# Indian Minerals Yearbook 2012

## (Part- III : Mineral Reviews)

## 51st Edition

# DUNITE & PYROXENITE

## (FINAL RELEASE)

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**February, 2014**

# 17 Dunite & Pyroxenite

Dunite is a monomineralic ultrabasic rock consisting of more or less pure olivine. Dunite typically contains 36 to 42% MgO and 36 to 39% $SiO_2$. Pyroxenite is also an ultrabasic rock consisting of pyroxenes; i.e., predominantly ferromagnesian minerals other than olivine. Olivine is a commercial source of magnesia combined with silica for use 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 and Nagaland and magnesite-bearing areas in Karnataka and 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 and Singhbhum (East) districts of Odisha and Jharkhand, respectively. However, no resource estimates are available.

## EXPLORATION

During the course of Platinum Group of Elements (PGE) investigations, GSI conducted preliminary exploration in 2010-12 in the pyroxenite bearing basic/ultrabasic/ultramafic rocks in parts of Andhra Pradesh, Karnataka, Kerala, Manipur, Odisha & Tamil Nadu and also during the investigation for chromite, diamond & REE mineralisation in parts of Andhra Pradesh, Meghalaya & Odisha. The details of exploration are given in Table - 2.

## PRODUCTION, STOCKS AND PRICES

### Dunite

Dunite is mainly obtained incidental to mining of magnesite. Its production at 39,223 tonnes during the year under review increased by 65% 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 public sector located in district Chickmagalur of Karnataka. In addition, dunite was also obtained as an associated mineral from public and private sector magnesite mines located in Salem and Tiruppur districts of Tamil Nadu. Thus, the 85% production of dunite during the year was reported from public sector and 15% was reported by private sector only (Tables - 3 to 5).

Mine-head stocks of dunite at the beginning of 2011-12 were 9,845 tonnes as against 11,225 tonnes at the end of the year (Table - 6).

Average daily employment of labour in the sole primary mine of dunite was 7 during 2011-12 as against 3 in the preceding year. Prices of dunite are furnished in General Review on 'Prices'.

**Table – 3 : Producers of Dunite, 2011-12**

| 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 |
| Steel Authority of India Ltd Visvesvaraya Iron & Steel Plant, Bhadravati – 577 301, Karnataka. | Karnataka | Chickmagalur |
| B.B. Mehta,* B-9/6451, Vasantkunj, New Delhi - 110 070. | Tamil Nadu | Salem |
| A.S. Shankarganesan,* 22/A, Kumarnagar South, 3rd ST, Gandhinagar, Tiruppur- 641 603 Tamil Nadu. | Tamil Nadu | Tiruppur |

** 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 | | Total (A) | Feasibility STD211 | Pre-feasibility | | Measured STD331 | Indicated STD332 | Inferred STD333 | Reconnaissance STD334 | Total (B) | |
| | | STD121 | STD122 | | | STD221 | 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 |

*Figures rounded off.*

**Table – 2 : Details of Exploration Activities for Dunite & Pyroxenite, 2011-12**

| 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 & Khamman | Area between Kondapalli & Gangineri | - | - | - | - | - | Reconnaissance stage investigation (G-4) during FS 2010-12 for chromite mineralisation was taken up in this area. The rock types encountered in Kondapalli and surrounding areas are pyroxenite, granulite & charnockite with enclaves of pyroxenite. In North of village Koduru of a pyroxenite body (28 m length & 17 m width) was delineated. The work was in progress. |
| Nalgonda | Palurayi and Bhimanapali blocks | - | - | - | - | - | For searching of kimberlite (diamond) during (G-4) investigation, remanants of Pyroxenite composition was observed. |
| | Ramagiri Schist belt | - | - | - | - | - | During PGE investigation (G-4), litho- variants of ultramafic rock are serpentinite dunite body about 14 km long with pinching/swelling nature. |
| **Karnataka** Hassur | Tagadur, Ranganatha Betta & Bakhtarahalli | - | - | - | - | - | Major ultramafics observed in Nuggihalli schist belt are serpentinite, meta-pyroxenite, etc. during PGE investigation. |
| **Kerala** Palakkad | Kalkandi & Narasimukku areas (Attapadi Valley) | - | - | - | - | - | Meta-pyroxenites found with an average width of 20 m was traced over 1.25 km & intermittently up to 2.2 km during PGE investigations. |
| **Manipur** Ukhrul | Ukhrul-Gamnom-Chingal-Chingsao-Hangkau | - | - | - | - | - | Host rocks in ultramafics suits comprising chromatiferous dunite, peridotite and pyroxenite with 30 m to 40 m width are recorded as outcrops during PGE mineralisation. |
| **Meghalaya** East Khasi Hills | Periphery of Sung valley | - | - | - | - | - | During G-4 investigation for REE mineralisation, major rock types comprising sung ultramafic complex observed are serpentinite, pyroxenite, etc. |
| **Odisha** | | | | | | | |
| Dhenkanal | Raibola-Kanheipal (South area) | - | - | - | - | - | Bed rock samples in chromatiferous serpentine and pyroxenite in core samples having depth between 60.90 m and 62 m. |

(Contd.)

