

**REPORT ON
RECONNAISSANCE SURVEY
(G4-STAGE) FOR LIMESTONE
IN AND AROUND NANHWARA- KYMORE LIMESTONE BLOCK, AREA (22.52 Sq. Km),
DISTRICT KATNI, MADHYA PRADESH**

प्रतिवेदन
चूना पत्थर हेतु प्रारंभिक अन्वेषण सर्वेक्षण (जी4-स्तर)
नन्हवारा-कैमोर और उसके आसपास क्षेत्र, जिला कटनी, मध्य प्रदेश

टोपोशीट संख्या 63 डी/12 & 64A9 / Toposheet No. 63 D/12 & 64A/9



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वर्ष 2026

**ENGEOTECH CONSULTANT, JABALPUR
Year 2026**

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**REPORT ON
RECONNAISSANCE SURVEY
(G4-STAGE) FOR LIMESTONE
IN AND AROUND NANHWARA- KYMORE LIMESTONE BLOCK, AREA (22.52 Sq. Km),
DISTRICT KATNI, MADHYA PRADESH**

SALIENT FEATURES

1	Name of Block	NANHWARA- KYMORE LIMESTONE BLOCK, DISTRICT KATNI, MADHYA PRADESH			
2	Mineral	Limestone			
3	Total Area	22.52 Sq. Km.			
4	Area covered under the present scheme	22.52 Sq. Km.			
5	Period of Exploration	10-02-2025 to 08-07-2026			
6	Meterage drilled	260m			
7	No. of Boreholes drilled				
8	Thickness of Different Grades of Limestone	Cement Grade			
9	Cut-off grade	As per the end-use grade classification recommended by Indian Bureau of Mines (IBM).			
		Grade	CaO (min)	MgO Max)	Sio2 (Max)
		Cement	>44	3.5	16
		Blendable	38-34	5	16-18
		Blendable / Benificiable	>34	6	16
10	Resources	Cement Grade Limestone CaO 42%-52 and MgO ≤ 5% 127.09 MT , Blandable Grade Limestone CaO 34-38% and MgO ≤ 4% 43.06 MT Blandeble/Benficiable Grade Limestone CaO 38-42% and MgO ≤ 5% 100.79 MT			
11	Grade	Cement Grade Limestone, Blendable Grade Limestone, Blendable / Benificiable Grade Limestone			
12	UNFC Category	Reconnaissance (334)			
13	Report Submission	8-07-2026			

प्रतिवेदन
चूना पत्थर हेतु प्रारंभिक अन्वेषण सर्वेक्षण (जी4-स्तर)
नन्हवारा-कैमोर और उसके आसपास क्षेत्र, जिला कटनी, मध्य प्रदेश

अध्याय-1

कार्यकारी सारांश

(Executive Summary)

1.1.0 कार्यकारी सारांश

1.1.1 प्रस्तावित अन्वेषण ब्लॉक सेमरी समूह के रोहतासगढ़ चूना पत्थर (Rohtasgarh Limestone) संरचना के समीप स्थित है, जो मध्य-प्रोटोरोज़ोइक आयु के विंध्यन सुपरग्रुप का भाग है। यह क्षेत्र कटनी जिले की प्रसिद्ध झुकेही-कैमोर-भदनपुर चूना पत्थर पट्टी (Jhukehi-Kymore-Bhadanpur Limestone Belt) का हिस्सा है। ब्लॉक की उत्तर-पश्चिमी सीमा पर मेसर्स ए.सी.सी. लिमिटेड की कैष्टिव चूना पत्थर खदानें, अर्थात् मेहगांव लाइमस्टोन माइंस तथा कैमोर-बामनगांव लाइमस्टोन माइंस स्थित हैं। इन समीपवर्ती खदानों से उपलब्ध विस्तृत शैलक्रमीय (Lithological) एवं अधस्तलीय भूवैज्ञानिक जानकारी का समालोचनात्मक अध्ययन कर वर्तमान अन्वेषण ब्लॉक के परिसीमन में विचार किया गया है। मौजूदा खनन क्षेत्रों के निकट स्थित होने तथा रोहतासगढ़ चूना पत्थर स्तरों की निरंतरता से यह संकेत मिलता है कि इस क्षेत्र में चूना पत्थर खनिजीकरण की उपस्थिति हेतु अनुकूल भूवैज्ञानिक परिस्थितियाँ विद्यमान हैं।

नन्हवारा-कैमोर चूना पत्थर ब्लॉक, जिसका क्षेत्रफल 22.52 वर्ग किलोमीटर है, विजय राघवगढ़ तहसील, जिला कटनी, मध्य प्रदेश में स्थित है। यह ब्लॉक मध्य-प्रोटोरोज़ोइक आयु के विंध्यन सुपरग्रुप के सेमरी समूह की रोहतासगढ़ चूना पत्थर संरचना से संबद्ध झुकेही-कैमोर-भदनपुर चूना पत्थर पट्टी का भाग है। यह क्षेत्र कटनी-सतना सीमेंट बेल्ट में रणनीतिक रूप से स्थित है तथा मेसर्स ए.सी.सी. लिमिटेड की मेहगांव तथा कैमोर-बामनगांव चूना पत्थर खदानों के निकट अवस्थित है। वर्तमान अन्वेषण ब्लॉक के परिसीमन के दौरान इन निकटवर्ती निक्षेपों की भूवैज्ञानिक एवं शैलक्रमीय विशेषताओं को ध्यान में रखा गया।

एमईएमसी नियमावली, 2015 के अनुसार इस क्षेत्र में राष्ट्रीय खनिज अन्वेषण न्यास (NMEDT), खान मंत्रालय, भारत सरकार की वित्तीय सहायता से जी-4 (Reconnaissance Survey) स्तर का अन्वेषण कार्य किया गया। अन्वेषण कार्यक्रम के अंतर्गत 22.52 वर्ग किलोमीटर क्षेत्र में 1:12,500 मापक पर विस्तृत भूवैज्ञानिक मानचित्रण, पिटिंग, भूवैज्ञानिक नमूनाकरण, पेट्रोग्राफिक एवं रासायनिक अध्ययन, बल्क घनत्व निर्धारण तथा डायमंड कोर ड्रिलिंग कार्य संपादित किया गया। प्रस्तावित 9 बोरहोलों के विरुद्ध कुल 8 बोरहोल सफलतापूर्वक पूर्ण किए गए, जिनकी कुल ड्रिलिंग गहराई 260 मीटर रही।

इनमें 7 बोरहोल 30 मीटर गहराई तक तथा 1 बोरहोल 50 मीटर गहराई तक ड्रिल किया गया। चूना पत्थर कोर रिकवरी 79% से 86% के मध्य रही तथा औसत रिकवरी 83% प्राप्त हुई, जो अधस्तलीय भूवैज्ञानिक नियंत्रण की संतोषजनक स्थिति को दर्शाती है।

भूवैज्ञानिक दृष्टि से क्षेत्र मुख्यतः रोहतासगढ़ चूना पत्थर तथा गौण रूप से रामपुर शेल से आच्छादित है। चूना पत्थर धूसर से गहरे धूसर रंग का, सघन, सूक्ष्म-दानेदार, माइक्राइटिक से माइक्रोक्रीस्टलीय प्रकृति का है, जिसमें कहीं-कहीं शेल की अंतःस्तरित परतें विद्यमान हैं। भूवैज्ञानिक मानचित्रण एवं ड्रिलिंग से अनेक चूना पत्थर स्तरों की निरंतरता स्थापित हुई है, जो स्तरित (Bedded) एवं स्तरीय (Stratiform) निक्षेपों के रूप में विकसित हैं। इनका निर्माण मध्य-प्रोटोरोज़ोइक काल में उथले समुद्री शेल्फ से ज्वारीय समतल (Tidal Flat) वातावरण में हुआ माना जाता है।

संरचनात्मक रूप से चूना पत्थर की परतें ENE–WSW से E–W दिशा में प्रहार (Strike) प्रदर्शित करती हैं तथा 5° से 15° तक का मंद उत्तरी से उत्तर-पश्चिमी नति (Dip) दर्शाती हैं। निक्षेप मुख्यतः जोड़ों (Joints) तथा सीमित भंगुर विकृति (Brittle Deformation) से प्रभावित है, जबकि प्रमुख वलन (Folding) एवं भ्रंशन (Faulting) का अभाव है, जो क्षेत्र की स्थिर विवर्तनिक अवस्था को इंगित करता है। तीन प्रमुख जॉइंट सेट तथा परत-अनुगामी जॉइंट्स की पहचान की गई है, जो स्थानीय स्तर पर अपक्षय एवं भूजल संचरण को प्रभावित करते हैं।

पेट्रोग्राफिक अध्ययन से ज्ञात होता है कि चूना पत्थर मुख्यतः सूक्ष्म क्रिस्टलीय कैल्साइट से निर्मित है, जिसमें गौण रूप से क्वार्ट्ज, मृत्तकीय पदार्थ (Argillaceous Matter) तथा डोलोमाइट उपस्थित हैं। माइक्राइटिक से माइक्रोस्पैरिटिक बनावट, पुनःस्फटीकरण (Recrystallization) तथा कैल्साइट सीमेंटेशन से यह संकेत मिलता है कि इसका निक्षेपण निम्न-ऊर्जा वाले उथले समुद्री वातावरण में हुआ तथा बाद में डायजेनेटिक प्रक्रियाओं द्वारा इसका स्थिरीकरण हुआ। शैल अत्यंत सघन एवं निम्न रंध्रता (Porosity) वाली है।

कुल 237 कोर नमूनों का रासायनिक विश्लेषण किया गया। भारतीय खान ब्यूरो (IBM) के सीमा मानकों (Threshold Values) तथा भारित औसत ग्रेड (Weighted Average Grade) गणना के आधार पर चूना पत्थर को सीमेंट ग्रेड, सीमेंट (ब्लेन्डेबल/बेनेफिशिएबल) ग्रेड तथा ब्लेन्डेबल ग्रेड श्रेणियों में वर्गीकृत किया गया। संसाधन आकलन हेतु 2.60 टन प्रति घन मीटर का बल्क घनत्व मान अपनाया गया।

सतही मानचित्रण एवं ड्रिलिंग द्वारा स्थापित भूवैज्ञानिक निरंतरता के आधार पर चूना पत्थर संसाधनों का आकलन बहुभुजीय (Thiessen Polygon) विधि द्वारा किया गया तथा इन्हें UNFC कोड 334 (G4 स्तर) के अंतर्गत Reconnaissance Mineral Resources के रूप में वर्गीकृत किया गया। अन्वेषण कार्यक्रम द्वारा कुल 270.94 मिलियन टन (MT) अनुमानित चूना पत्थर संसाधन स्थापित किए गए हैं।

अन्वेषण से यह सिद्ध हुआ है कि क्षेत्र में पर्याप्त मात्रा में चूना पत्थर निक्षेप उपलब्ध है, जिसमें अनुकूल भूवैज्ञानिक विशेषताएँ एवं सीमेंट तथा संबंधित उद्योगों हेतु उपयुक्त रासायनिक गुणवत्ता विद्यमान है। ब्लॉक

की स्थिति कैमोर, अमेठा, मैहर तथा आसपास स्थित प्रमुख सीमेंट संयंत्रों के निकट होने के कारण इसकी आर्थिक महत्ता और अधिक बढ़ जाती है। विशाल संसाधन क्षमता, अनुकूल संरचनात्मक स्थिति, सुगम पहुँच तथा उपलब्ध आधारभूत संरचना इस क्षेत्र को संसाधनों की विश्वसनीयता बढ़ाने हेतु जी-3 (Preliminary Exploration) स्तर के व्यवस्थित अन्वेषण के लिए अत्यंत उपयुक्त बनाती है।

1.1.2 निष्कर्षतः, वर्तमान जी-4 स्तर के अन्वेषण ने नन्हवारा-कैमोर चूना पत्थर ब्लॉक की भूवैज्ञानिक क्षमता को सफलतापूर्वक स्थापित किया है तथा भविष्य में विस्तृत अन्वेषण, खनिज ब्लॉक की नीलामी तथा कटनी जिले, मध्य प्रदेश में चूना पत्थर संसाधनों के सतत विकास के लिए एक सुदृढ़ आधार प्रदान किया है।

**REPORT ON
RECONNAISSANCE SURVEY (G4-STAGE) FOR LIMESTONE
IN AND AROUND NANHWARA KYMORE LIMESTONE BLOCK,
AREA (22.52 Sq. Km), DISTRICT KATNI, MADHYA PRADESH**

CHAPTER- I

1.1.0 EXECUTIVE SUMMARY

1.1.1 The present proposed exploration block is situated in the vicinity of the Rohtasgarh Limestone Formation of the Semri Group, belonging to the Vindhyan Supergroup of Meso-Proterozoic age. The area forms a part of the well-known Jhukehi–Kymore–Bhadanpur Limestone Belt of Katni District, Madhya Pradesh. Along the north-western boundary of the block, the captive limestone mines of M/s ACC Ltd., namely Mehgaon Limestone Mine and Kymore–Bamangaon Limestone Mines, are located. The detailed lithological succession and subsurface geological information available from these adjoining mines have been critically examined and taken into consideration while delineating the present exploration block. The proximity of the block to the existing mining areas and the continuity of the Rohtasgarh Limestone horizons indicate favorable geological conditions for the occurrence of limestone mineralization within the area.

The Nanhwara–Kymore Limestone Block, covering an area of 22.52 sq. km in Vijayraghavgarh Tehsil, Katni District, Madhya Pradesh, forms part of the Jhukehi–Kymore–Bhadanpur Limestone Belt belonging to the Rohtasgarh Limestone Formation of the Semri Group, Vindhyan Supergroup of Meso-Proterozoic age. The block is strategically located within the Katni–Satna Cement Belt and occurs in proximity to the captive limestone mines of M/s ACC Ltd., namely Mehgaon Limestone Mine and Kymore–Bamangaon Limestone Mine. The lithological and geological characteristics of these adjoining deposits were considered while delineating the present exploration block.

As per MEMC Rules, 2015, the area was investigated under G4 (Reconnaissance Survey) stage with financial assistance from the National Mineral Exploration Trust (NMET), Ministry of Mines, Government of India. The exploration program comprised large-scale geological mapping on a 1:12,500 scale over 22.52 sq. km, pitting, geological sampling, petrographic and chemical studies, bulk density determination, and diamond core drilling. Against the proposed nine boreholes, eight boreholes were completed for a cumulative depth of 260 m, comprising seven boreholes up to 30 m depth and one borehole up to 50 m depth. Limestone core recovery ranged from 79% to 86%, with an average recovery of 83%, indicating satisfactory subsurface geological control.

Geologically, the area is occupied predominantly by Rohtasgarh Limestone with subordinate

Rampur Shale. The limestone occurs as grey to dark-grey, compact, fine-grained, micritic to microcrystalline beds with occasional shale intercalations. Geological mapping and drilling have established the continuity of multiple limestone horizons occurring as bedded and stratiform deposits formed under shallow marine shelf to tidal-flat depositional conditions during the Mesoproterozoic.

Structurally, the limestone beds exhibit ENE–WSW to E–W strike with gentle northerly to north westerly dips ranging from 5° to 15°. The deposit is affected mainly by jointing and minor brittle deformation, while major folding and faulting are absent, indicating a stable tectonic regime. Three prominent joint sets and bedding-plane joints have been recognized and locally influence weathering and groundwater movement.

Petrographic studies reveal that the limestone is composed predominantly of microcrystalline calcite with subordinate quartz, argillaceous matter, and dolomite. Micritic to microsparitic textures, recrystallization, and calcite cementation indicate deposition in a low-energy shallow marine environment followed by diagenetic stabilization. The rock is characterized by very low porosity and a compact nature.

A total of 237 core samples were analyzed for chemical constituents. Based on IBM threshold values and weighted-average grade calculations, the limestone has been categorized into Cement Grade, Cement (Blendable/Beneficiable) Grade and Blendable Grade. A bulk density value of 2.60 t/m³ has been adopted for resource estimation.

Based on geological continuity established through surface mapping and drilling data, limestone resources have been estimated by the Polygonal (Thiessen Polygon) Method and classified under Reconnaissance Mineral Resources (UNFC Code 334, G4 stage). The exploration program has established an inferred limestone resource of 270.94 million tonnes (MT) within the block.

The investigation has demonstrated the presence of a substantial limestone deposit possessing favorable geological characteristics and acceptable chemical quality suitable for cement and allied industries. The proximity of the block to major cement plants at Kymore, Ametha, Maihar, and adjoining areas further enhances its economic significance. The sizeable resource potential, favorable structural disposition, ease of accessibility, and infrastructure support indicate excellent prospects for systematic advancement to the G3 (Preliminary Exploration) stage for upgrading the confidence level of resources.

1.1.2 In conclusion, the present G4-stage exploration has successfully established the geological potential of the Nanhwara–Kymore Limestone Block and provides a sound basis for future detailed exploration, mineral block auction, and sustainable development of limestone resources in Katni District, Madhya Pradesh.

CHAPTER – 2

2.0.0 DETAILS OF THE QUALIFIED PERSON(S) / EXPLORATION AGENCY

2.1.0 INVESTIGATING AGENCY

S. No	Investigating Agency	Address	Credentials	Contact Details	Project Coordinator
1	ENGEOTECH CONSULTANT	Office: 1338, Kachnar City Road, Vijay Nagar, Jabalpur- 482002 M.P.	Notified Private Exploration Agency (by Min. of Mines, Govt. of India) Accredited by NABET (A-Category Exploration Agency) ISO 9001:2015 Certified	WhatsApp: +91- 9425387402, +91- 8989771405 Email: engeotech@red iffmail.com	Indraneel Dawande (M. Tech. Applied Geology)

2.2.0 PERSONNEL INVOLVED WITH PRELIMINARY EXPLORATION (G4) FOR LIMESTONE IN AND AROUND NANHWARA- KYMORE LIMESTONE BLOCK, AREA (22.52 Sq. Km), DISTRICT KATNI, MADHYA PRADESH

S. No.	Title	Name of Person
1	Project Co-Ordinator (Overall planning, Coordination & Supervision)	Mr. Indraneel Dawande M. Tech (Applied Geology)
2	Overall Guidance	Mr. Anil Kumar Dawande, Director (R) (GSI), M. Tech (Applied Geology)
3	Overall Guidance	Mr. Padmakar Nahar (Geologist, (R), IBM), M.Sc. (Geology)
4	Physical Execution of Work	
4.1	Geology	Mr. Anand Kumar Raikwar, M.Sc. (Geology)
4.2	Geology	Mr. Ashutosh Chourasiya, M.Sc. (Geology)
4.3	Geology	Mr. Ganesh Bisen (Geologist) M.Sc. (Geology)
5	Drilling	Mr. Anshul Sharma B. Tech (Mech. Engineer)
6	Sample Preparation	Mr. Ashutosh Chourasiya M.Sc. (Geology)
7	Chemical Laboratory	BSS Labs. Pvt. Ltd., Jabalpur & RK testing Lab. Pvt., Jabalpur
8	Petrological Studies	Mr. Anil Kumar Dawande, M. Tech (Applied Geology)

CHAPTER – 3

3.0.0 TITLE OF THE REPORT & OWNERSHIP

Title: Reconnaissance survey (G4-stage) for Limestone In and around Nanhwara- Kymore Limestone block, area (22.52 sq. Km), District Katni, Madhya Pradesh.

Ownership: The area under investigation is administratively governed by the Department of Geology & Mines, Government of Madhya Pradesh.

3.1.0 DETAILS ABOUT PERIOD OF PROSPECTING

The exploratory drilling in the block commenced on 27-11-2025 and was completed on 19-01-2026 in the Nanhwara Kymore Limestone Block. A total of 08 boreholes were drilled with a cumulative meterage of 260 m, and borehole core sampling etc., were completed simultaneously. The analytical / laboratory studies were also carried out simultaneously in the laboratories of BSS Lab Jabalpur and other NABL-accredited laboratories, R K Testing Lab in Katni.

3.2.0 DETAILS OF EXPLORATION AGENCY, QUALIFICATION, AND EXPERIENCE OF ASSOCIATED TECHNICAL PERSONS ENGAGED IN EXPLORATION

Exploration Agency	ENGEOTECH CONSULTANT
Qualification	M. Tech (Applied Geology)
Experience	20 Years
Address of the Prospector	Office: 1338, Kachnar City Road, Vijay Nagar, Jabalpur-482002 M.P.
Email	Email: engeotech@rediffmail.com
Phone No.	WhatsApp: +91-9425387402, +91-8989771405

CHAPTER - 4

4.0.0 DETAILS OF THE AREA

4.1.0 LOCATION OF THE BLOCK

The study area, which covers a block area of 22.52 Sq.km is situated in Vijayraghavgarh Tehsil of Katni District, lies approximately 35–45 km from Katni (from District Headquarters) and about 10–20 km from Vijayraghavgarh of Katni District. The area falls under Toposheet Nos. 63D/12 and 64A/9. These are the villages present in the study are Kymore, Nanhwara Kalan, Deori Majhgawan, Khalwara, Ametha, Amuwari, Kalaehara, and Guddadauhan. Tehsil: Vijayraghavgarh, District: Katni, State: Madhya Pradesh. The Blocks fall in the Survey of India Toposheet No. 63D/12 and 64A/9, and the co-ordinates of the area covered by large-scale mapping at a 1:12,500 scale are bounded by GPS Co-ordinates of the following corner points of the Nanhwara -Kymore Limestone Block, Katni district, Madhya Pradesh. Shown in Table No: 4.1.

Table No. 4.1: DGPS Co-ordinates of the Nanhwara -Kymore Limestone Block

Nanhwara Kymore Limestone Block Limestone Block G-4				
BP-No.	Easting	Northing	LATITUDE	LONGITUDE
BP-1	453422.975	2652840.814	23° 59' 12.4812" N	80° 32' 31.6152" E
BP-2	462074.868	2656928.634	24° 01' 26.2279" N	80° 37' 37.4214" E
BP-3	460437.211	2658968.473	24° 02' 32.4098" N	80° 36' 39.2484" E
BP-4	459869.427	2658947.536	24° 02' 31.6776" N	80° 36' 19.1480" E
BP-5	458707.513	2659582.059	24° 02' 52.2017" N	80° 35' 37.9455" E
BP-6	457811.108	2657935.285	24° 01' 58.5714" N	80° 35' 06.3789" E
BP-7	457514.234	2657954.617	24° 01' 59.1714" N	80° 34' 55.8668" E
BP-8	457511.799	2657514.065	24° 01' 44.8465" N	80° 34' 55.8269" E
BP-9	457300.551	2657524.833	24° 01' 45.1762" N	80° 34' 48.3473" E
BP-10	457327.711	2657056.864	24° 01' 29.9627" N	80° 34' 49.3582" E
BP-11	456696.855	2656990.2	24° 01' 27.7335" N	80° 34' 27.0329" E
BP-12	454371.145	2655697.442	24° 00' 45.4643" N	80° 33' 04.8486" E
BP-13	454044.486	2655188.876	24° 00' 28.8942" N	80° 32' 53.3437" E
BP-14	452918.455	2654683.964	24° 00' 12.3580" N	80° 32' 13.5461" E

4.2.0 DETAILS OF THE AREA WITH LAND USE

The exploration area is primarily covered by black soil, predominantly used for the cultivation of wheat, rice, pulses, and paddy. The terrain is generally flat with a gentle slope towards the south. The highest elevation, at 394 m above mean sea level (AMSL), is located in the northeastern part of the area, while the lowest elevation is around 366 in the southwestern section. The cadastral

details reveal that most of the exploration area is privately owned land, with no forest cover.

4.3.0 MINERAL(S) UNDER INVESTIGATION

Mineral (s) under investigation or granted under the G4 category for the exploration of Limestone.

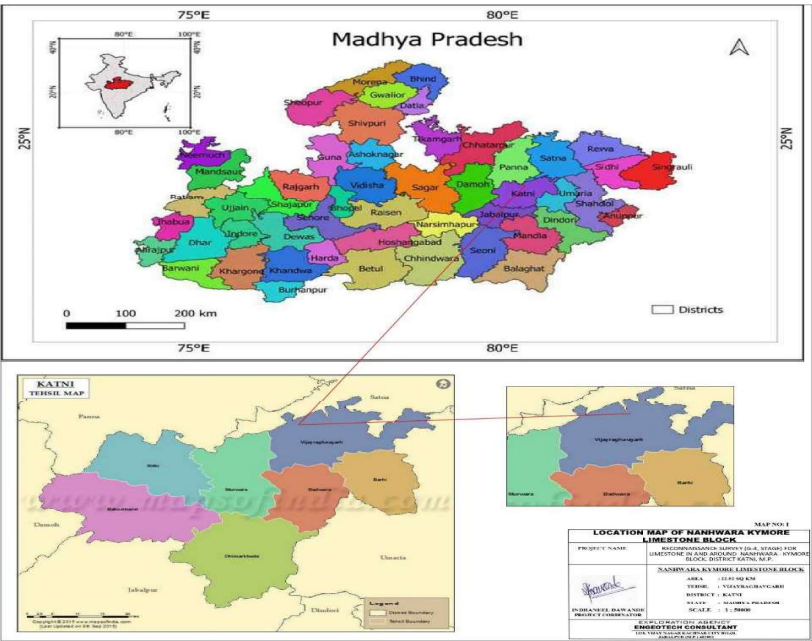


Figure No 4.1 Location map of Block Area.

CHAPTER – 5

5.0.0 PHYSIOGRAPHY AND ENVIRONMENT

5.1.0 RELIEF OF THE AREA WITH MINIMUM AND MAXIMUM ELEVATION, DRAINAGE PATTERN, NATURAL WATER COURSES, RESERVOIRS, ETC.

The exploration area is primarily covered by black soil, predominantly used for the cultivation of wheat, rice, pulses, and paddy. The terrain is generally flat with a gentle slope towards the south. The highest elevation, at 394 m above mean sea level (AMSL), is located in the northeastern part of the area, while the lowest elevation is around 366 in the southwestern section. The cadastral details reveal that most of the exploration area is privately owned land, with no forest cover.

Physiographic the terrain is characterized by a gently undulating topography typical of the Vindhyan plateau. The region displays a prominent NE-SW trending ridge-and-valley morpho-structure, largely controlled by the underlying lithology of the Bhandar Group. The drainage is primarily dendritic to sub-parallel, with local streams feeding into Chhoti Mahanadi, which is a tributary of the Son River basin.

The drainage system of the Kymore-Nanhwarra area is structurally controlled and reflects the underlying lithological variations of the Vindhyan Supergroup. Regionally, the area falls within the Sone River Basin, which is a major sub-basin of the Ganges drainage system. Regional Drainage Pattern exhibits a predominantly dendritic to sub-parallel pattern. The primary regional slope is toward the North and North-East, dictated by the dip of the Bhandar Group strata and the regional tectonic grain of the Kymore Range. The area is drained by a network of seasonal streams (nallahs) and perennial rivers that are deeply incised into the limestone and shale units: The Chhoti Mahanadi River: This is the most significant drainage artery in the vicinity. It flows to the south and east of the study area, acting as the master stream for the localized drainage network. Numerous ephemeral streams originate from the Kymore Escarpment. These streams flow primarily in a radial or parallel fashion before joining the larger drainage channels. During the monsoon, these nallahs exhibit high discharge rates, leading to significant sediment transport and occasional flash floods in low-lying areas near Nanhwarra. The drainage is notably influenced by the NE-SW trending structural lineaments. In several locations, stream courses are observed to follow joint sets and minor fault planes within the Rohtasgarh Limestone, resulting in sharp, rectilinear bends in the stream channels.

5.2.0 ROADS, RAILWAY TRACK, ELECTRIC TRANSMISSION LINE, TELEPHONE LINE, ETC.

The study area, comprising Kymore and Nanhwarra Kalan, is situated within the Vijayraghavgarh

Tehsil of the Katni District, Madhya Pradesh. Geographically, the area is bounded by latitudes 23° 59' 12.4812" N to 24° 02' 52.2017" N and longitudes 80° 32' 13.5461" E to 80° 37' 37.4214" E. It falls under the Survey of India (SOI) Toposheet No. 63 D/12 and 63 D/16. The area serves as a significant industrial-mining hub and is well-connected by a network of roads and rail infrastructure. The primary approach to the area is via the Katni-Vijayraghavgarh State Highway. Kymore is located approximately 42 km NE of Katni city. Nanhwara Kalan is situated roughly 10 km to the southwest of Kymore and is accessible via all-weather metalled roads branching off from the main arterial network. These roads are designed to support heavy vehicular traffic, including multi-axle trucks utilized for mineral evacuation. Katni Junction (KTE), located about 40 km from the study area, acts as the nearest major railway hub, providing broad-gauge connectivity to Jabalpur, Prayagraj, and Bilaspur. Kymore is uniquely supported by several railway sidings, namely Bistara, Kachhagawan, Rajarwara, Saliya Paharai, Mehagaon, Badari, Ametha, and Bamangawan, that facilitate the bulk transport of limestone and cement. Additionally, the Jukehi Railway Station serves as a vital transit point for freight.

5.3.0 HOST POPULATION (LOCAL TRIBES), HUMAN SETTLEMENTS WITHIN AND NEARBY THE AREA

In the Nanhwara Pawai block, the following are villages present in the study area; the main village is Kymore population of 19,343, Kymore town is located approximately 48 km east of Katni, the district headquarters, and about 8 km from Vijayraghavgarh, the Tehsil headquarters. The town is well connected by road and serves as an important industrial center in the region. As per the Census 2011 of respective villages, the population of villages in the study area is given in Table 5.1.

Table No. 5.1 Population of villages in the study area (Census 2011)

S.No	Village Name	Latitude	Longitude	Population
1	Kymore	24° 2'43.06"N	80°35'39.51"E	19,343
2	Nanhwara Kalan	24° 0'26.09"N	80°33'37.37"E	4,014
3	Deori Majhgawan	24° 1'19.24"N	80°35'35.03"E	2,124
4	Khalwara	24° 2'21.06"N	80°36'43.15"E	1,335
5	Ametha	24° 0'18.16"N	80°32'41.62"E	1,257
6	Amuwari	23°59'18.08"N	80°32'31.34"E	1,235
7	Kalehra	24° 0'54.65"N	80°34'44.17"E	955
8	Guddadauha	24° 1'50.36"N	80°36'13.86"E	665

5.4.0 SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

The proposed exploration block is located near Kymore town in Vijayraghavgarh Tehsil of Katni District, Madhya Pradesh. The surrounding area comprises Kymore and several rural villages, with agriculture and limestone-based industries forming the backbone of the local economy. The major occupations of the local population include agriculture, agricultural labour, mining, cement industry employment, animal husbandry, and small-scale trade. The population consists of Scheduled Tribes, Scheduled Castes, Other Backward Classes, and other communities. Hindi is the principal language spoken, while Bundeli and Bagheli are commonly used in nearby villages. Basic infrastructure, such as schools, healthcare facilities, electricity, drinking water, banking, markets, and road connectivity, is available in Kymore and surrounding settlements, providing adequate support for exploration activities.

