GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G–3) FOR LIMESTONE IN CHHASRA BLOCK (FIELD SEASON-2024-25) TALUKA: ABDASA DISTRICT: KACHCHH, GUJARAT

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

गुजरात खनिज अनुसंधान एवं विकास सोसाइटी (जीएमआरडीएस) खनिज उद्योगों को सहायता प्रदान करने तथा भूविज्ञान एवं खनन आयुक्त की देखरेख में 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 काम करता है। अपने मुख्य मिशन के अलावा, जीएमआरडीएस राज्य की खनिज संपदा के लिए नए खनिज संसाधनों के संचालन में सक्रिय रूप से शामिल है।

2023-24 के फील्ड सीज़न में, गुजरात सरकार के भूविज्ञान और खनन आयुक्त की अन्वेषण शाखा ने भारत सरकार के खान मंत्रालय के राष्ट्रीय खनिज अन्वेषण ट्रस्ट (NMET) को गुजरात के कच्छ जिले के छसरा ब्लॉक में चूना पत्थर खनिज के G3-स्तर के अन्वेषण के लिए एक प्रस्ताव प्रस्तुत किया। इस परियोजना को 318 हेक्टेयर क्षेत्र में G3-स्तर के अन्वेषण के लिए फ़रवरी 2024 में NMET द्वारा अनुमोदित किया गया था, जिसमें गुजरात के कच्छ जिले के अब्दासा तालुका के छसरा, सुखपर और वडसर गाँव शामिल हैं।

पश्चिमी भारत में स्थित कच्छ अपनी सक्रिय तह और थ्रस्ट टेक्टोनिज़्म के लिए जाना जाता है, जिसने चूना पत्थर के जमाव सहित भूवैज्ञानिक संरचनाओं और तलछटी अनुक्रमों को प्रभावित किया है। यह क्षेत्र अपनी भूकंपीय गतिविधि के लिए भी जाना जाता है, जिसमें अक्सर भूकंप आते

रहते हैं। जुरासिक और इओसीन तलछटों के बीच डेक्कन ट्रैप ज्वालामुखी की उपस्थिति क्षेत्र की भूवैज्ञानिक जटिलता को बढ़ाती है। चूना पत्थर विभिन्न संरचनाओं और युगों में पाया जाता है, जिसमें ओलिगोसीन, इओसीन और मेसोज़ोइक काल शामिल हैं। इन संरचनाओं में मनियारा किला, फुलरा और जुमरा संरचनाएँ शामिल हैं। तृतीयक तलछट, जो मुख्य रूप से कच्छ के तटीय मैदानों में उजागर होती हैं, पैलियोजीन और नियोजीन काल के दौरान उथले समुद्री वातावरण में जमा हुई थीं। कैल्साइट के रूप में कैल्शियम कार्बोनेट (CaCO3) चूना पत्थर का प्रमुख खनिज घटक है। गैर-कार्बोनेट खनिजों के रूप में मौजूद टेरिजेनस क्वार्ट्ज, क्ले, पाइराइट, हेमेटाइट, चर्ट आदि की परिवर्तनशील मात्रा चूना पत्थर की गुणवत्ता/ग्रेड को नियंत्रित करती है। छसरा ब्लॉक क्षेत्र में पाया जाने वाला चूना पत्थर मिओसीन युग के छसरा फॉर्मेशन से संबंधित है। यह हल्के भूरे रंग का, मिट्टीयुक्त और जीवाश्मयुक्त प्रकृति का है, जो मिट्टी और अशुद्ध मार्ल के बीच में पाया जाता है। लिथोलॉजी का जमाव और जीवाश्म प्रकृति उप-तटीय वातावरण से लेकर उथले आंतरिक-शेल्फ स्थितियों में जमाव का सुझाव देती है।

गुजरात मिनरल रिसर्च एंड डेवलपमेंट सोसाइटी (जीएमआरडीएस), गांधीनगर द्वारा लगभग 318 हेक्टेयर के कुल ब्लॉक क्षेत्र का अन्वेषण किया गया था। ब्लॉक के भीतर, 800 x 800 मीटर ग्रिड पर 5 बोरहोल ड्रिल किए गए थे, जो छासरा ब्लॉक में 176 मीटर की कुल गहराई तक पहुँच गए थे। ड्रिल किए गए बोरहोल से प्राप्त कोर से कुल 94 नमूने तैयार किए गए और विश्लेषण के लिए पेट्रोग्राफी और मिनरल केमिस्ट्री प्रयोगशाला (पीएमसी लैब) गांधीनगर भेजे गए। सभी कोर ड्रिलिंग नमूनों का प्रमुख और मामूली ऑक्साइडों के लिए विश्लेषण किया गया, जिनमें CaO, MgO, Al_2O_3, SiO_2, Fe_2O_3, SO_3, P_2O_5, K_2O, Na_2O, MnO, TiO_2 और LOI विशिष्ट गुरुत्व के साथ शामिल थे। इस परियोजना के परिणामस्वरूप, गुजरात की खनिज संपदा में निम्नलिखित खनिज संसाधन स्थापित हुए: 3.88 मिलियन टन सीमेंट ग्रेड चूना पत्थर जिसमें CaO 42.02%, MgO 1.49%, SiO_2 15.40% और Fe_2O_3 7.98% है और 34.86 मिलियन टन मार्ल जिसमें CaO 27.37%, MgO 2.81%, SiO_2 23.29% और Fe_2O_3 12.59% है।

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 drilling explorations. 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 the State 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 new mineral resources for state's mineral wealth.

In the 2023-24 field season, the Exploration Branch of the Commissioner of Geology & Mining, Government of Gujarat, submitted a proposal to the National Mineral Exploration Trust (NMET), Ministry of Mines, Government of India, for G3-level exploration of Limestone mineral in the Chhasra Block, Kachchh District, Gujarat. The project was approved by NMET in February 2024 for G3-level exploration over an area of 318 hectares, covering the villages of Chhasra, Sukhpar and Vadsar in Abdasa Taluka, Kachchh District, Gujarat.

