

**GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION
(G-3) FOR LIMESTONE IN ISHWARIYA AREA, PATAN-
VERAVAL TALUKA, GIR SOMNATH DISTRICT, GUJARAT**

(T.S.No.41L/05 & 41L/09)

(TEXT, ANNEXURES, AND PLATES)

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COMMODITY: LIMESTONE

(Industrial Mineral)

Project Executed by



PRB INFRAPROJECTS PVT.LTD.

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GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3) FOR
LIMESTONE IN ISHWARIYA AREA, PATAN-VERAVAL TALUKA, GIR
SOMNATH DISTRICT, GUJARAT (T.S.NO. 41L/05 & 41L/09)

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अध्याय-1 कार्यकारी सारांश

ईश्वरिया चूना पत्थर ब्लॉक, जिसका क्षेत्रफल 3.43 वर्ग किलोमीटर है, गुजरात राज्य के गिर सोमनाथ जिले की पाटन-वेरावल तहसील के ईश्वरिया ग्राम के निकट स्थित है। यह ब्लॉक प्रारंभिक **प्लाइस्टोसीन कालीन मिलियोलाइट (Miliolite)** संरचना का भाग है, जिसके **अधःस्थित मायोसीन कालीन गज (Gaj) संरचना** में भी औद्योगिक महत्व का चूना पत्थर विद्यमान है। यह क्षेत्र राष्ट्रीय **राजमार्ग-51** से सड़क मार्ग द्वारा सुगमता से जुड़ा हुआ है तथा वेरावल रेलवे स्टेशन एवं **दीव हवाई अड्डा** निकट होने के कारण अन्वेषण एवं भविष्य की खनन गतिविधियों के लिए उत्कृष्ट परिवहन सुविधा उपलब्ध है।

इस ब्लॉक का चयन गुजरात के भूविज्ञान एवं खनन आयुक्तालय (CGM) द्वारा जारी अनापत्ति प्रमाण-पत्र (NOC), भारतीय भूवैज्ञानिक सर्वेक्षण (GSI) द्वारा उपलब्ध क्षेत्रीय भूवैज्ञानिक जानकारी, विभिन्न संस्थाओं द्वारा पूर्व में किए गए अन्वेषण कार्यों तथा **मैसर्स पीआरबी इंफ्राप्रोजेक्ट्स प्राइवेट लिमिटेड** द्वारा किए गए प्रारंभिक क्षेत्रीय अध्ययनों के आधार पर किया गया। सतही भूवैज्ञानिक मानचित्रण एवं शैल-नमूनों के रासायनिक विश्लेषण से उच्च कैल्शियम युक्त चूना पत्थर तथा उसके अनुकूल रासायनिक गुणों की पुष्टि हुई, जिसके आधार पर व्यवस्थित अन्वेषण कार्य प्रारंभ किया गया।

"गिर सोमनाथ जिला, गुजरात के ईश्वरिया ब्लॉक में चूना पत्थर हेतु प्रारंभिक अन्वेषण (जी-3)" परियोजना को राष्ट्रीय खनिज अन्वेषण एवं विकास न्यास (NMEDT) की 2 जून 2025 को आयोजित 42वीं **कार्यकारी समिति की बैठक** में स्वीकृति प्रदान की गई। इस अन्वेषण कार्य का निष्पादन मैसर्स पीआरबी इंफ्राप्रोजेक्ट्स प्राइवेट लिमिटेड द्वारा किया गया, जिसका उद्देश्य चूना पत्थर के खनिजीकरण की सीमा निर्धारित करना, उसकी मोटाई, गुणवत्ता एवं सततता का मूल्यांकन करना तथा खनिज (खनिज सामग्री के साक्ष्य) नियम, 2015 के अनुसार भूवैज्ञानिक संसाधनों का आकलन करना था।

अन्वेषण कार्यक्रम के अंतर्गत 1:4000 मापनी पर विस्तृत **भूवैज्ञानिक मानचित्रण, स्थलाकृतिक सर्वेक्षण 1:4000 के मानचित्र पैमाने पर, 2 मीटर समोच्च अंतराल के साथ, कोर ड्रिलिंग, भूवैज्ञानिक लॉगिंग, नमूना संकलन, पेट्रोग्राफिक अध्ययन, प्रयोगशाला परीक्षण, विशिष्ट गुरुत्व (Specific Gravity) निर्धारण** तथा भूवैज्ञानिक संसाधन आकलन किया गया। भूवैज्ञानिक मानचित्रण द्वारा मिलियोलाइट एवं गज संरचनाओं का वितरण निर्धारित किया गया, जबकि ड्रिलिंग से मृदा आवरण के नीचे चूना पत्थर की सततता की पुष्टि हुई।

अन्वेषण के दौरान कुल **06 बोरहोल** ड्रिल किए गए, जिनकी कुल ड्रिलिंग लंबाई **120 मीटर** रही। ड्रिलिंग हेतु **एनक्यू (NQ)** आकार की वायरलाइन डायमंड कोर ड्रिलिंग तकनीक का उपयोग किया गया। सभी बोरहोलों

में चूना पत्थर प्राप्त हुआ। निक्षेप में सतह के निकट अपक्षयित मिलियोलाइटिक चूना पत्थर तथा उसके नीचे जीवाश्मयुक्त एवं सघन चूना पत्थर पाया गया, जिसमें कुछ स्थानों पर मृत्तिका (क्ले) की अंतःपरतें विद्यमान हैं। ड्रिलिंग के दौरान औसत कोर रिकवरी 91.64 प्रतिशत प्राप्त हुई, जिससे भूवैज्ञानिक एवं भू-रासायनिक आंकड़ों की विश्वसनीयता सुनिश्चित हुई।

अन्वेषण कार्यक्रम के अंतर्गत विस्तृत विश्लेषणात्मक आंकड़े प्राप्त किए गए। कुल 78 प्राथमिक नमूनों, जिनमें 40 शैल-नमूने तथा 38 बोरहोल कोर नमूने सम्मिलित थे, का एक्स-रे फ्लोरोसेंस (XRF) तकनीक द्वारा प्रमुख ऑक्साइडों का विश्लेषण किया गया। गुणवत्ता आश्वासन हेतु 09 बाह्य जांच (External Check) नमूनों का परीक्षण किया गया। इसके अतिरिक्त 06 सम्मिश्र (Composite) नमूनों का विस्तारित रासायनिक विश्लेषण, 10 पतली शैल-पट्टिकाओं (Thin Sections) का पेट्रोग्राफिक अध्ययन तथा 05 नमूनों का विशिष्ट गुरुत्व परीक्षण किया गया। विश्लेषणात्मक परिणामों से यह स्पष्ट हुआ कि अधिकांश चूना पत्थर सीमेंट ग्रेड का है, जिसमें कैल्शियम ऑक्साइड (CaO) की मात्रा अधिक, मैग्नीशियम ऑक्साइड (MgO) की मात्रा कम तथा सिलिका (SiO₂) की मात्रा स्थानीय मृत्तिका अंतःपरतों के कारण परिवर्तनीय है।

भूवैज्ञानिक मानचित्रण, ड्रिलिंग, शैल-विवरण, नमूना विश्लेषण तथा विशिष्ट गुरुत्व के आधार पर भूवैज्ञानिक संसाधनों का आकलन थाइसन बहुभुज (Thiessen Polygon अथवा Polygon-cum-Outcrop) विधि द्वारा किया गया। मृदा आवरण के नीचे सीमित क्षेत्र में सघन चूना पत्थर की उपलब्धता को ध्यान में रखते हुए यह विधि उपयुक्त पाई गई। संसाधनों का वर्गीकरण खनिज (खनिज सामग्री के साक्ष्य) नियम, 2015 के अनुसार संयुक्त राष्ट्र फ्रेमवर्क वर्गीकरण (UNFC) की अनुमानित (333) श्रेणी में किया गया।

अन्वेषण के आधार पर कुल सकल (Gross) भूवैज्ञानिक संसाधन 29.88 मिलियन टन तथा कुल शुद्ध (Net) भूवैज्ञानिक संसाधन 24.30 मिलियन टन आंके गए। भूवैज्ञानिक अनिश्चितताओं, जैसे मोटाई में परिवर्तन, पार्श्वीय सततता में अंतर, मृत्तिका अंतःपरतों की उपस्थिति एवं अन्य भूवैज्ञानिक कारकों को ध्यान में रखते हुए संसाधन आकलन में 30 प्रतिशत कटौती कारक (Reduction Factor) लागू किया गया। संसाधनों में **सीमेंट ग्रेड (R1) तथा ब्लेन्डेबल ग्रेड (R2) चूना पत्थर सम्मिलित हैं।**

सीमेंट ग्रेड (R1) चूना पत्थर इस निक्षेप का प्रमुख भाग है, जिसके अंतर्गत 26.75 मिलियन टन सकल तथा 21.75 मिलियन टन शुद्ध भूवैज्ञानिक संसाधन आंके गए हैं। इसकी औसत रासायनिक संरचना 47.10 प्रतिशत CaO, 0.49 प्रतिशत MgO तथा 7.54 प्रतिशत SiO₂ है, जो इसे सीमेंट निर्माण हेतु अत्यंत उपयुक्त बनाती है। ब्लेन्डेबल ग्रेड (R2) चूना पत्थर के अंतर्गत 3.13 मिलियन टन सकल तथा 2.55 मिलियन टन शुद्ध भूवैज्ञानिक संसाधन आंके गए हैं। इसकी औसत रासायनिक संरचना 40.91 प्रतिशत CaO, 0.82 प्रतिशत MgO तथा

14.42 प्रतिशत SiO_2 है, जो इसे सीमेंट कच्चे मिश्रण (Raw Mix) में ब्लेंडिंग हेतु उपयुक्त बनाती है।

इस अन्वेषण से यह प्रमाणित हुआ है कि ईश्वरिया चूना पत्थर ब्लॉक में मुख्यतः उच्च गुणवत्ता का सीमेंट ग्रेड चूना पत्थर उपलब्ध है, जिसमें उच्च कैल्शियम ऑक्साइड, निम्न मैग्नीशियम ऑक्साइड तथा स्वीकार्य सिलिका मात्रा पाई जाती है। चूना पत्थर पार्श्वीय रूप से सतत, पतली परतों के रूप में विद्यमान है, जिनमें कुछ स्थानों पर मृत्तिका अंतःपरतें पाई जाती हैं। ऊपरी खनन योग्य स्तर में अच्छी सततता एवं आर्थिक दृष्टि से अनुकूल संभावनाएँ विद्यमान हैं। उत्कृष्ट कोर रिकवरी, विश्वसनीय विश्लेषणात्मक परिणाम तथा व्यवस्थित गुणवत्ता आश्वासन प्रक्रिया ने भूवैज्ञानिक व्याख्या एवं संसाधन आकलन की विश्वसनीयता को और अधिक सुदृढ़ किया है।

यह परियोजना अनेक अनुकूल विशेषताओं से युक्त है, जिनमें सीमेंट ग्रेड चूना पत्थर की प्रधानता, सतह के निकट उपलब्धता, अनुकूल भूवैज्ञानिक संरचना, उत्कृष्ट सड़क, रेल एवं वायु संपर्क, उच्च कोर रिकवरी तथा वैधानिक अन्वेषण मानकों का पूर्ण अनुपालन सम्मिलित है। यद्यपि कुछ स्थानों पर मृत्तिका अंतःपरतों एवं चूना पत्थर की मोटाई में परिवर्तन के कारण मध्यम स्तर की भूवैज्ञानिक अनिश्चितता विद्यमान है, तथापि संसाधन आकलन के दौरान **30 प्रतिशत** कटौती कारक लागू कर इन प्रभावों का समुचित समायोजन किया गया है।

जी-3 स्तर के इस अन्वेषण द्वारा ईश्वरिया ब्लॉक में चूना पत्थर की उपलब्धता, गुणवत्ता, मोटाई, सततता तथा भूवैज्ञानिक स्वरूप का सफलतापूर्वक निर्धारण किया गया है। अनुमानित (333) श्रेणी के अंतर्गत आंके गए भूवैज्ञानिक संसाधन इस क्षेत्र की महत्वपूर्ण खनिज क्षमता को प्रदर्शित करते हैं। **अतः यह ब्लॉक विस्तृत मूल्यांकन, खनन हेतु नीलामी तथा आगामी वैधानिक, तकनीकी, पर्यावरणीय एवं आर्थिक परीक्षणों के उपरांत विकास के लिए उपयुक्त पाया गया है।**

CHAPTER-1

EXECUTIVE SUMMARY

The **Ishwariya Limestone Block**, covering an area of **3.43 sq. km** is situated near **Ishwariya Village**, Patan–Veraval Taluka, Gir Somnath District, Gujarat. The block forms part of the **Early Pleistocene Miliolite Formation** with underlying **Miocene Gaj Formation** both of which host limestone of industrial importance. The area is well connected by road through **National Highway-51**, while **Veraval Railway Station** and **Diu Airport** provide convenient rail and air access, facilitating exploration and future mining activities.

The block was selected for exploration based on the **No Objection Certificate (NOC)** issued by the Commissionerate of Geology and Mining (CGM), Gujarat, supported by regional geological information available from the Geological Survey of India (GSI), previous investigations carried out by various agencies, and preliminary field investigations undertaken by **M/s PRB Infraprojects Private Limited**. Surface geological mapping and chemical analysis of bedrock samples indicated the occurrence of high-calcium limestone with favourable chemical characteristics, warranting systematic exploration.

The exploration project titled "**Preliminary Exploration (G3) for Limestone in Ishwariya Block, Gir Somnath District, Gujarat**" was approved by the **42nd Executive Committee** held on 2 June 2025 of the **National Mineral Exploration and Development Trust (NMEDT)**. The investigation was carried out by **M/s PRB Infraprojects Private Limited** with the objective of delineating limestone mineralization, establishing its thickness, grade and continuity, and estimating geological resources in accordance with the **Mineral (Evidence of Mineral Contents) Rules, 2015**.

The exploration programme comprised **detailed geological mapping on 1:4000 scale, topographic survey on 1:4000 scale with 2m contour interval, exploratory core drilling, geological logging, sampling, petrographic studies, laboratory analysis, specific gravity determination, and geological resource estimation**. Geological mapping established the distribution of the Miliolite and Gaj Formations, while drilling confirmed the subsurface continuity of limestone beneath the soil cover.

A total of **06 boreholes** were drilled with a cumulative drilling of **120 metres** using **NQ-size wireline diamond core drilling**. Limestone was intersected in all boreholes. The deposit comprises weathered miliolitic limestone near the surface underlain by fossiliferous and compact

limestone with localized clay intercalations. The drilling programme achieved an **average core recovery of 91.64%**, providing reliable geological and geochemical information for resource evaluation.

The exploration programme generated comprehensive analytical data. A total of **78 primary samples**, comprising **40 bedrock samples** and **38 borehole core samples**, were analysed for major oxides using the **XRF technique**. In addition, **09 external check samples** were analysed for quality assurance, **06 composite samples** were analysed for extended chemical parameters, **10 petrographic thin sections** were studied, and **05 specific gravity samples** were tested for resource estimation. The analytical results indicate predominantly good limestone quality, with cement -grade zone characterised with consistently high Cao, low MgO values and variable silica content influenced mainly by localized clay intercalations.

Based on geological mapping, drilling, lithological logging, sampling, analytical results and specific gravity data, geological resources were estimated using the **Thiessen Polygon (Polygon-cum-Outcrop) Method**, which is considered appropriate due to the localized occurrence of compact limestone beneath a laterally persistent Miliolite cover. Geological resources have been classified under the **UNFC Inferred (333) Category** in accordance with the **MEMC Rules, 2015**.

The exploration has established **Total Gross Geological Resources of 31.07 million tonnes** and **Total Net Geological Resources of 24.29 million tonnes** after applying a **30% reduction factor** to account for geological uncertainties such as variations in thickness, lateral continuity, clay intercalations, and other geological factors. The resource comprises **Cement Grade (R1)** and **Blendable Grade (R2)** limestone.

The **Cement Grade (R1)** limestone constitutes the major portion of the deposit with **31.07 million tonnes** of gross geological resources and **21.75 million tonnes** of net geological resources, having an average composition of **47.10% CaO, 0.49% MgO, and 7.54% SiO₂**, making it highly suitable for cement manufacture. The **Blendable Grade (R2)** limestone accounts for **3.64 million tonnes** of gross geological resources and **2.55 million tonnes** of net geological resources with an average composition of **40.91% CaO, 0.82% MgO, and 14.42% SiO₂**, making it suitable for blending in cement raw mix.

The investigation confirms that the **Ishwariya Limestone Block** hosts predominantly **high-quality Cement Grade limestone** with favourable chemical characteristics, including high CaO content, low MgO values, and acceptable silica content. The limestone occurs as laterally persistent, thinly bedded horizons with localized clay intercalations, while the upper mineable

horizon exhibits good continuity and economic potential. Excellent core recovery, reliable analytical results, and systematic quality assurance procedures significantly enhance confidence in the geological interpretation and resource estimation.

The project is characterized by several favourable features, including the predominance of Cement Grade limestone, shallow depth of occurrence, favourable geological disposition, excellent road, rail, and air connectivity, high drilling recovery, and compliance with statutory exploration guidelines. Although localized clay intercalations and variations in limestone thickness introduce moderate geological uncertainty, these factors have been appropriately addressed through the application of a **30% reduction factor** during resource estimation.

The **G3 stage exploration** has successfully established the occurrence, grade, thickness, continuity, and geological disposition of limestone within the Ishwariya Block. The delineated **Inferred (333) geological resources** demonstrate significant mineral potential, making the block suitable for **further detailed evaluation and auction for mining**, subject to statutory, technical, environmental, and economic considerations.

CHAPTER-2

DETAILS OF THE QUALIFIED PERSON(S) / EXPLORATION AGENCY

2.1.0 INVESTIGATING AGENCY

PRB INFRAPROJECTS PRIVATE LIMITED,
S1 & S3 3rd Floor, Ratan Height,
Medical Square, Nagpur-440024.

2.2.0 PERSONAL INVOLVED WITH PRELIMINARY EXPLORATION (G3) FOR LIMESTONE IN ISHWARIYA BLOCK, DISTRICT- GIR SOMNATH, GUJARAT.

Table Showing List of Personnel with Experience

Sr No.	Name of the Person	Designation	Qualification	Experience
1	Mr. M. Chandradas	Project Co-ordinator	M.Sc. Tech (Applied Geology)	>35Yrs
2	Mr. Prem Babu	Technical Area Expert Geology	M.Sc. (Geology), PGD (Hydrogeology)	>35Yrs
3	Mr. Milind Dhakate	Project Co-ordinator	M.Sc. Tech (Applied Geology)	30Yrs
4	Mr. Maschindra Bhanse	Sr. Geologist	M.Sc. (Applied Geology)	18Yrs.
5	Mr. Anand Harkare	Technical Area Expert Geology	M.Sc. Tech (Applied Geology)	30Yrs
6	Mrs. Priti Pusadkar	Sr. Geologist	M.Sc. (Geology)	12Yrs
7	Mr. Sebin Sebastian	Geologist	M.Sc. (Geology)	3 Yrs
8	Mr. Ankush Shukla	Geologist	M.Sc. (Geology)	1 Yrs
9	Mr. Rajat Raghushe	Surveyor and Drilling Engineer	Civil Engineering	6 Yrs

CHAPTER -3

TITLE OF THE REPORT & OWNERSHIP

3.1.0 DETAILS OF OWNERSHIP

Table Showing Details of Ownership

S.No.	Title	Details
1	Title of the report	PRELIMINARY EXPLORATION (G-3) FOR LIMESTONE IN ISHWARIYA BLOCK, GIR-SOMNATH DISTRICT, GUJARAT.
2	Ownership	CGM GUJARAT
3	Name of the Prospector	PRB INFRAPROJECTS PRIVATE LIMITED
4	Address of Prospector	S3 & S4 ,2nd Floor, Ratan Height, Medical Square, Nagpur-440024
5	E-Mail of the prospector	prbinfraprojects@gmail.com
6	Telephone numbers prospectors	9422835586

3.2.0 DETAILS ABOUT PERIOD OF PROSPECTING

The G3 stage of exploratory work in the Ishwariya block commenced with geological mapping stated on 9-9-25 and completed on 24-12-25 along with exploratory drilling in borehole No. G-ISH-BH-1 on 23-4-26 and completed with the closure of borehole No. G-ISH-BH-06 on 30-04-26. The analytical/laboratory studies were carried out simultaneously in the inhouse laboratories of PRB and other Govt. /NABL accredited laboratories.

3.3.0 DETAILS OF EXPLORATION AGENCY, QUALIFICATION, AND EXPERIENCE OF ASSOCIATED TECHNICAL PERSONS ENGAGED IN EXPLORATION

3.3.1 Exploration Agency (EA): PRB Infraprojects Private Limited.

3.3.2 Experience:

Organization established in year 2011, since from the established year, M/s. PRB Infraprojects Private Limited have executed lot more works for exploration projects for Atomic Mineral

Directorate, Karnataka State Mineral Development Corporation, Chhattisgarh Mineral Development Corporation, Director Geology and Mining Chhattisgarh. After the NABET accreditation, the company approaches to the NMEDT funded projects through proper channel. Presently we are having our works awarded through NMEDT funded projects which are given in below table: -

Sr. No.	Description	W.O. No /Date	Remark
1	Reconnaissance survey(G4) for Limestone in Bha area in the village Bhatiya-Gokalpur, Dist-Devbhumi Dwarka, in Gujarat state.	23/585/2025-NMET/930	Completed
2	Reconnaissance Survey (G4) for Iron ore in Nawagarh-Nelsod-Antagarh block in Uttar Bastar Kanker District, Chhattisagarh state.	23/578/2025-NMET/121	Ongoing
3	Preliminary Exploration (G3) for Limestone in Ishwariya block, Gir Somnath District, Gujarat State.	23/633/2025-NMET/184	Ongoing
4	Preliminary Exploration (G3) for Limestone in Vadekhan block Upleta Taluka, Rajkot District, Gujarat	23/652/2025-NMET/352	Completed
5	Preliminary Exploration (G3) For Limestone In Pransla Limestone Block,Upleta, Rajkot, Gujarat.	23/798/2026-NMEDT/162	Ongoing
6	Preliminary Exploration (G3) For Limestone Andhariya-Nes Block, Jam Jodhpur Taluka, Jamnagar District, Gujarat.	23/797/2026-NMEDT/161	Ongoing

3.2.3 Experience: Geologists have experience of 3 to more than 30 years.

3.2.4 Qualification of Geologist: M.Sc./M.Sc. Tech (Geology/ Applied Geology).

CHAPTER-4

DETAILS OF THE AREA

4.1.0 LOCATION AND ACCESSIBILITY OF THE BLOCK

- The Ishwariya Block is situated in Patan–Veraval Taluka of Gir Somnath District, Gujarat and comprises parts of Ishwariya village. The block area forms parts of **Toposheet No. 41 L/05 and 41 L/09**.
- The area is approachable through a network of State Highways, district roads, and village roads connecting it with Veraval, Kodinar, Mangrol, and other nearby towns. Veraval the nearest major town serves as an important commercial and administrative centre of the region and is connected to Ahmedabad and other parts of Gujarat by broad-gauge railway line.
- Veraval Railway Station (VRL), located about 10–15 km from the Ishwariya Block, is the nearest railhead. The station is well connected to major cities such as Ahmedabad, Rajkot, Junagadh, and other parts of Gujarat through the Western Railway network, facilitating efficient transportation of manpower, equipment, and exploration materials.
- Diu Airport, located approximately 70 km from the Ishwariya Block, is the nearest airport. It provides air connectivity to major cities and facilitates the movement of personnel and essential logistics required for exploration activities.
- The Ishwariya Block is well connected by road through National Highway 51 (NH-51), which passes through Veraval and connects the area with major towns such as Somnath, Kodinar, Mangrol, Porbandar, and other parts of Gujarat. The block is further accessible through a network of district and village roads, providing all-weather connectivity for exploration activities.
- This well-developed multimodal connectivity makes the Ishwariya block suitable for field operations, transportation of equipment, and overall exploration logistics.