5.5.0 HISTORICAL SITES AND ARCHAEOLOGICAL MONUMENTS, PLACES OF WORSHIP, PUBLIC UTILITIES, ETC. WITHIN OR NEARBY

The Nanhwara–Kymore area of Katni District, though primarily known for its limestone-bearing formations of the Vindhyan Supergroup, also falls within a region of moderate historical and ecological significance. While no major nationally protected archaeological monuments are reported directly within the immediate study area,

5.6.0 FOREST, SANCTUARIES, NATIONAL PARK AND WILDLIFE SANCTUARY

The region reflects a long history of human habitation, supported by favorable physiographic and resource conditions. From an ecological perspective, the area lies in proximity to important forested tracts and protected areas of central India. Notably, the Bandhavgarh National Park is located to the northeast, while the Panna National Park lies to the northwest of the study area. Both National Parks are famous for Tiger Capital in the country. These protected areas are characterized by tropical dry deciduous forests and are known for their rich biodiversity, including tiger habitats. Although the immediate Nanhwara–Kymore area is not part of any notified national park or wildlife sanctuary, it exhibits similar environmental characteristics with patches of scrubland, agricultural fields, and degraded forest cover.

5.7.0 FLORA AND FAUNA

The flora and fauna of the Kymore-Nanhwara area are characteristic of the tropical dry deciduous forest ecosystem typical of the Central Indian highlands. The region exhibits a mosaic of agricultural land, scrub forest, and dense forest patches, largely influenced by the underlying calcareous soil

derived from the Bhandar and Semri Group limestones. Flora: The vegetation in the study area and its buffer zone (10 km radius) is categorized as Southern Tropical Dry Deciduous Forest. The distribution of flora is heavily influenced by the proximity to the Surma Reserve Forest and the local drainage systems of the Chhoti Mahanadi and Umrer rivers. Dominant Tree Species: The forest canopy is dominated by *Tectona grandis* (Teak) and *Madhuca indica* (Mahua). Other significant species include *Diospyros melanoxylon* (Tendu), *Butea monosperma* (Palas/Flame of the Forest), *Azadirachta indica* (Neem), and *Terminalia arjuna* (Arjun), the latter typically occurring along perennial nallahs. Common undergrowth consists of *Lantana camara*, *Ziziphus mauritiana* (Ber), and various species of wild grasses. The surrounding plains are extensively cultivated, with major crops including wheat, gram, and paddy, supplemented by horticultural species like *Mangifera indica* (Mango) and *Psidium guajava* (Guava).

Fauna: The faunal diversity is concentrated in the fragmented forest patches and protected areas like the Samrat Ashok Wildlife Sanctuary (approx. 45 km away). The limestone mining belt of Kymore-Nanhwarra supports a range of mammalian and avian species adapted to the undulating terrain. Common sightings in the peripheral forest zones include *Sus scrofa* (Wild Boar), *Axis axis* (Spotted Deer/Cheetal), *Rusa unicolor* (Sambar), and *Lepus nigricollis* (Indian Hare). Small predators like *Vulpes bengalensis* (Indian Fox) and *Canis aureus* (Golden Jackal) are also prevalent. The area supports a variety of birds including the Indian Peafowl (*Pavo cristatus*), Black Drongo, Kingfishers (near river banks), and various species of Egrets and Herons associated with local tanks like the Sagona Tank. The region is known for a high density of arachnids, particularly large black and brownish-black scorpions. Common reptiles include the Indian Cobra and Rat Snake.

5.8.0 WATER BODIES SUCH AS RIVER, NALA, STREAM, RESERVOIR, ETC.

The drainage system of the Kymore-Nanhwarra area is structurally controlled and reflects the underlying lithological variations of the Vindhyan Supergroup. Regionally, the area falls within the Sone River Basin, which is a major sub-basin of the Ganges drainage system. Regional Drainage Pattern exhibits a predominantly dendritic to sub-parallel pattern. The primary regional slope is toward the North and North-East, dictated by the dip of the Bhandar Group strata and the regional tectonic grain of the Kymore Range. The area is drained by a network of seasonal streams (nallahs) and perennial rivers that are deeply incised into the limestone and shale units: The Chhoti Mahanadi River: This is the most significant drainage artery in the vicinity. It flows to the south and east of the study area, acting as the master stream for the localized drainage network. Numerous ephemeral streams originate from the Kymore Escarpment. These streams flow primarily in a radial or parallel

fashion before joining the larger drainage channels. During the monsoon, these nallahs exhibit high discharge rates, leading to significant sediment transport and occasional flash floods in low-lying areas near Nanhwara. The drainage is notably influenced by the NE-SW trending structural lineaments. In several locations, stream courses are observed to follow joint sets and minor fault planes within the Rohtasgarh Limestone, resulting in sharp, rectilinear bends in the stream channels.

5.9.0 CLIMATE CONDITIONS

The study area experiences a subtropical, monsoonal climate characterized by hot, dry summers and cool, pleasant winters. The climatic conditions are representative of the Central Indian shield and play a significant role in the chemical weathering processes of the Vindhyan Supergroup sediments. The meteorological year is traditionally divided into three distinct seasons. Summer (March to mid-June): Characterized by intense solar radiation and high evaporative rates. Temperatures typically peak in May, with mean daily maximums reaching 42°C to 45°C. This period is marked by hot, dry winds (locally known as "Loo"), which accelerate the dehydration of surface regolith. Monsoon (Mid-June to September): The region receives the bulk of its precipitation from the South-West monsoon. This season is critical for groundwater recharge within the fractured limestone aquifers of the Rohtasgarh and Rampur Shale formations. Winter was observed between October and February, which is the most favorable period for geological fieldwork and surveying. The weather remains dry and clear, with January being the coldest month. Mean daily minimum temperatures hover around 8°C to 10°C, though occasional cold waves can bring temperatures down to 4°C. The average annual rainfall for the Katni district is approximately 1,112 mm. Nearly 90% of the annual rainfall occurs during the monsoon months (June–September). August is historically the wettest month. Relative humidity varies significantly with the seasons. During the monsoon, humidity levels exceed 80%, whereas in the peak summer month of May, it may drop below 20%, leading to highly arid surface conditions.

Table No.5.2 Meteorological Data Summary (Averages)

Parameter	Summer (May)	Monsoon (Aug)	Winter (Jan)
Avg. Max Temp (°C)	44.2	30.5	24.5
Avg. Min Temp (°C)	28.5	23.8	9.2
Avg. Monthly Rainfall (mm)	8	310.5	15.4
Dominant Wind Direction	W / NW	SW	NE

5.10.0 OTHER PHYSIOGRAPHIC, SOCIAL AND ENVIRONMENTAL FACTORS

The proposed exploration block is situated in a gently undulating terrain with moderate relief and is drained by seasonal streams forming part of the local drainage system. The area is predominantly agricultural, interspersed with scrubland and scattered vegetation. No major perennial water bodies occur within the block.

The surrounding region is characterized by rural settlements with agriculture and limestone-based industrial activities as the primary sources of livelihood. Basic civic amenities, including roads, electricity, water supply, educational institutions, and healthcare facilities, are available in nearby towns and villages. The block area is surrounded by cement manufacturing industries, and some of them are as follows

S. No.	Cement Industry	Location	Approx. Distance from Kymore
1	ACC Limited (Adani Cement) Kymore Cement Works	Kymore, Katni District	Within Kymore Town
2	ACC Limited (Adani Cement) Ametha Cement Works	Ametha, Katni District	8–10 km
4	UltraTech Cement Ltd.	Satna	65 km

CHAPTER – 6

6.0.0 INFRASTRUCTURE AND ENVIRONMENT

6.1.0 LOCAL INFRASTRUCTURE DETAILS

The Nanhwara–Kymore area, falling under Vijayraghavgarh Tehsil of District Katni, Madhya Pradesh, is moderately well developed in terms of physical and social infrastructure. The town of Kymore serves as the principal infrastructural and service center for the surrounding villages, including Nanhwara Kalan, Kalehara, Ametha, and Amuwari. The area is reasonably well connected by a network of metalled (pucca) and unmetalled (kutchha) roads, facilitating movement between villages and linking them to the district headquarters at Katni. The regional connectivity is further strengthened by access to major road corridors within the district. Rail connectivity is available at Katni, which is an important railway junction providing links to major cities in central India. The proximity of railway infrastructure also supports the transportation of mineral resources and industrial goods.

Power supply in the area is provided through the MPSEB, and most of the villages are electrified. This supports domestic consumption, agricultural activities, and small-scale industrial operations. Water supply is primarily dependent on groundwater sources such as hand pumps, dug wells, and bore wells, supplemented locally by seasonal surface water availability. Communication facilities, including postal and telecommunication services, are available in the area. Mobile network coverage is generally satisfactory, although it may be intermittent in remote localities.

Basic educational infrastructure is present in the form of primary and middle schools within villages, while higher educational facilities are available at Kymore and Katni. Healthcare facilities in the region include primary health centers and sub-centers catering to rural populations, whereas advanced medical facilities are accessible at Katni. Administratively, the villages fall under the Panchayati Raj system, with governance at the Gram Panchayat level, and higher administrative control at the tehsil headquarters of Vijayraghavgarh. The presence of cement industries in and around Kymore, based on locally available limestone resources, indicates a well-established industrial base in the region. Overall, the existing infrastructure, particularly road connectivity, power availability, and proximity to rail transport, is adequate to support reconnaissance (G4 stage) investigations and is favorable for undertaking future detailed exploration activities.

6.2.0 HISTORICAL SITES

No major historical sites are within the buffer zone of 10 kms.

6.3.0 FORESTS, SANCTUARIES, NATIONAL PARK, AND ENVIRONMENT SETTING OF THE AREA

The Nanhwara–Kymore area is not part of any notified national park or wildlife sanctuary.

CHAPTER – 7

7.0.0 GEOLOGY OF THE AREA

7.1.0 REGIONAL GEOLOGY

The study area encompasses the sedimentary rocks of the Meso- Proterozoic Vindhyan Supergroup, located in north-central Peninsular India. This extensive geological unit stretches across regions including east Rajasthan, Madhya Pradesh, Uttar Pradesh, and Bihar. The Vindhyan basin extends from Sasaram in Bihar to Chittorgarh in Rajasthan, with its southern and southwestern boundaries partially covered by the Deccan Traps. The northern limit of the Vindhyan Supergroup is marked by the Bundelkhand Granite or partially extends beneath the Gangetic alluvium (Geological Survey of India, 1987; Chakraborty, 2006). The Vindhyan Supergroup represents a thick sequence of sediments deposited in an intracratonic basin, predominantly in a shallow marine environment. There is a notable lithotype variation within this supergroup, characterized by a distinct transition from carbonates to siliciclastic sediments. Litho-stratigraphically, the Vindhyan Supergroup is further subdivided into four major groups: the Semri Group (Lower Vindhyan) and the Kaimur, Rewa, and Bhandar Groups (Upper Vindhyan) (Kale & Phansalkar, 1991). The Semri Group is composed of various shale, sandstone, and limestone formations, including the Khenjua, Chorhat, Rampur, Rohtasgarh, and Suket Formations. The Kaimur Group features the Dhandraul Formation, predominantly consisting of sandstone. The Rewa Group encompasses the Jhiri and Govindgarh Formations, which are characterized by shale and sandstone, respectively. The Bhandar Group includes the Ganurgarh, Nagod, Sirbu, and Maihar Formations, with a composition of shale, limestone, and sandstone (Ghosh, 1980). The Lower Vindhyan unconformably overlies the Bundelkhand granitic basement. The Vindhyan Supergroup represents a significant portion of the Proterozoic time and holds valuable information regarding the evolution of the atmosphere, climate, and life on Earth. The deposition of the Lower Vindhyan succession began approximately 1.72 billion years ago and continued until around 1.6 billion years ago without significant interruptions.

An angular and erosional unconformity separates the Rohtas Limestone of the Semri Group from the overlying Kaimur Group. The sedimentation of the Upper Vindhyan is marked by the deposition of the Dhandraul Formation, which lies above this unconformity. The limestone units within the Vindhyan Supergroup are notable for exhibiting stromatolites, indicative of the presence of algal life during the Meso-Neoproterozoic era (Chakraborty, 2006). The Vindhyan Supergroup forms an ENE-WSW trending syncline, with the northern limb dipping gently towards the SSE. The southern limb exhibits subvertical NNW-dipping formations and faulted contacts with the Mahakoshal /Sidhi Group of rocks. The southern margin of the Vindhyan syncline shows a gentle NNW-dipping

homocline, with the Kaimur Sandstone and overlying formations primarily displaying a homochiral configuration.

The Suket Shale and underlying formations exhibit considerable variations, ranging from open warps to even close or tight, narrow-hinged folds, with both limestone and orthoquartzite beds involved in folding (Verma, 1995).

The limestone found in this region belongs to the Semri Group (Lower Vindhyan) of the Vindhyan Supergroup, a significant component of the Vindhyan system in Indian stratigraphy. The Semri Group is renowned for its extensive limestone deposits, which hold substantial economic value in the region. The Vindhyan basin, along with other Proterozoic basins such as the Cuddapah and Chhattisgarh basins, exemplifies a major Proterozoic intercontinental basin that developed within the central part of the Indian Shield (Ghosh, 1980; Kale & Phansalkar, 1991). The Vindhyan strata form a broad syncline that trends in an ENE-WSW direction. This syncline's axis is characterized by a slight curvature with a gentle westward inclination. The southern limb of the syncline exhibits a steeper dip compared to the northern limb, which results in a southward inclination of the axial plane. The Vindhyan Supergroup encompasses the complete Vindhyan rock sequence, with an estimated maximum thickness of approximately 3 kilometers. It is predominantly composed of sandstone, shale, and limestone, reflecting a complex depositional history (Chakraborty, 2006; Verma, 1995).

The regional geological succession of the Vindhyan Supergroup, as summarized by Soni et al. (1987), Kale & Phansalkar (1991), and Chakraborty (2006), is detailed in Table 5.1. This stratigraphic framework highlights the diverse lithological units and their respective formations within the Vindhyan Supergroup, illustrating the geological complexity and historical significance of this ancient sedimentary basin.

Table No. 7.1 The Regional Geological succession of Vindhyan Supergroup (After Soni et al (1987), Kale & Phansalkar (1991), and Chakraborty (2006))

Group	Formation	Alternative/Equivalent	Lithology
Bhander Group	Shikoda Formation	-	Sandstone, Limestone and Shale
	Sirbu Formation	-	Shale, Siltstone, and Sandstone
	Bundi Hill Formation	Lower. Bhander	Sandstone
	Lakheri Formation	Bhander Lst. / Nagod Lst.	Limestone with shale partings
	Ganurgarh Shale Formation	Simrawal Shale.	Shale
----- Disconformity /Gradational Contact-----			
Rewa Group	Govindgarh Formation	Upper Rewa Sandstone	Sandstone
	Drummondgang Formation	-	Sandstone
	Jhiri Formation	Varegadt Sh.	Shale with basal conglomerate (diamondiferous)
	Asan Formation	Lower Rewa Sandstone	Sandstone, Limestone, and chert.
	Panna Formation	-	Shale, Calcareous with Limestone interbeds
-----Normal Contact/Facies Change-----			
Kaimur Group	Dhandraul Formation	Upper Kaimur Sandstone	Sandstone
	Mangesar Formation	-	Sandstone with siltstone and shale interbeds

Group	Formation	Alternative/Equivalent	Lithology
	Bijaygarh Formation	-	Shale with glauconitic Siltstone
	Ghaghar Formation	Markundi Sandstone	Sandstone
	Susnai Formation	Ghurma Shale	Breccia, Conglomerate, gritty sandstone
	Sasaram Formation	Lower Kiamur Sandstone	Sandstone
-----Unconformity/Normal Contact-----			
Semri Group	Bhagwar Formation	Suket Shale	Shale and porcellanite
	Rohtasgarh Formation	Nimbahera Limestone	Limestone with shale partings
	Rampur Formation	Chorhat Sandstone	Glauconitic sandstone and shale
	Salkhan Formation	Bargawn Limestone	Siliceous and Cherty Limestone
	Koldaha Formation	Kheinjua Shale	Olive Green Shale
	Deonar Formation	Chopan Porcellanite	Porcellanite
	Kahrahat Formation	Kuteshwar Limstone	Limestone
	Arangi Formation	-	Shale
	Deoland Formation	Khardeol Sandstone	Sandstone with basal conglomerate
-----Angular Unconformity/ Non conformity-----			
Granite and Superacrustals			

7.2.0 REGIONAL STRUCTURE

The proposed exploration block lies within the stable Vindhyan Basin and is underlain by sedimentary rocks of the Vindhyan Supergroup. The rock formations exhibit a gentle homoclinal dip of about **1°–5° towards the north to northeast**, with a general strike of **NW–SE to WNW–ESE**. The area is structurally stable and free from major folding or regional faulting, ensuring good

lateral continuity of the limestone horizons.

7.2.1 Primary Sedimentary Structures

The limestone succession exhibits well-preserved primary sedimentary structures such as bedding, lamination, ripple marks, stromatolitic structures, mud cracks, and occasional shale partings. These features indicate deposition in a shallow marine to tidal-flat environment under relatively stable conditions.

7.2.2 Secondary/Diagenetic Structures

The limestone shows minor secondary structures developed during diagenesis, including joints, calcite veins, stylolites, recrystallization, and solution cavities. Joints are the most common structural feature and occur as vertical to steeply dipping fractures trending mainly NW–SE and NE–SW. Some joints are open, while others are filled with calcite. These joints facilitate groundwater movement and weathering but do not significantly affect the continuity of the limestone beds.

7.3.0 REGIONAL MINERALISATION

The Vindhyan Supergroup constitutes one of the largest Proterozoic sedimentary basins in India and hosts extensive deposits of limestone, making it one of the country's most important limestone-bearing geological provinces. Limestone mineralisation is widespread within the Vindhyan succession and is mainly associated with the carbonate formations of the Semri, Kaimur, and Bhandar Groups, with the Rohtasgarh Limestone Formation representing one of the major cement-grade limestone horizons in the Katni–Kymore region.

The limestone deposits are laterally persistent, thickly bedded, and generally grey to bluish-grey, compact, and fine- to medium-grained. They are commonly interbedded with shale and sandstone and exhibit favourable chemical characteristics for cement manufacture. Owing to the extensive distribution and continuity of these carbonate horizons, the Vindhyan Basin supports numerous limestone mines and large cement industries across Madhya Pradesh and adjoining states. In addition to limestone, the Vindhyan Supergroup hosts economically important deposits of dolomite, shale, sandstone, silica sand, and pyrophyllite–diaspore in different stratigraphic horizons. The extensive limestone mineralisation of the Vindhyan Supergroup has made it one of the principal sources of raw material for the cement industry in central India and an important target for continued mineral exploration and resource development.

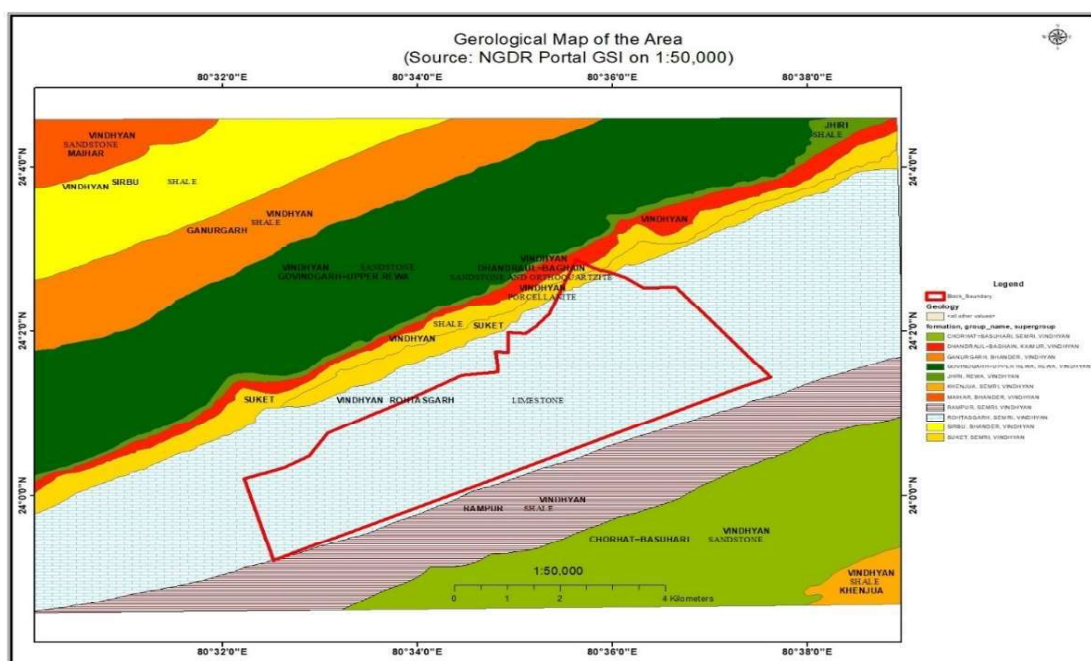


Figure No.7.1 Map showing the regional Geological setup around the exploration block. (Source: National Geoscience Data Repository (NGDR)).

7.4.0 GEOLOGY OF THE BLOCK

1.

The area under investigation, encompassing the Nanhwara- Kymore Limestone Block of Katni District, forms a part of the Lower Vindhyan sequence. The rock formations exposed herein belong to the Semri Group of the Vindhyan Supergroup in this region. Geological succession is shown in Table No. 7.2.

Table No. 7.2 The Geological succession of Nanhwara -Kymore Limestone Block 1:12,500 Scale (22.52 Sq.km area)

Lithology	Formation	Group	Supergroup	Age
Soil	-	-	-	Recent
Limestone	Rohtasgarh Formation	Semri Group	Vindhyan Supergroup	Meso Proterozoic
Shale	Rampur Formation			

7.5.0 DESCRIPTION OF ROCK TYPES IN THE BLOCK

7.5.1 The large-scale mapping was carried out in the Nanhwara- Kymore Limestone Block in part of Toposheet No. 63D/12 & 64 A/09, covering an area of 22.52 square kilometers on a scale of 1:12,500 to demarcate Limestone of Rohtasgarh Formation exposures in the study area. The majority of the area is covered by black soil at the top and grey clay at the bottom, primarily used for cultivation purposes. During the mapping, prominent litho-units, namely Limestone and Shale, belonging to the Semri group of the Vindhyan Supergroup, were observed and precisely mapped.

7.5.2 Semri Group

7.5.2.1 Rohtasgarh Formation

The Nanhwara–Kymore area forms part of the southeastern sector of the Vindhyan Basin and is underlain predominantly by sedimentary rocks of the Lower Vindhyan succession belonging to the Semri Group. Among these, the Rohtasgarh Limestone constitutes an important carbonate unit occurring extensively around Nanhwara, Badwar, Kymore, and adjoining tracts. The limestone horizon is stratigraphically assigned to the Rohtasgarh Formation and represents deposition in a shallow marine shelf to tidal flat environment developed during Mesoproterozoic time. The formation conformably overlies the Rampur Shale and is succeeded by shale and arenaceous horizons of younger Vindhyan sequences. Lithologically, the Rohtasgarh Limestone in the Nanhwara–Kymore sector is represented by grey, bluish grey to dark grey, compact, fine-grained limestone occurring in thin- medium and thick-bedded forms. The limestone is predominantly micritic to microcrystalline and occasionally dolomitic in nature. At places, the rock exhibits ripple marks, mud cracks, shrinkage features, and interclastic breccia horizons indicating periodic exposure and deposition under low-energy supratidal to intertidal conditions. Intercalations of calcareous shale, carbonaceous shale, and thin siliceous bands are commonly observed within the sequence. Chert nodules and silicified patches occur sporadically, particularly along joint planes and bedding contacts.

The general strike of the limestone beds in the Nanhwara–Kymore area varies from ENE–WSW to E–W, conforming to the regional structural grain of the Vindhyan Basin. The beds generally dip gently towards the north or northwest at angles ranging between 5° and 15°, though local variations are observed due to minor warping and tectonic disturbances, resulting in a change in the amount of dip of 45°-50°, but the strike is unchanged. The overall structure of the area is simple and stable, characteristic of the undeformed cratonic Vindhyan basin, though brittle deformation features are

well developed.

Jointing is one of the prominent structural characteristics of the Rohtasgarh Limestone in this area. Two to three major joint sets are commonly observed. The primary joint set generally NNE–SSW to NE–SW 80° – 90° SE/NW and is nearly vertical in attitude, while Bedding-plane joints are parallel to bedding, dipping 5° – 15° . These joints are generally open, persistent, and closely spaced in quarry sections. The spacing varies from a few centimeters to over a meter, depending upon bed thickness and degree of induration. Calcite fillings and secondary silicification are commonly observed along the joint planes. The joints play an important role in groundwater circulation, weathering, blasting characteristics, and bench stability in mining operations. Bedding planes are generally well developed and marked by thin shale partings, stylolitic, ferruginous coatings, and occasional carbonaceous films.

The bedding attitude commonly measures around ENE–WSW dipping 5° – 15° with gentle northerly dips. Cross-joints intersecting bedding planes often produce blocky to tabular rock masses. At places, minor drag folding, warping, and flexural bending are observed near lineament-controlled zones. However, large-scale folding is absent, indicating tectonic stability after deposition.

The limestone exhibits well-developed weathering patterns. Fresh rock is dark grey to bluish grey, whereas weathered surfaces become buff, yellowish brown, or pale grey due to oxidation and leaching. Differential weathering along bedding and joints often produces stepped topography and bench-like escarpments in quarry exposures. Solution cavities and incipient karstic features may locally develop along fracture-controlled zones, though mature karst topography is generally absent in the area. Petrographically, the limestone mainly consists of microcrystalline calcite with subordinate quartz, feldspar, clay minerals, and ferruginous matter. Fine laminations and peloidal textures are common. The presence of stromatolitic structures suggests microbial activity during deposition in shallow marine conditions. Geochemically, the limestone is characterized by high CaO content with comparatively low to moderate MgO and silica, making it suitable for cement-grade applications. However, localized argillaceous and siliceous bands may reduce chemical quality in some horizons.

7.5.2.2 Rampur Shale

The Nanhwara–Kymore area is underlain by sedimentary rocks of the Lower Vindhyan Supergroup belonging to the Semri Group. Among these lithounits, the Rampur Shale constitutes an important argillaceous horizon occurring below the Rohtasgarh Limestone and forms a significant marker bed within the regional stratigraphic succession. The formation is extensively exposed around Nanhwara, Kymore, Badwar, and adjoining areas where it occupies low-lying ground, gentle slopes, and intervening valleys beneath limestone ridges. Lithologically, the Rampur Shale is composed predominantly of greenish grey, bluish grey, dark grey to black shale, fissile shale, silty shale, and argillaceous horizons with occasional thin intercalations of limestone, calcareous shale, and siltstone. The shale is generally thinly laminated and highly fissile, breaking into platy fragments along bedding planes.

Carbonaceous matter is commonly present, imparting dark coloration to some horizons. In weathered exposures, the shale becomes soft, friable, yellowish brown, or buff colored due to oxidation and decomposition of clay minerals.

The formation exhibits fine lamination, parallel bedding, ripple marks, mud cracks, and occasional desiccation structures, indicating deposition under low-energy shallow marine to tidal flat conditions. The shale sequence reflects sedimentation in a relatively calm basin environment characterized by suspension settling of fine clastic material.

Structurally, the Rampur Shale in the Nanhwara–Kymore area follows the regional structural disposition of the Vindhyan basin. The beds generally strike ENE–WSW to E–W and dip gently towards the north or northwest at angles varying from 5° to 15°. Local changes in dip are observed near fracture zones and lineaments, where dips may steepen slightly. The shale horizons are generally less resistant and more susceptible to deformation compared to the overlying limestone units.

Jointing and fracturing are moderately developed within the formation. Two dominant joint sets are generally observed: one trending NW–SE to NNW–SSE and another trending ENE–WSW. The joints are mostly vertical to steeply dipping and are often closely spaced. Due to the fissile nature of the shale, joints commonly merge with bedding partings, producing slabby and splintery rock fragments. Minor shear zones and slickensided surfaces are occasionally observed in highly weathered zones. The joint planes frequently act as channels for groundwater seepage and weathering. The bedding planes are distinctly developed and often marked by carbonaceous films,

ferruginous coatings, and thin silty laminations. Soft-sediment deformation structures such as minor contortions and slump features are locally noticed, indicating syn-depositional instability within unconsolidated sediments. However, large-scale folding and metamorphism are absent, reflecting the tectonically stable nature of the Vindhyan Basin. Geomorphologically, the Rampur Shale forms low-relief topography and valley portions between resistant limestone ridges. Owing to its soft and easily weatherable character, the formation is generally covered by soil, colluvium, and weathered debris. Seasonal nala sections and quarry exposures provide the best exposures of the shale unit. The weathered shale contributes significantly to the development of clay-rich soil in the area. Petrographically, the shale is composed mainly of clay minerals, fine quartz, sericite, carbonaceous matter, and subordinate feldspar grains. Thin silty laminations and micaceous partings are common. The presence of pyrite specks and ferruginous patches in some horizons suggests reducing depositional conditions during sedimentation. Geochemically, the shale is characterized by higher silica, alumina, and iron content compared to the associated limestone horizons. The Rampur Shale thus represents an important argillaceous sedimentary unit of the Lower Vindhyan succession in the Nanhwara–Kymore area, recording quiet-water clastic sedimentation within a shallow marine epicontinental basin before the widespread carbonate deposition represented by the overlying Rohtasgarh Limestone.



Moderate Dipping nature of Limestone in the well cutting



A locally high-dipping limestone band, along with warping in the limestone.



Figure No. 7.2 Field Photographs of Nanhwara Kymore Limestone Block Tehsil Vijayragvgarh, District Katni, Madhya Pradesh

7.6.0 STRUCTURAL FEATURES OBSERVED IN THE BLOCK

7.6.1 STRUCTURE OF THE BLOCK

In the present exploration block, no major structure in the rocks was observed. All lithology belongs to the sedimentary type. The main structures in the study area are sedimentary, with the bedding planes, which show the natural layers of the rocks. Fractures are also present as secondary structures. Most of the area is covered by thick soil, which conceals much of the underlying rock formations, but where the rock is exposed, the bedding and fractures can be observed.

7.7.0 PETROGRAPHIC STUDIES

The petrological studies of the Limestone of the Rohtasgarh Formation from the Nanhwara Kymore Limestone Block, District Katni, State Madhya Pradesh, were carried out in the in-house laboratory in Jabalpur. This study aimed to identify various minerals present in the Limestone to understand their relationships and to ascertain how they have formed over time. The thin sections were prepared using a slide cutter and a polishing machine in-house. Thin sections of bedrock as well as borehole core samples were prepared to study the minerals present under different light conditions, including plane-polarized light (PPL) and crossed polarized light (XPL). The study was focused on 5 Limestone samples, each representing different types of Limestone present in the area. The examination was conducted using a Metzer-M microscope, equipped with a high-resolution Metzer-

M camera, which allowed for precise observation and documentation of the mineral textures and structures at up to 40 X POL magnification. The details of petrological samples (PS) are given in Table 7.3.

