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

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सारांश

गुजरात सरकार के उद्योग और खनन विभाग के भूगोल और खनन आयुक्त के अन्वेषण शाखा का कार्य राज्य में खनिज भंडार की पहचान करना है। इस शाखा ने अतीत में व्यापक अन्वेषण कार्य किया है. और संसाधनों की पहचान विभिन्न स्तरों पर प्री-डिटेल्ड खनिज सर्वेक्षणों, डिटेल्ड खनिज सर्वेक्षणों और ड्रिलिंग अन्वेषणों के माध्यम से की गई है। इन प्रयासों ने बोक्साइट, 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 की संभावनाओं की पहचान करना और नए MMDR संशोधन अधिनियम, 2015 और खनिज (खनिज सामग्री के प्रमाण) नियम 2015 के लागू कानूनी ढांचे के तहत भंडार की स्थापना करना है।

गुजरात मिनरल रिसर्च एंड डेवलपमेंट सोसाइटी (GMRDS) खनिज उद्योगों को समर्थन देने और भूगोल और खनन आयुक्त की देखरेख में खनिज प्रशासन के लिए तकनीकी सहायता प्रदान करने के लिए समर्पित है। GMRDS राज्य के भीतर खनिज वस्त्रों और संसाधनों की स्थापना और विकास पर कार्य करता है। अपनी मुख्य मिशन के अतिरिक्त, GMRDS राज्य के खनिज संपदा के लिए नए खनिज संसाधनों की खोज में सक्रिय रूप से संलिप्त है।

2023-24 के क्षेत्रीय सत्र में, गुजरात सरकार के भूगोल और खनन आयुक्त की अन्वेषण शाखा ने भारत सरकार के खनिज मंत्रालय के राष्ट्रीय खनिज अन्वेषण ट्रस्ट (NMET) को जड़वा ब्लॉक, कच्छ जिले, गुजरात में चूना पत्थर खनिज के G3-स्तरीय अन्वेषण के लिए एक प्रस्ताव प्रस्तुत किया। इस परियोजना को फ़रवरी 2024 में NMET द्वारा 294 हेक्टेयर क्षेत्र में G3-स्तरीय अन्वेषण के लिए मंजूरी प्राप्त हुई, जिसमें लखपत तालुका, कच्छ जिले, गुजरात के जड़वा गांवों का क्षेत्र शामिल है।

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 मनियार किला, फुलरा और जुमारा संरचनाएँ शामिल हैं। तृतीयक तलछट, जो मुख्य रूप से कच्छ के तटीय मैदानों में उजागर होते हैं, पैलियोजीन और नियोजीन काल के दौरान उथले समुद्री वातावरण में जमा हुए थे। 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। जादवा ब्लॉक क्षेत्र में पाया जाने वाला चूना पत्थर इओसीन युग के फुलरा फॉर्मेशन से संबंधित है। इसमें बेडेड, क्रीम, बफ़, क्रिस्टलीय विशाल सिल्टी, जीवाश्मयुक्त चूना पत्थर शामिल है, जो मिट्टी और शेल के साथ मिश्रित है, जो कच्छ के तृतीयक में एक बहुत ही विशिष्ट लिथूनिट बनाता है। लिथोलॉजी कम ऊर्जा, स्पष्ट पानी की विशेषता है जो संभवतः मध्य-शेल्फ पर्यावरण के अंतर्गत है।

कुल 294 हेक्टेयर क्षेत्र का अन्वेषण गुजरात मिनरल रिसर्च एंड डेवलपमेंट सोसाइटी (GMRDS), गांधीनगर द्वारा किया गया। इस ब्लॉक के भीतर, जड़वा ब्लॉक में 800 x 800 मीटर ग्रिड पर 6 बोरहोल ड्रिल किए गए, जिनकी कुल गहराई 229 मीटर रही। ड्रिल किए गए बोरहोल से प्राप्त कोर से कुल 175 सैंपल तैयार किए गए और विश्लेषण के लिए पेट्रोग्राफी और खनिज रसायन प्रयोगशाला (PMC लैब), गांधीनगर भेजे गए। सभी कोर ड्रिलिंग सैंपल्स का विश्लेषण प्रमुख और गौण ऑक्साइड्स के लिए किया गया, जिसमें CaO, MgO, Al_2O_3, SiO_2, Fe_2O_3, SO_3, P_2O_5, K_2O, Na_2O, MnO, TiO_2, और LOI, शामिल हैं, साथ ही विशिष्ट गुरुत्व (Specific Gravity) का भी निर्धारण किया गया। विश्लेषण परिणामों के आधार पर, पेट्रोलॉजी (Lithology) को संशोधित किया गया, और प्रत्येक बोरहोल के प्रभाव का मूल्यांकन करने के लिए धीसन पोलिगन (Thiessen Polygon) पद्धति का उपयोग करते हुए संसाधनों का अनुमान लगाया गया। इस परियोजना के परिणामस्वरूप गुजरात की खनिज संपदा में निम्नलिखित खनिज संसाधनों की पहचान की गईः 166.75 मिलियन टन सीमेंट ग्रेड चूना पत्थर (मिश्रण योग्य/लाभकारी, पोर्टलैंड) जिसमें CaO: 46.83%, MgO: 1.37%, SiO2: 6.58%, Fe2O3: 3.70% और 58.50 मिलियन टन मार्ल जिसमें CaO: 27.30%, MgO: 2.27%, SiO2: 17.90%, Fe2O3: 15.84%।

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 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 exploration & resource augmentation 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 Jadva Block, Kachchh District, Gujarat. The project was approved by NMET in February 2024 for G3-level exploration over an area of 294 hectares, covering the village of Jadva in Lakhpat 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 Maniyar fort, Fulra, and Jumara 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,

haematite, chert etc., present as non-carbonate minerals, control the quality/grade of limestone. The Limestone encountered in the Jadva Block area belongs to the Fulra Formation of Eocene age. It consists of bedded, cream, buff, crystalline massive silty, fossiliferous Limestone interspersed with clay and shale at places forms a very distinct lithounit in the Tertiary of Kachchh. The lithology is characteristic of low energy, clear waters probably under middle-shelf environment.

