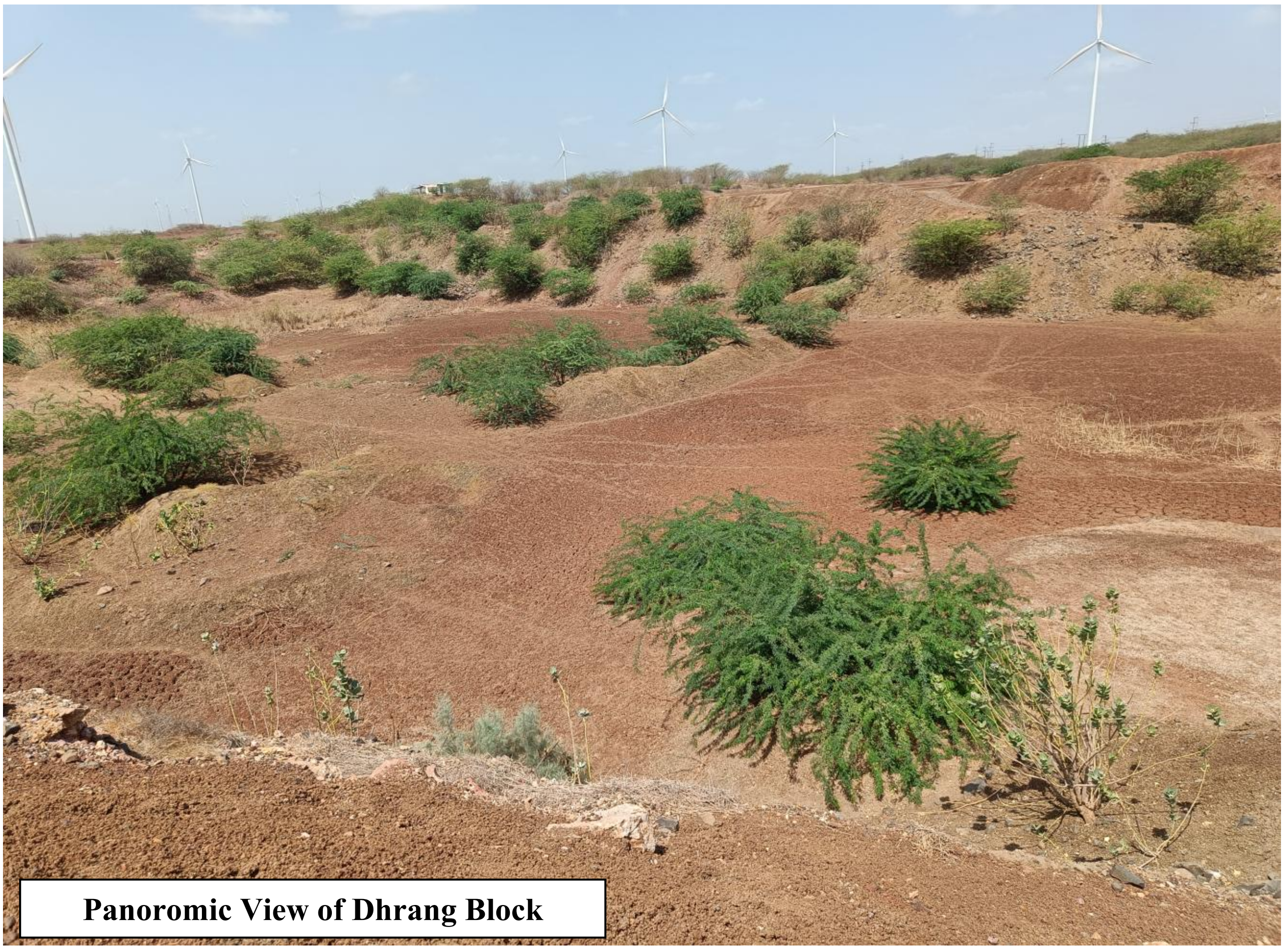
GEOLOGICAL REPORT ON THE PRELIMINARY (G-3) EXPLORATION OF BAUXITE AND ASSOCIATED MINERALS IN

DHRANG BLOCK

(AREA: 4.86 sq. km)

DISTRICT– KACHCHH, GUJARAT

(TEXT, ANNEXURES AND PLATES)



Panoromic View of Dhrang Block

MINERAL EXPLORATION AND CONSULTANCY LIMITED

(Formerly known as Mineral Exploration Corporation Limited)

A Government of India Enterprises

CORPORATE OFFICE, NAGPUR

March -2026

GEOLOGICAL REPORT ON THE PRELIMINARY (G-3) EXPLORATION FOR BAUXITE AND ASSOCIATED MINERALS IN DHRANG BLOCK
DISTRICT– KACHCHH, GUJARAT