Kachchh, in western India is known for its active fold and thrust tectonism, which has influenced the geological structures and sedimentary sequences, including the Limestone deposits. The region is also known for its seismic activity, with frequent earthquakes. The presence of Deccan Trap volcanics between Jurassic and Eocene sediments adds to the geological complexity of the area. The Limestone is found in various formations and ages, including Oligocene, Eocene, and Mesozoic periods. These formations include the Maniyara Fort, Fulra, and Jumra Formations, among others. The Tertiary sediments, exposed mainly in the coastal plains of Kutch, were deposited in shallow marine environments during the Paleogene and Neogene periods. Calcium carbonate ($CaCO_3$) in the form of calcite is the predominant mineral constituent of Limestone. Variable amount of terrigenous quartz, clay, pyrite, hematite, chert etc., present as non-carbonate minerals, control the quality/grade of limestone. The Limestone encountered in the Chhasra Block area belongs to the Chhasra

Formation of Miocene age. It is of light grey colour, argillaceous and fossiliferous in nature, found interbedded between clays and impure marl. The deposition and fossil nature of the lithology suggests deposition in sublittoral environment to shallow inner-shelf conditions of deposition.

The total block area of approximately 318 hectares was explored by the Gujarat Mineral Research & Development Society (GMRDS), Gandhinagar. Within the block, 5 boreholes were drilled on a 800 x 800 meter grid, reaching a total depth of 176 meters in the Chhasra Block. A total of 94 samples were prepared from the core recovered from the drilled boreholes and sent to the Petrography & Mineral Chemistry Laboratory (PMC Lab) Gandhinagar, for analysis. All core drilling samples were analysed for major and minor oxides, including, CaO, MgO, Al_2O_3, SiO_2, Fe_2O_3, SO_3, P_2O_5, K_2O, Na_2O, MnO, TiO_2, and LOI along with specific gravity. Based on the analysis 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 mineral resources were established in Gujarat's mineral wealth: 3.88 million tonnes of Cement Grade Limestone with CaO at 42.02%, MgO at 1.49%, SiO_2 at 15.40%, and Fe_2O_3 at 7.98% and 34.86 million tonnes of Marl with CaO at 27.37%, MgO at 2.81%, SiO_2 at 23.29%, and Fe_2O_3; at 12.59%.

Brief Details

<table>
<tr><th>Sr. No.</th><th>Parameter</th><th colspan="5">Data</th></tr>
<tr><td>01</td><td>Name of the Block</td><td colspan="5">Chhasra Limestone Block</td></tr>
<tr><td>02</td><td>Location</td><td colspan="5">Village: Chhasra, Sukhpar and Vadsar
Taluka: Abdasa
District: Kachchh</td></tr>
<tr><td>03</td><td>Block Area</td><td colspan="5">318 Hectare</td></tr>
<tr><td rowspan="6">04</td><td rowspan="6">Block Boundary Co-ordinates</td><td rowspan="2">Boundary Pillar</td><td colspan="4">DMS (WGS 84)</td></tr>
<tr><td colspan="2">Latitude</td><td colspan="2">Longitude</td></tr>
<tr><td>BP-1</td><td colspan="2">23°21'58.98"N</td><td colspan="2">68°44'44.25"E</td></tr>
<tr><td>BP-2</td><td colspan="2">23°21'57.84"N</td><td colspan="2">68°46'21.04"E</td></tr>
<tr><td>BP-3</td><td colspan="2">23°21'11.06"N</td><td colspan="2">68°46'22.12"E</td></tr>
<tr><td>BP-4</td><td colspan="2">23°21'10.80"N</td><td colspan="2">68°45'25.38"E</td></tr>
<tr><td>05</td><td>Total Area Covered under Geological Exploration</td><td>BP-5</td><td colspan="2">23°21'43.18"N</td><td colspan="2">68°44'57.79"E</td></tr>
<tr><td>06</td><td>No. of Boreholes Drilled</td><td colspan="5">05 Nos.</td></tr>
<tr><td>07</td><td>Total Meterage Drilled</td><td colspan="5">176 mts</td></tr>
<tr><td>08</td><td>Borehole Spacing</td><td colspan="5">800 mts x 800 mts</td></tr>
<tr><td>09</td><td>Depth of the Mineralized Zone</td><td colspan="5">3.67 mts to 56.61 mts</td></tr>
<tr><td>10</td><td>Economic Mineral Resource with Quality</td><td>Commodity</td><td>Average Thickness (m)</td><td>Resource (In million tons)</td><td colspan="2">Quality</td></tr>
</table>

		Limestone [Cement Grade (blendable/beneficiable, portland)]	1.33	3.88	CaO:42.02%, MgO:1.49%,SiO_2: 15.40%, Fe_2O_3: 7.98%
		Marl	4.32	34.86	CaO:27.37%, MgO:2.81%, SiO_2:23.29%, Fe_2O_3:12.59%
11	Average Overburden to Mineralized zone	4.98			
12	Linear Ratio Mineralized zone to OB (mts : mts)				
13	Linear Ratio Mineralized zone to OB (mts : mts)				
14	Toposheet No.	41A/11 and 41A/15			
15	Topography	undulating topography			
16	Average Rainfall	378.2 mm			
17	Lowest Temperature	9 ° C (January)			
18	Maximum Temperature	39.5° C (May)			
19	Nearest Railway station	Naliya Railway station- 13.50 km			
20	Road	Accessible through SH-6, NH-41 adjacent to block area			
21	Airport	Bhuj airport- 91.55 km			
22	Port	Jakhau port approx. 19.56 km away			

CHAPTER-1

Introduction

1.1 Details of Project:

On 20.01.2024 a proposal for G3 level Limestone exploration in Chhasra Block, Abdasa taluka, Kachchh district, Gujarat was submitted to NMET by Commissioner of Geology and Mining.

In the 33rd EC meeting held on 19.02.2024 the matter was discussed and EC approved the project with an estimated cost of Rs. 174.04 Lakhs. The sanction order was received on 28.02.2024 and accordingly work was started on 18.03.2024. Subsequently, CGM Gujarat presented the status of progress and sought a timeline extension for project completion. Based on the review of progress and justification provided, a time extension up to 28.02.2025 was approved during the 39th EC meeting held on 24.01.2025. Further, in view of delays in execution, CGM Gujarat submitted a request for additional time, and the TCC-II recommended approval of a second extension of 6 months, up to 27.08.2025, for the completion of the project.

The exploration proposal for the Chhasra Block was initially prepared with a total proposed area of 3537 hectares, within which 55 boreholes were planned. However, during the 61st TCC meeting held on 31.01.2024, it was suggested that the block boundary be modified to avoid major water bodies, where drilling would not be feasible. In line with this recommendation, the Commissioner of Geology and Mining (CGM), Gujarat revised the block boundary to exclude the water-covered regions. As a result, the revised exploration area was reduced to 318 hectares, and the number of proposed boreholes was also adjusted accordingly. Following this revision, the proposed drilling plan was modified, and 5 boreholes were drilled within the redefined block boundary to carry out G3 stage exploration in line with NMET guidelines.

