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# MAGNESITE OCCURRENCE IN HAZARA DISTRICT

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Magnesite occurs as three lens-like bodies near Sherwan (Hazara) in the Abbottabad Formation of Upper Paleozoic system. Total length of two outcrops is around 900 ft and width about 150 ft. The third outcrop is 150 ft. long and 20 ft wide. The deposit is probably hydrothermally metasomatized type. The properties of the magnesites were determined by utilizing microscopic, chemical, X-ray diffraction and differential thermal techniques. The conclusion drawn from the results obtained is that ores are fairly rich in magnesite with some minor impurities such as calcite, hematite, clay, siderite, quartz and limonite.

The magnesite deposit occurs in the Kumhar and Kulhar Khetar villages of Sherwan area, Abbottabad Tehsil (Survey of Pakistan topographic sheet No. 43 F/4). The outcrops are approachable by a 2–3 miles good trail from either Gadda, Sandho Gali and Sherwan on Abbottabad—Sherwan unmetalled fair weather road. The magnesite bearing area is covered by (longitudinal) grid Nos. 130–134 and (latitudinal) grid Nos. 1745–1770. The Kulhar Khelar deposit occurs at grid Nos. 1220–1700.

Previously general geology of Hazara area including the project area was discussed by Middlemiss,[1] Wadia,[2] Khan *et al.*[3] and Ali *et al.*[4] However, nobody has reported magnesite occurrence except Siddiqui *et al.*[5] who while investigating for iron-free dolomite, came across good quality magnesite embeded in dolomite.

Present work is a continuation of work by Siddiqui *et al.* who briefly described the geology and partial chemical composition of the magnesite. In the present project chemical and mineralogical properties of the magnesite have been worked out by microscopic, chemical, differential thermal and X-Ray diffraction techniques.

*Geology and Probable Origin.*—The rocks exposed in the area around Kumhar and Kulhar Khetar belong to Hazara Slates and Abbotabad formation of Palaeozoic age. The Hazara Slate consists of quartzose schist, shale and phyllites. The Abbottabad formation overlies Hazara Slates unconformably and consists of dolomites, sandstone and limestone. The magnesite presence in Abbottabad formation was first reported by Siddiqui *et al.*[5]

The magnesite deposit is found embeded in light-grey to grey dolomite and dolomitic limestone in the form of lens like bodies. It is white and at places greyish and occasionally brownish patches are seen in it. It is coarse grained and has an appearance of a crystalline limestone. The magnesite is thick bedded with 4–8 ft lamellae. The surrounding dolomite is thin to thick bedded. The thin lamellae is 2–6 in thick. The bedding of both dolomite and magnesite is almost same. The dolomite bed has 285°E strike bearing and dip 62° NNW, while magnesite bed has 282°E strike bearing and dip 69° NNW. The dolomite is grey and magnesite is white to light grey. The magnesite body is highly joined and fractured. There are three exposures of magnesite, two of them near Kumhar and one near Kulhar Khetar. The length and thickness of one of the Kumhar outcrop is 400–500 ft and 145–150 ft respectively. The other outcrop has more or less same dimensions. The Kulhar Khetar exposure is 150 ft long and 20 ft wide. This outcrop has about the same strike dip as the other two outcrops at Kumhar. On the basis of these factors. Siddiqui *et al*, calculated magnesite reserves of the three outcrops to ten million tons.

The genesis of magnesite in this area was previously described by Siddiqui *et al.* to the progressive replacement of limestone or dolomite by $MgCO_3$ through hydrothermal solutions yielding the crystalline variety of magnesite. In authors' view the crystalline limestone which escaped dolomitization was already present as lenses in dolomite and latter the hydrothermal solutions coming after nearby Mansehra granite crystallization, as in the Grenville area. Quebic,[6] selectively attacked the crystalline limestone and metasomatically replaced Ca by Mg. Moreover, the contact of magnesite and dolomite is quite sharp which is confirmed by analysing chemically both dolomite and magnesite (Table 1) from both sides of the contact. This shows that metasomatism is selective and is confined to coarse grained limestone parent rock. It is also seen in the field that both dolomite and magnesite have the same bedding and tectonic history as it is shown by the following bedding and joints pattern:

| | Magnesite | Dolomite |
|---|---|---|
| Bedding | 282°E/69°NNW | 285°E/62°NNW |
| Joint $J_1$ | 60°E/60°SE | 55°E/63°SE |
| ,, $J_2$ | 160°E/60°W | 160°E/62°W |
| ,, $J_3$ | 188°E/75°W | 146°E/67°W |
| ,, $J_4$ | 110°E/32°SW | 61°E/54°SE |

