

**GEOLOGICAL REPORT ON
PRELIMINARY EXPLORATION (G-3)
FOR LIMESTONE IN BOLAS BLOCK
(FIELD SEASON-2025-26)
TALUKA: PATAN-VERAVAL
DISTRICT: GIR SOMNATH, GUJARAT**



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अध्याय 1

सारांश

गुजरात सरकार के उद्योग एवं खान विभाग के भूविज्ञान एवं खनन आयुक्त की अन्वेषण शाखा राज्य में खनिज भंडार स्थापित करने के लिए कार्यरत है। इस शाखा ने अतीत में व्यापक अन्वेषण कार्य किए हैं और पूर्व-विस्तृत खनिज सर्वेक्षण, विस्तृत खनिज सर्वेक्षण और ड्रिलिंग के माध्यम से विभिन्न स्तरों पर संसाधनों की पहचान की है। इन प्रयासों से बॉक्साइट, चूना पत्थर, लिग्नाइट, सिलिका रेत, बेंटोनाइट, चाक, ग्रेनाइट आदि जैसे कई औद्योगिक रूप से महत्वपूर्ण खनिजों की पहचान हुई है। अन्वेषण शाखा का मुख्य उद्देश्य गुजरात में खनिज संसाधन क्षमता की पहचान करना और नए एमएमडीआर संशोधन अधिनियम, 2015 और खनिज (खनिज सामग्री का प्रमाण) नियम 2015 के लागू विधायी ढांचे के तहत भंडार स्थापित करना है।

गुजरात खनिज अनुसंधान एवं विकास समिति (जीएमआरडीएस) भूविज्ञान एवं खनन आयुक्त के पर्यवेक्षण में खनिज उद्योगों को सहयोग देने और खनिज प्रशासन के लिए तकनीकी सहायता प्रदान करने के लिए समर्पित है। जीएमआरडीएस राज्य के भीतर खनिज वस्तुओं और संसाधनों की स्थापना और विकास पर कार्य करती है। अपने मुख्य कार्य के अतिरिक्त, जीएमआरडीएस राज्य की खनिज संपदा के लिए नए खनिज संसाधनों की खोज में भी सक्रिय रूप से शामिल है।

2024-25 के फील्ड सीजन में, गुजरात सरकार के भूविज्ञान एवं खनन आयुक्त (सीजीएम) की अन्वेषण शाखा ने भारत सरकार के खान मंत्रालय के राष्ट्रीय खनिज अन्वेषण ट्रस्ट (एनएमईटी) को गिर सोमनाथ जिले के पाटन-वेरावल तालुका में स्थित बोलास, नखाड़ा और कुकरास गांवों के कुछ हिस्सों में 202.328 हेक्टेयर क्षेत्र में चूना पत्थर के जी3 चरण के अन्वेषण के लिए एक प्रस्ताव प्रस्तुत किया। इस प्रस्ताव को एनएमईटी ने अक्टूबर 2024 में मंजूरी दे दी।

सौराष्ट्र का तटीय क्षेत्र अपने चूना पत्थर भंडारों के लिए प्रसिद्ध है। भूवैज्ञानिक दृष्टि से, दक्कन ट्रैप आधार चट्टान का निर्माण करता है, जिसके ऊपर गज और द्वारका जैसी तृतीयक संरचनाएं हैं, और फिर मिलिओलाइट और छाया संरचनाओं सहित चतुर्थक निक्षेप और हाल के तलछट हैं। ये संरचनाएं तीन प्रमुख लिथोयूनिट्स - गज, द्वारका और मिलिओलाइट - के रूप में तटरेखा के लगभग समानांतर रेखिक बेल्ट में व्यवस्थित हैं। कैल्शियम कार्बोनेट (CaCO_3) कैल्साइट के रूप में चूना पत्थर का प्रमुख खनिज घटक है। बोलास ब्लॉक क्षेत्र में पाया जाने वाला चूना पत्थर प्लेस्टोसीन युग की मिलिओलाइट संरचना से संबंधित है। समेकित चतुर्थक निक्षेपों को मिलिओलाइट संरचना कहा जाता है क्योंकि इसमें फोरामिनिफर मिलिओलिडे के परीक्षण प्रचुर मात्रा में पाए जाते हैं। यह सबसे व्यापक रूप से पाई जाने वाली संरचना है।

लगभग 202.328 हेक्टेयर के कुल ब्लॉक क्षेत्र का अन्वेषण किया गया। ब्लॉक के भीतर, 800 x 800 मीटर ग्रिड पर 5 बोरहोल खोदे गए, जिनकी कुल गहराई 68 मीटर थी। बोरहोल कोर से कुल 67 प्राथमिक नमूने और 10 मिश्रित नमूने तैयार किए गए और विश्लेषण के लिए पेट्रोग्राफी और खनिज रसायन प्रयोगशाला (पीएमसी लैब), गांधीनगर भेजे गए। सभी कोर नमूनों का CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃, SO₃, P₂O₅, K₂O, Na₂O, MnO, TiO₂ और LOI सहित प्रमुख और गौण ऑक्साइडों के लिए विश्लेषण किया गया। विशिष्ट गुरुत्व निर्धारण के लिए तीन कोर नमूनों का उपयोग किया गया। विश्लेषणात्मक परिणामों के आधार पर, भू-आकृति विज्ञान को संशोधित किया गया और प्रत्येक बोरहोल के प्रभाव का आकलन करने के लिए थिसेन बहुभुज विधि का उपयोग करके संसाधनों की गणना की गई। इस परियोजना के परिणामस्वरूप, निम्नलिखित संसाधन स्थापित किए गए: बोलास ब्लॉक क्षेत्र में कुल 28.37 मिलियन टन सीमेंट ग्रेड चूना पत्थर और 8.55 मिलियन टन मार्ल का अंतर्निर्मित संसाधन उपलब्ध है। चूना पत्थर का औसत ग्रेड CaO $\geq 34\%$ और MgO $\leq 5\%$ की सीमा को ध्यान में रखते हुए परिकलित किया गया है, जबकि मार्ल का औसत ग्रेड 20-34% CaO की सीमा को ध्यान में रखते हुए परिकलित किया गया है।

CHAPTER-1

Executive Summary

The Exploration branch of Commissioner of Geology and Mining, Industries and Mines Department, Government of Gujarat operates to establish mineral reserves in the state. The branch has conducted extensive exploration in the past, and resources have been established at various levels through pre-detailed mineral surveys, detailed mineral surveys, and exploration through drilling. These efforts have identified several industrially important minerals such as Bauxite, Limestone, Lignite, Silica sand, Bentonite, Chalk, Granite, and others. The main objective of the Exploration branch is to identify mineral resource potential in Gujarat and establish reserves under the applicable legislative framework of the new MMDR Amendment Act, 2015 and Mineral (Evidence of Mineral Content) Rules 2015.

The Gujarat Mineral Research & Development Society (GMRDS) is dedicated to supporting the mineral industries and providing technical assistance for mineral administration under the supervision of the Commissioner of Geology & Mining. GMRDS works on the establishment and development of mineral commodities and resources within the state. In addition to its core mission, GMRDS is actively involved in conducting exploration for new mineral resources for state's mineral wealth.

In the Field Season 2024–25, the Exploration Branch of the Commissioner of Geology and Mining (CGM), Government of Gujarat, submitted a proposal to the National Mineral Exploration Trust (NMET), Ministry of Mines, Government of India, for G3-stage exploration of Limestone over a total area of 202.328 hectares, covering parts of Bolas, Nakhada and Kukras villages in Patan-Veraval Taluka, Gir Somnath District, Gujarat. The proposal was approved by NMET in October 2024.

The coastal region of Saurashtra is well known for its limestone deposits. Geologically, the Deccan Trap forms the basement rock, overlain by Tertiary formations such as the Gaj and Dwarka Formations, followed by Quaternary deposits including the Miliolite and Chaya Formations along with Recent sediments. These formations occur as three major lithounits—Gaj, Dwarka, and Miliolite—arranged in linear belts roughly parallel to the coastline. Calcium carbonate (CaCO_3) in the form of calcite is the predominant mineral constituent of Limestone. The Limestone encountered in the Bolas Block area belongs to the Miliolite Formation of Pleistocene age. The consolidated Quaternary deposits are termed as Miliolite Formation because of preponderance of tests of foraminifer Miliolidae. This is the most widespread

lithounit in the coastal belt overlapping all earlier lithounits. The colour of the limestone varies from white to pale yellow to pink, whitish and buff. In majority of places, the miliolitic limestone varies from white to pale yellow, relatively soft, friable, thinly laminated with alternate bands rich in foraminiferal tests and micrite. The Miliolite occurs as current bedded limestone in the form of coastal ridge.