CONTENTS

TEXT

LIST OF TABLES

LIST OF TEXT FIGURES

LIST OF FIELD PHOTOGRAPHS

LIST OF FIGURES

LIST OF PHOTOMICROGRAPHS

MECL

LIST OF ANNEXURES

LIST OF PLATES

GEOLOGICAL REPORT ON THE PRELIMINARY (G-3) EXPLORATION FOR BAUXITE AND ASSOCIATED MINERALS IN DHRANG BLOCK DISTRICT– KACHCHH, GUJARAT

SALIENT FEATURES

1.	Name of the block	Dhrang Block Tehsil- Lakhpat District – Kachchh, State – Gujarat
2.	Mineral	Bauxite & Associated Minerals (Titanium, Vanadium, Gallium, REE)
3.	Total Area	4.86 sq.km.
4.	Area covered under present scheme	4.86 sq.km.
5.	Period of Exploration	May 2025 to March 2026.
6.	Meterage drilled by MECL	Total 77.0 m
7.	No. of Boreholes drilled by MECL	Total 05 Nos
8.	Thickness of Different Grade Bauxite	Average thickness of bauxite is 3.0m
9.	Cut-off grade	As per end use grade classification recommended by IBM. cutoff grade of 1. **Metallurgical Grade II Bauxite:** Al_2O_3 > 40% and $SiO_2 \leq 4\%$ 2. Low Grade Bauxite: Al_2O_3 35-40% and $SiO_2 \leq 10\%$ 3. **Aluminous Laterite:** Al_2O_3 >20% 4. **TiO_2 demarcation**: TiO_2 >2% 5. **V demarcation** $\geq$500ppm 6. **Ga and Sc demarcation $\geq$50ppm** 7.
10.	Resources	**1.** Net resources of Metallurgical Grade-II Bauxite of 0.95 MT have been estimated at a cut-off of Al_2O_3 > 40% and $SiO_2 \leq 4\%$, with an average grade of Al_2O_3 42.21%, SiO_2 3.35%, Fe_2O_3 26.79%, TiO_2 5.26%, Sc 23.96 ppm, V 1008.84 ppm and Ga 65.61 ppm. In addition, Low Grade Bauxite resources of 1.26 MT have been estimated at Al_2O_3 35– 40% and SiO_2 $\leq$10% cut-off, with an average grade of Al_2O_3 40.55%, SiO_2 6.89%, Fe_2O_3 21.76% and TiO_2 6.05%. The block also hosts 1.85 MT of Aluminous Laterite resources estimated at Al_2O_3 $\geq$20% cut-off, with an average grade of Al_2O_3 35.53%, SiO_2 9.43%, Fe_2O_3 30.25% and TiO_2 4.35%. **2.** Associated trace element enrichment has also been observed within the lateritic profile. A TiO_2 resource

		of about 4.03 MT has been estimated at 2% TiO_2 cut-off with an average grade of 5.01%. In addition, Gallium-bearing resources of 4.21 MT (Ga ≥50 ppm) with an average Ga grade of 64.57 ppm, Scandium resources of 1.12 MT (Sc ≥50 ppm) with an average 66.79 ppm, and Vanadium resources of 1.12 MT (V ≥500 ppm) with an average 1129.02 ppm have been delineated within the bauxite–laterite horizon. *MT: Million Tonnes
11.	Grade	Low Grade Bauxite
12.	UNFC Category	Inferred Category (333)/ Reconnaissance mineral resource (334)
13.	Report Submission	March 2026

GEOLOGICAL REPORT ON THE PRELIMINARY (G-3) EXPLORATION FOR BAUXITE AND ASSOCIATED MINERALS IN DHRANG BLOCK, DISTRICT - KACHCHH, STATE – GUJARAT

CHAPTER-I

कार्यकारी सार (Executive Summary)

बॉक्साइट (Bauxite) एल्यूमिना (Al_2O_3) का प्रमुख स्रोत है, जिसका उपयोग घर्षक, अग्निरोधक, रसायन एवं सीमेंट उद्योगों में व्यापक रूप से किया जाता है। बॉक्साइट से प्राप्त एल्युमिनियम अपने हल्के भार, वायुमंडलीय क्षरण प्रतिरोध तथा उच्च विद्युत चालकता के कारण अत्यंत महत्वपूर्ण औद्योगिक धातु है।

गुजरात राज्य का कच्छ जिला, विशेषकर कच्छ बेसिन के माता-नो-माध क्षेत्र, लेटेराइटिक बॉक्साइट निक्षेपों के लिए प्रसिद्ध है। ये निक्षेप सामान्यतः पठारी सतहों पर लेटेराइटिक आवरण (capping) के रूप में विकसित होते हैं, जो दीर्घकालीन अपक्षय एवं लेटेरिटाइजेशन प्रक्रियाओं का परिणाम हैं।

