Studies on the geology and beneficiation of Chandak magnesite deposit from Pithoragarh District, Uttar Pradesh

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INTRODUCTION :

Stringent operating conditions in modern steel making furnaces demand high quality basic refractories based on magnesia. Source of good quality natural magnesite is scarce in India. Indian magnesite contains considerable amounts of SiO_2 and fluxing agents. Therefore, appropriate measures are to be taken to ensure the availability of good quality magnesite. Measures for meeting the demand of quality magnesite are as follows :-

i) Upgrading of the presently available natural magnesite by various beneficiation techniques ;

ii) Production of high quality magnesia from sea water.

Manufacture of magnesia from sea water is a very capital intensive process. The process also requires limestone and dolomite of high purity having very low silica contaminant which are not available in plenty. Amongst the various methods of recovery of good quality magnesia from natural magnesite, the methods which are reported (Ramachandran and Gupta, 1975; Sengupta et. al., 1974; Spencer and Glipin, 1972) to be commercially successful are :

a) Flotation (Austria);

b) Heavy media separation (USA and USSR);

c) Electrostatic separation (Yugoslavia);

d) Selective dissolution followed by reprecipitation (Israel),

e) Photometric sorting, heavy media separation and gravity separation (Greece).

Indian magnesite can be classified into cryptocrystalline type and crystalline type. The cryptocrystalline type occuring near Salem in Tamil Nadu has been under exploitation for a long time. The crystalline variety occurs in Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh. Out of these, only the magnesite from Uttar Pradesh is under exploitation.

This paper deals with the geological set-up and beneficiation studies on the Chandak magnesite of Pithoragarh dist, U.P. The detailed beneficiation work has shown that flotation technique is the most suitable technique for the upgradation of these magnesites. Heavy media separation is not applicable in view of the fine interlocking. During the present work, much attention has been paid in maintaining the CaO : SiO_2 ratio to the desired level in the concentrate and also on the ultimate RUL (Refractoriness-Under-Load) value of the bricks made out of the beneficiation concentrate.

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Effect of impurities in magnesite for refractory purposes :

The common impurities associated with the magnesite are ferrous-carbonate, dolomite, calcite, talc, chert, pyrite, pyrrhotite, chlorite, apatite, collophane, etc. The presence of these impurities impair the valuable properties like refractoriness-under-load, volume stability, slag resistance etc., of the magnesite bricks.

The $CaO : SiO_2$ ratio plays an important role on the properties of the bricks produced from natural magnesite. With $CaO : SiO_2$ ratio of less than 2, low melting compounds like monticellite (CaO, MgO, SiO_2) and merwinite (3 Cao. MgO. $2SiO_2$) are formed around the MgO grains, eliminating the possibility of direct bonding among them. This reduces the RUL value of the brick. At a $CaO : SiO_2$ ratio of about 2 and above, low melting compounds become less prominent with less quantity of impurities resulting in direct bonding of the grains and increased hot strength (i.e. RUL). Apart from this, the presence of alkalies contributed by the micaceous minerals would also greatly affect the RUL value of the bricks. The slag erosion of bricks in steel making can be considerably reduced if MgO content is maintained at more than 90% (Alper, 1970).

Chandak magnesite contains considerable quantity of impurities like SiO_2 , R_2O_3 and CaO. These impurities would affect the essential properties like hot strength, slag resistance and structural stability of periclase (MgO) grains in the magnesite bricks.

Typical composition of the magnesite bricks produced in different parts of the world :

The typical composition and the refractory properties of the magnesite bricks made out of the natural magnesite in different parts of the world are shown in Table-1.

World magnesite reserves :

Identified world resources of magnesite total 12 billion tons and magnesium-bearing brines are estimated to be in billions of tons. However, the known reserves in the world are 2.96 billion short tons (IBM 1981). Indian magnesite reserves are only of the order of 218 million tons. The country-wise break-up is given in Table - 2.

