

**GEOLOGICAL REPORT ON
PRELIMINARY EXPLORATION(G3)
FOR LIMESTONE & MARL
INDROI-MANDOR BLOCK
TALUKA: PATAN-VERAVAL
DISTRICT: GIR-SOMNATH, GUJARAT
(FIELD SEASON-2025-26)**



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भूविज्ञान एवं खनन आयुक्त, उद्योग एवं खन विभाग, गुजरात सरकार राज्य में खनिज भंडार स्थापित करने के उद्देश्य से कार्य करता है। आयुक्तालय ने पूर्व में व्यापक अन्वेषण कार्य किए हैं, जिनके परिणामस्वरूप विभिन्न स्तरों पर संसाधनों की स्थापना हुई है। यह कार्य पूर्व-विस्तृत खनिज सर्वेक्षण, विस्तृत खनिज सर्वेक्षण तथा ड्रिलिंग द्वारा अन्वेषण के माध्यम से सम्पन्न हुआ है। इन प्रयासों से बॉक्साइट, चूना पत्थर, लिग्नाइट, सिलिका बालू, बेंटोनाइट, चॉक, ग्रेनाइट आदि जैसे अनेक औद्योगिक दृष्टि से महत्वपूर्ण खनिजों की पहचान हुई है। आयुक्तालय का मुख्य उद्देश्य गुजरात राज्य में खनिज संसाधनों की संभावनाओं की पहचान करना तथा नए खनिज एवं खनिज विकास विनियमन संशोधन अधिनियम, 2015 और खनिज (खनिज सामग्री के साक्ष्य) नियम, 2015 के अंतर्गत भंडार स्थापित करना है।

गुजरात मिनरल रिसर्च एंड डेवलपमेंट सोसाइटी (GMRDS) खनिज उद्योगों को सहयोग प्रदान करने और खनिज प्रशासन हेतु तकनीकी सहायता उपलब्ध कराने के लिए समर्पित है। यह संस्था राज्य में खनिज वस्तुओं एवं संसाधनों की स्थापना और विकास पर कार्य करती है। इसके अतिरिक्त, GMRDS नए खनिज संसाधनों की खोज और राज्य की खनिज संपदा में वृद्धि के लिए सक्रिय रूप से कार्यरत है।

क्षेत्रीय सत्र 2025-26 में भूविज्ञान एवं खनन आयुक्त (CGM), गुजरात सरकार ने राष्ट्रीय खनिज अन्वेषण न्यास (NMET), भारत सरकार को एक प्रस्ताव प्रस्तुत किया। इसमें गिर सोमनाथ ज़िले के पाटन-वेरेवल तालुका के इन्द्रोई, मांडोर, ईश्वरिया, गाभा और पांडवा गाँवों के क्षेत्र में कुल 1015.594 हेक्टेयर (10.15 वर्ग किलोमीटर) क्षेत्रफल पर चूना पत्थर के G-3 स्तर के अन्वेषण का प्रस्ताव था। यह प्रस्ताव मार्च 2025 में NMET द्वारा अनुमोदित किया गया।

सौराष्ट्र का तटीय क्षेत्र चूना पत्थर के भंडारों के लिए प्रसिद्ध है। यहाँ का आधार शैल डेक्कन ट्रैप है, जिसके ऊपर गज एवं द्वारका संरचनाएँ तथा उसके बाद मिलियोलाइट एवं चाया संरचनाएँ सहित चतुर्थक निक्षेप पाए जाते हैं। ये संरचनाएँ तीन प्रमुख लिथो-इकाइयों—गज, द्वारका और मिलियोलाइट—के रूप में तटरेखा के समानांतर पट्टियों में व्यवस्थित हैं। चूना पत्थर का प्रमुख खनिज घटक कैल्शियम कार्बोनेट (CaCO_3) है, जो मुख्यतः कैल्साइट के रूप में पाया जाता है। इन्द्रोई-मांडोर क्षेत्र में प्राप्त चूना पत्थर प्लीस्टोसीन युग की मिलियोलाइट संरचना से संबंधित है। इसका रंग श्वेत से हल्का पीला, गुलाबी अथवा धूसर तक पाया जाता है। अधिकांश स्थानों पर यह अपेक्षाकृत नरम, भुरभुरा, पतली परतों वाला तथा फोरामिनिफेरल परीक्षणों एवं माइक्राइट से युक्त होता है।

कुल 1015.594 हेक्टेयर क्षेत्र में GMRDS, गांधीनगर द्वारा अन्वेषण किया गया। इस क्षेत्र में 11 बोरहोल 800 x 800 मीटर ग्रीड पर खोदे गए, जिनकी कुल गहराई 164.78 मीटर रही। इनसे प्राप्त कोर नमूनों से 149 प्राथमिक एवं 19 मिश्रित नमूने तैयार कर पेट्रोग्राफी एवं खनिज रसायन प्रयोगशाला (PMC Lab), गांधीनगर भेजे गए। नमूनों का विश्लेषण प्रमुख एवं गौण ऑक्साइडों (CaO , MgO , Al_2O_3 , SiO_2 , Fe_2O_3 , SO_3 , P_2O_5 , K_2O , Na_2O , MnO , TiO_2 , LOI) तथा विशिष्ट गुरुत्व के लिए किया गया। परिणामों के आधार पर लिथोलॉजी का पुनरीक्षण किया गया और संसाधनों की गणना Thiessen Polygon पद्धति से की गई।

इस परियोजना के परिणामस्वरूप गुजरात की खनिज संपदा में निम्नलिखित संसाधनों की स्थापना हुई: कुल 226.08 मिलियन टन सीमेंट ग्रेड चूना पत्थर (In-situ Resource) तथा 46.00 मिलियन टन मार्ल (In-situ Resource) इन्द्रोई-मांडोर क्षेत्र में G-3 स्तर पर उपलब्ध हैं।

CHAPTER-1

Executive Summary

The Commissioner of Geology and Mining, (CGM) Industries and Mines Department, Government of Gujarat operates to establish mineral reserves in the state. The CGM 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 CGM 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 and 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 resource exploration and augmentation for state's mineral wealth.

In the Field Season 2025-26, the Commissioner of Geology and Mining (CGM), Government of Gujarat, submitted a proposal to the National Mineral Exploration Trust (NMET), Ministry of Mines, Government of India, for G3-stage exploration of Limestone over a total area of 1015.594 Hectares (10.15 sq. km), covering parts of Indroi, Mandor, Ishwaria, Gabha and Pandava villages in Patan-Veraval Taluka, Gir Somnath District, Gujarat. The proposal was approved by NMET in March-2025.