4.1.1 Size and Shape of the Block

- The Ishwariya block is sub-pentagonal in shape and covers an area of 3.43 sq. km. The surface rights of the block primarily belong to the Government. Out of the total block area of 3.43 sq. km approximately 0.51–0.69 Sq.km (15–20%) is Government land, whereas about 2.74–2.92 Sq.km (80–85%) comprises private revenue land.

4.1.2 Geo Coordinates of the Block

The coordinates of the Ishwariya Limestone block are as shown in the table below.

Table No. 4.1- Co-ordinates of the Ishwariya Block

Sr No	Block corners	Latitude	Longitude
1	A	20°55'9.01" N	70°30'14.18" E
2	B	20°55'28.13" N	70°29'31.20" E
3	C	20°55'55.70" N	70°28'59.63" E
4	D	20°56'34.98" N	70°29'30.11" E
5	E	20°55'53.40" N	70°30'23.81" E

4.1.3 Location of the Block

The block is situated 2.10 km South of National Highway No-51 near to Ishwariya village. The block area forms part of SOI Toposheet No - 41 L/05 and 41 L/09 within Patan- Veraval Taluka, Gir Somnath district.

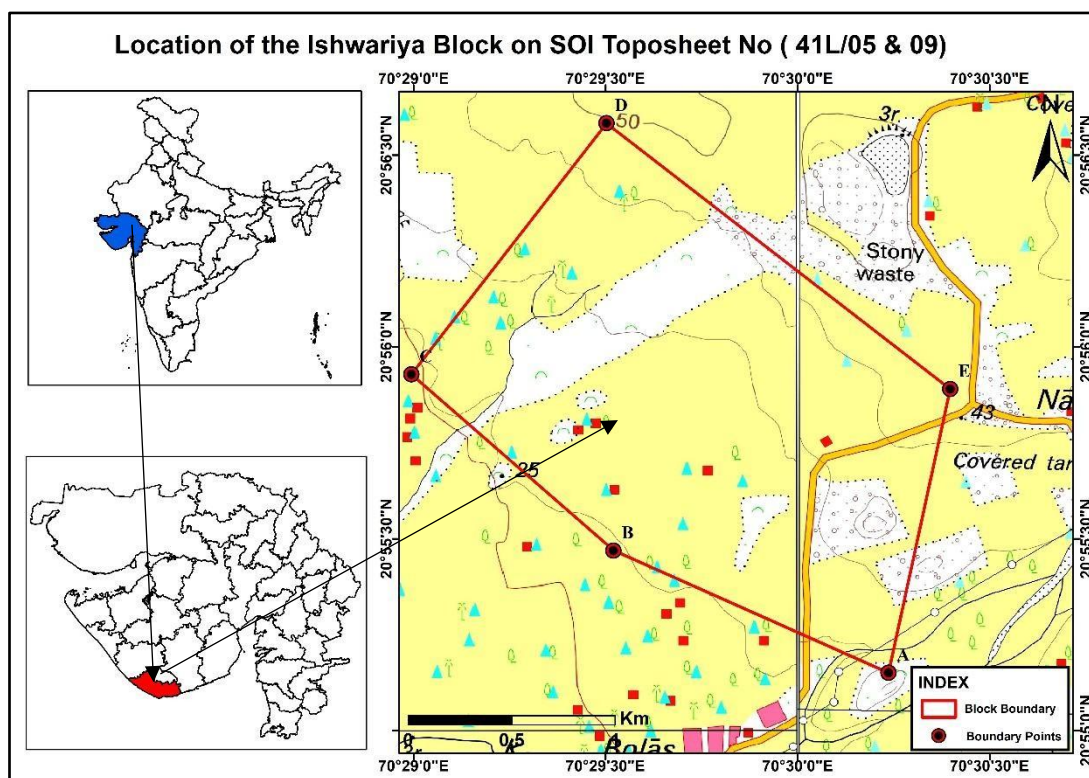


Plate No.-I: Location of Ishwariya Block Limestone Block on toposheet no. 41L/05 & 41L/09, Gir Somnath Gujarat.

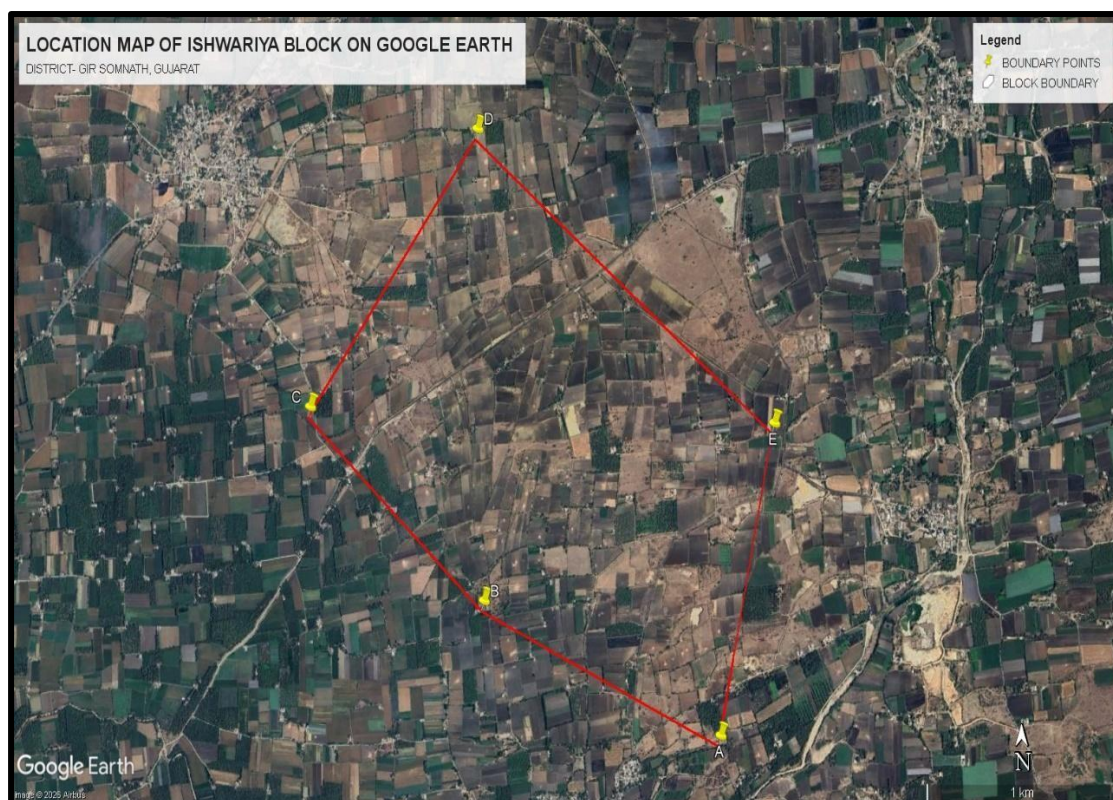


Plate No.-II: Location of Ishwariya Block on Google Earth Image, Gir Somnath district, Gujarat.

CHAPTER-5

PHYSIOGRAPHY AND ENVIRONMENT

5.1.0 PHYSIOGRAPHY

Relief of the Area

The Ishwariya Block forms part of the southern Saurashtra Peninsula and is characterized by low relief. The elevation within the block ranges from approximately **10 m to 22 m above Mean Sea Level (MSL)**. No prominent hills, ridges or escarpments occur within the block, and the overall relief of about 12 m throughout the area.

Topography

The block is a part of large pediplain characterized by a nearly flat to gently undulating terrain. The general ground surface slope is towards south to southwest direction. The area is predominantly occupied by agricultural land, interspersed with scattered wastelands under sparse scrub vegetation. The gentle terrain, stable ground conditions and good accessibility make the area favourable for geological mapping, drilling operations and other exploration activities.

Drainage Pattern

The block is drained by the south flowing Rupen Nadi and its minor tributaries. The drainage pattern is predominantly dendritic to sub-dendritic in nature and is controlled by the regional slope of the terrain. Seasonal streams and drainage channels remain active during the monsoon season and finally discharge into the Arabian Sea.

Water Bodies Present Near the Block

The area is drained by Rupen Nadi and its tributaries. Apart from seasonal streams, village ponds, irrigation tanks and agricultural water storage structures occur in and around the block. These water bodies serve as important sources of water for domestic, agricultural and livestock requirements.

5.2.0 ROAD/RAIL CONNECTIVITY

The Ishwariya Block is well connected by a network of State Highways, district roads, and village roads, providing all-weather accessibility. The nearest railhead is Veraval Railway Station, situated approximately 10–15 km from the block, which is connected to major cities such as Ahmedabad, Rajkot, and Junagadh through the Western Railway network.

Diu Airport, located about 70 km from the block, is the nearest airport and provides convenient air connectivity to the region.

5.3.0 HOST POPULATION (LOCAL COMMUNITIES) AND HUMAN SETTLEMENTS

The Ishwariya Block is situated near Ishwariya Village in Patan-Veraval Taluka of Gir Somnath District, Gujarat. The village represents the principal host community of the exploration area. As per the Census of India 2011, Ishwariya village has a population of 1,103 persons residing in 176 households. The village has a balanced demographic composition with a sex ratio of 977 females per 1,000 males and a child sex ratio (0–6 years) of 956.

The local population is predominantly engaged in agriculture and allied activities. Cultivation, agricultural labour, animal husbandry and small-scale trading constitute the major occupations of the residents. Human settlements are nucleated in pattern and comprise permanent residential houses with basic civic infrastructure. The exploration block is largely occupied by agricultural land and open fields, while the nearby villages provide the necessary workforce and support facilities for exploration activities.

5.4.0 SOCIO-DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

The area falls within Veraval Taluka of Gir Somnath District, which is characterized by a predominantly rural population. Agriculture, animal husbandry, fisheries, and small-scale trade constitute the principal economic activities. Basic amenities such as schools, healthcare centres, drinking water supply, electricity and communication facilities are available in the nearby villages and towns.

5.5.0 HISTORICAL SITES, PLACES OF WORSHIP AND PUBLIC UTILITIES

The famous **Somnath Temple**, one of the most important pilgrimage centres in India, is situated near Veraval at 10 km from block. Public utilities including schools, hospitals, banks, markets, post offices and government offices are available in Veraval and adjoining villages.

5.6.0 FORESTS, SANCTUARIES, NATIONAL PARKS, WILDLIFE SANCTUARIES, GRAZING LAND AND GOCHAR LAND

No Reserved Forest, Protected Forest, National Park or Wildlife Sanctuary occurs within the exploration block. However, **Gir National Park and Wildlife Sanctuary** is situated to

the **approximate distance 35km** northeast of the block. Village grazing lands (Gochar land) and common lands occur in the surrounding villages and are mainly utilized for livestock grazing.

5.7.0 FLORA AND FAUNA

The vegetation in and around the block mainly consists of scrub vegetation, grasses, thorny bushes and agricultural crops typical of the semi-arid region of Saurashtra such as groundnut, cotton, bajhara, sesame, wheat and cumin. The faunal population comprises common birds, reptiles, small mammals and domesticated livestock. The proximity of the Gir landscape contributes to the regional biodiversity.

5.8.0 CLIMATE

The area experiences a semi-arid to sub-humid climate. The average annual rainfall is about 580 mm, most of which is received during the southwest monsoon season between June and September. Summers are generally hot maximum temperature 42⁰ while winters remain mild and pleasant with minimum temperature 12⁰. The climatic conditions are conducive for exploration activities during most of the year except during periods of heavy monsoon rainfall.

5.9.0 OTHER PHYSIOGRAPHIC, SOCIAL AND ENVIRONMENTAL FACTORS

The area possesses favourable physiographic and infrastructural conditions for exploration activities. The terrain is generally flat to gently undulating with adequate road connectivity and availability of basic civic amenities. Agricultural land constitutes the predominant land-use pattern. No major environmental constraints affecting exploration activities have been observed within the block area.

CHAPTER 6

INFRASTRUCTURE

The Ishwariya Block is well developed in terms of transportation, communication and civic infrastructure. The block is easily accessible through a network of metalled roads and is connected to **Somnath Road** near **Pransli Village**. **National Highway-51** passes at a distance of about **3 km** from the block, providing excellent connectivity to Veraval, Somnath and other nearby towns. Public and private transport facilities, including buses, taxis and goods carriers, are readily available in the surrounding villages.

The nearest railway station is **Veraval Junction**, situated approximately **12–15 km** from the block area, while the nearest airport is **Diu Airport**, located about **70 km** away. **Veraval**, the district headquarters of **Gir Somnath District**, is situated approximately **8.3 km** from the study area. Thus, the block is well connected by road, rail and air transport. Postal, telecommunication and internet facilities are available in the nearby villages and towns. Reliable electricity supply is available throughout the area. Educational institutions, healthcare centres, banking facilities, markets and other civic amenities are present at Veraval, Somnath and adjoining villages. Adequate water resources for domestic and agricultural purposes are available through tube wells, village water supply systems and nearby surface water bodies. The existing infrastructure is adequate to support mineral exploration activities in the block.

Overall, the area possesses favourable transportation, communication, educational, healthcare, power and water infrastructure making it suitable for mineral exploration and related developmental activities.

CHAPTER -7

GEOLOGY

7.1.0 Regional Geology

Geologically, the Gir Somnath district is largely covered by the extensive Deccan Trap formations, which cover nearly two-thirds of the region and form characteristic plateaus, ridges, and gently undulating uplands. The trap sequence comprises a diverse suite of igneous rocks, including basalt, rhyolite, granophyre, micro-granite, porphyry, gabbro, and monzonite, intruded by both basic and acidic dykes. These elevated surfaces are often mantled by laterite, indicating prolonged weathering under tropical conditions.

The rock types exposed in the area can be classified into Deccan Trap and younger sediments of Tertiary and Quaternary Periods. Tertiary deposits are divided into an older calcareous facies represented by limestone and marl, known as Gaj Formation, and a younger arenaceous facies represented by calcareous grits, conglomerates, sandy shale and sandy limestone, known as Dwarka Formation. Quaternary deposits contain both consolidated as well as unconsolidated sediments. The consolidated part has been termed as Miliolite Formation while the overlying semi-consolidated part is called Chaya Formation. Some of the earlier workers differentiated only Gaj, Dwarka and Miliolite Formations in their maps whereas later workers made further sub-divisions of Quaternary sediments which is as given below (Table No.-7.1 and refer Plate No-1).

The general stratigraphic succession of the region is as follows (Gajanan Dumane Sr.Geologist and Surabhi Garg Geologist GSI F. S. 2019-20,2020-21)

Table No. 7.1**Showing Regional Stratigraphic Succession of area. (GSI Report F. S.-2019-2021)**

Age	Formation		Litho units
Recent	Mahuva Formation		Gravel, pebbles, cobbles and coarse to fine sand.
			Coarse sand with shell fragments and medium to fine sand.
			Dark greyish plastic clay
Sub-recent	Katpur Formation		Medium to fine grained sand, brownish silty clay.
			Greyish clay with thin bands of sand and silt
Holocene to Late Pleistocene	Chaya Formation		Semi-consolidated to consolidated calcrudite and calcarenite
Early Pleistocene	Miliolite Formation	Adityiana Member	Medium to fine grained calcarenite light brownish, fine grained calcarenite
		Dhobiya Talav Member	Alternating calcarenite, variegated marl and conglomerate
Lower to Upper Miocene	Dwarka Formation		Arenaceous, flaggy limestone
Lower Miocene	Gaj Formation		Alternation of fossiliferous fine grained light brownish colour limestone and variegated marl.
Eocene to Cretaceous	Deccan Trap		Laterite/Bauxite, Basalt

The area is underlain by a lithostratigraphic succession ranging from the Cretaceous–Eocene to Recent. The oldest unit is the Deccan Trap, overlain by the Gaj and Dwarka Formations of Miocene age. The principal limestone-bearing horizon comprises the Early Pleistocene Miliolite Formation, represented by the Dobiya Talav and Adityana Members, consisting predominantly of calcarenite with subordinate marl and conglomerate. Younger deposits include the Chhaya, Katpur, and Mahuva Formations, represented by calcareous sandstone, unconsolidated sand, silty clay, gravel, pebbles, and shell-bearing sediments.

HYDROGEOLOGY

Groundwater occurrence is limited across much of the basaltic terrain due to the compact nature of the trap flows; however, in the miliolite limestone areas near the coast, groundwater is available at shallow depths of around 5 m, reflecting higher secondary porosity and permeability.

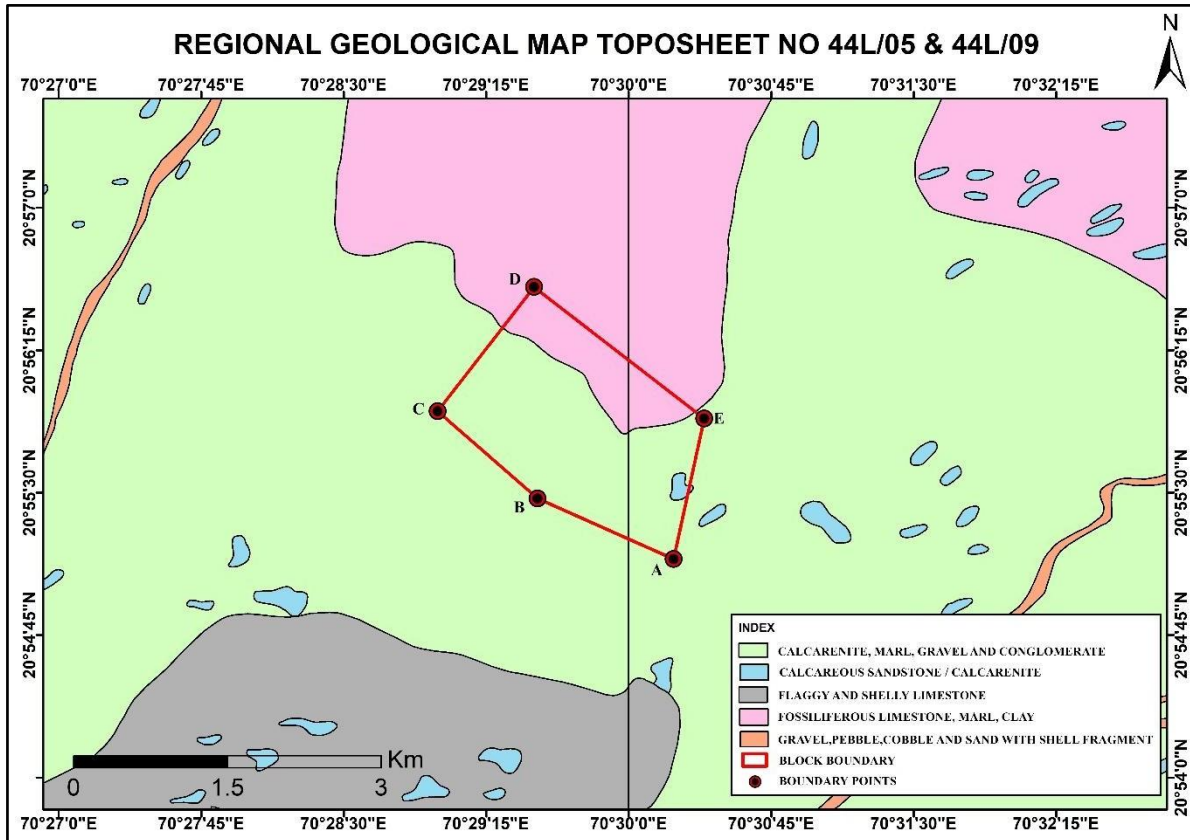


Plate No.-III: Regional Geological map with location of the block. (Source NGDR)

7.2.0 GEOLOGY OF THE BLOCK

The Ishwariya Limestone Block is situated in the coastal belt of the Saurashtra Peninsula, Gujarat, where the regional geological succession comprises the Deccan Trap, Gaj Formation, Dwarka Formation, Miliolite Formation, Chaya Formation and Recent coastal deposits. Geological mapping within the block indicates that the area is predominantly concealed beneath soil cover, with bedrock exposed only at isolated locations. Consequently, the geological interpretation is based on scattered rock exposures, quarry sections, field observations, structural measurements and lithological correlation between individual outcrops.

The block is largely covered by black cotton (regur) soil, supporting extensive agricultural land and coconut plantations. Bedrock exposure is discontinuous and generally restricted to isolated rocky patches, field boundaries, shallow excavations, dug wells and a small quarry located towards the eastern part of the block. The outcrop distribution indicates that only a small proportion of the total block area is exposed, while the geology of the remaining area has been interpreted from available field evidence.

Structural measurements recorded across the block indicate gently dipping sedimentary strata with strikes predominantly trending NW–SE and shallow dips ranging from 2° to 8° towards the southwest, although minor local variations in bedding attitude are observed. The contour pattern suggests a gently undulating topography with relatively higher elevations in the northern part, where isolated Gaj limestone exposures occur, while the Miliolite Formation occupies comparatively lower and more extensive terrain. The widespread distribution and lateral continuity of the Miliolitic Limestone indicate favourable conditions for delineating persistent limestone horizons, whereas the Gaj Formation is restricted in aerial extent and exhibits limited surface exposure due to soil cover and agricultural land use.

DESCRIPTION OF LITHOLOGY

Soil cover and Alluvium

Most of the study area is concealed beneath a thin to moderately developed cover of black cotton (regur) soil, with an average thickness ranging from 0.1 m to 0.4 m. The thickness of the soil cover varies locally depending on topography, being relatively greater in agricultural fields and lower in areas of exposed limestone. The regur soil is dark grey to black, clay-rich. Unconsolidated alluvial and colluvial deposits consisting of clay, silt, sand and limestone gravels are locally present along seasonal drainage channels and in low-lying areas. These superficial deposits obscure the underlying bedrock and limit the continuity of rock exposures across the block.

During the monsoon season, a large part of the block becomes temporarily waterlogged, particularly in low-lying agricultural fields and along earthen roads. The clay-rich nature of the regur soil, coupled with the occurrence of limestone at shallow depth, results in poor surface drainage and limited infiltration through the soil profile, leading to the accumulation of rainwater after heavy precipitation. Consequently, many of the earthen roads become inundated and slippery during the rainy season, considerably restricting accessibility to several parts of the block.



Fig. No. 1: Image showing Soil cover in the central part of the study area

Milolite Formation:

The Miliolite Formation constitutes the principal lithological unit exposed in the block. Although surface exposures are scattered and discontinuous, the formation is recognised at numerous isolated outcrops distributed throughout the area, suggesting that it forms the dominant subsurface lithology. The limestone is yellowish buff to pinkish buff in colour, medium- to fine-grained, moderately hard and locally porous, consisting predominantly of calcarenite composed of miliolid foraminiferal tests embedded within a micritic carbonate matrix. A quarry exposure near the eastern boundary reveals approximately 5–6 m of Miliolitic limestone, indicating the presence of a relatively thick limestone horizon.

The outcrop surface is highly cavernous and characterized by numerous small solution cavities, vugs and honeycomb-like structures produced due to prolonged chemical weathering and solution activity. The rock appears hard, compact and brittle in comparatively fresh portions, while the weathered portions are friable and decomposed along joints and fractures. The outcrops are moderately fractured and jointed, which have acted as channels for percolating groundwater, resulting in the development of karstic features and secondary porosity. 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 concentration of pellets varies from place to place. Underlying this is a marly horizon followed by Gaj Formation. Some conglomerate or gravel beds often appear locally in the basal part of the Miliolite Formation.



Fig. No. 2: Photograph showing Outcrop of Miliolitic limestone



Fig. No. 3: Photograph showing effects of chemical weathering and colour variations between the fresh and exposed surfaces of the limestone.