The total block area of approximately 294 hectares was explored by the Gujarat Mineral Research & Development Society (GMRDS), Gandhinagar. Within the block, 6 boreholes were drilled on a 800 x 800 meter grid, reaching a total depth of 229 meters in the Jadva Block. A total of 175 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: 166.75 million tonnes of Cement Grade Limestone (blendable/beneficiable, portland) with average CaO: 46.83%, MgO: 1.37%, SiO_2: 6.58%, Fe_2O_3: 3.70% and 58.50 million tonnes of Marl with CaO: 27.30%, MgO: 2.27%, SiO_2: 17.90%, Fe_2O_3: 15.84%.

Brief Details

Sr. No.	Parameter	Data		
01	Name of the Block	Jadva Block		
02	Location	Village: Jadva Taluka: Lakhpat District: Kachchh		
03	Block Area	294 Hectare		
04	Block Boundary Co-ordinates	**Boundary Pillar**	**DMS (WGS 84)**	
			Latitude	**Longitude**
		BP-1	23°30'53.02"N	68°38'1.95"E
		BP-2	23°30'56.31"N	68°37'48.65"E
		BP-3	23°31'12.15"N	68°37'59.13"E
		BP-4	23°31'26.41"N	68°38'8.85"E
		BP-5	23°31'34.08"N	68°38'14.09"E
		BP-6	23°31'40.86"N	68°38'18.78"E
		BP-7	23°31'19.21"N	68°39'5.25"E
		BP-8	23°31'10.71"N	68°39'18.66"E
		BP-9	23°30'60.00"N	68°39'14.49"E
		BP-10	23°30'48.92"N	68°39'12.84"E
		BP-11	23°30'44.12"N	68°39'12.39"E
		BP-12	23°30'37.46"N	68°39'11.91"E
		BP-13	23°30'33.59"N	68°39'11.83"E
		BP-14	23°30'46.61"N	68°38'31.99"E
		BP-15	23°30'47.85"N	68°38'18.15"E
05	Total Area Covered under Geological Exploration	294 Hectare		
06	No. of Boreholes Drilled	6 Nos.		
07	Total Meterage Drilled	229 mts		
08	Borehole Spacing	800 mts x 800 mts		
09	Depth of the Mineralized Zone	1 mts to 62 mts		

10	Economic Mineral Resource with Quality	Commodity	Average Thickness	Resource (In million tons)	Quality
		Limestone [Cement Grade(blendable, beneficiable, portland)]	21.12	166.75	CaO:46.83%, MgO:1.37%,SiO_2: 6.58%, Fe_2O_3: 3.70%
		Marl	6.87	58.50	CaO:27.30%, MgO:2.27%, SiO_2:17.90%, Fe_2O_3:15.84%
11	Average Overburden to Mineralized zone	0.21			
12	Toposheet No.	41A/10			
13	Topography	Plain with gentle slope			
14	Average Rainfall	Below 450 mm			
15	Lowest Temperature	7° C (December)			
16	Maximum Temperature	44° C (June)			
17	Nearest Railway station	Naliya Railway station- 34.49 km			
18	Road	Accessible through NH-41 – 3.16 km			
19	Airport	Bhuj airport- 106.47 km			

CHAPTER-2

Introduction

2.1 Details of Project:

On 20/01/2024 a proposal for G3 level Limestone exploration in Jadva Block, Lakhpat 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. 60.97 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 28th February 2025 was approved during the 39th EC meeting held on 24th January 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 27th August 2025, for the completion of the project.

The exploration proposal for the Jadva Block was initially prepared with a total proposed area of 1030 Hectares, within which 14 boreholes were planned. However, during the 61st TCC meeting held on 31st January 2024, it was suggested that the block boundary be restructured to avoid overlap with the existing mining lease held by J.K. Cement**.** Accordingly, the block boundary was revised to exclude the overlapping lease area and forest land. As a result, the revised exploration area was reduced to 294 Hectares**,** after excluding 686 hectares under the existing lease and 50 hectares of forest area**.** Following this revision, the proposed drilling plan was modified, and 6 boreholes were drilled within the redefined block boundary to carry out G3 stage exploration in line with NMET guidelines.

The Jadva Block falls in the toposheet no. 41A/10 in Jadva village of Lakhpat taluka, Kachchh district. The Preliminary Exploration (G3) for the mineral Limestone in Jadva Block was carried out on a grid of 800 x 800 meters, drilling a total of 06 boreholes comprising a total meterage of 229 meters within the block.

2.2 Investigation Agency:

Commissioner of Geology and Mining, Gandhinagar, Government of Gujarat.

2.3 Objective of the investigation:

i) To carry out detailed Topographical Survey and Geological mapping on 1:4000 scale over an extent of 294 Hectares.

ii) To delineate the strike and depth continuity of the limestone by drilling 06 boreholes on 800m strike interval, in Jadva 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.

2.4 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 48.53%. 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. Several lease areas are also present in the surrounding areas of the block, which would testify the Limestone prospectivity of the block, so it can be studied as an extension of the already existing mineable deposits. Thus, the block is suggested for G3 level of exploration.

2.5 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)	1030 Ha	294 Ha	294 Ha
2	Boundary and borehole demarcation with DGPS	14	6	6
3	Exploratory Drilling (One conditional BH to confirm the total thickness of limestone)	280 m 14 BHs	229 m 06 BHs	229 m 06 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	280 Core	175 Core	175 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	32	18	18
5	**Physical Studies**			
	a) Petrological Studies	5	4	4
	b) Specific gravity Determinations	32	6	6
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

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 Surveyor, 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 Jadva Block, Taluka: Lakhpat, District: Kachchh, Gujarat.

3.2 Details of the area

The project area falls in parts of Jadva village of Lakhpat taluka, Kachchh District, Gujarat. The Jadva Block has an area of 294 Hectares, , bounded by Longitude 68°37'48.65"E to 68°39'18.66"E and Latitude 23°30'33.59"N to 23°31'40.86"N.

