

DUNITE & PYROXENITE



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DUNITE & PYROXENITE

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

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Dunite is a monomineralic ultrabasic rock that consists of more or less pure olivine. Dunite typically contains 36 to 42% MgO and 36 to 39% SiO₂. Pyroxenite is also an ultrabasic rock that consists of pyroxenes i.e., predominantly ferromagnesian minerals other than olivine. Olivine is a commercial source of magnesia combined with silica that is mainly used in metallurgy, fertilizer, etc. There is a rising trend in use of dunite and pyroxenite in sintering and as a fluxing agent in blast furnace in place of dolomite.

RESOURCES

In India, occurrences of dunite are reported in association with other ultrabasic rocks in chrysotile-bearing areas of Jharkhand and Karnataka; chromite-bearing areas in Odisha, Karnataka, Jharkhand & Nagaland; and magnesite-bearing areas in Karnataka & Tamil Nadu. As per the UNFC system, total resources of dunite in the country as on 1.4.2010 are estimated at about 185 million tonnes of which 17 million tonnes constitute reserves (about 15 million tonnes proved reserves and 2 million tonnes probable reserves) and 168 million tonnes remaining resources. Dunite resources are located mainly in Tamil Nadu (63%) and Karnataka (17%). The remaining 20% resources are in Jharkhand, Odisha and Nagaland. Reserves/resources of dunite are furnished in Table-1.

The occurrences and production of pyroxenite are reported from Jajpur district in Odisha and Singhbhum (East) district in Jharkhand. However, no resource estimates are available.

EXPLORATION

During the course of Platinum Group of Elements (PGE) investigations, GSI conducted preliminary exploration in 2012-13 in the pyroxenite-bearing basic/ultrabasic/ultramafic rocks in parts of Andhra Pradesh, Kerala, Nagaland & Tamil Nadu and also during the investigation for chromite & diamond mineralisation in parts of Andhra Pradesh & Karnataka. The details of exploration are elicited in Table - 2.

PRODUCTION, STOCKS AND PRICES

Dunite

Dunite is mainly obtained as an incidental product during mining of magnesite. Its production at 86,495 tonnes during the year under review increased by 123% as compared to that in the previous year mainly due to increase in market demand.

The production of dunite was reported from only one primary mine which was in the Public Sector located in district Chickmagalur, Karnataka. In addition, dunite was also obtained as an associated mineral from magnesite mines under both Public and Private sectors located at district Salem in Tamil Nadu. Of all 81% production of dunite during the year was reported from the Public Sector and 19% was reported by Private Sector enterprises. Ninety-eight percent of the total production was reported by three principal producers from five operating mines (Tables - 3 to 5).

Mine-head stocks of dunite at the beginning of 2012-13 were 11,204 tonnes as against 15,506 tonnes at the end of the year (Table - 6).

Average daily employment of labour in the sole primary mine of dunite was 10 during 2012-13 as against 7 in the preceding year. Prices of dunite are furnished in General Review on 'Prices'.

Table – 3 : Principal producers of Dunite, 2012-13

Name and address of producer	Location of mine	
	State	District
Tamil Nadu Magnesite Ltd* 5/53, Omalur Main Road, Jagir Ammapalayam, Salem – 636 302, Tamil Nadu.	Tamil Nadu	Salem
B.B. Mehta,* B-9/6451, Vasantkunj, New Delhi - 110 070.	Tamil Nadu	Salem
Steel Authority of India Ltd, Ispat Bhavan, Lodhi Road, New Delhi - 110 003.	Karnataka	Chickmagalur

* Producing dunite as an associated mineral with magnesite.