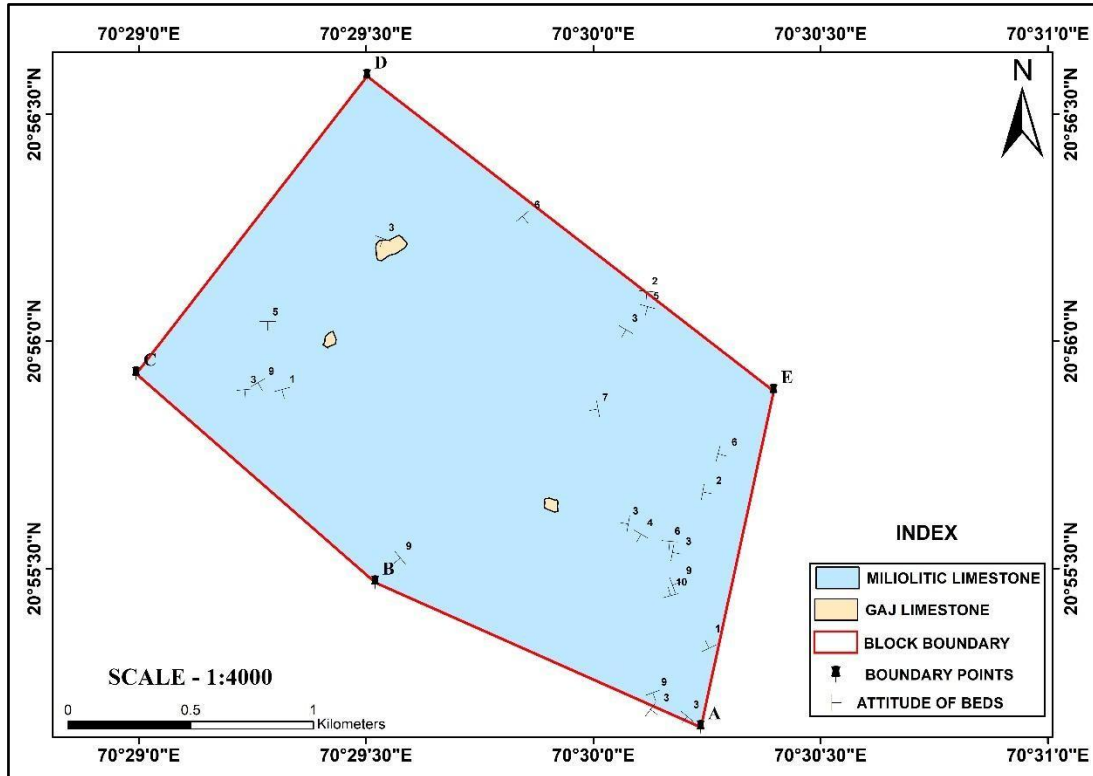
Gaj Formation:

The Gaj Formation is represented by a few isolated inliers and small discontinuous outcrops, mainly in the northwestern and central parts of the block. The formation comprises fossiliferous limestone interbedded with marl and represents the older marine sedimentary sequence of the area. The limestone is generally yellowish to buff coloured, fine to medium-grained, compact and moderately hard, containing abundant marine fossils. The fossil assemblage identified within the limestone includes bivalves, pelecypods, and gastropods, suggesting a marine depositional environment.

One of the distinguishing characteristics of the Gaj Formation is the marked horizontal and vertical impersistence of limestone beds. The limestone bands frequently pinch out over short distances and are replaced by marl, reflecting fluctuating carbonate sedimentation during deposition. Consequently, although locally exposed, the Gaj limestone lacks the continuity observed in the overlying Miliolite Formation.

Within the Ishwariya Block, fossiliferous limestone boulders occurring along agricultural field boundaries indicate the continuation of the Gaj Formation beneath the soil cover. Isolated inliers mapped in the northwestern part represent erosional remnants surrounded by younger Miliolitic Limestone. Three representative bedrock samples (BRS) collected from the Gaj Formation were subjected to chemical analysis. The analysed samples yielded CaO values of 52.60%, 53.20% and 52.20%, indicating consistently high calcium oxide content. These results suggest that the analysed Gaj limestone is of good chemical quality at the sampled locations. During the course of investigation, it was observed that limestone exposed at the surface generally exhibited comparatively higher CaO values than the corresponding limestone encountered at depth in drill cores. Core sample analyses indicate a slight decrease in CaO content with depth, suggesting that

the near-surface limestone has undergone localized enrichment, possibly due to secondary weathering and leaching processes. However, considering the limited number of analysed samples and the inherent lateral and vertical impersistence of the Gaj limestone, these observations should be regarded as local trends within the investigated area rather than representative of the entire formation.



**Plate No.-IV: Geological map on 1:4000 scale of Ishwariya limestone block
Gir Somnath district, Gujarat**

7.2.1 Mineralization Potential of Limestone

The limestone mineralization within the Ishwariya block exhibits favourable characteristics in terms of both quality and continuity, although the grade is influenced by lithological variations encountered with depth. The BRS analyses indicate consistently high-grade surface limestone, with CaO values predominantly ranging between 48 % and 53.5%, accompanied by uniformly low concentrations of MgO, SiO₂, Al₂O₃ and Fe₂O₃, suggesting that the exposed limestone has undergone minimal contamination and represents material suitable for cement-grade applications. In contrast, the borehole samples reveal a more heterogeneous chemical profile resulting from the intercalation of clay horizons, unconsolidated limestone and fossiliferous

limestone as can be observed in the graphical borehole core logs. The compact and fossiliferous limestone horizons generally retain comparatively high CaO values with low deleterious constituents, whereas intervals comprising yellowish-brown clay and unconsolidated limestone exhibit a marked reduction in CaO and corresponding enrichment of SiO₂, reflecting dilution of the carbonate content by argillaceous material. Although a slight decrease in CaO grade is observed in the subsurface compared to the surface exposures, this reduction is gradual and primarily confined to localized clay-rich horizons rather than representing a progressive deterioration of limestone quality with increasing depth.

The continuity of limestone across all boreholes, together with the recurrence of compact and fossiliferous limestone units, suggests that the deposit possesses good lateral as well as vertical continuity. Furthermore, the consistently low MgO content throughout both surface and subsurface samples indicates negligible dolomitization, thereby preserving the chemical suitability of the deposit for cement manufacture. The observed variation in chemical composition is therefore interpreted to be controlled predominantly by lithological heterogeneity and localized clay intercalations rather than by any systematic degradation of the carbonate sequence. All six boreholes initially intersect a 2–4 m thick horizon of loose miliolitic limestone, representing the weathered upper part of the carbonate sequence. Beneath this horizon, the subsurface lithology is predominantly characterized by yellowish-brown clay and unconsolidated to fossiliferous limestone. Among the drilled boreholes, G-ISH-BH-04 is the only borehole to intersect a continuous compact limestone bed of approximately 6 m thickness below the miliolitic limestone horizon. In the remaining boreholes (G-ISH-BH-01, G-ISH-BH-02, G-ISH-BH-03, G-ISH-BH-05, and G-ISH-BH-06), compact limestone is either absent or occurs only as thin, discontinuous bands intercalated with clay and unconsolidated limestone. This variation indicates that while the upper miliolitic limestone horizon is laterally persistent throughout the study area, the development of compact limestone at depth is localized, with the maximum thickness recorded in Borehole G-ISH-BH-04.

Overall, the exploration results establish that the Ishwariya block hosts a laterally continuous limestone body with predominantly high-calcium characteristics, wherein localized low-grade intervals associated with clay horizons are unlikely to significantly affect the overall mineralization potential. The integrated assessment of surface sampling, borehole geochemistry and lithological logging indicates that the block possesses favourable geological and chemical characteristics for the delineation of cement-grade limestone resources, with the surface horizons representing the highest-grade portion of the deposit and the underlying limestone maintaining acceptable quality over substantial thicknesses.

7.3.0 STRUCTURAL DETAILS OF THE STUDY AREA

The Ishwariya limestone block is structurally simple and exhibits a relatively undisturbed geological setting, which is favourable for the continuity of the limestone horizon. Measurements of bedding attitudes indicate that the limestone beds are generally sub-horizontal to gently dipping, with dip angles ranging from 1° to 20° and an average dip of approximately 10°. The general strike of the beds is predominantly NE–SW, although local variations in strike are observed due to minor depositional undulations. The interpreted geological map and cross-section indicate a gentle regional topographic gradient from the northwestern part of the block towards the southeast, while the limestone horizons maintain good lateral continuity without significant displacement. No major faults, folds, shear zones, or intrusive bodies were observed during the geological mapping or drilling programme, suggesting that the Gaj Formation limestone has remained structurally intact. Minor variations in bedding attitude are interpreted to result from primary depositional irregularities rather than tectonic deformation. The occurrence of isolated Gaj Limestone outcrops within the extensive Miliolitic Limestone cover further indicates that the older limestone is largely concealed beneath younger deposits rather than being structurally truncated. Overall, the simple structural framework, predominantly NE–SW striking and gently dipping carbonate beds, and the absence of major tectonic disturbances favour the persistence and lateral continuity of the limestone horizon, supporting its suitability for resource delineation.

7.4.0 TYPE OF DEPOSIT AND STYLE OF MINERALIZATION OF LIMESTONE

The Ishwariya limestone block represents a stratiform sedimentary carbonate deposit, with the Miliolite Formation forming the predominant surface lithology, while the underlying Gaj Formation is exposed only in limited areas and encountered at depth in boreholes. The limestone mineralization is syngenetic in origin, having been deposited in a shallow marine environment as part of the sedimentary sequence. The upper 2–4 m thick Miliolitic Limestone exhibits good lateral persistence throughout the study area; however, below this horizon, the limestone beds become discontinuous and irregular, with frequent intercalations of clay and unconsolidated limestone.

The observed variation in grade and thickness is controlled primarily by depositional facies changes and lithological heterogeneity rather than structural deformation or secondary mineralization. Thus, the deposit is best classified as a stratabound, layer-controlled

sedimentary limestone deposit, characterized by a laterally persistent surficial Miliolite horizon overlying discontinuous and localized Gaj limestone mineralization of economic interest.

7.5.0 THE EXTENT AND VARIABILITY OF LIMESTONE IN THE STUDY AREA.

The Miliolite Formation forms the dominant lithological unit and is extensively distributed across the entire study area, constituting a continuous surficial limestone cover. In contrast, the Gaj Formation has a comparatively limited areal extent, being exposed only in isolated patches at the surface and occurring discontinuously beneath the Miliolite Formation in the subsurface. The Miliolite limestone exhibits relatively uniform lithological characteristics throughout the block, whereas the Gaj limestone displays considerable local variability in lithology, occurring as compact, fossiliferous and unconsolidated limestone intercalated with clay horizons. The observed variability is primarily controlled by lateral changes and depositional conditions within the shallow marine carbonate environment rather than by structural disturbances.

7.6.0 PHOTOMICROGRAPHIC (THIN-SECTION) STUDIES

Photomicrographic studies are conducted for 10 samples and the study is reported hereunder.

Sample No. BRS-08

Granularity : Hetrogenous

Grain size : Ultrafine

Crystallinity : Poorly crystalline

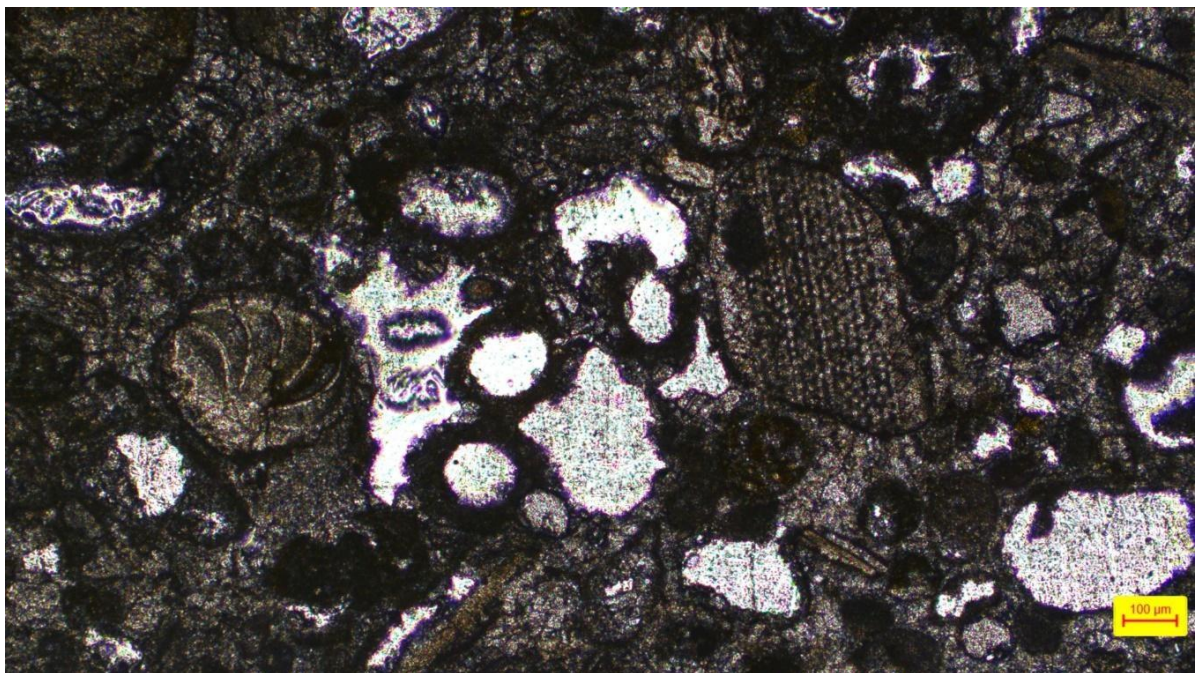
Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : Micritic texture

Digenesis: Moderately diagenetic



PMG 1 Photomicrograph showing ultrafine-grained, fossiliferous limestone containing different species of algae and foraminifera. The rock may be named as biomicrite (limestone).

Sample No. BRS-15

Granularity : Heterogenous

Grain size : Fine

Crystallinity : Poorly crystalline

Sorting : biogenic

Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : Oolitic texture

Digenesis: Moderately diagenetic



PMG 2- Photomicrograph showing the fossiliferous fine grained biogenic origin limestone. The foraminifera fossil shows iron encrustations developed in benthic environment. The rock may be named as biomicrite (limestone).

Sample No. BRS-18

Granularity : Heterogeneous

Grain size : Ultrafine

Crystallinity : Poorly crystalline

Sorting : poorly sorted

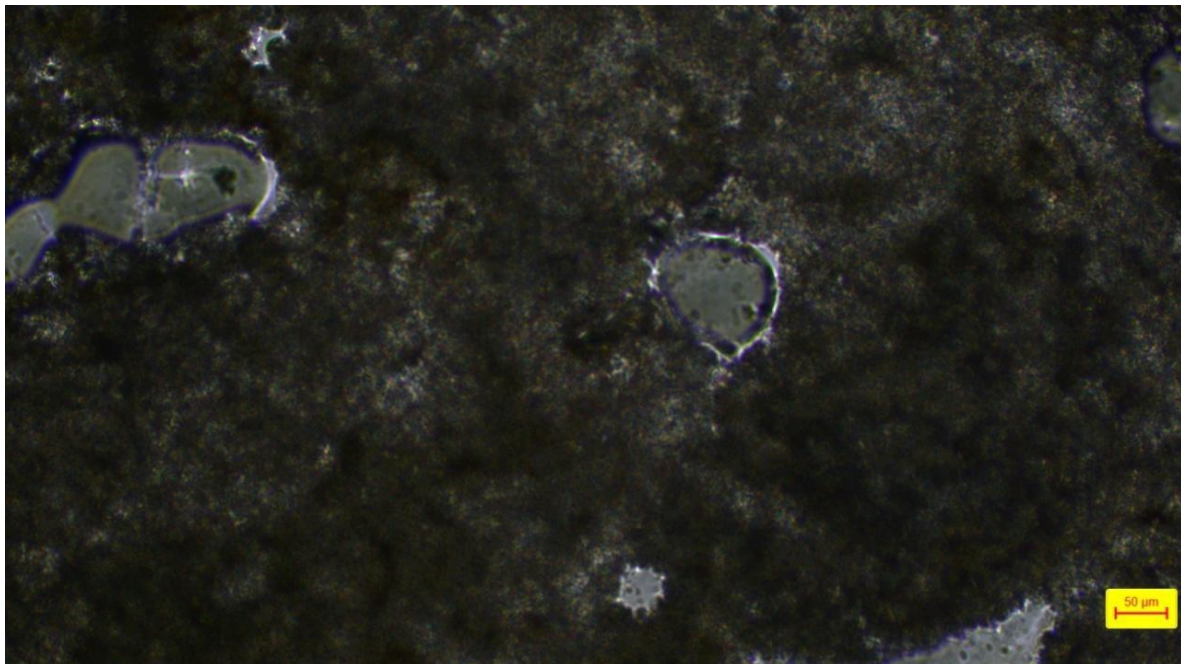
Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : Micritic texture

Digenesis: Moderately diagenetic



PMG 3- Photomicrograph showing the ultrafine grained noncrystalline limestone. Iron encrustation occurs as opaques mineral. Micritic matrix is visible. The rock may be named as micrite.

Sample No. BRS-30-40

Granularity : Heterogeneous

Grain size : Fine to medium

Crystallinity : Poorly crystalline

Sorting : poorly sorted

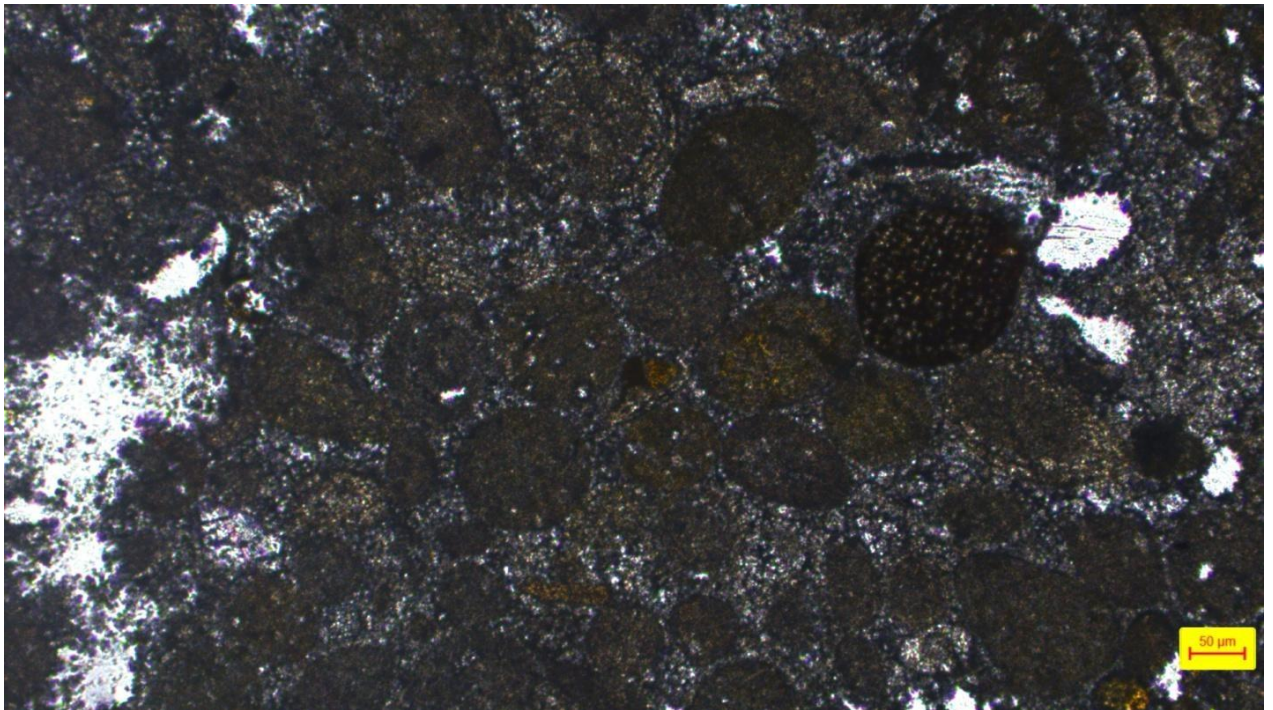
Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : Oolitic texture

Digenesis: Moderately diagenetic



PMG 4- Photomicrograph showing the fossiliferous limestone. have oolites varies size and algae. The rock may be named as biomicrite (limestone).

Sample No. BRS-31

Granularity : Heterogeneous

Grain size : Fine to medium

Crystallinity : Poorly crystalline

Sorting : poorly sorted

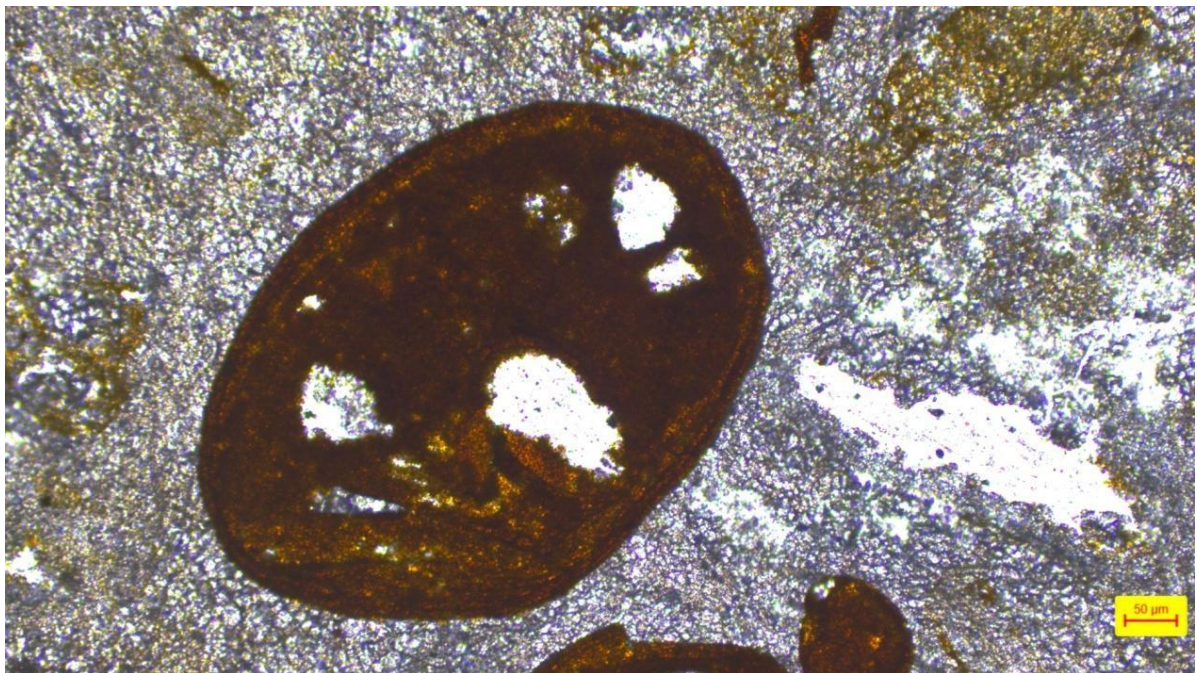
Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : not clear (altered)

Digenesis: Moderately diagenetic



PMG 5- Photomicrograph showing limestone containing benthic foraminifera with prominent iron encrustation on the fossil remains. The rock may be named as biomicrite (limestone).

