IRJSE *Int. Res. J. of Science & Engineering,* 2020; Special Issue A7: 652-659 SJIF Impact Factor 6.68
ISSN: 2322-0015
RESEARCH ARTICLE **OPEN ACCESS**

Major oxide chemistry and reserve of Badhreta limestone deposit, Morena District, Madhya Pradesh, India.

Wadpalliwar Gunwant G

Assistant Professor, Department of Geology, Shri. Govindrao Munghate, Art and Science College Kurkheada, District Gadchiroli.
Email:ggwadpalliwar@gmail.com

Manuscript Details
Available online on http://www.irjse.in
ISSN: 2322-0015

Cite this article as:
Wadpalliwar Gunwant G. Major oxide chemistry and reserve of Badhreta limestone deposit, Morena District, Madhya Pradesh, India, *Int. Res. Journal of Science & Engineering,* February, 2020, Special Issue A7 : 652-659.

ABSTRACT
This work is to show reserve and grade of limestone of Badhreta deposit of Morena district of Madhya Pradesh. Geologically the limestone of the study area belongs to Bhander group of the Vindhyan Super Group. Its thickness is various from 0.5 to 1.0 meters. In the areal extension, the limestone seems to start as grey colour flaggy, with red and green calcareous shale bed which overlies by dark grey, hard and compact limestone and finally it passes to more siliceous nature nodular limestone at hill capping. Geological reserve of the lime stone is 9.37 million tone, in which 6.25 million tonne reserve is under proved category, while 1.87 million tonne and 1.25 million tones belongs to probable and possible category respectively. Major oxide geochemistry of the limestone of the study area indicate that, a lime stone is good for cement production because proportionate weight % CaO and SiO_2 content. Avarage concentration of CaO is 50.14% which is ranges from 48.68% to 51.22% where as SiO_2 content is in between 9.02 to 6.19%.

Keywords: Badhreta, Kailaras, Morena, and Limestone.

INTRODUCTION

Limestone is a nonclastic sedimentary rock, most lime stone originated in seas and their genesis was associated with rock forming organism. Predominant mineral of limestone is calcite (calcium carbonate). Cement is the basic requirement for the development and industrialization of any country.

Madhya Pradesh is endowed with large reserves of all grade limestone- SMS grade, blast furnace grade and cement grades. With the anticipated growth of Cement industry, proving of limestone reserve has assumed high priority. In Morena District of Madhya Pradesh, Badhreta-Mehwa- Bhilampur-Saipura deposits of limestone can use for cement production. Geological exploration is carried out in this area. in the Analogous block method which is best on the principle that quantitative similarity exists between a in a deposit and another block which is better known (mined-out). The variables such as thickness and grade for the purpose, the method will be referred to as geological block and Analogous block method. The basic assumption in these methods are certain areas have geological and technical features similar to certain other block which has been explored or mined-out. The block in such cases may be constructed on the basis of geology, structure, thickness, depth, grade, value, overburden, etc.

Study Area:
District /State: Morena, Madhya Pradesh
Taluka: Kailaras
Village: Badhreta
Ownership/Occupancy: Govt. Revenue Land
Existence of public Road/ railway line and nearby approximate distance : The Badhreta village is about 15 kms from the Kailaras tehsil HQ and 55.0 kms from Morena district HQ. The area is approachable by the metallic roads and having all communication facilities. The nearest railway station is Kailaras, which is connected with Gwaliar-Sheopur-kalahan by narrow-gauge rail link of Central Railway passing through the area from northern part.

Toposheet No: Toposheet Nos. 54 F/12 and 54 F / 8.
Latitude / Longitude: Latitudes 26O13’30"N - 26814’30’’N
Longitudes 77829’30’’E - 77831’30’’E

Area comprises mostly of hill slope, hillock being on the southern side and gradually the slope is dimensioning to the ground level in the northern direction. In the north of the area, there are a few non-perennial streams running towards north-easterly. South of the area hills are comprises of sandstone. On the eastern boundary of the area, there is a Chambal main canal which is 1km. The main part of the area falls in extreme eastern portion of the Badhreta, West block and adjoining 600 m in the Badhreta Eastern block, thus our reserve estimation will confined to this block which is having a approximate strike length of 2500 m.