**Table – 1: Reserves/Resources of Dunite as on 1.4.2010
(By Grades/States)**

(In '000 tonnes)

Grade/ State	Reserves			Remaining resources							Total resources (A+B)	
	Proved STD111	Probable STD122	Total (A)	Feasibility STD211 STD221	Pre-feasibility		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334		Total (B)
						STD222						
All India: Total	14894	2243	17137	130	4717	107597	24516	1164	21471	8637	168231	185368
By Grades												
Grade-I	6005	1326	7331	130	-	37569	24516	780	11007	2157	76158	83489
Grade-II	5551	917	6468	-	4717	70028	-	384	5664	6480	87273	93741
Unclassified	3337	-	3337	-	-	-	-	-	4800	-	4800	8137
By States												
Jharkhand	373	570	943	130	-	140	607	780	6121	8637	16415	17358
Karnataka	3718	223	3940	-	-	-	23909	-	4149	-	28058	31998
Nagaland	-	-	-	-	-	-	-	-	4800	-	4800	4800
Odisha	3337	-	3337	-	4717	5267	-	384	627	-	10995	14333
Tamil Nadu	7466	1450	8916	-	-	102190	-	-	5773	-	107963	116879

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Figures rounded off.

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Table – 2 : Details of Exploration Activities for Dunite & Pyroxenite, 2012-13

Agency/ State/ District	Location Area/ Block	Mapping		Drilling		Sampling (No.)	Remarks Reserves/Resources estimated
		Scale	Area (sq km)	No. of boreholes	Meterage		
GSI							
Andhra Pradesh							
Krishna & Khammam	Area between Kondapalli & Gangineri	1:2000	-	-	-	-	Reconnaissance stage investigation (G-4) during FS 2012-13 for chromite & PGE mineralisation was taken up in this area. Chromite occurs within the ultramafic rocks particularly pyroxenite as lenses, veins, pockets, bands & as disseminations. At some places pyroxenite (ultramafic rocks) occurs as conformable bands & lenses of variable dimensions from 1-20 m in length & 0.5-5 m in width. The work was in progress.
Prakasam	Chimakurthi Igneous Complex	1:12,500	100	-	-	374	Samples were collected from pyroxenite & lenco-gabbro units during PGE investigation. Chimakurthi Igneous Complex consisted of pyroxenite. Out of 58 BRS samples of pyroxenite, 13 samples have yielded anomalous values of Cr ranging from 2026 ppm to 3189.5 ppm & 26 samples have yielded anomalous values of Ni ranging from 1006.3 ppm to 2055 ppm. The preliminary analysis results have shown that the pyroxenite units are the favourable locales for PGE mineralisation.
Kerala							
	Nilambur Valley	1:12,500	45	99	-	90	During PGE investigation, meta-pyroxenites rock was found to occur as linear conformable bands that vary in length from a few meters to several km & in width varied from 10 m to more than 30 m.
Nagaland							
-	-	-	-	-	-	-	Out of 5 different mineral phases pyroxene (ortho & clino) in ophiolites belt has been identified

(Contd.)

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Table-2 (Concl.)

Agency/ State/ District	Location Area/ Block	Mapping		Drilling		Sampling (No.)	Remarks Reserves/Resources estimated
		Scale	Area (sq km)	No. of boreholes	Meterage		
							during PGE investigation.
Tamil Nadu							
Namakkal	Tasampalaiyam block in Sitampundi Complex	-	-	9	869.80	226	In Sitampundi Anorthosite complex bands & lenses of meta-pyroxenite & garnet-pyroxenite granite were exposed. PGE mineralisation is mostly confined to chromatiferous meta-pyroxenite bands/layers with cumulative strike length of about 2.5 km.
Erode	Solavanur block	-	213	-	-	-	Mafic/ultramafic rocks ranging in composition from dunite through gabbro, pyroxenite, etc. were encountered during PGE (G3) investigation.
- do -	Karattadi- palaiyam, Gopichettipalayam- Dasampalayam Sector	1:12,500	100	-	-	-	During G4 stage for PGE investigation, major rock bands encountered are dunite & pyroxenite.
Tirupur	Tirumankaradau area	-	75	-	-	-	Pyroxenite is one of the litho unit mapped during PGE exploration. Pyroxenite occur in the SW part of the area.