The total block area of approximately 202.328 hectares was explored. Within the block, 05 boreholes were drilled on a 800 x 800 meter grid, reaching a total depth of 68 meters. A total of 67 primary samples and 10 composite samples were prepared from the boreholes core and sent to the Petrography & Mineral Chemistry Laboratory (PMC Lab) Gandhinagar, for analysis. All core samples were analysed for major and minor oxides, including, CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃, SO₃, P₂O₅, K₂O, Na₂O, MnO, TiO₂, and LOI. Three core samples were used for specific gravity determination. Based on the analytical results, the lithology was revised, and resources were calculated using the Thiessen Polygon method to assess the influence of each borehole. As a result of this project, the following resources were established: A total of 28.37 million tonnes in-situ resource of cement grade Limestone and 8.55 million tonnes in-situ resource of Marl is available within Bolas block area. The average grade of Limestone has been calculated by considering the threshold limit of CaO $\geq$ 34% and MgO $\leq$ 5%, while the average grade of Marl has been calculated by considering the threshold limit of 20-34% CaO.

Brief Summary

Sr. No.	Parameter	Data				
01	Name of the Block	Bolas Block				
02	Location	Villages: Bolas, Nakhada and Kukras Taluka: Patan-Veraval District: Gir Somnath				
03	Block Area	202.328 Hectares				
04	Block Boundary Co-ordinates					
	Sr. No.	Boundary Pillar	DMS (WGS 84)		UTM	
			Latitude	Longitude	Easting	Northing
	1	BP-1	20°56'22.060"N	70°30'0.100" E	655972.242	2316177.506
	2	BP-2	20°56'32.200"N	70°30'18.00 " E	656486.413	2316494.160
	3	BP-3	20°56'6.840" N	70°30'40.540" E	657144.894	2315720.462
	4	BP-4	20°56'3.870" N	70°30'29.180" E	656817.573	2315626.043
	5	BP-5	20°55'41.960"N	70°30'27.180" E	656766.129	2314951.764
	6	BP-6	20°55'43.040"N	70°30'39.490" E	657121.457	2314988.321
	7	BP-7	20°55'25.690"N	70°30'38.330" E	657092.970	2314454.490
8	BP-8	20°55'10.540"N	70°30'0.710" E	656010.439	2313978.425	
05	Total Area Covered under Geological Exploration	202.328 hectares				
06	No. of Boreholes Drilled	05				
07	Total Meterage Drilled	68 mts				
08	Borehole Spacing	800 mts x 800 mts				
09	Depth of the Mineralized Zone	0.10 mts to 15.00 mts				
10	Economic Mineral Resource with Quality	Commodity	Average Cumulative Thickness	Resource (In million tons)	Quality	

		Cement Grade Limestone	5.91	28.37	CaO:43.73%, MgO:1.67%, SiO ₂ : 13.39%, Fe ₂ O ₃ : 2.14%
		Marl	2.18	8.55	CaO:27.63%, MgO:3.22%, SiO ₂ :31.64%, Fe ₂ O ₃ :3.58%
		The resource calculations are based on threshold values as per IBM specifications (Limestone: CaO ≥ 34%, Mgo ≤ 5%)			
11	Average Overburden to Mineralized zone	0.49 m			
12	Toposheet No.	41L/9			
13	Topography	Undulating			
14	Average Rainfall	1340 mm (Source: CGWB, Gujarat)			
15	Lowest Temperature	9° C (Source: IMD)			
16	Maximum Temperature	42° C (Source: IMD)			
17	Nearest Railway station	Savni Railway station- 5.90 km			
18	Road	Accessible through NH-51			
19	Airport	Diu airport – 49 km			

CHAPTER-2

Introduction

2.1 Details of the Project:

A proposal for G3 stage Limestone exploration in Bolas Block, Patan-Veraval taluka, Gir Somnath district, Gujarat was submitted to NMET by the Commissioner of Geology and Mining, Government of Gujarat - Gandhinagar on 31/07/2024.

The original proposal for the block was initially prepared at the G2 exploration stage with drilling on a 400 m × 400 m grid. However, during the 68th TCC meeting held on 28–30 August 2024, the proposal was reviewed, and it was recommended that the exploration be taken up at the G3 level with drilling on 800 m × 800 m grid spacing. Subsequently, in the 37th EC meeting held on 23/10/2024, the matter was discussed, and the EC approved the project with an estimated cost of Rs. 39.97 Lakhs. The sanction order for the project was received on 23/10/2024.

The exploration proposal for the Bolas Block is prepared with a total proposed area of 202.328 Hectares. The Block falls in the toposheet no. 41L/9 in Bolas, Nakhada and Kukras villages of Patan-Veraval taluka, Gir Somnath district. The Preliminary Exploration (G3) for Limestone in Bolas Block was carried out on a grid of 800 x 800 meters, drilling a total of 05 boreholes comprising a total meterage of 68 meters.

2.2 Investigation Agency:

Commissioner of Geology and Mining, Government of Gujarat, Gandhinagar

2.3 Objective of the investigation:

1. To know the continuity of the mineral body both along the strike and dip.
2. To map the extent of the ore body.
3. To ascertain the grade of Limestone deposit.
4. Ore resource/reserve estimation in accordance with MEMC Rule-2015

2.4 Basis for taking up investigation:

The region was primarily investigated by the Commissioner of Geology and Mining (CGM) during 1965 and 1995–1997 through geological mapping using remote sensing techniques, surface exposure mapping, and sample collection

. The findings of these earlier investigations indicated that the coastal areas of the Saurashtra region host significant deposits of Milliolic Limestone, characterized by low overburden and occurring as low ridges and mounds, making them easily mineable.

As part of the recent geological traverse survey conducted by CGM/GMRDS Geologists, a total of 09 grab samples were collected from the block. The chemical analysis results revealed CaO content ranging from 49.64% to 52.15% indicating promising prospects for high-grade limestone.

The Bolas block is also surrounded by existing working limestone leases like Gujarat Heavy Chemicals Ltd., suggesting that this block can be studied as a potential extension of the already mineable deposits.

Considering the chemical analysis results, geological characteristics, and industrial demand, the block is recommended for G3-level exploration to assess its mineral potential in detail and facilitate future auction processes.

2.5 Details, nature and quantum of work proposed and achievement:

Table: 1 Details, nature and quantum of work proposed and achievement

Sr. No	Item of Work	Original Proposed	Achieved
1	Topographic Survey & Geological Mapping on 1:2000 scale (Ha)	202.328 Ha	202.328 Ha
2	Boundary and borehole demarcation with DGPS	Boundary:8 BH: 5	Boundary:8 BH: 5
3	Exploratory Drilling (One conditional BH to confirm the total thickness of limestone)	100 m 5 BHs	68 m 05 BHs
4	Laboratory Studies		
	i) Chemical Analysis; Primary samples for 12 radicals, CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , K ₂ O, Na ₂ O, MnO, TiO ₂ , and LOI by XRF	100 Core	67 Core
	ii) External Check (NABL) samples (10% of Primary samples) for analysis of for 12 radicals, CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , K ₂ O, Na ₂ O, MnO, TiO ₂ , and LOI by ICP-OES	10	04 (Sample no: BLBH-3/04, BLBH-4/04, BLBH-5/05, BLBH-5/16)
	iii) Chemical Analysis; Composite samples for 12 radicals, CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , K ₂ O, Na ₂ O, MnO, TiO ₂ , and LOI by XRF		10
5	Physical Studies		
	a) Petrological Studies	10	3
	b) Specific gravity Determinations	5	3
6	Report Preparation (5 Hard copies with one soft copy)	1	1
7	Preparation of Exploration Proposal (5 Hard copies with a soft copy)	1	1

2.6 Personal involved:

The entire work was carried out by Gujarat Mineral Research and Development Society (GMRDS), a technical arm of Commissioner of Geology and Mining, Gujarat. A team of senior technical officers from GMRDS along with Surveyors, Samplers, Geologists, GIS experts and Chemists are involved in this work.

