Thailand	++	36	++	8
Sri Lanka	++	348	-	-
UK	++	217	-	-
USA	++	90	-	-
Poland	++	36	-	-
China	++	6	-	-
Other countries	++	1	-	-

Table – 12 : Imports of Garnet (Abrasive) (By Countries)

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**647**	**10297**	**883**	**9953**
UAE	276	1815	769	9385
Australia	228	5622	78	232
China	136	2335	22	292
Norway	-	-	14	44
UK	7	525	-	-
Other countries	-	-	-	-

Table – 13 : Value of Imports of Garnet (Cut & Uncut) (By Countries)

Country	2014-15	2015-16 (P)
	Value (`'000)	Value (`'000)
All Countries	**68743**	**62637**
Hong Kong	26697	19664
Kenya	10764	12607
South Africa	7152	9637
Thailand	4701	5176
Tanzania	2399	4551
Mozambique	8378	2819
China	42	1807
Morocco	-	1783
Sri Lanka	3182	1253
Madagascar	136	758
Other countries	5292	2582

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

Table – 14 : Imports of Garnet (Cut) (By Countries)

Country	2014-15		2015-16 (P)	
	Qty ('000 crt)	Value (`'000)	Qty ('000 crt)	Value (`'000)
All Countries	**210**	**8990**	**26**	**2850**
Thailand	11	80	3	1365
Hong Kong	2	4165	9	925
USA	11	1418	13	495
Japan	++	48	1	65
Sri Lanka	185	3182	-	-
Zimbabwe	1	55	-	-
China	++	42	-	-
Other countries	-	-	-	-

Table – 15 : Imports of Garnet (Uncut) (By Countries)

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**33**	**59753**	**7**	**59779**
Hong Kong	10	22531	1	18739
Kenya	1	10764	1	12607
South Africa	1	7152	1	9637
Tanzania	3	2399	1	4551
Thailand	++	4621	++	3809
Mozambique	17	8378	1	2819
China	-	-	1	1807
Morocco	-	-	++	1783
Sri Lanka	-	-	++	1253
Madagascar	++	136	++	750
Other countries	1	3772	1	2024

FUTURE OUTLOOK

Garnet has wide range of applications, such as in production of abrasives, sand blasting, water filtration materials, abrasive blasting media, and water-jet cutting. Garnet is expected to continue displacing silica sand blasting media owing to its associated occupational health risks. Moreover , garnet is safer for the environment and cheaper to dispose of after recycling. Hence the worldwide demand for garnet is expected to increase, especially for waterjet cutting and for abrasive blasting media. China and India are expected to steadily increase garnet production and will become significant garnet sources for other countries.