The Chhasra Block falls in the toposheet no. 41A/11 and 41A/15 in Chhasra, Sukhpar and Vadsar villages of Abdasa taluka, Kachchh district. The Preliminary Exploration (G3) for the mineral Limestone in Chhasra Block was carried out on a grid of 800 x 800 meters, drilling a total of 05 boreholes comprising a total meterage of 176 meters within the block.

1.2 Investigation Agency:

Commissioner of Geology and Mining, Government of Gujarat, Gandhinagar

1.3 Objective of the investigation:

i) To carry out detailed Topographical Survey and Geological mapping on 1:4000 scale over an extent of 318 hectares.

ii) To delineate the strike and depth continuity of the limestone by drilling 05 boreholes on 800m strike interval, in Chhasra Block.

iii) To carry out exploration as per Minerals (Evidence of Mineral Contents) Rule-2015 & Mineral (Auction) Rules-2015 (Amendments) on G3 level.

iv) The proposed exploration programme will be helpful in demarcating zone of limestone in the block as per UNFC norms and estimation of limestone resources.

1.4 Basis for taking up investigation:

Previously GSI had mapped geological formation on the scale of 1:50000. The region was primarily investigated by CGM by means of sampling during the 2023-24 year field season and upon completing chemical analysis of the collected rock samples revealed an average CaO content of 42.32%. CGM officials found that the Geological data and Chemical analysis result of the area is very promising and recommended for the further exploration of Limestone mineral. In order to meet the demand of Limestone mineral in cement industries, CGM is planning for ML directly, which will expedite the auction process & as a result state will get more royalty income as well as industries will get profit. Existing mining leases of M/S Sanghi Cements and M/S JK Cement are present in the surroundings of the block, which testify to the limestone prospectivity of the region. Notably, the Ultratech Cement Sewagram mining lease is located approximately 8.82 km north of the block. These nearby working leases indicate the continuity of mineable limestone deposits in the broader area. However, no mining leases fall within the original study area of 3537 hectares. Thus, the block can be studied as an extension of the already existing mineable deposits, and is therefore suggested for G3 level of exploration.

1.5 Details, nature and quantum of work proposed V/S achievement:

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

Sr. No	Item of Work	Original Proposed	Modified	Achieved
1	Topographic Survey & Geological Mapping on 1:4000 scale (Ha)	3537 Ha	318 Ha	318 Ha
2	Boundary and borehole demarcation with DGPS	55	5	5
3	Exploratory Drilling (One conditional BH to confirm the total thickness of limestone)	1100 m 55 BHs	176 m 05 BHs	176 m 05 BHs
4	**Laboratory Studies**			
	i) Chemical Analysis; Primary samples for 12 radicals, CaO, MgO, Al_2O_3, SiO_2, Fe_2O_3, SO_3, P_2O_5, K_2O, Na_2O, MnO, TiO_2, and LOI by XRF	1000 Core	94 Core	94 Core
	ii) External Check (NABL) samples (10% of Primary samples) for analysis of for 12 radicals, CaO, MgO, Al_2O_3, SiO_2, Fe_2O_3, SO_3, P_2O_5, K_2O, Na_2O, MnO, TiO_2, and LOI by ICP-OES	100	9	9
5	**Physical Studies**			
	a) Petrological Studies	5	1	1
	b) Specific gravity Determinations	100	5	5
6	Report Preparation (5 Hard copies with one soft copy)	1	1	1
7	Preparation of Exploration Proposal (5 Hard copies with a soft copy)	1	1	1

1.6 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 Surveyor, Samplers, Geologists, GIS experts and Chemists are involved in this work.

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-2

Property description

2.1 Title of the Report

Geological Report on Preliminary Exploration (G–3) for Limestone in Chhasra Block, Taluka: Abdasa, District: Kachchh, Gujarat.

2.2 Details of the area

The project area falls in parts of Chhasra, Sukhpar and Vadsar villages of Abdasa taluka, Kachchh District, Gujarat. The Chhasra Limestone Block has an area of 318 hectares, bounded by Longitude 68°44'44.25"E to 68°46'22.12"E and Latitude 23°21'10.80"N to 23°21'58.98"N.

2.2.1 Survey of India Toposheet number

The block area falls under the Survey of India Toposheet No. 41A/11 and 41A/15 of Abdasa Taluka of Kachchh district, Gujarat. A map showing area on toposheet can be referred for the same, (i.e. Plate-3).

2.2.2 Geo-coordinates of the Chhasra 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 Chhasra Block boundary

Sr. No.	Boundary Pillar	DMS (WGS 84)	
		Latitude	Longitude
1	BP-1	23°21'58.98"N	68°44'44.25"E
2	BP-2	23°21'57.84"N	68°46'21.04"E
3	BP-3	23°21'11.06"N	68°46'22.12"E
4	BP-4	23°21'10.80"N	68°45'25.38"E
5	BP-5	23°21'43.18"N	68°44'57.79"E

Table: 4 Coordinates of drilled boreholes of Chhasra Block

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)	
			Latitude	Longitude
1	CHBH-1	24.00	23°21'46.50"N	68°45'12.30"E
2	CHBH-2	20.00	23°21'41.80"N	68°45'43.10"E
3	CHBH-24	18.00	23°21'16.50"N	68°45'41.50"E
4	CHBH-23	16.00	23°21'17.90"N	68°46'07.80"E
5	CHBH-3	15.00	23°21'50.30"N	68°46'11.90"E

2.2.3 Location and Accessibility

The project area falls in parts of Chhasra, Sukhpar and Vadsar villages of Abdasa taluka, Kachchh District, Gujarat. District headquarter is situated at Bhuj. The area is accessible through SH-6 and NH-41. A Key and Location plan can be referred for the same (i.e. Plate-1). The nearest airport from the study area is Bhuj airport which is around 91.55 Km away from the Chhasra Block. Nearest Railway station is Naliya which is approx. 13.50 Km away from the Chhasra Block. The area is accessible throughout the year. Jakhau, which is an intermediate type port, is located around 19.56 km away from the present Block. An aerial view of study area map of Chhasra Block has been also given (i.e. Plate-2).