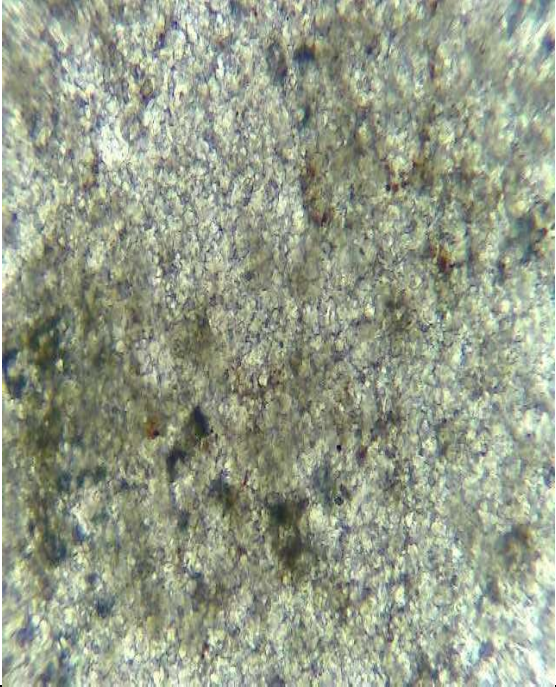
Following thin sections providing a detailed petrographic description of each thin section photomicrograph based on the observations made under various light conditions (PPL & XPL). A detailed petrographic report is provided in Annexure VII.

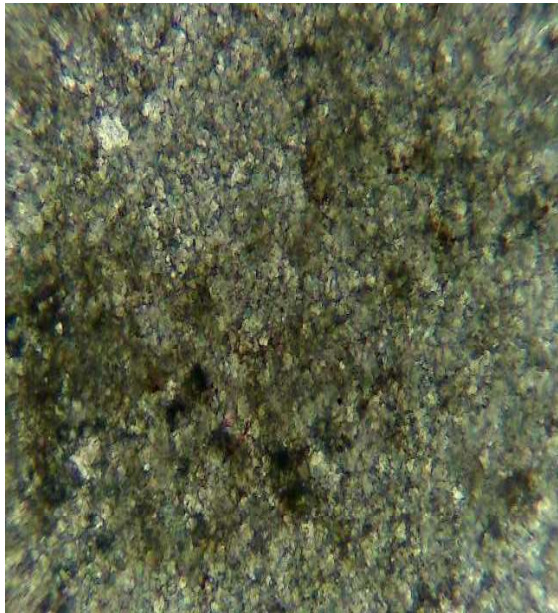
Table No. 7.3 List of petrological samples of the Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh.

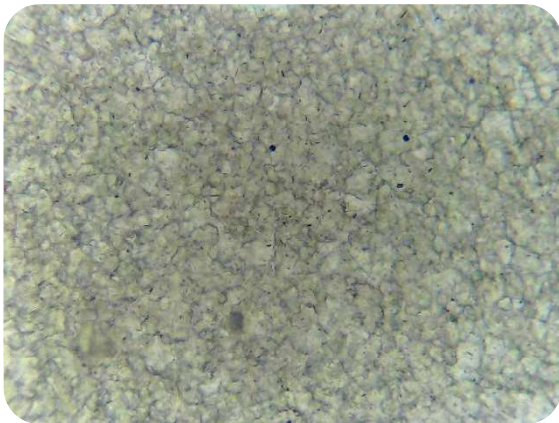
S. No	Sample No.	Location	Latitude	Longitude	Lithology
1	BRS- 39	Near Khalwara	24° 1' 53.24" N	80° 36' 58.12 " E	Limestone
2	BH-02 (13.0 -14.0m)	Nanhwara Kalan	24° 0' 44.10"N	80° 33' 23.80" E	Limestone
3	BH-04 (21.0 - 22.0m)	Kalahara	24° 0' 45.54"N	80° 34' 24.30"E	Limestone
4	BH-05 23.0 - 24.0m)	Kalahara	24° 01' 42.54"N	80°35'03.65"E	Limestone
5	BH-08 (9.0 -10.0m)	Deori Majhgawan	24° 01' 11.472"N	80° 36' 01.746"E	Limestone

S. No.	Photomicrograph	Petrographic Description
1		Sample No. BH-02 (Plane polarized light PPL) Petrographic Description: The rock is identified as Rohtasgarh Limestone of the Vindhyan Supergroup. Under Plane Polarized Light (PPL), it exhibits a fine-grained micritic to microsparitic texture composed predominantly of microcrystalline calcite with minor quartz and opaque minerals. The limestone shows a compact recrystallized carbonate fabric with a fine crystalline mosaic texture, reflecting diagenetic alteration of the original carbonate mud. Calcite-filled microfractures are locally present. The rock is dense and compact with very low primary porosity, while minor secondary porosity occurs locally along microfractures and veins. These characteristics indicate deposition in a shallow marine environment followed by recrystallization and cementation during diagenesis.

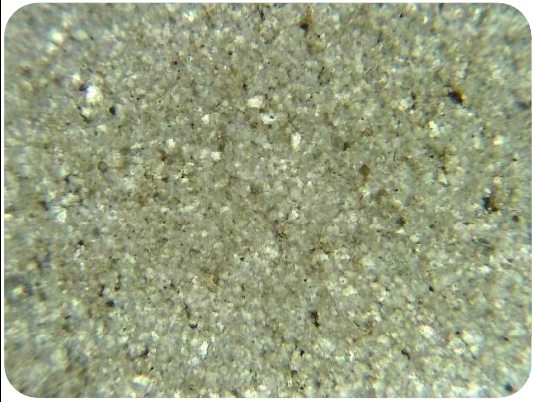
		Sample No. BH-02 (Under Cross Nicol XPL) Crossed Nicol (XPL) Description: The thin section reveals a carbonate-dominated limestone composed predominantly of calcite. Calcite occurs as both fine-grained micrite and coarser sparry calcite, displaying characteristic high-order interference colors. Minor dolomite is locally present and exhibits slightly lower birefringence than calcite. Scattered opaque minerals occur as small black patches. The rock is characterized by a predominantly micritic matrix with patches of sparry calcite cement and a recrystallized mosaic texture. Twinned calcite crystals and sparite-filled micro voids indicate diagenetic alteration and cementation. The rock is fine- to very fine-grained, consisting mainly of microcrystalline anhedral calcite. These features suggest deposition in a low-energy shallow marine environment followed by extensive diagenetic recrystallization and cementation, resulting in a compact rock with poor porosity.
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S. No.	Photomicrograph	Petrographic Description
2		Sample No. BH-04 (Plane polarized light) The rock is identified as Rohtasgarh Limestone of the Vindhyan Supergroup. Under PPL, it exhibits a fine-grained micritic texture characterized by a dense, homogeneous microcrystalline carbonate matrix composed predominantly of very fine calcite. The rock displays a compact, non-clastic, mud-supported fabric with scattered opaque impurities and minor dark patches. Recrystallization of the original carbonate mud is evident from the development of a fine crystalline mosaic texture, a characteristic feature of the Precambrian carbonates of the Semri Group. Locally, calcite-filled microfractures are present, reflecting diagenetic alteration. The limestone possesses very low primary porosity due to its dense micritic matrix and compact recrystallized nature, with only minor secondary porosity occurring along microfractures and calcite-filled veins. These petrographic features indicate deposition in a low-energy shallow marine environment followed by diagenetic recrystallization and cementation.

		Sample No. BH-04 (Under Cross Nicol XPL) Under crossed polarized light (XPL), the limestone is composed predominantly of calcite, occurring as fine-grained micrite and coarser sparry calcite, and displaying characteristic bright high-order interference colors. The carbonate matrix shows a fine crystalline mosaic of micrite and microspar, indicating partial recrystallization of the original carbonate mud during diagenesis. Sparry calcite occurs as cement and small veinlets, forming an interlocking mosaic texture. Minor dolomite is locally present, while trace opaque minerals (<1–2%), probably iron oxides, appear as black patches. Diagenetic features include calcite cementation, recrystallization to microspar, twinned calcite crystals, and occasional sparite-filled microfractures and pores. The compact micritic fabric and poor porosity indicate deposition in a low-energy shallow marine environment followed by diagenetic recrystallization and cementation.
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S. No.	Photomicrograph	Petrographic Description
3		Sample No. BH-05 (Plane polarized light) The rock is identified as Rohtasgarh Limestone of the Vindhyan Supergroup. Under PPL, it exhibits a fine crystalline micritic to microsparitic texture composed predominantly of very fine-grained calcite forming a dense, compact, and homogeneous carbonate matrix. Calcite crystals are closely packed and display an interlocking mosaic fabric, while patches of sparry calcite occur as cement within microvoids and fractures. The rock shows a grain-supported to partially matrix-supported fabric with minor micrite and locally intermixed shale material. Subtle compaction effects and possible pressure-solution features are indicated by irregular grain boundaries. The limestone is characterized by a cloudy appearance due to the micritic matrix and patchy distribution of sparry calcite, with little color variation typical of calcite under PPL. Primary porosity is very low, and secondary porosity is limited due to extensive calcite cementation and diagenetic compaction. These features indicate deposition in a low-energy shallow marine environment followed by mild diagenetic recrystallization, compaction, and cementation.

		Sample No. BH-05 (Under Cross Nicol XPL) Under crossed Nicols (XPL), the thin section shows a carbonate-dominated limestone composed predominantly of calcite occurring as fine-grained micrite and coarser sparry calcite, displaying characteristic bright high-order interference colors. Minor dolomite is locally present and exhibits slightly lower birefringence than calcite, while scattered opaque minerals, probably iron oxides, occur as black patches. The rock is characterized by a predominantly micritic to microsparitic matrix with patches of sparry calcite cement. Diagenetic features include calcite cementation, recrystallization into a fine crystalline mosaic texture, twinned calcite crystals, and occasional sparite-filled pores and microfractures. The petrographic characteristics indicate deposition in a low-energy shallow marine carbonate environment, followed by diagenetic recrystallization of the original carbonate mud, resulting in a compact, low-porosity limestone typical of the Rohtasgarh Limestone Formation (Semri Group) exposed in the Nanhwara–Vijayraghavgarh area of Katni District, Madhya Pradesh.
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S. No.	Photomicrograph	Petrographic Description
4		Sample No. BH-08 (Plane polarized light) The rock is identified as Rohtasgarh Limestone of the Vindhyan Supergroup. Under PPL, it exhibits a fine-grained micritic to microsparitic texture composed predominantly of very fine-grained calcite forming a dense, compact, and homogeneous carbonate matrix. Calcite crystals are closely packed and display an interlocking mosaic fabric, reflecting diagenetic stabilization and partial recrystallization of the original carbonate mud. The rock is predominantly micritic, with occasional slightly coarser recrystallized patches and patchy occurrences of sparry calcite. Subtle compaction effects and possible pressure-solution features are indicated by irregular grain boundaries. The limestone shows a cloudy appearance typical of micritic carbonate and little color variation under PPL. Primary porosity is very low, while minor secondary porosity is locally developed but largely reduced by calcite cementation and compaction. These petrographic features indicate deposition in a low-energy shallow marine environment followed by mild diagenetic recrystallization, compaction, and cementation, characteristic of the Precambrian carbonates of the Semri Group, Vindhyan Basin.

		Sample No. BH-08 (Under Cross Nicol XPL) Under crossed Nicols (XPL), the thin section shows a carbonate-dominated limestone composed predominantly of calcite occurring as fine-grained micrite and coarser sparry calcite. Calcite exhibits characteristic bright high-order interference colors, while minor dolomite, where present, shows slightly lower birefringence. Trace opaque minerals, probably iron oxides, occur as scattered black patches, and minor quartz grains display low-order grey interference colors. The rock exhibits a micritic to microsparitic texture with localized recrystallized patches of sparry calcite, producing a fine crystalline mosaic fabric. The texture is generally homogeneous, massive, and non-oriented, with no preferred grain alignment. Micrite appears relatively dull under XPL, whereas sparry calcite shows brighter interference colors and locally faint calcite twinning. Diagenetic features include calcite cementation, recrystallization, development of a mosaic texture, and occasional sparite-filled pores and microfractures. These petrographic characteristics indicate deposition in a low-energy shallow marine carbonate environment followed by diagenetic recrystallization of the original carbonate mud, resulting in a compact, low-porosity limestone typical of the Rohtasgarh Limestone Formation (Semri Group) exposed in the Nanhwara–Vijayraghavgarh area of Katni District, Madhya Pradesh.
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S. No.	Photomicrograph	Petrographic Description
5		Bed Rock Sample -39 (Plane polarized light PPL) The thin section represents a micritic limestone of the Rohtasgarh Formation (Vindhyan Supergroup). Under Plane Polarized Light (PPL), the rock is composed predominantly of colorless microcrystalline calcite (90–94%), forming a dense and homogeneous micritic matrix. Calcite appears colorless, transparent, and exhibits low relief. Minor argillaceous material occurs as dark brown to grey streaks and patches, locally concentrated along pressure-solution seams, while trace quartz is present as fine, colorless anhedral grains dispersed within the carbonate matrix. Sparse opaque minerals occur as minute black disseminations. The rock exhibits a micritic texture with occasional patches of microspar resulting from localized recrystallization. The fabric is generally massive and homogeneous, although minor heterogeneity is observed due to diagenetic alteration. Thin calcite-filled fractures and veins, locally showing iron staining, are present, and no fossil fragments are observed. Micritization is the dominant textural feature, with partial recrystallization to microspar in places. The limestone possesses very low to negligible primary porosity, largely obliterated by compaction and calcite cementation. These petrographic characteristics indicate deposition in a low-energy

		shallow marine environment, followed by diagenetic recrystallization and fracture-filling cementation.
		Bed Rock Sample -39 (Under Cross Nicol XPL) The limestone is composed predominantly of calcite occurring as a fine-grained micritic to microsparitic mosaic. Calcite displays characteristic low- to high-order interference colors, while localized recrystallization has produced patches of sparry calcite with an interlocking mosaic texture. Minor quartz grains show low-order grey interference colors, and scattered opaque minerals occur as black patches. The rock exhibits a homogeneous, non-oriented carbonate fabric with evidence of calcite cementation, recrystallization, and occasional sparite-filled microfractures. These features indicate a low-energy shallow marine depositional environment followed by diagenetic recrystallization and cementation, resulting in a compact, low-porosity limestone typical of the Rohtasgarh Limestone Formation (Semri Group).

Figure No. 7.3 Microphotographs & Petrographic Descriptions of Thin Sections.

7.8.0 MINERALISATION IN THE BLOCK

Massive limestone is dark grey to light grey in colour, micritic, fine-grained and compact. The intersection of soil cover, Cement Grade limestone, and blendable-grade limestone with Blendable /Beneficiable is tabulated below.

Table No. 7.4 Mineralisation in the Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh.

BH. No	Band No	Depth (m)		Thickness (m)	Grade
		From (m)	To (m)		
BH-1	1	4	9	5	Blendable
	2	10	12	2	Blendable
BH-2	1	4	6	2	Cement
	2	7	9	2	Cement
	3	10	18	8	Cement
BH-4	1	1	3	2	Cement
	2	4	9	5	Cement
	3	10	12	2	Cement
	4	13	15	2	Cement
	5	16	18	2	Cement
	6	19	21	2	Blendable /Beneficiable
	7	23	26	3	Blendable
	8	26	30	4	Blendable /Beneficiable
BH-5	1	1	3	2	Cement
	2	4	5	1	Cement
	3	6	12	6	Cement

	4	13	15	2	Cement
	5	16	17	1	Cement
	6	17	21	4	Blendable
	7	21	25	4	Blendable
	8	27	30	3	Blendable
	9	31	33	2	Blendable /Beneficial
	10	35	40	5	Blendable /Beneficial
BH-8	1	6	9.5	3.5	Blendable /Beneficial
BH-9	1	3	10	7	Blendable /Beneficial

CHAPTER – 8

8.0.0 PREVIOUS WORK

8.1.0 DETAILS OF PREVIOUS EXPLORATION CARRIED OUT BY OTHER AGENCIES/PARTIES

The Nanhwara–Kymore Limestone area of Katni District forms part of the Vindhyan Basin, which has been the subject of extensive geological investigations since the 19th Century. The earliest systematic studies were carried out by H. B. Medlicott and W. T. Blanford (1879), who established the fundamental stratigraphic framework of the Vindhyan Supergroup. Their work was later refined by E. H. Pascoe (1964) and M. S. Krishnan (1982), who provided comprehensive accounts of the geology of India, including lithostratigraphy, structure, and mineral resources of the Vindhyan Basin.

Subsequent detailed geological mapping and mineral investigations were undertaken by the Geological Survey of India (GSI), particularly during the 1980s. These studies established the regional geological setting of the Katni–Kymore belt, delineating limestone-bearing formations belonging to the Kymore and Semri Groups of the Vindhyan Supergroup. GSI's work confirmed the lateral persistence, thickness variation, and economic potential of limestone horizons, forming the basis for further exploration and mineral development.

The Directorate of Geology and Mining (DGM) has carried out preliminary investigations and resource assessments in the district, identifying multiple limestone-bearing blocks and facilitating the grant of mining leases. These studies indicate the presence of cement-grade and flux-grade limestone with variable thickness, reinforcing the economic viability of the region.

In recent years, exploration activities have been strengthened under the aegis of the National Mineral Exploration Trust (NMDET), which funds systematic mineral exploration across the country. A G4 stage exploration proposal for limestone in the Nanhwara–Kymore area was formulated based on earlier inputs from GSI and DGM. The Technical Committee of NMDET recommended reconnaissance investigations, including geological mapping and limited drilling, to assess subsurface continuity and grade variation of limestone deposits.

Exploration agencies such as Mineral Exploration and Consultancy Limited (MECL) have undertaken detailed exploration (G3–G2 stages) in similar limestone-bearing regions of the Vindhyan Basin, demonstrating the applicability of systematic drilling, geochemical analysis, and resource estimation techniques. These studies serve as important analogues for the Nanhwara–Kymore area.

CHAPTER – 9

9.0.0 GEO PHYSICAL EXPLORATION

A geophysical survey was not carried out by ENGEOTECH CONSULTANT, and it was also not proposed to the NMEDT for approval.

CHAPTER – 10

10.0.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 OBJECTIVES OF INVESTIGATION

The exploration of Limestone deposits in the Nanhwara- Kymore Limestone Block area, District Katni (M.P) has been undertaken with the following objectives:

The objective of the present proposal is-

1. To carry out a topographical survey and Geological mapping on a 1:12,500 Scale for the demarcation of the limestone band for mineralization with the structural features to identify the surface manifestations and lateral disposition of the mineralized zones.
2. Demarcation of various types of Limestone bands in the area, along with detailed lithology to identify the occurrence of Limestone within it.
3. To collect Geochemical samples (bedrock, old pits, cuttings, etc.) and analyze them for Limestone to pave the way for the further course of the exploration program.
4. To know the depth-wise and lateral continuity of the mineralization.
5. Attempt to delineate a block or more than one block to upgrade investigations in the G3 Stage.

10.2.0 EXPLORATION ACTIVITIES TAKEN UP

After the receipt of approval vide letter no F. No. 23/563/2025-NMET/843, dated 10-02-2025, with an estimated cost of Rs 70.14/- lakhs from the National Mineral Exploration and Development Trust (NMEDT). Mineral Exploration & Consultancy Ltd., ENGEOTECH Consultant, Jabalpur, has undertaken exploration activities in the designated areas. Later on, the revised NQT and cost were revised by NMEDT by Vide Letter No. F.N 23/563//2025-NMET/375 dated 12-09-2025 with an estimated cost of Rs. 103.58/-. Further, NMEDT reduces the NQT and cost of the project by vide letter no. F. No.23/563/2025-NMET/818 dated 10-02-2026 with an estimated cost of Rs. 98.40/-. The details regarding the nature, scope, and quantum of works completed are presented in **Table No.10.1, 10.2 & 10.3** shown below for Nanhwara Kymore Limestone Block.

Table No. 10.1: Nature and Quantum of work as per Office Memorandum F. No. 23/563/2025-NMET/843, dated 10-02-2025

S. No.	Component / Nature and Quantum Target	Quantity	Target	Achievement
1	Geological Mapping (1:12,500) & other Geological Work	22.52 Sq. Km	22.52 Sq. Km	22.52 Sq. Km
S. No.	Component / Nature and Quantum Target	Quantity	Target	Achievement
2	Survey Work			
i	DGPS Survey for Boundary Pillar & BH demarcation	BP-13 & BH-03	BP-13 & BH-03	-
3	Drilling	110m	110m	Initially, 3 Drilling was proposed in 3 BH in a triangular pattern up to a depth of 30m. Later on, considering the huge nature of great depth, Engeotech Consultant, Jabalpur, requested the Executive Committee of NMET to increase no of boreholes. Later on, they increased the number of boreholes to 9 Nos. and Vide letter no F.N06/22015-NMET/319 Dated 22-08-2025
4	Laboratory Studies			
i	Chemical Analysis	Drilling samples 110 Nos. BRS 40 Nos.	Drilling samples 110 Nos BRS 40 Nos.	-
ii	Bulk Density	05 Nos.	05 Nos.	-
iii	Petrological Studies	05 Nos.	05 Nos.	-

Table No. 10.2 Nature & Quantum of work (Revised OM No. F.N 23/563//2025-NMET/375 dated 12-09-2025)

S. No.	Component / NQT	Quantity	Target	Achievement
1	Geological Mapping (1:12,500) & other Geological Work	22.52 Sq. Km	22.52 Sq. Km	22.52 Sq. Km
2	Survey Work			
i	DGPS Survey for Boundary Pillar & BH demarcation	BP-13 & BH-09	BP-13 & BH-09	BP-13 & BH-8
3	Drilling	290 m	290m	-
4	Lab. Work			
i	Chemical Analysis	Drilling 200 BRS 40	Drilling 200 BRS 40	-
ii	Bulk Density	05	05	05
iii	Petrological Studies	05	05	05

Table NO. 10.3 Nature & Quantum of work (Revised OM F. No.23/563/2025-NMET/818 dated 10-02-2026)

S. No	Component / NQT	Quantity	Target	Achievement
1	Geological Mapping (1:12,500) & other Geological Work	22.52 Sq. Km	22.52 Sq. Km	22.52 Sq. Km
2	Survey Work			
i	DGPS Survey for Boundary Pillar & BH demarcation	BP-13 & BH-08	BP-13 & BH-08	BP-13 & BH-08
3	Drilling	260 m	260m	260m
4	Lab Work			
i	Chemical Analysis	Drilling core sample 185 Nos. BRS 40 nos.	Drilling core sample 185 Nos. BRS 40 nos.	Drilling core sample 185 Nos. BRS 40 nos.
ii	External Check Sample 10%	23 nos.	23 nos.	23 nos.
iii	Bulk Density	05 nos.	05 nos.	05 nos.
iii	Petrological Studies	05 nos.	05 nos.	05 nos.

10.2.1 Topographical Survey

The block boundaries of Nanhwara Kymore Block are surveyed with the help of DGPS (LEICA make) and topographical survey by total station in WGS-84 datum. A triangulation network has been laid in the explored area (as per proposed boundary coordinates) of 22.52 sq.km. for Nanhwara Block. Surface Contouring done at 2m contour intervals along with a survey of surface features for Nanhwara Kymore Block (Scale 1:12,500). During the current exploration, boreholes are fixed on the ground. RL's and coordinates of survey and exploration points are determined by DGPS survey. The RL and coordinates of the corner points and boreholes have been determined. Refer Table No. 10.4 & Table No.10.5

Table No. 10.4: DGPS Coordinates for the block boundary of the Nanhwara -Kymore Limestone Block

Nanhwara Kymore Limestone Block Limestone Block G-4				
BP-No.	Easting	Northing	LATITUDE	LONGITUDE
BP-1	453422.975	2652840.814	23° 59' 12.4812" N	80° 32' 31.6152" E
BP-2	462074.868	2656928.634	24° 01' 26.2279" N	80° 37' 37.4214" E
BP-3	460437.211	2658968.473	24° 02' 32.4098" N	80° 36' 39.2484" E
BP-4	459869.427	2658947.536	24° 02' 31.6776" N	80° 36' 19.1480" E
BP-5	458707.513	2659582.059	24° 02' 52.2017" N	80° 35' 37.9455" E
BP-6	457811.108	2657935.285	24° 01' 58.5714" N	80° 35' 06.3789" E
BP-7	457514.234	2657954.617	24° 01' 59.1714" N	80° 34' 55.8668" E
BP-8	457511.799	2657514.065	24° 01' 44.8465" N	80° 34' 55.8269" E
BP-9	457300.551	2657524.833	24° 01' 45.1762" N	80° 34' 48.3473" E
BP-10	457327.711	2657056.864	24° 01' 29.9627" N	80° 34' 49.3582" E
BP-11	456696.855	2656990.2	24° 01' 27.7335" N	80° 34' 27.0329" E
BP-12	454371.145	2655697.442	24° 00' 45.4643" N	80° 33' 04.8486" E
BP-13	454044.486	2655188.876	24° 00' 28.8942" N	80° 32' 53.3437" E
BP-14	452918.455	2654683.964	24° 00' 12.3580" N	80° 32' 13.5461" E

Table No. 10.5 Details of Drilled Boreholes in Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh.

S. No	BH-No	Latitude	Longitude	Surface RL(m)	Bottom RL (M)	Depth of BH	Date of Commencement	Date of closing
1	BH-1	23°59'51.798"N	80°32'44.814"E	387	357	30	27-11-2025	02-12-2025
2	BH-2	24°0'44.10"N	80°33'23.808"E	387	357	30	17-11-2025	25-11-2025
3	BH-4	24°00'45.54"N	80°34'24.30"E	370	340	30	04-12-2025	11-12-2025
4	BH-5	24°01'42.54"N	80°35'03.654"E	386	336	50	12-12-2025	21-12-2025

5	BH-6	24°00'52.854"N	80°35'25.95"E	371	341	30	24-12-2025	29-12-2025
6	BH-7	24°02'21.66"N	80°35'53.682"E	392	362	30	06-01-2026	11-01-2026
7	BH-8	24°01'11.472"N	80°36'01.746"E	370	340	30	31-12-2025	04-01-2026
8	BH-9	24°02'00.624"N	80°36'45.792"E	383	353	30	13-01-2026	19-01-2026

10.2.2 Geological Mapping

The large-scale mapping was carried out in the Nanhwara- Kymore Limestone Block in part of Toposheet No. 63D/12 & 64 A/09, covering an area of 22.52 square kilometers on a scale of 1:12,500 in order to demarcate Limestone of Rohtasgarh Formation exposures in the study area. The majority of the area is covered by black soil at the top and grey clay at the bottom, primarily used for cultivation purposes. During the mapping, prominent litho-units, namely Limestone and Shale, belonging to the Semri group of the Vindhyan Supergroup, were observed and precisely mapped.

10.2.3 Exploratory Drilling

Drilling constitutes a fundamental component of mineral exploration, serving to delineate the subsurface configuration of mineralized bodies and to facilitate the development of three-dimensional models of mineralization. In the present investigation, a cumulative 260 meters of drilling was done utilizing an in-house drilling rig, deploying one drill rig only. The drilling operations began on 27-11-2025 and were completed on 19-01-2026. A total of 8 vertical boreholes, designated as BH-1, BH-2, BH-4, BH-5, BH-6, BH-7, BH-8, & BH-8 were drilled. Each borehole depth was 30 meters below ground level except BH-5 (50m), resulting in the recovery of 237 core samples. These samples are undergoing chemical analysis, the results of which will be employed to evaluate mineral content, grade, and the potential economic viability of the deposit.

10.3.0. DETAILS OF SURFACE SAMPLING, DRILLING, ETC.

10.3.1 Bed Rock Samples

A total of 40 Nos. Bedrock samples (BRS) were randomly collected from various Limestone exposures / old mining pits. From each location, several chips weighing over 5 kg were gathered to ensure representativeness. Limestone chips having a size of 5-10mm were prepared in the field itself. After that, coning and quartering a sample of about 1 Kg was collected in cloth bags, and with proper numbering, was done on the bags. At HQ, collected chips were ground to a 200-mesh size fraction, thoroughly homogenized, and reduced to about 500 gm by the Coning and Quartering

method. Out of this, approximately 250 gm sample was sent to the Chemical Laboratory for chemical analysis (BSS Lab.), while the remaining portion was retained as a duplicate/ Counter sample.

Chemical analysis of 40 Nos. BRS samples of Limestone showing mineral content CaO (32.96 % to 53.18 %), Fe₂O₃ (0.560% to 3.64%), SiO₂ (3.54% to 24.86%), MgO (0.800% to 11.16%), Al₂O₃ (0.81% to 5.03%), Na₂O (0.11% to 0.23 %), K₂O (0.13 % to 1.60 %), MnO₂ (0.022% to 0.668%), SiO₂ (0.094 to 0.258%), TiO₂ (0.029% to 0.227%), P₂O₅ (0.024% to 0.114%) and Cl (0.072%. to 0.960%)

The Pearson Correlation Coefficient (r) is a fundamental statistical metric in geological reporting used to quantify the strength and direction of linear relationships between two continuous variables, such as the concentration of associated elements or the link between rock porosity and depth. Calculated as the covariance of two variables divided by the product of their standard deviations, r ranges from -1.0 (perfect inverse relationship) to +1.0 (perfect direct relationship), providing a standardized value that is essential for identifying pathfinder elements, estimating ore reserves, and validating lithological models. It is a powerful tool for streamlining large datasets and identifying key geochemical drivers. The correlation matrix heatmap of the 40 bedrock samples is shown in Figure No.10.1.

