GEOLOGICAL REPORT
ON PRELIMINARY EXPLORATION (G–3)
FOR BAUXITE, LIMESTONE,
ALUMINOUS LATERITE & MARL
IN MOTHALA BLOCK
(FIELD SEASON-2024-25)
TALUKA: ABDASA
DISTRICT: KACHCHH, GUJARAT

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अध्याय 1

सारांश

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 के माध्यम से अन्वेषण के माध्यम से विभिन्न स्तरों पर संसाधन स्थापित किए गए हैं। 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 गुजरात 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।

2024-25 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 मोथला ब्लॉक में चूना पत्थर खनिज के G3-स्तर के अन्वेषण के लिए एक प्रस्ताव प्रस्तुत किया। इस परियोजना को सितंबर 2024 में NMET द्वारा 747 हेक्टेयर क्षेत्र में G3-स्तर के अन्वेषण के लिए मंजूरी दी गई थी, जिसमें गुजरात के कच्छ जिले के अब्दासा तालुका में मोथला और बालाचोद मोती के गाँव शामिल थे।

पश्चिमी भारत में कच्छ अपनी सक्रिय तह और थ्रस्ट टेक्टोनिज़्म के लिए जाना जाता है, जिसने बॉक्साइट और चूना पत्थर के भंडार 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। बॉक्साइट एल्युमिना (Al2O3) का मुख्य अयस्क है, जिसका उपयोग एल्युमिनियम (Al) बनाने के लिए किया जाता है। बॉक्साइट अक्सर कच्छ क्षेत्र में डेक्कन ट्रैप के ऊपर लैटेराइट क्षितिज के भीतर पॉकेट

जमा के रूप में पाया जाता 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 किए गए 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।

गुजरात खनिज अनुसंधान एवं विकास सोसाइटी (जीएमआरडीएस), गांधीनगर द्वारा लगभग 747 हेक्टेयर के कुल ब्लॉक क्षेत्र का अन्वेषण किया गया था। ब्लॉक के भीतर, 400 x 400 मीटर ग्रिड पर 23 बोरहोल ड्रिल किए गए थे, जो मोथला ब्लॉक में 398 मीटर की कुल गहराई तक पहुंच गए थे। ड्रिल किए गए बोरहोल से प्राप्त कोर से कुल 321 नमूने तैयार किए गए और विश्लेषण के लिए पेट्रोग्राफी और खनिज रसायन विज्ञान प्रयोगशाला (पीएमसी लैब) गांधीनगर को भेजे गए। सभी कोर ड्रिलिंग नमूनों का प्रमुख और मामूली ऑक्साइड के लिए विश्लेषण किया गया था, जिसमें CaO, MgO, $Al2O3$, $SiO2$, $Fe2O3$, $SO3$, $P2O5$, $K2O$, $Na2O$, MnO, $TiO2$ और LOI विशिष्ट गुरुत्व के साथ शामिल थे। विश्लेषणात्मक परिणामों के आधार पर, लिथोलॉजी को संशोधित किया गया इस परियोजना के परिणामस्वरूप, गुजरात की खनिज संपदा में निम्नलिखित खनिज संसाधन स्थापित हुए: मोथला ब्लॉक क्षेत्र में बॉक्साइट का कुल 12.38 मिलियन टन इन-सीटू संसाधन, सीमेंट ग्रेड चूना पत्थर का 8.41 मिलियन टन इन-सीटू संसाधन, एल्युमिनस लैटेराइट का 11.35 मिलियन टन और मार्ल का 18.42 मिलियन टन इन-सीटू संसाधन उपलब्ध है।

CHAPTER-1

Executive Summary

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

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

In the 2024-25 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 Mothala Block, Kachchh District, Gujarat. The project was approved by NMET in September 2024 for G3-level exploration over an area of 747 hectares, covering the villages of Mothala and Balachod Moti 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 Bauxite and 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. Bauxite is the principal ore of alumina (Al2O3), which is used to produce aluminium (Al). Bauxite is often found as pocket deposits within the lateritic horizons above the Deccan Traps in the Kachchh region. 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 (CaCO3) 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 total block area of approximately 747 hectares was explored by the Gujarat Mineral Research & Development Society (GMRDS), Gandhinagar. Within the block, 23 boreholes were drilled on a 400 x 400 meter grid, reaching a total depth of 398 meters in the Mothala Block. A total of 321 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 analytical results, the lithology was revised, and resources were calculated and resources were calculated using the Plan Area 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: A total of 12.38 million tonnes in-situ resource of Bauxite, 8.41 million tonnes in-situ resource of cement grade Limestone, 11.35 million tonnes of Aluminous Laterite and 18.42 million tonnes in-situ resource of Marl is available within Mothala block area.