TABLE 1.—CHEMICAL ANALYSIS.

| Sample No. | | Ignition loss (%) | MgO (%) | CaO (%) | $SiO_2$ (%) | $Fe_2O_3$ (%) | $Al_2O_3$ (%) | Total |
|---|---|---|---|---|---|---|---|---|
| HS-1 | | 49.92 | 47.75 | 0.56 | 0.72 | 0.45 | 1.28 | 100.68 |
| HS-2 | | 49.54 | 46.17 | 0.98 | 0.80 | 0.40 | 2.15 | 100.04 |
| HS-3 | | 49.25 | 46.68 | 0.28 | 1.62 | 0.45 | 1.93 | 100.21 |
| HS-4 | | 48.46 | 45.97 | 1.26 | 0.89 | 0.65 | 1.78 | 99.01 |
| HS-5 | | 49.41 | 47.56 | 0.28 | 0.70 | 0.50 | 0.95 | 99.40 |
| HS-6 | | 49.00 | 47.85 | 0.42 | 0.98 | 0.53 | 0.67 | 99.45 |
| HS-7 | | 51.42 | 37.50 | 7.00 | 3.05 | 0.70 | 0.88 | 100.55 |
| HS-8 | | 49.36 | 47.12 | 0.56 | 1.58 | 0.55 | 0.97 | 100.14 |
| HS-9 | | 50.50 | 47.37 | 0.56 | 0.79 | 0.60 | 0.67 | 100.49 |
| HS-10 | | 48.57 | 47.87 | 2.10 | 0.36 | 0.65 | 0.50 | 100.05 |
| Snow-white magnesite Krnda NW Siberia | $CO_2$ | 51.93 | 47.46 | 0.52 | 0.08 | 0.02 | | 100.01 |
| | $H_2O$ | 0.13 | | | | | | |
| Compact white crystalline Alchar S. Siberia | $CO_2$ | 51.55 | 46.37 | 0.81 | 0.16 | 0.41 | | 99.30 |
| | $H_2O$ | 0.10 | | | | | | |
| Magnesite Brazil | | 51.93 | 46.62 | 0.43 | — | 0.56 | | 99.54 |
| Dolomite Kumhar | | 45.64 | 21.26 | 30.39 | 0.73 | 0.14 | 1.50 | 99.93 |

## Experimental

Chemical analyses were made to ascertain the range of variation in the composition of the bulk samples. Sampling was done by crushing the samples and quartering successively. Routine methods were used for chemical analysis. The results are given in Table 1.

Three samples were ground to pass through 200 mesh sieve. The powder patterns were mounted on a thin glass fibre which was rotated in the path of X-Ray beam using Copper $K\alpha$ radiation, and Ni filter. The calculated values of 'd' obtained are shown in Table 2.

The D.T.A. was run on the magnesite samples, heating them at the rate of 250°C hr from room temperature to 1000°C.

## Discussion

*Physical Properties.*—The magnesite of the Kumhar area occurs as compact and coarsely crystalline rock. It is white to snow-white, lustre nonmetallic and dull. Streak is white, grain-size ranges between 3 and 5 mm, and fractures irregularly. Hardness is $3\frac{1}{2}$–4. The specific gravity determined by pyconometer method is 2.988, 2.948 and 2.94 for the samples HS-2, HS-7 and HS-10.

*Microscopic Properties.*—Mineralogy of magnesite is quite simple. Minerals present are magnesite, siderite, quartz, hematite and limonite.

In all the samples magnesite is colourless, and is medium to coarse grained. Rhombohedral type cleavage is well developed in most grains. Grains of magnesite are anhedral to subhedral in form with curved faces. It is also seen that some times grains are elongated in certain directions showing slight foliation. Interference figure is uniaxial and always excentric. Some of the magnesite grains show replacement of calcite by magnesite. The refractive index for all the samples averages $\varepsilon=1.535$ $w=1.755$. Siderite occurs as small irregular veinlets and at most places show alternation to limonite. Hematite and quartz occur as very fine grains and they hardly exceed more than 2%. The rock samples are from 98–99.5% magnesite.