Sample No. BRS-39

Granularity : Heterogeneous

Grain size : Fine to medium

Crystallinity : Poorly crystalline

Sorting : moderately sorted

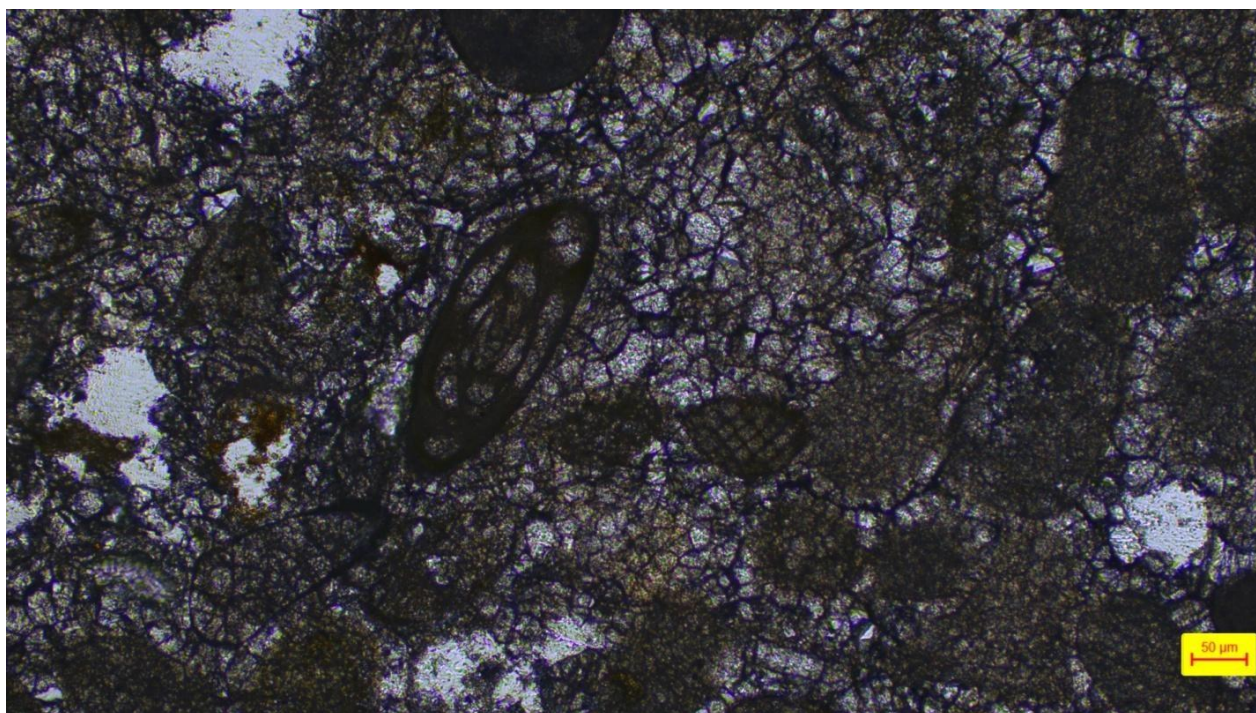
Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : fossiliferous texture

Digenesis: Moderately diagenetic



PMG 6- Photomicrograph showing fossiliferous limestone comprising abundant bioclasts and minor peloids embedded in a micritic matrix. The limestone contains different species of algae and foraminifera. The rock may be named as biomicrite (limestone).

Sample No. BRS-40

Granularity : Heterogeneous

Grain size : Fine to medium

Crystallinity : Poorly crystalline

Sorting : moderately sorted

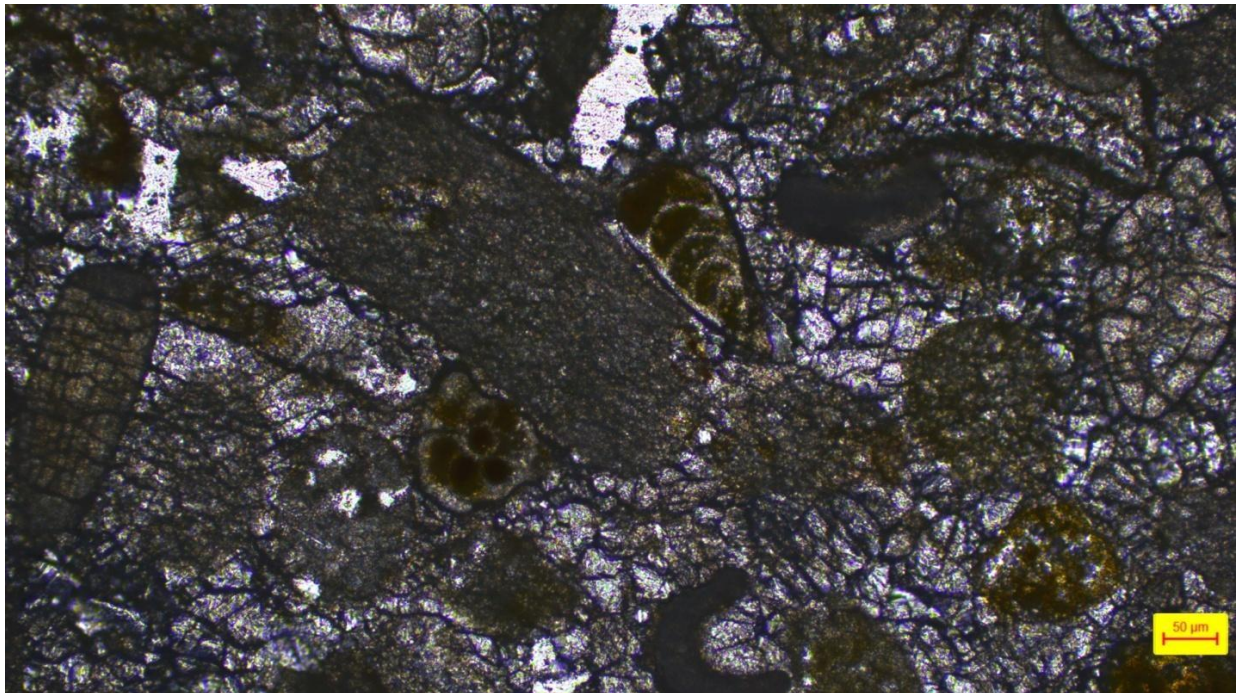
Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : fossiliferous texture

Digenesis: Moderately diagenetic



PMG 7- Photomicrograph showing highly fossiliferous limestone containing different species of coiled and lenticular foraminifera along with algal remains. The rock may be named as biomicrite (limestone).

Sample No. BRS-42

Granularity : Heterogeneous

Grain size : Fine to medium

Crystallinity : poorly crystalline

Sorting : moderately sorted

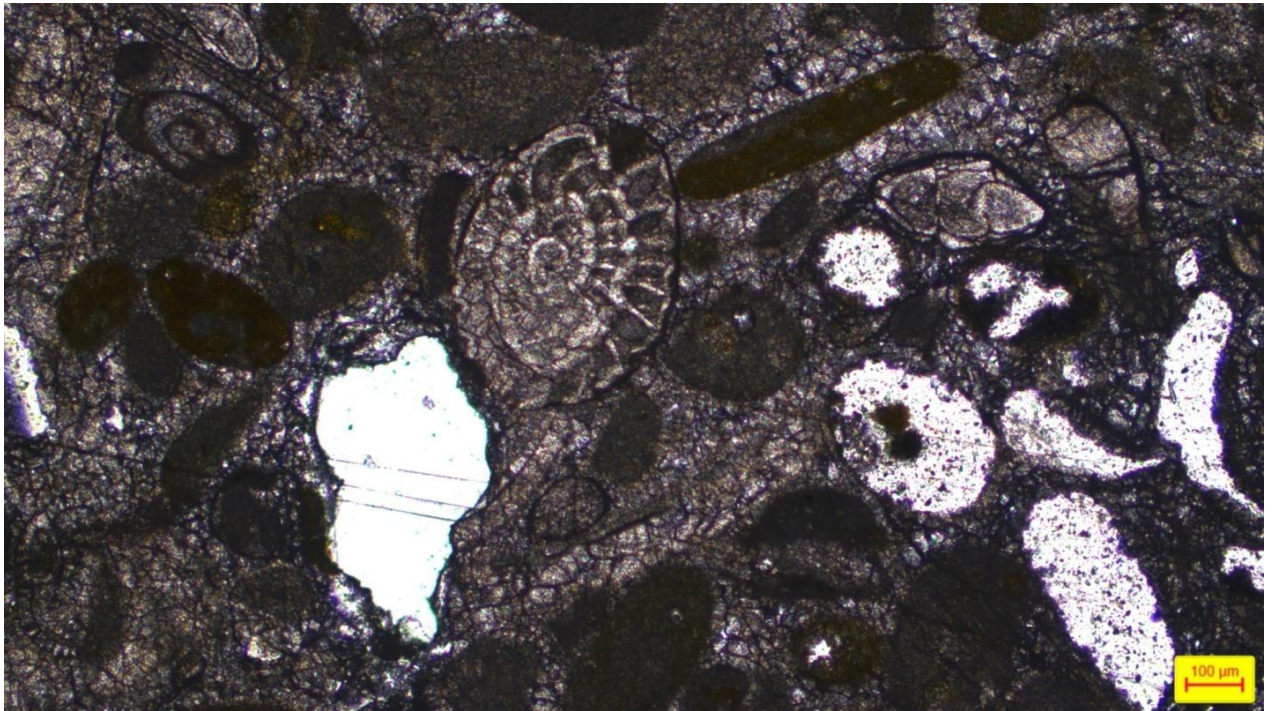
Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : fossiliferous texture

Digenesis: Moderately diagenetic



PMG 8- Photomicrograph showing fossiliferous limestone containing abundant foraminiferal fossils. The limestone is slightly altered, as indicated by the presence of clay-filled pockets. The rock may be named as biosparite (limestone).

Sample No. BRS-44

Granularity : Heterogeneous

Grain size : Fine to medium

Crystallinity : poorly crystalline

Sorting : moderately sorted

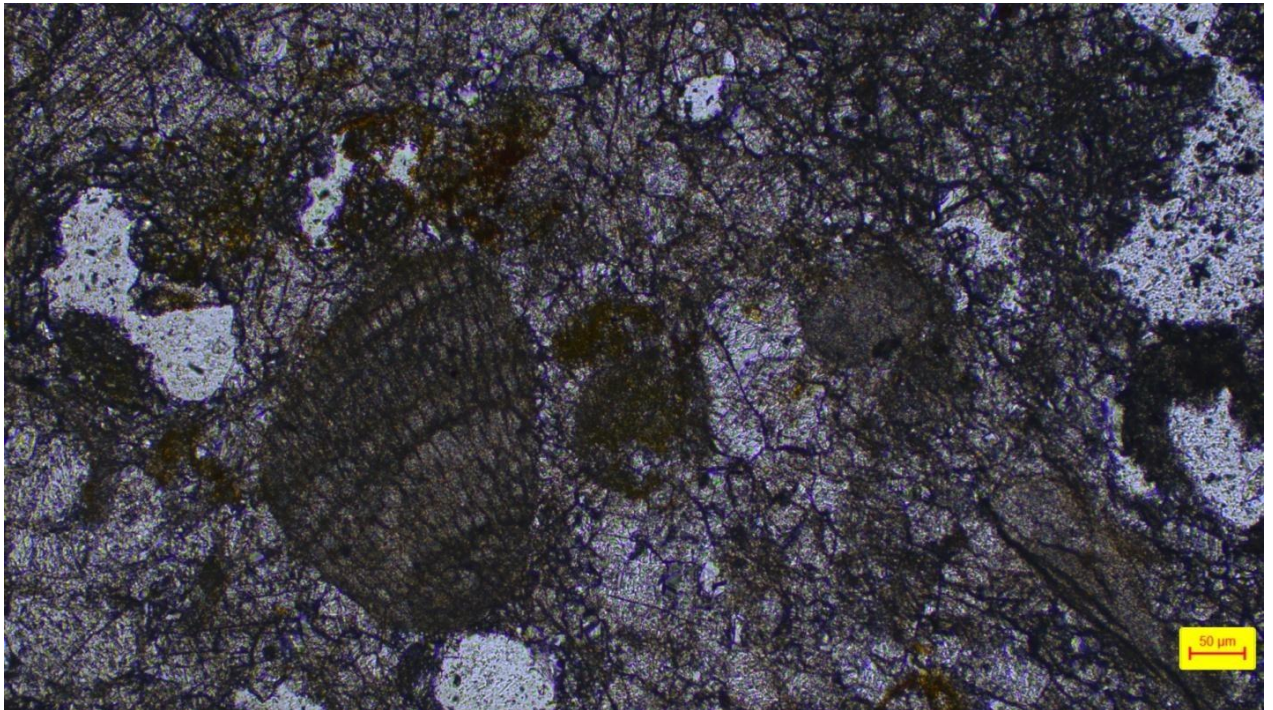
Matrix : Not visible

Cement : Calcareous

Porosity : Non porous

Texture : Fossiliferous texture

Digenesis: Moderately diagenetic



PMG 9- Photomicrograph showing fossiliferous limestone comprising abundant algal fossils. Iron oxides are present as opaque minerals within the rock. The rock may be named as biomicrite (limestone).

Findings on the basis of this section studies:

The limestone of the area was deposited in a shallow marine, near-shore depositional environment, as indicated by the presence of various benthic foraminiferal species. The occurrence of iron encrustation around aragonitic fossil shells further supports this depositional setting. Petrographic studies reveal that most samples are poorly sorted and fine- to ultra-fine-grained, suggesting deposition under moderate to high-energy conditions. The limestone is fossiliferous and represents a continental shelf depositional environment. Post-depositional diagenesis and compaction are reflected by the development of clay patches and clouds in thin sections. The limestone is predominantly micritic to amorphous in nature, with occasional goethite nodules, ferruginous droplets, and iron encrustations.

CHAPTER-8

PREVIOUS EXPLORATION

8.1.0 DETAILS OF PREVIOUS EXPLORATION CARRIED OUT BY OTHER AGENCIES/PARTIES

(A) Geological Survey of India (GSI)

- **Verma and Mathur (1971–72)** carried out a reconnaissance survey in the Saurashtra region to study the Quaternary geology. They examined miliolite limestone, shell limestone, coastal sand dunes, beach deposits, and alluvium, and studied the Gaj and Dwarka formations for stratigraphic correlation and age determination.
- **S. V. Dave (1985–1987)** reported the occurrence of chalk deposits for the first time in the area and delineated three chalk pockets during detailed investigations in Upleta Taluka.
- **R. C. Mody (1988–1989)** carried out a Pre-Detailed Mineral Survey in parts of Upleta and Jamjodhpur Talukas and identified occurrences of chalk and limestone, recommending detailed exploration.
- **Dey and A. R. V. Chowdhary (1991–1993)** conducted detailed geological mapping over an area of about 200 sq km and identified basalt, gabbro, granophyre, rhyolite and trachyte forming a ring structure. Geochemical investigations indicated gold values ranging from <10 ppb to 70 ppb, with higher values associated with chert vein intersections near Andheriya Nes.
- **Roychowdhury (1997–98, GSI)** carried out a preliminary appraisal of limestone in the coastal Saurashtra region and identified high-quality Miliolite and Gaj limestones suitable for SMS, BF, and chemical-grade applications.
- **K. B. Pandya (1999–2000)** confirmed the occurrence of chalk deposits and delineated additional chalk-bearing zones.
- **M. K. Joshi (2000–2001)** carried out detailed drilling investigations in the Pransla and Amrapar areas and established geological reserves of approximately 12 million tonnes of chalk and 5.73 million tonnes of limestone.

- **J. H. Vayeda (2004–2005)** extended drilling investigations in adjoining areas and estimated geological reserves of about 37.36 million tonnes of chalk and 83.69 million tonnes of limestone.
- **Jnana Ranjan Behera and Saikat Bhakta (2017–2018)** carried out a Reconnaissance Survey (G4 level) for gold and associated minerals in the Jamjodhpur Block (Alech Hills), confirming favourable geological conditions and identifying structurally controlled zones for mineralization.

(B) Other Agencies / Researchers

- **Fedden (1884)** presented the earliest account of the regional geology of the Kathiawar Peninsula and reported the occurrence of compact felsitic rocks within the Deccan Trap terrain, including acidic volcanic rocks associated with the Alech Hills igneous complex.
- **Adye (1914–1917)** carried out detailed petrological investigations on felsites, granophyres and rhyolites from the Porbandar and Navanagar regions.
- **Ghosh (1936)** contributed to the understanding of the regional lithology and geology of the area.
- **B. C. Roy (1941)** further documented the regional geology and lithological characteristics of the area.
- **H. Crookshank (1940)** conducted geological investigations and refined the structural interpretation of the region.
- **P. Duncum and W. P. Sladen (1942)** contributed to the understanding of the lithological succession and structural framework of the Deccan Trap terrain.
- **Auden (1949)** described dyke intrusions within the Deccan Trap terrain and interpreted the Alech Hills acidic volcanic rocks as granophyres.
- **Shekhar and Mukul (1966)** reported quartz monzonite dykes intruding basalt and suggested their petrological affinity with granophyres.
- **Bandopadhyay (1973–1975)** Allech hills area and proposed a central subsidence structure with ring fractures subsequently occupied by acidic intrusive rocks.

- **Bose (1980)** suggested that alkaline rock suites within the Deccan Volcanic Province are confined mainly to western India and are controlled by regional tectonic features and plume-related magmatism.
- **Mathur (2006)** described the Quaternary geology of India and reported the occurrence of Early Pleistocene Miliolite limestone along the western coast of India, including Gujarat, highlighting its stratigraphy and geological significance.

CHAPTER-9

DETAILS OF AERIAL, GROUND GEOPHYSICAL AND GEOCHEMICAL SURVEY

9.1.0 DETAILS OF AERIAL, GROUND GEOPHYSICAL AND GEOCHEMICAL SURVEY TAKEN UP AND THEIR RESULTS.

- During the current exploration program, no Aerial/Geophysical surveys were carried out.
- Based on literature survey of the available data on the NGDR and GSI portals, no records of previous geochemical mapping or geophysical investigations are available for the proposed block area.

CHAPTER - 10

EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 OBJECTIVES OF INVESTIGATION

The exploration programme was undertaken with the following objectives: -

- Geological mapping in 1:4000 scale to delineate the surface outcrops of Limestone.
- Systematic collection of Bed Rock samples and analysis
- To drill 6 Nos. of boreholes as per MEMC rules 2015 (Being varying thickness of the deposit) to decipher depth persistence and subsurface continuity of bedded deposits.
- To estimate the in-situ resource of Limestone for G3 stage of exploration and preparation of Geological Report (GR).
- Carry out mineral exploration works as per Minerals (Evidence of Mineral Contents) Rule-2015, Mineral (Auction) Rules-2015 and MMDR Amendment act-2015. In turn to facilitate the Government of Gujarat in auctioning of the block.

10.2.0 DETAILS OF WORK

After receipt of approval from the National Mineral Exploration and Development Trust (NMEDT) vide F. No. 23/633/2025-NMEDT/84 dated 01 July 2025 with an approved cost of Rs. **70,43,860/-** PRB Infraprojects Private Limited undertook exploration activities in the Ishwariya block.

The exploration work was carried out as per the approved exploration programme. Details regarding the nature scope proposed quantum of work and actual achievements are furnished in **Table No -10.1.**

Table No. 10.1
Nature & Quantum of Work - Proposed Vs Achieved Ishwariya Block, District- Gir
Somnath, Gujarat

S.No.	Item of Work	Unit	Proposed quantum	Achieved
1	Topographic Survey with 2m contour interval Geological Mapping (1:4000) Scale	sq. km	3.43	3.43
2	DGPS Survey BH fixation and RL determination (06 BHP + 5 BP)		11	11
3	Core Drilling 800x800 grid 6 BH	m	120 m	120m
4	Chemical Analysis			
a	Chemical Analysis core samples for 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI	Nos.	120	38
b	Chemical Analysis Surface (BRS) for 6 radicals i.e. CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ and LOI	Nos.	40	40
c	External Check Samples	Nos.	16	09
d	Composite Samples For 12 radicals (CaO, MgO, Al ₂ O ₃ , SiO ₂ , Fe ₂ O ₃ , SO ₃ , P ₂ O ₅ LOI, MnO ₂ , K ₂ O, Na ₂ O and Cl.)	Nos	06	06
5	Petrographic / Mineragraphic Study			
a	Preparation of thin sections	Nos	10	10
b	Petrographic study report	Nos	10	10
c	Digital Photographs	Nos.	10	10
6	Geotechnical Study			
a	Specific Gravity Determinations	Nos.	5	5

Core drilling was carried out in-house by PRB Infraproject Private Limited as per SoC Item No. 2.2.1.1(b), approved vide OM File No. 23/633/2025-NMEDT/184 dated 01 July 2025 issued by NMEDT.

Exploratory drilling commenced during Phase-II with borehole G-ISH-BH-01 on 23.04.2026 in the Ishwariya Block and was completed with the closure of borehole G-ISH-BH-06 on 30.04.2026. **Total 06 boreholes** were proposed in the approved exploration scheme with total drilling meterage of 120m. The allied field works, including surveying, drilling, and borehole core logging and sampling, were carried out simultaneously. The total core sampling achieved that is 38 was lower than the targeted quantity 120 because samples were collected only from the mineralized zones only. Analytical and laboratory studies were also carried out simultaneously in NABL accredited laboratories.

10.3.0 EXPLORATION ACTIVITIES TAKEN UP BY PRB

Exploration activities comprising geological mapping, topographical survey on 1:4000 scale with 2m contour interval over an area of 3.43 sq. km exploratory drilling and associated analytical works were carried out by PRB Infraprojects Private Limited. The exploration work commenced on 09.09.2025 and was completed on 04.05.2026.

10.3.1 Geological Mapping

A detailed topographic survey of the study area was carried out on a scale of 1:4000 with contour intervals of 2m. Topographically the study area is slightly undulating with elevations ranging from a minimum of 30 MSL to a maximum of 57 MSL.

Two limestone quarries are present in the northwestern part of the block and are disconnected from each other with depths varying from 4m to 6m. One additional limestone quarry is located in the central part of the block. Broad lithological units and litho-contacts were mapped with the help of handheld GPS and total survey station. Structural features such as bedding, folds, and joints were recorded using Brunton Compass. The general strike of the litho-units varies irregularly due to the deposits are formed in the valleys of the trachytic mounds, with dip angles ranging from 2° to 10° . The field observations and structural readings were plotted on the topographical map (**Refer Plate No.-V**).

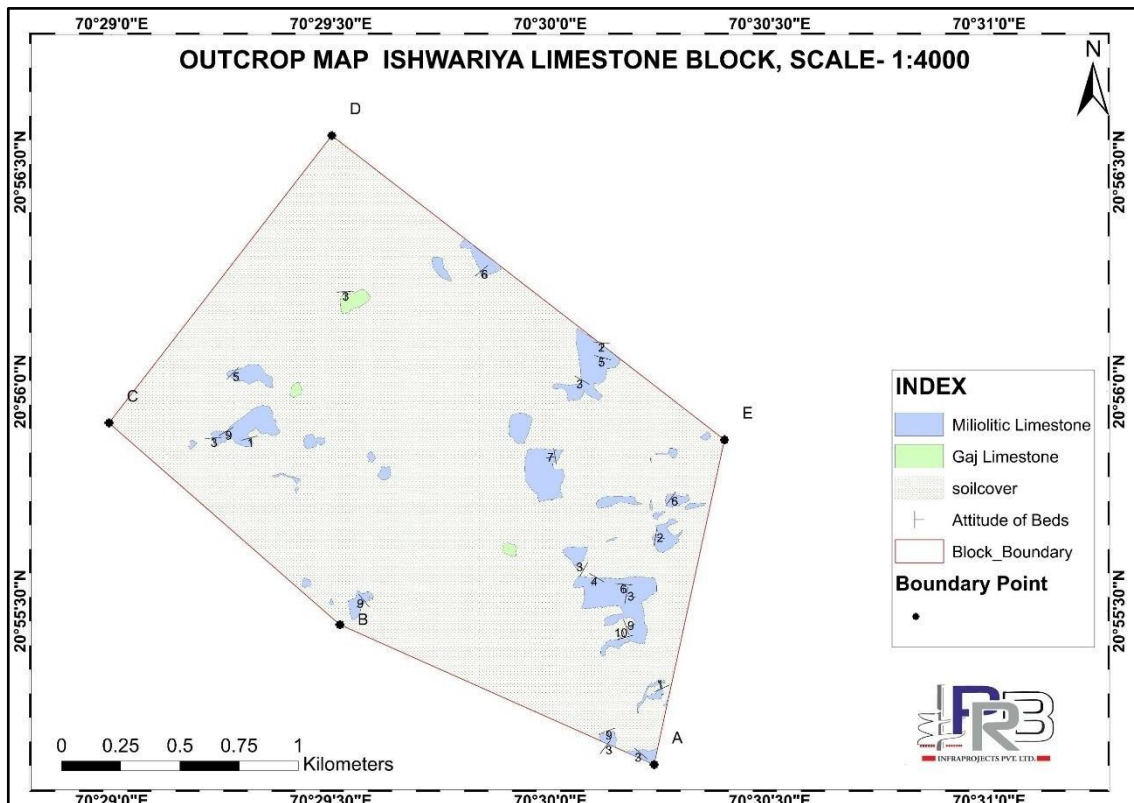


Plate No.-V: Outcrop Map of Ishwariya Limestone Block, Gir Somnath, Gujarat.