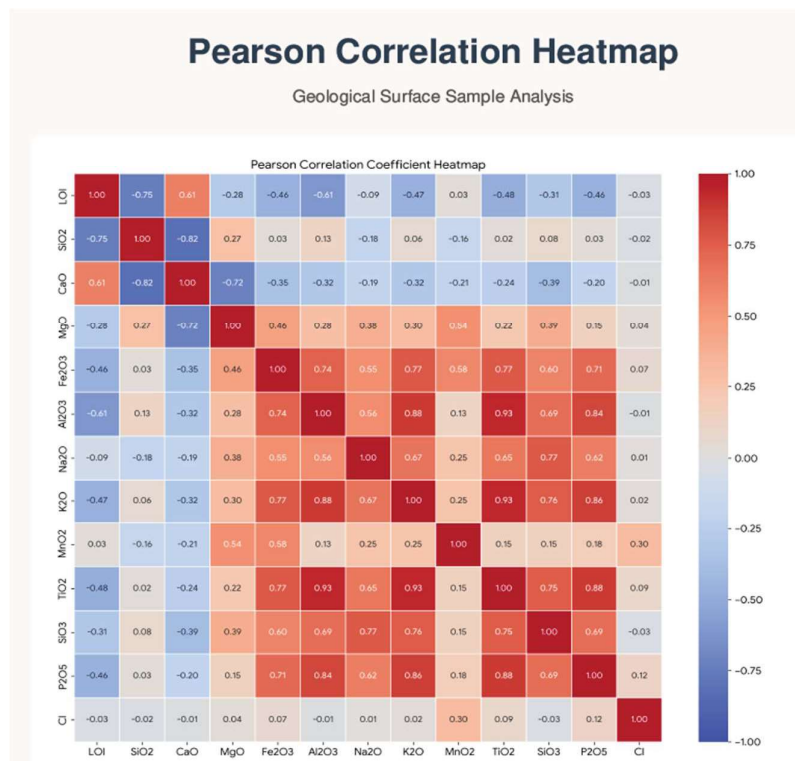


Figure No. 10.1 Correlation matrix heatmap of the 40 bedrock samples.

Table No. 10.6 Details of 27 BRS samples of the Nanhwara -Kymore Limestone Block, Katni District, Madhya Pradesh

S. No	Sample No	Latitude	Longitude	Lithology
1	Sample-01	23° 59' 17.05" N	80° 32' 38.34 " E	Limestone
2	Sample-02	24° 0' 7.54" N	80° 32' 22.43 " E	Limestone
3	Sample-03	24° 0' 2.63" N	80° 32' 29.18 " E	Limestone
4	Sample-04	23° 59' 51.54" N	80° 32' 48.83 " E	Limestone
5	Sample-05	23° 59' 31.02" N	80° 33' 1.42 " E	Limestone
6	Sample-06	24° 0' 4.98" N	80° 32' 59.26 " E	Limestone
7	Sample-07	23° 59' 35.80" N	80° 33' 19.32 " E	Limestone
8	Sample-08	23° 59' 42.36" N	80° 33' 34.59 " E	Limestone
9	Sample-09	24° 0' 20.19" N	80° 33' 46.89 " E	Limestone
10	Sample-10	23° 59' 55.45" N	80° 34' 0.00 " E	Limestone
11	Sample-11	24° 0' 2.445" N	80° 34' 4.31 " E	Limestone
12	Sample-12	24° 0' 53.19" N	80° 34' 2.19 " E	Limestone
13	Sample-13	24° 0' 29.90" N	80° 34' 20.60 " E	Limestone
14	Sample-14	24° 0' 22.016" N	80° 34' 22.71 " E	Limestone
15	Sample-15	24° 0' 17.98" N	80° 34' 49.93 " E	Limestone
16	Sample-16	24° 0' 29.01" N	80° 34' 39.71 " E	Limestone
17	Sample-17	24° 0' 25.41" N	80° 34' 47.63 " E	Limestone
18	Sample-18	24° 0' 53.72" N	80° 35' 0.68 " E	Limestone
19	Sample-19	24° 0' 27.81" N	80° 34' 58.43 " E	Limestone
20	Sample-20	24° 0' 56.70" N	80° 35' 13.66 " E	Limestone
21	Sample-21	24° 0' 46.54" N	80° 35' 9.18 " E	Limestone
22	Sample-22	24° 0' 2.50" N	80° 35' 30.48 " E	Limestone
23	Sample-23	24° 0' 21.42" N	80° 35' 28.51 " E	Limestone
24	Sample-24	24° 0' 25.14" N	80° 35' 32.04 " E	Limestone
25	Sample-25	24° 0' 40.65" N	80° 35' 48.55 " E	Limestone
26	Sample-26	24° 0' 47.93" N	80° 35' 35.35 " E	Limestone
27	Sample-27	24° 0' 14.47" N	80° 35' 45.95 " E	Limestone
28	Sample-28	24° 0' 3.44" N	80° 35' 41.50 " E	Limestone
29	Sample-29	24° 0' 33.69" N	80° 35' 55.97 " E	Limestone
30	Sample-30	24° 0' 31.93" N	80° 35' 47.18 " E	Limestone
31	Sample-31	24° 0' 24.04" N	80° 36' 3.96 " E	Limestone
32	Sample-32	24° 0' 33.80" N	80° 36' 20.65 " E	Limestone
33	Sample-33	24° 0' 13.46" N	80° 36' 12.65 " E	Limestone
34	Sample-34	24° 0' 30.69" N	80° 36' 16.59 " E	Limestone
35	Sample-35	24° 0' 28.87" N	80° 36' 38.42 " E	Limestone
36	Sample-36	24° 0' 26.25" N	80° 36' 26.99 " E	Limestone
37	Sample-37	24° 0' 42.76" N	80° 36' 44.55 " E	Limestone
38	Sample-38	24° 0' 31.31" N	80° 36' 39.17 " E	Limestone
39	Sample-39	24° 0' 53.24" N	80° 36' 58.12 " E	Limestone
40	Sample-40	24° 0' 39.78" N	80° 37' 8.31 " E	Limestone

Statistical Evaluation of Geochemical Data of BRS Samples

To ascertain the geochemical associations, paragenetic relationships, and nature of impurities within

the limestone horizons of the Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh, a bivariate statistical analysis was carried out. Pearson's correlation coefficients (r) were computed for the major and minor elemental oxides analyzed from the surface bedrock samples. The correlation matrix reveals distinct primary carbonate precipitation trends and secondary terrigenous/argillaceous influx signatures.

Carbonate-Silica Antagonism (Calcareous vs. Siliceous Facies)

The geochemical data exhibit a highly significant negative correlation between Calcium Oxide (CaO) and Silica (SiO₂) ($r=-0.82$).

This strong inverse relationship reflects the fundamental lithological variation within the deposit, indicating a binary system where pure carbonate precipitation is periodically diluted by siliceous impurities (detrital quartz or diagenetic chert). Furthermore, Loss on Ignition (LOI) demonstrates a strong negative correlation with SiO₂ ($r=-0.75$) and a positive correlation with CaO ($r=0.61$). This confirms that the LOI is primarily associated with the volatilization of carbon dioxide (CO₂) from the calcium carbonate fraction, and its value systematically decreases as the non-carbonate siliceous fraction increases.

Calcite-Dolomite Dynamics

A pronounced negative correlation is observed between CaO and Magnesia (MgO) ($r=-0.72$). In the context of the Vindhyan carbonate sequences, this inverse relationship signifies varying degrees of dolomitization or the existence of discrete dolomitic limestone interbands. As the magnesium content increases via the substitution of calcium in the carbonate lattice, the overall calcium tenor proportionally decreases. The moderate positive correlations of MgO with Fe₂O₃ ($r=0.46$) and MnO₂ ($r=0.54$) suggest that minor amounts of iron and manganese may be accommodated within the dolomitic structure or associated with ferroan-dolomite phases.

Signature of Terrigenous and Argillaceous Influx

The correlation matrix identifies a distinct, highly cohesive suite of elements comprising Al₂O₃, K₂O, TiO₂, and Fe₂O₃. Exceptionally strong positive correlations are recorded between Al₂O₃ and TiO₂ ($r=0.93$), K₂O and TiO₂ ($r=0.93$), and Al₂O₃ and K₂O ($r=0.88$). This strong covariance is the classic geochemical signature of aluminosilicates, specifically indicating the presence of clay minerals (such as Illite, given the strong K₂O association) and associated heavy minerals (rutile/ilmenite, contributing to TiO₂). This group represents the argillaceous/terrigenous detrital material deposited contemporaneously with the carbonates.

Phosphorus Pentoxide (P_2O_5) shows strong positive correlations with this argillaceous suite (TiO_2 : $r=0.88$; K_2O : $r=0.86$; Al_2O_3 : $r=0.84$). This indicates that the minor phosphatic phases in the deposit are genetically linked to the terrigenous clastic input rather than being primary biogenic precipitates within the clean carbonate facies.

In summary, the correlation matrix validates that the limestone of the Nanhwara Kymore Limestone Block is governed by three primary controls:

1. The dominant calcium carbonate phase (represented by CaO and LOI).
2. The siliceous/cherty impurities (represented by SiO_2 and its strong antagonism with CaO).
3. A distinct argillaceous/detrital component (Al_2O_3 - K_2O - TiO_2 - Fe_2O_3 - P_2O_5), which dictates the non-silica impurity profile of the ore body.

Table No. 10.7 Statistical Analysis of Bed Rock samples of exploration Nahnawara Kymore Limestone Block, Katni District (M.P)

	LOI	SiO ₂	CaO	MgO	Fe ₂ O ₃	Al ₂ O ₃	Na ₂ O	K ₂ O	MnO ₂	TiO ₂	SiO ₃	P ₂ O ₅	Cl
Mean	32.76	13.26	45.39	2.57	1.56	2.23	0.15	0.53	0.12	0.09	0.14	0.04	0.12
Standard Error	0.46	0.89	0.81	0.35	0.10	0.17	0.00	0.06	0.02	0.01	0.01	0.00	0.02
Median	32.79	11.99	46.69	1.81	1.54	1.97	0.14	0.46	0.08	0.08	0.13	0.05	0.10
Mode	#N/A	#N/A	#N/A	1.00	1.92	1.54	0.13	0.79	0.17	0.10	0.16	0.00	0.10
Standard Deviation	2.93	5.65	5.14	2.19	0.64	1.09	0.03	0.38	0.11	0.04	0.04	0.03	0.14
Sample Variance	8.57	31.88	26.42	4.78	0.40	1.20	0.00	0.14	0.01	0.00	0.00	0.00	0.02
Kurtosis	-0.91	-0.90	0.09	5.35	2.09	0.32	0.31	1.38	15.95	1.30	1.55	-0.41	38.64
Skewness	0.01	0.43	-0.87	2.19	1.10	0.94	0.83	1.29	3.44	1.18	1.33	0.10	6.17
Range	12.07	21.32	20.22	10.36	3.08	4.22	0.12	1.47	0.65	0.20	0.16	0.11	0.89
Minimum	26.52	3.54	32.96	0.80	0.56	0.81	0.11	0.13	0.02	0.03	0.09	0.00	0.07
Maximum	38.59	24.86	53.18	11.16	3.64	5.03	0.23	1.60	0.67	0.23	0.26	0.11	0.96
Sum	1310.31	530.23	1815.79	102.84	62.36	89.05	6.01	21.32	4.77	3.57	5.57	1.72	4.88
Count	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00

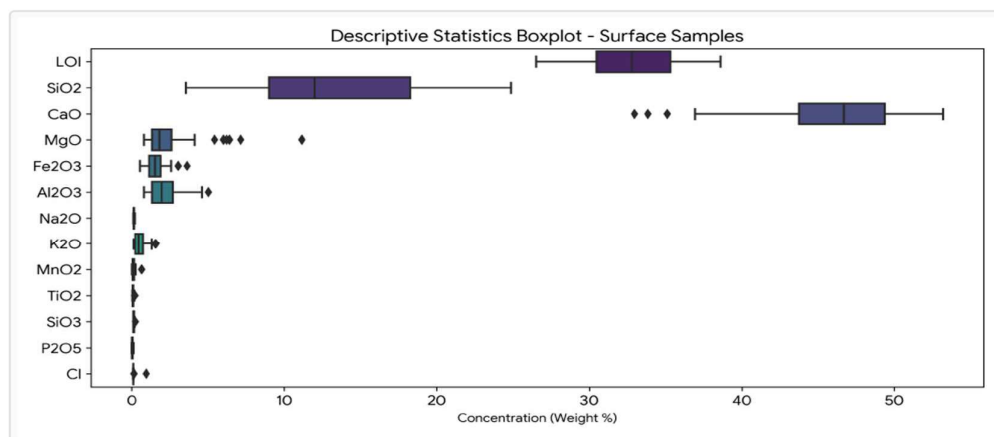


Figure No. 10.2 Descriptive Statistics Box Plots of BRS Samples

Statistical Interpretation of Bivariate Scatter Plots of BRS Samples

The scatter plots utilize linear regression ($y=mx+c$) to model the geochemical behavior of the bedrock samples. The Coefficient of Determination (R^2) is used to evaluate how well the variance in one element is explained by the variance in another, providing quantitative evidence for the mineralogical substitutions within the deposit.

1. Carbonate-Silica Antagonism (SiO₂ vs. CaO)

Model: $y=-0.745x+55.270$ ($R^2=0.670$)

Interpretation: This plot demonstrates a strong negative linear relationship between silica and calcium oxide. The R^2 value of 0.670 indicates that 67% of the variance in the CaO grade is directly caused by the fluctuating influx of SiO₂. The slope (-0.745) reveals the specific rate of dilution: for every 1% increase in siliceous impurities (detrital quartz or diagenetic chert), the overall calcium oxide grade is suppressed by approximately 0.75%. This confirms that silica is the primary diluent of the pure calcareous facies in this block.

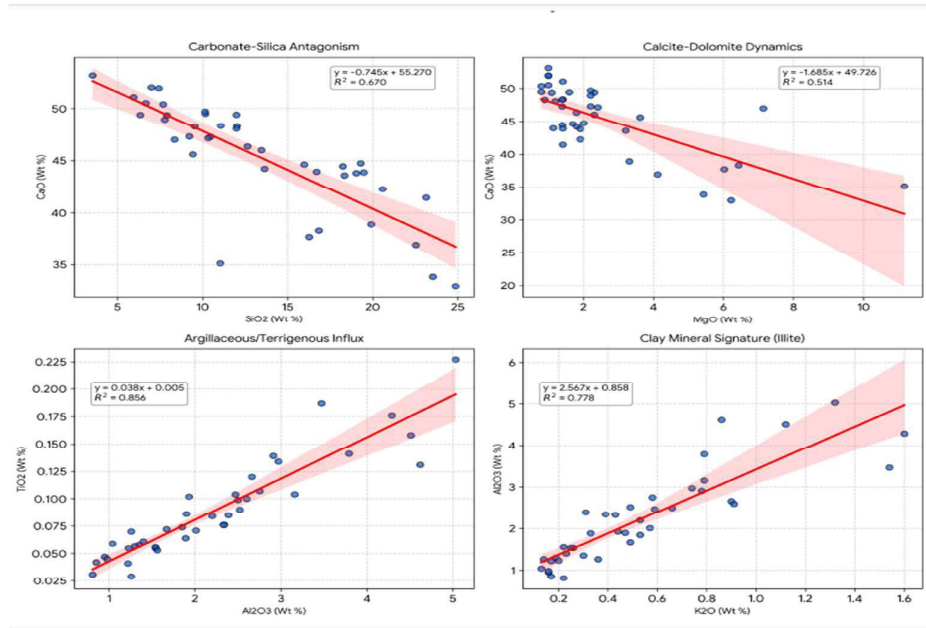


Figure No. 10.3 Bivariate Scatter Plots of BRS Samples

2. Calcite-Dolomite Dynamics (MgO vs. CaO)

Model: $y = -1.685x + 49.726$ ($R^2 = 0.514$)

Interpretation: This inverse relationship statistically captures the process of dolomitization within the sequence. The negative slope (-1.685) is steep, indicating a sharp decrease in calcium as magnesium increases. This points toward the stoichiometric replacement of calcium by magnesium in the carbonate crystal lattice (forming dolomite or magnesian limestone). The moderate R^2 value (0.514) suggests that while dolomitization is a major factor reducing the CaO grade, it is not the only factor, as silica dilution is operating concurrently.

3. Argillaceous/Terrigenous Influx (Al_2O_3 vs. TiO_2)

Model: $y = 0.038x + 0.005$ ($R^2 = 0.856$)

Interpretation: This plot shows an exceptionally tight positive correlation. An R^2 of 0.856 signifies that aluminum and titanium concentrations are moving almost entirely in tandem. Geologically, this proves that the titanium is not occurring as isolated mineral grains, but is firmly housed within the same terrigenous clay fractions or heavy mineral suites (such as rutile or ilmenite) that are transporting the aluminum into the depositional basin.

4. Clay Mineral Signature (K_2O vs. Al_2O_3)

Model: $y=2.567x+0.858$ ($R^2=0.778$)

Interpretation: This strong positive relationship is highly diagnostic of the specific type of clay impurities present in the limestone. The predictable covariance of potassium and aluminum (77.8% of variance explained) is a classic geochemical signature for micaceous minerals or Illite. It indicates that the argillaceous bands or partings within the limestone sequence are primarily Illitic in composition, rather than being dominated by potassium-poor clays like kaolinite. The regression models quantitatively validate that the limestone grade in this block is controlled by a primary calcite phase that is subjected to two distinct downgrading mechanisms: Chemical Substitution, and Localized dolomitization (indicated by the MgO-CaO inverse dynamic). Mechanical Dilution: Influx of both free silica (quartz/chert) and Illitic clays (the Al_2O_3 - K_2O - TiO_2 assemblage)

Cluster Analysis of Bed Rock Samples

For cluster analysis, Ward's method was used based on the Pearson correlation distances between the different geochemical variables. This method is an excellent way to visually summarize which mineral suites group together in bed rock limestone deposit.

The dendrogram cleanly divides the geochemical variables into two major branches (macro-clusters), which perfectly define the fundamental geological controls of the Nanhwara Kymore Limestone Block:

Cluster 1: The Calcareous / Primary Carbonate Suite (Orange Branch)

Elements: LOI (Loss on Ignition) and CaO

This tightly linked cluster represents the pure primary carbonate fraction of the rock (Calcium Carbonate, $CaCO_3$). The fact that these two isolates are entirely on their own primary branch indicates that they form the host matrix, dictating the base grade of the limestone. Their isolation reflects their strong inverse relationship (antagonism) to almost all other detrital impurities.

Cluster 2: The Terrigenous Impurity & Alteration Suite (Green Branch). This large secondary branch represents all the non-calcareous materials introduced into or altered within the basin. It further subdivides into two distinct sub-clusters:

Sub-Cluster 2A: The Argillaceous/Clay Assemblage

Elements: Fe_2O_3 , P_2O_5 , Al_2O_3 , K_2O , TiO_2 (along with minor Na_2O and SiO_3)

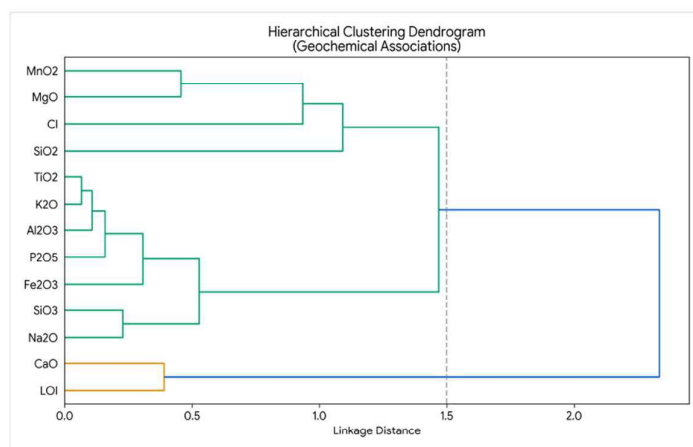


Figure No. 10.4 Hierarchical Clustering Dendrogram of BRS Samples

The incredibly tight linkage between Al_2O_3 , K_2O , and TiO_2 at the very bottom of the tree is the classic fingerprint for Illitic clays and heavy terrigenous minerals. The dendrogram clearly proves that iron (Fe_2O_3) and phosphorus (P_2O_5) are genetically associated with this same argillaceous influx event, rather than being primary chemical precipitates.

Sub-Cluster 2B: The Siliceous & Dolomitic Assemblage

Elements: SiO_2 , Cl, MgO, MnO_2 . This branch groups the free silica (SiO_2 quartz/chert) and the magnesium/manganese phases. The pairing of MgO and MnO_2 indicates that manganese is likely substituting alongside magnesium during dolomitization episodes. The fact that SiO_2 links to the dolomitic phases before it links to the clay phases suggests that the siliceous impurities may share a closer depositional or diagenetic relationship with the dolomitized zones than with the mud/clay partings.

10.3.2 Check Sample

Check sampling is essential for evaluating the accuracy and reliability of chemical analytical results. In the Nanhwara- Kymore Limestone Block, eight bore holes were drilled, and the 23 samples out of 6 bore holes were collected, processed, and sent for geochemical analysis to RK Testing Pvt. Ltd. (NABL Accredited Lab.) District Katni. The results are shown in Annexure No. V.

10.3.3 Bulk Density

The Bulk density of the bedrock and core samples was tested at the NABL-accredited Geotechnical Lab (RKT Lab. Private Ltd.) in Jabalpur. The results showed an average of 2.54 bulk density in the 5 BRS samples. The details of the Bulk density test results for the BRS samples are provided in Annexure VI.

10.3.4 Pitting

In cases where the Limestone-bearing area is covered with soil or the surface exposures are slightly weathered with the possibility of fresh rocks at shallow depths, pitting is undertaken at random intervals to collect data on the probability of Limestone deposits and the form of mineralization. Channel sampling is done in the pit on one wall, opposite walls, or all four sides, depending on the type of probable Limestone deposit and mineralization. The data recorded during sampling were taken from the pit walls.

During the mapping & field investigation, a total of 18 cubic meters of pitting was completed as per NQT to determine the strike continuity and thickness of soil cover. The pits excavated have dimensions of 6x1x1m dimension, corresponding to 18 cubic meters, and are 03 PTS. Samples were collected in quantities of 5 Kg. each (Annexure-III). The samples were prepared and submitted for chemical analysis (BSS Lab Jabalpur). The details of petrological samples (PTS) are given in Table 5.8.

Table No. 10.8: List of PITS samples of the Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh.

PIT No.	Location	Latitude	Longitude	Exploration Cu.m	No. of PTS sample	Av. CaO %
PTS-1	Nanhwara Kalan	24° 0' 8.898" N	80°33'30.618" E	6	11	43.09
PTS-2	Jhiriya	24° 0' 18.30" N	80° 34' 43.55" E	6	11	6.30
PTS-3	Gudgatauha	24°1'37.854" N	80° 36' 17.94" E	6	11	40.75

Table No. 10.9 Chemical Analysis of Samples, Pit / Trench / Channel of Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh

SAMPLE ID	CaO	MgO	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	TiO ₂	Na ₂ O	K ₂ O	MnO ₂	P ₂ O ₅	Cl	LOI
N.L./CHANNEL SAMPLE/01	42.09	1.71	14.54	1.29	2.41	0.156	0.377	0.536	0.043	0.053	0.065	36.5
N.L./PIT-01/01	39.00	1.81	19.76	1.79	3.17	0.26	0.34	0.82	0.08	0.04	0.04	32.62
N.L./PIT-01/02	46.71	1.11	9.68	1.29	2.15	0.13	0.32	0.36	0.07	0.07	0.05	37.91
N.L./PIT-01/03	45.08	1.21	12.86	1.40	2.41	0.17	0.30	0.43	0.08	0.05	0.05	35.90
N.L./PIT-01/04	43.33	1.41	14.13	1.69	2.79	0.21	0.32	0.61	0.09	0.07	0.04	35.30
N.L./PIT-01/05	43.92	1.41	13.74	1.10	2.41	0.15	0.36	0.46	0.04	0.07	0.06	36.17
N.L./PIT-01/06	41.72	1.51	13.14	1.20	2.28	0.15	0.39	0.49	0.05	0.04	0.06	38.77

SAMPLE ID	CaO	MgO	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	TiO ₂	Na ₂ O	K ₂ O	MnO ₂	P ₂ O ₅	Cl	LOI
N.L./PIT-01/07	44.89	1.51	12.53	1.39	2.53	0.19	0.32	0.53	0.05	0.07	0.04	35.87
N.L./PIT-01/08	45.02	1.21	10.29	1.39	2.41	0.16	0.30	0.48	0.07	0.04	0.05	38.50
N.L./PIT-01/09	42.76	1.41	15.07	1.69	2.53	0.17	0.31	0.51	0.09	0.07	0.05	35.27
N.L./PIT-01/10	37.06	1.51	17.64	1.49	3.04	0.20	0.37	0.75	0.04	0.04	0.05	37.73
N.L./PIT-01/11	44.45	1.21	12.14	1.20	2.15	0.14	0.28	0.39	0.06	0.07	0.05	37.76
N.L./PIT-02/01	4.76	3.02	64.38	7.97	9.00	1.04	0.64	2.60	0.09	0.05	0.03	6.24
N.L./PIT-02/02	3.78	3.12	64.23	8.66	9.38	1.11	0.69	2.61	0.10	0.03	0.03	5.98
N.L./PIT-02/03	4.34	2.11	68.04	6.37	9.51	0.93	0.63	3.71	0.08	0.04	0.04	4.00
N.L./PIT-02/04	3.91	3.22	63.41	8.26	9.75	1.04	0.59	3.04	0.11	0.05	0.03	6.45
N.L./PIT-02/05	8.80	2.91	61.24	7.36	9.24	0.99	0.69	2.95	0.10	0.04	0.03	5.54
N.L./PIT-02/06	4.48	3.02	64.91	8.07	9.51	1.10	0.64	2.92	0.10	0.05	0.03	5.11
N.L./PIT-02/07	7.69	2.92	61.78	7.57	9.12	1.02	0.65	2.88	0.10	0.03	0.03	5.91
N.L./PIT-02/08	5.18	1.91	65.98	6.08	9.26	1.03	0.74	3.70	0.07	0.05	0.03	5.74
N.L./PIT-02/09	8.95	2.91	60.78	6.57	8.99	0.97	0.62	3.05	0.09	0.04	0.02	6.83
N.L./PIT-02/10	8.40	2.92	61.01	7.17	8.87	0.94	0.57	2.85	0.10	0.05	0.03	6.92
N.L./PIT-02/11	9.92	2.71	60.99	4.68	8.86	0.89	0.68	4.21	0.07	0.07	0.04	6.72
N.L./PIT-03/01	40.84	1.11	19.15	0.90	1.77	0.10	0.28	0.17	0.04	0.04	0.05	35.52
N.L./PIT-03/02	40.16	2.72	16.06	1.49	2.41	0.17	0.38	0.29	0.07	0.07	0.06	36.02
N.L./PIT-03/03	40.86	2.21	15.24	1.39	2.28	0.15	0.37	0.35	0.08	0.05	0.05	36.72
N.L./PIT-03/04	32.86	1.91	20.34	1.89	3.29	0.24	0.39	0.83	0.09	0.05	0.04	37.94
N.L./PIT-03/05	40.41	1.51	17.37	1.49	2.03	0.14	0.32	0.24	0.07	0.04	0.05	36.22
N.L./PIT-03/06	42.80	1.31	12.66	1.10	2.28	0.17	0.38	0.48	0.04	0.05	0.07	38.44
N.L./PIT-03/07	44.24	1.21	16.30	0.70	1.65	0.09	0.35	0.15	0.04	0.07	0.07	35.01
N.L./PIT-03/08	42.51	3.52	13.41	1.19	2.03	0.12	0.31	0.21	0.06	0.05	0.05	36.44
N.L./PIT-03/09	41.90	1.81	16.69	0.80	1.77	0.10	0.32	0.16	0.04	0.04	0.06	36.22
N.L./PIT-03/10	42.00	1.91	16.33	1.40	1.90	0.12	0.37	0.20	0.05	0.05	0.06	35.51
N.L./PIT-03/11	39.71	1.81	18.66	1.29	2.15	0.14	0.32	0.31	0.04	0.05	0.05	35.40

The chemical analysis of pit and channel samples from the Nanhwara- Kymore Limestone Block, Katni District, indicates significant lithological and compositional variation between the investigated pits. Samples from PIT-01 show consistently high CaO values ranging from 37.06% to 46.71% with silica (SiO₂) content between 9.68% and 19.76%, indicating the presence of good-quality calcareous limestone. The Fe₂O₃ and MgO contents are generally low, suggesting comparatively purer limestone horizons suitable for cement and flux grade considerations. PIT-03 also represents calcareous formations with CaO values varying from 32.86% to 44.24% and silica content ranging from 12.66% to 20.34%, indicating slightly impure siliceous limestone. In contrast, PIT-02 samples exhibit very low CaO values (3.78%–9.92%) and exceptionally high SiO₂ content (60.78%–68.04%), along with elevated Fe₂O₃ and Al₂O₃ values, suggesting dominance of shale/siliceous lithology rather than limestone. The channel sample records 42.09% CaO and 14.54% SiO₂, which closely corresponds with the limestone horizons encountered in PIT-01 and

PIT-03. Overall, the analytical results indicate that PIT-01 contains the best quality limestone within the investigated area, while PIT-02 represents non-calcareous siliceous intercalations and PIT-03 contains moderately siliceous limestone horizons. Refer Annexure III.

Table No. 10.10 Details of Pit in the Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh.

Details of Pit No. Pit. No. TS-1						
Name of the Investigation: Limestone				Date of Commencement: 27-01-2026		
Location: Nanhwara Kalan						
Co-ordinates: N24⁰ 0' 8.898" / E 80⁰33'30.618"						
Pit top measurements (Length x Width x Depth)				6m x1m x 1m		
Recorded By: Mr. Anand Raikwar (Geologist)						
Lithology Details: Limestone						
Structural Details: Bedded Deposit						
No. of samples taken: 11 nos.						
Details of the transverse section of the trench:						
S.no.	Location		From	To	Width	Lithology / Structural details
1.	East wall	South Side	0.00	2.00	2m	Black soil with purple to light grey colour fine grain Limestone.
2.		Middle Side	2.00	4.00	2m	
3.		North Side	4.00	6.00	2m	
4.	West wall	South Side	0.00	2.00	2m	
5.		Middle Side	2.00	4.00	2m	
6.		North Side	4.00	6.00	2m	
7.	North Side	North Side Wall	1.00	1.00	1m	
8.	South Side	South Side Wall	1.00	1.00	1m	
9.	Bottom	South Side	0.00	2.00	2m	
10.		Middle Side	2.00	4.00	2m	
11.		North Side	4.00	6.00	2m	

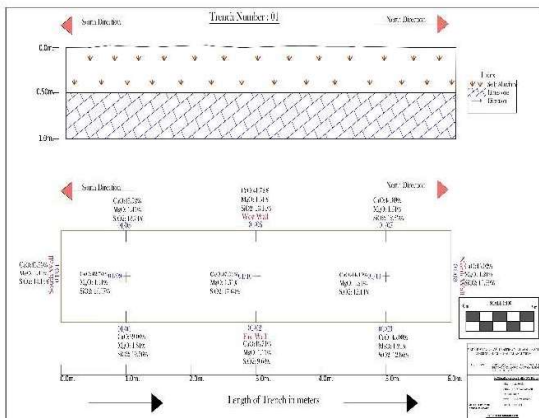


Fig. No.10.5 Details of Pit TS-1



Fig. No.10.6 Field Photo of Pit TS-1

Details of Pit No. Pit. No. TS-2

Name of the Investigation: **Limestone**

Date of Commencement: 27-01-2026

Location: **Jhiriya**

Co-ordinates: **N 24° 0' 18.30" / E 80° 34' 43.55"**

Trench top measurements (Length x Width x Depth) 6m x 1m x 1m

Recorded By: Mr. Anand Raikwar

Lithology Details: Shale

Structural Details: Bedded Deposit

No. of samples taken: 11 nos.