ध्रांग ब्लॉक, जिसका क्षेत्रफल लगभग 4.86 वर्ग किमी है, लाखपत तहसील, जिला कच्छ (गुजरात) में स्थित है। इस ब्लॉक का अन्वेषण MECL द्वारा प्रारंभिक अन्वेषण (G-3 स्तर) के अंतर्गत मई 2025 से मार्च 2026 के दौरान किया गया, जिसका उद्देश्य डेक्कन ट्रैप पर विकसित लेटेराइटिक प्रोफ़ाइल में बॉक्साइट एवं सहवर्ती रणनीतिक तत्वों का परिसीमन करना था।

अन्वेषण कार्यक्रम में भू-वैज्ञानिक मानचित्रण (1:4000 पैमाना), नमूना संग्रहण एवं अन्वेषण ड्रिलिंग सम्मिलित थे। कुल 05 बोरहोल में 77 मीटर ड्रिलिंग की गई, जिससे बॉक्साइट परत की उपसतही निरंतरता एवं ग्रेड का आकलन किया गया।

भूवैज्ञानिक रूप से, यह क्षेत्र कच्छ पेरिक्रेटोनिक रिफ्ट बेसिन का भाग है, जहाँ डेक्कन ट्रैप बेसाल्ट पर विकसित लेटेराइटिक अपक्षय प्रोफ़ाइल पाई जाती है, जिसमें लेटेराइट, बॉक्साइट, बॉक्साइटिक क्ले, लिथोमार्जिक क्ले एवं बेंटोनाइटिक क्ले सम्मिलित हैं। बॉक्साइट मुख्यतः

मातानोमाध संरचना में विकसित है और इसका गठन तीव्र रासायनिक अपक्षय एवं डी-सिलिकेशन प्रक्रियाओं से हुआ है। प्रस्तावित कार्य के स्वरूप एवं मात्रात्मक प्रावधान की तुलना में वास्तविक उपलब्धियों का विवरण निम्नलिखित है।

S. No	Item details	Unit	Proposed Quantum	Achieved Quantum	Remarks
1	Geological Mapping (1:4000 scale)	Sq. Km.	4.86	4.86	
2	Topographic Survey (Contour interval 2m) at 1:4000 scale	Sq. Km.	4.86	5.86	
3	Pitting	cu. m	100	50.08	
4	Trenching	cu. m	50	0	
5	Bore Hole Fixation and determination of co-ordinates & Reduced Level (RL) of the boreholes and demarcation of lease hold boundary points by DGPS	Nos.	15+4=19	9	
6	Core drilling (400m x 400m grid).	m	450	77	5 Nos BH in phase I drilling
7	**Sampling & Chemical Analysis**				
A)	Primary samples to be analyzed for 7 radicals viz. Al_2O_3, SiO_2, Fe_2O_3, TiO_2, V, Ga, Sc & LOI				
i.	Bedrock samples	Nos.	20	20	
ii.	Trench/ Pit samples	Nos.	20	20	
iii.	Borehole Core samples	Nos.	300	54	
iv.	For Each additional Trace Element viz.V, Ga, Sc. (from BH Core Sample)	Nos.	300	54	
v.	Check samples (10% external)	Nos.	34	16	
8	**Physical Studies**				
a)	ICP-AES/ICPMS (sequential technique) for 34 elements i.e. 16 other elements viz. Li, Ga, In, Be, Ge, Mo, Ni, Cr, Ta, W, Ba, Co, Rb, Sr, Zr, Nb ;16 REE viz. La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y; 02 Actinides viz. U, Th.	Nos.	15	15	

S. No	Item details	Unit	Proposed Quantum	Achieved Quantum	Remarks
b)	X-RD studies for mineral identification	Nos.	10	5	
9	Petrographic Studies	Nos.	10	6	
10	Mineragraphic Studies	Nos.	10	4	
11	Preparation of Polished Section & Thin Section (05+05)	Nos.	10		
12	Bulk density	Nos.	10	2	
13	Combined determination of Trihydrate Alumina (THA-140°C), Monohydrate Alumina (MHA-240°C) & Reactive Silica	Nos.	10	5	
14	Geological Report Preparation {As per Mineral (Evidence of mineral contents) Rule-2015}	Nos.	1	1	

उपलब्ध भूवैज्ञानिक एवं रासायनिक आंकड़ों के आधार पर, मेटालर्जिकल ग्रेड-II बॉक्साइट के 0.95 मिलियन टन (MT) संसाधन का आकलन किया गया है (कट-ऑफ: Al_2O_3 ≥ 40% एवं SiO_2 ≤ 4%), जिसका औसत ग्रेड Al_2O_3 42.21% एवं SiO_2 3.35% है। इसके अतिरिक्त, निम्न ग्रेड बॉक्साइट (1.26 MT) तथा एल्यूमिनस लेटेराइट (1.85 MT) के संसाधन भी परिकलित किए गए हैं।