3.2.1 Survey of India Toposheet number

The block area falls under the Survey of India Toposheet No. 41A/10 of Lakhpat Taluka of Kachchh 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 Jadva Block boundary and drilled boreholes

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

Table: 3 Coordinates of corner points of Jadva Block boundary

Sr. No.	Boundary Pillar	DMS (WGS 84)	
		Latitude	Longitude
1	BP-1	23°30'53.02"N	68°38'1.95"E
2	BP-2	23°30'56.31"N	68°37'48.65"E
3	BP-3	23°31'12.15"N	68°37'59.13"E
4	BP-4	23°31'26.41"N	68°38'8.85"E
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9	BP-9	23°30'60.00"N	68°39'14.49"E
10	BP-10	23°30'48.92"N	68°39'12.84"E
11	BP-11	23°30'44.12"N	68°39'12.39"E

12	BP-12	23°30'37.46"N	68°39'11.91"E
13	BP-13	23°30'33.59"N	68°39'11.83"E
14	BP-14	23°30'46.61"N	68°38'31.99"E
15	BP-15	23°30'47.85"N	68°38'18.15"E

Table: 4 Coordinates of drilled boreholes of Jadva Block

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)	
			Latitude	Longitude
1	JDBH-2	76.00	23°31'18.30''	68°38'12.80''
2	JDBH-3	88.00	23°31'14.45''	68°38'38.12''
3	JDBH-4	80.00	23°31'14.03''	68°39'06.37''
4	JDBH-6	25.00	23°30'48.90''	68°38'19.60''
5	JDBH-7	84.00	23°30'48.70''	68°38'38.40''
6	JDBH-8	85.00	23°30'48.00''	68°39'06.10''

3.2.3 Location and Accessibility

The project area falls in parts of Jadva village of Lakhpat taluka, Kachchh District, Gujarat. District headquarter is situated at Bhuj. The area is accessible through NH-41 which is about 3.16 km from the block area. 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 106.47 Km away from the Jadva Block. Nearest Railway station is Naliya which is approx. 34.49 km away from the Jadva Block. An aerial view of study area map of Jadva Block has been also given (i.e. Plate-2).

3.2.3 Climate

The climate is typically arid with negligible rainfall. There is not much vegetation - coyer 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 44° C higher in the summer and 7° C lowest in the winter. The average temperature during summer it is 38° C, while in winter is around 20° C. The average annual rainfall is below 450 mm.

3.2.4 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.

3.2.5 Drainage

Studying the drainage system is essential for gaining insights into geomorphology and structural fabrics of the area. No perennial river or stream is present in the area. Though, small ephemeral water bodies are found occurring in the relatively low relief areas. The general drainage pattern of the area is characterized by sub-dendritic pattern formed by second and third order seasonal gullies during monsoon. No perennial river or water reservoir falls inside the block.

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 Jadva 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. Harudi, Ratipar, Bhujpar, Maniara are the nearby villages to Jadva Block. This Block is located around 107.51 Km towards SE from district headquarters Bhuj and around 405.80 Km from state capital Gandhinagar. Lakhpat is around 34.40 Km far from this block. Shanghipuram Township is located at around 5.11 kms S-W from the block area and Ultratech Colony is located at about 7.34 kms SE from the block area, where all major economic facilities are available. Sanghi Industries Ltd. Cement plant is located at about 14.15 km towards SW of the block area.

CHAPTER-4

Previous work

Previously Geological Survey of India had conducted geological mapping on 1:50000, revealing the geological potential for limestone in the area. CGM officials have carried out field in 2023-24 year of the area with surface sampling and had done the chemical analysis of 10 grab samples out of which 06 samples fall within the proposed area. The calculated average analysis of the 06 samples is:

Chemical Composition (%)										
SiO_2	**Al_2O_3**	**Fe_2O_3**	**TiO_2**	**CaO**	**MgO**	**Na_2O**	**K_2O**	**P_2O_5**	**SO_3**	**LOI**
6.58	1.42	2.16	0.07	49.33%	1.38	0.08	0.12	0.012	0.03	38.95

Sanghi Cement mining lease is adjacent to the proposed block. Ultratech Cement mining lease is 550 meters in east and southeast direction away from proposed block. Both leases are in working condition. These leases (Sanghi Industries Ltd., Ultratech Cement Ltd.) are surrounding the areas of the proposed block which testify the limestone prospectivity of this block, supporting the exploration project to find the extension of the Limestone deposit. The chemical analysis of grab samples and the existing leases near the block suggests that high grade Limestone is present in the study area.

During F. S: 1982-83, Shri G. Vijayasarathi, Geologist (Jr.), GSI had carried out Geological Mapping of the Tertiary Rocks of Lakhpat Taluka, Kutch District, Gujarat in toposheet no. 41A/10 covering an area of 430 sq. km. on a scale of 1:50000. Five Lithostratigraphic Formations were reported during the field season and based on paleontological evidence all these rocks were of marine origin. Of the reported five Formations the Formation 3 is encountered in the study area corresponding to the Fulra Formation comprising of the cream/dirty white coloured foraminiferal Limestones.

During F. S: 1983-84, 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.

Details of Aero-geophysical and Geophysical mapping

A systematic regional gravity and magnetic surveys were carried out in toposheet no. 41A/10 in parts of Lakhpat taluka, Kachchh district, Gujarat under National Geophysical Programme (NGPM) of GSI. The Bouguer gravity contour map shows values ranging from +6 mGal to -4 mGal with an overall variation of 10 mGal and the magnetic contour map shows values ranging from +1012nT to -490nT with an overall variation of 1502 nT.

CHAPTER-5

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 (S. K. BISWAS, 2016- Mesozoic and Tertiary Stratigraphy of (Kachchh) – A Review). 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.

Kachchh basin is geotechnically divided into three sub basins, while as per the chronology and lithology there are three groups.