Brief Summary

Sr. No.	Parameter	Data			
01	Name of the Block	Mothala Block			
02	Location	Villages: Mothala, Balachod Moti Taluka: Abdasa District: Kachchh			
03	Block Area	747 Hectare			
04	Block Boundary Co-ordinates	**Boundary Pillar**	**DMS (WGS 84)**		
			Latitude	**Longitude**	
		BP-1	23°13'4.14"N	69° 7'36.63"E	
		BP-2	23°13'4.24"N	69° 7'36.56"E	
		BP-3	23°14'40.05"N	69° 7'25.32"E	
		BP-4	23°14'27.83"N	69° 8'32.84"E	
		BP-5	23°13'48.19"N	69° 9'0.46"E	
		BP-6	23°13'51.81"N	69° 9'55.67"E	
		BP-7	23°13'19.79"N	69° 9'46.66"E	
05	Total Area Covered under Geological Exploration	747 Hectare			
06	No. of Boreholes Drilled	23 Nos.			
07	Total Meterage Drilled	398 mts			
08	Borehole Spacing	400 mts x 400 mts			
09	Depth of the Mineralized Zone	0 mts to 28 mts			
10	Economic Mineral Resource with Quality	Commodity	Average Thickness	Resource (In million tons)	Quality
		Bauxite	9.67	12.38	Al_2O_3:33.97% SiO_2:29.54%, Fe_2O_3:16.66%

		Aluminous Laterite	3.39	11.35	Al_2O_3:24.30% SiO_2:39.51%, Fe_2O_3:14.53%
		Limestone	1.40	8.41	CaO:39.72%, MgO:1.97%,SiO_2: 15.10%, Fe_2O_3: 4.74%
		Marl	2.55	18.42	CaO:27.32%, MgO:5.35%, SiO_2:25.89%, Fe_2O_3:6.77%
11	Average Overburden to Mineralized zone	2.60			
12	Linear Ratio Mineralized zone to OB (mts : mts)				
13	Linear Ratio Mineralized zone to OB (mts : mts)				
14	Toposheet No.	41E/4			
15	Topography	Highly Undulating			
16	Average Rainfall	Below 450 mm			
17	Lowest Temperature	7° C (December)			
18	Maximum Temperature	47° C (June)			
19	Nearest Railway station	Mothala Railway station- 3.56 km			
20	Road	Accessible through SH-49 – 1.50 km			
21	Airport	Bhuj airport- 51.25 km			

CHAPTER-2

Introduction

2.1 Details of Project:

A proposal for G3 Bauxite exploration in Mothala Block, Abdasa taluka, Kachchh district, Gujarat was submitted to NMET by Commissioner of Geology and Mining on 23/02/2024.

In the 37th EC meeting held on 23/09/2024 the matter was discussed and EC approved the project with an estimated cost of Rs. 225.60 Lakhs. The sanction order was received on 22/10/2024.

The exploration proposal for the Mothala Block is prepared with a total proposed area of 747 Hectares. The Mothala Block falls in the toposheet no. 41E/4 in Mothala and Balachod Moti villages of Abdasa taluka, Kachchh district. The Preliminary Exploration (G3) for the mineral Bauxite in Mothala Block was carried out on a grid of 400 x 400 meters, drilling a total of 23 boreholes comprising a total meterage of 398 meters within the block. In the areas within the block where mineralization is present the 400 x 400 m grid has been followed but where the mineralization is not present the grid has been extended to larger scale to prove the lateral continuity.

2.2 Investigation Agency:

Commissioner of Geology and Mining, Government of Gujarat, Gandhinagar

2.3 Objective of the investigation:

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

2.4 Basis for taking up investigation:

The region was primarily investigated by CGM by means of pitting, trenching and sample collection of the area. It was found that the Bauxite occurs as pocket deposit in ferruginous Laterite in and around proposed block area. The Mothala block is surrounded by the Bauxite leases and exploration blocks of Bauxite, 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	Achieved
1	Topographic Survey & Geological Mapping on 1:4000 scale (Ha)	747 Ha	747 Ha
2	Boundary and borehole demarcation with DGPS	Boundary:6 BH's:43	Boundary:7 BH's:23
3	Exploratory drilling (One conditional BH to confirm the total thickness of limestone)	1075 m 14 BHs	398 m 23 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	1075 Core	321 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	107	25
5	**Physical Studies**		
	a) Petrological Studies	5	–
	b) Specific gravity Determinations	5	4
6	Report Preparation (5 Hard copies with one soft copy)	1	1
7	Preparation of Exploration Proposal (5 Hard copies with a soft copy)	1	1

2.6 Personal involved:

The entire work was carried out by Gujarat Mineral Research and Development Society (GMRDS), a technical arm of Commissioner of Geology and Mining, Gujarat. A team of senior technical officers from GMRDS along with 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 Bauxite, Limestone, Aluminous Laterite & Marl in Mothala Block, Taluka: Abdasa, District: Kachchh, Gujarat.