Table - 3 (Contd.)

| Agency/ State/ District | Location Area/ Block | Mapping | | Drilling | | Sampling (No.) | Remarks Reserves/Resources estimated |
|---|---|---|---|---|---|---|---|
| | | Scale | Area (sq km) | No. of boreholes | Meterage | | |
| Kendujhar | Bangur and Banaipank areas | - | - | - | - | - | Area represented by a litho-melange consisting of assorted megaclasts of dunite, chromatiferous dunite, peridotite, etc. during general exploration (G-2) for PGE investigation. |
| **Tamil Nadu** | Solavanur and Karappadi block | - | - | 3 | - | 42 | In Solavanur & Karappadi block, each three meta-pyroxenite bands have been delineated with cumulative thickness of 36.25 m & 10.55 m respectively. In other boreholes, seven meta-pyroxenite bands with a cumutative thickness of 18.5 m have been delineated during the Reconnaissance stage for PGE investigation (G-4). |
| -do- | Mallanayakan-palayam block | - | - | 7 | - | - | Several meta-pyroxenite bands have been intersected in boreholes of this block. |
| Coimbatore | Vedavalli, Melbavi, Attikadavu, Velliyankadu, Tolampalaiyam, Karamadai & Pugalwe. | - | - | - | - | - | Ten meta-pyroxenite bands have been demarcated. Of which one from Devangapuran to Vadavalli and other at Melbavi village were exposed & extending over strike length about 3 km during Reconnaissance (G-4) stage investigation for PGM in FS 2010-12. |

**Table – 4 : Production of Dunite, 2009-10 to 2011-12**
**(By States)**

(Qty in tonnes; value in ₹'000)

| State | 2009-10 | | 2010-11 | | 2011-12(P) | |
|---|---|---|---|---|---|---|
| | Quantity | Value | Quantity | Value | Quantity | Value |
| **India** | **71642** | **19281** | **23716** | **6879** | **39223** | **25386** |
| Karnataka | 37346 | 8830 | 1971 | 360 | 3846 | 513 |
| Tamil Nadu | 34296 | 10451 | 21745 | 6519 | 35377 | 24873 |

**Table – 5 : Production of Dunite, 2010-11 and 2011-12**
**(By Sectors/States/Districts)**

(Qty in tonnes; value in ₹'000)

| State/District | 2010-11 | | | 2011-12 (P) | | |
|---|---|---|---|---|---|---|
| | No. of mines | Quantity | Value | No. of mines | Quantity | Value |
| **India** | **1(3)** | **23716** | **6879** | **1(3)** | **39223** | **25386** |
| Public sector | 1(2) | 18106 | 5055 | 1(1) | 33173 | 22526 |
| Private sector | (1) | 5610 | 1824 | (2) | 6050 | 2860 |
| **Karnataka** | **1(1)** | **1971** | **360** | **1** | **3846** | **513** |
| Chickmagalur | 1 | 1101 | 147 | 1 | 3846 | 513 |
| Mysore | (1) | 870 | 213 | - | - | - |
| **Tamil Nadu** | **(2)** | **21745** | **6519** | **(3)** | **35377** | **24873** |
| Erode | - | - | - | (1) | 2490 | 946 |
| Salem | (2) | 21745 | 6519 | (2) | 32887 | 23927 |

*Figures in parentheses indicate the number of associated mines producing magnesite.*

**Table – 6 : Mine-head Stocks of Dunite**
**2011-12(P)**
**(By States)**

(In tonnes)

| State | At the beginning of the year | At the end of the year |
|---|---|---|
| **India** | **9845** | **11225** |
| Karnataka | 3381 | 3840 |
| Tamil Nadu | 6464 | 7385 |

## Pyroxenite

The total production of pyroxenite at 87,310 tonnes in 2011-12 decreased by 66% over the previous year due to nil production reported by Bhimtanagar Sukinda Mine from October 2011 onwards due to lack of market demand. There were three reporting mines during both the years. Besides, production of pyroxenite was reported as an associated mineral by one chromite mine which contributed about 28% of the total output (Tables - 7 to 9).

The mine-head stocks at the beginning of 2011-12 was 19,066 tonnes as against 8,365 tonnes at the end of the year (Table - 10).

The average daily labour strength employed in pyroxenite mines in 2011-12 was 137 as against 127 in the previous year.