2.2.4 Climate

The climate is typically arid with negligible rainfall. There is not much vegetation - cover over the greater part of the study area. The low dipping beds form wide outcrop over the rather flat terrain permitting collection of larger number of fossiliferous samples. The summer months are not suitable for field due to extreme temperatures. The period from November to March is most suitable for carrying out systematic field work in this arid region. The temperature in Kachchh District ranges from 39.5° C higher in the summer and 9° C lowest in the winter. The average annual rainfall is 378.2 mm. (Source: CGWB, Aquifer Map and Management Plan, Kachchh District, Gujarat, 2022 and Local Meteorological Department)

2.2.5 Flora and Fauna

Climate has a direct bearing on the life of this area. Xerophytes dominate over all other plants in this area and are concentrated along topographic lows. The flora is mostly dominated by the thorny bushes of *Acacia nilotica* (Acacia), *Commiphora wightii*(Guggal), *Senegalia catechu* (Khair) and sacculants like *Cactaceae*(Cactus). Major crop of cultivated in the area is *Pennisetum glaucum* (Bajra). Although rain comes after several years, regular cultivation is being carried out in parts of the low areas with the help of ground water.

Common fauna includes desert dweller reptiles which inhabit rocky areas. These are *Uromastyx* (spiny tailed lizards) and *Serpentes*(snakes), *Pseudomys desertor (*desert rodents), *Oryctolagus cuniculus* (rabbits) and *Erethizontidae* (porcupines). Other animals include*Cervidae* (deer), *Camelus* (camel), *Boselaphus tragocamelus* (nilgai),

Bubalus arnee(Wild Buffalo) and *Sus scrofa*(Wild Boar). *Perdix perdix*(Grey Partridges) are common bird in the area.

2.2.6 Drainage

Studying the drainage system is essential for gaining insights into geomorphology and structural fabrics of the area. The block area is characterized by a generally flat to gently undulating terrain. No perennial rivers or streams pass through the block. However, small seasonal water bodies and ephemeral drainage channels are observed, particularly near low-lying areas. Khari Nadi lies outside the southeastern boundary. The drainage pattern is sub-dendritic, formed by seasonal runoff during the monsoon.

2.2.7 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 Chhasra Block. The Kachchh district covers an area of 45,674 km^2 and population of the district is 20,92,371 as per 2011 census. Chhasra, Sukhpar and Vadsar are are nearby villages to Chhasra Block. This Block is located around 91.95 Km towards South-East from District headquarters Bhuj and around 382.26 Km from state capital Gandhinagar. Abdasa is around 11.62 Km far from this block.

CHAPTER-3

Previous work

Previously Geological Survey of India conducted a geological mapping on 1:50000 scale in Toposheet no. 41A/10, 41A/11 and 41A/15, revealing the geological potential for Limestone in the area. CGM officials has also carried out field in 2023-24 year survey of the initial proposed area and a total of 36 grab samples were collected during preliminary surface exploration across the originally proposed block area (3537 ha). These samples were analyzed to assess the surface expression of limestone. However, following boundary revision, the block area was reduced to 318 hectares. Only 12 of the originally collected samples now fall within the revised block boundary. The average CaO content of these 12 samples is given below and they form the basis for interpreting surface limestone presence in the current block.

Chemical Composition (%)										
SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	LOI
10.68	4.78	6.39	0.31	41.13	1.01	0.24	0.38	0.14	0.07	34.34

During F. S: 1982-83, Shri G. Vijayasarathi Geologist s (Jr.), GSI, had carried out systematic mapping of the toposheets no. 41A/10, 41A/11 and 41A/15 covering an area about 430 sq Km was mapped on 1:50000 scale in the western part of Kutch district, mainly comprising of Tertiary rocks.

During F. S: 1984-85, Shri G. Vijayasarathi & Shri A.B. Sabale, Geologist s (Jr.), GSI, had carried out systematic mapping of the toposheets no. 41A/10, 41A/11 and 41A/15 covering the Tertiary rocks of Kutch District.

Shri S. K. Biswas (1992) carried out the detailed geological stratigraphic sequence for Tertiary Stratigraphy of Kutch,

Details of Aero-geophysical and Geophysical mapping

A systematic regional gravity and magnetic surveys were carried out in toposheet nos. 41A/11, 15 in parts of Abdasa taluka, Kachchh district, Gujarat under National Geophysical Programme (NGPM) of GSI. The Bouguer gravity contour map shows values ranging from +8 mGal to -11 mGal with an overall variation of 19 mGal and the magnetic contour map shows values ranging from +404 nT to -354 nT with an overall variation of 758 nT.

CHAPTER-4

Geology of the area

4.1 Regional Geology:

The Kachchh basin preserves about 2000 to 3000 m thickness of Mesozoic sediments and about 1000 m thickness of Cenozoic sediments (Biswas, 1977, 1982). The Tertiary rocks are exposed along the coastal belt of southern and western Kachchh, bordering the Mesozoic rocks. The Quaternary sediments consist of a wide variety of sediments, ranging from marine to fluvial, laccustrine and aeolian deposits. In the coastal plains the late Quaternary deposits mostly consist of alluvium and calcreted or ferricreted loose sediments, covering the older deposits. The exposed Tertiary sediments are mostly littoral to shallow marine shelf sediments, deposited in the peripheral and intervening structural lows that border the Mesozoic uplift areas.

4.2 Mesozoic Stratigraphy:

The Mesozoic rocks of Kachchh were first mapped by Wynne (1872), who classified the sequence into the upper and the lower Jurassic groups. These were further subdivided into the Pachham, Chari, Katrol, and Umia series. The litho-statigraphic sequence of the mainland is divided into the following formations:

4.2.1 Jhurio Formation

The Jhurio Formation consists of a thick sequence of limestones and shales with bands of 'golden oolites'. The type section occurs in Jhurio Hill, north-central mainland. The upper part comprises thinly bedded white to cream-coloured limestones (pelmicrite and biomicrite) with thin bands of 'golden oolite'. The middle part is thick grey-yellow weathered shales alternating with thick beds of golden oolitic limestones. The lower part consists of thin beds of yellow and grey limestones. This formation ranges from Bathonian to Lower Callovian in age.

4.2.2 Jumara Formation

The Jumara Formation conformably overlying the Jhurio Formation. It has been named after its type section in Jumara hill to the north of Jumara village and near the Great Rann. The formation is characterized by monotonous olive-grey gypseous laminated shales with thin red ferruginous bands. Local disconformity is observed at places where the Jhuran shales are seen resting over the eroded Dhosa oolite member. The Jumara formation ranges age between Callovian and Oxfordian.