लेटेराइटिक प्रोफ़ाइल में टाइटेनियम, गैलियम, वैनेडियम एवं स्कैंडियम जैसे महत्वपूर्ण तत्वों का भी संवर्धन पाया गया है। लगभग 4.03 MT TiO_2 संसाधन, 4.21 MT गैलियम, 1.12 MT स्कैंडियम तथा 1.12 MT वैनेडियम संसाधन का आकलन किया गया है। उपर्युक्त संसाधनों को UNFC कोड 333 (अनुमानित संसाधन श्रेणी) के अंतर्गत वर्गीकृत किया गया है।

इसी के अतिरिक्त, मेटालर्जिकल ग्रेड-II बॉक्साइट के 0.44 MT शुद्ध संसाधन (कट-ऑफ: Al_2O_3 ≥ 40% एवं SiO_2 ≤ 4%) का आकलन किया गया है, जिसका औसत ग्रेड Al_2O_3

43.24%, SiO_2 3.03%, Fe_2O_3 12.39% एवं TiO_2 5.05% है, तथा इसमें Sc 5.99 ppm, V 247.79 ppm एवं Ga 16.09 ppm जैसे ट्रेस तत्व उपस्थित हैं। इसके अतिरिक्त, 0.69 MT निम्न ग्रेड बॉक्साइट संसाधन (कट-ऑफ: Al_2O_3 35-40% एवं $SiO_2 \leq$ 10%) का औसत ग्रेड Al_2O_3 44.04%, SiO_2 8.14%, Fe_2O_3 13.09% एवं TiO_2 6.81% है, जिसमें Sc 32.62 ppm, V 830.43 ppm एवं Ga 62.55 ppm की समृद्धि पाई जाती है। इसी प्रकार, 0.99 MT एल्यूमिनस लेटेराइट संसाधन (कट-ऑफ: $Al_2O_3 \geq$ 20%) का औसत ग्रेड Al_2O_3 34.68%, SiO_2 10.11%, Fe_2O_3 31.39% एवं TiO_2 4.45% है, जिसमें Sc 54.62 ppm, Ga 68.12 ppm एवं V 802.45 ppm उपस्थित हैं। उपर्युक्त सभी संसाधनों को UNFC कोड 334 (Reconnaissance Mineral Resource श्रेणी) के अंतर्गत वर्गीकृत किया गया है।

समग्रतः, धांग ब्लॉक में लेटेराइटिक बॉक्साइट का महत्वपूर्ण निक्षेप विकसित है, जिसमें रणनीतिक तत्वों की उपस्थिति इसके आर्थिक महत्व को और बढ़ाती है। अतः संसाधनों की विश्वसनीयता बढ़ाने एवं उच्च श्रेणी (G-2 स्तर) में उन्नयन हेतु अतिरिक्त विस्तृत अन्वेषण की अनुशंसा की जाती है, जिससे भविष्य में इसके तकनीकी-आर्थिक मूल्यांकन एवं वाणिज्यिक दोहन को सुदृढ़ आधार प्राप्त हो सके।

EXECUTIVE SUMMARY

1.1.1 Bauxite holds prime importance as the primary source for producing alumina (Al_2O_3), which is further used in a range of industries such as abrasives, refractories, chemicals, and cement. Aluminium, derived from bauxite, is valued for its light weight, excellent resistance to atmospheric corrosion, and high electrical conductivity. These unique properties make it widely used in manufacturing—from industrial applications to everyday household utensils—earning it the name *"poor man's gold."* Moreover, aluminium serves as an efficient and economical substitute for scarce and expensive non-ferrous metals like copper and zinc, thereby driving the growth of the aluminium industry across the globe.

1.1.2 Kachchh district of Gujarat is recognized for its occurrence of lateritic bauxite deposits, notably developed in the Mata-no-Madh region within the Kachchh Basin. These deposits are typically preserved as cappings over plateau tops, and elevated geomorphic surfaces, formed through prolonged subaerial weathering and lateritization of underlying lithologies, including Tertiary sediments and Deccan Trap–related basement rocks under tropical to sub-tropical climatic conditions. The bauxite is generally characterized by pisolitic to earthy textures.

1.1.3 The Dhrang Block, covering an area of 4.86 sq. km, is located in Lakhpat Taluka of Kachchh District, Gujarat, within Survey of India Toposheet No. 41A/14. Dhrang is located at a distance of 100 kms from the district headquarter Bhuj. The block is well connected by motorable roads. The nearest railway station and airport is at Bhuj which is well connected with the rest of the country. The block has been explored by Mineral Exploration and Consultancy Limited (MECL) under Preliminary Exploration (G-3) stage during the period May 2025 to March 2026 with the objective of delineating bauxite and associated strategic elements within the lateritic profile developed over the Deccan Trap.

1.1.4 The exploration programme comprised systematic geological mapping, bedrock and pit sampling, and exploratory drilling, followed by detailed geological core logging, laboratory investigations and interpretation of analytical results. A total of 05 boreholes aggregating 77 m of drilling were completed to assess the subsurface continuity and grade characteristics of the bauxite horizon.