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

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

The total block area of approximately 1015.594 Hectares (10.15 sq. km) was explored by the Gujarat Mineral Research & Development Society (GMRDS), Gandhinagar. Within the block, 11 boreholes were drilled on an 800 x 800 meter grid, reaching a total depth of 164.78 meters in the Indroi-Mandor block. A total of 149 primary samples and 19 composite 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, Al₂O₃, SiO₂, Fe₂O₃, SO₃, P₂O₅, K₂O, Na₂O, MnO, TiO₂, and LOI along with specific gravity. Based on the analytical results, the lithology was revised, and resources were calculated using the Thiessen Polygon method to assess the influence of each borehole. As a result of this project, the following mineral resources were established in Gujarat's mineral wealth: A total of 226.08 million tonnes in-situ resource of cement grade Limestone and 46.00 million tonnes in-situ resource of Marl is available within Indroi-Mandor block area at G-3 level

Brief Summary

Sr. No.	Parameter	Data				
01	Name of the Block	Indroi-Mandor block				
02	Location	Villages: Indroi, mandor,Gabha and Pandava. Taluka: Patan-Veraval District: Gir Somnath				
03	Block Area	1015.594 Hectares (10.15 sq. km)				
04	Block Boundary Co-ordinates					
	Sr. No.	Boundary Pillar	UTM (Universe Transverse Mercator)		DMS (WGS 84)	
			Easting	Northing	Longitude	Latitude
	1	BP-1	655558.071	2316721.649	70°29'45.940° E	20°56'39.880" N
	2	BP-1/1	655361.467	2316758.349	70°29'39.147° E	20° 56' 41.135" N
	3	BP-1/2	655164.863	2316795.049	70°29' 32.353" E	20°56' 42.388" N
	4	BP-1/3	654968.259	2316831.749	70° 29'25.560"E	20° 56' 43.641" N
	5	BP-1/4	654771.655	2316868.449	70° 29' 18.766" E	20° 56 44.894" N
	6	BP-1/5	654575.051	2316905.149	70° 29' 11.972" E	20° 56' 46.147" N
	7	BP-1/6	654378.447	2316941.849	70° 29' 5.17" E	20° 56' 47.399" N
	8	BP-1/7	654181.843	2316978.549	70° 28' 58.385" E	20° 56' 48.652" N
	9	BP-1/8	653985.239	2317015.249	70° 28' 51.591" E	20° 56' 49.904" N
	10	BP-1/9	653788.635	2317051.949	70° 28' 44.79" E	20° 56' 51.157" N
	11	BP-1/10	653592.031	2317088.649	70° 28' 38.004" E	20° 56' 52.409" N
	12	BP-1/11	653395.427	2317125.349	70°28' 31.210" E	20°56' 53.661" N
	13	BP-2	653282.29	2317146.468	70'28'27.300"E	20°56'54.380"N
	14	BP-2/1	653361.888	2317329.946	70° 28' 30.114" E	20°57'0.325"N
	15	BP-2/2	653441.486	2317513.424	70° 28' 32.928" E	20° 57'6.267"N
	16	BP-2/3	653521.083	2317696.902	70° 28' 35.742" E	20° 57' 12.209" N
	17	BP-2/4	653600.681	2317880.38	70° 28' 38.556" E	20° 57'18.152" N
	18	BP-2/5	653680.28	2318063.858	70°28' 41.370" E	20°57' 24.094" N
	19	BP-2/6	653759.878	2318247.336	70°28' 44.184" E	20°57'30.037" N
	20	BP-2/7	653839.475	2318430.814	70°28' 46.998" E	20° 57' 35.979"N
21	BP-2/8	653919.073	2318614.292	70°2849.812" E	20° 57' 41.921" N	
22	BP-2/9	653998.671	2318797.77	70° 28' 52.627" E	20° 57'47.864" N	

23	BP-2/10	654078.27	2318981.248	70° 28' 55.441" E	20° 57'53.806" N
24	BP-2/11	654157.867	2319164.726	70° 28' 58.256" E	20° 57' 59.748" N
25	BP-2/12	654237.455	2319348.203	70° 29' 1.070"E	20° 58' 5.690" N
26	BP-2/13	654317.063	2319531.682	70°29'3.885" E	20°58' 11.633" N
27	BP-2/14	654396.661	2319715.16	70°29' 6.699" E	20°58' 17.575" N
28	BP-2/15	654476.259	2319898.637	70°29'9.514" E	20°58'23.517"N
29	BP-2/16	654555.857	2320082.116	70°29' 12.329" E	20°58' 29.459" N
30	BP-2/17	654635.455	2320265.593	70°29' 15.144" E	20°58' 35.401" N
31	BP-2/18	654715.053	2320449.071	70° 29' 17.959" E	20° 58' 41.344" N
32	BP-2/19	654794.651	2320632.549	70° 29' 20.774" E	20° 58' 47.286" N
33	BP-2/20	654874.249	2320816.027	70° 29' 23.589" E	20° 58' 53.228" N
34	BP-2/21	654953.847	2320999.505	70° 29' 26.404" E	20° 58' 59.170" N
35	BP-2/22	655033.445	2321182.983	70°29' 29.219" E	20° 59' 5.112" N
36	BP-2/23	655113.043	2321366.461	70°29' 32.034" E	20° 59' 11.054" N
37	BP-2/24	655192.641	2321549.939	70°29' 34.850" E	20° 59'16.996" N
38	BP-3	655227.147	2321629.478	70°29'36.070" E	20°59'19.570"N
39	BP-3/1	655397.918	2321733.581	70°29' 42.017" E	20° 59' 22.905" N
40	BP-3/2	655568.688	2321837.685	70° 29' 47.963" E	20° 59' 26.239" N
41	BP-3/3	655739.458	2321941.788	70° 29' 53.910" E	20° 59' 29.572" N
42	BP-3/4	655910.228	2322045.892	70° 29'59.857"E	20° 59' 32.905" N
43	BP-3/5	656080.999	2322149.995	70° 30'5.804" E	20° 59' 36.238" N
44	BP-3/6	656251.769	2322254.098	70°30' 11.751" E	20°59' 39.571" N
45	BP-3/7	656422.539	2322358.202	70°30'17.698"E	20° 59' 42.904" N
46	BP-3/8	656593.309	2322462.305	70° 30' 23.645" E	20° 59' 46.237" N
47	BP-3/9	656764.08	2322566.409	70° 30' 29.592" E	20° 59' 49.569" N
48	BP-3/10	656934.85	2322670.512	70° 30' 35.539" E	20° 59' 52.902" N
49	BP-4	657043.998	2322737.05	70°30'39.340"E	20°59'55.030" N
50	BP-4/1	656996.036	2322542.886	70° 30' 37.616" E	20° 59' 48.733" N
51	BP-4/2	656948.074	2322348.722	70°30' 35.892" E	20° 59' 42.434" N
52	BP-4/3	656900.111	2322154.558	70°30'34.167"E	20° 59' 36.135"N
53	BP-4/4	656852.149	2321960.395	70° 30' 32.443" E	20° 59' 29.837" N
54	BP-4/5	656804.186	2321766.231	70° 30' 30.719" E	20° 59' 23.538" N
55	BP-4/6	656756.224	2321572.067	70° 30' 28.995" E	20° 59' 17.239" N
56	BP-4/7	656708.261	2321377.903	70° 30' 27.271" E	20° 59' 10.940" N
57	BP-4/8	656660.299	2321183.739	70° 30' 25.547" E	20°59'4.641" N