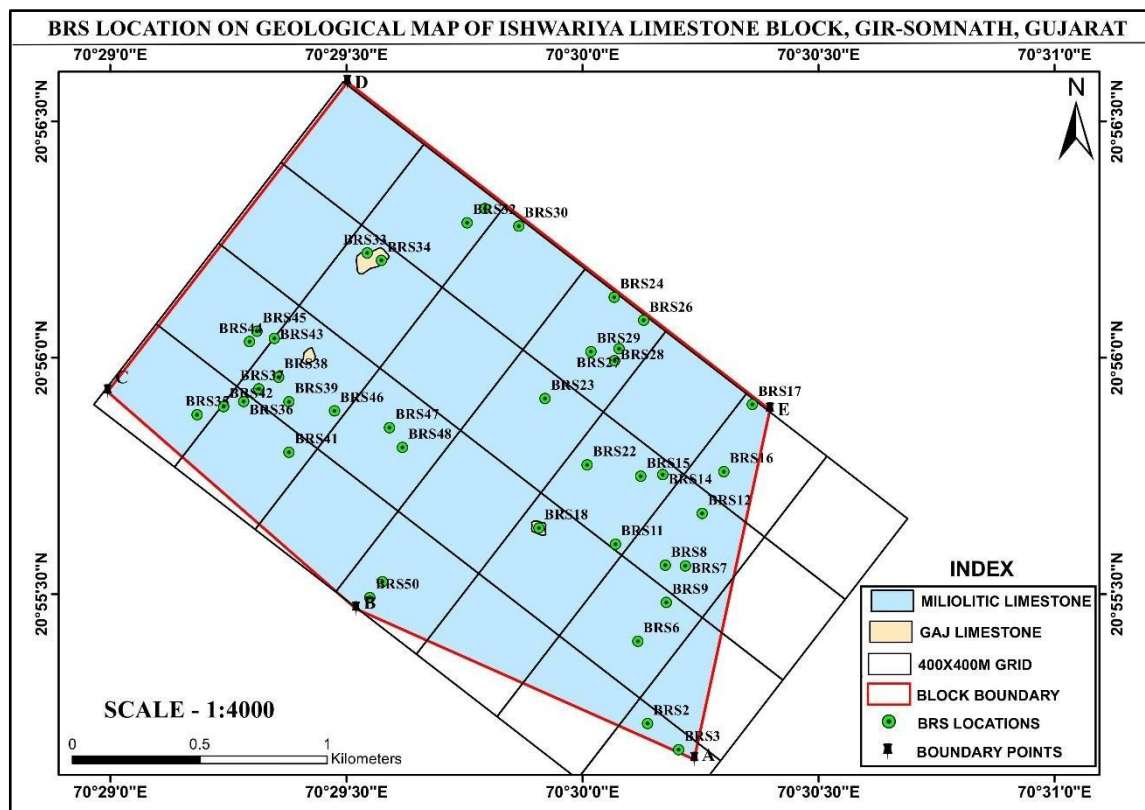


Plate No.-VI: Geological Base Map Showing Bed Rock Sample (BRS) Locations

A total of 40 Bed Rock Samples (BRS) were collected from representative limestone outcrops exposed within the Ishwariya Block during geological mapping. The locations of all BRS samples have been plotted on the geological base map to illustrate their spatial distribution with respect to the mapped lithological units and geological features. These samples were collected to assess the surface chemical characteristics of the limestone and to support the geological interpretation of the block. **(Refer Plate No- VI)**

10.3.3 Exploratory Drilling

Topographical survey, exploratory drilling and borehole core sampling were carried out concurrently during the course of investigation. The analytical and laboratory studies were conducted at Inspectorate Griffith India Private Limited a NABL accredited laboratory. Core samples recovered from the exploratory boreholes were systematically logged based on geological parameters such as grain size, rock type, lithology, structural features and mineralogical characteristics. The detailed summarized lithologs are enclosed as **Annexure 1**.

Limestone bands were encountered in all 06 boreholes drilled within the Ishwariya Block. The borehole coordinates along with Reduced Levels (RL) were determined using the WGS-84 datum.

The drilling programme commenced with borehole **G-ISH-BH 01** on 23.04.2026 and was completed with borehole **G-ISH-BH 06** on 30.04.2026. The details of boreholes drilled are furnished in **Table No.10.3**.

Table No. 10.3 Details of section-wise boreholes drilled in Ishwariya Block Gir-Somnath District Gujarat State

Sr. No.	Borehole Id	Latitude	Longitude	Total Depth (m)	RL (m)
1	G-ISH-BH-01	20°55'55.7" N	70°29'17.1" E	20	30
2	G-ISH-BH-02	20°56'15.1" N	70°29'32" E	10	42
3	G-ISH-BH-03	20°55'57.10"N	70°29'54.50"E	15	38
4	G-ISH-BH-04	20° 55' 47.5" N	70° 29' 38.4"E	35	37
5	G-ISH-BH-05	20° 25' 26.3" N	70° 30' 0.2" E	20	25
6	G-ISH-BH-06	20° 55' 43.2"N,	70° 30'14.0" E	20	33

A comparable clay horizon is also present in the Bhatia Limestone Block, located at approximately Latitude 22° 5'40.76"N & 69°15'43.88"E and Longitude 22° 3'18.46"N & 69°14'43.97"E, in the broader regional setting of the Ishwariya Block, where representative clay samples from the Bhatia Block were subjected to **ICP-MS analysis**. The analytical results indicate that the **total REE content ranges from 119.92 to 196.27 ppm**. However, no significant enrichment of REE, trace elements, or critical elements was observed. The Bhatia Block analytical data have therefore been considered as supporting comparative geochemical information for the present investigation.

10.3.3.1 A comprehensive Quality Assurance and Quality Control (QA/QC) protocol was implemented during drilling, sampling, sample preparation and analytical stages to ensure the accuracy and reliability of the geochemical data. Core samples obtained from NQ size diamond drilling were geologically logged and sampled at nominal 1.0 m intervals or based on lithological boundaries to ensure representativeness of the mineralized horizon. The core was systematically split and representative half-core samples were collected for analysis while the remaining half was retained for reference. All samples were properly labelled, sealed, and transported to the Chemical Laboratory. A total of **78(BRS 40+38 CS)** primary samples were analysed for major oxides including CaO, MgO, SiO₂, Al₂O₃, Fe₂O₃, and Loss on Ignition (LOI). As part of the QA/QC programme approximately 10% of the samples (09 samples) were submitted to an independent external laboratory **Shiva Analytical India Private Limited** for check analysis to assess analytical precision and accuracy. The QA/QC procedures adopted during sampling preparation and analysis are considered adequate for the level of exploration (G3) and provide confidence in the geological interpretation and resource estimation.

10.3.3.2 In the Ishwariya Block two geological cross-sections were prepared along the strike and across the strike in the SW-NE direction. Totally **06** boreholes were considered for the preparation geological cross section and all these (06) boreholes intersected limestone zones.

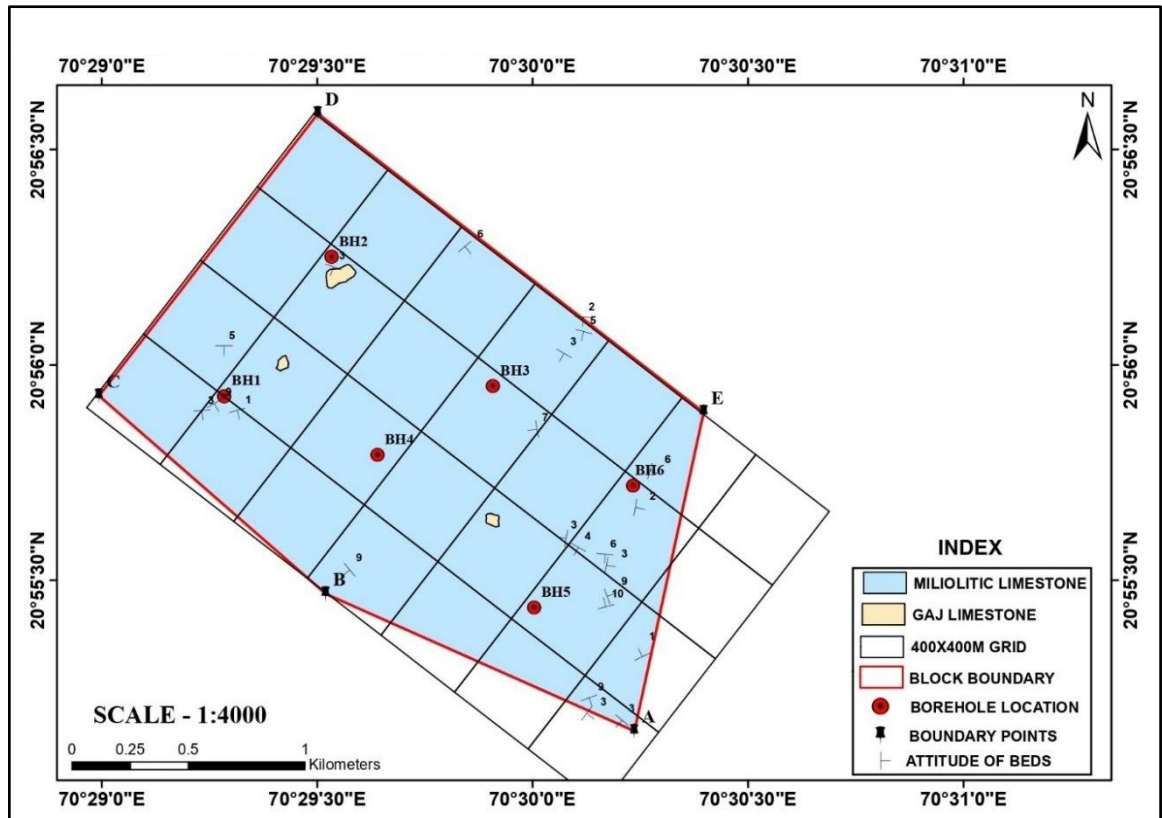


Plate No. VII: Borehole location on Geological Map of Ishwariya Limestone Block, Gir Somnath, Gujarat.

CHAPTER-11

LOCATION OF DATA POINTS

11.1.0 ACCURACY AND QUALITY OF SURVEY USED TO LOCATE BLOCK BOUNDARY AND DRILL HOLES

- The area lies southeast of Ishwariya village in Patan Veraval Taluka, Gir Somnath district, Gujarat and is reasonably accessible via rail, road, and air transport. The nearest railhead is Veraval Railway Station located approximately 10-15km from the area providing connectivity to regional and intercity routes. National Highway 51 (NH 51) is the nearest major highway offering efficient road access to the block area and linking it with key towns and cities in Gujarat. The closest airport is Diu Airport situated about 70 km away which provides domestic flight services primarily connecting to larger cities like Ahmedabad and Mumbai. This multimodal access makes Ishwariya suitable for field activities, transportation of equipment and exploration logistics.
- The Topographical survey, Borehole location and Block Boundary demarcation in this block has been carried out by the CHCNAV i89 Instrument.
- The Survey of India (SOI) base station was utilized for Topographical survey, Borehole fixation and Block Boundary demarcation. The base stations used from the Survey of India CORS network.
- The coordinates of the SOI base station are provided in **Table No. 11.1**

Table No. 11.1
Showing the R.L & Coordinates of the SOI CORS Base Point

Base Station	Latitude	Longitude	Easting (m)	Northing (m)	RL (m)
SURVEY OF INDIA BASE STATION	21°04'41.88" N	70°32'55.32"E	70.548700	21.078300	112

11.2.0 TECHNICAL SPECIFICATIONS OF DGPS

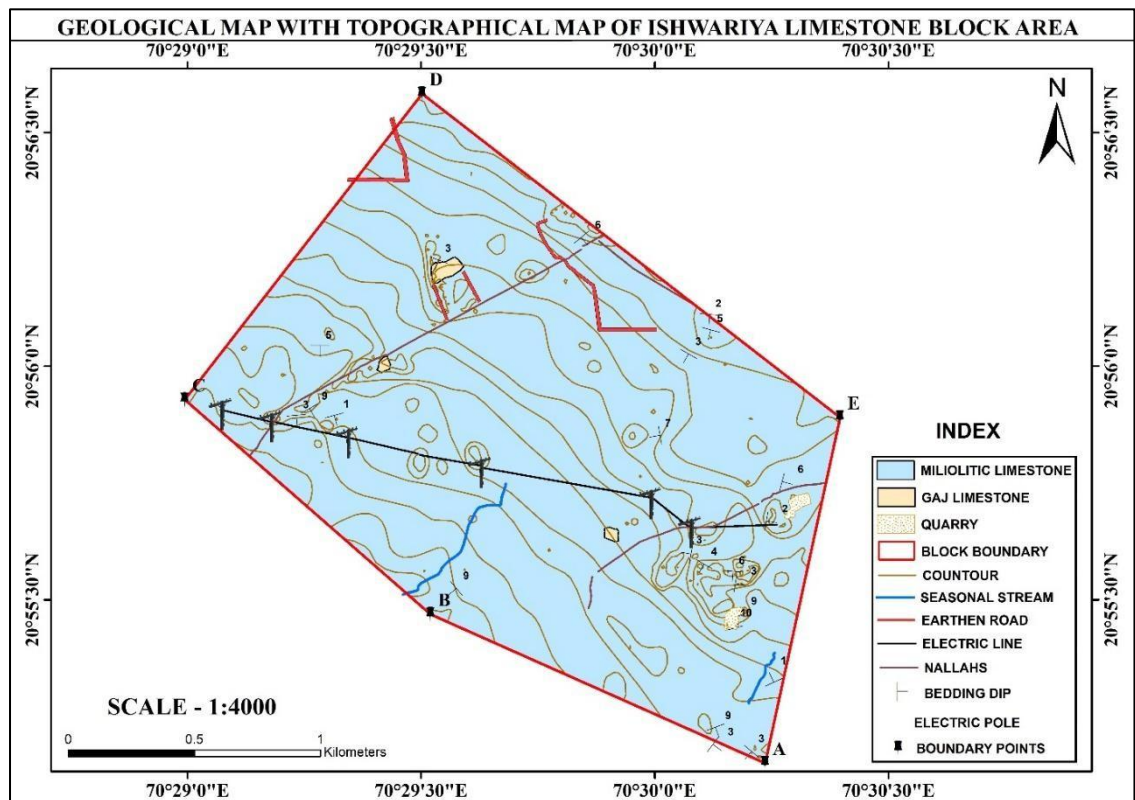
- **Make:** CHCNAV
- **Model:** CHCNAV i89
- **Year:** 2025

11.3.0 BASELINE PROCESSING RESULTS:

Total five block boundary (Refer Table no 4.1) points has been fixed by PRBIPPL as part of present G3 stage exploration. Co-ordinates and Reduced level (RL) of the 6 boreholes are given in **Table-10.3** and also shown in **Plate No-VII**.

11.4.0 QUALITY AND ADEQUACY OF TOPOGRAPHIC CONTROL

Topographic control for the exploration area was established using Differential Global Navigation Satellite System (DGPS/GNSS), ensuring high positional accuracy for all survey observations. Adequate topographic control points and data density were maintained to accurately depict the terrain, exploration features, and cultural details on the topographic map. The survey data were processed and compiled to generate an Excel-based point list, which is appended to this report. The survey was carried out by qualified survey personnel in accordance with the prevailing standard survey procedures, ensuring the quality, accuracy, and adequacy of the topographic control for geological mapping and exploration activities. (Refer Plate- VIII)



**Plate No.-VIII: Geological Map with Topography of Ishwariya Limestone Block
Gir Somnath, Gujarat**

CHAPTER-12

SAMPLING TECHNIQUES

12.1.0 NATURE AND QUALITY OF SAMPLING AND MEASURES TAKEN TO ENSURE SAMPLE REPRESENTATIVITY

- The present work programme was formulated to undertake **Preliminary Exploration (G3 Stage)** for limestone in the Ishwariya Block. A total of **40 bedrock samples** were collected from the block for Chemical analysis.
- Exploratory drilling of **120m** was carried out through **06 boreholes** to assess the subsurface continuity and quality of the limestone horizon. Sampling and analytical work were undertaken on all identified limestone-bearing intervals encountered in surface exposures and boreholes. Sample intervals were delineated based on detailed geological observations considering lithological variations and the characteristics of the mineralized zones. Generally, a sampling interval of **1.0 m** was maintained for borehole core sampling. However, the interval was modified wherever necessary to honour lithological contacts and changes in rock characteristics thereby ensuring representative sampling of the mineralized horizons.
- Borehole core sampling was carried out in the presence of a qualified geologist and a sampling technician. The geologist identified and marked the limestone-bearing zones for sample preparation and the samples were generated under the supervision of the sampling technician. The recovered core was longitudinally split into two equal halves to ensure uniform distribution of the material. One half of the core was preserved in the core box for record and future reference while the other half was processed for laboratory analysis. Core recovery exceeded above **91%** in nearly all boreholes, thereby providing a reliable and representative profile of the subsurface lithology.
- Based on the recovered core, a total of **38 primary borehole core samples** were generated for chemical analysis. The samples were crushed, pulverized, and sieved to a particle size of **(-150) microns**. The prepared material was thoroughly homogenized through repeated mixing, followed by coning and quartering to obtain representative analytical samples. All stages of sample preparation were carried out using standardized industry practices under appropriate supervision. Sample preparation equipment was regularly cleaned and maintained to prevent contamination and ensure consistency and reliability of analytical results.

- The primary samples were analyzed for major oxides, namely **CaO, MgO, SiO₂, Fe₂O₃, Al₂O₃ and Loss on Ignition (LOI)** using the **XRF method**. In addition, **10 samples** were selected for petrographical studies, while **5 borehole samples** were tested for **specific gravity** determination. To assess the quality and reliability of analytical data, **09 External check samples** were also generated and analyzed as part of the quality control programme.
- The entire sampling, sample preparation, handling, storage, and dispatch process was carried out under the supervision of qualified geological personnel following standardized procedures. The adopted sampling methodology, sample preparation techniques and quality control measures are considered appropriate for **Preliminary Exploration (G3 Stage)** and ensured the generation of representative accurate, and reliable geological and geochemical data for resource assessment of the Ishwariya Limestone Block.

CHAPTER-13

DRILLING TECHNIQUES AND DRILL SAMPLING EMPLOYED

13.1.0 DRILLING TYPES AND DETAILS

- The core drilling was carried out inhouse by M/S PRBIPPL. Total 6 nos. of vertical boreholes were drilled with a total meterage of **120m** and other associated geological analytical works in the Ishwariya block. The header details of boreholes are given in **Annexure 3**.



Fig. No. 4: Photograph showing plugging of borehole
after completion of drilling

- The drilling operations in the block were carried out using a tractor-mounted hydraulic drilling rig. All boreholes were drilled in NQ size using the triple-tube barrel wireline wet core drilling method. Drilling was conducted in NQ size up to the planned total depth of each borehole using NQ diamond bits and continued until the completion and closure of the respective boreholes.
- The quality of drilling was continuously monitored and maintained throughout the drilling operations. Upon completion, all boreholes were properly plugged and sealed with cement plugs in accordance with standard drilling practices.

- All the exploratory boreholes drilled in the block, namely G-ISH-BH-01 to G-ISH-BH-06, are vertical in nature. All the boreholes were drilled up to the planned depth of 20 m as per the approved exploration programme. The terminal lithological unit encountered at the bottom of the boreholes is yellowish-brown clay, as recorded in the respective borehole lithologs (**Refer Annexure-1**). As the boreholes were relatively shallow and no significant deviation was observed during drilling, deviation surveys were not carried out.

13.2.0 WHETHER CORE AND CHIP SAMPLE RECOVERIES HAVE BEEN PROPERLY RECORDED AND RESULTS ASSAYED

- The core samples have been recorded properly and the detailed run wise litholog and summarized concise lithologs for boreholes are given in **Annexure-1**. The logging of run wise core as well as the cuttings from boreholes have helped in discerning the physical characters like colour, shape, size and nature of the mineralisation as well as texture, structural features and identification of different litho units.
- Core recovery with reference to the lithologies are properly recorded and represented in **Annexure-1**
- The mineralised zones /length recorded during the geological core logging have been sampled for limestone analysis consisting 6 radicals i.e. SiO₂, CaO, Al₂O₃, Fe₂O₃, MgO and LOI.
- The primary samples were marked within the mineralized zones intersected in the boreholes based on visual inspection and lithological characteristics. In general, the sample length was maintained at 1m however, it varied in certain instances due to variations in lithology type and concentration of mineralization. The details of analysis of the primary core samples are provided in **Annexure-3**.

13.3.0 MEASURES TAKEN TO MAXIMIZE SAMPLE RECOVERY AND ENSURE REPRESENTATIVE NATURE OF THE SAMPLES

- The drilling has been done by NQ size diamond drill bit with single barrel wire line, wet core drilling method. The polymer was used as drilling fluid to flush out the cuttings and stabilize the borehole wall. The drilling fluid also works as a coolant to avoid burning of drill bits. Proper core recovery of more than 91.64% was maintained in limestone by using double tube core barrel, however in case of weathered, loose and fractured zone and in solution cavities, the core recovery was low. Whenever core recovery is less, the grade of the recovered portion has been extrapolated over the non-recovered section. However, all

the precautions like modulated water pressure, proper liner, optimum head pressure and the hands of an expert drilling technician had been taken care of to maintain the quality of drilling.

13.4.0 WHETHER THE RELATIONSHIP EXISTS BETWEEN SAMPLE RECOVERY AND GRADE

No significant relationship has been observed between sample recovery and grade of limestone.

13.5.0 CORE LOGGING

The core recovered by drilling was logged systematically in detail describing lithological units with mineralisation details that can be observed by visual inspection. The details of lithology, grain size, colour, texture, structural feature presence of intercalations and cavities have been recorded. Wherever the recovery is less than 100% 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 GI core boxes of specifications given by NMEDT following “Book pattern”. The detailed run wise lithologs for boreholes are given in **Annexure-1**.





Fig. No. 6: ISH-BH-04 before and after splitting



Fig. No 7: ISH-BH- 05 before and after splitting.



Fig. No 8: ISH-BH- 06 before and after splitting.