4.2.3 Jhuran Formation

Jhuran Formation comprises of a thick sequence of alternating beds of sandstones and shales. It is divided into four members, the lower, the middle (Rudramata shale), the upper and the Katesar (Biswas, 1977). The lower member consists of alternating red and yellow sandstone and shale. The middle member is mostly shale, comprising of dark grey to black laminated gypseous shales. The upper member is predominantly arenaceous and is composed of red and yellow massive current-bedded sandstones with intercalations of shale, siltstone and calcareous sandstone. Kimmeridgian to Valanginian age is fixed for this formation.

4.2.4 Bhuj Formation

The Bhuj Formation, named after its type locality around Bhuj, consists of a thick sequence of non-marine sandstones of uniform character. It occupies about three-fourths of the total Mesozoic outcrop area in mainland Kachchh. In the south, Deccan Trap flows unconformably overlie this formation. The sediments represent deltaic deposits, with the distal part of a large Cretaceous delta to the west and the proximal part to the east. This formation is of Lower Cretaceous age.

The Deccan Tarps forms a more or less linear outcrop extending across the mainland with a maximum width of about 10 km in the east near the town of Anjar, and gradually tapering westward. Lava flows are dominantly tholeiitic basalts, occupying the southern and southwestern slopes of the central highland.

4.3 Tertiary Stratigraphy

Biswas (1974) proposed a revised stratigraphy and established that the Tertiary sediments in Kachchh were deposited on the eroded surface of the Deccan Trap and the Mesozoic sedimentaries. Deposition started with a marine transgression during Lower Eocene and ended in Pliocene. During Paleogene, deposition was restricted to the western part of the Kachchh Mainland, the thickest parts being exposed in the southwestern coastal plain which was the deepest part of the basin. The following is a brief summary of the Tertiary formations:

4.3.1 Madh Series

The type area of the rocks of this series is the well-known village of Matano-Madh in western Kachchh. It consists of volcanoclastic sediments deposited in variable environments, ranging from fluviatile to littoral.

4.3.2 Berwali Series

The series is divisible into two stages, the lower consisting of gypseous and ochreous clays and marl containing several varieties of mollusks and foraminifers, and is seen in Kakdi Nadi section (Kakdi Stage), and the upper stage is well exposed in Babia hill in westem Kachchh comprising a fossiliferous fragmental limestone with a basal calcareous clay bed (Babia Stage).

4.3.3 Bermati Series

This series forms a well exposed continuous belt south of Lakhpat in northwestern Kachchh. It is divisible into two stages; the lower Ramania stage consists of greenish-grey marl and argillaceous limestone with a basal boundary clayey marl bed deposited in an epineritic environment of a slowly regressive sea (Biswas,1974) and the upper part is composed of thinly bedded, very hard, grey to yellowish foraminiferal limestones with interbeds of silty marlite.

4.3.4 Khari Series

This series overlies unconformably the Bermoti series and is well exposed in the cliffy banks of the Khari River in southwestem Kachchh. The Khari series is made up of two distinct stages distinguishable. The lower Aida stage is composed of variegated siltstone, the lower 16 m of which is barren, but the upper part contains Lower Burdigalian fossil assemblage. The upper part of the series, the Vinjhan Stage consists of grey to khakhi-coloured gypseous clay with hard marl bands packed with fossils. This stage forms the main bulk of the Lower Miocene of Kachchh. The clays of this stage 16 contain a rich assemblage of Upper Burdingalian fossils. As the Khari series is seen overlapping the Deccan Trap directly, it suggests that this marine transgression was the most powerful one in the history of the Tertiary sedimentation in Kachchh.

4.3.5 Kankawati Series

Exposed around Kankawati River between Sandhan and Vinjhan, this series consists of grey micaceous and calcareous sandstone, lenticular bands of conglomerate containing abundant foraminifers.

4.4 Quaternary Sediments

The Quaternary sediments include marine, fluvial, lacustrine, and aeolian deposits. These unconsolidated formations form the alluvial plains, river terraces, coastal deposits, Rann sediments, and aeolian sand pockets across Kachchh.

The regional geology of the area is as follows:

Table: 5-Regional Geology of the Area

Age	Formation		Lithology
Holocene	Rann Formation		Rann clay and deposits
	Jantral Formation		Unstabilized sand sheet and sand dune deposit
Lower Pleistocene	Kothara Formation		Pebbly sandstone, conglomerate gravel and sand
Pliocene	Sandhan Formation		Micaceous sandstone,siltstone, conglomerate andcalcareous clay with marl
Lower to Middle Miocene	Chhasra Formation/ Gaj Formation		Shale interbedded withfossiliferous limestone and marl
Upper Oligocene to Lower Miocene	Khari Nadi Formation		Variegated siltstone andgypseous claystone
Middle to Upper Oligocene	Maniyara Fort Formation		Calcareous and gypseous claystone/siltstone, clay, coral limestone and sandstone
Middle Eocene	Fulra Formation		Foraminiferal limestone, glauconitic shale and clay
Lower Eocene	Kakdi Nadi Formation		Gypseous, lignite- bearing shale, fossiliferous nodular limestone and clay, ferruginous shale and clay with intercalated marl
Palaeocene	Matanomadh Formation		Laterite, sandstone, conglomerate and bentonitic and kaolinitic clay
Upper Cretaceous to Eocene	Deccan Volcanics	Extrusive	Andesitic trachyte
		Intrusive	Olivine gabbro, basalt and dolerite dyke
		Extrusive	Basalt flows with intertrappean sediments
Cretaceous	Bhuj Formation		Glauconitic and burrowed sandstone, siltstone, shale, limestone, marl, conglomerate, ironstone and clay with marine and plant fossil
Upper Jurassic to Lower Cretaceous	Katrol Formation		Shale, fossiliferous sandstone, marl and conglomerate
Middle to Upper Jurassic	Chari Formation		Gypseous shale, siltstone and conglomerate with phosphatic nodule, oolitic limestone
Middle Jurassic	Pachchham Formation		Gypseous shale, siltstone, limestone, sandstone and conglomerate

