# 65 Pyrophyllite

Pyrophyllite ($Al_2O_3 . 4SiO_2 . H_2O$) is a hydrous silicate of aluminium. It resembles closely with talc in many physical and optical properties but differs in chemical composition in that talc contains magnesia instead of alumina. Pyrophyllite finds application in high grade ceramics and refractories as also as a filler in pesticide industry.

## RESOURCES

The total resources of pyrophyllite in India as per UNFC system as on 1.4.2005 are placed at 33.69 million tonnes of which more than 58%; i.e., 19.49 million tonnes are in reserves category. Madhya Pradesh accounts for 46% resources, followed by Orissa (36%) and Uttar Pradesh (13%). The remaining resources are in Andhra Pradesh, Maharashtra and Rajasthan. Gradewise, insecticide grade accounts for 31%, followed by refractory grade 25%, ceramic grade 16% and insecticide and ceramic mixed 9%. The remaining 19% are others, unclassified and not-known grades (Table - 1).

## EXPLORATION & DEVELOPMENT

In 2006-07 and 2007-08, DGM, Maharashtra, carried out geological survey around Khatgaon village in Sindevahi tehsil of Chandrapur district by mapping and drilling. About 60-m wide sillimanite schist body over one km strike length was located where subsurface borehole data revealed the presence of pyrophyllite zones. Resources of 0.29 million tonnes and 0.92 million tonnes pyrophyllite/ sillimanite were estimated in 2006-07 and 2007-08, respectively. In 2007-08, DMG, West Bengal conducted mapping and sampling to explore pyrophyllite in Jinamanipur area of Midnapur district. Occurrences of pyrophyllite were observed for a strike length of 150 m.

## PRODUCTION, STOCKS & PRICES

The production of pyrophyllite at 205 thousand tonnes during 2007-08 registered an increase of about 39 % due to high market demand as compared to that in the previous year.

There were 32 reporting mines in 2007-08 as against 30 in the preceding year. Besides, the production of pyrophyllite was reported as an associated mineral by four mines in Maharashtra. Five principal producers accounted for 75 % of total production during the year. The share of public sector in the total production was 9 % in 2007-08 whereas it was 10 % in the previous year.

Four mines each reporting more than 15,000 tonnes accounted for about 66 % of total production and 16 mines each reported production between 1000 to 10,000 tonnes contributed about 32 % of total output. The remaining 2 % of total output was reported by 12 mines along with four associated mine, each reporting less than 1,000 tonnes.

Madhya Pradesh continued to be the leading producing state accounted for 83 % of output, followed by Uttar Pradesh 11 %, Orissa 3 % and Jharkhand 2 %. The remaining 1 % of the production was reported from Maharashtra during the year (Tables 2 to 5).

Mine-head stock of pyrophyllite at the end of 2007-08 were 96 thousand tonnes as against 92 thousand tonnes at the beginning of the year (Table - 6).

The average daily employment of labour in pyrophyllite mines during 2007-08 was 1,206 as against 1,210 in the previous year. The prices of pyrophyllite are given in Table - 7.

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

(In tonnes)

| Grade/State | Reserves | | | | Remaining resources | | | | | | | | Total resources (A+B) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Proved STD111 | Probable | | Total (A) | Feasibility | Pre-feasibility | | Measured STD331 | Indicated STD332 | Inferred STD333 | Reconnaissance STD334 | Total (B) | |
| | | STD121 | STD122 | | STD211 | STD221 | STD222 | | | | | | |
| **All India : Total** | **9584547** | **3653843** | **6251227** | **19489617** | **47400** | **118304** | **3449665** | **867742** | **1638452** | **6870521** | **1213236** | **14205319** | **33694936** |
| **By Grades** | | | | | | | | | | | | | |
| Refractory | 3179948 | 1118261 | 776106 | 5074315 | – | 50000 | 215527 | – | 1514000 | 1512527 | – | 3292054 | 8366369 |
| Ceramic | 1664817 | 530323 | 828626 | 3023766 | – | – | 7888 | 555850 | 48114 | 1060980 | 793955 | 2466787 | 5490553 |
| Insecticide | 3750675 | 1717941 | 2303055 | 7771671 | – | 16800 | 23100 | 189000 | 3992 | 2484708 | – | 2717600 | 10489271 |
| Insecticide & ceramic mixed | 205310 | 72297 | 1534702 | 1812309 | – | 48354 | – | 21330 | – | 882475 | 170876 | 1123035 | 2935344 |
| Others | 615762 | – | 589111 | 1204873 | – | – | 3200000 | – | 2025 | 135895 | – | 3337920 | 4542793 |
| Unclassified | 137554 | 215021 | 92272 | 444847 | 47400 | – | – | 94450 | 49848 | 600096 | 248405 | 1040198 | 1485045 |
| Not known | 30481 | – | 127355 | 157836 | – | 3150 | 3150 | 7112 | 20473 | 193840 | – | 227725 | 385561 |
| **By States** | | | | | | | | | | | | | |
| Andhra Pradesh | 11220 | – | 9720 | 20940 | – | – | – | – | – | 15880 | – | 15880 | 36820 |
| Madhya Pradesh | 3539365 | 2447445 | 4309863 | 10296673 | 47400 | 48354 | – | 257000 | 6017 | 4706948 | 248405 | 5314124 | 15610797 |
| Maharashtra | 235741 | 226873 | 41000 | 503614 | – | – | 190000 | – | – | 20000 | – | 210000 | 713614 |
| Orissa | 4529600 | 824800 | 1097800 | 6452200 | – | 66800 | 3223100 | 80 | 1514040 | 1024800 | – | 5828819 | 12281019 |
| Rajasthan | 132260 | 4725 | 100955 | 237940 | – | 3150 | 36565 | 232212 | 68587 | 216993 | – | 557507 | 795447 |
| Uttar Pradesh | 1136361 | 150000 | 691889 | 1978250 | – | – | – | 378450 | 49808 | 885900 | 964831 | 2278989 | 4257239 |