Details of the transverse section of the trench:

S.No.	Location		From	To	Width	Lithology / Structural details
1.	North wall	East side	0.00	2.00	2m	Black soil with light Grey colour weathered Shale
2.		Middle side	2.00	4.00	2m	
3.		West side	4.00	6.00	2m	
4.	South wall	East side	0.00	2.00	2m	
5.		Middle side	2.00	4.00	2m	
6.		West side	4.00	6.00	2m	
7.	West wall	West side wall	1.00	1.00	1m	
8.	East wall	East side wall	1.00	1.00	1m	
9.	Bottom	East Side	0.00	2.00	2m	
10.		Middle side	2.00	4.00	2m	
11.		West side	4.00	6.00	2m	

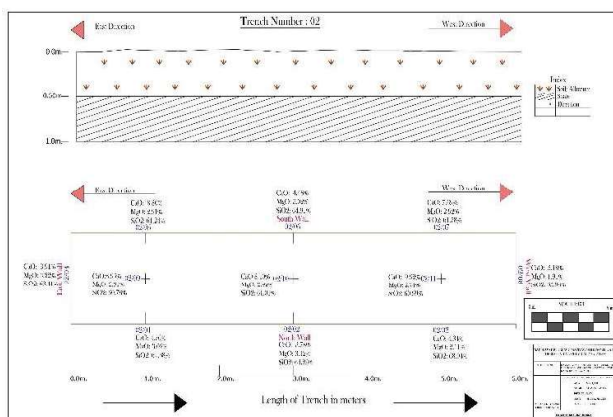


Fig. No.10.7 Details of Pit TS-2



Fig. No.10.8 Field Photo of Pit TS-2

Details of Pit No. Pit. No. TS-3						
Name of the Investigation: Limestone				Date of Commencement: 28-01-2026		
Location: Gudgaduha						
Co-ordinates: N 24⁰1’37.854’’ / E 80⁰ 36’ 17.94’’						
Trench top measurements (Length x Width x Depth)				6m x1m x1m		
Recorded By: Mr. Anand Raikwar (Geologist)						
Lithology Details: Limestone						
Structural Details: Bedded Deposit						
No. of samples taken: 11nos.						
Details of the transverse section of the trench:						
S.No.	Location		From	To	Width	Lithology / Structural details
1.	North wall	East side	0.00	2.00	2m	Black soil with purple to light Grey colour fine grain Limestone
2.		Middle side	2.00	4.00	2m	
3.		West side	4.00	6.00	2m	
4.	South wall	East side	0.00	2.00	2m	
5.		Middle side	2.00	4.00	2m	
6.		West side	4.00	6.00	2m	
7.	East wall	East side wall	1.00	1.00	1m	
8.	West wall	West side wall	1.00	1.00	1m	
9.	Bottom	East side	0.00	2.00	2m	
10.		Middle side	2.00	4.00	2m	
11.		West side	4.00	6.00	2m	

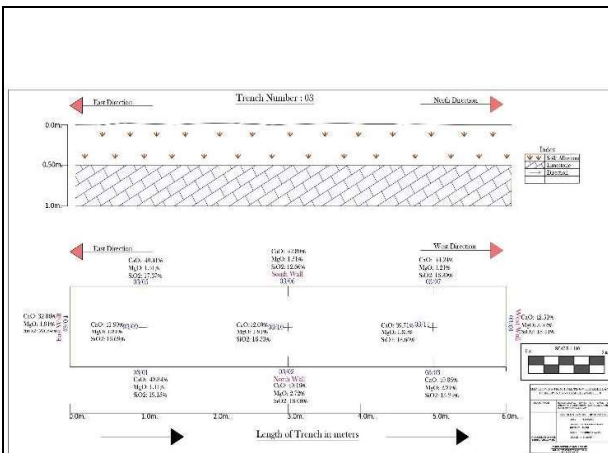


Fig. No. 10.9 Details of Pit TS-3



Fig. No.10.10 Field Photo of Pit TS-3

CHAPTER – 11

11.0.0 LOCATION DATA POINTS

11.1.0 ACCURACY AND QUALITY OF SURVEY USED TO LOCATE BLOCK BOUNDARY AND DRILL HOLES

The study area, which covers a block area of 22.52 Sq.km is situated in Vijayraghavgarh Tehsil of Katni District, lies approximately 35–45 km from Katni (from District Headquarters) and about 10–20 km from Vijayraghavgarh of Katni District. The area falls under Toposheet Nos. 63D/12 and 64A/9.

The co-ordinates of the area covered by large-scale mapping at a 1:12,500 scale are bounded by GPS Co-ordinates of the following corner points of the Nanhwara -Kymore Limestone Block, Katni district, Madhya Pradesh. The area under investigation lies within the Survey of India Toposheet Nos. 63D/12 and 64A/9. The Topographical survey, Borehole connection and Block Boundary demarcation in this block has been carried out by the LEICA VIVA GS14 Instrument. Coordinates for base station is shown below.

11.1.2 TECHNICAL SPECIFICATIONS OF DGPS

Make: LEICA VIVA GS14

Model: CS10

Year: 2018

Measurement Accuracy:

Static Mode

Horizontal: 3 mm + 0.1 ppm or better

Vertical: 3.5 mm + 0.4 ppm or better

Co-ordinate of the Primary Control Point:

POINT NAME	LONGITUDE			LATITUDE			UTM Co-ordinates (WGS84)	
	D	M	S	D	M	S	Easting (X)	Northing (Y)
BASE1	80	33	29.02	24	00	19.24	455051.48	2654888.77
BASE2	80	36	13.39	24	01	59.69	459703.18	2657964.23
BASE3	80	34	53.31	24	01	3.27	457436.90	2656235.61

Table No. 11.1: DGPS Co-ordinates of the Nanhwara -Kymore Limestone Block

Nanhwara Kymore Limestone Block Limestone Block G-4				
BP-No.	Easting	Northing	LATITUDE	LONGITUDE
BP-1	453422.975	2652840.814	23° 59' 12.4812" N	80° 32' 31.6152" E
BP-2	462074.868	2656928.634	24° 01' 26.2279" N	80° 37' 37.4214" E
BP-3	460437.211	2658968.473	24° 02' 32.4098" N	80° 36' 39.2484" E
BP-4	459869.427	2658947.536	24° 02' 31.6776" N	80° 36' 19.1480" E
BP-5	458707.513	2659582.059	24° 02' 52.2017" N	80° 35' 37.9455" E
BP-6	457811.108	2657935.285	24° 01' 58.5714" N	80° 35' 06.3789" E
BP-7	457514.234	2657954.617	24° 01' 59.1714" N	80° 34' 55.8668" E
BP-8	457511.799	2657514.065	24° 01' 44.8465" N	80° 34' 55.8269" E
BP-9	457300.551	2657524.833	24° 01' 45.1762" N	80° 34' 48.3473" E
BP-10	457327.711	2657056.864	24° 01' 29.9627" N	80° 34' 49.3582" E
BP-11	456696.855	2656990.2	24° 01' 27.7335" N	80° 34' 27.0329" E
BP-12	454371.145	2655697.442	24° 00' 45.4643" N	80° 33' 04.8486" E
BP-13	454044.486	2655188.876	24° 00' 28.8942" N	80° 32' 53.3437" E
BP-14	452918.455	2654683.964	24° 00' 12.3580" N	80° 32' 13.5461" E

Table No. 11.2 Details of Drilled Boreholes in Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh.

S. No	BH-No	Latitude	Longitude	Surface RL(m)	Bottom RL (M)	Depth of BH	Date of Commencement	Date of closing
1	BH-1	23°59'51.798"N	80°32'44.814"E	387	357	30	27-11-2025	02-12-2025
2	BH-2	24°0'44.10"N	80°33'23.808"E	387	357	30	17-11-2025	25-11-2025
3	BH-4	24°00'45.54"N	80°34'24.30"E	370	340	30	04-12-2025	11-12-2025
4	BH-5	24°01'42.54"N	80°35'03.654"E	386	336	50	12-12-2025	21-12-2025
5	BH-6	24°00'52.854"N	80°35'25.95"E	371	341	30	24-12-2025	29-12-2025
6	BH-7	24°02'21.66"N	80°35'53.682"E	392	362	30	06-01-2026	11-01-2026
7	BH-8	24°01'11.472"N	80°36'01.746"E	370	340	30	31-12-2025	04-01-2026
8	BH-9	24°02'00.624"N	80°36'45.792"E	383	353	30	13-01-2026	19-01-2026

11.2.0 QUALITY AND ADEQUACY OF TOPOGRAPHIC CONTROL

The survey work has been carried out with the help of DGPS(GNSS) for higher level measurement accuracy. A point list was then generated as .csv file for topographical points attached in report as

Annexure VIII. The baseline processing results are also enclosed in the report. Survey work carried out by the experienced qualified surveyor as per the prevailing standard procedures.

CHAPTER – 12

12.0.0 SAMPLING TECHNIQUES

12.1.0 NATURE AND QUALITY OF SAMPLING AND MEASURES TAKEN TO ENSURE SAMPLE REPRESENTATIVITY

The sampling and analyses have been carried out for the entire mineralized zones/length encountered in bed rocks, and boreholes drilled on a visual identification basis. The primary samples have been marked in the mineralized zones based on type and concentration of mineralisation/lithology, and in general, the sample length has been kept as 1.00 m to 2.00 m, which varies in some instances because of variation in lithology and type and concentration of mineralisation. The mineralized core has been split into two halves in such a way that the concentrations of ore minerals are uniform in both halves. One-half of the core sample has been crushed to (-) 200 mesh size. By progressive coning and quartering, and repeatedly mixing the sample has been reduced to 600 g. A representative sample of 200 g has been collected and analysed for CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃, Na₂O, SO₃, TiO₂, P₂O₅, K₂O, and LOI at the Chemical Laboratory of BSS Lab., Jabalpur.

12.2.0 NATURE, QUALITY, AND APPROPRIATENESS OF THE SAMPLE PREPARATION TECHNIQUE

The details of the sampling procedure for primary samples are described in Para 12.1.1. Quality of the sample preparation is maintained by proper cleaning, maintenance of the equipment, and proper crushing, sieving, and coning and quartering of samples. For sample preparation, proper technique and expertise have been used.

12.3.0 QUALITY CONTROL PROCEDURES ADOPTED

The primary core samples have been collected from the entire mineralized zones/length intersected in the boreholes drilled, and the samples have been prepared at a centralized mechanized sampling unit. The standard sampling procedure in supervision of a qualified sampling technician has been adopted to control the quality of samples. Similarly, internal check and external check samples have also been prepared under the supervision of a qualified sampling technician following the standard sampling procedure.

12.4.0 MEASURES TAKEN TO ENSURE THE SAMPLING IS REPRESENTATIVE OF THE IN-SITU MATERIAL COLLECTED

All the primary samples have been marked and prepared from limestone cores. During the preparation of primary samples, the mineralised cores have been studied meticulously, and samples have been marked properly. These mineralised cores are subjected to the preparation of primary

samples as per the sampling procedure for primary samples are described in Para 12.1.1. The proper marking of primary samples from drilled cores and following the standard procedure for sample preparation shows that the representative samples have been collected from the in-situ materials.

12.5.0 WHETHER SAMPLE SIZES ARE APPROPRIATE TO THE GRAIN SIZE OF THE MATERIAL BEING SAMPLED

The primary samples have been prepared (-) with a 200 mesh size, and all the other samples have been prepared from the primary samples. As per the previous studies in the area, (-) a 200 mesh size is appropriate for the analysis of limestone mineralization in the block area.

CHAPTER – 13

13.0.0 DRILLING TECHNIQUES AND DRILL SAMPLING EMPLOYED

Drilling constitutes a fundamental component of mineral exploration, serving to delineate the subsurface configuration of mineralized bodies and to facilitate the development of three-dimensional models of mineralization. In the present investigation, a cumulative 260 meters of drilling was done utilizing an in-house drilling rig, deploying one drill rig only. The drilling operations began on 27-11-2025 and were completed on 19-01-2026. A total of 8 vertical boreholes, designated as BH-1, BH-2, BH-4, BH-5, BH-6, BH-7, BH-8, & BH-8 were drilled. Each borehole depth was 30 meters below ground level except BH-5 (50m), resulting in the recovery of 237 core samples. These samples are undergoing chemical analysis, the results of which will be employed to evaluate mineral content, grade, and the potential economic viability of the deposit.

Table No. No. 13.1 Details of proposed boreholes in Nanhwara-Kymore Limestone Block, Katni District, Madhya Pradesh. (Shown in Plate No. VIII)

S. No	PBH-No	Latitude	Longitude	Surface RL(m)
1	PBH-1	23°59'51.798"N	80°32'44.814"E	387
2	PBH-2	24°0'44.10"N	80°33'42.25"E	387
3	PBH-3	24°00'53.52"N	80°34'23.808"E	385
4	PBH-4	24°00'45.54"N	80°34'24.30"E	370
5	PBH-5	24°01'42.54"N	80°35'03.654"E	386
6	PBH-6	24°00'52.854"N	80°35'25.95"E	371
7	PBH-7	24°02'21.66"N	80°35'53.682"E	392
8	PBH-8	24°01'11.472"N	80°36'01.746"E	370
9	PBH-9	24°02'00.624"N	80°36'45.792"E	383

Table No. No. 13.2 Details of Drilled Boreholes in Nanhwara Kymore Limestone Block, Katni District, Madhya Pradesh.

S. No	BH-No	Latitude	Longitude	Surface RL(m)	Bottom RL (M)	Depth of BH	Date of Commencement	Date of closing
1	BH-1	23°59'51.798"N	80°32'44.814"E	387	357	30	27-11-2025	02-12-2025
2	BH-2	24°0'44.10"N	80°33'23.808"E	387	357	30	17-11-2025	25-11-2025
3	BH-4	24°00'45.54"N	80°34'24.30"E	370	340	30	04-12-2025	11-12-2025
4	BH-5	24°01'42.54"N	80°35'03.654"E	386	336	50	12-12-2025	21-12-2025
5	BH-6	24°00'52.854"N	80°35'25.95"E	371	341	30	24-12-2025	29-12-2025
6	BH-7	24°02'21.66"N	80°35'53.682"E	392	362	30	06-01-2026	11-01-2026
7	BH-8	24°01'11.472"N	80°36'01.746"E	370	340	30	31-12-2025	04-01-2026
8	BH-9	24°02'00.624"N	80°36'45.792"E	383	353	30	13-01-2026	19-01-2026

13.1.0 DRILLING TYPES AND DETAILS

The drilling for this exploration project was conducted using NQ Diamond Bits to obtain core samples with a diameter of 47.6 mm. To ensure the stability of the borehole, casing was used. For efficient drilling in hard and compact limestone, as well as other limestone types, triple tube barrels were used. These barrels enhanced drilling efficiency and improved core recovery rates. For harder formations, including limestone and shaly limestone, diamond core bits were used. These bits are specifically designed to cut through tough rock and ensure successful core retrieval. Vertical drilling was used to accurately intersect and sample the mineralized zones, which are horizontal to sub-horizontal. The wireline drilling method was employed to facilitate efficient core retrieval. This method involves using an overshot attached to a wireline to engage and remove the core barrel without pulling out the entire drill string. Core barrels ranged in length from 0.5 meters to 3.2 meters and were handled with wire rope. The drill rods, made of fine high-tensile steel, were designed to be thin yet strong, maximizing the core size during the drilling process.

13.2.0 DEVIATION SURVEY IN DRILLING

Due to the horizontal disposition and soft nature of the strata, the boreholes were drilled vertically. A specific borehole deviation test was not conducted.

13.3.0 WHETHER CORE AND CHIP SAMPLE RECOVERIES HAVE BEEN PROPERLY RECORDED AND RESULTS ASSAYED

The core samples have been recorded properly, and the detailed run-wise lithologs and summarized concise lithologs for boreholes are given in Annexure-I. The logging of run-wise core as well as the cuttings from boreholes has helped in discerning the physical characters like colour, shape, size, and nature of the mineralization, as well as texture, structural features, and identification of different litho units. Core recovery with reference to the lithologies are properly recorded and presented in Annexure-I. The mineralized zones /length recorded during the geological core logging have been sampled for limestone analysis, consisting 13 radicals i.e., CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃, Na₂O, SO₃, TiO₂, P₂O₅, K₂O, and LOI at the Chemical Laboratory of BSS Lab, Jabalpur. The primary sample had been marked in the mineralized zones intersected in the borehole based on visual inspection/lithology, and in general, the sample length has been kept as 1.00m to 2.00m, which varied in some instances because of variation in lithology and type and concentration of mineralization. The details of analysis of primary core samples are given in Annexure-I.

13.4.0 MEASURES TAKEN TO MAXIMIZE SAMPLE RECOVERY AND ENSURE REPRESENTATIVE NATURE OF THE SAMPLES

The drilling for this exploration project was conducted using NQ Diamond Bits to obtain core samples with a diameter of 47.6 mm. To ensure the stability of the borehole, casing was used. For efficient drilling in hard and compact limestone, as well as other limestone types, triple tube barrels were used. These barrels enhanced drilling efficiency and improved core recovery rates. For harder formations, including limestone and shaly limestone, diamond core bits were used.

These bits are specifically designed to cut through tough rock and ensure successful core retrieval. Vertical drilling was used to accurately intersect and sample the mineralized zones, which are horizontal to sub-horizontal. The wireline drilling method was employed to facilitate efficient core retrieval. This method involves using an overshot attached to a wireline to engage and remove the core barrel without pulling out the entire drill string. Core barrels ranged in length from 0.5 meters to 3.2 meters and were handled with wire rope. The drill rods, made of fine high-tensile steel, were designed to be thin yet strong, maximizing the core size during the drilling process.

13.5.0 WHETHER CORE AND CHIP SAMPLE RECOVERIES HAVE BEEN PROPERLY RECORDED AND RESULTS ASSAYED

The core samples have been recorded properly, and the detailed borehole-wise run-wise lithologs and summarized lithologs for boreholes are given in Annexure I. The run-wise lithologs of drilled core as well as the cuttings from boreholes have helped in discerning the physical characters like color, shape, size and nature of the mineralization as well as texture, structural features and identification of different litho units.

13.6.0 CORE LOGGING

The core recovered by drilling was logged systematically in detail, describing lithological units with mineralization details that can be observed by visual inspection. The details of lithology, grain size, color, texture, structural features, presence of intercalations, and cavities have been recorded. Wherever the recovery is less than 100%, extrapolations of drilled depth were done on a proportionate basis, considering the physical characteristics of individual units recovered. All the cores were kept and preserved properly in the GI core boxes of specifications given by NMEDT, following the “Book pattern”. The detailed run-wise lithologs and summarized lithologs for boreholes are given in Annexure I.



Figure No.13.1 Showing Drilling Operation in the exploration Block.

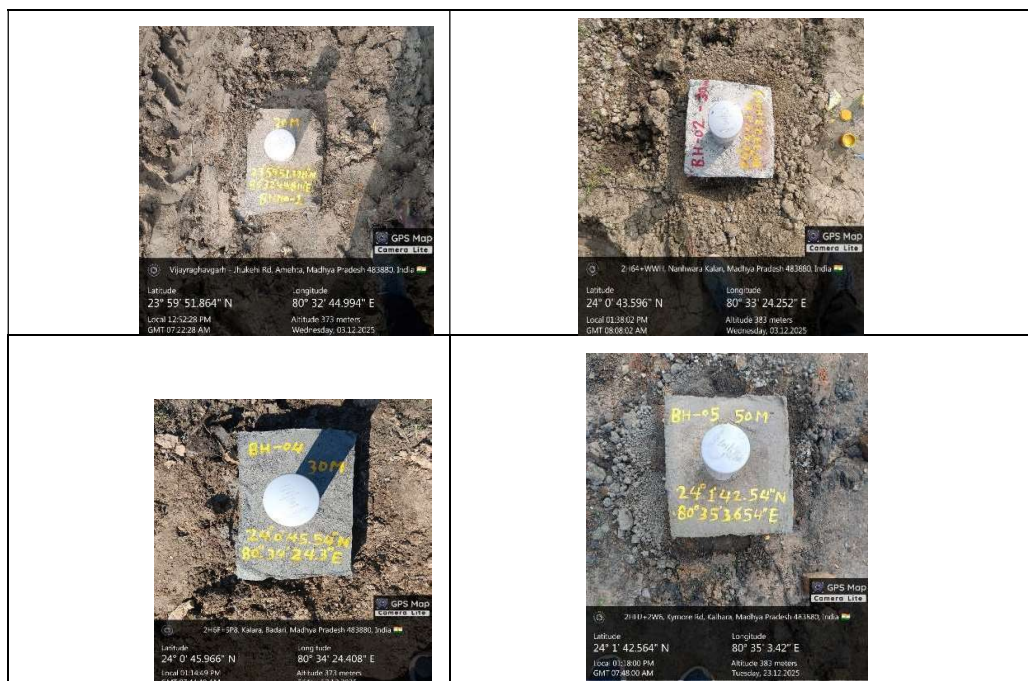




Figure No. 13.2 Showing Bore Closures in the exploration Block.



Figure 13.3 Limestone zone of borehole no BH-01 from 20.00 m to 25.00m.