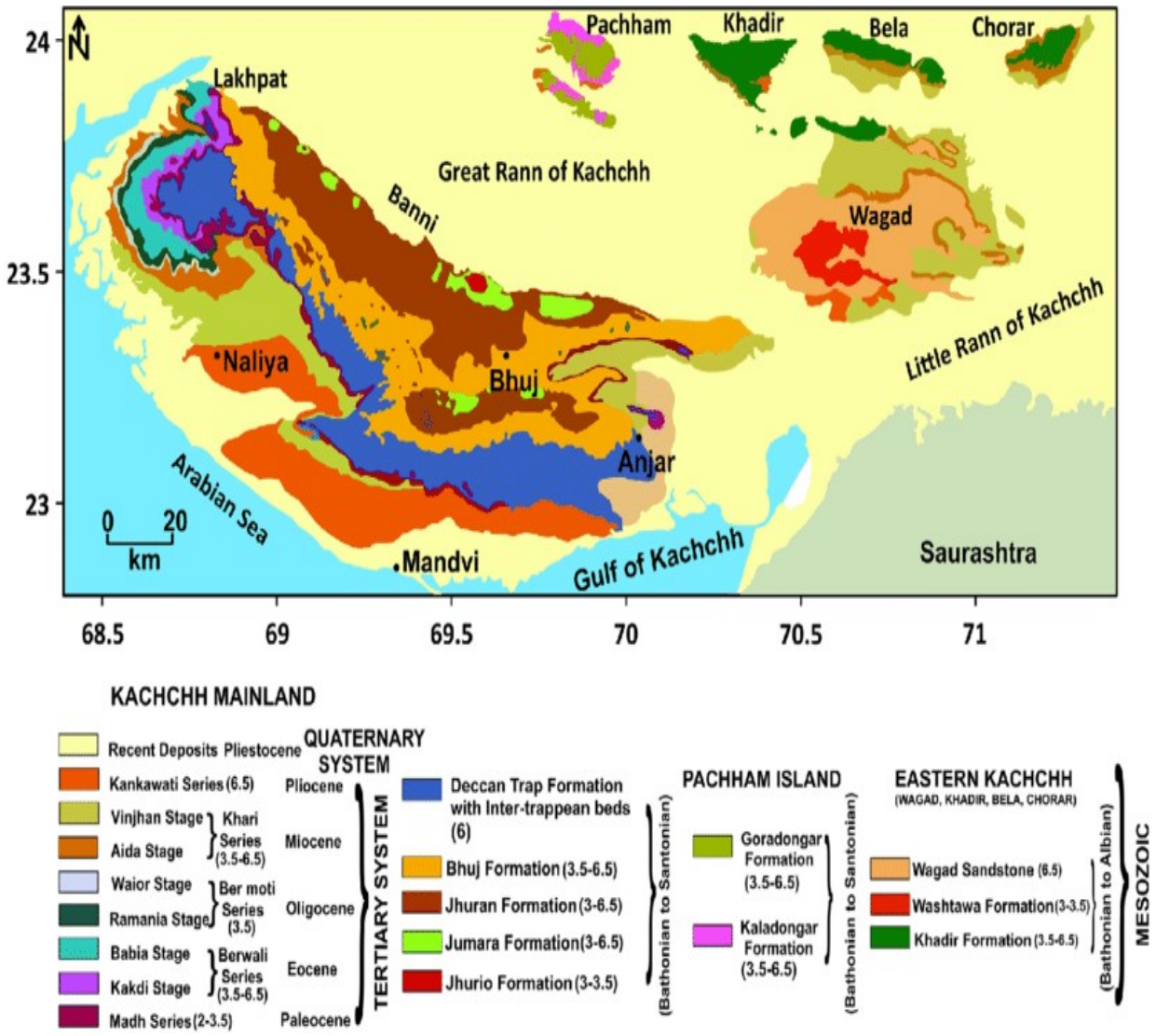

Figure 1 (Regional Geological map of the Kachchh Rift Basin after Biswas and Deshpande 1970)

Geology of the Block

The Limestone deposits occurring in the block area of Chhasra village mainly belong to the Chhasra Formation of the Miocene age. The Formation was named after the Chhasra village. This Formation is originally described as Gaj Beds (*Tewari 1957; Poddar 1959; Chatterjee and Mathur 1966*), Argillaceous group (*Wynne, 1972*) and also Vinjhan shale (*Biswas and Raju, 1971, 1973*). The Chhasra Formation is divided into two members, upper siltstone member consisting of argillaceous formations with few thin fossiliferous Marl beds and lower claystone member consisting of clay with alterations of thin, fossiliferous argillaceous limestones (*Biswas, 1992*). The surveyed area is covered with soil with few scanty outcrops within block.

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

Table: 6-Local Geology of the Study Area

Age	Formation	Member	Litho-units/Rock Type
Holocene	Recent		Yellowish to brownish top soil
Lower to Middle Miocene	Chhasra Formation	Upper	silty shales interbedded with thin fossiliferous marl
		Lower	Clay with thin fossiliferous limestone

Soil: It is the youngest unit exposed in the Chhasra Block, which is yellowish to brownish in colour, with fine to medium grain size and comprises loose material including clayey and calcareous fragments. It likely represents weathered surface cover having thickness of about 1 meter.

Limestone:

The Limestone encountered in the block is of light grey colour, argillaceous and fossiliferous in nature, found interbedded between clays and impure marl. A very thin layer of Limestone is encountered during the exploration within the block from only two drilled boreholes CHBH-1 and CHBH-3 in the study area ranging in thickness from 0.33 m to 2.32 m with an average of 1.33 m.

Clay:

Clay is the most common lithology found in the Chhasra block. The colour of the clay varies from yellowish brown to dark grey. It is fine grained, fossiliferous and varying from ferruginous to siliceous in nature. At few instances thin interbeds of shale-like material were observed, though visually similar to siliceous clay.

Marl:

Marl is encountered in all drilled boreholes in the present study area. It is a non-clastic sedimentary rock composed primarily of fine to medium-grained, fossiliferous, greyish-colored lime-rich mud contains variable amounts of clay and silt. The thickness of the marl ranges from 1.38 m to 7.03 m with an average thickness of 4.13 m in the Chhasra block. The presence of Marl suggests shallow marine environment conditions of deposition.

Sandstone: A very thin section of Sandstone is encountered in borehole CHBH-3 which is light yellow colored, medium-grained, visibly granular with a clastic texture and well-cemented, calcareous matrix. It is found interbedded between siliceous clays and shale having a thickness of 0.57 m at the depth of 19 m within the block.