3.2 Details of the area

The project area falls in parts of Mothala and Balachod Moti villages of Abdasa taluka, Kachchh District, Gujarat. The Mothala Block has an area of 747 hectares, , bounded by Longitude 69° 7'25.32"E to 69° 9'55.67"E and Latitude 23°13'4.14"N to 23°14'40.05"N

3.2.1 Survey of India Toposheet number

The block area falls under the Survey of India Toposheet No. 41E/04 of Abdasa 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 Mothala 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 Mothala Block boundary

Sr. No.	Boundary Pillar	DMS (WGS 84)	
		Latitude	Longitude
1	BP-1	23°13'4.14"N	69° 7'36.63"E
2	BP-2	23°13'4.24"N	69° 7'36.56"E
3	BP-3	23°14'40.05"N	69° 7'25.32"E
4	BP-4	23°14'27.83"N	69° 8'32.84"E
5	BP-5	23°13'48.19"N	69° 9'0.46"E
6	BP-6	23°13'51.81"N	69° 9'55.67"E
7	BP-7	23°13'19.79"N	69° 9'46.66"E

Table: 4 Coordinates of drilled boreholes of Mothala Block

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)	
			Latitude	Longitude
1	MBH-41	92.00	23°13'14.90"N	69°08'07.40"E
2	MBH-31	93.00	23°13'28.32"N	69°08'06.42"E
3	MBH-42	118.00	23°13'17.35"N	69°08'22.60"E
4	MBH-32	119.00	23°13'27.99"N	69° 8'20.81"E
5	MBH-33	95.00	23°13'28.40"N	69°08'36.0"E
6	MBH-23	161.00	23°13'40.50"N	69°08'34.80"E
7	MBH-22	99.00	23°13'41.30"N	69°08'21.20"E
8	MBH-16	98.00	23°13'54.69"N	69° 8'20.68"E
9	MBH-10	110.00	23°14'07.30"N	69°08'06.10"E
10	MBH-5	108.00	23°14'20.50"N	69°08'05.70"E
11	MBH-3	124.00	23°14'19.90"N	69°07'37.50"E
12	MBH-1	57.00	23°14'33.20"N	69°07'36.70"E
13	MBH-25	111.00	23°13'41.80"N	69°09'03.10"E
14	MBH-39	108.00	23°13'14.46"N	69° 7'36.57"E
15	MBH-13	137.00	23°13'53.70"N	69°07'34.20"E
16	MBH-14	92.00	23°13'53.70"N	69°07'59.40"E
17	MBH-28	159.00	23°13'42.00"N	69°09'45.00"E
18	MBH-27	139.00	23°13'37.88"N	69°09'29.72"E
19	MBH-26	111.00	23°13'42.20"N	69°09'16.20"E
20	MBH-36	120.00	23°13'28.70"N	69°09'16.60"E
21	MBH-35	109.00	23°13'29.50"N	69°09'02.40"E
22	MBH-34	121.00	23°13'29.99"N	69° 8'47.82"E
23	MBH-38	76.00	23°13'30.50"N	69°09'43.70"E

3.2.3 Location and Accessibility

The project area falls in parts of Mothala and Balachod Moti villages of Abdasa taluka, Kachchh District, Gujarat. District headquarter is situated at Bhuj. The area is accessible through SH-49 which is about 1.50 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 51.25 Km away from the Mothala Block. Nearest Railway station is Mothala which is approx. 3.56 km away from the Mothala Block. An aerial view of study area map of Mothala 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 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. The general drainage pattern of the area is characterized by sub-dendritic pattern.

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 Mothala 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. Balachod Moti, Sarguara, Balachod Nani, Bhavanipar are the nearby villages to Mothala Block. This Block is located around 51 Km towards west from district headquarters Bhuj and around 351.89 Km from state capital Gandhinagar. Abdasa is around 30.41 Km far from this block.

CHAPTER-4

Previous work

Previously H.R. Vyas (Field Season-1964-65) has done the work on Kukma, Lakhond, Satapar, Ratnal, Mamuara, Wamoti (M), Wamoti (N), Khanpar, Deban, Rasaliya, Netra and Bhunjai of the Kutch District, Gujarat State during the year 1964-65, was part of a project to assess the quality and quantity of Bauxite for its economical utilization. During the period under report total number of 262 pits was opened up and total number of 245 samples was collected and have been sent for laboratory analysis. An area of 4,60,000 square meters was found to be under bauxite and the reserves have been estimated to be about 12,70,000 tonnes.

B.A. Amin (Field Season 1963-70) has done the Bauxite Deposits in Kutch District, Gujarat State. During the field work, general reconnaissance survey on the scale 1:63, 360, was done covering an area of about 20sq. kilometres and detail mapping of the bauxite bearing area was also done on the scale 1:2000, covering an area of 8.60 sq. kilometers. The area mapped is depicted on survey of India top sheet No.41 E/4.

During F. S: 2018-19, Shreya Basu & Barnali Sahoo, Geologists, GSI had carried out Specialized thematic mapping and studies of Mesozoic sedimentary litho packages with the Deccan Trap volcanics in parts of Kachchh district, Gujarat in toposheet no. 41E/04.

