Production of Magnesium Oxide at the Industrial Research and Consultancy Center of the Sudan for local Industrial Uses

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Abstract:

Sudan enjoys diverse wealth of mineral resources of which, magnesite mineral is a potential source of raw material for industry. The objective of this work is the production of magnesium oxide from local magnesite. Samples from the Ingassana Hills and Qala En Nahal areas were chemically analyzed, the results showed that the ore of the Ingassana Hills area is of high quality and it is chemically suitable for the production of magnesium oxide; the basic material in the manufacture of magnesia cement. Hollow partition boards bind by magnesia cement were prepared using Ingassana magnesite ore were subjected to performance tests for certain properties as: board weight, bending, impact, fire, acid and alkali resistance, one point hanging, and water absorption tests. The results of the tests indicated that the boards were qualified to be used in buildings for non-bearing walls. Mineral processing trails were strongly recommended to indicate if the magnesite from other areas could be upgraded to be used in the other magnesium chemical industries.

Key words:

Magnesite, magnesium oxide, magnesium chloride, boards, Sorel cement,

Introduction:

Sudan presented potentially attractive exploration opportunities. it enjoys diverse wealth of mineral resources e.g. metals like iron, copper, lead, manganese, chromium, gold, silver, energetic like petroleum, natural gas and uranium and industrial minerals like gypsum, salt, trona, marble, talc, magnesite, lime stone, china clay, silica sand etc [1]. All these resources represent potential source of raw material for industry. The objective of this work deals with the production of magnesium oxide from local magnesite mineral as it represent one of the important industrial minerals found extensively in Sudan. Magnesite mineral is known to occur in all areas of the mafic-ultramafic rocks in Sudan but differ in size and grade. Deposits of interest are those occurring at Ingessana Hills, Qala En Nahal, Nuba Mountains and Sole Hamid of Northern Red Sea Hills [2].

Although Qala En Nahal and Nuba Mountains deposits are of considerable reserves but, the detailed geological and geochemical studies indicated that the Ingessana Hills magnesite deposit is the best than the others [3],[4].

Magnesite mineralization in Ingassana Hills occur in several places in the form of lenses , pockets, veins and fissure like filling, sometimes ramifying and branching [3]. They are included in serpentine rocks as stuccoworks or along joint plains. They are different in size from microscopic scale to several meters. The magnesite of the Ingassana Hills area is assumed to have been formed as a result of carbon dioxide metasomatisim with water rich fluids, which have reacted with the magnesia rich serpentine [3]. Table 1 show the chemical composition of the magesite ore of the Ingassana Hills area [4].

Table (1) results of chemical analysis of magnesite samples from Ingassana Hills

No.	MgO %	CaO %	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	LOI %
1	46. 69	0.99	2.00	0.0458	0.4740	49.5
2	46.40	0.63	1.00	0.1315	0.8185	50.0
3	43.45	1.30	2.60	0.6505	1.9995	48.0
4	46.06	0.46	0.59	0.0986	1.5489	51.0
5	46.30	0.60	1.94	0.2373	1.1809	50.0
6	46.10	0.80	0.90	0.1830	1.9854	50.0
7	44.20	0.27	5.90	0.9608	1.9690	45.9
8	32.50	17.70	3.00	0.3689	1.9342	44.4

Qala EnNahal ultra-mafic hills were considered by most of the geologists as the north continuation of the Ingassana-Kurmuk ophiolite complex, which include also the small hills and outcrops. The area was composed of strongly sheared tectonized and crushed rocks of serpentinite and talc-carbonate as the two most dominant rock types; in addition a few minor occurrences of amphibolite, dolomite and secondary quartz veins were also identified. Talc-magnesite schist is composed mainly of talc and magnesite with iron oxide, calcite, quartz and tremolite etc as minors.

Table (2): chemical composition of talc-magnesite of Qala EnNahal area in (%)

No	MgO	CaO	SiO_2	Fe_2O_3	Al_2O_3	LOI
1	35.34	0.32	31.2	6.1	0.24	26.00
2	33.09	0.30	32.4	7.3	0.26	25.75
3	36.08	0.80	26.0	6.0	0.28	30.65
4	34.80	0.17	32.0	6.6	0.22	25.08
5	34.40	1.20	18.7	7.0	0.30	39.3

According to previous studies [5] the proved reserve calculated was found to be 15.6 million tons of talc-magnesite whereas, the probable and the possible reserves were supposed to be 19.4 and 5.7 million tons respectively. Raw talc-magnesite schist samples were floated on a laboratory scale to generate talc rich float and magnesite rich tailings (using single stage froth floatation), the work resulted in finding of 53% talc and 41% magnesite, the remaining 6% represent associated minerals that present in the original rock. The chemical analysis of the magnesite rich tailings revealed 37.7% MgO, 15.19% SiO_2, 8.38% Fe_2O_3, 38.0% LOI, 0.2% CaO and 0.28% Al_2O_3. The production of magnesium oxide based on the presence of high quality magnesite (magnesium carbonate) that should be burnt to produce MgO [6].

Table (3) Chemical Specifications of Commercial grade magnesite.

MgO min	CaO max	SiO_2 max	Fe_2O_3 max	Al_2O_3 max	LOI min
42.5 %	1.0%	2.5%	2.0%	2.0%	48.5%

Recent trends of using lightweight partition boards; bind by magnesia cement is an eye-opening expertise in the construction industry in many countries e.g. China, Ethiopia, Canada etc… [7], [8]. The later technology was known as agro stone technology. It utilizes magnesium-based chemicals (magnesium oxide and magnesium chloride) as binder, agricultural waste and/or mineral raw material as aggregate (filler), and fiberglass as reinforcing material, the product was known as five-proof light partition boards. The products are light, easy to fix fire and sound proof and shock resistant. The binder (cement) was scientifically known as Magnesium Oxychloride cement, which is known also as Sorel cement, historically was firstly prepared by Sorel 1867 [9]. It is made of a mixture of magnesium oxide powder and magnesium chloride solution. The initial product of the reaction is believed to be $Mg_6(OH)_{10}Cl_2.7H_2O$, which slowly change into $Mg_2(OH)_6Cl.4H_2O$ [10].