Mode of operation of different work components and associated agency:

Table: 2 Mode of operation of different work components and associated agency

Sr. No.	Work Components	Involved agencies
01	Survey & Geological Mapping	Departmental by CGM & GMRDS
02	Laboratory Studies	Petrography and Mineral Chemistry Laboratory (PMC), CGM, Gandhinagar, Gujarat
	Samples for XRD	
	Petrographic study	
	Specific gravity	
03	Check samples from External NABL approved laboratory	M/S. Lucid Laboratory, Hyderabad (NABL approved laboratory)
04	Core Drilling	External Drilling agency- M/S. Vinayak Engimech Pvt. Ltd., Ahmedabad
04	Geological Report preparation	GMRDS, Gujarat
05	Preparation of Exploration proposal	CGM, Gujarat
06	Peer review of Exploration report	Exploration Branch - CGM, Gujarat

CHAPTER-3

Property description

3.1 Title of the Report

Geological Report on Preliminary Exploration (G-3) for Limestone in Bolas Block, Taluka: Patan-Veraval, District: Gir Somnath, Gujarat.

3.2 Details of the area

The project area falls within parts of Bolas, Nakhada and Kukras villages in Patan-Veraval Taluka, Gir Somnath District, Gujarat. The Bolas Block has an area of 202.328 hectares, bounded by latitude 20°55'10.540" N and longitude 70°30'0.100" E.

3.2.1 Survey of India Toposheet number

The block area falls under the Survey of India Toposheet No. 41L/9 of Patan-Veraval Taluka of Gir Somnath district, Gujarat. A map showing area on toposheet can be referred for the same (i.e. Plate-3).

3.2.2 Geo-coordinates of the Bolas Block boundary and drilled boreholes

The sheet of coordinates of Block boundary has given as separate annexure-6.

Table: 3 Coordinates of corner points of Bolas Block boundary

Sr. No.	Boundary Pillar	DMS (WGS 84)		UTM	
		Latitude	Longitude	Easting	Northing
1	BP-1	20°56'22.060"N	70°30'0.100" E	655972.242	2316177.506
2	BP-2	20°56'32.200"N	70°30'18.00 " E	656486.413	2316494.160
3	BP-3	20°56'6.840" N	70°30'40.540"E	657144.894	2315720.462
4	BP-4	20°56'3.870" N	70°30'29.180"E	656817.573	2315626.043
5	BP-5	20°55'41.960"N	70°30'27.180"E	656766.129	2314951.764
6	BP-6	20°55'43.040"N	70°30'39.490"E	657121.457	2314988.321
7	BP-7	20°55'25.690"N	70°30'38.330"E	657092.970	2314454.490
8	BP-8	20°55'10.540"N	70°30'0.710"E	656010.439	2313978.425

Table: 4 Coordinates of drilled boreholes in the Block

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)		UTM	
			Latitude	Longitude	Easting	Northing
1	BLBH-1	45.50	20°56'12.90"N	70°30'12.00"E	656318.65	2315898.99
2	BLBH-2	38.50	20°56'8.20"N	70°30'32.40"E	656909.34	2315760.00
3	BLBH-3	38.00	20°55'40.80"N	70°30'16.30"E	656452.13	2314913.08
4	BLBH-4	25.50	20°55'15.30"N	70°30'3.50"E	656089.67	2314125.49
5	BLBH-5	31.00	20°55'26.40"N	70°30'27.90"E	656791.42	2314473.42

3.2.3 Location and Accessibility

The project area falls in parts of Bolas, Nakhada and Kukras villages of Patan-Veraval taluka, Gir Somnath District, Gujarat. District headquarter is situated at Veraval. The area is accessible through NH-51. A Key and Location plan can be referred for the same (i.e. Plate-1). The nearest airport is at Diu airport which is around 49 Km away from the Block. Nearest Railway station is Savni which is approx. 5.90 km away from the Block. An aerial view of the Block has been also given (i.e. Plate-2).

3.2.3 Climate

The climate is typically semi-arid. Extreme temperatures, erratic rainfall and high evaporation are the characteristics feature of climate. The majority of this precipitation during the monsoon season is episodic and happens in short duration, owing to which large-scale erosion of unconsolidated sediments is triggered. The overall dryness throughout the year except monsoon season also has led to lack of vegetation in riverbanks. The temperature in Gir Somnath District ranges from 42° C higher in the summer and 9° C lowest in the winter. The average annual rainfall is below 1340 mm. (Source: CGWB, Gujarat and IMD)

3.2.4 Flora and Fauna

Flora of an area depends on climatic conditions, topography, rainfall, soil type, land use and demography of an area. These factors highly affect the floral cover and quality of an area. The common flora of the area are species of *Azadirachta indica* (Neem), *Ficus religiosa* (Pipal), *Mangifera indica* (Aam), *Ischamum indicum* (Bordi), *Tamarindus indica* (Imli) and *Plumeria alba* (Champa). Among the faunas *Boselaphus tragocamelus* (Nilgai), *Canis aureus indicus* (Jackal), *Rattus rattus* (House Rat), *Serpentes* (Snake), *Pavo cristatus* (Peacock), *Scorpiones* (Scorpion) are common.

3.2.5 Drainage

Studying the drainage system is essential for gaining insights into geomorphology and structural fabrics of the area. The block area is characterized by gently undulating terrain with no major perennial rivers flowing through the block boundary. However, small seasonal drainage channels are observed, primarily active during the monsoon, contributing to a sub-dendritic to sub-parallel drainage pattern in the surrounding areas. A major seasonal river lies east of the block boundary, likely serving as the main surface water outlet during periods of heavy rainfall. Overall, the drainage is controlled by local topography and lithology, with no significant waterlogging observed within the block area.

3.2.6 Infrastructure

The local infrastructure, such as bus stop, hotels/restaurants, primary health centers, school, and temples are present within the periphery of 6-10 km from Bolas Block. The Gir Somnath district covers an area of 3,775 km² with a population of the is 9,46,790 as per 2011 census. Nakhada, Kukrash, Indroi are the nearby villages to Bolas Block. This Block is located around 15 Km towards east from district headquarters Veraval and around 335 Km from state capital Gandhinagar. Patan-Veraval is around 12 Km far from this block. Gujarat Heavy Chemicals Ltd soda ash plant is situated at around 8.85 km south-west from the block area and Ambuja Cements Limited (Adani Cement), Ambujanagar Plant is about 21 km south-east from the block area.

CHAPTER-4

Previous work

- During F.S. 1965–66 Shri U.D.G. Rao carried out investigation of limestone deposits in the eastern parts of Veraval Taluka, Junagadh District. An area of about 200 sq. km between Kodinar and Veraval was geologically mapped on a 1:10,000 scale using chain and compass, and representative samples were collected for chemical analysis.
- During F.S. 1967–68 Shri A.A. Waheed investigated limestone deposits northwest of Prachi, Junagadh District. Drilling operations revealed Miliolitic Limestone of white to medium-fine grain size, with thickness ranging from 0.50 m to 8.61 m.
- During F.S. 1969–70 Shri R.N. Goswami conducted 30 boreholes totaling 650.87 m of drilling near proposed region. The borehole data confirmed the occurrence of high-grade limestone deposits.
- During F.S. 1971–72 Shri J.V. Bhatt and Shri B.S. Nadhamuni continued detailed exploration in the Prachi–Ranavav belt of Saurashtra coast, drilling 25 boreholes with a cumulative depth of 694 m on a 1,000 m grid to assess chemical-grade limestone potential.
- During F.S. 1995–96–97 Shri S.D. Kapse and Shri Y.C. Patel undertook geological mapping of Junagadh and Jamnagar districts on a 1:50,000 scale, covering about 2,580 sq. km using Remote Sensing Techniques. Geological maps were prepared using False Colour Composite (F.C.C.) data of LANDSAT and SPOT satellite in parts of toposheets 41 G/5, 41 G/10, 41 G/6, 41 K/4, 41G/15, 41 G/11, 41 L/5, 41 L/1, 41 L/9, 41 L/10.
- During recent CGM/GMRDS Surveys (F.S. 2024-25) A total of 09 grab samples were collected from the Bolas block during geological traverses. Chemical analysis revealed CaO content ranging from 49.64% to 52.15%, confirming the presence of high-quality limestone. The chemical analysis are as follows:

Chemical Composition (%)														
Sr. No.	Sample ID	Latitude	Longitude	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	LOI
1	Bolas-01	20°55'43.701"	70°30'19.373"	3.55	0.88	1.73	0.13	50.56	0.44	0.00	0.13	0.04	0.06	41.65
2	Bolas-02	20°55'44.523"	70°30'18.277"	4.66	0.65	1.01	0.12	50.90	0.39	0.00	0.11	0.03	0.00	41.96
3	Bolas-03	20°56'02.176"	70°30'28.964"	3.00	0.79	1.60	0.12	51.81	0.38	0.05	0.12	0.05	0.04	41.45
4	Bolas-04	20°56'11.309"	70°30'17.112"	3.52	0.63	1.28	0.08	51.79	0.37	0.00	0.11	0.06	0.03	41.97
5	Bolas-05	20°56'10.546"	70°30'11.404"	3.92	0.58	1.28	0.12	50.95	0.37	0.00	0.09	0.07	0.06	41.83
6	Bolas-06	20°56'05.662"	70°30'09.133"	4.82	1.06	2.82	0.18	50.35	0.30	0.00	0.13	0.02	0.00	40.15
7	Bolas-07	20°56'04.662"	70°30'09.456"	4.55	1.03	2.97	0.16	49.64	0.28	0.00	0.13	0.01	0.02	40.32
8	Bolas-08	20°56'24.306"	70°30'17.332"	4.55	1.17	3.13	0.15	50.19	0.29	0.00	0.13	0.02	0.00	40.17
9	Bolas-09	20°55'43.662"	70°30'30.037"	4.70	1.40	3.21	0.21	52.15	0.33	0.00	0.16	0.06	0.02	37.46

In addition, Gujarat Heavy Chemicals Ltd. holds a mining lease adjoining the eastern boundary of the Bolas block, validating the limestone prospectivity and continuity of the mineralized horizon.

Details of Aero-geophysical and Geophysical mapping

Systematic regional gravity and magnetic surveys were carried out in toposheet nos. 41L/9 in parts of Patan-Veraval taluka, Gir Somnath district, Gujarat under National Geophysical Programme (NGPM) of GSI. The Bouguer gravity contour map shows values ranging from +10 mGal to -90 mGal with an overall variation of 100 mGal and the magnetic contour map shows values ranging from +547 nT to -308 nT with an overall variation of 855 nT.

CHAPTER-5

Geology of the area

The coastal Saurashtra is known for its limestone deposits. Stratigraphically the Deccan trap is the oldest lithounit in the area and forms the basement for the overlying sedimentary units. The Deccan Traps are overlain by rocks of Gaj Formation and Dwarka Formation of Tertiary period and Miliolite Formation and Chaya Formation of Quaternary period along with Recent and Sub-recent loose sediments. The three major lithounits, i.e. Gaj, Dwarka and Miliolite Formations occur broadly in three linear belts parallel to the coastline.

Gaj Formation

Gaj formation includes an intercalated sequence of marl/clay and limestone, dominated by the former. The marl/clay is light yellow to grey and it is difficult to distinguish between the two in transitional cases. Gaj limestone is light to deep yellow to brown, compact, and cryptocrystalline. At places, this limestone contains very little free silica or is almost devoid of it. The thickness of limestone band is highly variable and often a quite thick band pinches abruptly within short distance., In almost all places, where Gaj Formation is exposed, a thin crust (less than 2 m thick) of compact, dark limestone, which is a secondary leaching product, is present followed downward by Gaj clay/marl. Gaj Formation is rich in marine mega- and micro- fossils. Mega fossils include pelecypods, gastropods, cephalopods, echinoids, alcyonaria, decapoda and bryozoa. Earlier workers have assigned an Upper Miocene age to Gaj Formation but Mathur et al (1980) advocated that the Gaj Formation is at least of Mid Miocene age, if not older, as it contains fossils of *Taberina malabarica* a Lower to Middle Miocene foraminifer.

Dwarka Formation

Dwarka Formation is equivalent to the Dwarka bed of Fedden (1884). It overlies the Gaj Formation. Although there are pebbly or conglomeratic bands at the contacts, in most places the relation is conformable. The Dwarka Formation, as exposed in this area, generally comprises grey and gritty to sandy limestone almost devoid of megafossils. Near Dwarka, the Dwarka formation was divided into Upper and Lower Dwarka Member by Jain and Agarwal (1989-90). The lower Member, which overlies Gaj Formation, is an intercalated sequence of clay and kankar, friable/compact sandstone, yellow and red marl beds and yellow ferruginous and grayish sandy limestone. The

Upper Dwarka is mainly bioclastic limestone, often cavernous and contains very little silica.

Miliolite Limestone

The consolidated Quaternary deposits are termed as Miliolite Formation because of preponderance of tests of foraminifer Miliolidae. This is the most widespread lithounit in the coastal belt overlapping all earlier lithounits. The colour of the limestone varies from white to pale yellow to pink, whitish and buff. In majority of places, the miliolitic limestone varies from white to pale yellow, relatively soft, friable, thinly laminated with alternate bands rich in foraminiferal tests and micrite. The Miliolite occurs as current bedded limestone in the form of coastal ridge. This Limestone primarily comprise of broken shells of foraminifer-milioline around which calcite grains have been formed.

Chaya Formation

This is a semi-consolidated highly porous limestone occurring near the present day coastline and rich in both mega and microfossils. The thickness shows wide variation decreasing away from the coast. It is generally a bit ferruginous particularly below the ground level.

Soil and Alluvium

Major portion of the area is covered with soil or alluvium. This can be divided as the type formed due to weathering of limestone and the type formed due to deposition of clays brought by rivers. The soil formed due to weathering of limestone is regur soil and that of river is sticky black clayey soil.

The general stratigraphic succession of the region is as follows:

Table: 5-Regional Geology of the Area by K. K. Verma et.al. (1972-73)

Age	Formation	Litho-units/Rock Type
Holocene	Recent beds	Beach sands, Coastal dunes, Rann clays & Fresh water Alluvium
Holocene to Late Pleistocene	Chaya Formation	White to reddish brown calcilutites, at places highly fossiliferous containing semi-fossilised remains of lamellibranchs, gastropods, corals etc. (including 'Dead coral reefs ', Oyster beds ' and 'Raised beaches' of Fedden)
Early Pleistocene	Miliolite Formation	Pelitic and oolitic calc-arenites, micrites, calcareous conglomerate.
		Buff & grayish white colored medium to coarse grained, coquinoideal limestone
Pliocene to Lower Miocene	Dwarka Formation	Limestone having Balanus and molluscan fossils and their fragments, sub-rounded to rounded quartz grains (sand size). Dirty white to variegated clays, poorly fossiliferous
Lower Miocene	Gaj Formation	Deep ocherous marls and marly limestones with Foraminifers and marine invertebrates, variegated, unfossiliferous clays.
Up. Cretaceous to Eocene	Deccan Trap Formation	Laterite/Bauxite/Lithomarge Basalt, trachytes, andesite and other trappean rocks.

Geology of the Bolas Block

With the help of core-drilling, sampling and data assessment of the Bolas Block local geological successions of the area are given as below:

Table: 6-Local Geology of the Study Area

Age	Formation	Litho-units/Rock Type
Holocene	Recent to Sub-Recent	Top brownish-black soil
Early Pleistocene	Miliolite Formation	Buff white to yellowish brown colored fine to medium grained Miliolite limestone
Pliocene to Lower Miocene	Dwarka Formation	Yellowish brown marl and clays.

Soil: It is the youngest unit exposed in the Block, which is brownish to black in colour, with fine to medium grain size. It is composed of calcareous and clayey material with fragmented limestone. Soil layer is having average thickness of 0.35 m.

Limestone:

The Miliolitic Limestone of Pleistocene age is typically buff white, pinkish white, light yellowish to brownish. It is a fine to medium grain, composed predominantly of foraminiferal fossils embedded in a calcitic matrix. This limestone formation is primarily found in shallow marine deposits. It is dense, hard, porous and of economic significance due to its high calcium carbonate content and low impurities. The average cumulative thickness of limestone bands observed across the boreholes is 5.91 m.