Table — 2 : World magnesite reserves

Country	Reserves (in '000 short tons)
Australia	95,000
Austria	15,000
Brazil	150,000
Canada	30,000
China, Mainland	820,000
Czechoslovakia	20,000
Greece	30,000
India	218,000
North Korea	490,000
Turkey	10,000
USA	10,000
USSR	720,000
Yugoslavia	5,000
Others	360,000
World Total :	2,973,000

Indian magnesite reserves :

Natural magnesite deposits in India are primarily located in the Chalk hills of Salem district in Tamil Nadu, Almora and Pithoragarh districts of Uttar Pradesh, Nanjangud of Mysore district in Karnataka, and in some parts of Himachal Pradesh and Jammu and Kashmir. Indian magnesite can be classified into two groups viz., Cryptocrystalline type and crystalline breunnerite type. The milky white deposits in the Chalk hills

Table — 1 : Properties of magnesite bricks produced in different parts of the world

Sl. No.	Properties, Unit	India I S : 1749-1972	USSR	Austria	Greece	W. Germany	U.K.
1.	Chemical composition :						
	MgO%	85.0	91.0	94.0	93.0	88.0	91.3
	CaO%	2.5	3.0	2.5	3.3	—	1.4
	SiO_2 %	5.5	—	1.0	2.6	—	1.1
	Al_2O_3 %	—	—	0.3	0.1	—	0.5
	Fe_2O_3 %	—	—	2.0	1.0	4.7	6.5
2.	Physical Properties :						
	Bulk density g/cc	3.53	—	2.85 - 3.00	2.90	3.00 - 3.15	2.80 - 2.94
	Apparent Porosity %	24.0	27.0	16-20	19.0	14-18	14-18
	Cold Crushing strength Kg/cm^2	350.0	400.0	250 – 600	500	700	—
	Refractoriness under load Ta°C	1550	1500	1750	1650	1750	1600

Table — 3 : Indian Magnesite Reserves (Recoverable)

State	Measured	Indicated	Inferred	Total
Himachal Pradesh	—	—	87,620	87,620
Karnataka	436,000	428,380	138,500	1,002,880
Rajasthan	—	252,392	12,000	264,392
Tamil Nadu	4,641,597	5,728,882	25,155,100	35,525,579
Uttar Pradesh	7,514,011	132,519,253	41,445,265	181,478,529
All India	12,591,608	138,928,907	66,838,485	218,359,000

Table — 4 : Stratigraphy of the Chandak area

Tectonic unit		Stratigraphical unit	Equivalents
Krol Nappe	Calc-zone of Pithoragrah	Dolomitic cherty limestones, Magnesite with talc, Stromatolitic limestones, Brown slate & shales	Deobans Shalis Nalderas

of Salem and the Nanjangud deposits of Mysore are of cryptocrystalline type. Almora and Pithoragarh deposits are of crystalline variety (partly breunnerite type) showing the existence of siderite in solid solution of magnesite. Table-3 gives the total Indian magnesite reserves as reported by the Indian Bureau of Mines (I.M.Y.B., 1981).

Pithoragarh (Chandak) magnesite deposit :

The Chandak magnesite area falls between N. Lat. 29°35'15" to 29°37'12" and E. Long. 80°10'28" to 80°13'12". The village, Chandak is north-west of Pithoragarh town and lies in the Survey of India Toposheet No. 62 C/2.

The highest altitude of Chandak magnesite area is 6901 ft. above MSL. Water is very cold and intense with occassional snow falls. Both local and mansoon rain is very predominant. Topographically, the area is rugged terrain with high cliffs intersected by deep gorges. Magnesite here occurs to the steep southern slopes of the ridges. Southern, eastern and northern sides of the deposit are covered by hills, like a horse-shoe having a deep valley at the central part. Gaurigad, a perennial stream flows in this valley which meets the Ramaganga river on the West.