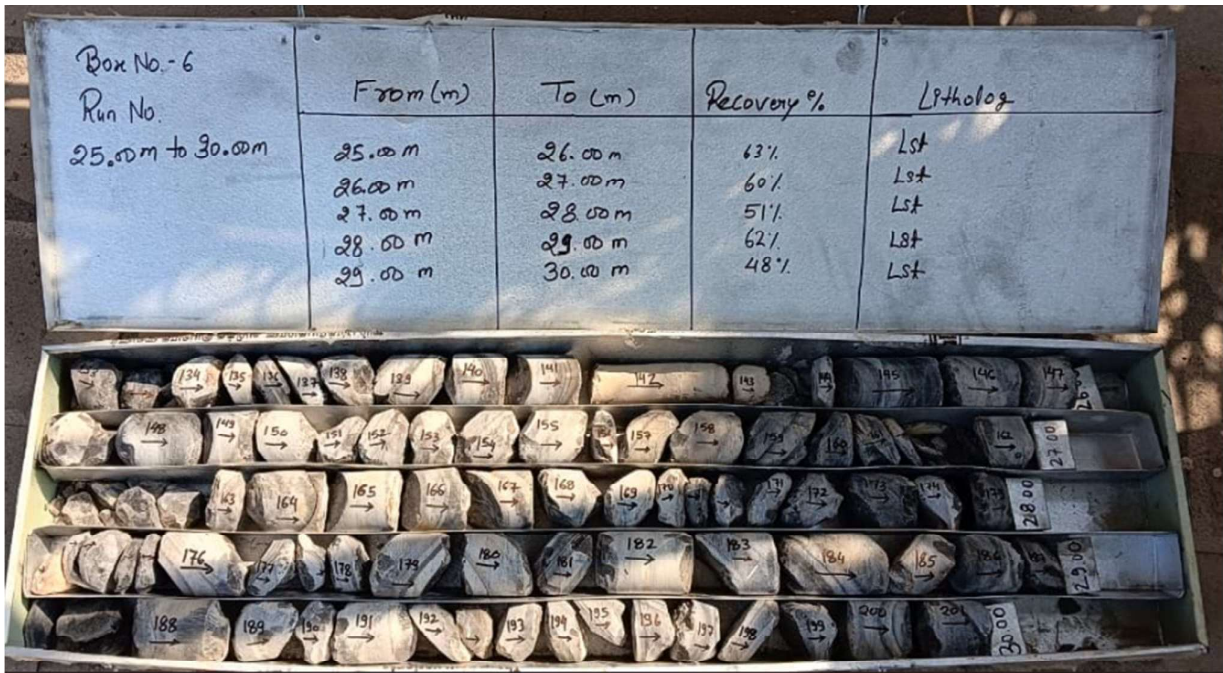


Figure 13.4 Limestone zone of borehole no BH-04 from 25.00 m to 30.00m

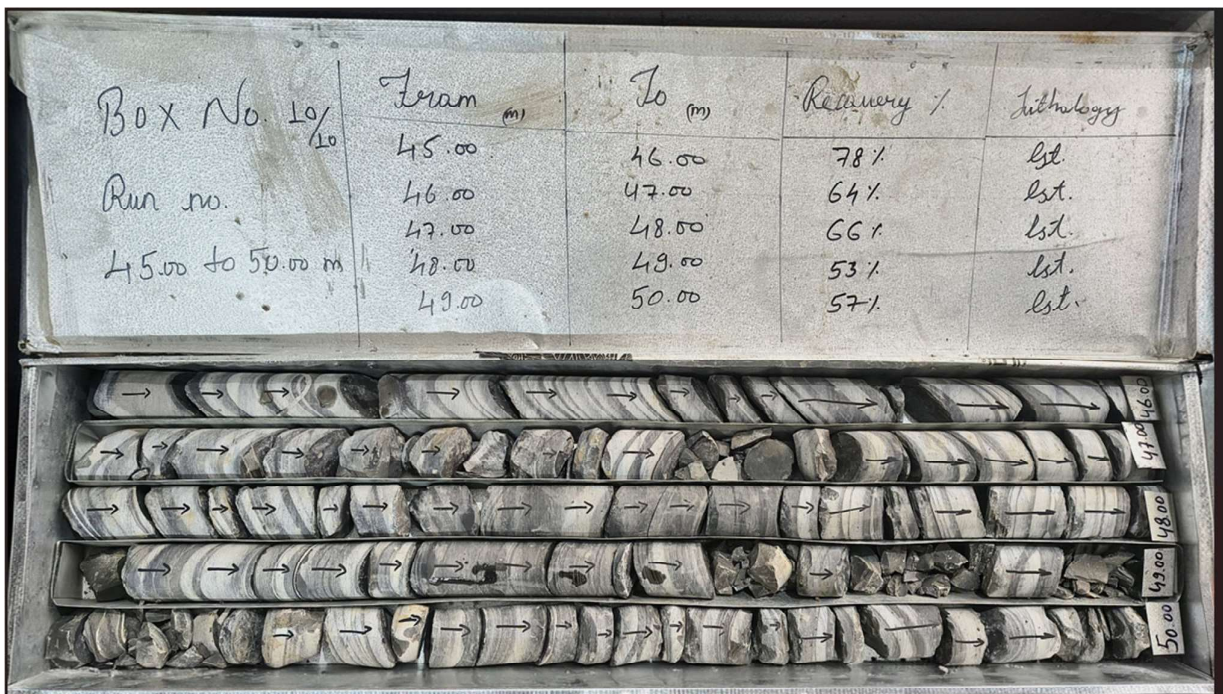


Figure 13.5 Limestone zone of borehole no BH-05 from 45.00 m to 50.00m



Figure 13.6 Limestone zone of borehole no BH-08 from 25.00 m to 30.00m



Figure 13.7 Limestone zone of borehole no BH-08 from 25.00 m to 30.00m

Graphical Representation of Core Logs

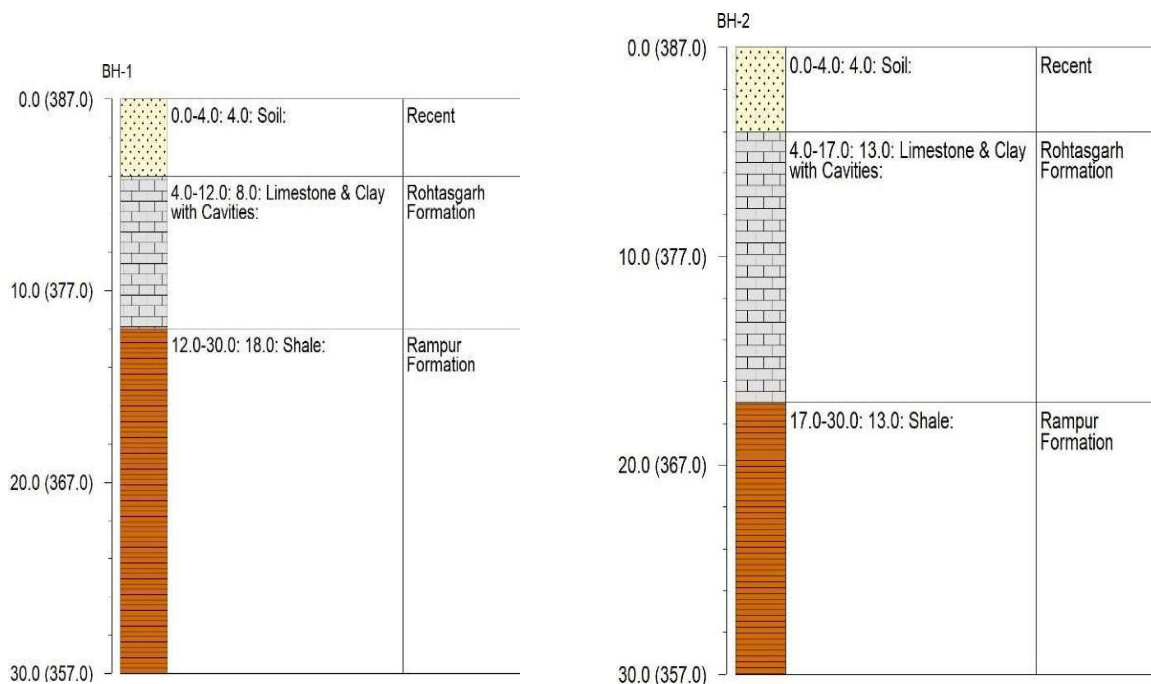


Figure No. 13.8 Showing Lithologs of BH-1 & BH-2

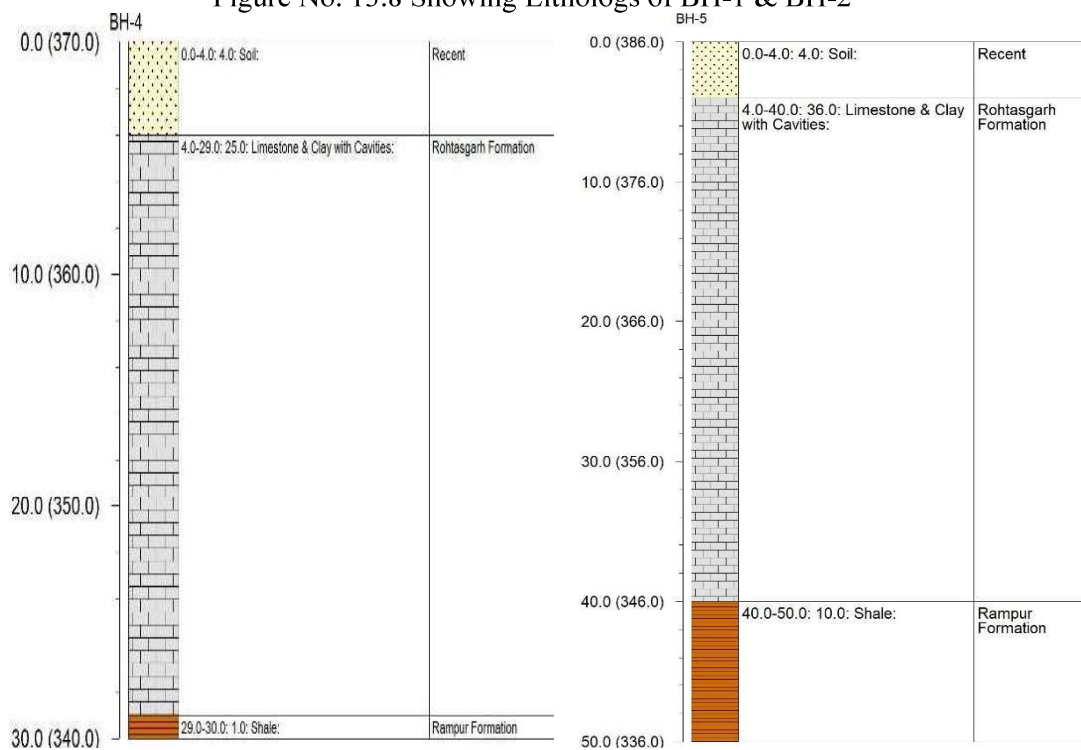


Figure No. 13.9 Showing Lithologs of BH-4 & BH-5

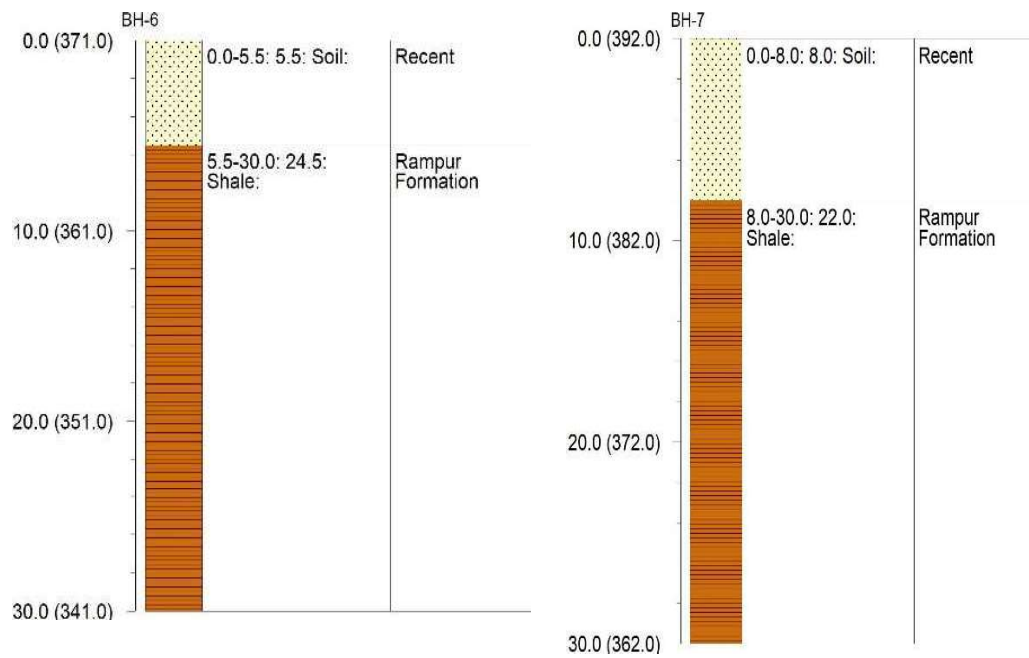


Figure No. 13.10 Showing Lithologs of BH-6 & BH-7



Figure No. 13.11 Showing Lithologs of BH-8 & BH-9

CHAPTER – 14

14.0.0 SUB SAMPLING TECHNIQUES AND SAMPLE PREPARATION

14.1.0 WHETHER CUT OR DRAWN AND WHETHER QUARTER, HALF, OR ALL CORE TAKEN

The core sampling and chemical analysis of core samples have been carried out for the entire mineralized zones/length intersected in the boreholes drilled. Samples were marked in limestone zones marked on the basis of visual inspection. The mineralized core has been split into two halves by a core splitter in such a way that the concentrations of ore minerals are uniform in both halves. The whole quantity of half portion of the sample was crushed to (-) 200 mesh, and about 600g representative sample was drawn by coning and quartering method of gradual size reduction with the help of a crusher and pulveriser. Two sample pouches weighing 200g each were drawn, one of which was analyzed for limestone analysis of 13 radicals CaO, SiO₂, MgO, MnO₂, Na₂O, K₂O, TiO₂, P₂O₅, Al₂O₃, Fe₂O₃, Cl & LOI. were analyzed in the Chemical Laboratory of BSS Lab. Jabalpur and external check samples were analyzed in R.K. Testing Lab, Katni, M.P. (NABL-accredited Laboratory). The remaining 200g fraction was kept for future purposes, including composite sample analysis, etc.

14.2.0 NATURE, QUALITY, AND APPROPRIATENESS OF THE SAMPLE PREPARATION TECHNIQUE

Quality of the sample preparation is maintained by proper cleaning, maintenance of the equipment, and proper crushing, sieving, and coning and quartering of samples. For sample preparation, proper technique and expertise have been used.

14.3.0 QUALITY CONTROL PROCEDURES ADOPTED

Quality of the sample preparation is maintained by proper cleaning, maintenance of the equipment, and proper crushing, sieving, and coning and quartering of samples. For sample preparation, proper technique and expertise have been used.

14.4.0 QUALITY CONTROL PROCEDURES ADOPTED

The primary core samples have been collected from the entire mineralized zones/length intersected in the boreholes drilled, and the samples have been prepared at the centralized mechanized sampling unit, ENGEOTECH CONSULTANT, Jabalpur. The standard sampling procedure in supervision of a qualified sampling technician has been adopted to control the quality of samples. Similarly, external check samples have also been prepared under the supervision of a qualified sampling technician following the standard sampling procedure and analyzed at an NABL-accredited external lab.

14.5.0 MEASURES TAKEN TO ENSURE THE SAMPLING IS REPRESENTATIVE OF THE INSITU MATERIAL COLLECTED

All the primary samples have been marked and prepared from mineralized cores. During the preparation of primary samples, the mineralized cores have been studied meticulously, and samples have been marked properly. These mineralized cores are subjected to the preparation of primary samples as per the sampling procedure for primary samples are described in Para 14.1.0. The proper marking of primary samples from drilled cores and following the standard procedure for sample preparation shows that the representative samples have been collected from the in-situ materials.

14.6.0 WHETHER SAMPLE SIZES ARE APPROPRIATE TO THE GRAIN SIZE OF THE MATERIAL BEING SAMPLED

The primary samples have been prepared (-) 200 mesh size, and all the other samples have been prepared from the primary samples. As per the previous studies in the area (-) 200 mesh size is appropriate for the analysis of limestone, etc., mineralization in the block area.

CHAPTER – 15

15.0.0 QUALITY OF ASSAY DATA AND LABORATORY TESTS

15.1.0 THE NATURE, QUALITY, AND APPROPRIATENESS OF THE ASSAYING AND LABORATORY PROCEDURES

The primary samples from limestone mineralization have been analysed for 13 radicals i.e., CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃, Na₂O, SO₃, P₂O₅, K₂O and LOI by in Chemical Laboratory of BSS Lab Jabalpur, and external check samples for same 13 radicals have been analysed in R.K. Testing Lab, Katni, M.P. (NABL-accredited Laboratory) a NABL accredited Laboratory.

15.2.0 STANDARD OPERATING PROCEDURE (SoP) FOR THE ANALYSIS BY BSS Lab & R.K. Testing Lab

Representative samples collected from the bedrock and drill cores were subjected to wet chemical analysis for the determination of major oxides and deleterious constituents. The analyses were carried out following the standard procedures prescribed by the Bureau of Indian Standards (BIS) (IS:1760), IBM Manual of Procedure (IBM, 2012), and other accepted analytical protocols.

The samples were initially dried, pulverized to 200 mesh fineness, and accurately weighed (1 g). The powdered material was decomposed by acid digestion using suitable mineral acids depending upon the nature of the sample. In cases where complete dissolution could not be achieved through acid treatment, fusion techniques employing appropriate fluxes were adopted.

The resulting solutions were analyzed using conventional gravimetric and volumetric methods. Silica (SiO₂) was determined gravimetrically after dehydration and filtration, whereas calcium oxide (CaO) and magnesium oxide (MgO) were estimated by EDTA complexometric titration. Total iron, wherever applicable, was determined by standard redox titration using potassium dichromate. Other constituents were analyzed by suitable wet chemical procedures based on their chemical characteristics.

Wet chemical analysis provides reliable and accurate results and is widely accepted as a reference method for determining the chemical composition of mineral samples.

The analytical data generated through this method formed the basis for assessing the grade characteristics and industrial suitability of the mineralized horizons encountered during the investigation.

The analytical results obtained from wet chemical methods were utilized to evaluate the suitability of the limestone for cement, metallurgical flux, and other industrial applications based on the concentrations of CaO, MgO, SiO₂, Al₂O₃, Fe₂O₃, and Loss on Ignition (LOI). In accordance with

GSI-NABET guidelines, these analytical results were integrated with geological and lithological information for the delineation of mineralized zones and the assessment of the quality characteristics of the limestone deposit.

15.3.0 STANDARD OPERATING PROCEDURE (SoP) FOR THE DETERMINATION OF LOSS ON IGNITION (L.O.I.) AT BSS LAB

Procedure

1. Weigh 1 g of dry sample in a silica or platinum crucible.
2. Place this crucible in the muffle furnace at a temperature below 300°C. Raise the temperature of the furnace to 1000°C. Keep this at this temperature for about 30 minutes.
3. Cool the crucible in desiccators and weigh the crucible.
4. Find the loss in weight.
5. % Loss on Ignition (LOI) = $\frac{\text{Loss in weight}}{\text{Sample weight}} \times 100$

15.4.0 NATURE OF QUALITY CONTROL PROCEDURES ADOPTED

Check sampling is essential for evaluating the accuracy and reliability of chemical analytical results. In the Nanhwara- Kymore Limestone Block, eight bore holes were drilled, and the 23 samples out of 6 bore holes were collected, processed, and sent for geochemical analysis to RK Testing Pvt. Ltd. (NABL Accredited Lab.) District Katni. The results are shown in Annexure No. V.

CHAPTER – 16

16.0.0 MOISTURE

16.1.0 All the analyses of borehole core samples have been carried out with natural moisture.

CHAPTER – 17

17.0.0 BULK DENSITY

17.1.0 BULK DENSITY ANALYSIS DETAILS

The Bulk density of the bedrock and core samples was tested at the NABL-accredited Geotechnical Lab (RKT Lab. Private Ltd.) in Jabalpur. The results showed an average of 2.54 bulk density in the 5 BRS samples. The test for Bulk Density was carried out using IS Code TS133030:1991 RA-216. The details of the Bulk density test results for the BRS samples are provided in Table 5.6. Refer Annexure VI.

Table No.17.1 Bulk Density Test Results of Five BRS & Core Samples

S. No	Sample ID	Bulk Density g/cm ³	Latitude	Longitude	Type	From (m)	To (m)	Lithology
1	N/L/BD/S-1	2.55	24° 1'22.01"N	80°34'22.71"E	BRS	-	-	Limestone
2	N/L/BD/S-2	2.45	24° 2'13.46"N	80°36'12.65"E	BRS	-	-	Limestone
3	N/L/BD/S-3	2.50	24° 0'44.10"N	80°33'23.81"E	BH-02	23	24	Limestone
4	N/L/BD/S-4	2.65	24° 1'42.43"N	80°35'2.97"E	BH-05	48	49	Limestone
5	N/L/BD/S-5	2.65	24° 2'0.48"N	80°36'45.42"E	BH-09	12	13	Limestone

CHAPTER – 18

18.0.0 BENEFICIATION STUDIES

18.1.0 The present exploration has no provision for beneficiation studies.

CHAPTER – 19

19.0.0 RESOURCE ESTIMATION TECHNIQUE

19.1.0 GENERAL

In the Nanhwara Kymore Limestone Block, 237 core samples were analyzed at the BSS Lab, Jabalpur, an NABL-accredited lab. These samples were tested for major oxides, including SiO₂, Al₂O₃, Fe₂O₃, CaO, MgO, Na₂O, TiO₂, P₂O₅, and K₂O. The borehole cores were thoroughly logged in detail and the analytical results are provided in Annexure IX. To classify the different grades of limestone, a weighted average was calculated for key components like CaO and SiO₂. According to the threshold values prescribed by IBM's End Use Grade classification, limestone is categorized as follows:

1. Cement Grade (Portland): CaO 42% to 52%
2. Cement Grade (Blendable): CaO 38% to 42%
3. Blendable Grade: CaO 34% to 38%

Additionally, MgO content is up to 4%, SiO₂ ranges from 12% to 16%, Fe₂O₃ from 1% to 2%, and Al₂O₃ from 1% to 2% for estimating the grade of Limestone.

19.2.0 ASSUMPTIONS FOR RESOURCE ESTIMATION

19.2.1 Assumptions for Resource Estimation

1) Cut-off Grade

The cut-off grade for different types of limestone is determined based on the specifications from the IBM Mineral Year Book, 2020 (Refer to Table 10.2). Cutoff grade for Cement Grade of Limestone is min 42% Cao and 3.5 % MgO max. The analysis of core samples and related pitting/bedrock samples shows they meet the cut-off grades for three limestone categories: Cement Grade, Cement (Blendable/Beneficiable), and Blendable.

2) Stopping Width

Mining of Limestone in the area will be done by the open-cast method, hence it is not applicable.

3) True Width of the Ore Zone

Eight boreholes were drilled vertically into horizontally to sub-horizontally bedded limestone. The true width of the different limestone grades equals the combined thickness of all core samples that fall within each grade, as per the IBM Mineral Year Book, 2020.

Table No 19.1: Borehole-wise and depth-wise grade and resource (Grade specification as per IBM Yearbook, 2020).

BH. No.	Band No	Depth (m)		Thickness (m)	Grade
		From (m)	To (m)		
BH-1	1	4	9	5	Blendable
	2	10	12	2	Blendable
BH-2	1	4	6	2	Cement
	2	7	9	2	Cement
	3	10	18	8	Cement
BH-4	1	1	3	2	Cement
	2	4	9	5	Cement
	3	10	12	2	Cement
	4	13	15	2	Cement
	5	16	18	2	Cement
	6	19	21	2	Blendable /Benificiable
	7	23	26	3	Blendable
	8	26	30	4	Blendable /Benificiable
BH-5	1	1	3	2	Cement
	2	4	5	1	Cement
	3	6	12	6	Cement
	4	13	15	2	Cement
	5	16	17	1	Cement
	6	17	21	4	Blendable
	7	21	25	4	Blendable
	8	27	30	3	Blendable
	9	31	33	2	Blendable /Benificiable
	10	35	40	5	Blendable /Benificiable
BH-8	1	6	9.5	3.5	Blendable /Benificiable
BH-9	1	3	10	7	Blendable /Benificiable

4) Area of Influence Around Each Borehole

Exploration drilling in the block was carried out through eight vertical boreholes arranged in a random and zig-zag pattern, with a spacing between each borehole of more than 1500 m. as per MEMC Rule 2015. In view of the above, the present Limestone deposit is placed under the G4 stage of the MEMC Rule 2015 Reconnaissance Survey Stage (G4). Eight boreholes, namely (BH-1, BH-2, BH-4, BH-5, BH-6, BH-7, BH-8, and BH-9) were drilled in which the occurrence of limestone was found. The entire two-borehole Shale was encountered in BH-6 & BH-7; therefore, it was excluded from resource estimation. The limestone resources were estimated using the Polygonal (Thiessen Polygon) Method. The area of influence of each borehole was obtained by constructing Thiessen polygons around the boreholes, considering the geological continuity established from both surface and subsurface data. Where borehole control was absent, but positive pit exposures

and bedrock samples indicated continuity of mineralization, the polygon boundaries were defined based on geological interpretation.

The thickness of mineralized limestone intersected in each borehole was assigned to the corresponding polygon area. Resource volume was computed by multiplying the polygon area by the true mineralized thickness, and tonnage was derived by applying the appropriate bulk density. Average grades for the various limestone categories were calculated from the borehole samples and assigned to their respective polygons for resource estimation.

5) Bulk density

The Bulk density of the core samples was tested at the RKCT, Geotechnical Lab in Jabalpur. The results showed a range between 2.50 and 2.65. Based on the laboratory results, for resource estimation, a bulk density of 2.60 was adopted. The details of the Bulk density test results for the samples are provided in Table 10.3. Refer Annexure-VI.

Table No. 19.2 Bulk Density Test Results of Five BRS & Core Samples

S. No	Sample ID	Bulk Density g/cm ³	Latitude	Longitude	Type	From (m)	To (m)	Lithology
1	N/L/BD/S-3	2.50	24° 0'44.10"N	80°33'23.81"E	BH-02	23	24	Limestone
2	N/L/BD/S-4	2.65	24° 1'42.43"N	80°35'2.97"E	BH-05	48	49	Limestone
3	N/L/BD/S-5	2.65	24° 2'0.48"N	80°36'45.42"E	BH-09	12	13	Limestone
	Average	2.60						

6) Weighted Average of the Different Grades of Limestone

The mineralized zones in the five boreholes have been classified based on the specifications in the IBM Mineral Year Book, 2020. Weighted averages of CaO, SiO₂, MgO, Al₂O₃, and Fe₂O₃ were used to identify limestone bands of different grades. The weighted average for each borehole was calculated based on the grades that met the cut-off criteria. The final weighted average for each limestone grade (Cement), (Cement Blendable/ Beneficiable), and (Blendable) was calculated across all boreholes using the following formula

$$G = \frac{(As_1 * L_1) + (As_2 * L_2) + \dots + (As_n * L_n)}{L_1 + L_2 + \dots + L_n}$$

where; G = Weighted average, As₁ = Assay value of sample, and L₁ = Length of sample.

7) Methodology of limestone resource estimation

The primary objective of ore reserve estimation is to determine the volume, grade and economic feasibility of commercially extracting the mineralized material. In the Nanhwara-Kymore Limestone Block, resource estimation was conducted using the Polygon Method.

19.3.0 PARAMETERS FOR RESOURCE ESTIMATION

19.3.1 SAMPLING PROCEDURE

A total of 237 core samples from eight boreholes were collected and prepared for chemical analysis. The sample preparation process began with longitudinal splitting of each core sample into two halves using a core splitter. One-half of each sample was carefully preserved as a reference, while the other half was processed for analysis. The processed half was pulverized to a particle size of more than 120 mesh using a mechanical grinder. The powdered samples were then homogenized through thorough mixing and blending to ensure compositional uniformity and eliminate any potential variations within each sample. Following homogenization, the samples were subjected to coning and quartering to produce two equal sub-samples of approximately 250 grams each. This technique ensured that representative sub-samples were obtained, guaranteeing that the analytical results would accurately reflect the composition of the entire core sample. One of the 250-gram sub-samples from each sample was submitted to the BSS Lab, Jabalpur (an NABL-accredited lab), for chemical analysis. The analysis focused on determining the major oxide composition of the samples. The remaining 250-gram sub-sample from each sample was actively preserved as a duplicate, serving as a backup to enable potential reanalysis or verification in the future if required.

19.3.2 CHEMICAL ANALYSIS

Based on the results from 237 chemical analyses, three distinct limestone bands have been identified within the study area, each characterized by different calcium oxide (CaO) content ranges. The first zone exhibits CaO concentrations ranging from 42 % to 52 %, indicating a high grade of limestone. The second zone shows slightly lower CaO levels, varying between 38% and 44% third band varying between 34% 38% CaO. These variations in CaO content help in classifying the limestone quality across different sections of the area. Refer Annexure IV.

19.4.0 OVERBURDEN

Overburden of limestone includes the top layer of soil and subsequent sticky clay, which lies immediately above the Limestone in the Nanhwara Kymore Limestone Block. The minimum overburden of soil cover is 3.00m in BH-09, and the maximum is 8.0 m in MRB-08. The average thickness of the overburden in the block is around 13.33 m.

19.5.0 METHODOLOGY

The resources have been estimated by the polygonal method as per MEMC rules, 2015 (Amended 2021). The methodology adopted, keeping the above assumptions in view, for resource estimation is described further.

19.6.0 METHODOLOGY ADOPTED IN POLYGONAL METHOD FOR RESOURCE ESTIMATION (PRINCIPAL METHOD)

The main objective of this method is to demarcate the area of influence of the limestone intersected by a particular borehole. The influence area has been obtained by constructing polygons by drawing perpendicular bisectors of triangles and rectangles that connect the adjoining boreholes. The area of the influence of zones has been ascertained by Auto-Cad software. The area of non-development of respective zones is shown on the resources plan. The height of polygons is the cumulative thickness of limestone horizon/bands encountered by the corresponding borehole. The entire limestone body in a block is divided into number of polygons. The zone wise borehole wise resources estimation by Polygonal method for Cement Grade, Blendable Grade and Blendable / Beneficial grade of Limestone of this block are calculated.

19.7.0 Core samples Analysis

A total of 237 Nos. Core samples were collected at 1-meter intervals using standard rotary drilling procedures to ensure consistency and representativeness of the subsurface material. Each recovered core was carefully split into two halves immediately after extraction. One-half was designated for sample preparation and subsequent laboratory analysis, while the other half was securely stored in labeled core boxes for archival purposes and later submission to the state unit GSI, Bhopal, thereby maintaining a permanent record of the drilling program. Half of the core samples were then divided into two parts: one part was kept as the original sample, and the other was sent to the Chemical analysis BSS Lab, Jabalpur, for geochemical analysis of various oxides, including CaO, SiO₂, MgO, MnO₂, Na₂O, K₂O, TiO₂, P₂O₅, Al₂O₃, Fe₂O₃, Cl & LOI.

Method of Chemical Analysis

Representative samples collected from the bedrock and drill cores were subjected to wet chemical analysis for the determination of major oxides and deleterious constituents. The analyses were carried out following the standard procedures prescribed by the Bureau of Indian Standards (BIS) (IS:1760), IBM Manual of Procedure (IBM, 2012), and other accepted analytical protocols.

The samples were initially dried, pulverized to 200 mesh fineness, and accurately weighed (1 g). The powdered material was decomposed by acid digestion using suitable mineral acids depending upon the nature of the sample. In cases where complete dissolution could not be achieved through acid treatment, fusion techniques employing appropriate fluxes were adopted.

The resulting solutions were analysed using conventional gravimetric and volumetric methods. Silica (SiO_2) was determined gravimetrically after dehydration and filtration, whereas calcium oxide (CaO) and magnesium oxide (MgO) were estimated by EDTA complexometric titration. Total iron, wherever applicable, was determined by standard redox titration using potassium dichromate. Other constituents were analysed by suitable wet chemical procedures based on their chemical characteristics.

Wet chemical analysis provides reliable and accurate results and is widely accepted as a reference method for determining the chemical composition of mineral samples.

The analytical data generated through this method formed the basis for assessing the grade characteristics and industrial suitability of the mineralized horizons encountered during the investigation.

The analytical results obtained from wet chemical methods were utilized to evaluate the suitability of the limestone for cement, metallurgical flux, and other industrial applications based on the concentrations of CaO , MgO , SiO_2 , Al_2O_3 , Fe_2O_3 , and Loss on Ignition (LOI). In accordance with GSI-NABET guidelines, these analytical results were integrated with geological and lithological information for the delineation of mineralized zones and the assessment of the quality characteristics of the limestone deposit.

The borehole-wise chemical distribution is as follows

Bivariate scatter plots combined with ordinary least squares (OLS) linear regression provide a rigorous mathematical framework for evaluating deposit homogeneity, impurity distribution, and mineralogical correlations. In carbonate exploration, the behavior of major oxides defines the core lithological domains, guides ore-grading protocols, and indicates down-hole deposit quality variations.

This analysis delivers a systematic borehole-by-borehole geochemical analysis for the Nanhwara Kymore Limestone Block (BH-1 through BH-9).

For each borehole, four baseline chemical relationships have been mathematically modeled to evaluate carbonate purity, dolomitization trends, silicate mineralogy, and volatile displacement:

1. CaO % vs SiO₂ %: Tracks the primary dilution of the limestone matrix by silicate impurities.
2. CaO % vs MgO %: Highlights stoichiometric replacement mechanisms indicating dolomitization degrees.
3. Al₂O₃ % vs SiO₂ %: Determines whether silica is hosted in structural clays (aluminosilicates) or free quartz silt.
4. LOI % vs SiO₂ %: Assesses volatile displacement metrics within the mineral matrix.

1. BH-1

Twenty-Five core samples analysis revealed that CaO content ranged from 22.92 % to 39.16%, while SiO₂ values varied from 15.46 % to 31.92 %. MgO content varies from 4.52 % to 11.05 %, Al₂O₃ from 1.90 % to 4.43 %, and Fe₂O₃ from 0.90 % to 3.18 %. Limestone was encountered at depths of 4–12m, with samples 1 to 7 showing relatively high CaO content. Refer Annexure IX.

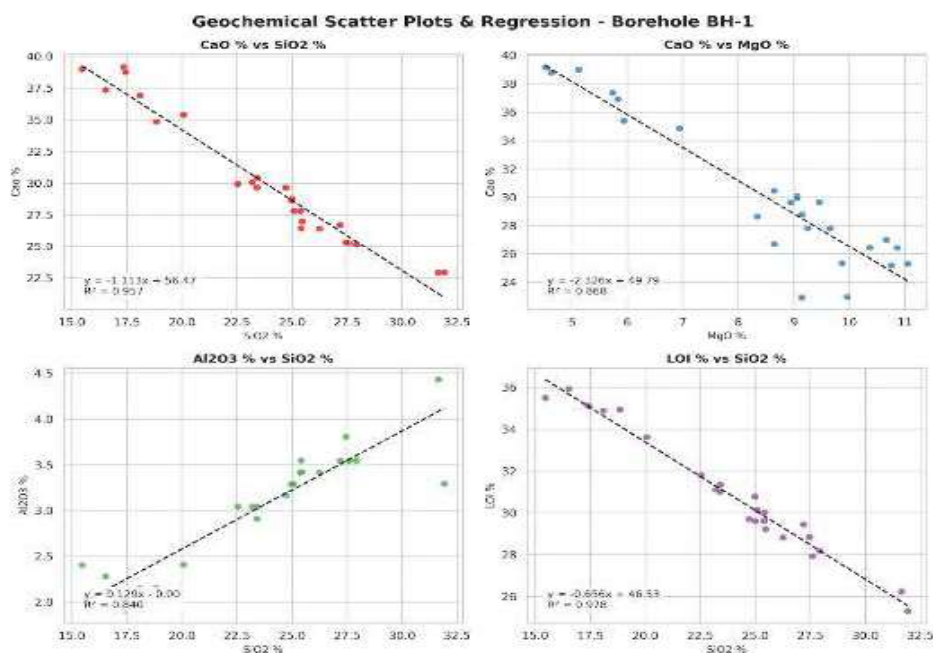


Figure No.19.1 Geochemical Scatter plot with Regression Model for BH-1

BOREHOLE: BH-1

CaO % vs SiO₂ % Regression Model: $y = -1.113x + 56.47 (R^2 = 0.957)$

Equation exhibits a highly predictable, high-confidence linear dilution trend. The slope ($m = -1.113$) establishes that every 1 % increase in silica directly compromises the calcium oxide concentration by 1.113 %. The theoretical pure calcite intercept (56.47 % CaO at 0 % SiO₂) aligns with high-purity limestone, confirming that the baseline rock matrix is exceptionally clean.

CaO % vs MgO % Regression Model: $y = -2.326x + 49.79 (R^2 = 0.868)$

A strong negative slope tracks systematic ion exchange within the crystal lattice.

As magnesium concentrations rise, calcium is replaced at a 2.326:1 ratio, verifying a structured transition into localized dolomitic limestone intervals.

Al₂O₃ % vs SiO₂ % Regression Model: $y = 0.129x - 0.00 (R^2 = 0.840)$

The strong positive correlation and near-zero intercept indicate that alumina and silica enter the depositional basin together. They maintain a fixed 1:8 weight ratio, confirming that clastic impurities are dominantly structural clay minerals (aluminosilicates).

LOI % vs SiO₂ % Regression Model: $y = -0.656x + 46.53 (R^2 = 0.978)$

The highest correlation coefficient in BH-1 confirms a binary system where non-volatile silicates displace volatile-releasing carbonates (CO₂).

2. BH-2

Twenty-Eight core samples analysis revealed that CaO content ranged from 22.10 % to 52.76 %, while SiO₂ values varied from 2.97 % to 27.58 %. MgO content ranged from 0.97 % to 13.97 %, Al₂O₃ from 0.89 % to 3.93 %, and Fe₂O₃ from 0.40 % to 2.99 %. Limestone was encountered at depths of 4–7m, with samples 1 to 12 & 17 showing relatively high CaO content. Refer Annexure IX.

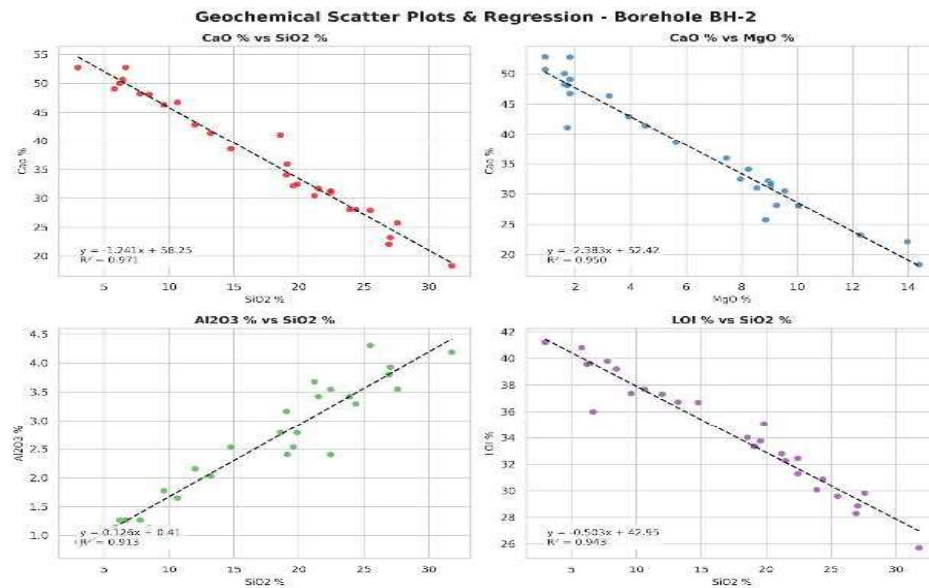


Figure No.19.2 Geochemical Scatter plot with Regression Model for BH-2

BOREHOLE: BH-2

CaO % vs SiO₂ % Regression Model: $y = -1.241x + 58.25 (R^2 = 0.971)$

BH-2 displays a highly rigorous linear fit. The steep slope ($m = -1.241$) indicates that the limestone quality is sensitive to silica influxes.