Marl:

Marl associated with Limestone encountered in four drilled boreholes in the present study area. It is a non-clastic sedimentary rock composed primarily of fine to medium-grained, greyish to yellowish-brown calcium carbonate mineral. The thickness of the marl ranges from 1.00 m to 2.62 m across the boreholes within the Block. Incidence of marl in the boreholes change with cutoff grade of CaO.

Clay:

The clay exhibits yellowish brown to grey colors. It is fine grained, soft, calcareous and fossiliferous in nature. It is found interbedded between the limestone and marl beds within the block.

CHAPTER-6

Activity during the period (Geoscience investigation)

6.1 Geological Mapping:

The DGPS survey in the Bolas Block involved the establishment of both horizontal and vertical controls, along with the placement of reference grids and benchmarks across the area. Grids measuring 50 meters by 50 meters, indicating latitude and longitude, were set up in the North-South and East-West directions. Additionally, level surveying was conducted at 3-meter intervals for contouring the area, all of which were carried out during the G3 level exploration in the study area using DGPS.

Boreholes were fixed on the ground at 800 x 800 m grid interval. The block boundary as provided by the CGM, was surveyed by DGPS and Total Station in WGS-84 Datum. In the DGPS Survey report, the details of location, identification and demarcation of area, methodology of Topographic Survey and methodology adopted for vectorized cadastral map have been provided.

To carry out this survey Dual Frequency Sokkia DGPS, Total station Leica TS 02 / 407 equipment's were used in various stage of Topographic survey. After topographic survey, draft drawing was generated at site and a complete topographical representation was drawn with the help of AutoCAD. List of boundary pillar points of the block boundary along with the co-ordinates are given in annexure-6.

The geological mapping of the Bolas Block was conducted with the objective of understanding the lithological setup, mineralization, and other structural features within the area. The mapping was carried out on a 1:2000 scale, focusing on the limestone deposits in the region, which are critical for industries such as cement and chemicals. The study involved systematic traverses across the block, along both east-west and north-south orientations, to document the variations in lithology and mineralization.

The mapping was carried out over a total area of 202.328 hectares, covering the entire Bolas Block. During the fieldwork, limestone outcrops were observed, and the thickness and nature of the formations were recorded. The block area was characterized by flat topography with a few isolated elevations, which allowed easy access for traversing.

Samples were collected systematically from areas showing good quality limestone exposures. These samples were analyzed to determine their suitability for industrial applications such as cement and chemical production. 07 samples were collected during the mapping and the analysis for those is as follows:

Table: 7 Field Grab sample analysis of Bolas Block

Chemical Composition (%)															
Sr. No.	Sample ID	Latitude	Longitude	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O	MnO	SO ₃	LOI
1	BS-1	20°56'22.90"	70°30'05.10"	1.66	0.88	1.62	0.17	53.72	0.43	0.06	0.09	0.05	0.00	0.05	41.08
2	BS-2	20°56'25.70"	70°30'15.10"	3.48	1.40	2.48	0.03	52.79	0.70	0.08	0.23	0.02	0.09	0.03	38.35
3	BS-3	20°56'07.90"	70°30'33.80"	1.41	0.56	0.96	0.14	54.88	0.44	0.05	0.09	0.03	0.02	0.06	41.14
4	BS-4	20°55'40.20"	70°30'15.30"	2.22	0.96	1.87	0.19	53.54	0.55	0.09	0.17	0.05	0.12	0.06	39.99
5	BS-5	20°55'14.10"	70°30'09.00"	3.06	1.33	2.62	0.26	51.64	0.57	0.06	0.20	0.07	0.04	0.05	39.90
6	BS-6	20°55'32.00"	70°30'30.70"	2.40	0.95	2.13	0.19	52.80	0.55	0.05	0.13	0.08	0.02	0.00	40.47
7	BS-7	20°56'05.30"	70°30'09.60"	2.77	1.17	2.21	0.23	52.98	0.52	0.06	0.17	0.06	0.03	0.00	39.66



Fig. 1 Unconsolidated Miliolitic Limestone
(20°56'25.70" N - 70°30'15.10" E)



Fig. 2 Layered Miliolitic Limestone
(20°55'33.48" N - 70°30'7.87" E)

Distribution of Limestone on the surface.

Structure

General structure in the block is deciphered from the exploratory boreholes. The sedimentary rocks of the area are horizontal to sub horizontal and are not affected by any diastrophic movement. Bedding can be easily identified as compositional and color differences in the Limestone and Clays. No major faults or joints are encountered in the study area.

Metamorphism

No metamorphism has taken place in the proposed block. The stratigraphy encountered in the block is of marine sedimentary origin.

6.2 Mineralogy of the ore zones: (Mineralization/Rock types)

A total of 03 samples have been subjected to megascopic and microscopic study. The results are as below:

1. Name of Rock: Limestone

Megascopic study

The sample is brown in color. It comprises of medium to fine grain size. There is presence of quartz grains at some places. The nature of the specimen is compact and hard. It gives profuse effervescence when treated with dilute HCL. Based on megascopic study the given sample is Limestone.

Microscopic Study

The thin section shows fine to medium-grained texture. It is mainly composed of microcrystalline calcite. Calcite shows rhombohedral cleavage and shows lamellar twinning. Quartz and few fine-grained clay particles are also seen. Fossil shells are found scattered in matrix.

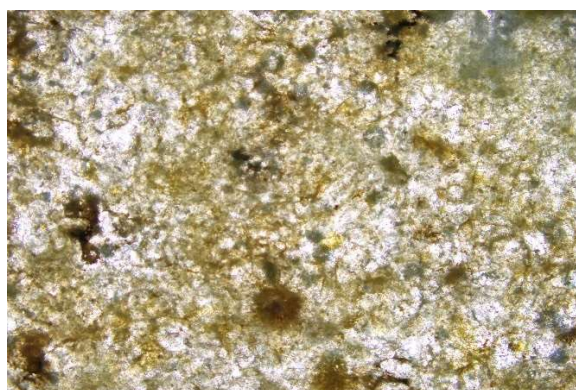


Figure 3 Photomicrograph of Limestone (ppl)

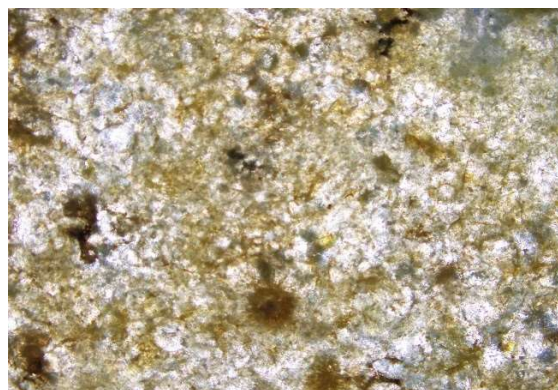


Figure 4 Photomicrograph of Limestone in (xpl)

2. Name of Rock: Limestone

Megascopic study

The sample is yellowish in color. It comprises of medium to fine grain size. There is presence of quartz grains at some places. The nature of the specimen is compact and hard. It gives profuse effervescence when treated with dilute HCL. Based on megascopic study the given sample is Limestone.

Microscopic Study

The thin section shows fine to medium grained texture. It is mainly composed of microcrystalline calcite. Calcite shows rhombohedral cleavage and shows lamellar twinning. Quartz and few fine-grained clay particles are also seen. Iron oxide grains (may be Goethite) are also found in the matrix.