1.1.5 Geologically, the area forms part of the Kachchh peri-cratonic rift basin, which preserves a stratigraphic succession ranging from Mesozoic sedimentary formations to Deccan Trap volcanics and younger Tertiary sediments. In the explored block, the lithological succession is dominated by Deccan Trap basalts overlain by a well-developed lateritic weathering profile comprising laterite, bauxite, bauxitic clay, lithomargic clay and bentonitic clay horizons. The bauxite deposits occur mainly within the Matanomadh Formation, developed through intense chemical weathering, desilicification and lateritization of the underlying basaltic parent rocks. The bauxite is typically pisolitic to oolitic in texture and occurs as pocket-type and discontinuous bodies, generally associated with laterite and clay horizons along elevated surfaces and flat-topped hillocks.

1.1.6 The details of the nature and quantum of work proposed Vs actual achievement is given in **below:**

Approved Quantum of Work vis a vis Achievement by MECL in Dhrang block, District: Kachchh, State: Gujarat

S. No	Item details	Unit	Proposed Quantum	Achieved Quantum	Remarks
1	Geological Mapping (1:4000 scale)	Sq. Km.	4.86	4.86	
2	Topographic Survey (Contour interval 2m) at 1:4000 scale	Sq. Km.	4.86	5.86	
3	Pitting	cu. m	100	50.08	
4	Trenching	cu. m	50	0	
5	Bore Hole Fixation and determination of co-ordinates & Reduced Level (RL) of the boreholes and demarcation of lease hold boundary points by DGPS	Nos.	15+4=19	9	
6	Core drilling (400m x 400m grid).	m	450	77	5 Nos BH in phase I drilling
7	**Sampling & Chemical Analysis**				
A)	Primary samples to be analyzed for 7 radicals viz. Al_2O_3, SiO_2, Fe_2O_3, TiO_2, V, Ga, Sc & LOI				
i.	Bedrock samples	Nos.	20	20	
ii.	Trench/ Pit samples	Nos.	20	20	
iii.	Borehole Core samples	Nos.	300	54	
iv.	For Each additional Trace Element viz.V, Ga, Sc. (from BH Core Sample)	Nos.	300	54	

v.	Check samples (10% external)	Nos.	34	16	
8	**Physical Studies**				
a)	ICP-AES/ICPMS (sequential technique) for 34 elements i.e. 16 other elements viz. Li, Ga, In, Be, Ge, Mo, Ni, Cr, Ta, W, Ba, Co, Rb, Sr, Zr, Nb ;16 REE viz. La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y; 02 Actinides viz. U, Th.	Nos.	15	15	
b)	X-RD studies for mineral identification	Nos.	10	5	
9	Petrographic Studies	Nos.	10	6	
10	Mineragraphic Studies	Nos.	10	4	
11	Preparation of Polished Section & Thin Section (05+05)	Nos.	10		
12	Bulk density	Nos.	10	2	
13	Combined determination of Trihydrate Alumina (THA-140°C), Monohydrate Alumina (MHA-240°C) & Reactive Silica	Nos.	10	5	
14	Geological Report Preparation {As per Mineral (Evidence of mineral contents) Rule-2015}	Nos.	1	1	

1.1.7 Based on geological interpretation and analytical data generated from drilling and surface investigations, net resources of 0.95 million tonnes (MT) of Metallurgical Grade-II Bauxite have been estimated at a cut-off grade of Al_2O_3 > 40% and SiO_2 ≤ 4%, with an average grade of Al_2O_3 42.21%, SiO_2 3.35%, Fe_2O_3 26.79% and TiO_2 5.26%. In addition, 1.26 MT of Low-Grade Bauxite net resources have been delineated at Al_2O_3 35–40% and SiO_2 ≤10% cut-off, with an average grade of Al_2O_3 40.55%, SiO_2 6.89%, Fe_2O_3 21.76% and TiO_2 6.05%. The exploration has also established 1.85 MT of Aluminous Laterite at Al_2O_3 ≥20% cut-off, averaging Al_2O_3 35.53%, SiO_2 9.43%, Fe_2O_3 30.25% and TiO_2 4.35%.

1.1.8 The lateritic profile also shows significant enrichment of strategic and critical elements, including Titanium, Gallium, Vanadium and Scandium. A TiO_2 resource of about 4.03 MT has been estimated at >2% cut-off, with an average grade of 5.01% TiO_2 within the bauxite–laterite horizon. Additionally, Gallium-bearing resources of about 4.21 MT with an average grade of 64.57 ppm Ga at >50ppm cut-off, Scandium resources of 1.12 MT averaging 66.79 ppm Sc at >50ppm cut-off, and

Vanadium resources of 1.12 MT averaging 1129.02 ppm V at >500ppm cut-off have been estimated, highlighting the multi-element potential of the lateritic profile. All the above resources have been classified under the Inferred Resource (UNFC Code 333) category.