SUMMARISED LITHOLOGS OF BOREHOLES

LITHOLOGS OF ISHWARIYA LIMESTONE BLOCK, GIR SOMNATH, GUJARAT

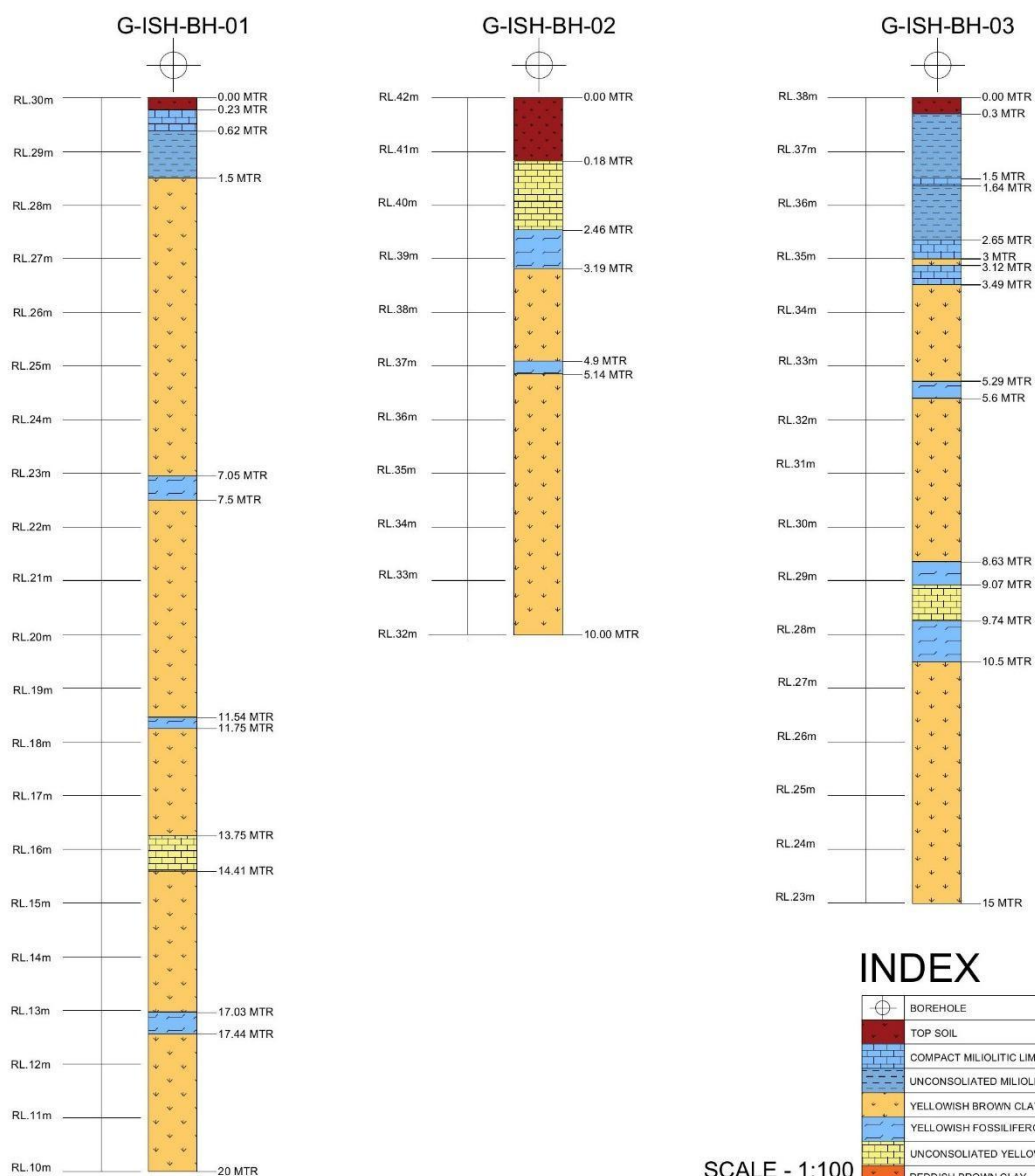


Plate No. IX(A): Lithologs of Borehole – 1, 2 and 3 of Ishwariya Limestone Block, Gir Somnath district, Gujarat.

LITHOLOGS OF ISHWARIYA LIMESTONE BLOCK, GIR SOMNATH, GUJARAT

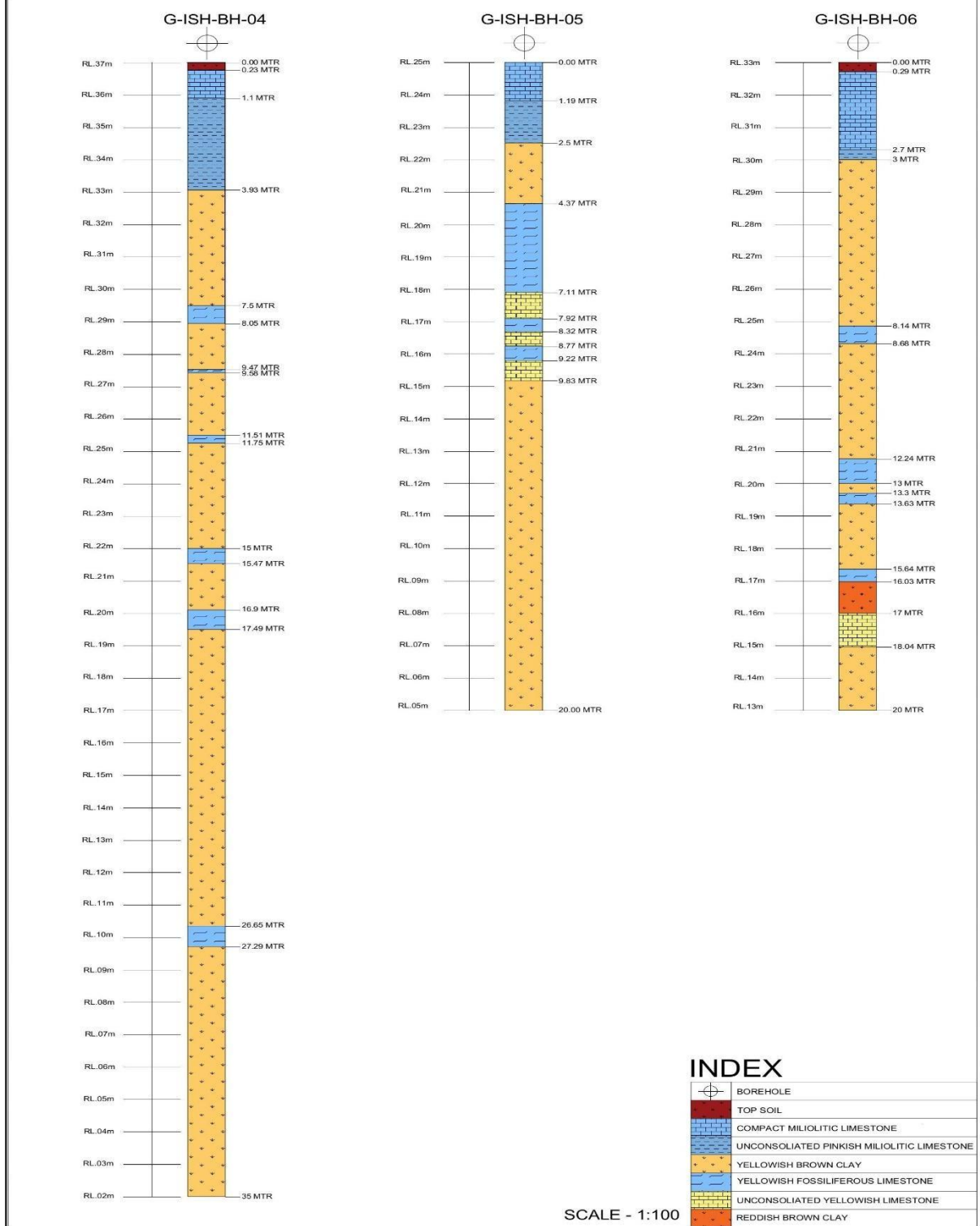


Plate No. IX(B): Lithologs of Borehole – 4, 5 and 6 of Ishwariya Limestone Block, Gir Somnath district, Gujarat.

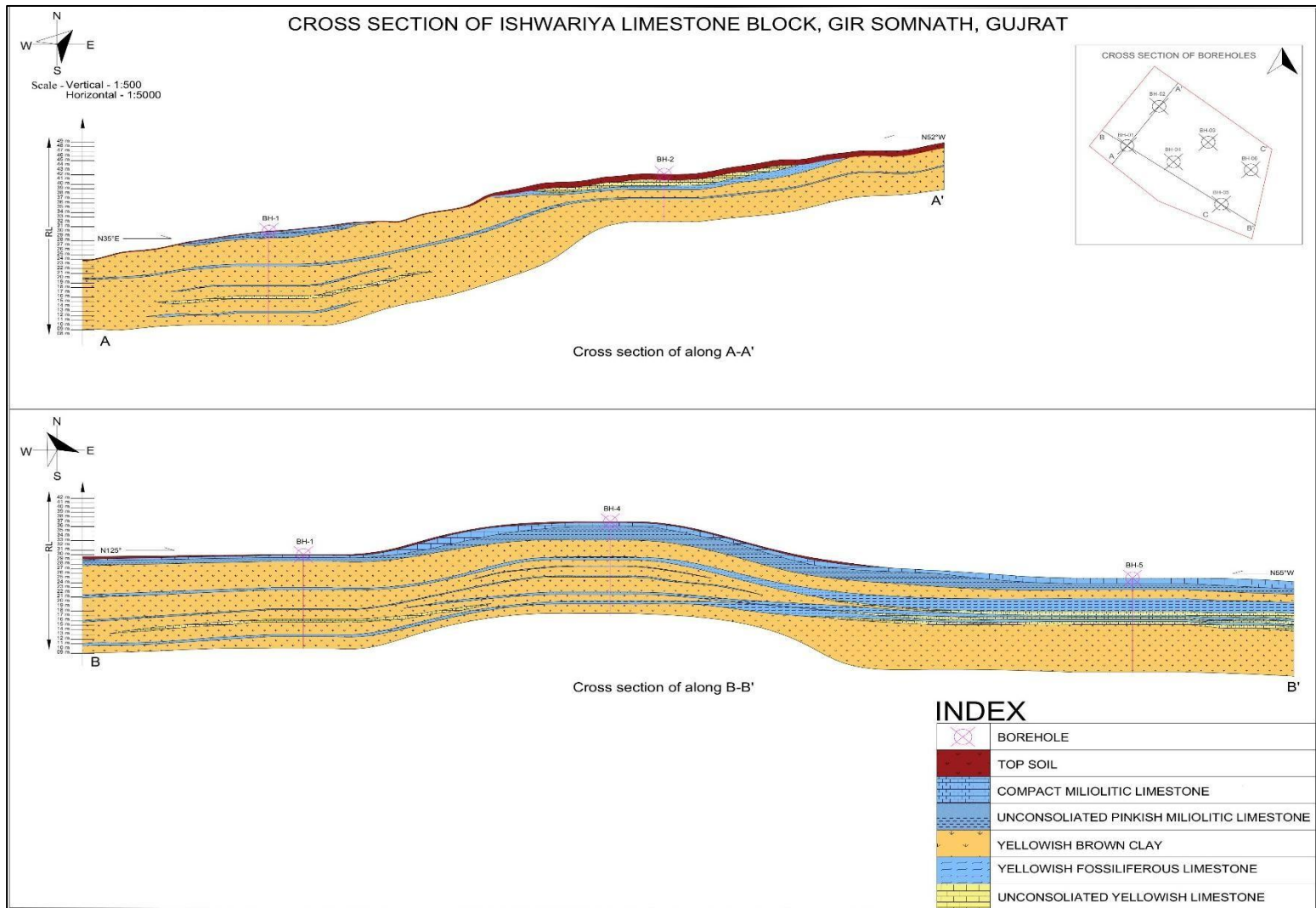


Plate No.X: Cross Section of Boreholes of Ishwariya Limestone Block, Gir Somnath district, Gujarat.

CHAPTER – 14

SUB SAMPLING TECHNIQUES AND SAMPLE PREPARATIONS

14.1.0 WHETHER CUT OR DRAWN AND WHETHER QUARTER, HALF OR ALL CORE TAKEN

Core sampling and chemical analysis were carried out for the entire mineralized zones/lengths intersected in the drilled boreholes. Based on visual inspection, samples were delineated within the limestone-bearing zones. The mineralized core was split into two equal halves using a core splitter in such a manner that the concentration of ore minerals remained uniform in both halves. One half of the core sample was crushed to 150 mesh size, and an approximately 600 gm representative sample was prepared by gradual size reduction through the coning and quartering method using a crusher and pulveriser. Thereafter, two sample pouches each weighing 200 gm were prepared. One sample pouch was analysed at the **Inspectorate Griffith India Pvt. Ltd. Gandhidham**, Gujarat for limestone analysis of major oxides. External check samples were also sent to the **Shiva Analytical India Pvt. Ltd.** Bengaluru for analysis. The remaining 200 gm portion of the sample was preserved for future purposes, including composite sample analysis etc.

14.2.0 NATURE, QUALITY AND APPROPRIATENESS OF THE SAMPLE PREPARATION TECHNIQUE

Quality of the sample preparation is maintained by proper cleaning, maintenance of the equipment and proper crushing, sieving and coning and quartering of samples. For sample preparation proper technique and expertise has been used.

14.3.0 QUALITY CONTROL PROCEDURES ADOPTED

Primary core samples were collected from the entire mineralized zones intersected in the drilled boreholes, and the samples were prepared with utmost care following standard sampling procedures. A total of 78 primary samples (38 Borehole Samples, 40 Bedrock Samples) were collected and analysed. The CaO content of the 40 Bedrock Samples ranged from 48.82% to 53.78%, the 38 Borehole Samples from 12.00% to 53.20%. A total of 6 composite samples were prepared and analysed for 12 major oxides/radicals by the Conventional Wet chemical method. Standard sampling procedures were followed under the supervision of a qualified sampling technician to ensure sample quality.

Similarly, 9 External Check samples were prepared under the supervision of a qualified sampling technician to ensure sample quality, at a NABL-accredited laboratory.

14.4.0 MEASURES TAKEN TO ENSURE THE SAMPLING IS REPRESENTATIVE OF THE INSITU MATERIAL COLLECTED

All the primary samples have been marked and prepared from mineralised cores. During the preparation of primary samples, the mineralised cores have been studied meticulously and samples have been marked properly. These mineralised cores are subjected for preparation of primary samples as per the sampling procedure for primary samples are described in section 14.1.0. The proper marking of primary samples from drilled cores and following standard procedure for sample preparation shows the representative samples have been collected from the in-situ materials.

14.5.0 WHETHER SAMPLE SIZES ARE APPROPRIATE TO THE GRAIN SIZE OF THE MATERIAL BEING SAMPLED

The primary samples have been prepared by 150 mesh size and all the other samples have been prepared from primary samples. As per the previous studies in the area 150 mesh size is appropriate for the analysis of limestone etc. mineralization in the block area.



Fig. No. 9: Photograph showing sample preparation

14.6.0 COMPOSITE SAMPLE PREPARATION

Composite samples were prepared from the core samples to obtain a representative sample for chemical analysis. For this purpose, metre-wise portions of the core samples

were collected from the selected **20 m borehole interval** and combined to prepare a representative composite sample. The procedure followed for preparation of the composite sample is described below:

Sample Selection: Representative metre-wise core samples covering the selected 20 m borehole interval were identified and selected for composite preparation. Portions from each metre were taken so that the complete interval was represented in the composite sample.

Cleaning: The selected core samples were cleaned to remove adhering drilling material and other extraneous matter, thereby minimizing the possibility of contamination during subsequent sample preparation.

Crushing and Pulverization: The selected sample portions were crushed and pulverized to obtain a fine and homogeneous material suitable for chemical analysis. The powdered material was sieved to obtain the required particle size for analysis.

Mixing: Appropriate portions of the powdered material from each metre-wise sample were thoroughly mixed to ensure uniform distribution and to obtain a representative composite sample of the selected 20 m interval. The composite was prepared to represent the overall/bulk chemical composition of the interval, including the variation in grade within the sampled section.

Coning and Quartering: The thoroughly mixed material was subjected to coning and quartering to reduce the bulk sample to the required quantity while maintaining its representativeness.

Final Sample: The prepared composite sample was properly packed, labelled and submitted for chemical analysis. The composite sample thus represents the combined material from the selected 20 m borehole interval and provides an assessment of its overall chemical composition.

CHAPTER-15

QUALITY OF ASSAY DATA AND LABORATORY TESTS

15.1.0 THE NATURE, QUALITY AND APPROPRIATENESS OF THE ASSAYING AND LABORATORY PROCEDURES

15.1.1 The primary samples 78 from limestone mineralization have been analysed for 06 radicals i.e., CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃ and LOI by XRF Chemical Laboratory of Inspectorate Griffith India Pvt. Ltd, Gandhidham, Gujarat, NABL accredited Laboratory.

15.2.0 STANDARD OPERATING PROCEDURE (SOP) FOR THE ANALYSIS BY INSPECTORATE GRIFFITH INDIA PVT.LTD, GANDHIDHAM, GUJARAT.

CHEMICAL ANALYSIS

1. Fusion Bead (using XRF)
2. XRF (Rigaku ZSX Primus IV)
3. CRM used- IPT-44

Procedure for Preparation of Fusion Bead:

Procedure for Preparation of Fusion Bead:

For XRF measurement a sample must be homogenized, pulverized to -100 mesh and pressed into Fusion Bead

- (i) Weigh accurately 1 gms of sample and used 10 gms of Lithium Tetraborate Meta borate acid as a binder.
- (ii) Press the mixer in a fusion bead machine for making of bead.
- (iii) Calibrate the XRF equipment using known standards for elements present in limestone (Calcium, Magnesium etc)
- (iv) Ensure the instrument is set up correctly according to standard guidelines
- (v) Place the prepared Fusion Bead into the sample holder
- (vi) Ensure the sample cup is positioned correctly in the instrument for carrying out analysis
- (vii) Start the XRF analysis using software and initiate the analysis process automatically.

- (viii) Allow the XRF instrument to scan the sample. It will emit X-rays onto the sample, causing the atoms to emit fluorescence.
- (ix) Record the results in a report, including elemental concentrations and any relevant information about the analysis conditions.
- (x) Intermediate check also performed using bead with inbuilt software.

LOSS ON IGNITION

WCL procedure for determination of LOI

Weighed quantity of sample (duly dried at 110°C) is placed in platinum crucible and heated to 1000°C for about an hour. Sample is again weighed after it is cooled. Difference in weight expressed in percentage as LOI.

15.3.0 NATURE OF QUALITY CONTROL PROCEDURES ADOPTED

15.3.1 In order to ensure the accuracy of the analyzed samples, **IPT-44** has been used as certified reference material. The Certified Reference Material (CRM) was processed under similar conditions as samples and run after every 20 samples.

15.3.2 A total 09 nos. of external check samples have been analyzed by Shiva analytical India Private Limited, laboratory, Bangaluru, for 06 radicals by XRF methods, however 4 radicals i.e. **CaO, MgO and Fe₂O₃, SiO₂** analysis have been statically comparing to check the reliability of chemical analysis and the results are given in **Annexure IV**. Statistical comparison has been furnished below in the following **Table No.15.1.** and corresponding **Figure No.18.**

Table No. 15.1 Showing Statistical comparison between Primary samples Vs External samples.

ELEMENTS	CaO%				MgO%				Fe ₂ O ₃				SiO ₂			
	Primary Sample CaO%	External Sample CaO%	Difference	Percentile%	Primary Sample MgO%	External Sample MgO%	Difference	Percentile%	Primary Sample Fe ₂ O ₃ %	External Sample Fe ₂ O ₃ %	Difference	Percentile%	Primary Sample SiO ₂ %	External Sample SiO ₂ %	Difference	Percentile%
ISH-BRS-02	53.48	53.02	0.46	0.25	0.33	0.43	-0.10	0.001	0.21	0.40	-0.20	0.0004	1.30	1.60	-0.30	0.004
ISH-BRS-14	53.01	52.58	0.43	0.23	0.40	0.49	-0.09	0.001	0.54	0.84	-0.30	0.0016	1.38	1.55	-0.17	0.002
ISH-BRS-17	49.17	48.91	0.26	0.13	0.88	0.94	-0.06	0.001	1.28	1.82	-0.54	0.0069	5.24	5.08	0.16	0.008
ISH-BRS-37	53.46	51.71	1.75	0.93	0.42	0.47	-0.05	0.004	0.66	1.09	-0.43	0.0028	2.32	2.36	-0.04	0.001
ISH-BRS-48	53.26	52.35	0.91	0.49	0.40	0.43	-0.03	0.002	0.69	1.10	-0.41	0.0028	1.63	1.72	-0.09	0.001
ISH-BHS-3	29.46	27.01	2.45	0.72	1.50	1.48	0.02	0.011	3.29	4.71	-1.43	0.0468	27.38	25.92	1.46	0.399
ISH-BHS-15	53.20	52.14	1.06	0.56	0.44	0.48	-0.05	0.003	0.84	1.22	-0.38	0.0032	2.69	2.15	0.54	0.014
ISH-BHS-24	12.21	9.74	2.47	0.30	2.18	2.13	0.04	0.006	4.79	6.42	-1.63	0.0781	50.19	49.88	0.31	0.157
ISH-BHS-33	51.00	50.53	0.47	0.24	0.42	0.47	-0.05	0.001	1.51	2.11	-0.60	0.0091	4.58	3.35	1.23	0.057

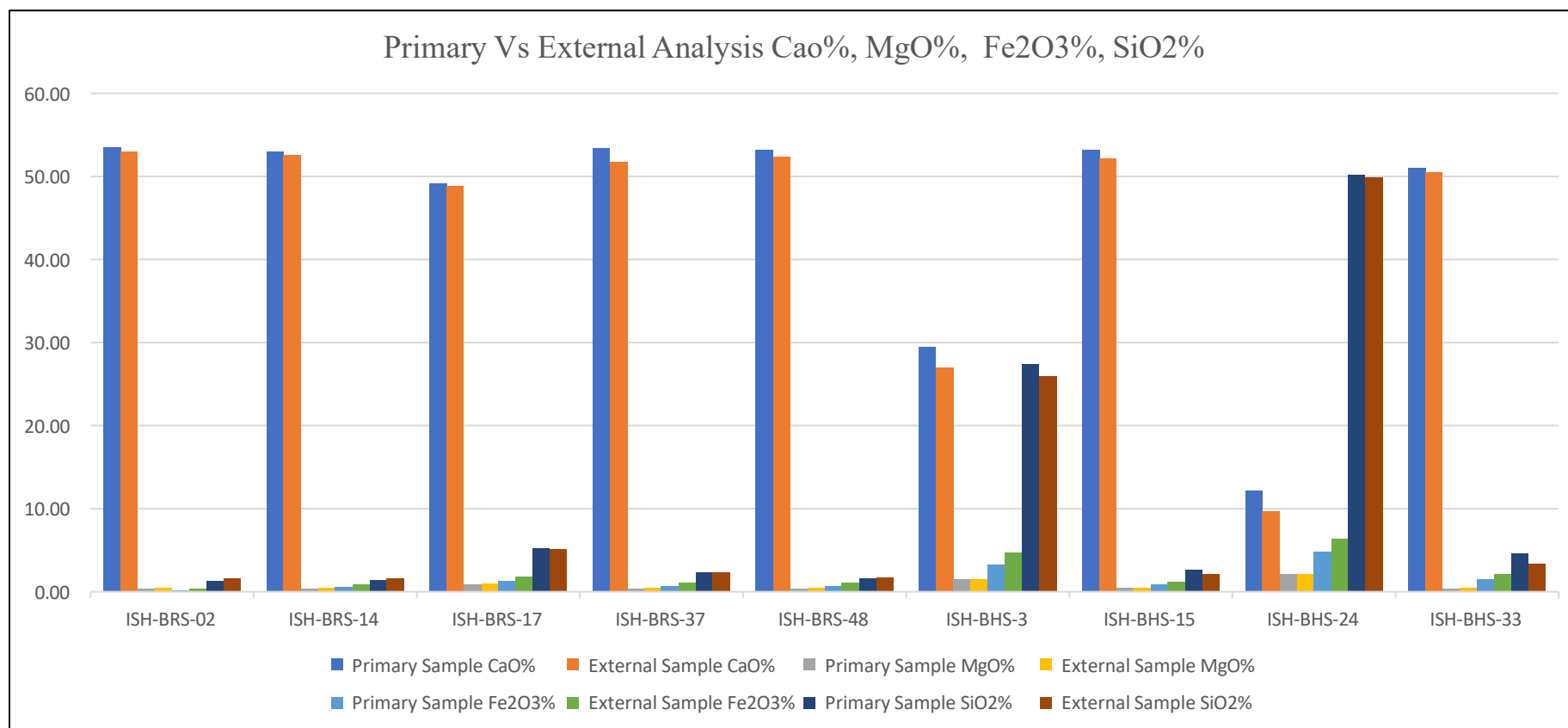


Fig. No. 10– Graphical Representation of Primary Vs External Check Analysis Cao%, MgO%, Fe₂O₃%, SiO₂%

15.3.3 It has been observed that: -

- The analytical results obtained from the primary laboratory and the external check laboratory exhibit a close correlation for the major oxides, namely (CaO, MgO, Fe₂O₃, and SiO₂), indicating high analytical consistency. The average variation between the two analyses is approximately 1.22% for CaO, 0.05% for MgO, 0.66% for Fe₂O₃, and 0.50% for SiO₂. These minor variations are within acceptable analytical limits, confirming the precision, accuracy, and reliability of the analytical data.
- The comparison indicates only minor variations between the two datasets, which are within acceptable analytical limits. CaO values show good agreement, while MgO, Fe₂O₃ and SiO₂ contents also demonstrate satisfactory consistency across all check samples.
- A relatively lower CaO value with corresponding higher impurity is observed in sample **ISH-BHS-24**, and this trend is consistently reflected in both analyses.
- The close correspondence between the primary and external analytical results confirms the precision, reproducibility and reliability of the chemical analyses.
- Accordingly, the primary analytical data are considered dependable for geological interpretation, grade classification and mineral resource estimation.