*Chemical Properties.*—Chemical composition of the magnesite samples collected at a regular interval is fairly constant as shown in Table 1. Most of these samples have fairly simple composition where MgO is the major content and CaO, $SiO_2$, $Al_2O_3$ and $Fe_2O_3$ are minor constituents either present in the structure or occur as different phases. The C.I.P.W. norm type calculations of the chemical analysis were not possible because the samples could not be purified as $Al_2O_3$ and $SiO_2$ are probably in the form of finest particles of clay which is not separable. The chemical analyses of the magnesite, were compared with snow-white and compact white crystalline magnesite of Siberia and Brazil.[7] The comparision shows that Hazara magnesite is a good variety of which MgO contents are 45.97–47.87%, whereas Siberian and Brazilian samples have MgO 47.46% and 46.62%. In Hazara the minimum MgO content is 37.50, and in the same sample CaO is 7.00%. In all other samples CaO is considerably low mainly around 0.56%. Total iron is somewhat comparable with Brazilian while it is slightly higher as compared with Siberian. $SiO_2$ content is also higher in almost all the samples.

*Differential Thermal Properties.*—Differential thermal analysis curves for magnesite show a broad vigorous endothermic reaction which starts at about 400°C, ends at 690°C and has a peak at 650°C.[8] The thermal curves obtained from samples HS-1, HS-2, HS-3, HS-4, HS-5, HS-6, HS-7, HS-8, HS-9 and HS-10, are given in Fig. 1. These curves show slight deviation from the curve obtained by Cuthbert. These samples show broad peaks at 654, 680, 676,667 669, 675, 652, 660, 661 and 658°C respectively. Sample No. HS-4 is very similar in behaviour to a magnesite studied earlier[9] from Hindubagh in Baluchistan. There is also a much smaller endothermic reaction of a much different character immediately following the first reactions at 740, 750, 732, 763, 720, 732, 700, 769 and 775°C respectively in samples No. HS-1, HS-2, HS-3, HS-4, HS-5, HS-6, HS-8, HS-9 and HS-10 respectively, and an enlarged second endothermic reaction in HS-7 at 883°C. The second

Table 2.—X-Ray Diffraction Data.

| Sample No. HS-2, HS-7, HS-8 | | Magnesite A.S.T.M. | | Smithsonite A.S.T.M. | |
|---|---|---|---|---|---|
| D 'A' | Intensity | d'A' | Intensity | d'A' | Intensity |
| 4.70 | W | 2.742 | 100 | 3.55 | 49 |
| 3.60 | F | 2.503 | 17 | 2.75 | 100 |
| 3.05 | W | 2.318 | 4 | 2.327 | 25 |
| 2.57 | S | 2.102 | 43 | 2.110 | 18 |
| 2.54 | F | 1.939 | 12 | 1.946 | 26 |
| 2.48 | W | 1.769 | 3 | 1.776 | 11 |
| 2.33 | W | 1.700 | 34 | 1.703 | 44 |
| 2.10 | M | 1.510 | 4 | 1.515 | 13 |
| 1.95 | MW | 1.488 | 5 | 1.493 | 13 |
| 1.87 | MW | 1.426 | 4 | 1.411 | 9 |
| 1.77 | WF | 1.371 | 3 | 1.408 | 2 |
| 1.68 | MS | 1.354 | 7 | 1.374 | 3 |
| 1.65 | F | 1.252 | 3 | 1.343 | 9 |
| 1.55 | F | 1.238 | | 1.252 | 1 |
| 1.50 | W | to | 1 | 1.183 | 8 |
| 1.48 | W | 1.101 | | 1.103 | 2 |
| 1.40 | W | 1.0669 | 4 | 1.071 | 6 |
| 1.35 | MW | 1.051 | 1 | 1.055 | 2 |
| 1.34 | MW | 1.0145 | 1 | 0.947 | 1 |
| 1.25 | W | 0.9134 | 7 | 0.8878 | 1 |
| 1.19 | F | | | 0.852 | 1 |
| 1.18 | W | | | 0.787 | 1 |
| 1.17 | F | | | 0.784 | 1 |
| 1.10 | F | | | | |
| 1.07 | MW | | | | |
| 1.015 | W | | | | |
| 0.97 | MW | | | | |
| 0.948 | WW | | | | |
| 0.915 | M | | | | |
| 0.888 | MW | | | | |
| 0.878 | MW | | | | |
| 0.852 | F | | | | |
| 0.798 | W | | | | |
| 0.787 | MW | | | | |
| 0.784 | MW | | | | |