	58	BP-4/9	656612.336	2320989.575	70°30' 23.823" E	20° 58' 58.342" N
	59	BP-4/10	656564.374	2320795.412	70° 30' 22.099" E	20°58'52.043"N
	60	BP-4/11	656516.411	2320501.248	70°30' 20.375" E	20° 58' 45.744" N
	61	BP-4/12	656468.449	2320407.084	70°30' 18.651" E	20° 58' 39.445" N
	62	BP-4/13	656420.486	2320212.92	70° 30' 16.928" E	20° 58' 33.146" N
	63	BP-4/14	656372.524	2320018.756	70° 30' 15.204" E	20° 58' 26.847" N
	64	BP-4/15	656324.561	2319824.592	70° 30' 13.480" E	20° 58' 20.548" N
	65	BP-4/16	656276.599	2319630.428	70°30' 11.757" E	20° 58' 14.249" N
	66	BP-4/17	656228.637	2319436.265	70° 30' 10.033" E	20°58'.950"N
	67	BP-4/18	656180.674	2319242.101	70°30'.309"E	20°58' 1.651" N
	68	BP-4/19	656132.712	2319047.937	70" 30' 6.586" E	20° 57' 55.352" N
	69	BP-4/20	656084.749	2318853.773	70°30' 4.863" E	20°57'49.053" N
	70	BP-4/21	656036.787	2318659.609	70°30'3,139"E	20° 57'42.754" N
	71	BP-4/22	655988.824	2318465.445	70° 30'1.416"E	20° 57' 36.455" N
	72	BP-4/23	655940.862	2318271.281	70° 29' 59.692" E	20° 57'30.156" N
	73	BP-4/24	655892.899	2318077.118	70° 29' 57.969" E	20°57'23.857" N
	74	BP-4/25	655844.937	2317882.954	70° 29' 56.246" E	20° 57'17.557" N
	75	BP-4/26	655796.974	2317688.79	70° 29' 54.523" E	20° 57'11.258" N
	76	BP-4/27	655749.012	2317494.626	70°29' 52.800" E	20°57'4.959" N
	77	BP-4/28	655701.049	2317300.462	70° 29' 51.077" E	20°56'58.6601"N
	78	BP-4/29	655653.087	2317105.298	70° 29' 49.353" E	20° 56' 52.361" N
	79	BP-4/30	655605.124	2316912.134	70° 29'47.630" E	20° 56' 46.062" N
05	Total Area Covered under Geological Exploration		1015.594 Hectares (10.15 sq. km)			
06	No. of Boreholes Drilled		11			
07	Total Meterage Drilled		164.78 mts			
08	Borehole Spacing		800 mts x 800 mts			
09	Mineralized Zone		2.50 Mtr to 19.80 Mtr			

10	Economic Mineral Resource with Quality	Commodity	Average Thickness (in meter)	Resource (In million tons)	Quality
		Cement Grade Limestone	8.36	226.08	CaO:44.43%, MgO:0.73%, SiO ₂ :8.18%, Fe ₂ O ₃ :2.71%
		Marl	1.88	46.00	CaO:26.96%, MgO:1.33%, SiO ₂ :25.31%, Fe ₂ O ₃ :6.48%
11	Ratio of OB thickness over the ore body	0.75			
12	Toposheet No.	41L/05 & 41L/09			
13	Topography	Undulating			
14	Average Rainfall	1340 mm (Source: Local Meteorological Department)			
15	Lowest Temperature	16° C (Source: IMD)			
16	Maximum Temperature	45° C (Source: IMD)			
17	Nearest Railway station	Somnath Railway station- 9.910 km			
18	Road	Accessible through NH51-5.05 KM and SH26-3.56 KM			
19	Airport	Diu airport – 50.90 km			

CHAPTER-2

Introduction

2.1 Details of the Project:

A proposal for G3 stage Limestone exploration in Indroi-Mandor block, Patan-Veraval Taluka, Gir Somnath district, Gujarat was submitted to NMET by Commissioner of Geology and Mining, GOG- Gandhinagar on March-2025.

The proposal for the block was initially prepared at the G3 exploration stage with drilling on a 800 m × 800 m grid to NMET in March-2025. Subsequently, in the 42th EC meeting held on 02/06/2025, the matter was discussed, and the EC approved the project with an estimated cost of Rs. 73,83,532. The sanction order for the project was received on 26/06/2025. Subsequently, the project was approved of timeline extension until 25.02.2026.

The exploration proposal for the Indroi-Mandor block is prepared with a total proposed area of 1015.594 Hectares (10.15 sq. km). The Indroi-Mandor block falls in the toposheet no. 41L/05 & 41L/09 in Indroi, Mandor, Gabha and Pandava villages of Patan-Veraval Taluka, Gir Somnath district. The Preliminary Exploration (G3) for the mineral Limestone in Indroi-Mandor block was carried out on a grid of 800 x 800 meters, drilling a total of 11 boreholes comprising a total meterage of 164.78 meters within the block.

2.2 Investigation Agency:

Commissioner of Geology and Mining, Government of Gujarat, Gandhinagar

2.3 Objective of the investigation:

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

2.4 Basis for taking up investigation:

The region was primarily investigated by the Commissioner of Geology and Mining (CGM) during 1965 and 1995–1997 through geological mapping using remote sensing techniques, surface exposure mapping, and sample collection in the proposed area. The findings of these earlier investigations indicated that the coastal areas of the Saurashtra region host significant deposits of Miliolitic Limestone, characterized by low overburden and occurring as low ridges and mounds, making them easily mineable.

As part of the recent geological traverse survey conducted by CGM/GMRDS Geologists, a total of 07 grab samples were collected from the block. The chemical analysis results revealed CaO content ranging from 47.67% to 54.88% indicating promising prospects for high-grade limestone.