Regional Geology:
The Vindhyans Super group were given the status of a system when it was first recognized by Oldham [1]. The system derives its name from the great Vindhyan mountains a part of which form a prominent plateau-like range of sandstone occurring north of the Narmada Valley particularly in Bundelkhand and Malwa. The land barrier which is believed to have separated from northern sea and southern sea during the Cuddapah period giving rise to the Vindhyan Formation in Central India. The Vindhyan basin of Central India occupies nearly an area of 104000 sq. kms spreading over four states viz. Bihar, Madhya Pradesh, Uttar Pradesh and Rajasthan.

Figure 1: Toposheet and elevation map of the study area

Figure 2: Field photographs of the study area showing limestone

The eastern extension of this great basin is concealed under the alluvial cover of the Yamuna and Ganga river and the western margin is largely concealed under the Traps with isolated inliers exposed near Indore. Oldham [1] classified the Vindhyans in two-fold and further subdivided them. Mallet, [2] gave a comprehensive geological account of the Vindhyan system and divided further in Lower and Upper Vindhyans. Significant contribution to the geology of the Vindhyan system have been made by Moorbath, et. al. [3] Kumar and Shrivastava [4], Kumar et al. [5] , Kumar [6]and recently by a number of workers from the Geological Survey of India. Auden in his classic memoir on the Vindhyan sediments in the Son valley published in the year 1933 presented a detailed classi-fication of the Vindhyan[7] System into different series, stages and sub-Stages, thereby replacing the earlier classification of Mallet [2]. The code of stratigraphic nomenclature of India has also favored the status of Vindhyan as a Super Group. The Vindhyan sedimentation have taken place in a synclinal trough and has been continuous along the axis while there was upheaval and denudation along the edges. Auden [7], opines that the Vindhyan sediments represent alternate sequence of marine and fluvio-deltloic deposits with associated eustatic changes. Vindhyans as largely of marine origin with local evidence in favour of fluvatile and lacustrine conditions. Studies by Das and Kumar [5] in the eastern and middle part of the Vindhyan basin indicated that the marine shallow water conditions with intertidal conditions of deposition during the most part of Vindhyan sedimentation.

Taken as a whole, the structure of the Vindhyan area is that of a basin, the sandstone forming plateaux. Over the greater past of the area, the beds are nearly horizontal, but show evidence of disturbance near the north-west and south-west margins. The presence of current-bedding and ripple marks in the strata is indicative of shallow water origin; while the red sandstones of Bhanders and Kaimurs indicate semi-arid and continental conditions.

Geological Setup:

The area is part of Upper Vindhyan Supergroup formations and the rocks of Bhander Series are well

exposed in the area. On the regional scale generalized geological sequence is as under:

Ganurgarh Shale:
The lowest stage of the Bhander Group is represented by Ganurgarh shale comprises of red colour (catachu red), well-laminated shale band which is well exposed on the southern side of the hill along the scarp face with intercalation of green clay band. The shale band dies out as moves northward.

Bhander Limestone:
Next to Ganurgarh shale, Bhander limestone overlain it in the form of hillock capping with altitude of about 60 meters height. It comprised mainly of grey colour limestone in the lower part with the dark grey and compact limestone at the top. Just above the hill capping on summit a small patch of nodular mottled coneretionary limestone locally known as 'Gohra Marble' is well exposed. It is brown, bluish-green, red and yellow in colour (showing spherulitic structure). Its thickness is various from 0.5 to 1.0 meters. In the areal extension, the limestone seems to start as grey colour flaggy, with red and green calcareous shale bed which overlies by dark grey, hard and compact limestone and finally it passes to more siliceous nature nodular limestone at hill capping. It is clear from field evidence that siliceous nature increase as goes upward. The Bhander limestone shows much variation in their nature from bottom level to top level. They are medium to fine-grained, well-bedded and compact. The colour varies from grayish to light yellowish cream. The total thickness of these limestone including middle and lower shaly limestone and upper compact grey limestone reaches upto 60 meters above Ganurgarh shales. A very peculiar characteristic feature of Bhander limestone in the area is presence of well-formed structural dome. The domal structure is very well prominent on the slope of all dimensions ranging from smallest to largest as goes upward and seems to be associated with close folding or warping of limestone strata. In dome flank, bed is hard compact, siliceous in nature with high dip in all directions. The horizontal flaggy grey coloured limestone in the core and from the close inspection of the dome, it is seen that the domal structure is associated with post depositional activity of limestone in the form uplift of beds forming dome or humps. Various sedimentary structures such as ripple marks, cracks, solution cavities, vein filling etc are present in limestone band on the exposed faces. In the area two members of Bhander group i.e. Bhander limestone and Ganurgarh shale are exposed in the area. The generalized sequence of rocks in the area is as under:

Light Grey, Flaggy Limestone:
The limestone is light grey in colour, fine-grained, horizontal-bedded, thin to thick lamination, with layering of siliceous and shaly/clayish material. The general strike of limestone in the area is ENE-WSW with gentle dip towards NNW. At places, towards eastern side, the light grey limestone shows facial variation vertically. The light grey limestone shows change in colour from grey to yellowish with alteration of red siliceous layer. The colour variation as well as chemical variation in the form of Ca, Mg to SiO_2. Numerous other features such as dome, joints, veinlets and solution cavities are also present. The joint are vertical and at places show secondary filling in the form of coarse-grained siliceous filling and at places in the form of vein filling. Other very important structure present in the form of domal structure. The dome of all dimensions is present in the limestone band and exposed along the slope or scarp face. The typical dome shows symmetrical dipping of overlying strata. The outer layer seems to be dome shows the light grey flaggy limestone with sloping die out in the plain.

Red and brown Calcareous Shale:
This band of calcareous shale is well-exposed on the slope particularly on the spur. It is about 2 to 3 m thick. The colour of shale is ranging from bownish grey to red in colour, which may be due to presence of iron-oxide. The shale is horizontal-bedded with thin to thick lamination with fine-grained and earthy texture.

Dark Grey massive Limestone:
On the top of the hill mound and scarp face, dark grey colour, hard and compact limestone is present with expose thickness of about 8 meters. The limestone is microcrystalline in nature with hard and compact, homogeneous and on fracturing exhibit subconcoidal fracture. The limestone band trending $N26^0W$ to $N60^0W$ with dip ranges 3 to 9^0 NE. The hardness of light grey, fine-grained, hard-compact limestone is 4.5 and sp. Gr. is 2.5.

Table 1: Geological Succession of the Vindhyans Super group

Bhander Series	Upper Bhander Sandstones	
	Semaria Shales, dolomitic Lst.	
	Lower Bhander Sandstone	
	Bhander Limestone(Nagod)	
	Ganurgarh Shales	
Diamond bearing Conglomerate		
Rewa Series	Upper Rewa Sandstones	
	Jhiri Shales	
	Lower Rewa Sandstones	
	Panna Shales	
Diamond bearing Conglomerate		
Kaimur Series	Upper	Dhandraul Quartzite
		Carp Sandstone & Conglomerate
	Lower	Bijaigarh Shales
		Upper Quartzites and Sandstones
		Susnai Breccia
		Lower Quartzites and Shales

Table 2: Generalized geological sequence

Alluvium--- Clayish, sandy in nature				
Vindhyan Supergroup	Upper Vindhyan	Bhander Series (Lower)	Bhander Sandstone	Hard compact white, pinkish in colour with shale partings medium fine-grained.
			Semaria Shales	Greenish to grayish green shales and buff color micaceous shales (dolomitic).
			Bhander Limestone	Ash grey to greenish grey, dark grey. Fine grained laminated hard and compact, nodular and concretionary at the top.
			Ganurgarh Shales	Dark red (catachu red) and olive green with white band of shale, flaggy in nature.

Table 3: Generalized Local Geology of the study area.

Alluvium	
Bhander Group	Bhander sandstone
	Semaria shale (dolomitic)
	Dark Grey, massive limestone
	Red & brown calcareous shale or limestone
	Light Grey, flaggy limestone

Chemistry of Limestone:

Major oxide geochemistry of the limestone of the study area indicate that, a lime stone can use for cement production because proportionate weight % CaO and SiO_2 content. Avarage concentration of CaO is 50.14% which is ranges from 48.68%-51.22% where as SiO_2 content is in between 9.02-6.19%. This content of limestone is can use for the production cement, but beneficiation is needed.