**Table – 7: Principal Producers of Pyroxenite**
**2011-12**

| Name and address of producer | Location of mine | |
|---|---|---|
| | State | District |
| Tata Steel Ltd,* Bombay House, 24-Homi Mody Street, Mumbai - 400 001. | Odisha | Jajpur |
| Bishnu Chandra Choudhary, 31/C, 1st Phase, Industrial Area, Adityapur, Jamshedpur-832 109, Jharkhand. | Jharkhand | Singhbhum (East) |
| Khirod Mudi, P.O. Haldipokhar, Dist. Singhbhum (East) - 831 002, Jharkhand. | Jharkhand | Singhbhum (East) |
| Pravat Kumar Aditya Deo, 605/39, Radha Colony, Khasmahal, Gopalpur, Singhbhum (East) -831 002, Jharkhand. | Jharkhand | Singhbhum (East) |

** Associated mine with chromite.*

**Table – 8 : Production of Pyroxenite, 2009-10 to 2011-12**
**(By States)**

(Quantity in tonnes; value in ₹'000)

| State | 2009-10 | | 2010-11 | | 2011-12 (P) | |
|---|---|---|---|---|---|---|
| | Quantity | Value | Quantity | Value | Quantity | Value |
| **India** | **279332** | **152371** | **253205** | **126179** | **87310** | **29150** |
| Jharkhand | 49638 | 13176 | 54986 | 14978 | 62747 | 19060 |
| Odisha | 229694 | 139195 | 198219 | 111201 | 24563 | 10090 |

**Table – 9 : Production of Pyroxenite, 2010-11 & 2011-12**
**(By Sectors/States/Districts)**

(Quantity in tonnes; value in ₹'000)

| State/District | 2010-11 | | | 2011-12 (P) | | |
|---|---|---|---|---|---|---|
| | No. of mines | Quantity | Value | No. of mines | Quantity | Value |
| **India** | **3(1)** | **253205** | **126179** | **3(1)** | **87310** | **29150** |
| Private sector | 3(1) | 253205 | 126179 | 3(1) | 87310 | 29150 |
| **Jharkhand** | **3** | **54986** | **14978** | **3** | **62747** | **19060** |
| Singhbhum (East) | 3 | 54986 | 14978 | 3 | 62747 | 19060 |
| **Odisha** | **(1)** | **198219** | **111201** | **(1)** | **24563** | **10090** |
| Jajpur | (1) | 198219 | 111201 | (1) | 24563 | 10090 |

*Figures in parentheses indicate number of associated mines.*

**Table – 10 : Mine-head Stocks of Pyroxenite, 2011-12 (P)**
**(By States)**

(In tonnes)

| State | At the beginning of the year | At the end of the year |
|---|---|---|
| **India** | **19066** | **8365** |
| Jharkhand | 4189 | 4818 |
| Odisha | 14877 | 3547 |

## USES

Dunite and pyroxenite are preferred as flux to dolomite as a source of MgO in sintering and also in iron and 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 $CO_2$ emissions. Presence of higher amount of silica in dolomite leads to lower sinter basicity (i.e. CaO/$SiO_2$) 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), a 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 partly limestone and dolomite flux in the reduction of iron ore. In comparison with dolomite, olivine has a higher MgO content (requires less material for a given MgO level), MgO: $SiO_2$ 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 max thus producing harder sinter and less fines. Olivine is added directly to the iron ore as a flux during the formation of the 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 to low silica iron ores because a high total silica content creates excessive slag formation.

Dunite is well suited as a refractory having low and uniform coefficient of thermal expansion. Besides, it containing property of good resistance to thermal shock, spalling and slag attack, a high green strength and resistance to metal attack. Dunite may be calcined in rotary kilns at 1,650°C for 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 poduction platforms. Olivine also contributes magnesia and iron as nutrients to the soil.

## SPECIFICATIONS

Olivine should contain 45 to 51% MgO, 40 to 43% $SiO_2$, 7 to 8% $Fe_2O_3$, 0.2 to 0.8% CaO and 1.8 to 2% $Al_2O_3$ and $TiO_2$, MnO, $Cr_2O_3$, 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 had been classified as Gr. I and Gr. II, respectively. However, it was recommended to also assign chemical specification to these grade based on the experience of Tata Steel Ltd and GSI as given below:

| Grade | MgO% | $SiO_2$% | LOI% | $Cr_2O_3$% |
|---|---|---|---|---|
| Grade-I | 41.12 | 33.41 | 12.74 | below 1 |
| Grade-II | 32.44 | 29.16 | 24.09 | – |

For steel and alloy manufacturing, pyroxenite lumps as well as fines/dust are being consumed. Tata Steel is a major supplier of pyroxenite to the ferro-alloy manufacturers. The specifications of pyroxenite as per Indian Ferro Alloys Producers Association (IFAPA) are as follows:

| Grade | MgO% | $SiO_2$% | $Al_2O_3$% | CaO% | $Cr_2O_3$% |
|---|---|---|---|---|---|
| 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

Dunite is being consumed almost entirely by the refractory industry. Reported consumption of dunite in the organised sector was 10,800 tonnes in the year 2011-12, an increase of 77% from the previous year. Entire consumption was in Refractory industry; iron and steel industry did not report consumption (Table - 11).

**Table – 11: Reported Consumption of Dunite 2009-10 to 2011-12 (By Industries)**

(In tonnes)

| Industry | 2009-10 | 2010-11(R) | 2011-12(P) |
|---|---|---|---|
| **All Industries** | **4200** | **6100** | **10800** |
| Refractory | 4200(4) | 6100(4) | 10800(4) |

*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).*