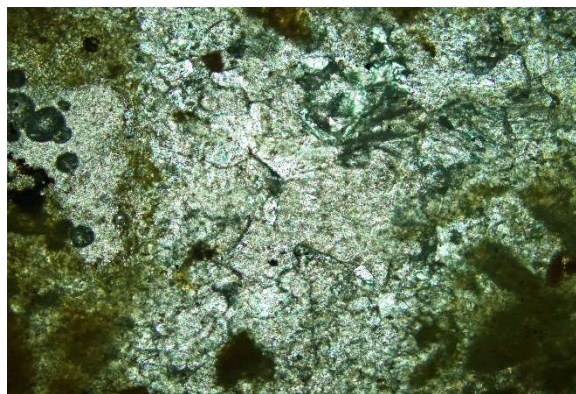


Figure 5 Photomicrograph of Limestone (ppl)

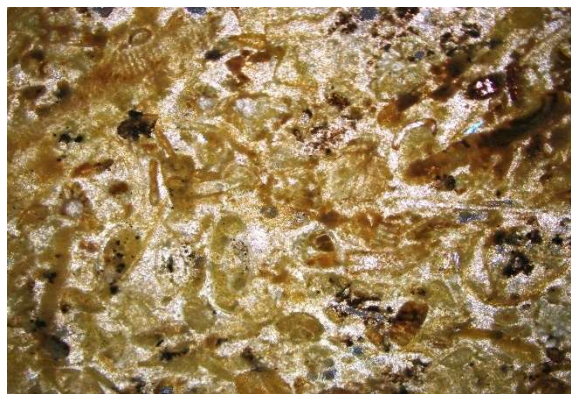


Figure 6 Photomicrograph of Limestone in (xpl)

3. Name of Rock: Clay

Megascopic study

The sample is gray in color. It is extremely fine grained which shows its argillaceous nature. No effervescences with dil. HCl. It can be scratched by penknife. It gives earthy smell with water.

Microscopic Study

The thin section shows extremely fine grained texture. It is mainly composed extremely fine grained clay minerals. Opaque are also seen under microscope. Poorly developed orientation of clay minerals are seen.

6.3 Sampling:

The selected recovered core was arranged properly in core boxes of 1 m long with 5 riffles covered with lid. Each run was marked properly by plastic tag and the core boxes were numbered properly.

The core was cut vertically from the centre with the help of core splitter dividing it into two equal halves. One half of core was kept aside for preservation purpose and other half was crushed upto desired mesh size of 200 mesh. Then coning and quartering was done for representative sample. Sampling was done to understand the quality of Limestone encountered in boreholes.

Samples were collected during the exploratory drilling programme and were prepared as composite samples for chemical analysis. A total of 10 representative composite samples were prepared and submitted to Petrography and Mineral Chemistry Laboratory, Gandhinagar for analysis of 12 chemical radicals. The analytical results are enclosed as Annexure-13.

Details of interpreted ore zones based on geological investigation

The delineation of Limestone-bearing zones is based on the results of systematic core drilling and geological logging. A total of five boreholes were drilled on a 800 × 800 meters grid, generating lithological logs and chemical analysis data, which were used to identify the depth, thickness, and grade variation of the Limestone. Based on these subsurface investigations, Limestone was encountered, varying in thickness, often intercalated with clay or marl layers. The interpretation of ore zones was guided by lithological continuity, core recovery, and CaO/MgO content, which together help assess the prospectivity and economic potential of the limestone within the block.

Geophysical exploration

The ground Geophysical exploration was not carried out during the G3 stage of exploration.

Geochemical exploration

Geochemical exploration was not carried out during the G3 stage of exploration.

CHAPTER-7

Integration of Geology, Geo physics and Geochemical exploration and interpretation

The investigation here was conducted at the G3 stage, and since it involves limestone- a bedded deposit, no geophysical components were planned. Since the area exhibits bedded deposits of regular habit type of deposit, such type of integration and interpretation work is not significant.

CHAPTER-8

Mineral Prospect

Gir Somnath is a mineral rich region with very large reserves of Limestone, Marl, Blacktrap and Ordinary Sand. This is one of the preferred destinations for most of the mineral based industries.

As per the regional geology of the area, coastal Saurashtra is known for its Limestone deposits. These calcium rich rocks were the manifestations of the higher sea levels during the Tertiary and Quaternary period due to geostatic sea level rise. Stratigraphically the Deccan trap is the oldest litho unit in the area and forms the basement for the overlying sedimentary units. Rocks of Gaj Formation and Dwarka Formation of Tertiary period and Miliolite Formation and Chaya Formation of Quaternary period along with recent and sub-recent loose sediments overlie the Deccan Traps.

Limestone is a sedimentary rock composed primarily of calcium carbonate (CaCO_3) in the form of mineral calcite. It most commonly forms in clear, warm, shallow marine water. It is usually an organic sedimentary rock that forms from the accumulation of shell, coral, algal, and fecal debris. The Limestone encountered in the block belongs to Miliolite Limestone of Pleistocene age. It consists of bioclastic carbonate deposits formed from shells, corals, and other marine life in warm, shallow, agitated tropical water. This unique formation features coastal shell limestone, aeolianites (wind-blown deposits), and fluvial reworked sediments, often seen as low mounds and ridges along the coastline, providing evidence of past sea level stands

Along with Limestone, Marl is encountered at places. Marl is an impure low grade Limestone. It is defined as a lime-rich mud that contains variable amounts of clays and silt. The proportion of CaO is lower than that of Limestone.

Due to wide reserves of Limestone, major

cement industries like Ambuja Cement, Siddhi Cement as well Soda-ash plant like Gujarat Heavy Chemicals Limited are situated in Gir Somanth district.

The exploration on G3 stage within the block has exhibited promising deposit of limestone mineral with high CaO values. This will further cater the need to fulfill the demand of Limestone in cement industries, which will generate more revenue for the State.

CHAPTER-9

Subsurface Exploration (Drilling)

9.1 Spacing of the Boreholes:

A G-3 stage exploration was carried out in this block and as per guideline of MEMC rule, 2015 and its amendments, the spacing between two boreholes in case of bedded stratiform and tabular deposits of regular habit is 800 mts x 800 mts. Accordingly M/s Vinayak Engimech Private Limited have planned and carried out drilling through 05 nos. of exploratory boreholes at a grid interval of 800 mts x 800 mts in this block with a cumulative meterage of 68.00 meters.

Table: 8 Coordinates of drilled boreholes of Bolas Block with RL

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)	
			Latitude	Longitude
1	BLBH-1	45.50	20°56'12.90"N	70°30'12.00"E
2	BLBH-2	38.50	20°56'8.20"N	70°30'32.40"E
3	BLBH-3	38.00	20°55'40.80"N	70°30'16.30"E
4	BLBH-4	25.50	20°55'15.30"N	70°30'3.50"E
5	BLBH-5	31.00	20°55'26.40"N	70°30'27.90"E

9.2 Methodology of drilling with details of type of drilling:

Drilling technique and drill sampling employed:

i) Drill type (eg. core, reverse circulation, open-hole hammer, rotary air blast, auger, Bangka, sonic, etc.) and details (eg. core diameter, triple or standard tube)

Core drilling was carried out by GMRDS through M/s Vinayak Engimech Private Limited. Drilling was carried out during May 2025 by deploying hydraulic core drill rigs using NQ diamond bits with core diameter of 47.6 mm. Double tube core barrels were used to obtain maximum core recovery.

ii) Whether core and chip sample recoveries have been properly recorded and results assessed

Core recovery of every run of drilling for all the drilled boreholes was recorded properly. The core recovery of the boreholes in the area is 87.67% to 96.44% and is considered to be well within acceptable limit for resource/reserve estimation purposes. There is

minimal core loss due to washing of clay intercalations, loose and fractured formation etc.

iii) Measures taken to maximize sample recovery and ensure representative nature of samples.

In order to maximize the core recovery, the rate of penetration, bit pressure and speed of rotation was controlled while drilling and more significantly in the fractured/loose formation and at depth. Sufficient numbers of core barrels were maintained at site and were regularly checked for any undue bends.

iv) Whether a relationship exists between sample recovery and grade and whether sample bias may have occurred due to preferential loss/gain of fine/coarse material

The core recovery in Limestone is 87.67% to 96.44% hence grade analyzed for limestone is reliable.

v) Logging: Whether core and chip samples have been logged to a level of detail to support appropriate Mineral Resources estimation, mining studies and metallurgical studies

The entire core recovered by drilling was logged systematically in detail describing lithological units that can be observed by visual inspection. The details of lithology, grain size, colour, texture, structural features, presence of intercalations and cavities have been recorded. Wherever the recovery is less, extrapolations of drilled depth were done on proportionate basis considering the physical characteristics of individual units recovered. All the cores were kept and preserved properly in the PVC core boxes of specifications given by NMET following "Book Pattern". The core logging has well correlated with the chemical analysis of individual samples and will support the mineral resource estimation and mining studies.

vi) Discussion on the analysis results of handheld X-ray fluorescence (XRF), if used in the investigation

Handheld X-ray fluorescence (XRF) was not used by GMRDS for analysis during investigation.