1. Hard rock like limestones, shales, and sandstones of Mesozoic age
2. Volcanic rocks, limstones and sandstones of Tertiary age
3. Alluvium, coastal plains, river terraces, aeolian pockets, Rann and Banni sediments etc are unconsolidated loose quaternary formation

The regional geology of the area is as follows:

Table: 5-Regional Geology of the Area

Age	**Formation**		**Litho-units/Rock Type**
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 and calcareous clay with marl
Lower to Middle Miocene	Gaj Formation		Shale interbedded with fossiliferous limestone and marl
Upper Oligocene to Lower Miocene	Khari Nadi Formation		Variegated siltstone and gyspeous claystone
Middle to Upper Oligocene	Maniyara Fort Formation		Calcareous and gyspseous 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 Volacanics	Extrusive	Andesitic trachyte
		Intrusive	Olivine gabbro, basalt, and dolerite dyke
		Extrusive	Basalt flows with intertrappen

			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

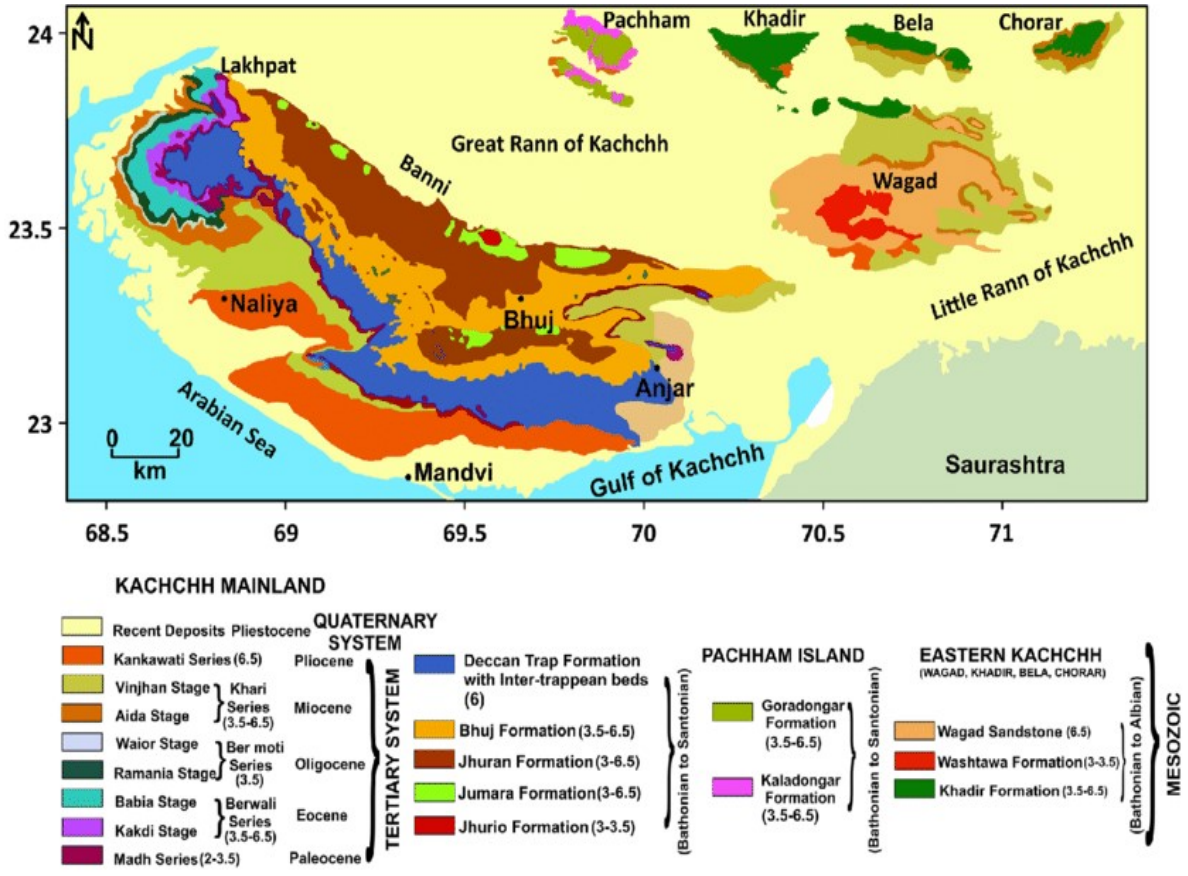

Figure 1(Regional Geological map of the Kachchh Rift Basin after Biswas and Deshpande 1970)

Geology of the Block

The Limestone deposits occurring in the block area of Jadva village mainly belong to the Fulra Formation of the Eocene age. The older formations, namely the Kakdi Series of clay occurs to the north of the block area within the revenue of the Baranda village. The surveyed area is covered with limestone within the block area. There are some small patches of soil at places.

With the help of core-drilling, sampling and data assessment of the Jadva 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
Recent		Yellowish top soil with clay
Middle Eocene	Fulra Formation	White and buff coloured foraminiferal limestone
Early Middle Eocene	Harudi Formation	Greyish to dark grey clay, calcareous claystone with shale
Cretaceous-Eocene	Deccan Trap	Fine to medium grained Basalt

Soil: It is the youngest unit exposed in the Jadva Block, which is yellowish in colour, with fine to medium grain size. It is composed of calcareous and clayey material with traces of fossils. Soil layer having thickness ranges from 0.00 m to 0.50 m.

Limestone:

The Fulra Formation is encountered in Jadva Block. The Limestone typically exhibits a dirty white to bedded, cream, buff, crystalline, fossiliferous Limestone interspersed with clay and shale at places. The Limestone is highly fossiliferous. The thickness of the Limestone varies in different part of the Jadva Block. Limestone encountered in all drilled boreholes in the study area ranging in thickness from 9.69 m to 35.33 m with an average of 20.62 m.