Geology of the Chandak magnesite deposit :

The magnesite formation of Pithoragarh district is a conspicuous horizon of the lower Himalayn stratigraphy of the district. Misra and Nautiyal (1961) have given a detailed account of the geology of the Chandak area. Valdiya (1962) recognised three stratigraphical formations in the southern part of Pithoragarh district, viz., the Calc-zone, the Quartzite zone and the Crystalline zone of Askot. In the Chandak area, however, only the formations of the Calc-zone are observed. This Calc-zone consists of dolomitic and cherty limestones, slates, stromatolite-limestone and magnesite beds. This Calc-zone has been compared by Valdiya (op. cit) with the Deoban limestone, shali series and the Naldera-Kakarhotti limestone of the Simla series. The stratigraphical sequence of this area as given by Valdiya (op. cit) is shown in Table 4.

Brown slates and shales :

The slates of the area are brownish in colour, compact, heavy and relatively hard. The extreme hardness and high density is ascribed to the large iron content. The shales are fine grained, greyish in colour and are interbedded with limestones. The shales are carbonaceous and dark coloured towards the upper limit.

Stromatolitic limestones :

The stromatolitic limestone unit has got a peculiar structure and the thickness vary from 5' to 15'. The horizon is significantly persistent throughout the magnesite deposits of this locality. The limestone is black to bluish black in colour and slightly dolomitic. It gives a fetid odour on hammering. The limestone reacts easily and vigorously with cold dilute hydrochloric acid and the residue left behind consists of crystals of pyrite and black cherty matter of collophane which remains insoluble even if boiled with the acid.

Magnesite with talc :

The magnesite of the area is medium to coarse grained in nature. Sometimes magnesite is fine grained and compact. Pockets and layers of greyish and blackish grey talc are common within the deposit. Another striking feature of the deposit is the occurrence of big and small masses of bluish dolomitic limestone enclaves within magnesite. Magnesite is extremely amenable to erosion. Sapped by water and hollowed by wind, the magnesite outcrops have given rise to different shapes. The total reserve of the Chandak magnesite deposit has been estimated to be about 3 million tons by U. P. Mines and Geology department.

Dolomitc cherty limestone :

The thickly bedded dolomitic limestone is characterised by the presence of nodules and irregular masses of chert of black colour. This band overlies the magnesite bed with a sharp contact.

Mineralogical studies :

Under the microscope, Chandak magnesite samples show the characteristic granoblastic to seriate-porphyroblastic fabric. The magnesite grains are of variable sizes and shapes ranging from 2 mm to 8 mm. Sometimes elongated irregular lenses and large xenomorphic grains of more than 10 mm size are also common. Coarse to medium grained variety of magnesite is showing mosaic texture. The elongated untwinned crystals are at places terminally ragged and commonly curved and strongly undulant. Few grains are showing well developed rhombic cleavage, whereas most of the grains are not showing cleavage. Large xenomorphic crystals are often showing two sets of lamellar twinning. In some cases stellate clusters of white magnesite have been developed in the equigranular magnesite matrix. At places, magnesite grains show highly sutured boundary and marginal granulation of the grains is also observed. This suggests disturbed geological conditions of formation. At some places, the magnesite grains show simple boundary. By far the main impurity associated with this magnesite is talc which has been observed in a number of thin sections. There are two modes of occurrence of talc within magnesite :
(i) Talc is occurring in the form of triangular patches and as thin veins in the interstices of magnesite grains. Talc often occurs within the magnesite grains as stringers which might be due to secondary reaction and replacement. In the low grade, impure magnesites, quartz and talc vary inversely in abundance. Whereever talc is well developed, quartz is absent in most of the cases and vice-versa. Textural and mineralogical studies suggest that the formation of talc is due to the interaction of siliceous fluid on the magnesite; (ii) talc is also observed along the rhombic planes of the magnesite crystals. Quantitatively this type of talc is less when compared to the first type of talc. Petrographic modal analysis indicate the presence of an average of 3.46 by weight of talc in this magnesite. The value is also corroborated by chemical analysis. For the purpose of confirmation, the amount of acid insolubles in magnesite was determined additionally by adding 25 cc of 1 : 1 HCl to 5 gms. of (−200 mesh) magnesite. After evolution of CO_2 the volume was made upto 100 cc and was digested on hot plate for 2 hrs. The solution was then filtered and washed repeatedly. From the residue, the percentage of the insolubles was calculated and was found to be 3.53 by weight. The insoluble fraction was examined under microscope. It consists of mostly talc and micaceous minerals with a little amount of quartz in association with magnesite.