Table 4: Major oxide chemistry of the limestone of the study area

Major Oxide (Wt %)	SiO_2	CaO	MgO	Fe_2O_3	K_2O	Na_2O	Al_2O_3	LOI	Total
B-1	7.04	50.90	0.62	1.23	0.84	0.14	1.87	37.26	99.90
B-2	7.35	51.22	0.55	0.81	0.85	0.13	1.78	37.16	99.85
B-3	7.87	50.44	0.75	0.72	0.84	0.14	2.21	36.81	99.78
B-4	7.40	50.71	0.75	0.84	0.83	0.13	1.92	37.42	100.00
B-5	8.69	48.68	0.53	0.88	0.84	0.14	2.27	37.81	99.84
B-6	9.02	50.12	0.58	1.11	0.92	0.13	2.34	35.77	99.99
B-7	7.57	50.38	0.58	0.95	0.81	0.14	2.13	37.43	99.99
B-8	6.19	49.90	0.49	0.81	0.72	0.13	1.66	39.60	99.50
B-9	8.50	49.69	0.44	0.72	0.95	0.13	0.81	37.92	99.16
B-10	7.98	49.36	0.43	0.95	0.95	0.13	2.43	37.72	99.95
AVG	7.761	50.14	0.572	0.902	0.855	0.134	1.942	37.49	
MIN	6.19	48.68	0.43	0.72	0.72	0.13	0.81	35.77	
MAX	9.02	51.22	0.75	1.23	0.95	0.14	2.43	39.60	

Table 5: Showing the total Geological Reserve:

Category	Reserves	Remarks
Prove reserve	6.25 Million tonnes	Partly proved by DGM M.P. and fully confirmed by us by detailing geological mapping
Probable reserve	1.87 Million tonnes	
Possible reserve	1.25 Million tonnes	Below the 200 m level upto 5m
Total	**9.37** Million tonnes	

Table 6: Geological Reserve as per UNFC:

United Nations Frame- work Classification (UNFC)	UNFCode	National Mineral Inventory	Proposed equivalent UNFC code	Geological Reserves (Million Tonnes)	Recoverable Reserve (Million Tonnes)
Proved Minerals Reserve	111	Proved Recoverable Reserve	111	6.25	5.625
Probable Mineral Reserves	121+ 122	Probable Recoverable Reserve	121+122	1.87	1.683
Feasibility mineral Resource	211	Proved & probable Conditional	211	-	-
Pre-Feasibility Mineral Resource	221+ 222	Probable & possible Conditional	221+222	-	-
Measured Mineral Resource	331	Proved	331	-	-
Indicated Mineral Resource	332	Probable	332	-	-
Inferred Mineral Resource	333	Possible	333	1.25	1.125
Reconnaissance Mineral Resources	334	Prospective Resources	334	-	-

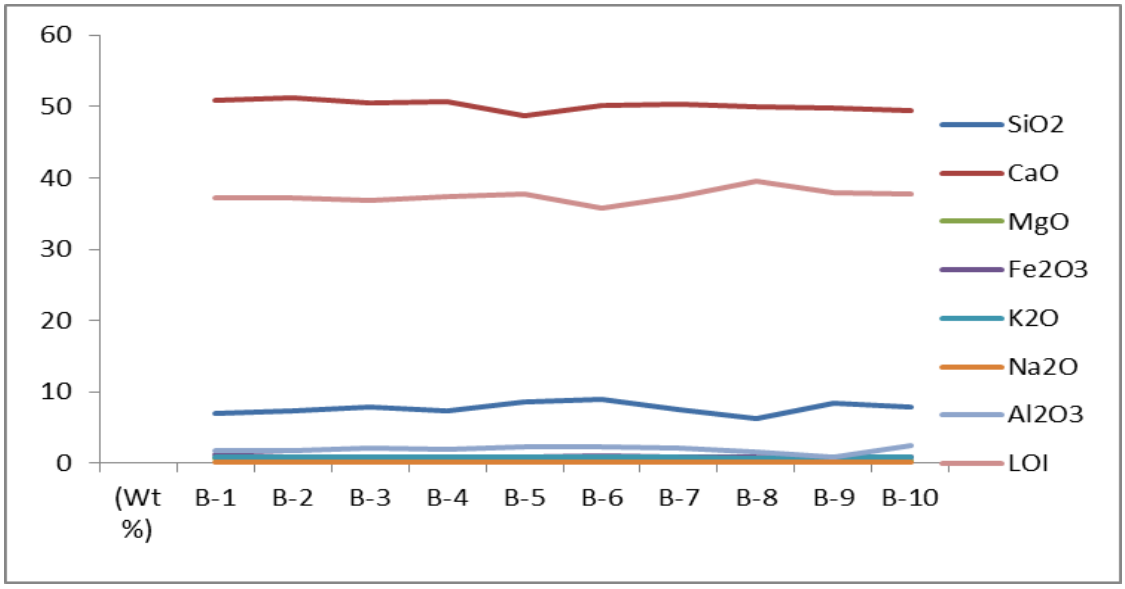

Figure 3: Graph showing relation of the chemical content of the limestone of the study area