*Figures rounded off.*

**Table - 2 : Principal Producers of Pyrophyllite, 2007-08**

| Name and address of producer | Location of mine | |
|---|---|---|
| | State | District |
| Khajurao Minerals, Toria House,<br>Post Box No. 26,<br>Distt. Chhatarpur- 471 001,<br>Madhya Pradesh. | Madhya Pradesh | Chhatarpur |
| Jindutta Mineral (P) Ltd, Toria House,<br>Post Box No. 26,<br>Distt. Chhatarpur – 471 001,<br>Madhya Pradesh. | Madhya Pradesh | Chhatarpur |
| Madhya Pradesh State Mining Corp. Ltd.<br>Paryavas Bhavan, Area Hills,<br>Jail Road, Bhopal<br>Madhya Pradesh. | Madhya Pradesh | Tikamgarh |
| Ishwar Mining & Ind. Corp. (P) Ltd.<br>Sanjeev Bhaskar<br>7, Ishwar Nagar, Charan Kamal<br>Mathura Road<br>New Delhi. | Madhya Pradesh | Shivpuri |
| M/s Eastern Minerals<br>Vivekanand Marg, Cantt.<br>PO- Jhansi- 284 002<br>Uttar Pradesh. | MadhyaPradesh | Chhatarpur |

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

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

| State | 2005-06 | | 2006-07 | | 2007-08(p) | |
|---|---|---|---|---|---|---|
| | Quantity | Value | Quantity | Value | Quantity | Value |
| **India** | **182526** | **35948** | **147807** | **29929** | **204889** | **42398** |
| Andhra Pradesh | 258 | 54 | 15 | 2 | – | – |
| Jharkhand | 1580 | 507 | 1451 | 464 | 3898 | 1247 |
| Madhya Pradesh | 143375 | 28890 | 114309 | 23147 | 170637 | 35205 |
| Maharashtra | 4161 | 1141 | 3099 | 785 | 1693 | 551 |
| Orissa | 8211 | 1295 | 7359 | 1104 | 5997 | 901 |
| Uttar Pradesh | 24941 | 4061 | 21574 | 4427 | 22664 | 4494 |

**Table - 4: Production of Pyrophyllite, 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 |
| **India** | **30(3)** | **147807** | **29929** | **32(4)** | **204889** | **42398** |
| Public sector | 1(1) | 15269 | 3915 | 1(1) | 19290 | 4952 |
| Private sector | 29(2) | 132538 | 26014 | 31(3) | 185599 | 37446 |
| **Andhra Pradesh** | **1** | **15** | **2** | **–** | **–** | **–** |
| Cuddapah | 1 | 15 | 2 | – | – | – |
| **Jharkhand** | **1** | **1451** | **464** | **1** | **3898** | **1247** |
| Sarikela Kharas | 1 | 1451 | 464 | 1 | 3898 | 1247 |
| **Madhya Pradesh** | **19** | **114309** | **23147** | **19** | **170637** | **35205** |
| Chhatarpur | 10 | 76166 | 14355 | 10 | 106592 | 20347 |
| Shivpuri | 1 | 14035 | 3158 | 1 | 17881 | 4023 |
| Tikamgarh | 8 | 24108 | 5634 | 8 | 46164 | 10835 |
| **Maharashtra** | **(3)** | **3099** | **785** | **(4)** | **1693** | **551** |
| Bhandara | (3) | 3099 | 785 | (4) | 1693 | 551 |
| **Orissa** | **3** | **7359** | **1104** | **4** | **5997** | **901** |
| Keonjhar | 3 | 7359 | 1104 | 4 | 5997 | 901 |
| **Uttar Pradesh** | **6** | **21574** | **4427** | **8** | **22664** | **4494** |
| Jhansi | – | – | – | 2 | 281 | 42 |
| Lalitpur | 3 | 8744 | 1852 | 3 | 8199 | 1719 |
| Mahoba | 3 | 12830 | 2575 | 3 | 14184 | 2733 |