Details of Aero-geophysical and Geophysical mapping

Systematic regional gravity and magnetic surveys were carried out in toposheet nos. 41E/04, in parts of Abdasa taluka, Kachchh district, Gujarat under National Geophysical Programme (NGPM) of GSI. The Bouguer gravity contour map shows values ranging from +6 mGal to -15 mGal with an overall variation of 21 mGal and the magnetic contour map shows values ranging from +604.25 nT to -329.24 nT with an overall variation of 933.49 nT.

CHAPTER-5

Geology of the area

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.

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. Further it subdivided, namely, the Pachham, the Chari, the Katrol and the Umia Series. The litho-statigraphic sequence of the mainland is divided into four Formations, named as the Jhurio (Jhura), Jumara, Jhuran and Bhuj Formations. The major lithological characteristics of these formations are a thick sequence of Limestone and shales with bands of 'golden oolites'. The type section occurs in Jhurio hill, in the north-central Mainland. The upper part of the Formation is made up of thinly bedded white to cream coloured Limestones (pelmicrite and biomicrite), with thin bands of 'golden oolite'. The middle part is composed of thick beds of grey-yellow weathered shales, alternated with thick beds of golden oolitic Limestones. The lower part comprises of thin beds of yellow and grey. The Formation ranges from Bathonian to lower Callovian. Jumara Formation is thick argillaceous, conformably overlying the Jhurio Formation. The Formation is characterized by monotonous olive-grey gypseous larninated shales with thin red femrgenous bands. The Jumara Formation ranges age between Callovian and Oxfordian. Jhuran Formation comprises of a thick sequence of alternating beds of sandstones and shales. Bhuj Formation is named after its type locality around Bhuj. This Formation is characterized by a huge thickness ofnon-marine sandstones ofuniform character. These rocks occupy about 3/4th of the total area of the Mesozoic outcrop in Mainland Kachchh. ln the south, Deccan Trap rests on the eroded undulating surface of this Formation. The sediments represent deltaic deposits with distal partof the large

Cretaceous delta front towards the west and the proximal part to the east in the direction of the land. Lower Cretaceous time range is fixed for this formation. 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.

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 as described by Biswas (1974). Madh Series: The type area of the rocks of this series is the well-known village of Matano-Madh in westem Kachchh. It consists of volcanoclastic sediments deposited in variable environments, ranging from fluviatile to littoral. 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). Bermati Series: This series forms a well exposed continuous belt south of Abdasa 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). 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 fonns 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. Kankawati Series: Well 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. Volcanisam, 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 (Geology and Mineral Resources of Gujarat, Daman and Diu, GSI 2001)

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

Paleocene	Matanomadh Formation		Laterite, sandstone, conglomerate and bentonitic and kaolinitic clay
Upper Palaeocene	Supra trappean		Bauxite and Laterite
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

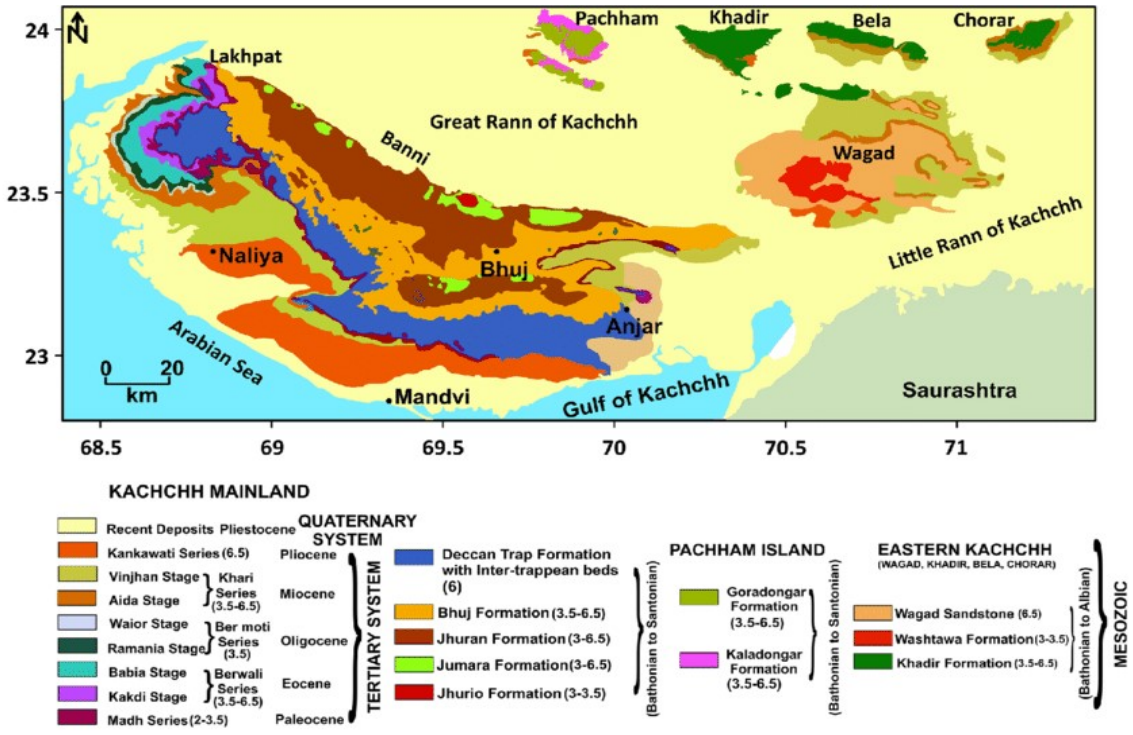

Figure 1(Regional Geological map of the Kachchh Rift Basin after Biswas and Deshpande 1970)