The high R^2 value (0.971) indicates excellent chemical uniformity, pointing to distinct stratification of high-grade vs low-grade beds.

CaO % vs MgO % Regression Model: $y = -2.383x + 52.42 (R^2 = 0.950)$

The R^2 value of 0.950 is a clear geochemical indicator of uniform, stoichiometric dolomitization. Fluctuations in magnesium concentration directly dictate the remaining calcium grade in a highly predictable manner.

Al₂O₃ % vs SiO₂ % Regression Model: $y = 0.126x + 0.41 (R^2 = 0.913)$

A tight linear fit verifies homogeneous clay mineral distributions throughout the core sequence. The small positive intercept (0.41 %) suggests minor excess alumina or distinct clay types.

LOI % vs SiO₂ % Regression Model: $y = -0.503x + 42.95 (R^2 = 0.943)$

Confirms typical volatile displacement patterns, demonstrating robust mineral structural integrity.

3. BH-4

Twenty-Four core samples analysis revealed that CaO content ranged from 27.87 % to 49.34 %, while SiO₂ values varied from 7.38 % to 26.17%. MgO content ranged from 1.00 % to 9.26 %, Al₂O₃ from 1.14 % to 3.98 %, and Fe₂O₃ from 0.598 % to 0.798 %. Limestone was encountered at depths of 4–29m, with samples 1-15 & 18-24, showing relatively high CaO content. Refer Annexure IX

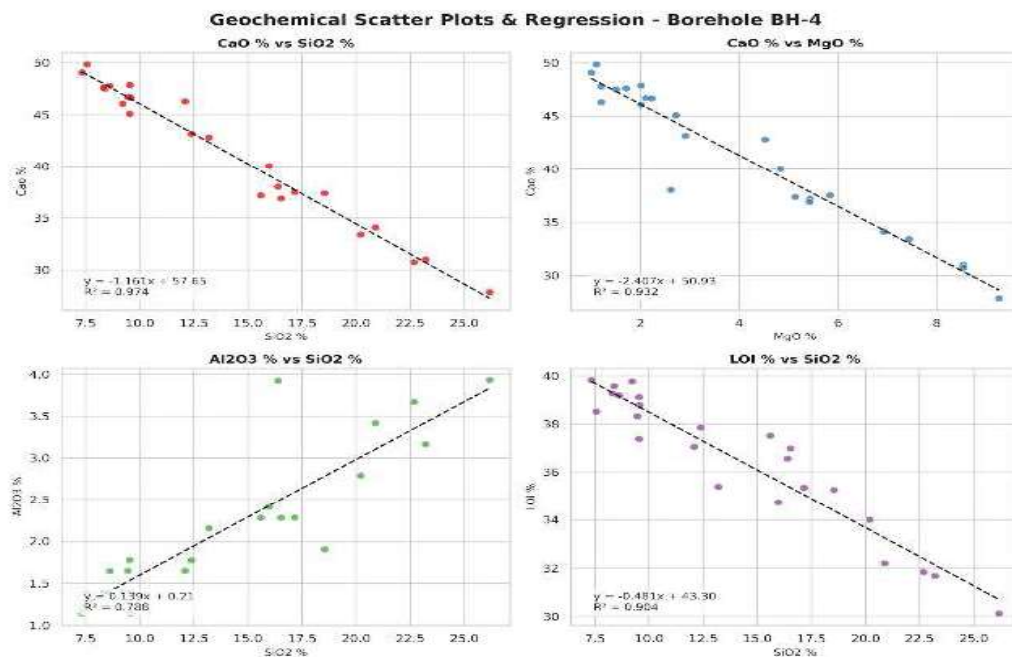


Figure No.19.3 Geochemical Scatter plot with Regression Model for BH-4

BOREHOLE: BH-4

CaO % vs SiO₂ % Regression Model: $y = -1.161x + 57.65 (R^2 = 0.974)$

BH-4 exhibits one of the most reliable calcite dilution trends in the deposit area. The R^2 of 0.974 proves that silica serves as the single primary control over CaO content variance.

CaO % vs MgO % Regression Model: $y = -2.407x + 50.93 (R^2 = 0.932)$

Indicates a clean, predictable line of magnesium substitution, defining a highly systematic dolomitic gradient down the profile.

Al₂O₃ % vs SiO₂ % Regression Model: $y = 0.139x + 0.21 (R^2 = 0.788)$

While the relationship remains strongly positive, the slight decrease in R^2 (0.788) hints at secondary clastic influxes, likely via thin intervals containing minor independent quartz grains or silty laminae.

LOI % vs SiO₂ % Regression Model: $y = -0.481x + 43.30 (R^2 = 0.904)$

Follows standard inverse carbonate-silicate scaling laws, establishing predictable weight loss curves during calcination.

4. BH-5

Fourth, the seven core samples analysis revealed that CaO content ranged from 19.42 % to 49.81 %, while SiO₂ values varied from 6.21 % to 33.02%. MgO content ranged from 1.61 % to 11.77 %, Al₂O₃ from 1.52 % to 4.05 %, and Fe₂O₃ from 0.70 % to 4.18 %. Limestone was encountered at depths of 4–40m, with samples 1-20,23-25,27-28,31-33,35-36 & 41 showing relatively high CaO content. Refer Annexure IX.

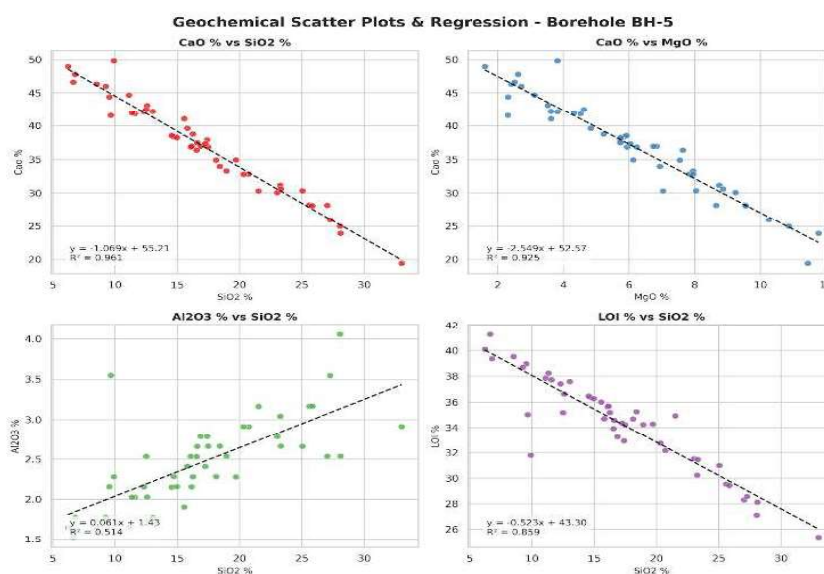


Figure No.19.4 Geochemical Scatter plot with Regression Model for BH-5

BOREHOLE: BH-5

CaO % Vs SiO₂ % Regression Model: $y = -1.069x + 55.21$ ($R^2 = 0.961$)

Reflects a stable, predictable dilution gradient across a long, continuous sample run. The intercept confirms a reliable, standard high-calcium carbonate matrix.

CaO % vs MgO % Regression Model: $y = -2.549x + 52.57$ ($R^2 = 0.925$)

The steep slope of -2.549 signals that magnesium substitution impacts the total calcium percentage more aggressively in this block, outlining prominent dolomitic sub-facies.

Al₂O₃ % vs SiO₂ % Regression Model: $y = 0.061x + 1.43$ ($R^2 = 0.514$)

Significant Geochemical Anomaly. The R^2 drops sharply to 0.514, and the slope flattens out to 0.061. This proves a multi-source origin for silica in BH-5.

Silica variations are no longer controlled solely by clay layers; instead, a major portion occurs as standalone free silica (chert nodules or quartz veins) independent of alumina.

LOI % vs SiO₂ % Regression Model: $y = -0.523x + 43.30$ ($R^2 = 0.859$)

The variance expands due to the irregular silica source distributions noted above, though it maintains a strong foundational negative trend.

5. BH-6

Twenty-Five core samples analysis revealed that CaO content ranged from 6.99 % to 24.87 %, while SiO₂ values varied from 37.31 % to 65.25%. MgO content ranged from 2.21 % to 5.52 %, Al₂O₃ from 4.43 % to 9.37 %, and Fe₂O₃ from 2.59 % to 6.67 %. Limestone was encountered at depths of 4–40m, with samples 1-20,23-25,27-28,31-33,35-36 & 41 showing relatively high CaO content. Refer Annexure IX.

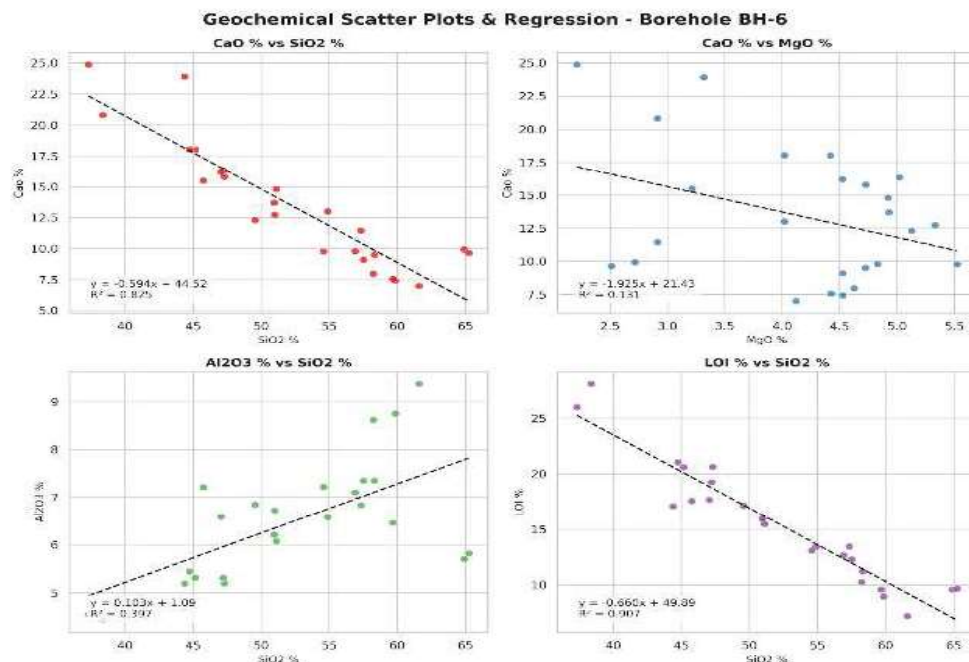


Figure No.19.5 Geochemical Scatter plot with Regression Model for BH-6.

BOREHOLE: BH-6

CaO % vs SiO₂ % Regression Model: $y = -0.594x + 44.52$ ($R^2 = 0.825$)

Lithological Transition Zone. The slope is significantly shallower ($m = -0.594$), and the absolute CaO intercept drops to 44.52 %.

This mathematically demonstrates that BH-6 intersects an inherently low-grade, highly siliceous lithofacies where the baseline rock matrix is mixed.

CaO % vs MgO % Regression Model: $y = -1.925x + 21.43$ ($R^2 = 0.131$)

Breakdown of Correlation. A very low R^2 (0.131) proves that MgO and CaO do not participate in systematic crystalline substitution within this borehole. Magnesium distributions are low and scattered, controlled by trace accessory minerals rather than structured dolomitization.

Al₂O₃ % vs SiO₂ % Regression Model: $y=0.103x+1.09(R^2=0.397)$

A weak linear fit ($R^2=0.397$) confirms that silica variations in BH-6 are predominantly driven by free quartz silt or secondary cherty precipitation, decoupled from clay influxes.

LOI % vs SiO₂ % Regression Model: $y=-0.660x+49.89(R^2=0.907)$

Despite erratic single-oxide dynamics, the broad-scale replacement of volatile-bearing matrices by stable silicates continues to hold a reliable linear trend.

6. BH-7

Twenty-Three core samples analysis revealed that CaO content ranges from 21.13 % to 28.42 %, while SiO₂ values varied from 28.89 % to 35.18%. MgO content ranges from 5.53 % to 14.69 %, Al₂O₃ from 2.68 % to 3.84 %, and Fe₂O₃ from 1.99 % to 3.18 %. No Limestone zone above 34 % Cao was encountered at any depths up to 0-30m. Refer Annexure IX.

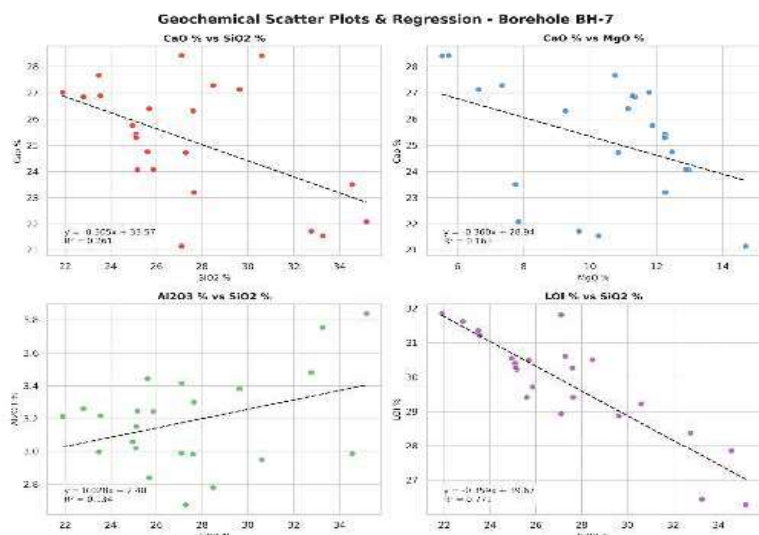


Figure No.19.6 Geochemical Scatter plot with Regression Model for BH-7

BOREHOLE: BH-7

CaO % vs SiO₂ % Regression Model: $y=-0.305x+33.57(R^2=0.261)$;

Major Depositional Anomaly. BH-7 shows a severe breakdown in the standard carbonate dilution model ($R^2=0.261$). The exceptionally low intercept (33.57 % CaO) strongly suggests that this core sequence does not represent true limestone beds. Instead, it indicates a highly altered, heavily contaminated argillaceous sequence (marly shale/clastic dominant domain) where calcium content does not scale directly against simple silica dilution.

CaO % vs MgO % Regression Model: $y=-0.360x+28.94(R^2=0.163)$

No organized dolomitization trends are present. The magnesium and calcium counts vary erratically within a clastic sediment framework.

Al₂O₃ % vs SiO₂ % Regression Model: $y=0.028x+2.40(R^2=0.134)$

The flat, scattered distribution indicates complex clastic sorting, where diverse sediment sources or post-depositional weathering decoupled aluminium concentrations from raw silica trends.

LOI % vs SiO₂ % Regression Model: $y=-0.359x+39.67(R^2=0.771)$

This represents the only statistically valid trend in BH-7, capturing the baseline displacement of carbonaceous mass by stable terrigenous inputs.

1. BH-8

Twenty-six core samples analysis revealed that CaO content ranged from 2.90 % to 42.97 %, while SiO₂ values varied from 12.90 % to 61.69 %. MgO content ranged from 1.00 % to 5.83 %, Al₂O₃ from 2.53 % to 10.52 %, and Fe₂O₃ from 1.69 % to 8.26 %. Limestone was encountered at depths of 6–9.50 m, with samples 1-4 showing relatively high CaO content. Refer Annexure IX.

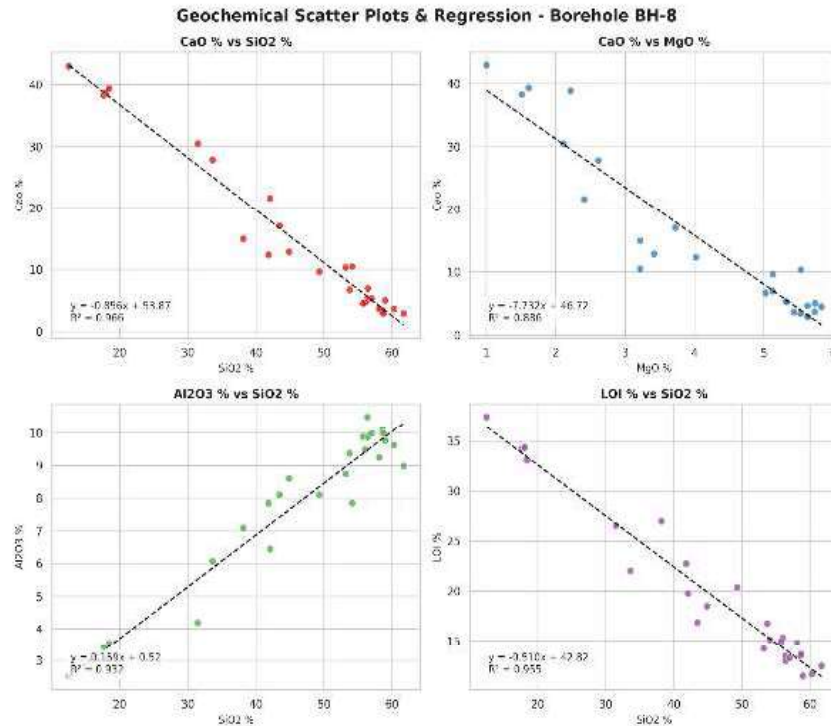


Figure No. 19.7 Geochemical Scatter plot with Regression Model for BH-8

BOREHOLE: BH-8

CaO % vs SiO₂ % Regression Model: $y = -0.856x + 53.87 (R^2 = 0.966)$

Exhibits a strong, highly continuous linear fit ($R^2 = 0.966$). The slope shows that quality decreases at a moderate rate, tracking standard cyclical shifts between limestone layers and silicate-rich beds.

CaO % vs MgO % Regression Model: $y = -7.732x + 46.72 (R^2 = 0.886)$

Distinct Mineralogical Feature. BH-8 features an unusually steep negative slope (-7.732). This indicates that even minor increases in magnesium oxide result in a severe reduction in calcium oxide levels. This suggests a sharp mineralogical transition into distinct magnesium-rich beds.

Al₂O₃ % vs SiO₂ % Regression Model: $y = 0.159x + 0.52 (R^2 = 0.932)$

An excellent linear correlation proves that silica variations are tied to clay frameworks, with a highly predictable clastic profile.

LOI % vs SiO₂ % Regression Model: $y = -0.510x + 42.82 (R^2 = 0.955)$

Follows a clean linear relationship, confirming typical volatile loss characteristics during carbonate breakdown.

2. BH-9

Twenty-Nine core samples analysis revealed that CaO content ranged from 19.60 % to 40.28 %, while SiO₂ values varied from 16.18 % to 34.09 %. MgO content ranged from 2.61 % to 13.36 %, Al₂O₃ from 1.90 % to 4.69 %, and Fe₂O₃ from 0.90 % to 2.98 %. Limestone was encountered at depths of 3–16.0 m, with samples 1-9 & 20 showing relatively high CaO content. Refer Annexure IX.

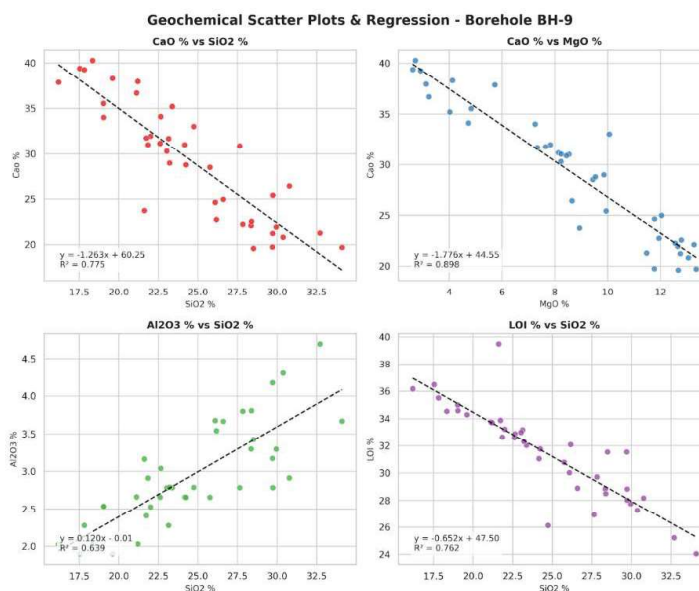


Figure No.19.8 Geochemical Scatter plot with Regression Model for BH-9

BOREHOLE: BH-9

CaO % vs SiO₂ % Regression Model: $y = -1.263x + 60.25 (R^2 = 0.775)$

Displays a robust negative trend but with increased scatter ($R^2 = 0.775$). The elevated intercept (60.25 %) reveals that the pure carbonate end members are high-grade, but the structural trend is partially disrupted by localized variations.

CaO % vs MgO % Regression Model: $y = -1.776x + 44.55 (R^2 = 0.898)$

A strong negative fit tracks regular crystalline substitution, marking a reliable dolomitic grading profile across the block.

Al₂O₃ % vs SiO₂ % Regression Model: $y = 0.120x - 0.01 (R^2 = 0.639)$

A moderate correlation suggests a mixed mineral system where silica is split between argillaceous clay components and free, non-alumina silica phases.

LOI % vs SiO₂ % Regression Model: $y = -0.652x + 47.50 (R^2 = 0.762)$

Tracks the CaO variance closely, matching the overall structural profile of the borehole.

DEPOSITIONAL & ECONOMIC SYNTHESIS

Based on the regression models across all eight boreholes, the Nanhwara- Kymore Limestone Block can be segmented into distinct geochemical domains:

High-Purity Uniform Limestone Domain (BH-1, BH-2, BH-4, BH-5): Characterized by extremely high R² values (>0.95) for CaO % vs SiO₂ % and high intercepts (42 % to 52 % CaO). These zones represent open, high-energy carbonate platforms where calcite precipitation was steady and interrupted only by regular influxes of uniform fine-grained clay. These boreholes represent prime targets for high-grade cement manufacturing or industrial lime feedstock.

Silicified & Free-Quartz Domains (BH-5 & BH-6 anomalies): While still retaining reasonable limestone traits, the distinct drop in the Al₂O₃ vs SiO₂ correlation indicates intervals enriched with free quartz or chert nodules. For industrial processing, this implies increased rock abrasiveness and potential variations in silica moduli that require adjustments during raw mix design.

The Clastic-Dominant Domain (BH-7): BH-7 represents a localized low-energy sub-basin, channel-fill deposit, or highly weathered profile where clastic shale inputs dominate over carbonate precipitation. Economically, this borehole represents low-grade overburden or sub-grade material requiring selective mining protocols.

Dolomitic Transition Sequences (BH-8 & BH-9): These blocks show strong structural tracking of magnesium oxide. The exceptionally steep replacement lines indicate zones where magnesian influxes have altered the limestone beds, necessitating close attention to total magnesium blending limits for industrial applications.

Pearson’s Correlation Coefficient for Borehole data chemical values.

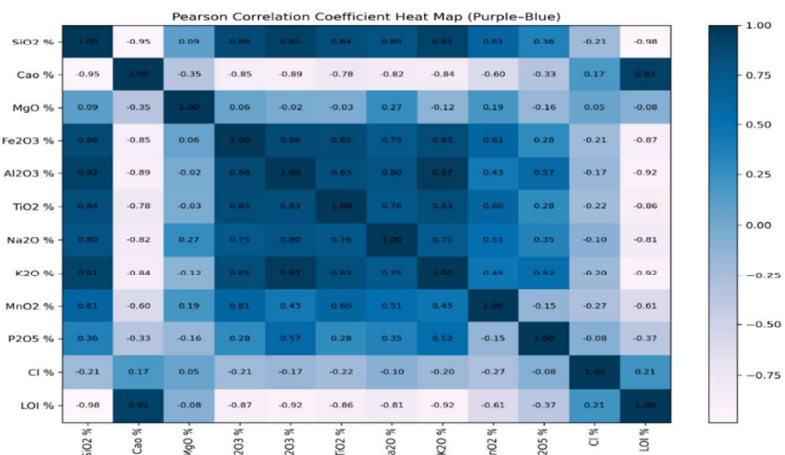


Figure No. 19.9 Showing Pearson’s Correlation Coefficient for Borehole data chemical values.

Detailed Description of Pearson's Correlation Coefficient Heat Map for Borehole Data Chemical Values-

The Pearson Correlation Coefficient Heat Map prepared for the geochemical data of the Nanhwara Kymore Limestone Block core samples illustrates the degree of linear relationship among major oxides and chemical constituents present in the study area. The correlation coefficient values range from +1 to -1, where positive values indicate direct proportionality between two variables and negative values indicate inverse relationships. The heat map provides important insight into the geochemical behavior, mineralogical association, and compositional variation of the limestone and associated lithologies.

The heat map reveals a very strong negative correlation between SiO_2 and CaO ($r = -0.95$), indicating that silica content increases with a corresponding decrease in lime content. This relationship is characteristic of limestone deposits where higher silica represents argillaceous or siliceous impurities, whereas higher CaO indicates relatively pure carbonate material.

Similarly, Loss on Ignition (LOI) shows a very strong positive correlation with CaO ($r = 0.92$) and a strong negative correlation with SiO_2 ($r = -0.98$). This indicates that carbonate-rich samples possess higher volatile content due to the decomposition of calcite during ignition, confirming the dominance of carbonate minerals in high-grade limestone zones.

Fe_2O_3 exhibits strong positive correlations with SiO_2 ($r = 0.86$), Al_2O_3 ($r = 0.86$), TiO_2 ($r = 0.85$), and K_2O ($r = 0.85$), suggesting a common association with clayey and terrigenous impurities. The positive association of Fe_2O_3 with alumina and titania indicates the presence of shale, clay, or ferruginous materials admixed with the limestone horizons. Al_2O_3 also demonstrates a very strong positive correlation with K_2O ($r = 0.97$) and strong positive relationships with TiO_2 ($r = 0.83$) and Na_2O ($r = 0.80$), which further supports the contribution of aluminosilicate minerals such as feldspar, clay minerals, and mica-bearing detrital components within the formation.

TiO_2 shows a strong positive correlation with Fe_2O_3 , Al_2O_3 , and SiO_2 , indicating that titanium-bearing minerals occur mainly within the non-carbonate silicate fraction. Similarly, Na_2O and K_2O display positive correlations with silica and alumina, suggesting the influence of feldspathic or clay-rich materials in the limestone sequence. MnO_2 exhibits moderate positive correlation with Fe_2O_3 ($r = 0.61$) and SiO_2 ($r = 0.61$), implying partial association with iron-bearing silicate phases and

secondary mineralization processes. MgO displays comparatively weak correlations with most oxides, indicating that magnesium-bearing minerals are not uniformly distributed within the study area. The weak negative correlation between MgO and CaO ($r = -0.35$) suggests limited dolomitization within the limestone horizons. P_2O_5 shows moderate positive correlation with Al_2O_3 and K_2O , indicating minor association with clay minerals or phosphatic impurities. Chlorine (Cl) exhibits generally weak correlations with other constituents, suggesting localized or insignificant geochemical influence.

Overall, the correlation matrix indicates that the limestone deposits are characterized by two dominant geochemical associations: (i) carbonate-rich components represented by high CaO and LOI values, and (ii) silicate-clastic impurities represented by SiO_2 , Fe_2O_3 , Al_2O_3 , TiO_2 , Na_2O , and K_2O .

The strong inverse relationship between carbonate and silicate constituents reflects varying degrees of purity within the limestone bands. From an industrial perspective, the high CaO and LOI values with lower silica and alumina content indicate the favorable suitability of selected limestone horizons for cement-grade applications. The heat map, therefore, serves as an important tool for understanding the geochemical characteristics, mineralogical control, and industrial potential of the limestone deposits in the Nanhwara Kymore Limestone Block.

19.8.0 CATEGORISATION OF RESOURCE

Resources have been categorized under Inferred (334) category of resources as per UNFC classification. The assumptions and parameters are already discussed earlier in this chapter.

Limestone zones are computed and categorized based on end use grade specifications prescribed by Indian Bureau of Mines. The average grades for 3 radicals CaO, MgO and SiO_2 have been calculated. Thus, average grade of the block is calculated for all grades of Limestone.

Table No. 19.3 Thickness of ore zone intersected in boreholes of Nanhwara Kymore Block, Katni District, Madhya Pradesh.

S. No.	Borehole No.	Total Depth of Drilling (m)	Depth of intersection of Limestone (m)	Thickness of Intersected Limestone (m)
1	BH-1	30	4	7
2	BH-2	30	4	12
3	BH-4	30	1	22

S. No.	Borehole No.	Total Depth of Drilling (m)	Depth of intersection of Limestone (m)	Thickness of Intersected Limestone (m)
4	BH-5	50	1	30
5	BH-6	30	-----	0
6	BH-7	30	-----	0
7	BH-8	30	6	3.5
8	BH-9	30	3	7

Table No.19.4 Borehole-wise and depth-wise grade and resource (Grade specification as per IBM Yearbook, 2020).