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

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

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

Sr. No	Item of Work	Original Proposed	Achieved
1	Topographic Survey & Geological Mapping on 1:2000 scale (Ha)	1019 Ha	1015.594 Ha
2	Boundary and borehole demarcation with DGPS	Boundary: 4 BH: 11	Boundary: 4 BH: 11
3	Exploratory Drilling (One conditional BH to confirm the total thickness of limestone)	220 m 11 BHs	164.78 m 11 BHs
4	Laboratory Studies		
	i) Chemical Analysis; Primary samples for 12 radicals, CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , K ₂ O, Na ₂ O, MnO, TiO ₂ , and LOI by XRF	250 Core	16 grab samples +149 Drill hole samples and 19 composite samples
	ii) External Check (NABL) samples (10% of Primary samples) for analysis of for 12 radicals, CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ , K ₂ O, Na ₂ O, MnO, TiO ₂ , and LOI by ICP-OES	25	16 core samples
5	Physical Studies		
	a) Petrological Studies	10	7
	b) Specific gravity Determinations	10	19
6	Report Preparation (5 Hard copies with one soft copy)	1	1
7	Preparation of Exploration Proposal (5 Hard copies with a soft copy)	1	1

2.6 Personal involved:

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

Mode of operation of different work components and associated agency:

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

Sr. No.	Work Components	Involved agencies
01	Survey & Geological Mapping	Departmental by CGM & GMRDS
02	Laboratory Studies	Petrography and Mineral Chemistry Laboratory (PMC), CGM, Gandhinagar, Gujarat
	Samples for XRD	
	Petrographic study	
	Specific gravity	
03	Check samples from External NABL approved laboratory	M/S. Lucid Laboratory, Hyderabad (NABL approved laboratory)
04	Core Drilling	External Drilling agency- M/S. Horizon Consultants, Gandhinagar
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 Indroi-Mandor block, Taluka: Patan-Veraval, District: Gir Somnath, Gujarat.

3.2 Details of the area

The project area falls within parts of Indroi and Mandor villages in Patan-Veraval Taluka, Gir Somnath District, Gujarat. The Indroi-Mandor block has an area of 1015.594 Hectares (10.15 sq. km), bounded by Longitude 70°29'16.70"E to 70°30'14.97"E and Latitude 20°57'11.41"N to 20°59'12.94"N.

3.2.1 Survey of India Toposheet number

The block area falls under the Survey of India Toposheet No. 42L/05 & 41L/09 of Patan-Veraval Taluka of Gir Somnath district, Gujarat. A map showing area on toposheet can be referred for the same (i.e. Plate-5).

3.2.2 Geo-coordinates of the Indroi-Mandor 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 Indroi-Mandor block boundary

Sr. No.	Boundary Pillar	DMS (WGS 84)		UTM (Universe Transverse Mercator)	
		Latitude	Longitude	Easting	Northing
1	BP-1	655558.071	2316721.649	70°29'45.940° E	20°56'39.880" N
2	BP-1/1	655361.467	2316758.349	70°29'39.147° E	20° 56' 41.135" N
3	BP-1/2	655164.863	2316795.049	70°29' 32.353" E	20°56' 42.388" N
4	BP-1/3	654968.259	2316831.749	70° 29'25.560"E	20° 56' 43.641" N
5	BP-1/4	654771.655	2316868.449	70° 29' 18.766" E	20° 56 44.894" N
6	BP-1/5	654575.051	2316905.149	70° 29' 11.972" E	20° 56' 46.147" N
7	BP-1/6	654378.447	2316941.849	70° 29' 5.17" E	20° 56' 47.399" N
8	BP-1/7	654181.843	2316978.549	70° 28' 58.385" E	20° 56' 48.652" N
9	BP-1/8	653985.239	2317015.249	70° 28' 51.591" E	20° 56' 49.904" N

10	BP-1/9	653788.635	2317051.949	70° 28' 44.79" E	20° 56' 51.157" N
11	BP-1/10	653592.031	2317088.649	70° 28' 38.004" E	20° 56' 52.409" N
12	BP-1/11	653395.427	2317125.349	70°28' 31.210" E	20°56' 53.661" N
13	BP-2	653282.29	2317146.468	70'28'27.300"E	20°56'54.380"N
14	BP-2/1	653361.888	2317329.946	70° 28' 30.114" E	20°57'0.325"N
15	BP-2/2	653441.486	2317513.424	70° 28' 32.928" E	20° 57'6.267"N
16	BP-2/3	653521.083	2317696.902	70° 28' 35.742" E	20° 57' 12.209" N
17	BP-2/4	653600.681	2317880.38	70° 28' 38.556" E	20° 57'18.152" N
18	BP-2/5	653680.28	2318063.858	70°28' 41.370" E	20°57' 24.094" N
19	BP-2/6	653759.878	2318247.336	70°28' 44.184" E	20°57'30.037" N
20	BP-2/7	653839.475	2318430.814	70°28' 46.998" E	20° 57' 35.979"N
21	BP-2/8	653919.073	2318614.292	70°28'49.812" E	20° 57' 41.921" N
22	BP-2/9	653998.671	2318797.77	70° 28' 52.627" E	20° 57'47.864" N
23	BP-2/10	654078.27	2318981.248	70° 28' 55.441" E	20° 57'53.806" N
24	BP-2/11	654157.867	2319164.726	70° 28' 58.256" E	20° 57' 59.748" N
25	BP-2/12	654237.455	2319348.203	70° 29' 1.070"E	20° 58' 5.690" N
26	BP-2/13	654317.063	2319531.682	70°29'3.885" E	20°58' 11.633" N
27	BP-2/14	654396.661	2319715.16	70°29' 6.699" E	20°58' 17.575" N
28	BP-2/15	654476.259	2319898.637	70°29'9.514" E	20°58'23.517"N
29	BP-2/16	654555.857	2320082.116	70°29' 12.329" E	20°58' 29.459" N
30	BP-2/17	654635.455	2320265.593	70°29' 15.144" E	20°58' 35.401" N
31	BP-2/18	654715.053	2320449.071	70° 29' 17.959" E	20° 58' 41.344" N
32	BP-2/19	654794.651	2320632.549	70° 29' 20.774" E	20° 58' 47.286" N
33	BP-2/20	654874.249	2320816.027	70° 29' 23.589" E	20° 58' 53.228" N
34	BP-2/21	654953.847	2320999.505	70° 29' 26.404" E	20° 58' 59.170" N
35	BP-2/22	655033.445	2321182.983	70°29' 29.219" E	20° 59' 5.112" N
36	BP-2/23	655113.043	2321366.461	70°29' 32.034" E	20° 59' 11.054" N
37	BP-2/24	655192.641	2321549.939	70°29' 34.850" E	20° 59'16.996" N