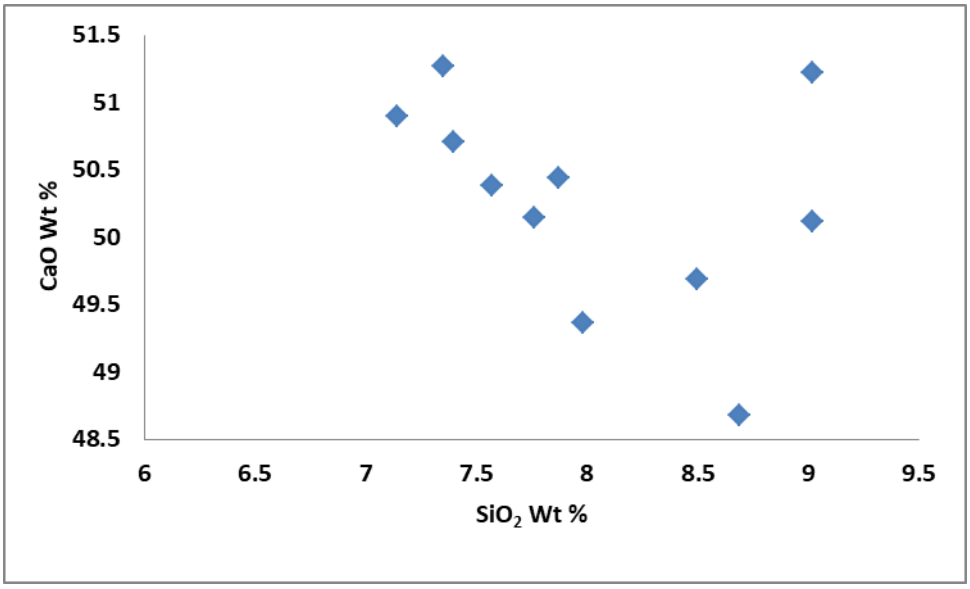

Figure 4: Binary diagram in between Cao and SiO_2 wt %

Reserve Estimation:

Limestone along with intercalated shale as a whole has been considered for rough estimation. The length, width and thickness of Limestone along with shale have been taken into consideration. The volume that arrived at has been multiply by specific gravity of limestone which is considered as 2.5. The insitu reserve has been calculated considering the whole volume of rock available there in the prospect area. Proved, Probable and Possible reserve are calculated and also reported as per the norms of UNFC (United nation Framework classification)

Proved Reserve:

Length of the limestone mineralization: 2,500 m
Approximate width of the limeston:- 100m
Thickness of limestone/blendable shaly limestone and calc-shale :- 13m
Bulk Density (tonnage factor 2.5tonnes/cum):- 2.5
Thus the reserve will be 2500 × 100 × 10 × 2.5 = 62,50,000 tonnes

Probable Reserve:

Length of the limestone mineralization :- 2,500 m
Approximate width of the limestone - 100m

Thickness of limestone/blendable shaly limestone and calc-shale :- 3m
Bulk Density (tonnage factor 2.5tonnes/cum):- 2.5
Thus the reserve will be 2500 × 100 × 3 × 2.5 = 18,70,000tonnes

Possible Reserve:
Length of the limestone mineralization :- 1,000 m
Approximate width of the limestone :- 100m
Thickness of limestone/blendable shaly limestone and calc-shale :-5m
Bulk Density (tonnage factor 2.5tonnes/cum) :- 2.5
Thus the reserve will be 2500 × 100 × 5 × 2.5 = 12,50,000 tonnes

CONCLUSIONS AND DISCUSSIONS

Inferences drawn from observations of the Badhreta limestone deposit of Morena district of Madhya Pradesh conclude that it s chemically suitable for the cement production but beneficiation need to be required for better result of cement industry. This lime stone can be use as blast furnace grade. Major oxide geochemistry of the limestone of the study area indicate that, a lime stone can be use for cement production because proportionate weight % CaO and SiO_2 content. Average concentration of CaO is 50.14% which is ranges from 48.68%-51.22% where as SiO_2 content is in between 9.02-6.19%.

Geological reserve of the lime stone is 9.37 million tone, in which 6.25 million tonne reserve is under proved category, while 1.87 million tonne and 1.25 million tones belongs to probable and possible category respectively. Reserve wise deposit is feasible but not suitable for bulk mining because of thin alternate bands of shale occurs with limestone. Sorting of shale need to be require for economic and quality production of cement.

Conflicts of interest: The authors stated that no conflicts of interest.

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