Materials and methods:

This research was executed into two stages; stage one deal with the assessment of some magnesite ores in Sudan in the three promising areas. The study includes field geological observations and sample collection, and the lab work including the determination of mineral grade and chemistry of the deposits.

Firstly magnesium oxychloride cement from Ingessana Hills Magnesite Ore was prepared and its properties were tested in the Industrial Research and Consultancy Center laboratories [11].

At stage two; a pilot 6ton/day vertical shaft kiln was built by the Industrial

Research and Consultancy Center for semicomercail production of magnesium oxide for industrial purpose using Ingassana hills high quality magnesite [12]. The locally produced caustic calcined magnesite (magnesium oxide); is then used as basic material for the manufacture of magnesia cement (Sorel cement). Then the magnesium oxide was used to prepare Light-weight hollow partition boards (300x60x10 cm), as the major component of magnesia cement at this stage. The boards were subjected to performance test, including certain mechanical and physical properties as follows: weight, bending resistance, impact resistant, fire resistance, one point hanging, and water absorption and acid and alkali resistance tests. The results of the tests done indicated that the partition boards produced were so good to be used in buildings for inner non-bearing walls.

Three boards with dimensions of 2700 x 600 x 100 (mm) were made using a mixture of bagasse fibers, volcanic ash, (as fillers) fiber glass (as reinforcing agent), and magnesium oxide and magnesium chloride (as binder). The hollow boards were kept for 15 day curing and then tested for the following: Partition wall weight/m^2, bending resistance, impact test (shock resistance), Fire resistance, one point hanging, Acid and alkali resistance, water absorption, following the Chinese standard procedure [13]. The bending resistance test was done by adding static load on the center of board until failure occur hence bending resistance was calculated as

$$B = \frac{F}{W} \text{ ……………………. } (1)$$

Where:

B = bending resistance value

F = static load when the failure occur

W = weight of the board

The shock resistance (impact) test was done by dropping 30 kg sandbag from 0.5 m level on the board repeatedly until through cracks occur. Single point hanging test was done by hanging 800N in a central point for 24 hours and observing the change. Acid and alkali resistance tests were done by immersing a piece of the partition material on 5% HCl or 15% NaOH separately for seven days and observing the change. Water absorption test was done by immersing a piece of the material on water for 24 hours and then calculating the change in the weight.

Results and discussion:

The results showed that the magnesite of Ingassana hills is of high quality and it is chemically suitable for the production magnesium oxide; deposits at Nuba Mountains and Qala EnNahal areas are found to be talc-magnesite schist and hence it is not suitable to be used for the production of magnesium oxide.

Further more. Results of froth floatation of raw talc-magnesite schist from Qala EnNahal area on a laboratory scale indicated the presence of 53% talc and 41% magnesite, the remaining 6% represent associated minerals that present in the original rock.

The results of the physical and mechanical properties of the boards obtained in this study table: 1, indicated that they are light weight i.e. the board wall weight/m^2 is 36.4 kg, acid and alkali resistant, it can withstand fire up to 110 minutes, it can carry load weighting 8.22 times the board weight without bending. It has good shock and impact resistant i.e. it withstand more than 32 times by dropping 30 kg sandbag from 0.5 m level on the board repeatedly without cracks and it has good resistant for single point hanging load by hanging 800N in a central point for 24 hours and cracks or change observed .

The performance of these boards as compared with the Chinese Standard[13] Table: 4, showed that the important mechanical and physical properties namely partition wall weight, bending resistance, impact resistant test, fire resistance, one point hanging, water absorption and acid and alkali resistance are qualified .

Table (4): Performance of hollow Partition Boards as compared with the Chinese Standard [14].

Item	Standard value	Test result	conclusion
Partition wall weight kg /m^2	Not more than 60	36.4	Qualified
Bending resistance load(times the board weight)	Not less than 0.75	8.22 times (485 kilos)	Qualified
Shock resistance (impact) clashing by 30 kg sand bag	Clash three times from 0.5 m drop in level by 30 kg sandbag no through cracks	More than 32 times no cracks	Qualified
Fire resistance	Not inflammable	Resist fire for110 min.	Qualified
One point hanging	no through cracks	No cracks	Qualified
Water absorption max.	22%	16%	Qualified
Acid and alkali resistance	No change	No change	Qualified

Conclusions and Recommendations:

It can be seen that the chemical composition of the talc-magnesite of Qala EnNahal area is not comparable to commercial magnesite, because the silica and iron contents are very much on the higher side and magnesia content is lower. The high silica content may be due to the presence of significant amount of siliceous materials like talc, quartz and tremolite that present on the original rock which could not be removed during single stage froth floatation.

Hollow partition boards prepared from local raw materials, namely Ingessana Hills Magnesite ore, sugar cane bagasse fibers and local volcanic ashes forming one compound. The mechanical and physical test results (table 2) showed that they are fire resistant, withstand adverse weather conditions, rough treatment, (handling, transportation and erection) providing flexibility in design and hence significant structural cost savings, i.e. they arrive ready to install. Panels can be cut with power tools and are ready to use or to finish with any decorative treatment. The hollow partition boards are suitable for non-load bearing walls.

Mineral processing trails were strongly recommended to indicate if the magnesite from other areas could be upgraded to a standard suitable for use as magnesium oxide to be used in the other magnesium chemical industries.

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