CHAPTER-5

Activity during the period (Geoscience investigation)

5.1 Geological Mapping:

The DGPS survey in Chhasra Block was carried out with Triangulation network have been laid down during G3 level exploration in the proposed study area with the help of DGPS. Boreholes have been 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. DGPS Survey was carried out by two methods: 1) Rapid Static Mode and 2) Real Time Kinematic mode. To carry out this survey Dual Frequency Sokkia (GSX2) DGPS, Total station Theodolite CHCNAV Total Station (CTS-112R4 Make) and Electronic Total Station (ETS) Theodolite 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 drafted 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 was carried out in 318 Ha area by taking traverses. The most of the area of the block is covered with soil/alluvium. The surface exposures of Limestone and are very less, therefore some nala cutting and small pits were observed and mapped in the study area. At places, mounds of hard rocks were also observed.

Fig. 2 Geological Mapping of the Chhasra Block, Kachchh.

Structure

General structure of the block is deciphered on the exploratory boreholes drilled. The Tertiary rocks of the area are horizontal to sub horizontal and are not affected by any major diastrophic movements within the block. 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.

5.2 Mineralogy of the ore zones:

Total 01 number of sample have been subjected to megascopic and microscopic study. The results are as below:

Name of Rock: Quartz-Arenite

Megascopic study

The received sample is light yellow colour, medium-grained, visibly granular with a clastic texture and well-cemented, calcareous matrix.

Microscopic Study

The thin section shows sub-rounded to sub-angular quartz grains (equigranular) dominate the grain supported framework with very low matrix content, which is calcareous. Most of the quartz grains are plain igneous quartz. Some quartz grains exhibit undulose extinction, suggesting a metamorphic origin. Minor mica flakes are present. Feldspar content is <5%, confirming classification as a quartz arenite. Few microfossils are present.

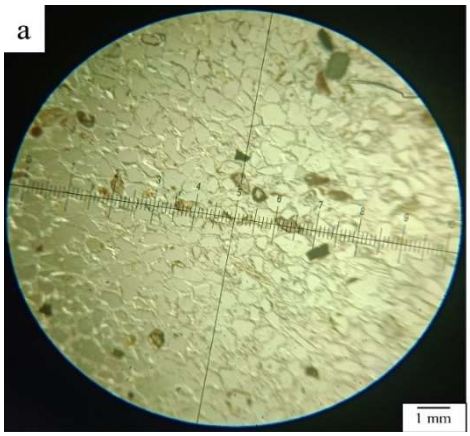

Figure 3 (a) Quartz arenite thin section in ppl ***(b) Quartz arenite thin section in xpl***

5.3 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.

Then core containing mineral 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 as per the instruction given by the authority.

The entire sampling process was carried out in presence of site Geologist of GMRDS and according the suggested procedures of CGM. Samples were collected during this exploratory drilling programme and sent to Petrography and Mineral Chemistry Lab, Gandhinagar for chemical analyses.

Details of interpreted ore zones based on geological investigation

The analytical results of grab samples collected from available outcrop patches helped to preliminarily delineate the limestone zone within the block. Although outcrop exposure was limited, sampling was conducted across accessible locations to provide broad spatial coverage prior to initiating systematic drilling. The purpose of this initial sampling was to confirm the presence of limestone and support lithological interpretation based on surface observations.

Geophysical exploration

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

Geochemical exploration

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

CHAPTER-6

Integration of Geology, Geo physics and Geochemical exploration and interpretation

The investigation here was conducted at the G3 stage of exploration, and since it involves 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 will not be required.

CHAPTER-7

Mineral Prospect

Kachchh is a mineral rich region with very large reserves of Lignite, Bauxite, Gypsum, Limestone, and Bentonite. Kachchh district is one of the preferred destinations for most of the mineral based industries and other minerals.

As per the regional geology of the area, the formations are non-deformed and sedimentary formations of each period from Mesozoic rest unconformable over the previous one. This shows the periodic invasion and regression of sea. The surface of the study area is covered by the recent sediments which underlain by the Chhasra Formation.

The Chhasra Formation, originally described as Vinjhan Shale by Biswas and Raju (1971, 1973), and later equated with the Gaj Beds. The formation is named after Chhasra village (23°21'20'', 68°46'40'') (Biswas, 1992). The Claystone Member of the Chassara Formation is characterized by highly fossiliferous limestone beds (30-75 cm) separated by silty shale/clay of variable thickness. The limestone beds are hard and compact, comprising of fossils like foraminifera. In the middle part of the succession, thin limestone beds are intervened by shale. The varying amounts of carbonate within the formation along with clays/shale resulted into presence of marl beds suggests shallow marine environment of deposition.

Kachchh hosts major cement plants such as Sanghi Cement, Ultratech, JP Cement, and Reliance ADG Cement. The total resource of Cement grade Limestone within the Chhasra Block is 3.88 million tonnes and resource of Marl is 34.86. The industrial utilization of both those mineral requires proper blending & value addition for further utilization.

CHAPTER-8

Exploration Systematic Drilling

8.1 Spacing of the Boreholes:

It was decided to carry out G-3 level exploration 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 habitis 800 mts x 800 mts. Accordingly M/s Vinayak Engimech Private Limited have planned and carried out drilling of 05 nos. of exploratory boreholes at a grid interval of 800 mts x 800 mts in this block with a cumulative meterage of 176.00 meters.

Table: 7 Coordinates of drilled boreholes of Chhasra Block

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)	
			Latitude	Longitude
1	CHBH-1	24.00	23°21'46.50"N	68°45'12.30"E
2	CHBH-2	20.00	23°21'41.80"N	68°45'43.10"E
3	CHBH-24	18.00	23°21'16.50"N	68°45'41.50"E
4	CHBH-23	16.00	23°21'17.90"N	68°46'07.80"E
5	CHBH-3	15.00	23°21'50.30"N	68°46'11.90"E

8.2 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 in the Chhasra block was carried out during October and November 2024 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 drilled in the area is varying from 52.17% to 89.67% 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 boreholes is 52.17% to 89.67% hence grade analyzed 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.

8.3 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. PVC separators 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 inserted separators. 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 to ....m. 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 0.31 to 5.75 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.

8.4 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 0.31 to 5.75 m. The sample length varied depending upon the change in lithology or physical appearance.

A total of 94 nos. of core samples were analyzed for major and minor oxides i.e. LOI, SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2 and SO_3. Also 94 nos. samples of limestone were analyzed for specific gravity.

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 check analysis of 9 samples has been analyzed from NABL approved laboratory LUCID Laboratories Pvt. Ltd., Hyderabad. The analysis has been attached as Annexure-7.