38	BP-3	655227.147	2321629.478	70°29'36.070" E	20°59'19.570"N
39	BP-3/1	655397.918	2321733.581	70°29' 42.017" E	20° 59' 22.905" N
40	BP-3/2	655568.688	2321837.685	70° 29' 47.963" E	20° 59' 26.239" N
41	BP-3/3	655739.458	2321941.788	70° 29' 53.910" E	20° 59' 29.572" N
42	BP-3/4	655910.228	2322045.892	70° 29'59.857"E	20° 59' 32.905" N
43	BP-3/5	656080.999	2322149.995	70° 30'5.804" E	20° 59' 36.238" N
44	BP-3/6	656251.769	2322254.098	70°30' 11.751" E	20°59' 39.571" N
45	BP-3/7	656422.539	2322358.202	70°30'17.698"E	20° 59' 42.904" N
46	BP-3/8	656593.309	2322462.305	70° 30' 23.645" E	20° 59' 46.237" N
47	BP-3/9	656764.08	2322566.409	70° 30' 29.592" E	20° 59' 49.569" N
48	BP-3/10	656934.85	2322670.512	70° 30' 35.539" E	20° 59' 52.902" N
49	BP-4	657043.998	2322737.05	70°30'39.340"E	20°59'55.030" N
50	BP-4/1	656996.036	2322542.886	70° 30' 37.616" E	20° 59' 48.733" N
51	BP-4/2	656948.074	2322348.722	70°30' 35.892" E	20° 59' 42.434" N
52	BP-4/3	656900.111	2322154.558	70°30'34.167"E	20° 59' 36.135"N
53	BP-4/4	656852.149	2321960.395	70° 30' 32.443" E	20° 59' 29.837" N
54	BP-4/5	656804.186	2321766.231	70° 30' 30.719" E	20° 59' 23.538" N
55	BP-4/6	656756.224	2321572.067	70° 30' 28.995" E	20° 59' 17.239" N
56	BP-4/7	656708.261	2321377.903	70° 30' 27.271" E	20° 59' 10.940" N
57	BP-4/8	656660.299	2321183.739	70° 30' 25.547" E	20°59'4.641" N
58	BP-4/9	656612.336	2320989.575	70°30' 23.823" E	20* 58' 58.342" N
59	BP-4/10	656564.374	2320795.412	70° 30' 22.099"E	20°58'52.043"N
60	BP-4/11	656516.411	2320501.248	70°30' 20.375" E	20° 58' 45.744" N
61	BP-4/12	656468.449	2320407.084	70°30' 18.651" E	20° 58' 39.445" N
62	BP-4/13	656420.486	2320212.92	70° 30' 16.928" E	20° 58' 33.146" N
63	BP-4/14	656372.524	2320018.756	70° 30' 15.204" E	20° 58' 26.847" N
64	BP-4/15	656324.561	2319824.592	70° 30' 13.480" E	20° 58' 20.548" N
65	BP-4/16	656276.599	2319630.428	70°30' 11.757"E	20° 58' 14.249" N

66	BP-4/17	656228.637	2319436.265	70° 30' 10.033" E	20°58'.950"N
67	BP-4/18	656180.674	2319242.101	70°30'.309"E	20°58' 1.651" N
68	BP-4/19	656132.712	2319047.937	70" 30' 6.586" E	20° 57' 55.352" N
69	BP-4/20	656084.749	2318853.773	70°30' 4.863" E	20°57'49.053" N
70	BP-4/21	656036.787	2318659.609	70°30'3,139"E	20° 57'42.754" N
71	BP-4/22	655988.824	2318465.445	70° 30'1.416"E	20° 57' 36.455" N
72	BP-4/23	655940.862	2318271.281	70° 29' 59.692" E	20° 57'30.156" N
73	BP-4/24	655892.899	2318077.118	70° 29' 57.969" E	20°57'23.857" N
74	BP-4/25	655844.937	2317882.954	70° 29' 56.246" E	20° 57'17.557" N
75	BP-4/26	655796.974	2317688.79	70° 29' 54.523" E	20° 57'11.258" N
76	BP-4/27	655749.012	2317494.626	70°29' 52.800" E	20°57'4.959" N
77	BP-4/28	655701.049	2317300.462	70° 29' 51.077" E	20°56'58.6601"N
78	BP-4/29	655653.087	2317105.298	70° 29' 49.353" E	20° 56' 52.361" N
79	BP-4/30	655605.124	2316912.134	70° 29'47.630" E	20° 56' 46.062" N

Table: 4 Coordinates of drilled boreholes of Indroi-Mandor block

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)		UTM (Universe Transverse Mercator)	
			Latitude	Longitude	Easting	Northing
1	BH-01	64	20°59'12.94"N	70°30'14.97"E	656352.44 m E	2321436.07 m N
2	BH-02	65.5	20°58'56.10"N	70°29'47.36"E	655559.94 m E	2320910.75 m N
3	BH-03	61	20°58'55.22"N	70°30'13.51"E	656315.40 m E	2320890.78 m N
4	BH-04	68	20°58'27.86"N	70°29'47.79"E	655580.48 m E	2320042.48 m N
5	BH-05	51.5	20°58'1.25"N	70°29'20.20"E	654791.25 m E	2319216.79 m N
6	BH-06	60	20°57'59.87"N	70°29'46.29"E	655545.20 m E	2319181.38 m N
7	BH-07	45.5	20°57'43.07"N	70°29'16.70"E	654695.36 m E	2318656.82 m N
8	BH-08	54	20°57'35.56"N	70°29'45.67"E	655534.28 m E	2318433.68 m N
9	BH-09	39	20°57'13.06"N	70°28'52.65"E	654009.24 m E	2317727.57 m N
10	BH-10	46.5	20°57'13.38"N	70°29'17.40"E	654724.06 m E	2317744.03 m N
11	BH-11	52.5	20°57'11.41"N	70°29'42.72"E	655456.00 m E	2317690.27 m N

3.2.3 Location and Accessibility

The project area falls in parts of Indroi, Mandor, Gabha and Pandava villages of Patan-Veraval Taluka, Gir Somnath District, Gujarat. District headquarter is situated at Veraval. The area is accessible through NH-51 and SH-26. A Key and Location plan can be referred for the same (i.e. Plate-1). The nearest airport from the study area is Diu airport which is around 50.90 Km away from the Indroi-Mandor block. Nearest Railway station is Somnath which is approx. 9.910 km away from the Indroi-Mandor block. A glimpse of map of toposheet nos 41C/05 & 41L/09 provides comprehensive topographic information of Indroi-Mandor Block (i.e. Plate-2).