1.1.9 Net resources of Metallurgical Grade-II Bauxite amounting to 0.44 MT have been estimated at a cut-off of $Al_2O_3 \geq 40\%$ and $SiO_2 \leq 4\%$, with an average grade of Al_2O_3 43.24%, SiO_2 3.03%, Fe_2O_3 12.39% and TiO_2 5.05%, along with trace elements such as Sc 5.99 ppm, V 247.79 ppm and Ga 16.09 ppm. In addition, Low Grade Bauxite resources of 0.69 MT have been delineated at a cut-off of Al_2O_3 35–40% and $SiO_2 \leq 10\%$, with an average grade of Al_2O_3 44.04%, SiO_2 8.14%, Fe_2O_3 13.09% and TiO_2 6.81%, and enriched in Sc 32.62 ppm, V 830.43 ppm and Ga 62.55 ppm. The block also hosts 0.99 MT of Aluminous Laterite at a cut-off of $Al_2O_3 \geq 20\%$, with an average grade of Al_2O_3 34.68%, SiO_2 10.11%, Fe_2O_3 31.39% and TiO_2 4.45%, along with Sc 54.62 ppm, Ga 68.12 ppm and V 802.45 ppm. All the above resources have been classified under the Reconnaissance Mineral Resource (UNFC Code 334) category.

1.1.10 On the basis of available exploration data and geological interpretation, the resources of bauxite and associated elements have been estimated under the Inferred Mineral Resource category (UNFC-333) using the polygonal method in accordance with the reporting standards prescribed by IBM and UNFC guidelines.

1.1.11 The results of the present investigation indicate that the Dhrang Block hosts significant lateritic bauxite mineralization along with enrichment of strategic elements such as Ti, Ga, Sc and V, which enhances the economic significance of the deposit. Considering the geological continuity of the lateritic profile and the encouraging analytical results, further exploration at the G-2 stage is recommended to improve resource confidence, delineate additional mineralized zones and upgrade the resource category for future techno-economic evaluation.

CHAPTER-2

DETAILS OF THE QUALIFIED PERSON(S) / EXPLORATION AGENCY

2.1.1 EXPLORATION AGENCY

MINERAL EXPLORATION AND CONSULTANCY LIMITED

(Formerly Mineral Exploration Corporation Limited)

(A Govt. of India Enterprise; A Miniratna-I CPSE)

(Ministry of Mines, Govt. of India)

Dr. Babasaheb Ambedkar Bhawan, High Land Drive Road,

Seminary Hills, Nagpur-440006.

2.1.2 QUALIFIED PERSONS

Exploration agency: Mineral Exploration and Consultancy Limited

Experience: 52 Years, Since 1972

Email: cmd@mecl.gov.in; gm-exploration@mecl.gov.in

Table 2.1
List of qualified persons involved in exploration of the block

Sl.No.	Name of the Person	Designation
1	Shri Shrikant Sharma	HOD (Exploration)
2	Shri P. Ravindran	Retd. GM (Exploration)
3	Shri Swarup Dhara	Sr. Manager (Geology)
4	Shri Shubham Kumar	Geologist
5	Shri Hiresh Shrirame	Young Professional (Geology)
6	Shri Rohit Kumar Sharma	Manager (Chemical Lab)
7	Smt. Deepti Rahangdale	Manager (Chemical Lab)
8	Shri Pradeep Negi	OIC, Survey/ASMO
9	Shri Durgesh Devarshree	ASMO
10	Shri. Puneet khandale	Sr. Technician

CHAPTER-3

TITLE AND OWNERSHIP

3.1.0 DETAILS OF OWNERSHIP

S No	Title	Details
1	Title of the report	GEOLOGICAL REPORT OF PRELIMINARY (G-3) EXPLORATION FOR BAUXITE AND ASSOCIATED MINERALS IN DHRANG BLOCK, DISTRICT - KACHCHH, STATE – GUJARAT.
2	Ownership	Government of Gujarat
3	Name of the Prospector	**MINERAL EXPLORATION AND CONSULTANCY LIMITED** **(Formerly Mineral Exploration Corporation Limited)** (A Govt. of India Enterprise; A Miniratna-I CPSE) (Ministry of Mines, Govt. of India)
4	Address of Prospector	Dr. Babasaheb Ambedkar Bhavan High Land Drive Road, Seminary Hills, Nagpur, Maharashtra, Pin- 440006
5	E-Mail of the prospector	cmd@mecl.co.in, gm-exploration@mecl.co.in
6	Telephone numbers of prospectors	0712-2510289, 0712-2511829

3.2.0 DETAILS OF PERIOD OF PROSPECTING

3.2.1 The G-3 stage exploration in the Dhrang Block commenced on 28.05.2025 with the initiation of systematic geological mapping, bedrock sampling and pitting over the study area to delineate lithological units and identify surface indications of mineralization.