Geology of the Mothala Block

The Bauxite, Limestone, Aluminous Laterite and Marl deposits occurring in the block area of Mothala village belong to the Supra-Trappen of the Paleocene age.

With the help of core-drilling, sampling and data assessment of the Mothala 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		brownish top soil with clay
Paleocene	Supra-trappean	Bauxite , Aluminous Laterite, Limestone and Marl with clays
Cretaceous-Eocene	Deccan Trap	Fine to medium grained Basalt

Soil: It is the youngest unit exposed in the Mothala Block, which is brownish in colour, with fine to medium grain size. It is composed of sandy and clayey material. Soil layer having thickness ranges from 0.34 m to 3.30 m with an average of 1.87 m across the block.

Limestone:

The Limestone of Paleocene age is encountered in Mothala Block. The Limestone typically exhibits a dirty white to cream, greyish yellow color, crystalline massive, porous and fossiliferous nature. The thickness of the Limestone varies in different part of the Mothala Block. Limestone encountered in 14 drilled boreholes in the study area ranging in thickness from 0.19 m to 5.53 m with an average of 1.40 m.

Marl:

Marl associated with Limestone encountered in 17 drilled boreholes in the present study area. It is a non-clastic sedimentary rock composed primarily of fine to medium-grained; greyish-white to brown colored lime-rich mud contains variable amounts of clay and silt. The thickness of the marl ranges from 0.30 m to 9.00 m with an average thickness of 2.55 m in the Mothala block.

Clay:

Clay found in the Mothala block is associated with the Marl, Limestone and Laterite. The color of the clay varies from yellow, brownish-red, light to dark grey. It is fine-grained to silty in nature intercalated with silty sand at places.

Bauxite:

Bauxite in the block belongs to the Supra-trappean Formation of Paleocene age occurring over the Deccan Trap. Bauxite is the principal ore of alumina (Al2O3), which is used to produce aluminum (Al). Bauxite is observed in the area, as reddish brown and brown in color at places clayey in nature. The mineral occurs as a pocket deposit in the area and encountered in 03 boreholes. The thickness of Bauxite varies from 1.00 m to 14.00 m with average thickness of 9.67 m

Aluminous Laterite:

Aluminous Laterite belonging to Supra-trappean Formation of Paleocene age is found in 8 drilled boreholes in the Mothala Block. It is mostly found in fine grained to clayey form at places within the block and reddish-to-reddish brown in color. The thickness varies from 1.00 m to 12.00 m with average thickness of 3.39 m.

Trap:

Trap is the oldest formation in Mothala Block, which is greyish-black in color, 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 28 meters.

CHAPTER-6

Activity during the period (Geoscience investigation)

6.1 Geological Mapping:

The DGPS survey in Mothala Block was carried out with Triangulation method and triangulation points were laid down during G3 level exploration in the study area with the help of DGPS. Boreholes were fixed on the ground at 400 x 400 m grid interval. The block boundary 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 stages of topographic survey. After topographic survey, draft drawing was generated at site and a complete topographical representation was drawn with the help of AutoCAD. List of boundary pillar points of the block boundary along with the co-ordinates are given in annexure-6.

Fig. 2 Aluminous Laterite exposure of the Mothala Block.

Fig. 3 Soil Profile of the Mothala

The geological mapping was carried out in 747.00 Ha area by taking traverses. The most of the area of the block is covered with soil.

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 Bauxite, 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:

The economically significant litho-units in the Mothala Block include Bauxite, Aluminous Laterite, Cement Grade Limestone, and Marl. The Bauxite zone is characterized by high alumina content and physical traits such as earthy texture and reddish-brown coloration, indicating the presence of hydrated aluminum minerals typically associated with bauxitic deposits in lateritic weathering environments and occurs as pocket-type deposits with reddish to brown hues. Aluminous Laterite, found interbedded or overlying bauxite and clay, shows residual enrichment of alumina along with iron oxides like goethite and hematite. Limestone, associated with the Paleocene Formation, is dominantly calcareous, composed largely of calcite ($CaCO_3$) with fossil fragments, and exhibits a porous to crystalline texture. Marl, intercalated with limestone and clays, is composed of calcite mixed with clay minerals and silt-sized grains, forming a lime-rich matrix. Clay units are fine-grained to silty interbedded with silty sand. The mineralogical characteristics of these ore zones support the classification of mineral resources under UNFC 333 and confirm the suitability of the area for further exploration.