Figure 2 Field photographs showing Limestone exposures in Jadva Block

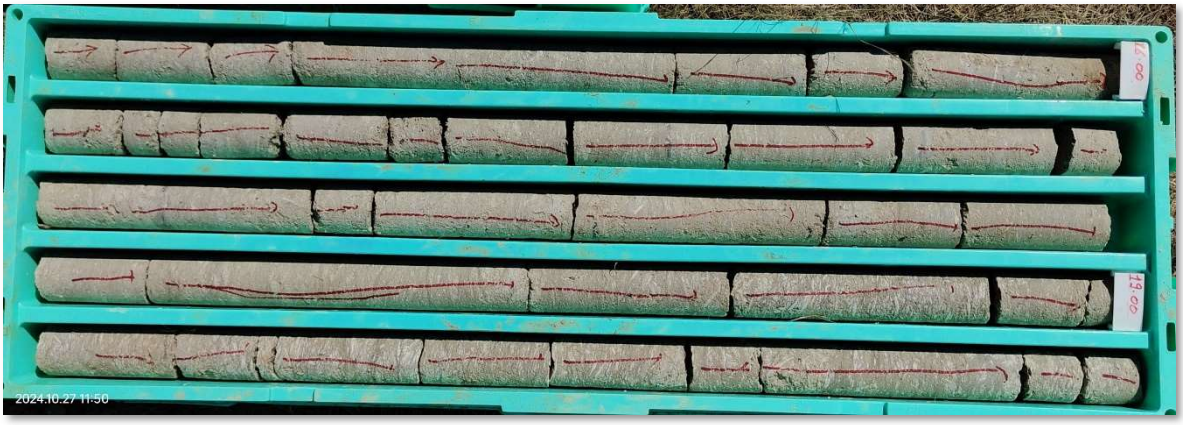

Figure 3 Fulra Formation Limestone in JDBH 4

Marl:

Marl associated with limestone encountered in two drilled boreholes in the present study area. It is a non-clastic sedimentary rock composed primarily of fine to medium-grained, greyish-colored lime-rich mud contains variable amounts of clay and silt. The thickness of the marl ranges from 1.00 m to 9.37 m with an average thickness of 6.87 m in the Jadva block.

Clay:

Clay is the next most common formation after Limestone found in the Jadva block. The clay belongs to the Harudi Formation underlying conformably with the Fulra Formation Limestones. The colour of the clay varies from yellowish, light to dark grey. It is fine grained, highly calcareous and fossiliferous in nature varying to claystone at depth.

Trap:

Trap is the oldest formation in Jadva Block which is greenish-black in colour, fine- to medium-grained with visible vesicles and amygdales filled with secondary minerals such as calcite and zeolites. The rock exhibits a porphyritic texture. It is encountered in only one drilled borehole at the depth of 83 meters.

CHAPTER-6

Activity during the period (Geoscience investigation)

6.1 Geological Mapping:

The DGPS survey in Jadva Block was carried out, Triangulation network have been laid down during G3 level exploration in the 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.

Figure 4 Geological Mapping of the Jadva Block, Kachchh.

The geological mapping was carried out in 294.00 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 were observed and mapped in the study area. At places, mounds of hard rocks were also observed.

Figure 5 Limestone section exposed in river channel near block area

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 study block. The stratigraphy encountered in the block is of marine sedimentary origin.

6.2 Mineralogy of the ore zones:

A total of 04 samples have been subjected to megascopic and microscopic study. The results are as below:

1. **Name of Rock:** Limestone (Biomicirite)

Megascopic study

The received sample is light yellow in colour with a fine- to medium-grain size. Texture of the rock is non-clastic. It displays a compact structure with visible fossil fragments of Nummulites. Distinct effervesces of CO_2 with dilute HCl indicates its calcareous nature. Grain size and composition along with fossils suggest that it is a Nummulitic Limestone, which belongs to the Fulra Limestone Formation of western Kachchh region.

Microscopic Study

The sample under observation is composed predominantly of fine to medium grained calcite grains within a micritic (microcrystalline calcite) matrix. The rock contains abundant bioclasts, primarily Nummulites and foraminifera, indicating a shallow marine depositional environment. Fossils are well-preserved and embedded in a calcareous matrix.

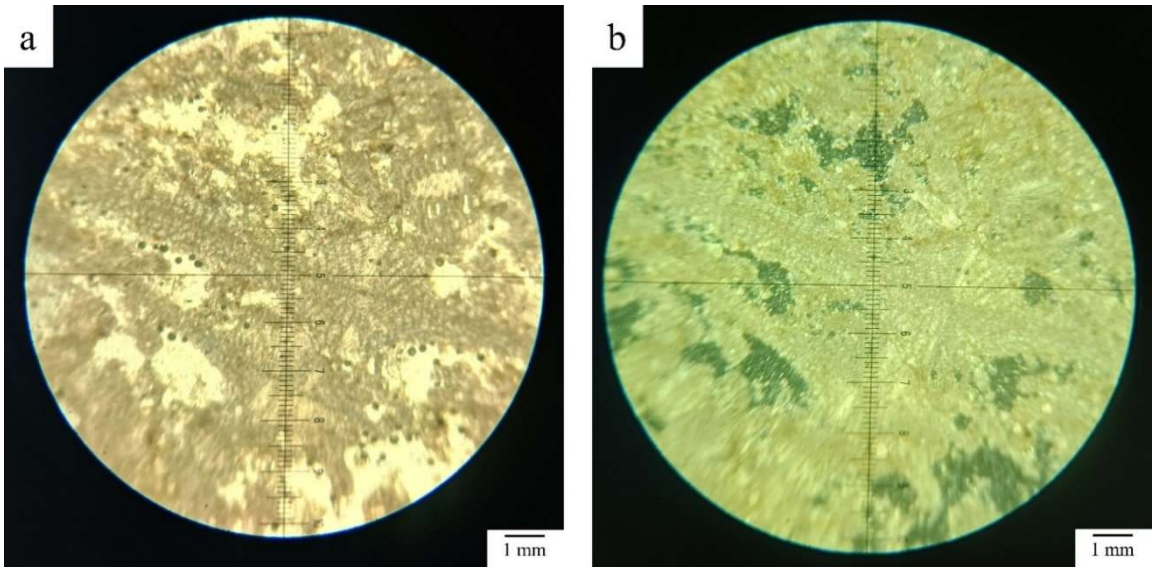

Fig. 6 (a) Bio-micrite thin section in ppl ***(b) Bio-micrite thin section in xpl***

2. Name of Rock: Vesicular-Amygdaloidal Basalt

Megascopic study

The received sample is Greenish-black in colour, fine- to medium-grained with visible vesicles and amygdales filled with secondary minerals such as calcite and zeolites. The rock exhibits a porphyritic texture.