Based on the analytical results obtained from the surface bedrock and pit samples, exploratory drilling was subsequently undertaken to assess the subsurface continuity and extent of mineralization. Drilling operations commenced with borehole MBD-04 on 14.10.2025 and were completed with the closure of borehole MBD-01 on 07.11.2025.

During the execution of the exploration programme, allied field activities including surveying, drilling, geological logging and systematic sample collection were carried out concurrently. The collected samples were subjected to chemical analysis and laboratory investigations at the laboratories of MECL and Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC). The analytical results thus generated were utilized for interpretation of mineralization and preparation of the present Geological Report.

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

3.3.1 Exploration Agency (EA):

Mineral Exploration and Consultancy Limited

(Formerly Mineral Exploration Corporation Limited)

(A Govt. of India Enterprise-A Miniratna-I CPSE)

(Ministry of Mines, Govt. of India)

3.3.2 Experience: Organization established in year 1972

Experience: Geologist have experience of more than 30 years

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

Table no. 3.1 List of Personnel with Experience

Sl.No.	Name of the Person	Designation	Qualification	Experience
1	Shri Shrikant Sharma	HOD (Exploration)	M.Sc. (Geology)	23 Years
2	Shri P. Ravindran	Retd. GM (Exploration)	M.Sc. (Geology)	35 Years
3	Shri Swarup Dhara	Sr. Manager (Geology)	M.Sc. (Geology)	20 Years
4	Shri Shubham Kumar	Geologist	M.Sc. (Geology),	9 Years
5	Shri Hiresh Shrirame	Young Professional (Geology)	M.Sc. (Geology)	3 Years
6	Shri Rohit Kumar Sharma	Manager (Chemical Lab)	M.Sc., Chemistry	15 Years
7	Smt. Deepti Rahangdale	Manager (Chemical Lab)	M.Sc., Chemistry	15 Years
8	Shri Pradeep Negi	OIC, Survey/ASMO	Survey and Draftsman	35 Years
9	Shri Durgesh Devarshree	ASMO	Survey and Draftsman	13 Years
10	Shri. Puneet Khandale	Sr. Technician	Survey and Draftsman	5 Years