Among the other associated impurities, dolomite and calcite are however, closely similar to magnesite except for the granularity. Dolomite is mostly fine grained, whereas magnesite is coarsely crystalline showing rhombic cleavage some times. The impurities are occurring mostly at the margins of magnesite grains and as relicts in between the big magnesite crystals. The textural studies of magnesite and dolomite indicate that magnesite has been formed at the expense of fine grained dolomite. For confirmation of dolomite and calcite in the magnesite, staining tests have been conducted. It was observed that magnesite consists of more of dolomite impurity and a little amount of calcite. Next to dolomite, pyrite and goethite are occurring within magnesite as fine crystals. Sometimes, it is possible to see the pyrite crystals physically within magnesite and talc associated with magnesite. Other ferruginous impurities viz, magnetite and pyrrhotite occur as minute crystals in between the grains and also occassionally as inclusions within magnesite grains with minute reddish brown colour. The percentage of these ferruginous impurities has been found to be less than 2% with the help of modal analysis. The presence of higher ferruginous content is ascribed to siderite occurring as solid solution, evidenced also by higher refractive indices compared to magnesite from Salem. Subhedral grains of apatite rarely occur as inclusions within magnesite. The presence of apatite is also found in the parent rock dolomite which indicates the mineralisation of magnesite from the parent dolomitic rocks.

X-ray diffraction studies and differential thermal analysis studies have confirmed the presence of the above minerals observed under the petrological microscope.

Origin of magnesite deposit from Chandak area :

Muktinath (1949), Nautiyal (1953), Hore and Viswanathan (1961) and Dubey and Srivastava (1965) considered the Garhwal Kumaun magnesites to have been formed by the secondary process involving the replacement of dolomites by magnesium-rich hydrothermal solutions. These hydrothermal solutions are thought to have been derived from the basic intrusions of the region. Misra and Valdiya (1961) suggested a sedimentary origin for these magnesites and believed that the precipitation of $MgCO_3$ took place in an essentially sedimentary environment and was probably aided by algal activity. On the basis of field characters, Basu (1973) and Gupta (1973) advocated a sedimentary origin for the magnesite deposits of Kanda region. According to Valdiya (1968) the magnesites of Pithoragarh region are due to a volume for volume replacement during the diagenesis of the sediments. He disregards the possibility of an external source of MgO such as the thin impersistent metabasic bodies. He further considers that in view of the absence of appreciable amounts of calcite deposits in the vicinity of magnesite and strong stratigraphical control of mineralisation and post-diagenetic replacement, the formation of magnesite by an external source is not tenable. Tiwari (1970, 1973), on the basis of fluid inclusions in magnesites of Kanda and studies on synthetic nesquehonite (hydrous $MgCO_3$) pleaded for a sedimentary origin.

Detailed field studies on the Chandak magnesite show that the magnesites are formed by the replacement of stromatolite bearing dolostones. The following observations support the above view :—

(1) The stromatolite bearing algal columnar structures are well preserved within magnesite; (2) The magnesite is medium to coarsely crystalline and emits fetid odour indicating the presence of sulphur; (3) The phosphorite present in the from of apatite and collophane within stromatolite dolostones is also observed within magnesite body; (4) The fraying out of magnesite into dolostones and the dentition of magnesite and dolomite at their contacts are also supporting the replacement theory. The above observations indicate that the almost invariably associated stromatolite bearing dolostone was replaced by magnesite.

Beneficiation studies :

Chandak magnesite though of good grade, has not been found suitable for the manufacture of super quality basic bricks that will stand a temperature above 1600°C due to the presence of dolomite/calcite in association of other impurities like silicates and alkalies which brought down its RUL value to 1540°C. (Ta). Therefore, a representative sample was collected to develop a suitable process of beneficiation for the production of a suitable concentrate.