9.3 Methodology of core zone sampling and sample preparation:

i) If core, whether cut or sawn and whether quarter, half or all core taken

The cores recovered from the boreholes after logging were split longitudinally into two halves by core splitter. One half of the split core was kept in the core box while the other half was subjected to sampling.

ii)

a) If non-core, whether riffled, tube sampled, rotary split etc. and whether sampled wet or dry

Only core samples were collected from the boreholes drilled in the area during exploration.

b) For all sample types, the nature, quality and appropriateness of the sample preparation technique

For sampling the ore zone, the drilled cores were logged, sample numbers were marked and then split longitudinally to equal halves. One half was kept for core repository. The other half of the split cores was crushed to 200-mesh size. The weight of the crushed core samples varied from 2 to 4 kg depending upon the sample length and recovery. After coning and quartering of the crushed 200-mesh size fraction, individual samples of about 500 gm samples each were sent to Petrography and Mineral Chemistry Laboratory, CGM, Gandhinagar for further processing and chemical analysis.

iii) Quality control procedures adopted for all sub-sampling stages to maximize representation of samples

Before and after preparation of each sample, the crusher, pulverizer, pestle & mortar, sieves and sample trays were properly cleaned to avoid intermixing of samples. The samples were packed properly to avoid entry of any foreign material as well as moisture. The samples were properly labeled for easy identification.

iv) Measures taken to ensure that the sampling is representative of the in-situ material collected

Prior to drilling, each borehole was given a unique label for easy identification. The core retrieved from the drill holes was stored in PVC core boxes. For easy identification and traceability, the core was preserved from the left to the right side of the box with increasing depth and the core was marked with an arrow giving down the hole direction. Separator plates were inserted at the end of each run. The length of the borehole at the end of each run was also marked on the inserted separator plates. Loose

soil /sludge collected in the course of drilling was packed in polythene, properly marked and kept at their respective depth. The core boxes were marked properly on the top, inner side of the lid and the front side giving details like, drill hole number, box number, indicating meterage i.e. From.....m tom. The core boxes were properly preserved and stored for protection from inclement weather and any other damage. The above procedures ensure the representation of the material collected at each place in the area in terms of its location, depth and litho-unit sample.

v) Whether sample sizes are appropriate to the grain size of the material being sampled

The individual core samples were formulated for a linear length of 0.28 to 2.28 m. Each sample was subjected to crushing, coning and quartering by applying the standard method of size and weight reduction. The crushed sample was finally pulverized to 200-mesh size to prepare sample pellets. The pellets were then used in XRF for chemical analysis.

Since entire mineralized area has been sampled and analyzed and in view of the homogenous quality of the limestone the sample size is appropriate to the grain size.

A total of 67 primary samples and 10 composite samples were collected from the mineralized zones intersected in the drilled boreholes. Out of these primary samples 4 samples were also prepared for check sample analysis. The objective of sampling and chemical analysis was:

To confirm the presence and continuity of cement grade limestone and marl horizons in the block. To determine the chemical suitability of the limestone for cement industry by analysing major oxides such as CaO, MgO, SiO₂, Al₂O₃, Fe₂O₃, and LOI. To differentiate between cement grade limestone and marl, and to generate representative analytical data for grade classification, estimation of average grade, and resource estimation.

The analytical results of these 4 check samples (Sample no: BLBH-3/04, BLBH-4/04, BLBH-5/05, BLBH-5/16) have been annexed as Annexure-7. The external check analysis results (Annexure-12) support the accuracy and consistency of the primary chemical analysis data, and therefore the analytical dataset is considered reliable for resource estimation.

9.4 Chemical analysis and Laboratory procedure:

a) The nature, quality and appropriateness of the assaying and laboratory procedures used and whether the technique is considered partial or total

The cores recovered from the boreholes after logging were split longitudinally into two halves. One half of the split core was kept in the core box while the other half was subjected to sampling. Sampling intervals were marked after identifying the different litho-units in the process of core logging.

The individual core samples were formulated for a varied linear length of 0.28 to 2.28 m. The sample length varied depending upon the change in lithology or physical appearance.

A total of 67 nos. of primary core samples and 10 nos. of composite samples were analyzed for major and minor oxides i.e. LOI, SiO₂, Al₂O₃, Fe₂O₃, CaO, MgO, Na₂O, K₂O, TiO₂, P₂O₅, MnO and SO₃.

b) Nature of quality control procedures adopted (e.g. standard, blanks, duplicates, external laboratory checks) and whether acceptable level of accuracy (i.e. lack of bias) and precision has been established

The samples have been analyzed in the laboratory by wet chemical and instrumental method following standard procedures.

c) Check analysis of at least 10% of samples may be analyzed from third party National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited or Department of Science and Technology (DST) or Bureau of Indian Standards (BIS) recognized laboratories or government laboratories for assessing the acceptable level of accuracy.

The external check analysis of 04 samples (Sample no: BLBH-3/04, BLBH-4/04, BLBH-5/05, BLBH-5/16) have been analyzed from NABL approved laboratory LUCID Laboratories Pvt. Ltd., Hyderabad. The analysis has been attached as Annexure-7. The details of analysis of comparative study of primary core samples and external check samples by XRF are given in Annexure-12. The external check analysis results (Annexure-12) support the accuracy and consistency of the primary chemical analysis data, and therefore the analytical dataset is considered reliable for resource estimation.

Moisture

Whether the tonnages are estimated on a dry basis or with natural moisture and the method of determination of moisture content whether assumed or determined. If assumed, the basis for the assumptions. If determined, the method used, whether wet or dry, the frequency of measurements, the nature, size and representativeness of the samples

The laboratory tests are also carried out for specific gravity measurements on limited number of core samples on air dried basis. The specific gravity for Limestone varies from 2.70 to 2.71. The specific gravity of 2.71 are considered for estimation of resources of cement grade limestone. The specific gravity of 2.66 is considered for estimation of resources of Marl.

CHAPTER-10

Geotechnical studies on borehole core samples of mineralized zone, hanging wall and foot wall side

The Geological mapping and exploration result are indicating hard surficial Limestone deposit from depth of 0.10 to 15 meters across boreholes and as such the mining activity involved will be an open cast mining method and such type of studies are not required in this block.

CHAPTER-11

Resource Estimation

Based on exploration data, resource estimation was done for Limestone. Based on analysis result of CaO % and MgO %, Limestone is categorized as Cement Grade Limestone.

Grades and Resource have been assessed on the basis of end-use grade classification given by IBM's National Mineral Inventory (NMI) and Threshold value of minerals, Indian Mineral yearbook 2022, Volume – III Mineral Reviews – Limestone and Other Calcareous minerals, , IBMS, Ministry of Mines, Govt. Of India, October 2024 in following categories:

Table: 9: Specifications of Limestone grades by IBM

Grade	CaO %	MgO % (Max)	Fe₂O₃ % (Max)
Chemical	> 52	–	≤ 0.25
Limestone [Cement Grade (blendable/beneficiable, portland)]	34-52	≤ 5.00	–
Marl	20-34	–	–

The following parameters and assumptions have been taken into consideration for resource estimation: -

1. In each borehole area of influence has been considered for resource calculation, as the mineral deposit is of regular habit.
2. Tonnage is estimated on dry basis, after removing moisture content. If sludge chemical analysis results show promising lithology then sludge analysis lithology calculated for resource estimation.
3. Average cumulative thickness is taken for each borehole fall under different category regions, i.e., G3.
4. As per MEMC guidelines for the deposits of Regular habit, the area covered by wide spaced bore holes with bore holes spacing is 800 m are marked for G3 category resource.