3.2.3 Climate

The climate is typically semi-arid. Extreme temperatures, erratic rainfall and high evaporation are the characteristics feature of climate. Mostly, precipitation occurs in short, episodic bursts, which in turn trigger extensive erosion of unconsolidated sediments. The overall dryness throughout the year except monsoon season also has led to lack of vegetation in riverbanks. The temperature in Gir Somnath District ranges from 42° C higher in the summer and 9° C lowest in the winter. The average annual rainfall is below 1340 mm. (Source: Local Meteorological Department and IMD)

3.2.4 Flora and Fauna

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

3.2.5 Drainage

Studying the drainage system is essential for gaining insights into geomorphology and structural fabrics of the area to understand modifying factors for mining. The block area is characterized by gently undulating terrain with no major perennial rivers flowing through the block boundary. However, small seasonal drainage channels are observed, primarily active during the monsoon, contributing to a sub-dendritic to sub-parallel drainage pattern in the surrounding areas. Overall, the drainage is controlled by local topography and lithology, with no significant waterlogging observed within the block area. The highest contour of the area is 74.5 mRL and Lowest is 36.5 mRL.

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 Indroi-Mandor block. The Gir Somnath district covers an area of 3,775 km² and population of the district is 9,46,790 as per 2011 census. Gabha, Pandva, Ishwaria, Indroi, Mandor are the nearby villages to Indroi-Mandor block. This Block is located around 12 Km towards North-East from district headquarters Veraval and around 404 Km from state capital Gandhinagar. Sutrapada is around 11.84 Km far from this block. Gujarat Heavy Chemicals Ltd soda ash plant is situated at around 11.24 km south-east from the block area and Ambuja Cements Limited (Adani Cement), Ambujanagar Plant is about 23.21 km South-east from the block area. (Collector Office) is 8.24 KM from the block area.

CHAPTER-4

Previous work

- During F.S. 1965–66 Shri U.D.G. Rao carried out investigations of limestone deposits in the eastern parts of Veraval and Kodinar in the Gir Somnath District, Gujarat State. During this field Season an area of about 200 sq.kms. between Kodinar and Veraval was examined, and all-important limestone outcrops were mapped and assessed and 228 chip sample had been collected systematically along and across the dip direction and sent for analysis. The reserves had been estimated to be about 30 million tonnes of limestone and 26 million tonnes of calcareous sand.
- During the Field Seasons of 1979–1981, Shri A.K. Trivedi carried out a geological investigation in the Morasa to Padruka village area, Veraval Taluka, Junagadh District, Gujarat. The study involved geological mapping at a scale of 1:2000 and contouring at 2-meter intervals over 4.8 square kilometers. A total of 36 boreholes were drilled, with depths ranging from 10.67 to 30.50 meters, at 400-meter intervals in a grid pattern. Most boreholes intersected Gaj clays, while the milliolite limestone strata ranged from 6 to 21 meters in thickness, averaging 15 meters. 654 samples were collected, and 86 chip samples were analyzed. The investigation identified an estimated reserve of 138.24 million tonnes of cement-grade limestone in the area.
- During F.S. 1995–96–97 Shri S.D. Kapse and Shri Y.C. Patel undertook geological mapping of Junagadh and Jamnagar districts on a 1:50,000 scale, covering about 2,580 sq. km using Remote Sensing Techniques. Geological maps were prepared using False Colour Composite (F.C.C.) data of LANDSAT and SPOT satellite in parts of toposheets 41 G/5, 41 G/10, 41 G/6, 41 K/4, 41G/15, 41 G/11, 41 L/5, 41 L/1, 41 L/9, 41 L/10.
- During F.S. 2019-21 Commissioner of Geology and Mining (CGM), Gujarat had carried out G2 level exploration of limestone in the Barvela-Singhsar Block, Junagadh District. The exploration was carried out by drilling 53 boreholes at nearly 200-meter grid spacing. A total of 51 boreholes tested positive for Limestone. All boreholes were drilled in 50mts depth and still mineralized zone is continuing in the depth.

CHAPTER-5

Geology of the area

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

Gaj Formation

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

Dwarka Formation

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

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

Miliolite Limestone

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

Chaya Formation

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

Soil and Alluvium

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

The general stratigraphic succession of the region is as follows:

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

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

Geology of the Indroi-Mandor block

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

Table: 6-Local Geology of the Study Area

Age	Formation	Litho-units/Rock Type
Holocene	Recent to Sub-Recent	Top black soil/ Alluvium
Early Pleistocene	Miliolite Formation	Pelitic and Oolitic calc-arenites, micrites, calcareous Conglomerate.
		Buff & grayish white colored medium to coarse grained, coquinoidal limestone
Lower Miocene	Gaj Formation	Deep ocherous marls and marly limestones with <u>Foraminifers</u> and <u>marine invertebrates</u> . Variegated, unfossiliferous clays.
-----unconformity-----		
	Deccan Trap	weathered basalt etc.,

Soil: It is the youngest unit exposed in the Indroi-Mandor block, which is brownish black in colour, with fine to medium grain size. It is composed of calcareous material with fragmented limestone. Soil layer is having average thickness of 0.82 m.

Limestone:

The Miliolitic Limestone of Pleistocene age is encountered in the Indroi-Mandor block. It is typically buff white, pinkish white, light yellowish to brownish in color. It is characterized by a fine to medium grain structure, composed predominantly of foraminiferal fossils embedded in a calcitic matrix. This limestone formation is primarily found in shallow marine deposits of Pleistocene age. It is dense, hard, porous and of economic significance due to its high calcium carbonate content and low impurities. The average thickness of limestone observed across the boreholes is 8.36 m.

Marl:

Marl associated with Limestone encountered in the present study area. It is a non-clastic sedimentary rock composed primarily of fine to medium-grained, yellowish to yellowish-brown colored calcium carbonate mineral. The average thickness of marl observed across the boreholes is 1.88m within the Indroi-Mandor block.

Clay:

The clay exhibits yellowish to brown colors. It is fine grained, soft, calcareous and fossiliferous in nature. It is found interbedded between the limestone and marl beds within the block. The average thickness is 1.63.

Trap:

It typically exhibits black to dark green coloration, with occasional light greenish tints along weathered surfaces. The rock is generally fine- to medium-grained and igneous in origin, representing the Deccan Trap basaltic flows. In the subsurface, it occurs as a compact and hard unit, though weathering along the upper sections is common. The presence of Trap at depth forms the basement rock for the overlying sedimentary formations in the block.

CHAPTER-6

Activity during the period (Geoscience investigation)

6.1 Geological Mapping:

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

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

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

The geological mapping of the Indroi-Mandor block was conducted with the objective of understanding the lithological setup, mineralization, and other structural features within the area. The mapping was carried out on a 1:12000 scale, focusing on the limestone deposits in the region, which are critical for industries such as cement and chemicals. The study involved systematic traverses across the block, along both east-west and north-south orientations, to document the variations in lithology and mineralization.