Microscopic Study

The received sample under observation exhibits phenocrysts of plagioclase feldspar and Fe-Mg minerals are set within a fine-grained groundmass, which is partly crystalline and partly glassy. Ferromagnesian (Fe-MG) minerals like - pyroxene or olivine appears as brown in plane-polarized light and isotropic under crossed polars, suggesting alteration. Vesicles are lined or filled with calcite, zeolite, and quartz, typical of amygdaloidal texture.

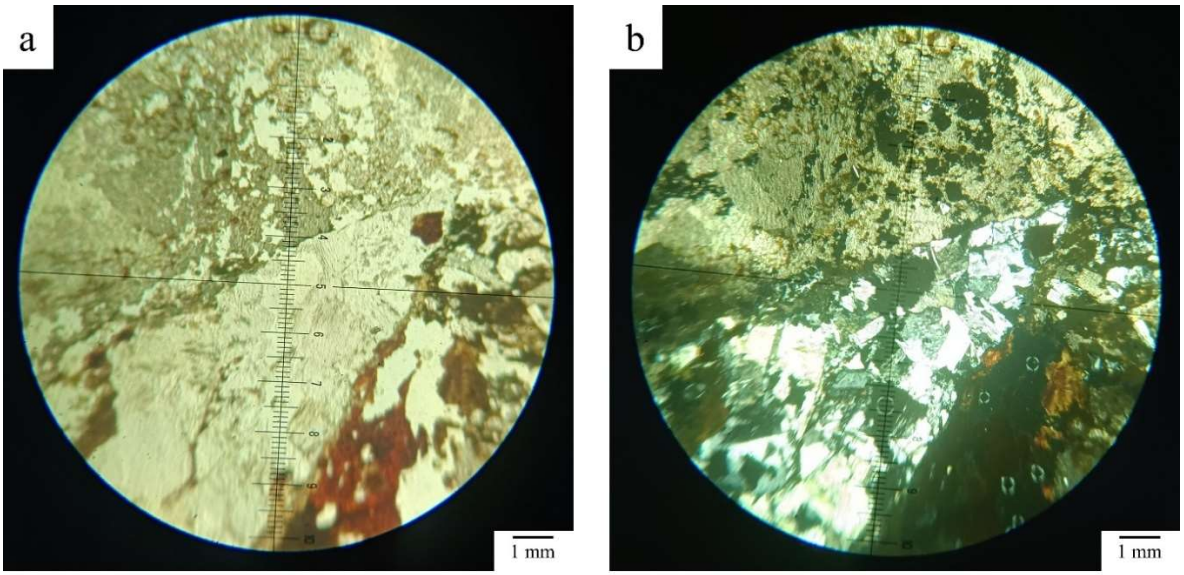

Fig 7 (a) Vesicular-Amygdaloidal Basalt thin section in ppl (b) Vesicular-Amygdaloidal Basalt thin section in xpl

3. Name of Mineral: Clay

Megascopic study

The received sample is Greenish-black, extremely fine-grained, soft and sticky when wet. It displays a smooth texture with even grained nature.

Microscopic Study

The thin section shows extremely fine-grained matrix with a yellowish colour in plane-polarized light. In cross-polarized light, it appears dark green to isotropic. Numerous

micro-fractures are present. Likely dominated by smectite group clays (e.g., montmorillonite)

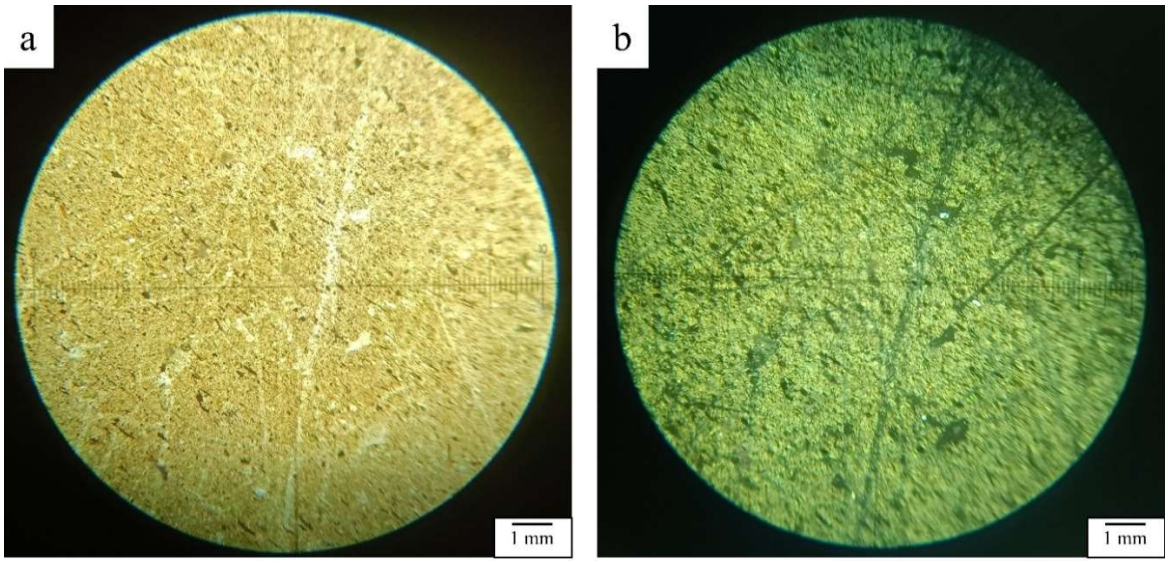

Fig. 8 (a) Clay thin section in ppl ***(b) Clay thin section in xpl***

4. Name of Mineral: Clay

Megascopic study

The received sample is Green in colour, fine- to silty-grained with a slightly greasy feel. It exhibits a homogeneous appearance.

Microscopic Study

The received sample is yellowish under plane-polarized light with minor scattered quartz grains. It shows numerous micro-cracks. In cross-polarized light, it is dark greenish and appears isotropic, indicating a fine-grained clay-rich matrix with minor calcareous matrix.