15.4.0 SECURITY AND CHAIN OF CONTROL OF SAMPLES SHOULD BE CLEARLY MENTIONED

The samples have been prepared at centralized mechanized sampling unit with proper labelling and tag and sent to chemical laboratory in supervision of qualified sampling technician. At the sampling unit, standard procedure has been followed and all the precautionary measures have been taken to avoid the contamination. The sampling unit is separate from the chemical laboratory, so there is no chance of contamination.

CHAPTER - 16

MOISTURE

16.1.0 All the analysis of borehole core samples has been carried out with natural moisture.

CHAPTER – 17

BULK DENSITY/SPECIFIC GRAVITY

17.1.0 SPECIFIC GRAVITY

17.1.1 A total of 05 samples is analysed for Specific Gravity studies in NABL accredited laboratory, Inspectorate Griffith India Pvt.Ltd. and the results are tabulated here under.

Table No. 17.1
Showing Specific Gravity of Ishwariya limestone block

Sr.No.	Sample No.	Specific Gravity
1	ISH-BD-01	2.74
2	ISH-BD-02	2.82
3	ISH-BD-03	2.60
4	ISH-BD-04	2.69
5	ISH-BD-05	2.74
	AVARAGE TOTAL	2.72

17.1.2 The average Specific Gravity of the limestone zones in the block is determined as **2.72** which has been utilised for the resource estimation. specific gravity study report is presented in **Annexure 7.**

CHAPTER – 18

BENEFICIATION STUDIES

18.1.0 The present exploration has no provision for beneficiation studies

CHAPTER – 19

RESOURCE ESTIMATION TECHNIQUE

19.1.0 GENERAL

Estimation of geological resources is the scientific and technical process of determining the quantity, quality, and economic value of any mineral deposit. Following data was considered for resource estimation in the present study (1) Geological mapping (2) Exploratory drilling (3) Core logging (4) Chemical analysis and geological data of adjacent areas. The mineralized limestone horizons were delineated based on lithological and grade continuity. The in-situ Geological Resources have been estimated in accordance with the **UNFC guidelines** and classified under **UNFC Category 333 (Inferred Mineral Resource)**.

For the Ishwariya Limestone Block, the **Thiessen Polygon Method** has been modified and adopted for resource estimation. This method is particularly suitable where the mineralized bodies occur as isolated or discontinuous pockets and where lateral continuity between boreholes cannot be confidently established. The method provides a realistic estimate of resources by assigning an area of influence around each borehole based on its spatial location. The thickness and grade of each mineralized zone intersected in the borehole have been considered as it is for the entire influence area of the borehole. The influence area has been taken for the whole area of the limestone outcrop instead of restricting to the polygon containing borehole only.

19.1.1 Grades and Resource have been assessed on the basis of end-use grade classification given by IBM's National Mineral Inventory (NMI) in following three categories i) Threshold grade (≥ 34 to $< 38\%$ CaO) in addition to ii) Blendable grade (≥ 38 to $< 44\%$ CaO, $< 5\%$ MgO and $< 18\%$ SiO₂) and iii) Cement grade ($\geq 44\%$ CaO, $< 3.5\%$ MgO and $< 16\%$ SiO₂).

19.1.2 Further Resource have been estimated and categorized as per UNFC and placed as **Inferred Resource (333) category**.

19.2.0 ASSUMPTIONS FOR RESOURCE ESTIMATION

For limestone grade categorization into cement, blendable and threshold grade, CaO has been considered strictly. For other radicals like in case of MgO and CaO, slight variation on higher side is also considered.

Resource estimated for Cement grade limestone CaO $\geq 44\%$, 3.5% MgO (Max) and 16% SiO₂ (Max), Blendable Grade CaO $\geq 38\%$ to $< 44\%$, 5.00% MgO (Max) and 18% SiO₂ (Max)

and Threshold grade limestone is $\text{CaO}\% \geq 34\%$ to $< 38\%$ and 6.00% MgO (Max) are considered for the assessment of limestone resource.

- The zones of different grades have been demarcated from the values of primary sample analysis as per cut-off limits by End Use Grade specifications by IBM for CaO , MgO and SiO_2 . The minimum cumulative thickness of 1.00m of all grades has been considered for resource calculation in methods.
- The exploration scheme was formulated for G-3 level exploration after completing the exploration program, which involved drilling 06 boreholes ISH-BH-1 to ISH-BH-06 in Ishwariya block.
- The limestone body in the block is represented by a laterally persistent, thinly bedded horizons exhibiting predominantly high-calcium characteristics. Considering the continuity of the mineralized zone and its surface disposition, resource estimation has been carried out by adopting the Polygon-cum-Outcrop Method.
- The average **specific gravity** of limestone has been taken as **2.718** based on the analysis of five limestone samples carried out at the Inspectorate Griffith India Private Limited Laboratory, Gandhidham Gujarat. This value has been used for the computation of resources for **Cement-Grade, Blendable-Grade, Threshold-Grade** limestone.
- A **deduction of 30%** from Gross in-situ resource has been made to arrive at Net-in-situ resource by polygon method for unseen geological factors i.e. volume of ore body, nature of core, recovery factor, cavities/caverns and other structural features.
- Polygonal resource is calculated for Cement, Blendable and Threshold grades for thickness of limestone zone of respective grades encountered in each borehole is enclosed as **Annexure 11A, 11B** for Polygonal resources.

19.2.1 Evaluation of Mineralisation Zones

- The mineralized thickness of the limestone was determined from detailed lithological logging of boreholes. Only those intervals satisfying the prescribed grade specifications were considered for resource estimation. The thickness of mineralized limestone encountered in each borehole was assigned to the corresponding Thiessen polygon/outcrop.
- The limestone horizon exhibits good lateral continuity, whereas compact limestone at depth is localized and variable in thickness. Grade variations are primarily controlled by localized clay intercalations and lithological heterogeneity. Based on lithological continuity, borehole correlation and chemical characteristics, the mineralized zones have been delineated and

classified for resource estimation using the **Polygon-cum-Outcrop Method** towards the margins of the block. Consequently, the thickness distribution is highly variable and non-uniform across the deposit.

- A total of **38** core samples was generated from **120 m** of core drilling conducted across **06** exploratory boreholes drilled at 800x800 m grid. Out of these, boreholes **BH-01, BH-02 BH-03, BH-04, BH-05, BH-06** intersected limestone of **Cement Grades**. Whereas **BH-2, BH-5 intersected** predominantly **Blendable Grade**.

19.2.2 Resources Estimation Methods

The limestone deposit in the Ishwariya Block is a **stratified sedimentary deposit** intercalated with localized clay horizons and unconsolidated limestone. Measurements of bedding attitudes indicate that the limestone beds are generally **sub-horizontal to gently dipping**, with dip angles ranging from **1° to 20°**. The steeper dips are of local nature probably representing foreset dips instead of beds. In view of this geometry, detailed geological mapping on a **1:4,000** scale was carried out to accurately delineate the surface extent and distribution of the limestone deposit.

The mapping exercise enabled precise demarcation of the limestone outcrops and their spatial continuity within the block. To establish the subsurface continuity and determine the thickness variation of the deposit, a total of 06 boreholes were drilled at suitable locations across the mineralized zone. The details of the boreholes, including their coordinates, Reduced Levels (R.L.) and depths, are furnished in **Table No.10.3**.

Based on the integrated interpretation of surface geological mapping, borehole lithological data, and analytical results, the lateral extent and thickness of the limestone deposit were established. Subsequently, the **Thiessen Polygon Method** was adopted for resource estimation, wherein individual areas of influence were assigned to each borehole and the resources were computed using the polygonal/outcrop area, mineralized thickness, and bulk density data. This method was considered appropriate in view of the nature of the limestone bodies and the variable thickness distribution within the depositional environment.

The resource estimation has been restricted to the **upper mineable limestone horizon**, which exhibits sufficient thickness, lateral continuity, and grade to constitute an economically viable resource. Thin and discontinuous limestone beds encountered at deeper levels below the overburden have **not been incorporated** in the resource estimation, as they lack adequate

thickness and continuity and are not considered economically viable under the present geological conditions.

19.3.0 PARAMETERS OF RESOURCE ESTIMATION

19.3.1 Sampling Procedure

The primary samples have been collected as per the litho-contact and sample length of one meter has been taken, however due to lithological variations in some instances the sample length was also taken less than 1m, but resource has not been calculated for the zones which are less than 1m. Samples from bore hole cores were crushed to (-) 150 mesh size, reduced by conning and quartering, thoroughly mixed and representative samples of 200g were prepared and sent to laboratory for analysis of 6 radicals by XRF methods i.e. CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃, and LOI at Chemical Laboratory Inspectorate Griffith India Private Limited Laboratory Gandhidham Gujarat, and results were obtained to delineate the ore zones.

19.3.2 Chemical Analysis

A total of 78 primary samples, 40 bedrock and 38 core samples, collected from the Ishwariya Block were analysed for six major radicals. The analytical results of 40 Bedrock Samples (BRS) are enclosed as **Annexure-2** and **Annexure-8**, respectively. The 38 core samples obtained from 06 boreholes (ISH-BH-1 to ISH-BH-06), drilled by PRB Infraprojects Private Limited, Nagpur, were also analysed for six radicals and the results are enclosed as **Annexure-3**. Further, 09 external check samples were sent to **Shiva Analytical India Private Limited, Bengaluru**, for analysis, and the analytical results are enclosed as **Annexure-4**. Considering the open cast potentiality of the block, the minimum workable thickness / minimum stopping width of 1.00 m and minimum non ore parting of 1.00 m is considered for resource estimation.

19.4.0 OVERBURDEN

The study area is concealed beneath a thin to moderately developed cover of black cotton (regur) soil, with an average thickness ranging from 0.1 m to 0.4 m. The thickness of the soil cover varies locally depending on topography, being relatively greater in agricultural fields and lower in areas of exposed limestone. The regur soil is dark grey to black and clayey. Unconsolidated alluvial and colluvial deposits consisting of clay, silt, sand, and limestone gravels are locally present along seasonal drainage channels and in low-lying areas. These

superficial deposits obscure the underlying bedrock and limit the continuity of rock exposures across the block. The distribution of soil-covered and exposed limestone areas has been delineated and mapped in **Plate No-IV**.

19.5.0 METHODOLOGY

Thiessen Polygon Method was adopted for resource estimation, wherein individual areas of influence were assigned to each borehole and the resources were computed using the polygonal area, mineralized thickness, and bulk density data. This method was considered appropriate in view of the discontinuous nature of the limestone bodies and the variable thickness distribution within stratified depositional environment.

The Thiessen Polygon Method, also known as the Nearest Neighbour Method, is based on the principle that each borehole represents the geological characteristics of the area nearest to it. The method divides the mineralized area into a series of polygons around each borehole such that every point within a polygon is closer to its corresponding borehole than to any other borehole.

The geological parameters such as thickness, grade, and bulk density observed in a borehole are assumed to represent the entire area enclosed by its respective polygon. Resources are estimated independently for each polygon and subsequently aggregated to derive the total geological resource. This method is suitable for preliminary exploration (G-3) level investigations where borehole density is moderate and geological continuity cannot be established with a high degree of confidence.

19.5.1 Methodology Adopted in Thiessen's Polygonal Method of Resource Estimation

Geometric Modelling and Area of Influence (Polygon Method)

The primary objective of this method is to demarcate the distinct area of influence for the limestone intersected by individual boreholes. This area of influence was determined geometrically by constructing Thiessen polygons, generated through perpendicular bisectors drawn between adjoining boreholes. Within each individual polygon, only the proven mineralized area has been considered for resource estimation, while non-mineralized zones have been strictly excluded.

The spatial extent of these zones was calculated using GIS software, and areas showing non-development of the respective limestone zones are explicitly demarcated on the Resource Plan. The block's entire limestone body has been divided into six (06) major geometric polygons.

Volumetric Constraints and Horizon-wise Classification

The vertical dimension (height) of each polygon corresponds to the cumulative thickness of the limestone horizons encountered within the respective borehole. However, to account for depth-wise continuity, extraction constraints, and stratigraphic position, the resource has been classified as follows:

- **Surface-Mineable Resource:** The surface-mineable resource estimation has been strictly confined to the primary upper limestone horizon directly underlying the overburden contact.
- **Total/Sub-surface Resource:** Deeper sedimentary or thin limestone bands interbedded at depth, beneath the primary upper horizon, have been excluded from the surface-mineable calculations due to data constraints and immediate mining feasibility. Instead, these thin, lower-lying limestone beds have been integrated solely into the **Total Resource** inventory of the block.

Grade Assignment and Deductions

Resource estimation has been carried out borehole-wise and polygon-wise, categorized into distinct commercial grades, namely **Cement Grade** and **Blendable Grade** limestone. Based on chemical analysis grade assigned to each polygon block matches the weighted average grade calculated from its corresponding borehole intersection. Furthermore, any zones demonstrating non-development of a specific grade within a borehole have been precisely deducted from the final volume calculations.

19.5.2 Database Used for Resource Estimation

The resource estimation was carried out using the following exploration data generated during the investigation:

- i) Geological mapping data.
- ii) DGPS surveyed borehole collar coordinates.
- iii) Borehole lithological logs.
- iv) Chemical analytical data of limestone samples.
- v) Bulk density measurements.

- vi) Geological cross-sections and plans.
- vii) Topographical survey data.

The above datasets were integrated and interpreted to delineate mineralized limestone zones and estimate the geological resources.

19.5.3 Preparation of Thiessen Polygons

The Thiessen polygons were prepared using the borehole collar coordinates plotted on the geological plan.

The procedure adopted is summarized below:

- i) All boreholes were plotted using DGPS coordinates.
- ii) Adjacent boreholes were connected by straight lines to form a network of triangles.
- iii) Perpendicular bisectors were drawn for each connecting line.
- iv) The intersection of the perpendicular bisectors generated closed polygons around individual boreholes.
- v) The resultant polygons defined the area of influence of each borehole.
- vi) The polygon boundaries were subsequently constrained within the mineralized zone limits, geological boundaries and block boundary.

The area enclosed by each polygon was calculated using GIS software and utilized for resource estimation.

19.5.4 Estimation of Polygonal Area

The area of influence of each borehole was determined through Thiessen polygon construction.

The actual limestone outcrop area contained within each polygon was measured using GIS software and expressed in square metres (m²).

The polygon area thus obtained represents the areal extent of limestone influenced by the respective borehole.

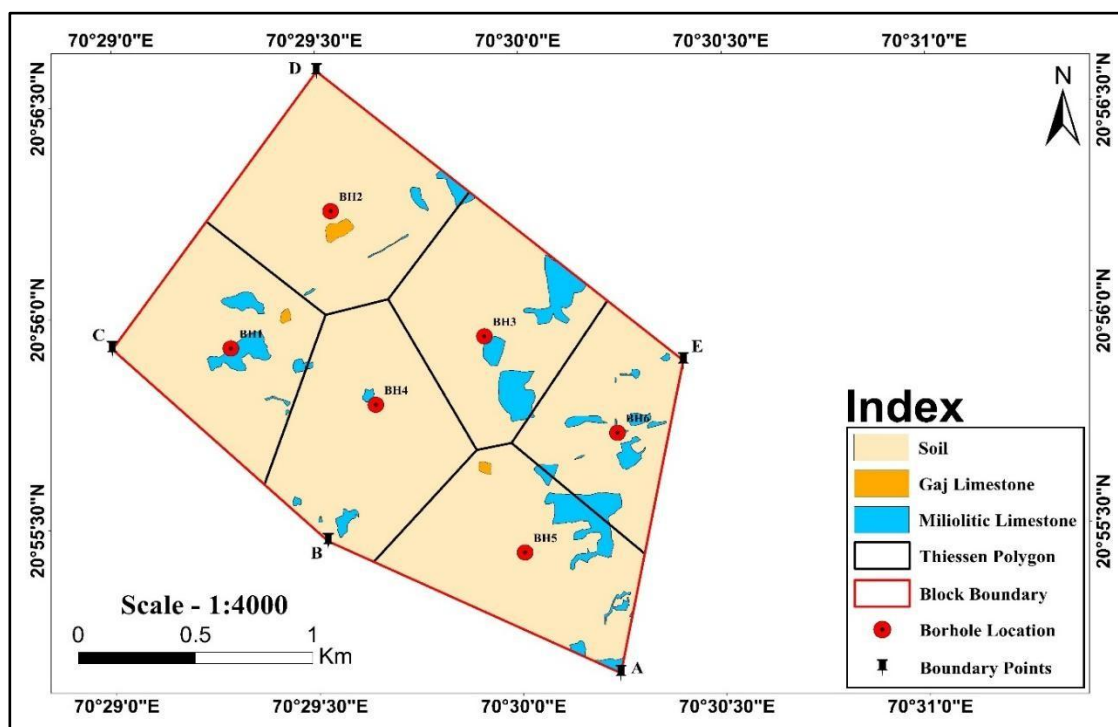


Plate No. XI: Geological map using Thiessen's Polygon Method Showing influence area of borehole calculated using Thiessen's Polygon method.

Table No. 19.1
Surface area of influence for the mineralized area of each borehole.

BH No.	Polygon Bo.	Surface area of Limestone (Sq. Km)
BH-1	POLYGON-1	0.038142
BH-2	POLYGON-2	0.019509
BH-3	POLYGON-3	0.068932
BH-4	POLYGON-4	0.009804
BH-5	POLYGON-5	0.051961
BH-6	POLYGON-6	0.039644
Total		0.23

19.5.5 Volume Estimation

The volume of limestone within each polygon was calculated using the following formula:

$$\text{Volume (m}^3\text{)} = \text{Polygon Area (m}^2\text{)} \times \text{Average Mineralized Thickness (m)}$$

Where:

- Polygon Area = Area of influence of the borehole.
- Average Mineralized Thickness = Thickness of limestone established from drilling and pitting data.

The total geological volume was obtained by summing the volumes of all individual polygons.

Table No. 19.2
Showing surface area and the thickness of the limestone deposit.

BH.No.	Polygon Bo.	Surface area of Limestone (Sq. Km)	Thickness (m)
BH-1	POLYGON-1	0.038142	1.27
BH-2	POLYGON-2	0.019509	3.01
BH-3	POLYGON-3	0.068932	3.07
BH-4	POLYGON-4	0.009804	3.70
BH-5	POLYGON-5	0.051961	7.96
BH-6	POLYGON-6	0.039644	2.71
Total		0.23	21.72

19.5.6 Tonnage Estimation

The geological resource tonnage was estimated by multiplying the volume of limestone by the average bulk density determined from laboratory studies.

$$\text{Geological Resource (Tonnes)} = \text{Volume (m}^3\text{)} \times \text{Bulk Density (t/m}^3\text{)}$$

Where:

- Volume = Estimated limestone volume.

- Bulk Density = Average bulk density of limestone.

The total geological resources were computed separately for Cement Grade, Blendable Grade, and Beneficiable–Blendable Grade limestone.

Specific Gravity

A total of five nos. of limestone core samples from boreholes were subjected to specific gravity determination by Calliper Method in Inspectorate Griffith India Private Limited, Gandhidham Gujarat. The average specific gravity of these five samples has been determined as **2.718 gm/cc** and the same have been considered for estimation of resources. The results of specific gravity determination are calculated in **Annexure-7**. Minimum thickness of 2m for the demarcated grade was considered for resource estimation.

19.5.7 Application of Reduction Factors

The Thiessen Polygon Method assumes that the thickness encountered in a borehole is representative of the entire polygonal area. However, geological observations in the Ishwariya Limestone Block indicate that a **stratified sedimentary deposit** intercalated with localized clay horizons and unconsolidated limestone.

The Ishwariya limestone block constitutes a stratified, sub-horizontal sedimentary deposit exhibiting its maximum net thickness 7.95 m in the southeastern sector (G-ISH-BH-5) and progressively tapering toward the central southwestern margin (G-ISH-BH-01) accordingly, standard reduction factors 30% for thickness variations, clay intercalations, and spatial continuity was applied during polygonal resource estimation.

Accordingly, reduction factors of **30%** were applied to the gross geological resources estimated by the Thiessen Polygon Method.

The reduced resource estimates represent more realistic and conservative assessments of the potentially mineable limestone resources considering:

- i) Irregular bedded sedimentary sequence.
- ii) Gradual Thinning Towards Peripheral Margins.
- iii) Discontinuous & Interbedded Nature of limestone bodies.
- iv) Geological uncertainty between borehole intersections.
- v) Variability in thickness and lateral continuity.

The resources after application of 30% reduction factors have been reported separately to provide a range of realistic resource scenarios.

Table No. 19.3
Showing tonnage calculated by considering 30% reduction of thickness and covering surface area of limestone

AREA INFLUENCE FOR ESTIMATION OF RESOURCE BY THIESSEN POLYGON METHOD IN ISHWARIYA LIMESTONE BLOCK ,GIR SOMNATH DISTRICT ,GUJARAT.												
BH No.	Polygon Bo.	Surface area of	Surface area of	Total Surface Area (Sq. Km)	Thickness (m)	volume	Sp.Gravity	Tonnage	After Reduction of 30% of Thickness			
									Reduction	volume	Sp.Gravity	Tonnage
BH-1	POLYGON-1	0.038142	0.503099	0.541241	1.27	687376.07	2.718	1868288.16	0.89	481163.25	2.718	1307801.71
BH-2	POLYGON-2	0.019509	0.630308	0.649817	3.01	1955949.17	2.718	5316269.84	2.11	1369164.42	2.718	3721388.89
BH-3	POLYGON-3	0.068932	0.498003	0.566935	3.07	1740490.45	2.718	4730653.04	2.15	1218343.32	2.718	3311457.13
BH-4	POLYGON-4	0.009804	0.607334	0.617138	3.70	2283410.60	2.718	6206310.01	2.59	1598387.42	2.718	4344417.01
BH-5	POLYGON-5	0.051961	0.567097	0.619058	7.96	4927701.68	2.718	13393493.17	5.57	3449391.18	2.718	9375445.22
BH-6	POLYGON-6	0.039644	0.394173	0.433817	2.71	1175644.07	2.718	3195400.58	1.90	822950.85	2.718	2236780.41
Total		0.23	3.20	3.43	21.72	12770572.04		34710414.80	15.20	8939400.43		24297290.36
								34.71 Million Tonnes				24.29 Million Tonnes

19.6.0 GRADE WISE CATEGORISATION OF RESOURCES

- For limestone, grade categorization into cement, blendable and threshold grade, CaO has been considered strictly. For other radicals like in case of MgO and SiO₂, slight variation on higher side is also considered.
- Resource estimated for Cement grade limestone CaO ≥ 44%, 3.5% MgO (Max) and 16% SiO₂ (Max), Blendable Grade CaO ≥ 38 % to <44%, 5.00% MgO (Max) and 18% SiO₂ (Max) and Threshold grade limestone is CaO% ≥ 34% to <38% and 6.00% MgO (Max) are considered for the assessment of limestone resource

Table No. 19.4
Showing grade wise classification criteria for limestone

Grade Category	CaO (%)	MgO (%)	SiO ₂ (%)
Cement Grade	>44.00	≤3.50	≤16.00
Blendable Grade	>38.00 to <44.00	≤5.00	16.00–18.00
Threshold Grade	≥34.00	≤6.00	≤18.00
Beneficiable–Blendable Grade	>38.00 to <44.00	≤5.00	>18.00

The grade wise classification has been conducted after the detailed classification of the chemical analysis results variation with respect to the depth. The total quantity and quality of the deposit in Ishwariya Limestone block is shown below.