The mapping was carried out over a total area of 1015.594 Hectares (10.15 sq. km), covering the entire Indroi-Mandor block. During the fieldwork, limestone outcrops were observed, and the thickness and nature of the formations were recorded. The block area was characterized by flat topography with a few isolated elevations, which allowed easy access for traversing. The highest contour of the block is 74.50 mRL and lowest contour is 36.50 Mrl.

Samples were collected systematically from areas showing good quality limestone exposures. These samples were analyzed to determine their suitability for industrial

applications such as cement and chemical production. 07 samples were collected during the mapping and the analysis for those is as follows:

Table: 7 Field Grab sample analysis of Indroi-Mandor block

Chemical Composition (%)														
Sr. No.	Sample ID	Latitude	Longitude	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	SO ₃	LOI
1	INDROI-MANDOR -01	20°58'32.94"	70°29'56.35"	1.05	0.63	0.90	0.10	54.76	0.24	0.09	0.07	0.02	0.00	41.91
2	INDROI-MANDOR -02	20°58'55.58"	70°30'08.96"	1.94	1.25	1.17	0.18	53.58	0.59	0.14	0.12	0.04	0.05	40.63
3	INDROI-MANDOR -03	20°59'10.08"	70°30'13.22"	1.85	0.80	0.88	0.13	54.06	0.39	0.07	0.12	0.00	0.06	41.41
4	INDROI-MANDOR -04	20°57'36.39"	70°29'42.42"	3.70	1.75	6.71	0.34	47.67	0.64	0.00	0.27	0.11	0.04	38.43
5	INDROI-MANDOR -05	20°58'0.51"	70°29'58.00"	2.54	1.08	3.98	0.24	52.23	0.48	0.00	0.15	0.00	0.00	39.15
6	INDROI-MANDOR -06	20°59'0.29"	70°30'0.04"	5.54	2.51	4.23	0.51	49.89	0.69	0.07	0.36	0.03	0.00	35.99
7	INDROI-MANDOR -07	20°57'0.58"	70°29'0.52"	1.13	0.65	1.00	0.13	54.88	0.30	0.00	0.06	0.03	0.00	41.61

6.2 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.

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

Details of interpreted ore zones based on geological investigation

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

together help assess the prospectivity and economic potential of the limestone within the block.

Geophysical exploration

The ground Geophysical exploration was not carried out during the G3 stage of exploration at Indroi-Mandor block.

Geochemical exploration

Geochemical exploration was not carried out during the G3 stage of exploration at Indroi-Mandor block.

CHAPTER-7

Integration of Geology, Geo physics and Geochemical exploration and interpretation

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

CHAPTER-8

Mineral Prospect

Gir Somnath is a mineral rich region with very large reserves of Limestone, Marl, Black trap and Ordinary Sand. Gir Somnath 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, coastal Saurashtra is known for its Limestone deposits. These calcium rich rocks were the manifestations of the higher sea levels during the Tertiary and Quaternary period due to geostatic sea level rise. Stratigraphically the Deccan trap is the oldest litho-unit in the area and forms the basement for the overlying sedimentary units. Rocks of Gaj Formation and Dwarka Formation of Tertiary period and Miliolite Formation and Chaya Formation of Quaternary period along with recent and sub-recent loose sediments overlie the Deccan Traps.

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

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

Due to wide reserves of Limestone, major cement industries like Ambuja Cement, Siddhi Cement as well Soda-ash plant like Gujarat Heavy Chemicals Limited are situated in Gir Somnath district.

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

CHAPTER-9

Subsurface Exploration (Drilling)

9.1 Spacing of the Boreholes:

A G-3 stage exploration was carried out in this block and as per guideline of MEMC rule, 2015 and its amendments, the spacing between two boreholes in case of bedded stratiform and tabular deposits of regular habit is 800 mts x 800 mts. Accordingly M/s Horizon Consultants have planned and carried out drilling through 11 nos. of exploratory boreholes at a grid interval of 800 mts x 800 mts in this block with a cumulative meterage of 164.78 meters.

Table: 8 Coordinates of drilled boreholes of Indroi-Mandor block with RL

Sr. No.	BH ID	R.L. (m)	DMS (WGS 84)		UTM (Universe Transverse Mercator)	
			Latitude	Longitude	Easting	Northing
1	BH-01	64	20°59'12.94"N	70°30'14.97"E	656352.44 m E	2321436.07 m N
2	BH-02	65.5	20°58'56.10"N	70°29'47.36"E	655559.94 m E	2320910.75 m N
3	BH-03	61	20°58'55.22"N	70°30'13.51"E	656315.40 m E	2320890.78 m N
4	BH-04	68	20°58'27.86"N	70°29'47.79"E	655580.48 m E	2320042.48 m N
5	BH-05	51.5	20°58'1.25"N	70°29'20.20"E	654791.25 m E	2319216.79 m N
6	BH-06	60	20°57'59.87"N	70°29'46.29"E	655545.20 m E	2319181.38 m N
7	BH-07	45.5	20°57'43.07"N	70°29'16.70"E	654695.36 m E	2318656.82 m N
8	BH-08	54	20°57'35.56"N	70°29'45.67"E	655534.28 m E	2318433.68 m N
9	BH-09	39	20°57'13.06"N	70°28'52.65"E	654009.24 m E	2317727.57 m N
10	BH-10	46.5	20°57'13.38"N	70°29'17.40"E	654724.06 m E	2317744.03 m N
11	BH-11	52.5	20°57'11.41"N	70°29'42.72"E	655456.00 m E	2317690.27 m N

Initially, the proposed BH meterage is estimated in accordance with the previous work in the surrounding areas. During drilling, older formation is encountered earlier and thus, the drilling meterage is less than expected.

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 Horizon Consultants. Drilling in the Indroi-Mandor block was carried out during November & December, 2025 by deploying hydraulic core drill rigs using NQ diamond bits with core diameter of 47.6 mm. Double tube core barrels were used to obtain maximum core recovery.

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

Core recovery of every run of drilling for all the drilled boreholes was recorded properly.

The core recovery of the boreholes drilled for limestone in the area is 73.00% to 96.00% 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 73.00% to 96.00% hence grade analyzed for limestone is reliable.

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

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

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

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

9.3 Methodology of core zone sampling and sample preparation:

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

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

ii)

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

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

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

For sampling the ore zone, the drilled cores were logged, sample numbers were marked and then split longitudinally to equal halves. One half was kept for core repository. The other half of the split cores was crushed to 200-mesh size. The weight of the crushed core samples varied from 2 to 4 kg depending upon the sample length and recovery. After coning and quartering of the crushed 200-mesh size fraction, individual samples of about 250 gm samples each were sent to Petrography and Mineral Chemistry Laboratory, CGM, Gandhinagar for further processing and chemical analysis.