BH. No	Band No	Depth (m)		Thickness (m)	Grade
		From (m)	To (m)		
BH-1	1	4	9	5	Blendable
	2	10	12	2	Blendable
BH-2	1	4	6	2	Cement
	2	7	9	2	Cement
	3	10	18	8	Cement
BH-4	1	1	3	2	Cement
	2	4	9	5	Cement
	3	10	12	2	Cement
	4	13	15	2	Cement
	5	16	18	2	Cement
	6	19	21	2	Blendable /Benificiable
	7	23	26	3	Blendable
	8	26	30	4	Blendable /Benificiable
BH-5	1	1	3	2	Cement
	2	4	5	1	Cement
	3	6	12	6	Cement
	4	13	15	2	Cement
	5	16	17	1	Cement
	6	17	21	4	Blendable
	7	21	25	4	Blendable
	8	27	30	3	Blendable
	9	31	33	2	Blendable /Benificiable
	10	35	40	5	Blendable /Benificiable
BH-8	1	6	9.5	3.5	Blendable /Benificiable
BH-9	1	3	10	7	Blendable /Benificiable

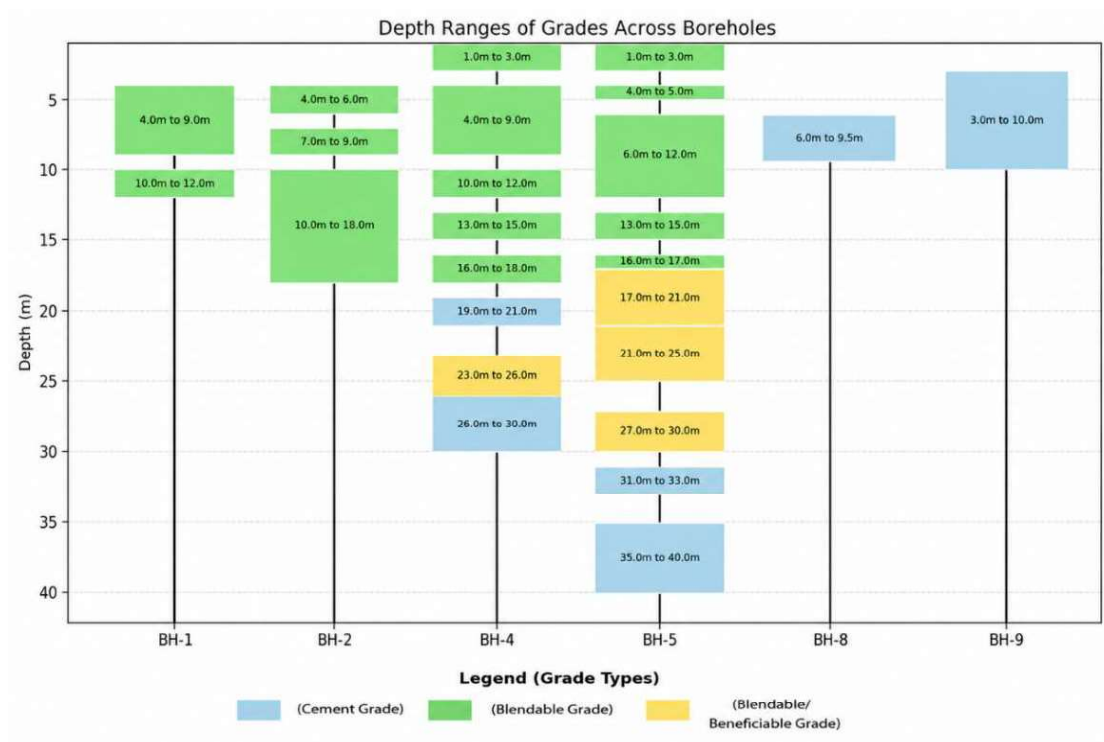


Figure No. 19.10 Graphical representation of the thickness and depth of limestone intersections in the boreholes.

CHAPTER – 20

20.0.0 REPORTING OF RESOURCE

20.1.0 RESOURCE ESTIMATION

Mineral resource estimation is a systematic and sequential process that integrates the precise definition of mineralization constraints (i.e., geological domains or ore zones) with statistical and geostatistical analysis of sample data, culminating in the application of a suitable grade interpolation technique. The primary objective of any geological survey conducted by the Engeotech Consultant, Jabalpur, is the reliable evaluation of the size, grade, quality, and lateral and vertical extent of rock, mineral, or other material occurrences—a process formally designated as resource estimation. This estimation is fundamental to determining the in-situ quantity, quality, and ultimately the commercial potential of the raw material under investigation. Resource estimation is an iterative exercise undertaken at every stage of exploration and mining, commencing from the preliminary (reconnaissance/unclassified) stage and continuing through the intermediate (prospecting/general exploration) to the final (detailed) stage of exploration. The entire methodology is predicated on the demonstrated continuity of the orebody along its strike, dip, true thickness, and grade, all of which are established through systematic drilling, sampling, and geological logging during exploration campaigns. The estimation of mineral resources is contingent upon a set of critical prerequisites, including the formulation of valid geological and mineralization assumptions, the maintenance of a well-documented, validated and audited sampling database, the precise three-dimensional definition of the ore zone (mineralized envelope) based on lithostratigraphic, structural and geochemical controls, and the careful consideration of key parameters such as strike length, true width, cut-off grade and comprehensive geological interpretation. Through the rigorous and integrated evaluation of these controlling factors, in accordance with nationally and internationally recognized reporting codes (e.g., UNFC, Minerals (Evidence of Mineral Contents) Rules 2015 and Minerals (Evidence of Mineral Contents) Amendment Rules, 2021), it is possible to reliably estimate the size, shape and physical-chemical characteristics of the orebody, thereby facilitating informed decisions regarding further exploration, resource classification, and potential economic extraction.

The estimation of mineral resources is contingent upon a set of critical prerequisites, including the formulation of valid geological and mineralization assumptions, the maintenance of a well-documented, validated, and audited sampling database, and the precise three-dimensional definition of the ore zone (mineralized envelope) based on lithostratigraphic, structural, and geochemical controls. Key parameters that must be carefully evaluated during this process include strike length, true width (thickness), cut-off grade, and comprehensive geological interpretation. Through the

rigorous and integrated evaluation of these controlling factors, in accordance with nationally and internationally recognized reporting codes UNFC, Minerals (Evidence of Mineral Contents) Rules 2015, and Minerals (Evidence of Mineral Contents) Amendment Rules, 2021, it is possible to reliably estimate the size, shape, and physical-chemical characteristics of the orebody.

In the Nanhwara Kymore Limestone Block, 237 core samples were analyzed at the BSS Lab, Jabalpur, an NABL-accredited lab. These samples were tested for major oxides, including SiO_2 , Al_2O_3 , Fe_2O_3 , CaO , MgO , Na_2O , TiO_2 , P_2O_5 , and K_2O . The borehole cores were thoroughly logged in detail and the analytical results are provided in Annexure IX. To classify the different grades of limestone, a weighted average was calculated for key components like CaO and SiO_2 . According to the threshold values prescribed by IBM's End Use Grade classification, limestone is categorized as follows:

4. Cement Grade (Portland): CaO 42% to 52%
5. Cement Grade (Blendable): CaO 38% to 42%
6. Blendable Grade: CaO 34% to 38%

Additionally, MgO content is up to 4%, SiO_2 ranges from 12% to 16%, Fe_2O_3 from 1% to 2%, and Al_2O_3 from 1% to 2% for estimating the grade of limestone.

20.1.1 Polygonal method

The Polygonal method of ore estimation is one of the simplest and most widely used geological methods for estimating ore reserves from borehole, pit, or sampling data. It is also called the Thiessen Polygon Method or Area of Influence Method. This method assumes that each borehole represents the ore characteristics within a surrounding area known as its zone of influence.

This method was utilized for resource estimation. The calculation involves the following parameters:

1. Borehole coordinates
2. Ore thickness
3. Depth of ore zone
4. Assay values/grade
5. Bulk density or specific gravity

Tonnage Calculation: The Tonnage of the deposit was calculated using the following formula:

Ore Reserve = $A \times T \times \rho$, where: A = Polygon area, T = Ore thickness (True Thickness), ρ = Bulk density/specific gravity.

Table No. 20.1 Showing Borehole wise calculation of Polygonal Area.

Block	Borehole No.	Polygonal Area
Nanhwara	BH-01	2681337
Kymore	BH-02	2449822
Limestone Block	BH-04	2588622
	BH-05	2533078
	BH-08	2517391
	BH-09	2477878

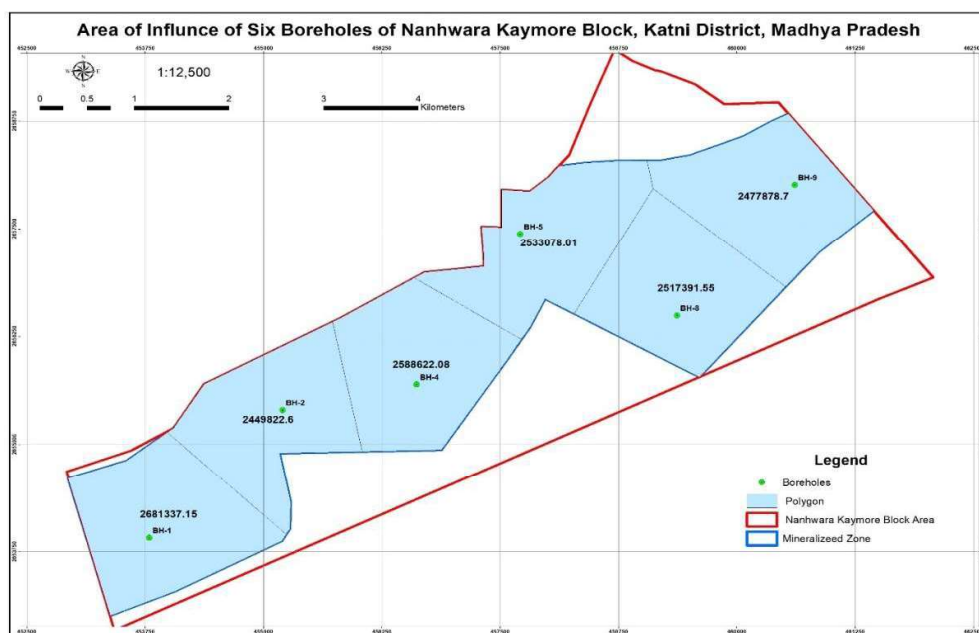


Figure No.20.1 Influence area of each borehole calculated by the polygon area method for the Nanhwara Kymore block, Katni District, Madhya Pradesh.

The estimation of resources for various grades of limestone was calculated based on the criteria and assumptions.

Table No. 20.2 Ore resource estimation of BH-1 for Cement (Blendable) grade at CaO 34-38% and MgO $\geq$ 5% cut-off (as per IBM Mineral Yearbook, 2020) by polygonal method for the Nanhwara-Kymore Block, Katni District, Madhya Pradesh.

S. No	Bore Hole No	Mineralized Zone	True Thickness	Area of Influence	Volume (m ³)	Bulk density	Tonnage (T)	50 % Deduction	Wt. Average Grade	Net Tonnage	Ore
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		(From-To) m	(m)	(m ²)							(MT)	
			(a)	(b)	c=a*b	(d)	e=c*d		Cao	Mgo		
1	BH-1	4-9	4.83	26813 37	12950 858	2.6	33672 230	168361 15	37. 80	5.40	16.8 3	Blendable
2	BH-I	10-12	1.93	26813 37	51749 80	2.6	13454 949	672747 5	36. 05	5.88	6.73	Blendable

Table 20.3 Ore resource estimation of BH-2 for Cement grade at CaO 42-52% and MgO ≤ 5% cut-off (as per IBM Mineral Yearbook, 2020) by polygonal method for the Nanhwara-Kymore Block, Katni District, Madhya Pradesh.

S. No	Bore Hole No	Mineralized Zone (From-To) m	True Thickness (m)	Area of Influence (m ²)	Volume (m ³)	Bulk density	Tonnage (T)	50 % deduction	Wt. Average Grade		Net Tonnage (MT)	Ore
			(a)	(b)	c=a*b	(d)	e=c*d		Cao	Mgo		
1	BH-2	4-6	1.93	244982 2	472815 6	2.6	122932 05	614660 3	45.0 8	1.30	6.15	Cement
	BH-2	7-9	1.93	244982 2	472815 6	2.6	122932 05	614660 3	47.2 8	2.41	6.15	Cement
	BH-2	10-18	7.73	244982 2	189371 24	2.6	492365 22	246182 61	47.5 4	2.40	24.6 2	Cement

Table No. 20.4 Ore resource estimation of BH-4 for Cement (Blendable) grade at CaO 42-52% and MgO ≤ 5% and CaO 34-38% and MgO ≥ 5% cut-off (as per IBM Mineral Yearbook, 2020) by polygonal method for the Nanhwara-Kymore Block, Katni District, Madhya Pradesh.

S. No	Bore Hole No	Mineralized Zone (From-To) m	True Thickness (m)	Area of Influence (m ²)	Volume (m ³)	Bulk density	Tonnage (T)	50 % deduction	Wt. Average Grade		Net Tonnage (MT)	Ore
			(a)	(b)	c=a*b	(d)	e=c*d		Cao	Mgo		

1	BH-4	1-3	1.93	2588622	5000834	2.6	13002168	6501084	48.88	1.15	6.50	Cement
2	BH-4	4-9	4.83	2588622	12502084	2.6	32505419	16252710	45.04	1.66	16.25	Cement
3	BH-4	10-12	1.93	2588622	5000834	2.6	13002168	6501084	45.45	2.29	6.50	Cement
4	BH-4	13-15	1.93	2588622	5000834	2.6	13002168	6501084	43.87	2.42	6.50	Cement
5	BH-4	16-18	1.93	2588622	5000834	2.6	13002168	6501084	47.26	2.12	6.50	Cement
6	BH-4	19-21	1.93	2588622	5000834	2.6	13002168	6501084	35.88	5.95	6.50	Blendable
7	BH-4	23-26	2.90	2588622	7501251	2.6	19503251	9751626	40.36	4.87	9.75	Cement
8	BH-4	26-30	3.86	2588622	10001667	2.6	26004335	13002168	34.75	6.75	13.00	Blendable

Table No. 20.5 Ore resource estimation of BH-5 for Cement (Blendable) grade at CaO 42-52% and MgO ≤ 5% and Cao 34-38% and MgO ≥ 5% cut-off (as per IBM Mineral Yearbook, 2020) by polygonal method for the Nanhwara-Kymore Block, Katni District, Madhya Pradesh.

S. No	Bore Hole No	Mineral ized Zone (From-To) m	True Thick ness (m)	Area of Influen ce (m2)	Volu me (m3)	Bulk densit y	Tonna ge (T)	50 % deduct ion	Wt. % Average Grade		Net Tonna ge (MT)	Ore
									Ca o	M go		
			(a)	(b)	c=a*b	(d)	e=c*d					
1	BH-5	1-3	1.93	2533078	4893531	2.6	12723180	6361590	44.95	1.99	6.36	Cement
2	BH-5	4-5	0.97	2533078	2446765	2.6	6361590	3180795	46.85	2.40	3.18	Cement
3	BH-5	6-12	5.80	2533078	14680593	2.6	38169541	19084771	44.25	3.01	19.08	Cement
4	BH-5	13-15	1.93	2533078	4893531	2.6	12723180	6361590	44.23	3.31	6.36	Cement
5	BH-5	16-17	0.97	2533078	2446765	2.6	6361590	3180795	41.96	4.32	3.18	Cement

S. No	Bore Hole No	Mineral ized Zone (From-To) m	True Thick ness (m)	Area of Influen ce (m2)	Volu me (m3)	Bulk densit y	Tonna ge (T)	50 % deduct ion	Wt. % Average Grade		Net Tonna ge (MT)	Ore
			(a)	(b)	c=a*b	(d)	e=c*d		Ca o	M go		
6	BH-5	17-21	3.86	2533078	9787062	2.6	25446361	12723181	38.18	5.57	12.72	Blendable/Beneficial
7	BH-5	21-25	3.86	2533078	9787062	2.6	25446361	12723181	43.49	6.54	12.72	Blendable/Beneficial
8	BH-5	27-30	2.90	2533078	7340296	2.6	19084771	9542386	39.42	9.04	9.54	Blendable/Beneficial
9	BH-5	31-33	1.93	2533078	4893531	2.6	12723180	6361590	36.90	7.92	6.36	Blendable/Beneficial
10	BH-5	35-40	4.83	2533078	12233827	2.6	31807951	15903976	36.73	7.85	15.90	Blendable/Beneficial

Table No. 20.6 Ore resource estimation of BH-8 for Cement (Blendable) grade at CaO 38-42% and MgO ≥ 5% cut-off (as per IBM Mineral Yearbook, 2020) by polygonal method for the Nanhwara-Kymore Block, Katni District, Madhya Pradesh.

S. No	Bore Hole No	Mineralized Zone (From-To) m	True Thickness (m)	Area of Influence (m ²)	Volume (m ³)	Bulk density	Tonnage (T)	50 % deduction	Wt. Average Grade		Net Tonnage (MT)	Ore
			(a)	(b)	c=a*b	(d)	e=c*d		CaO	MgO		
1	BH-8	6-9.5	3.38	2517391	8508782	2.6	43551184	21775592	39.85	1.99	21.77	Blendable / Beneficial

Table No. 20.7 Ore resource estimation of BH-9 for Cement (Blendable) grade at CaO 38-42% and MgO ≥ 5% cut-off (as per IBM Mineral Yearbook, 2020) by polygonal method for the Nanhwara-Kymore Block, Katni District, Madhya Pradesh.

S. No	Bore Hole No	Mineralized Zone (From-To) m	True Thickness (m)	Area of Influence (m ²)	Volume (m ³)	Bulk density	Tonnage (T)	50% deduction	Wt. Average Grade		Net Tonnage (MT)	Ore
			(a)	(b)	c=a*b	(d)	e=c*d		CaO	MgO		
1	BH-9	3-10	6.76	2477878	16750455	2.6	43551184	21775592	37.30	3.55	21.77	Blendable / Beneficial

**Table No. 20.8 Total Ore Resource Estimation from Six Boreholes in the Nanhwara-Kymore
Block, Katni District, Madhya Pradesh.**

S. No	Bore Hole No	Tonnage (MT)		
		Tonnage		
		Grade		
		Cement (Cement Grade) CaO 42%-52 and MgO $\leq$ 5%	Cement (Blandable/Beneficial) CaO 38-42% and MgO $\leq$ 5%	Blandable CaO 34-38% and MgO $\leq$ 4%
1	BH-1	0	0	23.56
2	BH-2	36.91	0	0
3	BH-4	52.01	0	19.50
4	BH-5	38.17	57.25	0
5	BH-8	0	21.77	0
6	BH-9	0	21.77	0
		127.09	100.79	43.06
Total		270.94 (MT) having UNFC Code 334		

CHAPTER – 21

21.0.0 SUMMARY AND RECOMMENDATIONS

21.1.0 SUMMARY

The Reconnaissance Survey (G4 Stage) for limestone was carried out in the Nanhwara–Kymore Limestone Block, covering an area of 22.52 sq. km in Vijayraghavgarh Tehsil, Katni District, Madhya Pradesh, under the financial assistance of the National Mineral Exploration Trust (NMET). The area forms part of the Rohtasgarh Limestone Formation of the Semri Group, Vindhyan Supergroup, a region well known for extensive cement-grade limestone deposits. The investigation comprised geological mapping, DGPS survey, pitting, drilling, geochemical analysis, petrographic studies, and bulk density determination to evaluate the occurrence, continuity, quality, and resource potential of limestone.

Geological investigations indicate that the area is predominantly underlain by bedded limestone with minor shale intercalations. The limestone is generally grey to dark grey, compact, fine-grained, and exhibits good lateral continuity. Structurally, the area is simple, characterized by gently dipping strata with minor joints and fractures and no major faulting or folding, making it favourable for future mining operations.

A total of eight boreholes were drilled, and 237 core samples, 40 bedrock samples, pit samples, and check samples were analysed for major oxides. Petrographic studies confirm that the limestone consists predominantly of microcrystalline calcite with minor quartz and argillaceous matter. Geochemical results indicate that the deposit contains Cement Grade, Blendable Grade, and Blendable/ Benificable Grade limestone, suitable for cement and allied industries.

Mineral resources were estimated using the Polygonal (Thiessen Polygon) Method in accordance with the Minerals (Evidence of Mineral Contents) Rules, 2015, and UNFC guidelines. The limestone deposit has been classified under UNFC Code 334 (Reconnaissance Mineral Resource), with an estimated inferred resource of approximately 270.94 million tonnes.

The investigation has successfully achieved the objectives of the G4-stage exploration by establishing the occurrence, continuity, quality, and resource potential of the limestone deposit. Considering the favourable geological setting, significant inferred resources, and proximity to major cement industries in the Katni–Satna Cement Belt, the block is recommended for G3 (Preliminary

Exploration) through closer-spaced drilling to enhance geological confidence and upgrade the mineral resource category.

21.2.0 RECOMMENDATIONS

The present G4 stage exploration has established the occurrence of laterally persistent limestone horizons of the Rohtasgarh Formation with significant resource potential within the Nanhwara–Kymore Limestone Block. The exploration results indicate favorable geological conditions for further detailed investigation. In view of the substantial inferred limestone resources estimated under UNFC Category 334, the block is recommended for advancement to the G3 (Preliminary Exploration) stage to improve the level of geological confidence and resource classification. Additional core drilling on a closer grid spacing is recommended to establish the continuity, thickness variation, grade distribution, and structural disposition of the limestone horizons with greater accuracy. Detailed geochemical studies, including systematic analysis of major oxides and deleterious constituents, should be undertaken to delineate grade-wise limestone domains and assess their suitability for cement, steel, lime, and other industrial applications. Geotechnical and hydrogeological investigations are recommended during subsequent stages of exploration to evaluate rock mass characteristics, groundwater conditions, and mineability of the deposit. Detailed topographic and geological modelling using integrated surface and subsurface data should be carried out for the preparation of a three-dimensional geological model and refined resource estimation.

Beneficiation and blending studies may be undertaken for limestone horizons containing marginal-grade material to evaluate their potential utilization in cement manufacture.

Considering the sizeable limestone resources, favorable geological setting, and proximity to major cement industries in the Katni–Satna Cement Belt, the block possesses good potential for future commercial exploitation.

The results of the present investigation provide a reliable geological basis for resource augmentation and future mine planning. Therefore, the block is recommended for detailed exploration and subsequent mineral development in accordance with the provisions of the MMDR Act, Minerals (Evidence of Mineral Contents) Rules, 2015, and UNFC guidelines. Based on the encouraging exploration results and estimated limestone resources of 270.94 million tonnes (UNFC-334), the Nanhwara–Kymore Limestone Block is considered suitable for further exploration under G3 stage and eventual development as a captive or merchant limestone source for the cement industry.

CHAPTER - 22

22.0.0 PLATES AND MAPS

22.1.0 Plate No.-I Location Map of Nanhwara Kymore Limestone Block Area

22.2.0 Plate No.-II Location Map of Nanhwara Kymore Limestone Block on Toposheet

22.3.0 Plate No.-III Location Map of Nanhwara Kymore Limestone Block on DRM

22.4.0 Plate No.-IV Topographic Map of the Nanhwara Kymore Limestone

22.5.0 Plate No.-V Large Scale Surface Geological Map of Nanhwara Kymore Limestone Block

22.6.0 Plate No.-VI Geological Cross Sections

22.7.0 Plate No.-VII Bed Rock Sample Location Map

22.8.0 Plate No.-VIII Proposed Bore Hole Location Map

22.9.0 Plate No.-IX Drilled Bore Hole Location Map

22. 10.0 Plate No.-X Large Scale Geological Map of Nanhwara Kymore Limestone Block

22.11.0 Plate No.-XI Pit Details of TS-1

22.12.0 Plate No.-XII Pit Details of TS-2

22.13.0 Plate No.-XIII Pit Details of TS-3

22.14.0 Plate No.-XIV Area Influence of Six Boreholes

CHAPTER – 23

23.0.0 ANNEXURE / ENCLOSURES TO THE REPORT

23.1.0 The report includes all the relevant annexures and maps/ plans, sections, and photographs, etc. A list of annexures, tables, maps/plans/sections, photographs, figures, etc., is provided before the start of the text and part of the Geological Report.

CHAPTER –24

24.0.0 ANY OTHER INFORMATION

24.1.0 UTILISATION ASPECTS AND MINEABILITY (AS PER NATIONAL COUNCIL FOR CEMENT AND BUILDING MATERIALS)

- 24.1.1 The specifications of limestone for various industrial used are as follows
24.1.2 CEMENT INDUSTRY SPECIFICATION

Table 24.1 Cement Industry Specification for Limestone

CaO	:	44% (min.) to 46%
MgO	:	3.50% (max.)
SiO ₂	:	16% (max.)
Al ₂ O ₃	:	2 (max.)
Fe ₂ O ₃	:	2% (max.)
SO ₃	:	1.75% (max.)

$$\text{Lime Saturation Factor (LSF)} = \frac{\text{CaO}}{2.8 (\text{SiO}_2) + 1.2 (\text{Al}_2\text{O}_3) + 0.65 (\text{Fe}_2\text{O}_3)}$$

(Ideal to be at 0.66 to 1.02)

$$\text{Silica Modules} = \frac{\text{SiO}_2}{\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3} = \text{ideal at (1.2 to 4.0)}$$

$$\text{Iron Modules} = \frac{\text{SiO}_2 + \text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3} = \text{ideal at (1.7 to 2.4)}$$

$$\text{Hydraulic Modules} = \frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3} = \text{ideal at (0.65 (min.))}$$

2. B. I. S. (BUREAU OF INDIAN STANDARDS) SPECIFICATION

Table 24.2 B. I. S. (Bureau of Indian Standards) Specification for Limestone

CaO (Min)	42%
MgO (Max.)	2.5%
SiO ₂ (Max.)	15%
P ₂ O ₅ (Max.)	1.5 %
FeS ₂ (Max.)	2%

IRON AND STEEL INDUSTRY:

24 Table 24.3 Iron and Steel Industry for Specification for Limestone

Elements	BF Grade	SMS Grade	LD Grade
CaO	42% (Min.)	48% (Min.)	52% (Min.)
MgO	4% (Max.)	3% (Max.)	2% (Max.)
SiO ₂	9% (Max.)	4% (Max.)	1% (Max.)
SiO ₂ + Al ₂ O ₃	11.5% (Max.)	-	-
Total Insoluble	12%	-	-
Acid Insoluble	-	6.5% (Max.)	-

1. CHEMICAL INDUSTRY SPECIFICATION

BIS Specifications (IS:3204-1978, Reaffirmed-2003)

Table 24.4 Chemical Industry Specification for Limestone

Characteristics	Requirement in percent by mass for			
	Calcium carbide	Bleaching Powder	Caustic soda	Sugar
CaO (Min.)	54.0	54.0	53.0	50.0
MgO (Max.)	0.8	2.0	1.0	1.0
SiO ₂ (Max.)	1.0	0.75	-	2.0
Fe ₂ O ₃ (Max.)	0.25	0.15	-	-
Mn ₂ O ₃ (Min.)	-	0.06	-	-
CO ₂ (Min.)	42.00	42.00	42.00	41.00
Loss on Ignition (LOI)	46.00	46.00	46.00	44.00
S (Max.)	0.10	-	-	-

P (Max.)	0.01	-	-	-
Al ₂ O ₃ + Fe ₂ O ₃ (Max.)	0.50	-	-	1.5
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ (Max.)	-	-	3.0	-

2. FERTILIZER INDUSTRY SPECIFICATION

CaCO₃+ MgCO₃: 85 %

(Min) SiO₂ : 5%

(Max.)

3. GLASS INDUSTRY SPECIFICATION

CaCO₃ : 94.5%

CaCO₃ +MgCO₃ : 97.5%

Fe₂O₃ : 0.20%

(Max)

BIS Specifications (IS:997-1973, Reaffirmed-1998)

CaO : 53.0 %

SiO₂ : 2.5 %

Fe₂O₃ : 0.10 %

CaO + MgO : 54.50 %

4. FOUNDRY INDUSTRY SPECIFICATION

BIS Specifications (1S:4149-1978, Re-affirmed-2008)

Table No: 24.5 Foundry Industry Specification for Limestone

Characteristics	Grade-1	Grade-2	Grade-3
CaO (Min.)	52 %	50 %	45 %
SiO ₂ (Max)	1.5 %	3 %	5 %
R ₂ O ₃ (Al ₂ O ₃ + Fe ₂ O ₃) Max.	1 %	1 %	2 %
MgO	2 %	3 %	5 %
Insoluble matter	0.5	1	2
Sulphur and Phosphorus	Traces	Traces	Traces

5. CEMENT, IRON AND STEEL AND CHEMICAL INDUSTRY SPECIFICATION

Table No: 24.6 Cement, Iron and Steel and Chemical Industry Specification for Limestone

Constituents	Cement Industry (Specification)	Iron and Steel Industry (Specification)			Chemical Industry BIS Specifications (1S:3204-1978, Reaffirmed-2003)			
					Requirement in percent by mass for			
		BF Grade	SMS- OH Grade	SMS- LD	Calcium carbide	Bleaching Powder	Caustic soda	Sugar
CaO (Min.)	44% (Min.) to 48% (Max)	42% (Min.)	48% (Min.)	52% (Min.)	54.0	54.0	53.0	50.0
MgO	3.50% (Max.)	4%	3%	2%	0.8	2.0	1.0	1.0
SiO ₂ (Max.)	16 % (Max.)	9%	4%	1%	1.0	0.75	-	2.0
Fe ₂ O ₃	2% (Max.)				0.25	0.15	-	-
Mn ₂ O ₃	--	--	--	--	-	0.06	-	-
CO ₂ (Min.)	--	--	--	--	42.00	42.00	42.00	41.00
Loss on Ignition	--	--	--	--	46.00	46.00	46.00	44.00
S (Max.)	--	--	--	--	0.10	-	-	-
P (Max.)	--				0.01	-	-	-
Al ₂ O ₃ + Fe ₂ O ₃	2%				0.50	-	-	1.5
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃	--	11.5% (Max.)			-	-	3.0	-
Acid Insoluble			6.5% (Max.)					

CHAPTER – 25

25.0.0 CERTIFICATE FROM THE QUALIFIED PERSON WITH NAME, DATE AND SIGNATURE

This is to certify that a Geological report has been prepared in respect of the “Reconnaissance Survey (G4-STAGE) for Limestone in and around Nanhwara- Kymore Limestone Block, Area (22.52 Sq. Km), District Katni, Madhya Pradesh”. The report was prepared by ENGEOTECH CONSULTANT, Jabalpur, on behalf of the National Mineral Exploration and Development Trust (NMEDT). The report adheres to the Minerals (Evidence of Mineral Contents) Rules, 2015, as specified under the Mineral Auction Rules, 2015, and amended up to 2021.

NAME: Indraneel Dawande

DESIGNATION: Project Coordinator

DATE: 08-07-2026

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ABBREVIATIONS USED

ABBREVIATIONS USED SL. No.	Abbreviation	Full form
1	GSI	Geological Survey of India
2	NMEDT	National Mineral Exploration and Development Trust
3	TCC	Technical cum Cost Committee
4	EC	Executive Committee
5	DMG	Directorate of Geology & Mines
6	UNFC	United Nation Framework Classification
7	NMI	National Mineral Inventory
8	NABL	National Accreditation Board for Testing and Calibration Laboratories
9	F.S.P.	Field Season Programme
10	MEMC	Minerals (Evidence of Mineral Contents)
11	MMDR	Mines & Minerals (Development and Regulation)
12	NH	National Highway
13	WGS-84	World Geodetic System-84
14	UTM	Universal Transverse Mercator
15	RL	Reduced Level
16	Cu.m	Cubic Meter
17	DGPS	Differential Global Positioning System
18	DMS	Degree Minute Second
19	M / m	Meter
20	mt	Million Tonne
21	Sq. km/sq.km	Square Kilometer
22	M. Sc.	Master of Science
23	M. Sc. (Tech.)	Master of Science in Technology
24	NDDP	Net District Domestic Product
25	mRL	Reduced Level in metre
26	R.F.	Reserve Forest
27	XRF	X-ray Fluorescence
28	ML	Mining Lease
29	CRM	Certified Reference Material
30	MMT	Million Metric Tonnes
31	GGR	Gross Geological Resources
32	NGR	Net Geological Resources
33	Geol. Res. (Mil. tons)	Geological Resources (Million tons)
34	MT	Million Tonnes
35	RQD	Rock Quality Determination
36	PSC	Project Sanctioning Committee