Table No. 19.5
Showing the grade wise total reserves with average CaO, MgO & SiO₂ in Ishwariya Limestone Block

Grade Category	Resource Category	Gross Geol. Res. (Mil. tons)	Net Geol. Res. (30% reduction) (Mil. tons)	Avg. CaO	Avg. MgO	Avg. SiO ₂
Cement Grade (R1)	333	31.07	21.75	47.10	0.49	7.54
Blendable Grade (R2)	333	3.64	2.55	40.91	0.82	14.42
Total R₁+R₂		34.71	24.30			

CHAPTER – 20

REPORTING OF RESOURCE

20.1.0 RESOURCE ESTIMATION

- 20.1.1 The limestone resources have been estimated grade-wise, borehole-wise and section-wise using the **Thiessen Polygon Method** based on the various mineralized zones intersected in the boreholes and the specifications and assumptions outlined earlier. Resource estimation has been carried out for each borehole and corresponding cross-sections considering the thickness and grade of limestone encountered. The estimated resources have been classified according to resource category and limestone grade. Detailed grade-wise and category-wise resource estimates derived through the polygonal method are presented in the respective **Annexures. 11 A, 12 B.**
- 20.1.2 The total gross in-situ resources of limestone are broadly categorized under inferred resource category. The details of the same are furnished in the following tables for Ishwariya Limestone block.

Table No. 20.1
Summary of Cement Grade Limestone Resource of Ishwariya Limestone Block

BH No.	Polygon No.	Surface area of Limestone (Sq. Km)	Category	100% Thickness calculation	Volume	Sp.Gravit y	Tonnage	Reduction factor 30% of Thickness				
				Thickness (m)				Reduction	Thickness after 30% reduction	volume	Sp.Gra vity	Tonnage
BH-1	POLYGON-1	0.541241	Cement Grade	1.27	687376.07	2.718	1868288.16	0.38	0.89	481163.25	2.718	1307801.71
BH-2	POLYGON-2	0.649817	Cement Grade	2.18	1416601.06	2.718	3850321.68	0.65	1.53	991620.74	2.718	2695225.18
BH-3	POLYGON-3	0.566935	Cement Grade	3.07	1740490.45	2.718	4730653.04	0.92	2.15	1218343.32	2.718	3311457.13
BH-4	POLYGON-4	0.617138	Cement Grade	3.70	2283410.60	2.718	6206310.01	1.11	2.59	1598387.42	2.718	4344417.01
BH-5	POLYGON-5	0.619058	Cement Grade	6.67	4129116.86	2.718	11222939.63	2.00	4.67	2890381.80	2.718	7856057.74
BH-6	POLYGON-6	0.433817	Cement Grade	2.71	1175644.07	2.718	3195400.58	0.81	1.90	822950.85	2.718	2236780.41
Total		3.43		19.60	11432639.11		31073913.10	5.88	13.72	8002847.38		21751739.17
							31.07					21.75

The total geological resources of Cement Grade limestone estimated in the Ishwariya Limestone Block amount to **26.75 million tonnes** based on 100% thickness consideration. Applying reduction factors of 30% to account for geological uncertainties yields estimated resources of **21.75 million tonnes**. The resource estimation has been carried out using the Thiessen Polygon Method based on borehole data and geological continuity established during exploration. Section-wise, borehole-wise, and zone-wise Reconnaissance (G4) and Inferred (G3) resources of Cement Grade limestone for the Ishwariya Limestone Block are furnished in **Annexure No. 11 A (Refer Table No. 20.)**

Table No. 20.2

Summary of Blendable Grade Limestone Resource of Ishwariya Limestone Block

BH No.	Polygon No.	Surface area of Limestone (Sq. Km)	Category	100% Thickness calculation	Volume	Sp.Gravity	Tonnage	Reduction factor 30% of Thickness				
				Thickness (m)				Reduction	Thickness after 30% reduction	volume	Sp.Gravity	Tonnage
BH-2	POLYGON-2	0.649817	Blendable Grade	0.83	539348.11	2.718	1465948.16	0.25	0.58	377543.68	2.718	1026163.71
BH-5	POLYGON-5	0.619058	Blendable Grade	1.29	798584.82	2.718	2170553.54	0.39	0.90	559009.37	2.718	1519387.48
Total		1.27		2.12	1337932.93		3636501.70	0.64	1.48	936553.05		2545551.19
							3.64					2.55

The total geological resources of Blend Grade limestone estimated in the Ishwariya Limestone Block amount to **3.64 million tonnes** based on 100% thickness consideration. Applying reduction factors of 30% to account for geological uncertainties yields estimated resources of **2.55 million tonnes**. The resource estimation has been carried out using the Thiessen Polygon Method based on borehole intersections and the geological continuity established during exploration. Section-wise, borehole-wise, and zone-wise Reconnaissance (G4) and Inferred (G3) resources of Bendable Grade limestone for the Ishwariya Limestone Block are furnished in **Annexure No. 11 B (Refer Table No. 20)**.

20.1.3 Reliability of Resource Estimation

The reliability of the limestone resource estimated in the Ishwariya Limestone Block is considered to be high to moderate commensurate with the level of exploration carried out under the G3 (Preliminary Exploration) stage. The resource estimation is based on geological mapping, borehole data, lithological logging and chemical analyses of representative core samples. A total of 06 boreholes were drilled to establish the continuity, thickness and grade distribution of the limestone horizons. Resource estimation has been carried out using the Thiessen Polygon Method which assigns an area of influence to each borehole and is an accepted method for preliminary-stage evaluations.

To account for geological uncertainties arising from variations in thickness, lateral continuity, and grade distribution, resource estimates have also been computed after applying 30% reduction factors. The resource estimate is dominated by Cement Grade Limestone, supported by consistent geological and chemical analytical data from the boreholes, indicating good continuity of mineralization and enhancing confidence in the resource estimation. However, owing to the wide borehole spacing and preliminary nature of exploration, the resources are classified under Inferred (333) category and their reliability may be further improved through detailed exploration with closer-spaced drilling and additional sampling.

CHAPTER – 21

SUMMARY AND RECOMMENDATION

21.1.0 SUMMARY

21.1.0 The Ishwariya Block for Preliminary Exploration (G-3 stage) for limestone which lies in the Patan Veraval taluka, Gir Somnath District, Gujarat State. It falls in parts of the Survey of India Toposheet No. 41 L/05 and 41 L/09.

21.1.1 The block was investigated through detailed geological mapping, borehole drilling, core logging, and geochemical analysis to assess the occurrence, quality, and resource potential of limestone.

21.1.2 Detailed geological mapping on a scale of 1:4000 was carried out in the block. The limestone deposit in the Ishwariya Block is a **stratified sedimentary deposit** intercalated with localized clay horizons and unconsolidated limestone. strike and dip due to depositional and geomorphological controls. The surface extent of the limestone has been accurately delineated through geological mapping and validated through subsurface exploration.

21.1.3 The limestone exposed in the block is predominantly miliolitic limestone, characterized by yellowish buff to pinkish buff in colour, medium- to fine-grained, moderately hard and locally porous, consisting predominantly of calcarenite composed of miliolid foraminiferal tests embedded within a micritic carbonate matrix. The rock appears hard, compact and brittle in comparatively fresh portions, while the weathered portions are friable and decomposed along joints and fractures

21.1.4 A thin soil cover ranging from 0.1 m to 0.4 m locally the thickness of the soil cover varies locally depending on topography, being relatively greater in agricultural fields and lower in areas of exposed limestone. To establish the subsurface continuity, thickness, and grade distribution of the limestone, 06 boreholes were drilled within the block. All boreholes intersected limestone zones of varying thickness and grade. The borehole locations, geological sections, and lithological details have been utilized for resource estimation (Refer Plate no-IX (A) IX (B) and X)

21.1.5 The limestone encountered in the boreholes comprises Cement Grade, Blendable Grade limestone. The resource estimation was carried out using the Thiessen Polygon Method based on borehole intersections, geological continuity, and analytical data. Grade-wise, borehole-wise, and section-wise resources have been estimated under appropriate UNFC category (333)

21.1.6 Representative core samples collected from the boreholes were analysed for major oxide constituents including CaO, MgO, Al₂O₃, SiO₂, Fe₂O₃ and LOI. The analytical results indicate that Cement Grade limestone constitutes the major portion of the deposit, with subordinate Blendable Grade limestone resources. The resource estimation indicates the presence of substantial Cement Grade limestone with limited quantities of Blendable Grade limestone. The estimated geological resources are summarized below-

Table showing the grade wise total reserves with average CaO, MgO& SiO₂ in Ishwariya Limestone Block

Grade Category	Resource Category	Gross Geol.Res (Mil. tons)	Net Geol. Res. (30% reduction) (Mil. tons)	Avg. CaO	Avg. MgO	Avg. SiO ₂
Cement Grade (R1)	333	31.07	21.75	47.10	0.49	7.54
Blendable Grade(R2)	333	3.64	2.55	40.91	0.82	14.42
Total R₁+R₂		34.71	24.30			

21.1.7 The resources of the Ishwariya Limestone Block have been estimated under **Inferred (333) category** based on geological evidence, borehole intersections and analytical results. Detailed section-wise, borehole-wise and zone-wise resource calculations are furnished in the relevant chapter. (Refer Chapter- 19).

21.2.0 CONCLUSION AND RECOMMENDATIONS

- The Ishwariya Limestone Block contains an estimated **31.07 million tonnes** of Cement Grade limestone, constituting the major resource of the deposit. In addition, **3.64 million tonnes** of Blendable Grade limestone have been established. Thus, the total geological resource of all grades is estimated at **34.71 million tonnes** based on 100% thickness consideration.
- The Total Geological Net in-situ Resource (**considering a 30% reduction factor**) for Cement Grade is estimated at **21.75 million tonnes** with an average grade of 47.10% CaO, 0.49% MgO, and 7.54% SiO₂. The Total Geological Net in-situ Resource of Blendable grade is **2.55 million tonnes** with an average grade of 40.91% CaO, 0.82% MgO, and 14.42% SiO₂. The combined total net geological resource for all grades is **24.30 million tonnes**.
- The resource estimation has been carried out in accordance with the provisions of the Minerals (Evidence of Mineral Contents) Rules, 2015, MMDR Amendment Act, 2015, Mineral Auction Rules, 2015 and subsequent amendments thereto. Geological mapping, drilling, sampling, and resource estimation have been undertaken following accepted exploration practices and UNFC guidelines.
- The exploration has successfully established the presence, continuity, thickness, and quality of limestone within the block. The delineated resources provide a reliable basis for future mine planning, feasibility studies and consideration of the block for mineral concession or auction by the Gujarat State Government. The predominance of Cement Grade limestone indicates good potential for utilization in the cement industry. The limited quantity of Blendable Grade limestone may be suitably blended or selectively mined depending upon end-use requirements.

CHAPTER -22

PLATES AND MAPS

22.1.0 LIST OF PLATES

PLATE NO.	LIST OF PLATES
Plate No.I	Location map of Ishwariya block on toposheet no. 41L/05 & 41L/09 Gir Somnath district, Gujarat.
Plate No.II	Location map of Ishwariya block on googles earth image, Gir Somnath district, Gujarat.
Plate No.III	Regional geological map with location of the block
Plate No.IV	Geological map on 1:4000 scale of Ishwariya limestone block Gir Somnath district Gujarat.
Plate No.V	Outcrop Map of Ishwariya Limestone Block, Gir Somnath, Gujarat
Plate No.VI	Geological Map Showing Bed Rock Sample (BRS) Locations of Ishwariya Limestone Block, Gir Somnath, Gujarat
Plate No.VII	Borehole location on Geological map of Ishwariya Limestone block, Gir Somnath, Gujarat.
Plate No.VIII	Geological Map with Topography of Ishwariya Limestone Block, Gir Somnath district, Gujarat.
Plate No.IX (A)	Lithologs of Borehole – 1, 2 and 3 of Ishwariya Limestone Block, Gir Somnath district, Gujarat.
Plate No.IX (B)	Lithologs of Borehole – 4, 5 and 6 of Ishwariya Limestone Block, Gir Somnath district, Gujarat.
Plate No. X	Cross Section of Boreholes of Ishwariya Limestone Block, Gir Somnath district, Gujarat.
Plate No. XI	Geological map using Thiessen's Polygon method showing influence area of borehole calculated using Thiessen's Polygon method.

CHAPTER - 23

ANNEXURE / ENCLOSURES TO THE REPORT

23.1.0 The report includes all relevant annexures, tables, maps, plans, sections, Figures, photographs, and photomicrographs. A list of these annexures and illustrations is provided before the main text of the Geological Report.

23.2.0 LIST OF ANNEXURES

1	Statement showing run-wise detail lithologs of boreholes G-ISH-BH-1 - G-ISH-BH-06, in Ishwariya limestone block, Gir Somnath district, Gujarat.
2	Statement showing analytical result of BRS samples in Ishwariya limestone block, Gir Somnath district, Gujarat.
3	Statement showing analytical result of BH samples in Ishwariya limestone block, Gir Somnath district, Gujarat.
4	Statement showing analytical result of BRS & BH external check samples in Ishwariya limestone block, Gir Somnath district, Gujarat.
5	Statement showing analytical result of composite samples in Ishwariya limestone block Gir Somnath district, Gujarat.
6	Statement showing determination of specific gravity in Ishwariya limestone block Gir Somnath district, Gujarat.
7	Statement showing area influence for estimation of resource by Thiessen Polygon Method. in Ishwariya limestone block Gir Somnath district, Gujarat.
8	Statement showing grade-wise distribution of limestone zones intersected in boreholes drilled in Ishwariya limestone block Gir Somnath district, Gujarat.
9A	Statement showing borehole-wise intersection of cement-grade limestone zones in Ishwariya limestone block Gir Somnath district, Gujarat.
9B	Statement showing borehole-wise intersection of blendable-grade limestone zones in Ishwariya limestone block Gir Somnath district, Gujarat.
10	Statement showing the grade wise Reserves with average Cao, MgO, SiO ₂ in Ishwariya limestone block.
11	Peer Reviewer Comments and Compliances

CERTIFICATE FROM THE QUALIFIED PERSON WITH NAME,
DATE AND SIGNATURE

Title of the Report: Geological Report on Preliminary Exploration
G-3) For Limestone in Ishwariya Area, Patan-Veraval Taluka,
Gir Somnath District, Gujarat
(T.S.No.41L/05, 41L/09)

This is to certify that the Preliminary Exploration (G3) for Limestone in the Ishwariya Block, Patan-Veraval Taluka, Gir Somnath District, has been carried out by PRB Infraprojects Private Limited, in accordance with the technical standards, procedures and guidelines prescribed under the NMEDT-approved Exploration Methodology for G3 stage exploration.

The exploration work, comprising geological mapping, exploratory drilling, core logging, sampling, sample preparation, chemical analysis, QA/QC procedures, and geological data processing, was executed under the supervision of qualified geologists and technical personnel of PRB Infraprojects Limited.

The Geological Report has been prepared by PRB Infraprojects Private Limited based on the exploration data generated during the course of investigation and in conformity with the applicable guidelines and reporting standards for mineral exploration. The report adheres to the Minerals (Evidence of Mineral Contents) Rules, 2015, framed under the Mineral (Auction) Rules, 2015, as amended up to 2021

NAME: Mr. M. Chandradas (PC)

Mr. Prem Babu Singh Lodhi (TAE)

DESIGNATION: PC/TAE

DATE:

**LIST OF PERSONNEL ASSOCIATED WITH EXPLORATION IN
ISHWARIYA BLOCK, DISTRICT- GIR SOMNATH, GUJARAT**

1	Overall planning, coordination and support	Mr. Bhupendra Raghushe (Director) Mr. M. Chandradas (PC)
2	Overall co-ordination, guidance, And technical Supervision	Mr. M. Chandradas (PC) Mr. Prem Babu (TAE Geology) Mr. Milind Dhakate (TAE Geology)
3	Proposal Preparation	Mr. Sebin Sebastian (Geology) Mr. Ankush Shukla (Geology)
4	Project Management	Mr. Rajat Raghushe
5	Physical Execution of work	
	a) Geology	Mr. Sebin Sebastian (Geology) Mr. Ankush Shukla (Geology)
	b) Survey	Mr. Rajat Raghushe (Surveyor)
	c) Drilling	Mr. Meet Raghushe (Drilling Engineering)
6	Chemical Laboratory	Inspectorate Griffith India Pvt. Ltd., Gandhidham, Gujarat. (Primary, XRF and ICPMS, Bulk density
		Shiva Analyticals India Pvt. Ltd. Bangalore Karnataka (External check Sample)
7	Petrographic Studies	Ms. Sakshi Mahule (Geology) Ms. Pallavi Dhapodkar (Geology)
8	Documentation	Priti N. Pusadkar (Geology)
9	Reprography and Printing	Vaishnavi Thakare (Geology)

LOCALITY INDEX

Locality	Latitude	Longitude	Toposheet No.
Veraval	20°54'55.46"N	70°21'47.17"E	41L/05
Somnath	20°54'22.48"N	70°23'5.15"E	41L/05
Patan	20°53'27.31"N	70°24'29.66"E	41L/05
Ishwariya	20°57'32.00"N	70°28'14.52"E	41L/05
Kukrash	20°56'39.62"N	70°30'54.68"E	41L/09
Navadra	20°55'32.84"N	70°27'33.47"E	41L/05
Meghpur	20°54'30.69"N	70°27'43.09"E	41L/05

BRS LOCATION INDEX

Sr. No.	Sample ID	Latitude	Longitude	Elevation In m	Lithology
1	ISH-BRS-02	20°55'13"	70°30'08"	35	Limestone
2	ISH-BRS-03	20°55'10"	70°30'12"	33	Limestone
3	ISH-BRS-06	20°55'24"	70°30'07"	39	Limestone
4	ISH-BRS-07	20°55'33"	70°30'13"	44	Limestone
5	ISH-BRS-08	20°55'33"	70°30'10"	43	Limestone
6	ISH-BRS-09	20°55'28"	70°30'10"	43	Limestone
7	ISH-BRS-11	20°55'36"	70°30'04"	42	Limestone
8	ISH-BRS-12	20°55'40"	70°30'15"	41	Limestone
9	ISH-BRS-14	20°55'45"	70°30'10"	47	Limestone
10	ISH-BRS-15	20°55'44"	70°30'07"	46	Limestone
11	ISH-BRS-16	20°55'45"	70°30'17"	47	Limestone
12	ISH-BRS-17	20°55'54"	70°30'21"	50	Limestone
13	ISH-BRS-18	20°55'38"	70°29'54"	39	Limestone
14	ISH-BRS-22	20°55'46"	70°30'00"	46	Limestone
15	ISH-BRS-23	20°55'54"	70°29'55"	43	Limestone
16	ISH-BRS-24	20°56'07"	70°30'04"	50	Limestone
17	ISH-BRS-26	20°56'04"	70°30'07"	54	Limestone
18	ISH-BRS-27	20°56'01"	70°30'04"	51	Limestone
19	ISH-BRS-28	20°55'59"	70°30'03"	49	Limestone
20	ISH-BRS-29	20°56'00"	70°30'00"	49	Limestone
21	ISH-BRS-30	20°56'16"	70°29'51"	53	Limestone
22	ISH-BRS-31	20°56'18"	70°29'47"	54	Limestone
23	ISH-BRS-32	20°56'17"	70°29'45"	52	Limestone
24	ISH-BRS-33	20°56'13"	70°29'32"	47	Limestone
25	ISH-BRS-34	20°56'04"	70°30'07"	54	Limestone
26	ISH-BRS-35	20°56'01"	70°30'04"	51	Limestone
27	ISH-BRS-36	20°55'59"	70°30'03"	49	Limestone
28	ISH-BRS-37	20°56'00"	70°30'00"	49	Limestone
29	ISH-BRS-38	20°56'16"	70°29'51"	53	Limestone
30	ISH-BRS-39	20°56'18"	70°29'47"	54	Limestone
31	ISH-BRS-41	20°56'17"	70°29'45"	52	Limestone
32	ISH-BRS-42	20°56'13"	70°29'32"	47	Limestone
33	ISH-BRS-43	20°56'02"	70°29'20"	36	Limestone
34	ISH-BRS-44	20°56'02"	70°29'17"	37	Limestone
35	ISH-BRS-45	20°56'03"	70°29'18"	38	Limestone
36	ISH-BRS-46	20°55'53"	70°29'28"	35	Limestone
37	ISH-BRS-47	20°55'51"	70°29'35"	37	Limestone
38	ISH-BRS-48	20°55'48"	70°29'37"	38	Limestone
39	ISH-BRS-49	20°55'31"	70°29'34"	30	Limestone
40	ISH-BRS-50	20°55'29"	70°29'32"	30	Limestone

REFERENCES

- Fedden, F. (1884).** Report on the Geology of the Kathiawar Peninsula, with special reference to the Deccan Trap and associated acidic igneous rocks.
- Adye, E.H. (1914–1917).** Petrological investigations on felsites, granophyres and rhyolites of the Pobandar and Navanagar regions.
- Ghosh, P.K. (1936).** Studies on the regional geology and lithology of the Kathiawar Peninsula.
- Crookshank, H. (1940).** Geological investigations and structural interpretation of the Kathiawar region.
- Roy, B.C. (1941).** Studies on the regional geology and lithological characteristics of the Kathiawar area.
- Duncum, P. and Sladen, W.P. (1942).** Studies on the lithological succession and structural framework of the Deccan Trap terrain.
- Auden, J.B. (1949).** Studies on dyke intrusions in the Deccan Trap and the granophyric nature of the Alech Hills acidic rocks.
- Shekhar and Mukul (1966).** Quartz monzonite dykes intruding basalt and their petrological affinity with granophyres.
- Verma, K.K. and Mathur, U.B. (1971–72).** *Report on Reconnaissance Survey of Quaternary Geology in Saurashtra Region.* Geological Survey of India (GSI), Field Season 1971–72. The study covered the Quaternary geology of the Saurashtra region, including miliolite limestone, shell limestone, coastal sand dunes, beach deposits, alluvium, and the Gaj and Dwarka formations for stratigraphic correlation and age determination.
- Bandopadhyay (1973–1975).** Geological studies of the Alech Hills proposing a central subsidence structure with ring fractures occupied by acidic intrusive rocks.

Bose, M.K. (1980). Studies on alkaline rock suites of the Deccan Volcanic Province and their tectonic significance.

Geological Survey of India (1982–1983). Detailed investigation for chalk deposits in Upleta Taluka, delineating three chalk pockets.

Mody, R.C. (1988–1989). Pre-Detailed Mineral Survey in parts of Upleta and Jamjodhpur Talukas for chalk and limestone.

Dey and Chowdhary, A.R.V. (1991–1993). Detailed geological mapping and geochemical investigations in parts of Upleta and Jamjodhpur Talukas.

Roychowdhury (1997–98). *Preliminary Appraisal of Limestone in Coastal Saurashtra Region.* Geological Survey of India (GSI), Field Season 1997–98. The investigation identified high-quality Miliolite and Gaj limestones suitable for SMS, Blast Furnace (BF), and chemical-grade applications in the coastal Saurashtra region.

Pandya, K.B. (1999–2000). Detailed investigation of chalk deposits and delineation of additional chalk-bearing zones.

Joshi, M.K. (2000–2001). Detailed drilling investigation in the Pransla and Amrapar areas for estimation of chalk and limestone reserves.

Vayed, J.H. (2004–2005). Extension drilling in adjoining areas for estimation of geological reserves of chalk and limestone.

Mathur, U.B. (2006). *Quaternary Geology: Indian Perspective.* Geological Society of India, Bengaluru.

Behera, J.R. and Bhakta, S. (2017–2018). Reconnaissance Survey (G4) for gold and associated minerals in the Jamjodhpur Block (Alech Hills), Gujarat.

Geological and exploration data pertaining to the Reconnaissance Survey (G4) for limestone in Bhatiya Area, Kalyanpur Taluka, Villages Bhatiya–Gokalpur, Devbhumi Dwarka District, Gujarat **(2025-2026)** (T.S. Nos. 41F/04 & 41F/08).