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

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

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

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

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

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

The individual core samples were formulated for a linear length of 0.25 to 3.00 m. Each sample was subjected to crushing, coning and quartering by applying the standard method of size and weight reduction. The crushed sample was finally pulverized to 200-mesh size to prepare sample pellets. The pellets were then used in XRF for chemical analysis.

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

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 0.25 to 3.00 m. The sample length varied depending upon the change in lithology or physical appearance.

A total of 149 nos. of primary core samples and 19 nos. of composite samples were analyzed for major and minor oxides i.e. LOI, SiO₂, Al₂O₃, Fe₂O₃, CaO, MgO, Na₂O, K₂O, TiO₂, P₂O₅, MnO and SO₃. (Annexure-5)

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

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

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

The external check analysis of 16 samples have been analyzed from NABL approved laboratory LUCID Laboratories Pvt. Ltd., Hyderabad. The analysis has been attached as Annexure-9.

Moisture

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

The laboratory tests are also carried out for specific gravity measurements on limited number of core samples on air dried basis. The specific gravity for Limestone varies from 2.73 to 2.79. The specific gravity of 2.73 to 2.79 is considered for estimation of resources of Marl.

CHAPTER-10

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

The Geological mapping and exploration result are indicating hard surficial Limestone and Marl deposit from depth of 2.50 to 19.80 meters across boreholes and as such the mining activity involved will be an open cast mining method and such type of studies are not required in this block.

CHAPTER-11

Resource Estimation

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

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

Table: 9: Specifications of Limestone grades by IBM

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

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

1. In each borehole area of influence has been considered for resource calculation, as the mineral deposit is of regular habit, Stratified and horizontal bedded.
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 between 2.73 to 2.79 and for Marl it is 2.73 to 2.79 in Indroi-Mandor 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 weighted average thickness and for estimating average grade of mineralized zone.
9. No cut off was fixed for thickness for delineation of mineralized zone Cement Grade Limestone.
10. To separate out different grades of Limestone and Marl, CaO % & MgO % values has been considered.

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

Resource estimation has been done by using ArcGIS Software. Area of influence of each borehole is estimated by considering the multiplication of length and width of rectangle covered by the borehole of Limestone [Cement Grade (blendable/beneficiable/portland)] specific gravity etc. and the classification of the estimated resource was done as per MEMC guidelines. The length, width and thickness of Cement Grade Limestone and Marl is considered in meters. The total area covered under the Indroi-Mandor block is 1015.594 Hectares (10.15 sq. km). The various terms expressed for computation of resource are mentioned in short term as below:

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

Where;

L = Length in m

Sp. Gr. = Specific Gravity

W = Width (in m)

R = Resources in Tonnes

A = Area in m²

Th = Thickness (in m)

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

11.1 Reporting of resources:

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

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

Table: 10-In-situ resources of Indroi-Mandor block, Gir Somnath

Litho-Unit	In-situ Resources at G3 (million tonnes) -
Cement Grade Limestone	226.08
Marl	46.00

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

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

Litho-Unit	Chemical Composition%									
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	Na ₂ O	K ₂ O	SO ₃	LOI
Cement Grade Limestone	8.19	3.69	2.71	0.23	44.43	0.73	0.06	0.23	0.04	37.15
Marl	25.32	10.25	6.48	0.61	26.97	1.33	0.26	0.75	0.07	25.56

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 226.08million tonnes in-situ resource of cement grade Limestone and 46.00million tonnes in-situ resource of Marl is available within 1015.594 Hectare of Indroi-Mandor block area under 333 category of UNFC for G3 stage.

Interpretation of Isopach map: Limestone

The isopach map of Cement Grade Limestone in the Indroi-Mandor block reveals gradual spatial variation in Limestone thickness. The maximum thickness of 19.45 meters is recorded at borehole IMBH-6, located in the center part of block, indicating a well-developed mineralized zone. The boreholes IMBH-5 shows thickness of 13.40 meters in the center of the block while B H - 7 a n d B H - 1 0 shows thickness of 6.50 and 11.30 meters towards Southern part of the block respectively. BH-9 show thickness of 10.00 meters towards Southwest side of block. BH-11 show thickness of 9.40 meters towards Southeast side of block. The borehole BH-1 and BH-3 towards North and Northeast corner shows thickness of 7.20 and 9.25 meters. Borehole GSBH-4 at the North from center of the block shows thickness of 3.80 and meter. The pattern of limestone distribution suggests gradual decrease in thickness from North to North west part whereas towards the South direction Limestone thickness is gradually increasing.

Interpretation of Isopach map: Marl

The isopach map of Marl indicates unevenly distributed zone of Marl mineralization in parts of the Indroi-Mandor block. The maximum thickness of 5.80 meters is found at borehole BH-8, located towards Northwest part of block, while borehole BH-6 in the southwest part of the block Marl has thickness of 0.35 meter. The borehole BH-3 and BH-2 shows thickness of 1.60 meters and 2.50 meters towards northern eastern and north parts of the block respectively. In the Eastern part borehole no. BH-5 the thickness is 3.00 meter. In the Southern East corner of block in BH-7 Marl encountered 1.00 meter. This spatial pattern suggests Marl deposition is decreasing as moving from North to South direction. Marl is commonly used as soil conditioner and manufacturing of cement.

CHAPTER-12

Core preservation

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

CHAPTER-13

Conclusion and recommendation

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

Drilling was carried out on an 800 m × 800 m grid, and a total of eleven boreholes were drilled with a cumulative meterage of 164.78 meters. A total of 149 primary core samples, 19 composite samples and 16 external check samples were analyzed chemically, and 7 petrographic samples were studied. The investigation revealed that Limestone is the dominant litho-unit encountered in all boreholes, with high CaO content and considerable thickness. Marl was intercepted, with limited thickness.

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

A total of 226.08 million tonnes of cement grade Limestone (blendable/beneficiable, portland) with average grade of CaO 44.43% and 46.00 million tonnes of Marl with average grade of CaO 26.96% have been estimated under the UNFC 333 (Inferred) category.

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

CHAPTER-14

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CHAPTER-15

Locality Index

Table: 12-Locality index

<u>Name of village</u>	<u>Latitude</u>	<u>Longitude</u>
Indroi	20°56'32.40"N	70°28'38.66"E
Mandor	20°58'45.13"N	70°28'52.74"E
Gabha	20°59'35.63"N	70°29'45.84"E
Ishwariya	20°57'30.10"N	70°28'17.46"E
Pandva	20°58'11.31"N	70°30'25.69"E

ABBREVIATIONS USED

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