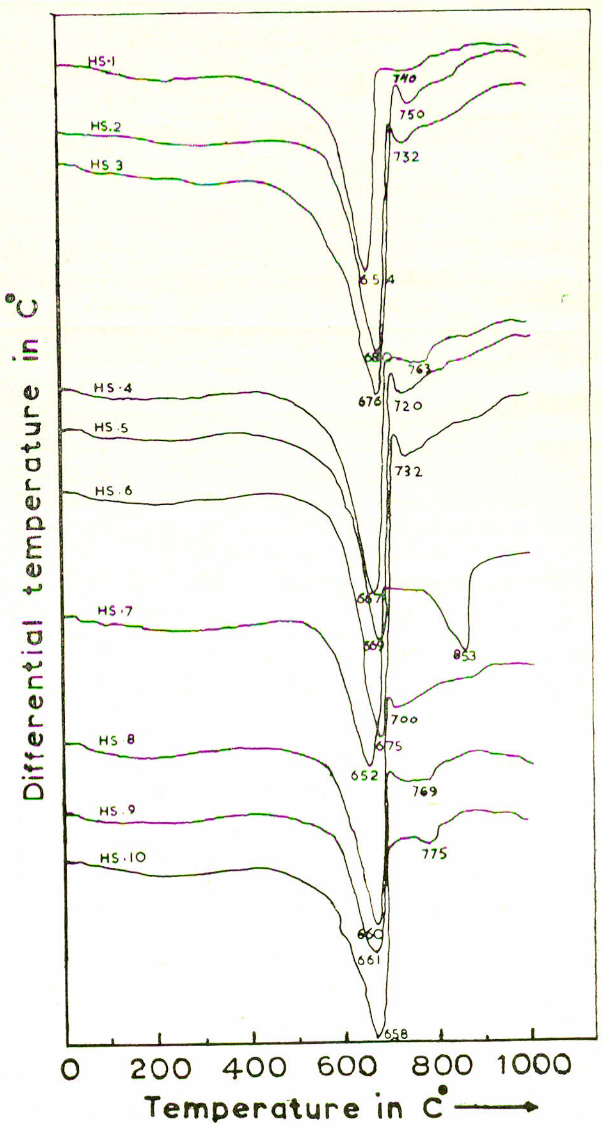


Fig. 1.—Differential thermal analysis curve of Hazara magnesite.

minor endothermic reaction by the samples in the magnesite curves is probably due to the presence of a small amount of calcite. The presence of calcite is in accordance with chemical analyses of the magnesite, shown in Table 1 where in the six samples CaO varies between 0.28–0.5% and in three other samples CaO is 0.98, 1.26 and 2.10%. Sample HS-7 gives altogether different result due to 7% of CaO in the magnesite where MgO content is also low i.e. 37.5%. This shows that the entire magnesite body in the Kumhar area has not been completely metasomatized.

*X-ray Properties.*—X-ray diffraction data were obtained of samples HS-2, HS-7 and HS-8, which represent almost the whole lot. The data of the three samples are comparatively same as no appreciable difference in the 'd' spacings is observed. That is why all the 'd' spacings for the three samples have been represented as one. The 'd' spacings shown in Table 2 are comparable with standard A.S.T.M. file[10] spacings for magnesite, as the strongest and corresponding weaker 'd' values are mainly for magnesite, i.e. 2.75/S1, 2.10/M, 1.68/MS (the strongest spacings) and 2.48/W, 1.95/MW, 0.915/M, 1.34/MW, 1.35/MW, 1.34/MW, 1.35/MW, 1.48/W, etc. Some other weaker spacings other than magnesite show that there are also minor constituents of calcite, siderite and dolomite. These minor minerals do not show all individual 'd' spacings possibly due to overlaping of the stronger spacings of magnesite. Therefore, the 'd' lines which could be differentiated from other than magnesite are 3.05/W and 1.87MW for calcite, 0.97/MW, 2.54/F, 3.60/F for siderite and 2.54/F for dolomite.

There are some moderate to weak and faint, 'd' lines which are unidentified possibly as these do not come in the range of different phases identified by thin section studies, chemical analysis and D.T.A. But by making thorough investigations it is found that the unidentified lines are possibly of smithsonite ($ZnCO_3$), the 'd' lines of which correspond with the 'd' lines of smithsonite. So there is likelihood of the presence of this mineral which is being calculated as traces during repeated chemical tests for smithsonite. Anyhow, further investigation for the confirmation of some minor constituents is recommended.

### Conclusions

1. The field relationship shows that the origin of magnesite is hydrothermal.
2. Microscopic identifictions reveal that magnesite rocks contain in addition to magnesite, some 1–2% of impurities like siderite, hematite, limonite and quartz.
3. Chemical composition is fairly good as MgO content approaches theoretical of value 47.6% MgO.
4. D.T.A. shows the presence of calcite impurity which could not be identified under the microscope.
5. X-ray diffraction pattern shows that major mineral in the ore is magnesite while calcite, siderate, dolomite and possibly smithsonite are present in small amounts.
6. From the different studies made above it is concluded that the major constituent of the ore is magnesite, and in minor amounts are siderite dolomite, hematite, limonite, quartz, clay and smithsonite.

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