*Figures in parentheses indicate the number of associated mines of sillimanite & kyanite.*

## Table - 5 : Production of Pyrophyllite, 2006-07 and 2007-08 (p)
## (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 |
| **All Groups** | **30(3)** | **32(4)** | **147807** | **204889** | **100** | **100** | **-** | **-** |
| Up to 500 | 11(2) | 10(3) | 2274 | 2347 | 2 | 1 | 2 | 1 |
| 501 –1000 | 3 | 2(1) | 2171 | 2379 | 1 | 1 | 3 | 2 |
| 1001 –2000 | 3 | 3 | 3901 | 5077 | 3 | 3 | 6 | 5 |
| 2001 –5000 | 5(1) | 7 | 19474 | 24052 | 13 | 12 | 19 | 17 |
| 5001 –10000 | 4 | 6 | 22844 | 35102 | 15 | 17 | 34 | 34 |
| 10001-15000 | 2 | - | 26704 | - | 18 | - | 52 | 34 |
| 15001 & above | 2 | 4 | 70439 | 135931 | 48 | 66 | 100 | 100 |

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

## Table - 6 : Mine-head stocks of Pyrophyllite, 2007-08 (p)
## (By States)

(In tonnes)

| State | At the beginning of the year | At the end of the year |
|---|---|---|
| **India** | **92542** | **96193** |
| Andhra Pradesh | 20 | 15 |
| Jharkhand | 98 | 206 |
| Madhya Pradesh | 26848 | 34824 |
| Maharashtra | 325 | 407 |
| Orissa | 13124 | 9538 |
| Rajasthan | 281 | 281 |
| Uttar Pradesh | 51846 | 50922 |

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

(In Rupees per tonne)

| Grade | Market | 2005-06 | 2006-07 | 2007-08(p) |
|---|---|---|---|---|
| Lumps | Ex-mine Girola/Sakra, (Maharashtra) | 150 | 150 | 150 |
| Grade I | Ex-mine Pohara, (Maharashtra) | 300-363 | 300-363 | 300-363 |
| Grade II | Ex-mine Pohara, (Maharashtra) | 175-212 | 175-212 | 175-212 |
| ROM | Ex-mine Garhi/Patan, (Madhya Pradesh) | 173 | 173 | 173 |
| ROM | Ex-mine Silon Salaiya, (Madhya Pradesh) | 173 | 173 | 173 |
| Lump | Ex-mine Dhurpada, (Jharkhand) | 275 | 275 | 275 |
| Lump | Ex-mine Jamunalia (Jharkhand) | 280 | 280 | 280 |
| Powder | Ex-factory Dhurpada, (Jharkhand) | 815 | 815 | 815 |
| Grade I | Ex-mine Tikamgarh, (Madhya Pradesh) | 840-890 | 890-944 | 890-944 |
| Fine Powder | Ex-factory Jhansi (Uttar Pradaesh) | 1124 | 1140 | 1140 |
| off grade | Ex-mine Nawrgaon (Maharashtra) | 150 | 150 | 150 |
| ROM | Ex-mine MPSMC Ltd (Madhya Pradesh) | 890 | 950 | 150 |
| ROM | Ex-mine Keonjhar (Orissa) | 160 | 180 | 180 |
| Lump | Ex-mine Dhurpada, Jharkhand | 275 | 275 | 275 |

## MINING, MARKETING AND TRANSPORT

All pyrophyllite mines in the country are being operated manually, except a few semi-mechanised opencast mines in Madhya Pradesh, which deploy excavators and payloaders. In some mines benches of height varying from 1.5 to 3.5 m and width varying from 4 to 10 m have been developed in overburden. For ensuring qualitative improvement in the mine environment and ecology, some mine owners have planted trees like Acacia, Shishum, Eucalyptus, Jamun and Mango. Pyrophyllite is sorted out by experienced workers on visual assessment and then transported to grinding units to obtain 70 to 300 mesh powder as per the requirement of consumers.

## CONSUMPTION

The reported domestic consumption of pyrophyllite was at 25,300 tonnes in 2007-08. Refractory was the main consuming industry accounting for about 93%. The ceramic industry shared the remaining 7% (Table -8).