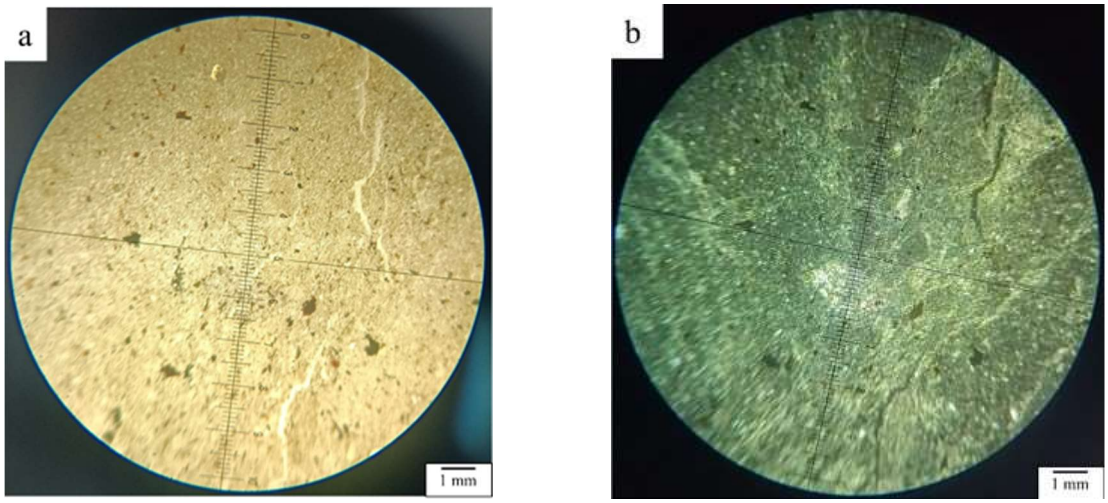

Fig 9 (a) Clay thin section in ppl ***(b) Clay thin section in xpl***

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.

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.

The surface samples of the area were collected from the scanty outcrops of the Limestone belonging to the Fulra Formation by CGM officials. Six samples were collected as grab samples from the following locations:

Table: 7 Coordinates of outcrop samples of Jadva Block

Sr. No.	Latitude	Longitude
1	23°30'48"	68°38'19"
2	23°31'06"	68°38'39"
3	23°31'06"	68°38'28"
4	23°31'04"	68°38'44"
5	23°31'01"	68°38'45"
6	23°31'09"	68°39'04"

Discussion of results of chemical analysis of samples

The calculated average analysis of the six grab samples of the block area is as follows:

Chemical Composition (%)										
SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	P_2O_5	SO_3	LOI
6.58	1.42	2.16	0.07	49.33%	1.38	0.08	0.12	0.012	0.03	38.95

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 Jadva Block.

Geochemical exploration

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

CHAPTER-7

Integration of Geology, Geo physics and Geochemical exploration and interpretation

The investigation here was conducted at the UNFC G3 stage, 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-8

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 Fulra Formation.

Limestone is a sedimentary rock composed primarily of calcium carbonate (CaCO3) in the form of mineral calcite. It most commonly forms in clear, warm, shallow marine waters. It is usually an organic sedimentary rock that forms from the accumulation of shell, coral, algal, and fecal debris. It can also be a chemical sedimentary rock formed by the precipitation of calcium carbonate from lake or ocean water. The Limestone encountered in the block belongs to Fulra Formation.

A massive sequence of foraminiferal Limestone has been named Fulra Limestone by Biswas and Raju (1971) after its type section exposed SW of village Fulra. The Fulra Limestone is composed of dirty white to cream, buff to gradually darker coloured bedded Limestone. The presence of saddle-shaped *Discocyclina*, flat *Nummulites* and ellipsoidal *Fasciolites* in this limestone gives a distinguishing appeareance to this Formation. Along with Limestone, Marl is encountered at depth. 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 plants like Sanghi Cement, Ultratech Cement, JP Cement, Reliance ADG Cement etc. have started in Kachchh. Sanghi Cement's 4.1 million tonnes per annum capacity plant located in Kachchh is one of the largest single location cement plant in India.

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

CHAPTER-9

Exploration Systematic Drilling

9.1 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 06 nos. of exploratory boreholes at a grid interval of 800 mts x 800 mts in this block with a cumulative meterage of 229.00 meters.

Table: 8 Coordinates of drilled boreholes of Jadva Block

Sr. No.	BH ID	R.L. (m)	Borehole depth (m)	DMS (WGS 84)	
				Latitude	Longitude
1	JDBH-2	76.00	85.00	23°31'18.30''	68°38'12.80''
2	JDBH-3	88.00	20.00	23°31'14.45''	68°38'38.12''
3	JDBH-4	80.00	30.00	23°31'14.03''	68°39'06.37''
4	JDBH-6	25.00	25.00	23°30'48.90''	68°38'19.60''
5	JDBH-7	84.00	26.00	23°30'48.70''	68°38'38.40''
6	JDBH-8	85.00	43.00	23°30'48.00''	68°39'06.10''

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 in the Jadva 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 for Limestone in the area is varying from 80.96% to 98.02% 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 80.96% to 98.02% 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 ore 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 splitted 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 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 4.60 m. However, 50% of the total samples generated are 1 m of linear length. 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.

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 0.31 to 4.60 m. The sample length varied depending upon the change in lithology or physical appearance. However, 50% of the individual samples were formulated for 1 m of linear length.

A total of 175 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, P_2O_5, MnO and SO_3. Also 175 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 XRF.

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 18 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 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

Details of moisture content in limestone are 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 for limestone varies from 2.71 to 2.78. The specific gravity of 2.74 is considered for estimation of resources of cement grade limestone. The specific gravity of 2.74 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, exploration result are indicating hard surficial limestone deposit up to depth of 10 to 62 meters and as such the mining activity involved will be an open cast mining method as 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

(Indian Minerals Yearbook, 2022, IBM, October 2024.)

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 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 2.74 in Jadva 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. Since the limestone was consistent for higher thickness, no cut off was fixed for thickness for delineation of mineralized zone Cement Grade Limestone.
10. To separate out different grades of Cement Grade Limestone, and Marl, CaO % & MgO % values has been considered.