**Table – 4 : Production of Dunite, 2010-11 to 2012-13
(By States)**

(Qty in tonnes; value in ₹'000)

State	2010-11		2011-12		2012-13 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	23716	6879	38774	25450	86495	75777
Karnataka	1971	360	3610	484	8750	1173
Tamil Nadu	21745	6519	35164	24966	77745	74604

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**Table – 5 : Production of Dunite, 2011-12 and 2012-13
(By Sectors/States/Districts)**

(Qty in tonnes; value in ₹'000)

State/District	2011-12			2012-13 (P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
India	1(4)	38774	25450	1(4)	86495	75777
Public sector	1(1)	32937	22509	1(1)	69795	66265
Private sector	(3)	5837	2941	(3)	16700	9512
Karnataka	1	3610	484	1	8750	1173
Chickmagalur	1	3610	484	1	8750	1173
Tamil Nadu	(4)	35164	24966	(4)	77745	74604
Erode	(1)	2269	1021	(1)	1520	1166
Karur	(1)	8	5	(1)	30	14
Salem	(2)	32887	23940	(2)	76195	73424

Figures in parentheses indicate the number of associated mines of dunite with magnesite.

**Table – 6 : Mine-head Stocks of Dunite
2012-13 (P)
(By States)**

(In tonnes)

State	At the beginning of the year	At the end of the year
India	11204	15506
Karnataka	3840	4822
Tamil Nadu	7364	10684

Pyroxenite

The total production of pyroxenite at 54,257 tonnes in 2012-13 decreased by 37% over the previous year owing to stoppage of pyroxenite production by Bhimtanagar Sukinda mine from October 2011 due to lack of market demand. There were three reporting mines in both the years (Tables - 7 to 9).

The mine-head stocks at the beginning of 2012-13 was 8,214 tonnes as against 8,844 tonnes at the end of the year (Table - 10).

The average daily labour strength employed in pyroxenite mines in 2012-13 was 150 as against 155 in the previous year.

**Table – 7: Principal Producers of Pyroxenite
2012-13**

Name and address of producer	Location of mine	
	State	District
Bishnu Chandra Choudhary, 31/C, 1 st Phase, Industrial Area, Adityapur, Jamshedpur-832 109, Jharkhand.	Jharkhand	Singhbhum (East)
Pravat Kumar Aditya Deo, 605/39, Radha Colony, Khasmahal, Singhbhum (East) -831 002, Jharkhand.	Jharkhand	Singhbhum (East)
Khirod Mudi, Gamarkocha, Manpur, Singhbhum (East) - 831 002, Jharkhand.	Jharkhand	Singhbhum (East)

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**Table – 8 : Production of Pyroxenite, 2010-11 to 2012-13
(By States)**

(Quantity in tonnes; value in ₹'000)

State	2010-11		2011-12		2012-13 (P)	
	Quantity	Value	Quantity	Value	Quantity	Value
India	253205	126179	86031	33113	54257	16817
Jharkhand	54986	14978	62747	19375	54257	16817
Odisha	198219	111201	23284	13738	-	-

**Table – 9 : Production of Pyroxenite, 2011-12 & 2012-13
(By Sectors/States/Districts)**

(Quantity in tonnes; value in ₹'000)

State/District	2011-12			2012-13 (P)		
	No. of mines	Quantity	Value	No. of mines	Quantity	Value
India	3(1)	86031	33113	3	54257	16817
Private sector	3(1)	86031	33113	3	54257	16817
Jharkhand	3	62747	19375	3	54257	16817
Singhbhum (East)	3	62747	19375	3	54257	16817
Odisha	(1)	23284	13738	-	-	-
Jajpur	(1)	23284	13738	-	-	-

Figures in parentheses indicate number of associated mines.

**Table – 10 : Mine-head Stocks of Pyroxenite, 2012-13 (P)
(By States)**

(In tonnes)

State	At the beginning of the year	At the end of the year
India	8214	8844
Jharkhand	4668	5298
Odisha	3546	3546

USES

Dunite and pyroxenite are preferred as flux to dolomite as a source of MgO in sintering and also in Iron & Steel Industry. Main benefits of olivine over dolomite in slag conditioning are higher MgO content, no requirement of preheat treatment, reduced energy consumption, lower coke consumption, reduced slag volume and lower CO₂ emissions. Presence of higher amount of silica in dolomite leads to lower sinter basicity (i.e. CaO/SiO₂) at around 2.5 than 3.5 of dolomite and the phases in sinter change to those having better reducibility. The net result is a reduction in the resistance of the cohesive zone to gas flow in the blast furnace leading to drop in fuel rate and higher productivity. In addition, the magnesium silicates do not call for calcination (unlike the carbonates) and thus lowers energy requirement in the blast furnace.