Moisture

Whether the tonnages are estimated on a dry basis or with natural moisture and the method of determination of moisture contentwhether 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

Details of moisture content in limestone is not available in Geological Report.

The laboratory tests are also carried out for specific gravity measurements on limited number of core samples on air dried basis. The specific gravity of 2.70 are considered for estimation of resources of cement grade Limestone. The specific gravity for Marl varies from 2.76 to 2.78. The specific gravity of 2.77 is considered for estimation of resources of Marl.

CHAPTER-9

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

The Geological mapping, exploration result are indicating very thin hard limestone deposit varying in boreholes drilled encountered at depth of 3.67 and 52.31 meters, having average thickness of 1.33 m. The limestone beds are separated by siltstone/clay and marl of variable thickness. In context of the exploration, studies were done to assess the specific gravity/density of limestone, essential to estimate the resource.

CHAPTER-10

Resource Estimation

Based on exploration data, resource estimation was done for Limestone [Cement Grade (blendable/beneficiable, portland)] and Marl. Based on analysis result of CaO % and MgO %, Limestone is categorized as Cement Grade Limestone and Marl.

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: 8: Specifications of Limestone grades by IBM

Grade	CaO %	MgO % (Max)	Fe_2O_3 % (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.
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 boreholes 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 2.70 and for Marl is 2.77 in Chhasra 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.
10. To separate out grades of Cement Grade Limestone and Marl CaO % & MgO % values has been considered.

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 Cement Grade 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 UNFC guidelines. The length, width and thickness of Cement Grade Limestone is considered in meters. The surface area covered by this Chhasra block is about 318 Hectare. The various terms expressed for computation of resource are mentioned in short term as below:

L x W (or A) x Th x Sp. Gr. = R

Where;

L	= Length in m	Sp. Gr.	=Specific Gravity
W	= Width (in m)	R	=Resources in Tonnes
A	= Area in m^2	Th	=Thickness (in m)

Average grade of Limestone i.e. Cement Grade (blendable/beneficiable, portland) and Marl 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, Limestone CaO% and MgO%.

10.1 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 litho-unit zone wise in-situ resource under various categories as per Minerals (Evidence of Mineral Contents) Rules 2015 and its amendments is presented in Table 9.

Table: 9-In-situ resources of Chhasra Block, Kachchh

Litho-Unit	In-situ Resources (million tonnes)	
	UNFC 333	Total
Cement Grade Limestone	3.88	3.88
Marl	34.86	34.86

The estimation of Limestone and Marl resources has been performed by dividing the explored vertical profile into depth-based intervals of 0–20 m, 20–40 m, and 40 m and beyond. These divisions were adopted for ease of modeling and correlation across boreholes. The total estimated resources of Limestone and Marl within the explored block subdivided into depth intervals are provided below:

Table 10: Depth Interval-wise Mineral Resource Estimation for Limestone and Marl

Depth Interval (m)	Mineral	Resources (million tonnes)
0-20	Cement Grade Limestone	1.42
20-40	Cement Grade Limestone	–
40 +	Cement Grade Limestone	2.46
Total		**3.88**
0-20	Marl	25.10
20-40	Marl	3.36
40 +	Marl	6.40
Total		**34.86**

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_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	P_2O_5	MnO	SO_3	LOI
Cement Grade Limestone	15.40	3.82	7.98	0.73	42.02	1.49	0.58	0.91	0.18	0.33	0.11	26.22
Marl	23.29	6.20	12.59	1.24	27.37	2.81	1.17	1.55	0.25	0.40	1.45	21.39

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 3.88 million tonnes resource of Cement grade Limestone (blendable/beneficiable, portland) and 34.86 million tonnes resource of Marl have been estimated in the area by under 333 category of UNFC.

Interpretation of Isopach map: Limestone

The isopach map for Cement Grade Limestone in the Chhasra Block displays a very limited spatial spread and variable thickness. Cement grade limestone is encountered only in two boreholes: CHBH-1 and CHBH-3. Among these, the maximum thickness is recorded in CHBH-3, with 2.32 meters, situated in the northeastern part of the block. Borehole CHBH-1, located in the northwestern part, shows a very thin limestone development of just 0.33 meters. The overall distribution suggests that the occurrence of Cement Grade Limestone is sparse, discontinuous, and largely localized, with no evident lateral continuity. This isolated development reflects limited depositional conditions or significant erosion or weathering of the limestone horizon within the block.

Interpretation of Isopach map: Marl

The isopach map of Marl in the Chhasra Block indicates a relatively more consistent distribution compared to limestone. Marl is recorded in all five drilled boreholes: CHBH-1, CHBH-2, CHBH-3, CHBH-23, and CHBH-24. The maximum marl thickness is observed in CHBH-3 in the northeastern part of the block, measuring 7.98 meters, suggesting a zone of enhanced deposition. Boreholes CHBH-2, CHBH-23, and CHBH-24, located centrally and eastward, exhibit moderate marl thicknesses ranging between 3.74 meters and 4.3 meters. CHBH-1, located toward the northwestern part, records the minimum marl thickness of 1.38 meters. The overall pattern indicates a thickening trend toward the east and southeast, suggesting that marl deposition was more prominent in those regions. The distribution also hints at better lateral continuity of Marl compared to Limestone, possibly linked to a more stable depositional environment.

CHAPTER-11

Core preservation

After completion of the drilling work, core boxes were carefully shifted to Chhasra 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, Kachchh.

CHAPTER-12

Conclusion and recommendation

The current exploration was undertaken to assess the potential of limestone resources in the Chhasra 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 a 800 m × 800 m grid, and a total of five boreholes were drilled with a cumulative meterage of 176.0 meters. A total of 94 core samples and 9 check samples were analyzed chemically, and one petrographic sample was studied.

The investigation revealed that marl is the dominant litho-unit encountered in all boreholes, with moderate CaO content and consistent thickness. Limestone was intercepted only in two boreholes, with very limited thickness. Although chemical analysis of the Limestone intervals indicates that the material meets cement-grade thresholds, the limited lateral continuity and volume suggest that Limestone is not a significant contributor to the block's resource potential at this stage.

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 3.88 million tonnes of cement grade limestone (blendable/beneficiable, portland) with average CaO 42.02% and 34.86 million tonnes of Marl with average CaO 27.37% have been estimated under the UNFC 333 (Inferred) category.

In view of the above, the block is recommended for further auction process.

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

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