The sample so collected for beneficiation studies had the following chemical composition :

Table—5 : Chemical composition of the feed sample

Constitutents	Assay %
MgO	43.45
CaO	1.70
SiO_2	1.84
Al_2O_3	0.85
Fe_2O_3	3.25
P_2O_5	0.20
LOI	48.21
RUL (Ta°C)	1540

The silicate minerals in the sample were identified as talc, muscovite, sericite, quartz and amphibole (tremolite).

Experimental work :

Preliminary flotation studies carried on this sample had indicated that selective separation is not possible due to the similar flotation characteristics of dolomite, calcite and magnesite. The iron content which seems to be in solid solution could not also be brought down by physical means of separation.

Hence, the beneficiation studies were mainly aimed at the reduction of silicates to the minimum possible extent so that low melting phases like monticellite and merwinite are not formed in the system. Since, the exact determination of very low values of SiO_2 poses certain problems, the evaluation of the concentrate was done by determination of its RUL value.

The sample was crushed in jaw and roll crusher to 10 mesh size which formed the stock feed for subsequent test work.

A grind of 73.7% minus 200 mesh (Tyler) was found suitable for the beneficiation studies.

Flotation of Talc :

Talc that constituted the major gangue was first floated out using MIBC as frother. The results are presentsd in the Table 6.

It is apparent from Table 6 that only about 38% SiO_2 could be discarded by floating out the talc leaving behind 62% SiO_2 as other silicates.

Flotation of talc and other silicates :

Amines were used in this test to float both talc and other silicate minerals. But it was observed that some mica minerals particularly sericite did not respond to flotation. Hence, in the subsequent test work the reverse flotation of magnesite was attempted.

Flotation of talc and silicates and reverse flotation of magnesite :

A number of flotation tests were carried out to determine the different flotation parameters and finally a two stage flotation flow sheet was developed as follows :

Grind	:	73.7 % −200 mesh (Tyler).
Dispersant	:	Sodium silicate.
Cell	:	Denver Sub-A (8.05 litres).
RPM	:	1800
Flotation of talc and other silicates	:	pH −8.0 (natural).
Collector cum frother	:	Amines.
Magnesite flotation	:	pH − 8.0 (natural)
Silicate depressants	:	Sodium silicate and organic acids.
Collector cum frother	:	Fatty acid soaps.

The rougher magnesite float was cleaned twice using additional dosages of reagents to depress silicates and float magnesite.

The results are presented in Table 7. It is seen from Table 7 that :

1. Bulk of the silicates could be discarded in silicates float.

2. A recleaner magnesite concentrate assayed 44.84 % MgO and 0.15 % SiO_2 with a MgO recovery of 62.43% (wt% yield 60.25) with an RUL value of 1680°C (Ta). This concentrate meets the requirements for the manufacture of super quality basic bricks.

3. Also, a secondary magnesite concentrate (composite of recleaner, cleaner and rougher tailings) could be obtained which assayed 43.26% MgO and 2.23 % SiO_2 with a MgO recovery of 34.18 % (wt % yield 34.75).

   This concentrate can be briquetted, fired and possibly mixed with ROM fired product and thus can be used for the manufacture of normal bricks.

Table — 6 : Talc flotation

Product	Wt %	Assay %		% Dist	
		MgO	SiO_2	MgO	SiO_2
Talc float	3.96	38.18	18.87	3.49	38.29
Magnesite Conc (Non-float)	96.04	43.98	1.26	96.51	61.71
Head (Calc)	100.00	43.76	1.95	100.00	100.00

Table — 7 : Results of two stage flotation

Product	Wt %	Assay%			CaO/	RUL	Dist %	
		MgO	CaO	SiO_2	SiO_2	Ta °C	MgO	SiO_2
Silicates float	5.00	38.62	2.25	19.71	—	—	4.39	53.26
Primary magnestite conc. (Rcl.Mg conc)	60.25	44.84	1.45	0.15	9.7	1680	61.43	4.89
Secondary magnesite conc. (composite of re-cleaner, cleaner and rougher tailings)	34.75	43.26	1.86	2.23	0.83	—	34.18	41.86
Head (Calc)	100.00	43.98	1.63	1.85	—	—	100.00	100.00