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 Bauxite, Limestone, Aluminous Laterite and Marl encountered in boreholes as per the instruction given by the authority.

Samples were collected during this exploratory drilling programme and sent to Petrography and Mineral Chemistry Lab, Gandhinagar for chemical analyses.

Geophysical exploration

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

Geochemical exploration

Geochemical exploration was not carried out during the G3 stage of exploration at Mothala 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 is not significant.

CHAPTER-8

Mineral Prospect

Kachchh district is a geologically diverse and mineral-rich region in Gujarat, endowed with significant reserves of Lignite, Bauxite, Limestone, Bentonite, Gypsum, and other industrial minerals. It is one of the preferred destinations for mineral-based industries due to both the abundance and accessibility of mineral resources. Major cement plants, alumina refineries, and ceramic units have been established in the district, driven by the sustained availability of raw materials. Geologically, the area falls within the sedimentary terrain of the Mesozoic to Cenozoic eras, characterized by gently dipping, undeformed sequences. The formations rest unconformably over the Deccan Trap and exhibit signatures of marine transgression and regression cycles, contributing to the diverse lithologies observed. The study area is largely covered with recent alluvium and soil, underlain by the Supra-trappean formation comprising Bauxite, Aluminous Laterite, and Limestone.

Bauxite, the principal ore of aluminium, is found as pocket-type occurrences over the lateritized surface. The mineralized zones display high alumina content with moderate silica. This mineral has extensive applications in the aluminium, refractory, and cement industries.

Aluminous Laterite is also encountered within the weathered profile, typically overlying the Bauxite and Deccan Trap. It contains elevated Al_2O_3 content and represents a transitional phase between lateritization and bauxitization. It can be used in alumina blending and for cement manufacturing.

Limestone is found within the block and belongs to Paleocene age. It occurs as bedded, fossiliferous, argillaceous to crystalline units. Analytical data show that the Limestone is suitable for cement-grade applications, particularly as blendable, beneficiable, and Portland-grade Limestone. Its presence supports the mineral potential of the area for industrial-grade extraction.

Marl is associated with the Limestone as an interbedded lithology. It is a lime-mud containing clay and silt, with lower CaO content compared to Limestone. Marl is used as an additive in cement manufacture and is a by-product of many limestone-bearing formations.

The presence of these minerals in a single block significantly enhances the economic prospect of the area. In particular, the demand for Limestone and Bauxite remains strong from cement and aluminum industries respectively. The G3-level exploration has delineated zones of mineralization, and the grade characteristics of the intersected samples indicate economic viability subject to further investigation at G2 and G1 levels. The availability of infrastructure, proximity to operational cement and alumina plants (like Ultratech Cement, Sanghi Industries, and others), and regional geological continuity make this block a favorable candidate for future commercial exploitation. Continued systematic exploration is recommended to upgrade the confidence level of the mineral resources and support future mining development.

CHAPTER-9

Subsurface Exploration (Drilling)

9.1 Spacing of the Boreholes:

A G3 stage exploration was carried out in this block and as per guideline of MEMC rule, 2015 and its amendments, the spacing between two boreholes in case of bedded stratiform and tabular deposits of regular habitis 400 mts x 400 mts. Accordingly M/s Vinayak Engimech Private Limited have planned and carried out drilling through 23 nos. of exploratory boreholes at a grid interval of 400 mts x 400 mts in this block with a cumulative meterage of 398.00 meters. In the areas within the block where mineralization is present the 400 x 400 m grid has been followed but where the mineralization is not present the grid has been extended to larger scale to prove the lateral continuity.

Table: 7 Coordinates of drilled boreholes of Mothala Block

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)	
			Latitude	Longitude
1	MBH-41	92.00	23°13'14.90"N	69°08'07.40"E
2	MBH-31	93.00	23°13'28.32"N	69°08'06.42"E
3	MBH-42	118.00	23°13'17.35"N	69°08'22.60"E
4	MBH-32	119.00	23°13'27.99"N	69° 8'20.81"E
5	MBH-33	95.00	23°13'28.40"N	69°08'36.0"E
6	MBH-23	161.00	23°13'40.50"N	69°08'34.80"E
7	MBH-22	99.00	23°13'41.30"N	69°08'21.20"E
8	MBH-16	98.00	23°13'54.69"N	69° 8'20.68"E
9	MBH-10	110.00	23°14'07.30"N	69°08'06.10"E
10	MBH-5	108.00	23°14'20.50"N	69°08'05.70"E
11	MBH-3	124.00	23°14'19.90"N	69°07'37.50"E
12	MBH-1	57.00	23°14'33.20"N	69°07'36.70"E
13	MBH-25	111.00	23°13'41.80"N	69°09'03.10"E
14	MBH-39	108.00	23°13'14.46"N	69° 7'36.57"E
15	MBH-13	137.00	23°13'53.70"N	69°07'34.20"E
16	MBH-14	92.00	23°13'53.70"N	69°07'59.40"E
17	MBH-28	159.00	23°13'42.00"N	69°09'45.00"E