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

(In tonnes)

| Industry | 2005-06(R) | 2006-07 | 2007-08(p) |
|---|---|---|---|
| **All Industries** | **25300** | **25300** | **25300** |
| Ceramic | 1800 (5) | 1800 (5) | 1800 (5) |
| Refractory | 23500 (9) | 23500(10) | 23500(10) |

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

## USES AND SPECIFICATIONS

Pyrophyllite is harder than talc and unlike talc, pyrophyllite does not flux when fired. It is, therefore, used in high-grade ceramic products, electric insulators and refractories. Pyrophyllite imparts thermal shock resistance to ceramic bodies. It is also used as filler and dusting powder in various industries. In glass industry, pyrophyllite is used instead of felspar as a source of aluminium. Owing to its softness and mode of occurrence in lumps it is used extensively in handicraft industries for making various articles.

Low thermal expansion and shrinkage characteristics of pyrophyllite make it a useful ingredient in ceramic blends and may substitute either pitcher (grog) or silica. Pyrophyllite allows faster firing cycles in the manufacture of whiteware. In production of stoneware and chinaware, more mechanical strength as well as improved whiteness can be achieved at lower firing temperature. Hence, pyrophyllite is consumed in refractory as well as in wall tiles, sanitaryware, electrical porcelain and other ceramic and vitreous china products.

The BIS has prescribed the following specifications for pyrophyllite for ceramic industry (IS:11477-1985; Reaffirmed 2001).

| Characteristic | Requirement (%) | |
|---|---|---|
| | Grade-I | Grade-II |
| Loss on ignition | 6% max. | 6% max. |
| $SiO_2$ | 65% max. | 60% max. |
| $Al_2O_3$ | 28% max. | 25% max. |
| $Fe_2O_3$* | 1% max. | 1.5% max. |
| $TiO_2$* | 1% max. | 1% max. |
| CaO | 0.5% max. | 1.5% max. |
| $K_2O$ & $Na_2O$ | 0.5% max. | 1.5% max. |

* *Sum of percentage of iron oxide and titanium oxide for Grade-I and Grade-II shall not exceed 1.5% and 2%, respectively.*

***Note** : Grade-I : Suitable for whiteware and insulator industry.*
*Grade-II : Suitable for other ceramic industry.*

The consumers in refractory industry generally prefer pyrophyllite, containing 26 to 28% $Al_2O_3$ to 4% alkali and having 23 to 25 PCE (orton cone). For insecticide industry, the specifications of talc/steatite can also be applicable to pyrophyllite as given below :

| | | |
|---|---|---|
| Loss of ignition | : | 7% max. |
| Matter soluble in HCl | : | 3% max. |
| $Fe_2O_3$ | : | 1.5% max. |

## WORLD REVIEW

The world resources of pyrophyllite are quite large and sufficient to meet the world demand. The world resources of talc and pyrophyllite are given in Table - 9. Resources of pyrophyllite are not available separately.

The world production of pyrophyllite in 2007 increased to 1.86 million tonnes from 1.39 million tonnes in the previous year. The Republic of Korea was the leading producer accounting for 43%, followed by Thailand 22%, Japan 13%, India 11% and South Africa 7% (Table - 10).

The prices of pyrophyllite are normally influenced by alumina content, levels of iron and other impurities, colour, abrasiveness, absorbency, etc.

**Table - 9 : World Resources of Talc and Pyrophyllite (By Principal Countries)**

(In '000 tonnes)

| Country | Reserve base |
|---|---|
| **World : Total (rounded)** | **Large** |
| Brazil | 250000 |
| China | Large |
| Finland | Large |
| India* | 9000 |
| Japan | 160000 |
| Korea, Republic of | 18000 |
| Other countries | Large |

***Source**: Mineral Commodity Summaries, 2008.*
* *India's resources of pyrophylite as per UNFC System as on 1.4.2005 are estimated at 33.69 million tonnes.*

**Table - 10 : World Production of Pyrophyllite**

(In '000 tonnes)

| Country | 2005 | 2006 | 2007 |
|---|---|---|---|
| **World : Total** | **1722** | **1385** | **1859** |
| Argentina | 8 | 9 | 10 |
| India* | 183 | 150 | 197 |
| Japan | 351 | 350(e) | 250(e) |
| Korea, Republic of | 886 | 677 | 798 |
| Peru | 10 | 15 | 23 |
| Spain | 1 | - | - |
| South Africa | 60 | 75 | 124 |
| Thailand | 178 | 132 | 415 |
| Vietnam(e) | 12(e) | 14(e) | 16(e) |

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

* *India's production of pyrophyllite in 2005-06, 2006-07 and 2007-08 was 182,526 tonnes, 147,807 tonnes and 204,889 tonnes respectively.*

# FUTURE OUTLOOK

The use of pyrophyllite in ceramic industry seems to be static whereas that in the refractory applications is facing the problems like the most other refractory minerals due to change in technology and reduction of refractory consumption per tonne of metal. Pyrophyllite will continue to face competition from bentonite and attapulgite in carrier applications. However, use in filler applications appears to be stable.