Table — 8 : Complete chemical analysis of feed and flotation products

Constituent	Feed (Calc)	Primary magnesite conc.	Secondary magnesite conc.	Rejects
MgO	43.98	44.84	43.26	38.62
CaO	1.63	1.45	1.86	2.25
SiO_2	1.85	0.15	2.23	19.71
Al_2O_3	0.84	0.65	0.81	—
Fe_2O_3	3.15	2.65	3.07	—
LOI	48.31	50.25	48.41	—
RUL (Ta)	1540°C	1680°C	—	—
Wt %		60.25	34.75	5.00

4. Hence, the only rejects would be sillicates float which is 5% by weight and accounts for 4.39 % MgO distribution. It is mostly composed of silicates and micaceous minerals.

Technological evaluation of magnesite concentrate :

To evaluate the complete physical properties of the bricks made from this primary magnesite concentrate for use in the super refractories, a bulk primary magnesite concentrate weighing about 25 kgs was produced by repetitive batch tests under the identical conditions of the final flotation flow sheet and tested at the works of M/s. Orissa Industries Ltd., Rourkela for its end use.

Methods and results :

Clots were made of the concentrate having the chemical composition described in Table 8.

Composition of the clots :

Magnesite conc.	:	100 %
Molasses	:	2 to 3 parts
Batch	:	25 kgs

The batch was mixed thoroughly with the addition of minium quantity of water.

Pressing :

The batch was pressed in friction screw-press in the form of bricks of $2.30 \times 115 \times 75$m.m. at a load of about 150 tonnes.

The bricks were fired in tunnel kiln at a temperature of 1550°C. The fired clot was used to make the brick composition equivalent to Orind's Magne — G bricks and tested for different physical properties. The results obtained are as follows :–

PCE	— Over 38 orton cone
Apparent porosity	— 20 %
B. D.	— 2.85 (min)
C. C. S.	— 400 kg / Cm^2
RUL (Ta°C)	— 1650 (min)

Simulative slag reaction tests on the bricks have shown very-very little amount of slag penetration.

Characteristics and uses :

Dense magnesite bricks for lining of EAF and basic DH furnaces and permanant lining of L.D. Converter and copper refining furnaces.

The magnesite concentrate can also be used to make the other super duty bricks as per the technology developed by Orissa Industries Limited.

However, it can be seen that dolomite / calcite, aluminium hydroxides and iron oxides could not be discarded substantially but the high RUL value of 1680°C (Ta) and other tests carried out show that they do not adversely affect the quality of the bricks when present in small amounts.

Summary and conclusions :

The crystalline magnesites of Uttar Pradesh are derived from the replacement of stromatolite-bearing dolostones. The magnesite deposit has also undergone post-formational deformations resulting in the alteration of the inherent minerals and addition of certain impurities. The main impurities in these magnesites are talc, calcite / dolomite, micaceous minerals, apatite / collophane and ferruginous minerals apart from sericite, amphiboles and quartz in small quantities.

The sample collected from the Chandak deposit in Pithoragarh assayed 43.45% MgO, 1.70% CaO, 1.84% SiO_2 , 0.85% Al_2O_3 , 3.25% Fe_2O_3 and 48.21% LOI with a RUL value of 1540°C (Ta).

Although this magnesite as such can be categorised as of good quality for normal bricks even the small percentage (less than 2% each of

CaO and SiO_2) of deleterious impurities have rendered it unsuitable for making super quality bricks. Due to their presence, the RUL value of the bricks made out of the sample was around 1540°C (Ta), whereas an RUL value of over 1600°C is desired for super quality bricks. Hence, this beneficiation investigation was undertaken by IBM with a view to lower the impurities such that an RUL value of +1600°C could be obtained on the bricks made out of the concentrates.