Olivine helps to condition the slag as well as to control the basicity through reduction of alkali recirculation. Its higher reaction temperature reduces low temperature breakdown and swelling of burden, thus maintaining permeability and reducing coke consumption. The olivine may be added directly to the blast furnace charge as lump (10 to 40 mm), sinter feed (3 to 6 mm), or mixed with low silica iron ore fines and pressed into pellets. When lump is added directly to the furnace, olivine can replace limestone partly and dolomite flux in the reduction of iron ore. In comparison with dolomite, olivine has higher MgO content (requires less material for a given MgO level), MgO: SiO₂ ratio (allows MgO levels to be raised without changing the basicity of the slag) and lower LOI, i.e., 0.3-0.7% (conserves the energy required to drive off unwanted carbon dioxide). As a sinter feed, olivine reduces the sintering temperature by 100° C maximum thus producing harder sinter and less fines. Olivine is added directly to the iron ore as flux during the formation of pellets so that the fluxed pellets swell less, reduce more quickly and have a narrower melting range. However, on the other side, high

silica content in olivine restricts its use in low silica iron ores because high silica content creates excessive slag formation.

Dunite is well-suited as a refractory material due to its low and uniform coefficient of thermal expansion. Besides, dunite exhibits properties such as, good resistance to thermal shock; spalling and slag attack; high green strength; and resistance to metal attack. Dunite, calcined in rotary kilns at 1,650° C increases its refractory and foundry applications. Other uses of olivine are as loose-grainshot blasting abrasive, filtration media, in mineral wool production, filler in speciality paints, asphalt, mastics and weighing agent in concrete oil production platforms. Olivine also contributes magnesia and iron as nutrients to the soil.

SPECIFICATIONS

Olivine should contain 45 to 51% MgO, 40 to 43% SiO₂, 7 to 8% Fe₂O₃, 0.2 to 0.8% CaO and 1.8 to 2% Al₂O₃ and TiO₂, MnO, Cr₂O₃, NiO and CaO for various uses. For blast furnace use, olivine should contain 47 to 48% MgO with 10 to 40 mm lump size. For foundry use, the size should be AFS 20, 30, 60, 90, 120 and for flour, filler and fertilizer grades, size recommended is up to 0.8 mm, up to 0.02 mm and less than 0.1 mm, respectively.

As per the end-use grade classification, the reserves of 'fresh' and 'weathered' dunite have been classified as Gr. I and Gr. II, respectively. However, recommendations to assign chemical specification to these grade based on the experience of Tata Steel Ltd and GSI have been incorporated which is provided below:

Grade	MgO%	SiO ₂ %	LOI%	Cr ₂ O ₃ %
Grade-I	41.12	33.41	12.74	below 1
Grade-II	32.44	29.16	24.09	–

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For steel and alloy manufacturing, pyroxenite lumps as well as fines/dust are being consumed. The specifications of pyroxenite as per Indian Ferro Alloys Producers Association (IFAPA) are as follows:

Grade	MgO%	SiO ₂ %	Al ₂ O ₃ %	CaO%	Cr ₂ O ₃ %
Grade-1	34 min.	36-39max.	1-2	1-3 min.	1 min.
Grade-2	34.38	35	1-2	1 max.	3.5 - 6

BIS has adopted IS: 7297-1974 (reaffirmed 2008) as specification for olivine sand for use in steel foundries.

CONSUMPTION

The Iron & Steel and Refractory Industries are the main consumers of dunite. Consumption of dunite in the organised sector was at 38,800 tonnes in the year 2012-13, which decreased by

about 7% as compared to that in the previous year. Iron & Steel Industry was the major consumer of dunite and accounted for about 67% share in 2012-13. The remaining 33% was consumed in the Refractory Industry (Table - 11).

**Table – 11: Consumption of Dunite
2010-11 to 2012-13
(By Industries)**

(In tonnes)			
Industry	2010-11	2011-12(R)	2012-13(P)
All Industries	22300	41700	38800
Iron & Steel	16200(2)	30500(4)	26100(4)
Refractory	6100(4)	11200(5)	12700(6)

Figures rounded off.

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

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