BH ID	Mineral	SAMPLE CODE	LAB REF. NO.	Specific Gravity
JDBH-2	Limestone [Cement Grade (blendable/beneficiable, portland)]	JDBH-2/01	C/D/24-25/2109	2.71
JDBH-3	Limestone [Cement Grade (blendable/beneficiable, portland)]	JDBH-3/10	C/D/24-25/2104	2.75
JDBH-4	Limestone [Cement Grade (blendable/beneficiable, portland)]	JDBH-4/14	C/D/24-25/2079	2.71
JDBH-6	Limestone [Cement Grade (blendable/beneficiable, portland)]	JDBH-6/04	C/D/24-25/2051	2.78
JDBH-7	Limestone [Cement Grade (blendable/beneficiable, portland)]	JDBH-7/05	C/D/24-25/1887	2.74
JDBH-8	Limestone [Cement Grade (blendable/beneficiable, portland)]	JDBH-8/19	C/D/24-25/2025	2.72

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 MEMC guidelines. The length, width and thickness of Cement Grade Limestone is considered in meters. The surface area covered by this Jadva block is about 294 Hectare.

The various terms expressed for computation of resource are mentioned in short term as below:

R = A x Th x Sp. Gr.

Where;

R =Resources in Tonnes

Sp. Gr. = Specific Gravity

A = Area in m^2

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, Limestone CaO% and MgO%.

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 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 10:

Table: 10-In-situ resources of Jadva Block, Kachchh

Litho-Unit	In-situ Resources (million tonnes)	
	UNFC 333	Total
Cement Grade Limestone	166.75	166.75
Marl	58.50	58.50

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

Depth Interval (m)	Mineral	Resources (million tonnes)
0-20	Cement Grade Limestone	128.09
20-40	Cement Grade Limestone	29.72
40 +	Cement Grade Limestone	8.94
Total		**166.75**
0-20	Marl	31.16
20-40	Marl	19.00
40 +	Marl	8.34
Total		**58.50**

The average quality of individual litho-unit zone is given in Table 12:

Table: 12-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	6.58	2.72	3.70	0.50	46.83	1.37	0.68	0.49	0.03	0.04	0.44	36.21
Marl	17.90	8.59	15.84	1.80	27.30	2.27	1.12	0.83	0.10	0.13	0.97	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 166.75 million tonnes resource of Cement grade Limestone (blendable/beneficiable, portland) and 58.50 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 of Limestone for the Jadva Block reveals a clear spatial variation in the thickness of the Limestone deposit across the area. The maximum thickness of 35.33 meters is observed in borehole JDBH-8, situated in the southeastern part of the block, indicating a zone of significant limestone development. Similarly, Borehole JDBH-4 in the northeastern part of the block records a substantial thickness of 28.5 meters, supporting this trend. Moving toward the central part of the block, boreholes JDBH-3 and JDBH-7 shows gradual decrease in thickness with moderate thicknesses of 11.23 meters and 9.69 meters, respectively. In the western and southwestern directions, the Limestone thickness gradually increases, as reflected in borehole JDBH-2 with 21.91 meters and JDBH-6 with 17.03 meters. This overall pattern suggests a thickening of limestone toward the eastern and western parts and thinning toward the central parts, possibly influenced by paleo-topography or depositional dynamics

Interpretation of Isopach map: Marl

The isopach map of Marl in the Jadva Block shows notable variability in thickness across the explored area. The maximum marl thickness of 9.37 meters is recorded in borehole JDBH-2, situated in the western part of the block. This is closely followed by 8.27 meters in JDBH-3 in the central part and 7.94 meters in JDBH-7 in the southern part. Moderate marl thickness is also observed in JDBH-6 (7.47 m) to the south-southwest and JDBH-8 (7.17 m) in the southeastern zone. Comparatively thinner marl development is found in JDBH-4 (1 m), suggesting a thinning trend toward the northeastern edges of the block. This distribution may be indicative of localized depositional control or paleotopographic influence during sedimentation.

CHAPTER-12

Core preservation

After completion of the drilling work, core boxes were carefully shifted to Jadva 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-13

Conclusion and recommendation

The current exploration was taken up to assess the limestone resources in the block considering the industrial needs for limestone. The investigation has provided valuable insights into its geological characteristics, quality and potential resource in the block. The comprehensive analysis revealed that Jadva Block limestone exhibits desirable physical and chemical properties, including high calcium carbonate content and low impurities, which make it a viable material for various industrial applications, particularly in cement production, construction, and the manufactureoflime.

All the boreholes have been drilled for varying length and have intercepted the complete thickness of limestone in the block area. A total of 06 boreholes were drilled totaling a cumulative length of 229.0 meters. A comprehensive analysis was conducted on 175 core samples, along with 18 check samples, to assess and characterize the subsurface behavior and grades of the limestone. Additionally, four petrographic samples were examined during the investigation. The Jadva block is explored at interval of 800 m x 800 m grid and the lateral continuity and thickness of some mineralized zones may vary if substantiated with further exploration by close spaced boreholes.

In consideration of nature of occurrence of Limestone the Jadva block can be categorized as "Bedded Stratiform and Tabular deposit of regular habit as Minerals (Evidence of Mineral Contents) Rules 2015 and its amendments. A total of 166.75 million tonnes resource of Cement grade Limestone (blendable/beneficiable, portland)with average CaO 46.83% and 58.50 million tonnes resource of Marl with average CaO 27.30% have been estimated in the area by under 333 category of UNFC.

In view of the estimated resource, the block seems promising and it is recommended for further auction process.

CHAPTER-14

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CHAPER-15

Locality Index

Table: 13-Locality index

Name of village	Latitude	Longitude
Jadva	23°30'17.47"N	68°36'43.99"E
Harudi	23°30'26.19"N	68°41'9.12"E
Maniyara	23°28'37.28"N	68°37'33.86"E
Ratipar	23°31'48.71"N	68°36'8.14"E
Bhujpar	23°32'44.05"N	68°36'40.38"E
Ber Moti	23°27'55.75"N	68°35'55.52"E
Baranda	23°33'16.82"N	68°40'34.06"E
Naredo	23°34'15.39"N	68°38'59.69"E
Vagapadar	23°28'11.41"N	68°41'7.17"E