Flotation flow-sheet developed on this sample is a two stage flotation. First, silicates are floated using amines as collectors. Thereafter, the silicates that did not float are depressed with sodium silicate and organic acids and magnesite is floated using fatty acid soaps as collector. The magnesite float is cleaned twice. The process yielded two magnesite concentrates :

1) a primary magnesite concentrate suitable for the manufacture of super refractories with a wt. % yield of 60.25 and RUL value of 1680°C (Ta).

2) a secondary magnesite concentrate of possibly blendable grade for normal refractories with wt. % yield of 34.75%.

The overall yield thus amounts to 95% by weight with 5% rejects by weight.

The simple process of beneficiation augurs well to establish a commercial plant to produce the magnesite concentrate of high purity for the manufacture of super refractories. However, a pilot plant study is being undertaken shortly to ascertain the suitability of the process for commercialisation and to obtain further data for the purpose.

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DISCUSSION :

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Question 1 : How is this Chandak deposit of magnesite of Pithoragarh as compared to the Jhiroli deposit of Almora dist. so far as resources and quality are concerned ?

Author : The Jhiroli magnesite deposit of Almora district has got similar geological set up as that of Chandak daposit of Pithoragarh district, since both of these magnesites are formed by the secondary process involving the replacement of dolostones by magnesium-rich hydrothermal solutions and undergone the same geological disturbances (in view of the proximity), both the deposits are similar in their mineralogy and chemistry. With regard to the resources, the Jhiroli deposit has not yet been completely explored and hence the reserves' estimation cannot be predicted with definiteness at present.

Question 2 : Since the refractories industries perfer to have −4″+1½″ lumps how are the −1½″ size chips obtained during mining and dressing of magnesite are properly utilised?

Author : It is true, refractory industry prefer the raw materials in coarse sizes for roasting. But beneficiated concentrates in fine sizes are also used after agglomeration. M/s. Orissa Industries Ltd. have developed the suitable process for agglomeration of magnesite as well as kyanite concentrates in fine sizes and have succeeded in making full size experimental bricks from the two concentrates obtained in IBM after beneficiation.

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Question 3 : This Pithoragarh magnesite was containing $FeCO_3$ as solid solution which did not respond to flotation for its separation as to lower down the iron content, while investigating at NML. Could you please tell me whether it could be eliminated by other physical methods ?

Author : Iron present in the sample in solid solution with magnesite could not be discarded by physical means of beneficiation. However, this has not effected the properties of the concentrate adversely.

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Question 4 : Whether percentage of SiO_2, calcite, iron oxide and dolomite present in solid solution with magnesite has been determined ?

Author : SiO_2 as silicates (like talc, mica, quartz and clay), calcite and dolomite were present as distinct minerals and not in solid solutions. Iron as iron oxides was present partly as coatings and partly in solid solution. XRD patterns of the original sample, silicate float, final concentrate and the rougher tailings clearly depict it. However, the assay values represent total SiO_2, CaO, MgO and Fe_2O_3 from all minerals in the sample. Separate assay for different mineral phases was not felt necessary as far as beneficiation studies were concerned and hence were not determined.

Question 5 : %SiO_2 is 0.15 in product, if it is in solid solution, how it is possible ?

Author : 0.15% SiO_2 is not in solid solution but as a distinct silicate mineral (mica) that could not be floated out or depressed. Moreover, in the beneficiation by physical means, 100% separation is not possible.

Question 6 : No mention of iron oxide in product is made. What will be percentage ?

Author : Iron has been determined in the concentrate and Table 8 shows its value as 2.65% Fe_2O_3.

Question 7 : Amount of CaO in product will be considerably high on LOI free basis; is it acceptable to refractory ?

Author : Calcite in association of silicates if CaO : SiO_2 is less than 2 is highly objectionable and unacceptable for refractory industry. However, you will appreciate that the concentrate has been evaluated on the basis of its actual RUL value and later on, again evaluated on differnet physical properties of the firebricks made out of this concentrate and found suitable in all respects. The details of test work, methodology and the test values have been described under the heading "Technological Evaluation of Magnesite Concentrate". Also, the CaO : SiO_2 ratio of the concentrate is more than 9. 6.