18	MBH-27	139.00	23°13'42.10"N	69°09'44.90"E
19	MBH-26	111.00	23°13'42.20"N	69°09'16.20"E
20	MBH-36	120.00	23°13'28.70"N	69°09'16.60"E
21	MBH-35	109.00	23°13'29.50"N	69°09'02.40"E
22	MBH-34	121.00	23°13'29.99"N	69° 8'47.82"E
23	MBH-38	76.00	23°13'30.50"N	69°09'43.70"E

9.2 Methodology of drilling with details of type of drilling:

Drilling technique and drill sampling employed:

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

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

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

Core recovery of every run of drilling for all the drilled boreholes was recorded properly. The recovery was monitored throughout the drilling process and recorded systematically in the lithologs. There is minimal core loss due to washing of clay intercalations, loose and fractured formations, etc. The recovery data has been considered adequate for resource estimation purposes.

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

Minor losses did not result in noticeable grade bias, and the samples are considered representative for G3-stage resource estimation.

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 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 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. 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 0.14 to 4.50 m. However, 52% 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 0.14 to 4.50 m. The sample length varied depending upon the change in lithology or physical appearance. However, 52% of the individual samples were formulated for 1 m of linear length.

A total of 321 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 4 nos. samples of Bauxite, Aluminous Laterite, Limestone and Marl 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 25 samples has been analyzed from NABL approved laboratory LUCID Laboratories Pvt. Ltd., Hyderabad. The analysis has been attached as Annexure-7. The details of analysis of comparative study of primary core samples and external check samples by XRF are given in Annexure-12.

Moisture

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

The laboratory tests are also carried out for specific gravity measurements on limited number of core samples on air dried basis. The specific gravity for Bauxite, Aluminous Laterite, Cement Grade Limestone and Marl is considered 2.81, 2.80, 2.80 and 2.79 respectively for resource estimation.

CHAPTER-10

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

The Geological mapping and exploration result are indicating Bauxite deposit from depth of 04 to 20 meters, Aluminous Laterite from depth of 0 to 28 meters, Limestone from 0 to 14.6 meters and Marl from 0 to 17.32 meters across the block 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 Bauxite, Limestone [Cement Grade (blendable/beneficiable, portland)], Aluminous Laterite and Marl. Based on analysis result of Al_2O_3%, Bauxite and Aluminous Laterite are categorized. 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:

Specifications grades by IBM

Grade	CaO %	MgO % (Max)	Fe_2O_3 % (Max)	Al2O3%	SiO2% (Max)
Chemical	> 52		≤ 0.25	–	–
Limestone [Cement Grade (blendable/beneficiable, portland)]	34-52	≤ 5.00	–	–	–
Marl	20-34	–	–		
Bauxite	–	–	–	≥30	≤7
Aluminous Laterite	–	–	–	≥20	

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

1. In each borehole area of influence has been considered for resource calculation, as the mineral deposit is of regular habit.
2. Tonnage is estimated on dry basis, after removing moisture content. If sludge chemical analysis results show promising lithology then sludge analysis lithology calculated for resource estimation.

3. Average cumulative thickness is taken for each borehole fall under different category regions, i.e., G3.
4. As per UNFC guidelines for the deposits of regular habit, the area covered by wide spaced bore holes with bore holes spacing is 400 m are marked for G3 category resource.
5. Specific Gravity has been estimated grade wise and average specific gravity for Bauxite, Aluminous Laterite, Cement Grade Limestone and Marl is considered 2.81, 2.80, 2.80 and 2.79 respectively for resource estimation.
6. Recovery loss has not been considered.
7. Total resources estimated here are insitu resources.
8. Clay part intersected in between the Bauxite, Aluminous Laterite, Cement Grade Limestone and Marl 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 zones
10. To separate out grades of Bauxite and Aluminous Laterite Al_2O_3%, while for Cement Grade Limestone, and Marl, CaO % & MgO % values has been considered. Silica percentage has been ignored for state industrial demand for Bauxite and Aluminous Laterite.

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 Bauxite, Cement Grade Limestone, Aluminous Laterite and Marl.

Resource estimation has been done by using Plan area method in 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 Bauxite, Aluminous Laterite, Cement Grade Limestone and Marl specific gravity etc. and the classification of the estimated resource was done as per UNFC guidelines. The length, width and thickness of Bauxite, Aluminous Laterite, Cement Grade Limestone and Marl is considered in meters. The surface area covered by this Mothala block is about 747 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 Bauxite, Aluminous Laterite, Cement Grade Limestone and Marl was calculated. In this method the average value of thickness of each grade, Al_2O_3%, CaO% and MgO% values were taken borehole wise. Then average value of these previously taken values was calculated for average grade of Bauxite, Aluminous Laterite, Cement Grade Limestone and Marl.