5. Specific Gravity has been estimated grade wise and average specific gravity for Limestone [Cement Grade (blendable/beneficiable, portland)] is 2.71 and for Marl it is 2.66 in Bolas Block.
6. Recovery loss has not been considered.
7. Total resources estimated here are insitu resources.
8. Clay part intersected in between the Limestone [Cement Grade (blendable/beneficiable, portland)] were not considered for resource estimation, for calculating average thickness and for estimating average grade of mineralized zone.
9. No cut off was fixed for thickness for delineation of mineralized zone Cement Grade Limestone. The cumulative thickness of limestone and marl in each borehole was derived from lithological logging. The average thickness values (5.91 m for limestone and 2.18 m for marl) represent arithmetic averages of borehole-wise thicknesses.
10. To separate out different grades of Limestone and Marl, CaO % & MgO % values has been considered. The resource calculations are based on threshold values as per IBM specifications (Limestone: CaO $\geq$ 34%, MgO $\leq$ 5%)
11. The average grade of Cement Grade Limestone and Marl has been derived from the chemical analysis results of the collected core samples (Annexure-4 and Annexure-5). The average values of CaO and MgO were calculated as the arithmetic mean of all individual samples which satisfy the respective threshold criteria.

The method of chemical analysis of samples and elements to be analyzed were decided by the state government and analysis results were given by State government which is accepted for the estimation of average grade of Limestone.

Resource estimation has been done by using an Arc GIS Software. Area of influence of each borehole is estimated by considering the multiplication of length and width of rectangle covered by the borehole of Limestone [Cement Grade (blendable/beneficiable, portland)] specific gravity etc. and the classification of the estimated resource was done as per MEMC guidelines. The length, width and thickness of Cement Grade Limestone and Marl is considered in meters. The total area covered under the Bolas Block is 202.328 hectares. The various terms expressed for computation of resource are mentioned in short term as below:

$$L \times W \text{ (or } A) \times Th \times Sp. Gr. = R$$

Where;

L = Length in m

W = Width (in m)

A = Area in m²

Sp. Gr. = Specific Gravity

R = Resources in Tonnes

Th = Thickness (in m)

Average grade of Limestone i.e. Cement Grade (blendable/beneficiable, portland) was calculated. In this method the average value of thickness of each grade, CaO% and MgO% values were taken borehole wise. Then average value of these previously taken values was calculated for average grade of cement grade Limestone and Marl.

11.1 Reporting of resources:

The resources have been categorized under Inferred Mineral Resource (333) category considering the drilling grid of boreholes drilled in the area.

The summary of total litho-unit zone wise in-situ resource across the Bolas Block as per Minerals (Evidence of Mineral Contents) Rules 2015 and its amendments is presented in Table 10:

Table: 10-In-situ resources of Bolas Block, Gir Somnath

Litho-Unit	In-situ Resources at G3 (million tonnes) -
Cement Grade Limestone	28.37
Marl	8.55

The resource estimation has been carried out for the entire Bolas Block. The block has been explored and resource estimation performed accordingly, using Thiessen polygon method. The average quality of individual litho-unit zone is given in Table 11:

Table: 11-Average quality of individual litho-unit zone

Litho-Unit	Chemical Composition (%)											
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	MnO	SO ₃	LOI
Cement Grade Limestone	13.39	4.16	2.14	0.24	43.73	1.67	0.12	0.41	0.05	0.02	0.03	33.76
Marl	31.64	8.90	3.58	0.48	27.63	3.22	0.32	1.44	0.06	0.03	0.03	22.53

The detail of litho-unit zone wise and level wise insitu resources is enclosed as Annexure-1. The resource discussed above, portrays an overall picture of the available resources within the block area and does not entail the mineability of the deposit. Following observations could be drawn from the In-situ resources discussed above. A total of 28.37 million tonnes in-situ resource of cement grade Limestone and 8.55 million tonnes in-situ resource of Marl is available within Bolas Block area under 333 category of UNFC for G3 stage.

Interpretation of Isopach map: Limestone

The isopach map of Cement Grade Limestone in the Bolas Block indicates significant variation in thickness across the boreholes. The maximum cumulative thickness of 9.7 m is recorded in Borehole BLBH-4, located in the southwestern part of the block, marking the zone of maximum limestone development. Borehole BLBH-5 also shows considerable thickness of 5.02 m, supporting this trend. Considerable thicknesses are observed in BLBH-2 (6.4 m) and BLBH-3 (4.52 m) towards northeastern and central parts respectively, while BLBH-1 records the minimum thickness of 3.9 m. The overall distribution suggests a thickening trend along the northeast-southwest and southern parts of the block, with thinning toward the northern peripheries. This pattern indicates a depositional control, possibly linked to paleo-topographic lows that favored greater accumulation of carbonate material.

Interpretation of Isopach map: Marl

The isopach map of Marl in the Bolas Block shows a relatively uniform distribution of thickness across the block with slight local variations. The maximum cumulative thickness of 2.62 m was recorded in Borehole BLBH-2, while other boreholes show thicknesses ranging from 2.53 m (BLBH-4) to 2.55 m (BLBH-3). The minimum thickness of 1.00 m was noted in BLBH-2, while BLBH-1 was negative for Marl. This pattern suggests that Marl occurs as a thin, consistent horizon, with localized thickening towards the southern part of the block.

CHAPTER-12

Core preservation

After completion of the drilling work, core boxes were carefully shifted to Bolas camp where sampling was carried out. Half-splitted cores were taken for sampling purpose and remaining half cores were stored in core boxes. On completion of all the field investigation, the core boxes were handed over in safe custody of Senior Geologist, Rajkot.

CHAPTER-13

Conclusion and recommendation

The current exploration was undertaken to assess the potential of limestone resources in the Bolas Block, keeping in mind the regional industrial demand for cement-grade raw materials. The investigation has provided insight into the geological characteristics, quality, and mineral potential of the area.

Drilling was carried out on an 800 m × 800 m grid, and a total of five boreholes were drilled with a cumulative meterage of 68.00 meters. A total of 67 primary core samples, 10 composite samples and 04 external check samples were analyzed chemically, and 3 petrographic sample was studied. The investigation revealed that Limestone is the dominant litho-unit encountered in all boreholes, with high CaO content and considerable thickness. Marl was intercepted, with limited thickness.

Chemical analysis of the Limestone indicates that the material meets cement-grade thresholds. Based on chemical analysis and current industrial requirements, the resources have been categorized into Limestone [Cement Grade (blendable/beneficiable, portland)] and Marl. The block falls under the “bedded, stratiform, and tabular deposit of regular habit” category as per MEMC Rules, 2015 and its amendments.

A total of 28.37 million tonnes of cement grade Limestone (blendable/beneficiable, portland) and 8.55 million tonnes of Marl have been estimated under the UNFC 333 (Inferred) category.

Considering the encouraging results, closer spaced drilling at 400 m × 400 m is recommended to further delineate resource continuity and upgrade resource confidence from the Inferred (333) to Indicated (332) category.

CHAPTER-14

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CHAPTER-15

Locality Index

Table: 12-Locality index

<u>Name of village</u>	<u>Latitude</u>	<u>Longitude</u>
Bolas	20°54'57.86"N	70°29'44.89"E
Nakhada	20°55'40.77"N	70°30'53.53"E
Kukrash	20°56'37.82"N	70°30'54.96"E
Indroi	20°56'32.48"N	70°28'44.05"E
Rampara	20°56'22.13"N	70°32'24.01"E
Gorakhmadhi	20°54'31.13"N	70°32'14.62"E
Sundarpara	20°54'0.41"N	70°30'37.77"E

ABBREVIATIONS USED

SL. No.	Abbreviation	Full form
1	CGM	Commissioner of Geology and Mining
2	GSI	Geological Survey of India
3	GMRDS	Gujarat Mineral Research & Development Society
4	F.S.	Field Season
5	NMET	National Mineral Exploration Trust
6	TCC	Technical cum Cost Committee
7	EC	Executive Committee
8	UNFC	United Nation Framework Classification
9	NMI	National Mineral Inventory
10	IBM	Indian Bureau of Mines
11	NABL	National Accreditation Board for Testing and Calibration Laboratories
12	MEMC	Minerals (Evidence of Mineral Contents)
13	MMDR	Mines & Minerals (Development and Regulation)
14	NH	National Highway
15	SH	State Highway
16	WGS-84	World Geodetic System-84
17	DGPS	Differential Global Positioning System
18	DMS	Degree Minute Second
19	XRF	X-ray Fluorescence
20	ML	Mining Lease
21	R.L.	Reduced Level