11.1 Reporting of resources:

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

The summary of 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 8:

Table: 8-In-situ resources of Mothala Block, Kachchh

Litho-Unit	In-situ Resources (million tonnes)	
	UNFC 333	Total
Bauxite	12.38	12.38
Cement Grade Limestone	8.41	8.41
Aluminous Laterite	11.35	11.35
Marl	18.42	18.42

The average quality of individual litho-unit zone is given in Table 9:

Table: 9-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
Bauxite	29.65	33.76	16.83	2.45	1.15	0.59	0.14	0.22	0.04	0.06	12.94	0.14
Aluminous Laterite	39.51	24.30	14.53	1.88	2.61	2.79	2.57	0.83	0.21	0.06	0.14	10.37
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 12.38 million tonnes in-situ resource of Bauxite, 8.41 million tonnes in-situ resource of cement grade Limestone, 11.35 million tonnes of Aluminous Laterite and 18.42 million tonnes in-situ resource of Marl is available within Mothala block area.

Interpretation of Isopach map: Bauxite

The isopach map of Bauxite in Mothala Block shows localized development, with significant thickness observed in the eastern to southeastern parts. The maximum thickness of Bauxite reaches 14.00 m near boreholes MBH-28 and MBH-27, while MBH-38 shows thickness of 1.00 m and rest boreholes show no Bauxite development. This suggests a patchy and pocket-type distribution typical of Bauxite towards the eastern part of the block.

Interpretation of Isopach map: Aluminous Laterite

Aluminous Laterite shows a more extensive distribution compared to Bauxite, with thicknesses ranging from 1.0 m to 12.0 m. The maximum development is noted in MBH-28 and MBH-27, indicating a thickened zone in the eastern part of the block. A few isolated patches of 1.00 m to 2.00 m thicknesses are present around the central and western region, while rest boreholes show reduced or negligible laterite development. The pattern suggests a lateritic capping with variable thickness, consistent with tropical weathering regimes.

Interpretation of Isopach map: Limestone

Cement Grade Limestone exhibits limited and discontinuous development across the block. The maximum thickness is observed at MBH-25 (5.53 m) in the central-eastern part. Other zones also show minor limestone development (1.75–3.05 m). Most boreholes record very thin to negligible limestone, indicating the limestone is either lensoidal or partly eroded. This suggests the economic limestone presence is sparse and localized.

Interpretation of Isopach map: Marl

The isopach map of Marl in Mothala Block reveals a relatively uniform and widespread presence across the area, with thickness varying from 0.30 m to 9.0 m. The maximum thickness of Marl is recorded at MBH-26, located in the central-eastern region, followed by consistent medium development in boreholes like MBH-10, MBH-38, MBH-41 and MBH-16. Thinner marl zones appear in peripheral areas. The distribution indicates a stratiform sedimentary deposition, typical of marl layers interbedded with limestone and clay.

CHAPTER-12

Core preservation

After completion of the drilling work, core boxes were carefully shifted to Mothala 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

CONCLUSION

1. Exploration in the Mothala block aimed to assess Bauxite and associated minerals for industrial use.
2. A total of 23 boreholes were drilled with a cumulative meterage of 398.0 m, covering the entire Mothala Block on a 400 m × 400 m grid, intercepted complete thickness of Bauxite, Aluminous Laterite, Cement Grade Limestone, and Marl.
3. A total of 321 core samples and 25 check samples were analyzed to assess the chemical and physical properties of the mineralized zones.
4. Bauxite and Limestone show desirable physical and chemical properties, including high alumina, calcium carbonate content and low impurities suitable for cement, lime, and other industrial applications. Marl and Aluminous Laterite also demonstrate significant industrial potential.
5. Total in-situ resources under Inferred (333) are:
    - Bauxite: 12.38 million tonnes with average Al2O3 33.97%
    - Aluminous Laterite: 11.35 million tonnes with average Al2O3 24.30%
    - Cement Grade Limestone (Blendable/Beneficiable/Portland): 8.41 million tonnes with average CaO 39.72%
    - Marl: 18.42 million tonnes with average CaO 27.32%

RECOMMENDATIONS

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

CHAPTER-14
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- National Geoscience Data Repository (NGDR): https://geodataindia.gov.in

CHAPER-15

Locality Index

Table: 10-Locality index

Name of village	Latitude	Longitude
Mothala	23°12'51.61"N	69° 7'53.17"E
Balachod Nani	23°13'54.88"N	69°10'37.32"E
Balachod Moti	23°13'50.21"N	69°11'8.15"E
Bhavanipur	23°13'40.72"N	69° 4'56.77"E
Kandhay	23°16'15.29"N	69° 8'31.07"E
Sanosara	23°12'31.74"N	69°13'50.31"E
Naredi	23°10'52.19"N	69°11'15.02"E
Kanakpar	23°10'47.00"N	69° 5'9.61"E