CHAPTER-4

DETAILS OF THE AREA

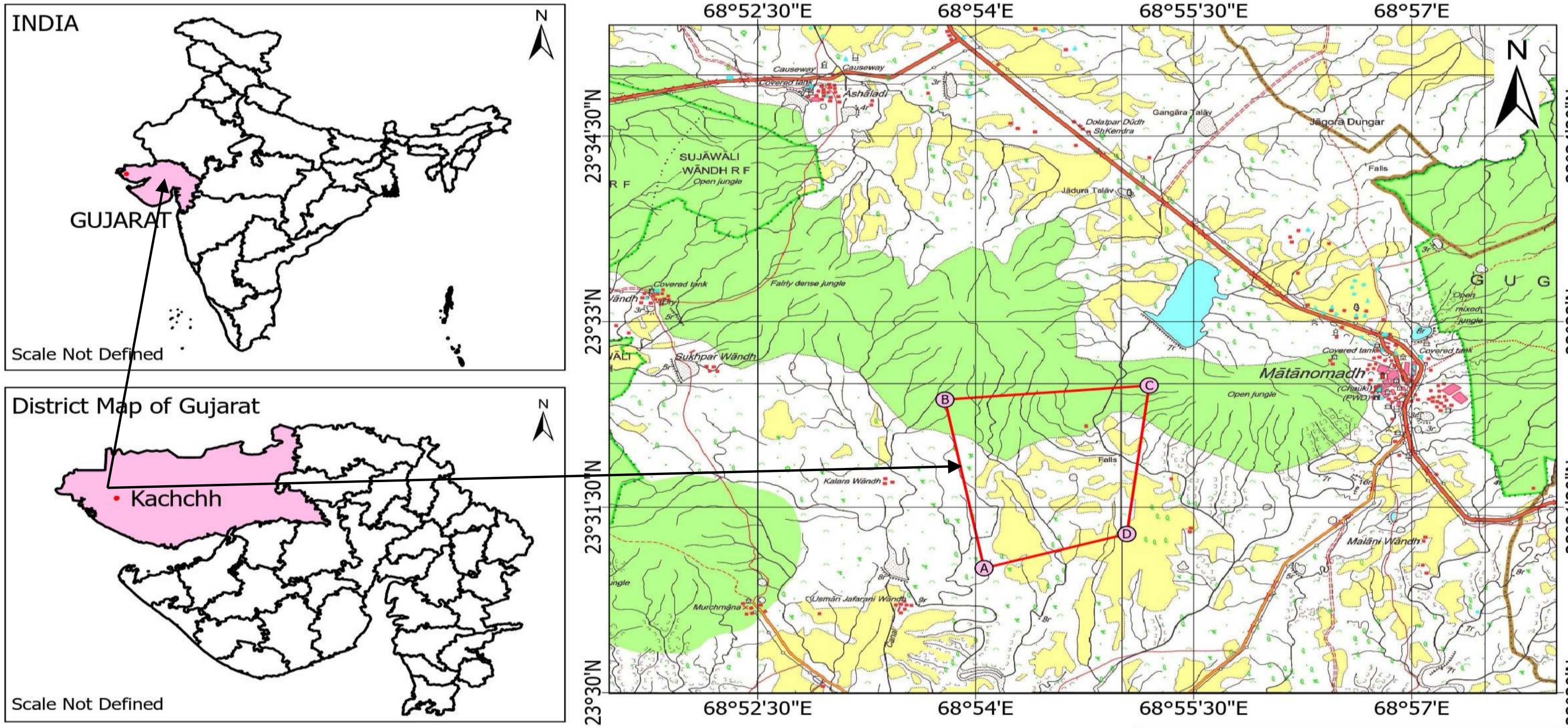
4.1.0 LOCATION AND ACCESSIBILITY OF THE BLOCK

4.1.1 The Dhrang Block is situated in the semi-arid terrain of western Kachchh, characterized by gently undulating topography comprising low plateaus, pedimented surfaces, and gently sloping plains developed over Tertiary sedimentary formations and the underlying Deccan Trap basement. The block falls within Survey of India Toposheet No. 41A/14 and covers an area of approximately 4.86 sq. km. Geographically, the block is located in and around the villages of Dhrang, Denma, and Matanomadh in Lakhpat Taluka of Kutch District, Gujarat. The region forms part of the western Kachchh mainland and lies within a well-connected transport network facilitating exploration activities. The nearest railhead is Bhuj railway station, located approximately 105 km from the block. Regional road connectivity is provided by National Highway 41 (India), which connects Bhuj–Mandvi–Narayan Sarovar and passes about 15 km west of the block. In addition, National Highway 754K lies approximately 18 km east of the area and provides connectivity towards Jodhpur and Bikaner. The block is accessible through a network of all-weather motorable roads linking the nearby villages and facilitating smooth transportation of personnel, equipment, and exploration materials. The nearest air connectivity is available at Bhuj Airport, situated about 103 km from the block, which connects the region with major cities in Gujarat and other parts of India.

4.1.2 The block location is presented as **Plate-I** and **Text Figure-1**. Dhrang block falls in part of Survey of India Toposheet No.41A/14 and is bounded by the following Co-ordinates presented in Annexure- IA and Table- 4.1.

Table-4.1
Co-ordinates of the corner points of the block boundary of Dhrang Block, District: Kachchh, Gujarat

S. No.	BOUNDARY POINT	DMS		UTM (42N) (WGS-84)		REDUCED LEVEL (M)
		LATITUDE	LONGITUDE	EASTING	NARTHING	
1	A	23° 31' 00.42775" N	68° 54' 03.47071" E	489889.693	2600733.131	75.998
2	B	23° 32' 22.19781" N	68° 53' 47.30088" E	489432.97	2603248.049	114.334
3	C	23° 32' 29.03644" N	68° 55' 11.61104" E	491823.51	2603456.821	107.294
4	D	23° 31' 17.01879" N	68° 55' 02.41888" E	491561.615	2601242.28	78.951



Scale: 1:50,000

0 1 2 4 Kilometers

Legend

- Corner Points of Dhrang Block
- DHRANG BLOCK

Co-ordinate of Corner Points of Dhrang Block					
Sr. No.	POINTS	WGS-84		UTM-ZONE 42	
		LATITUDE	LONGITUDE	EASTING	NORTHING
1	A	23° 31' 00.42775" N	68° 54' 03.47071" E	489889.693	2600733.131
2	B	23° 32' 22.19781" N	68° 53' 47.30088" E	489432.97	2603248.049
3	C	23° 32' 29.03644" N	68° 55' 11.61104" E	491823.51	2603456.821
4	D	23° 31' 17.01879" N	68° 55' 02.41888" E	491561.615	2601242.28

MINERAL EXPLORATION & CONSULTANCY LIMITED

LOCATION MAP
(Source: Part of Toposheet No. 41A14)
RF: 1:50000
DHRANG BLOCK
AREA: 4.86 sq km
DISTRICT: KACHCHH — STATE: GUJARAT
PROCESSED AT:
NON-COAL GR CELL,
EXPLORATION DIVISION,
MECL, NAGPUR
MECL/EXPL/MAR.2026 — PLATE- I — 01

TEXT FIGURE-1

4.2.0 DETAILS OF THE AREA WITH LAND USE

4.2.1 The Dhrang Block is characterized predominantly by gently undulating to nearly flat terrain, locally interspersed with low hillocks and minor topographic rises. The general relief of the area is moderate, with the landscape largely represented by plains developed over the underlying geological formations. The northern part of the block is covered by relatively dense vegetation, comprising scrub and small bushes typical of the semi-arid climatic conditions of the Kachchh region. In certain parts of the block, mining activities are observed, reflecting the mineral potential of the area. A significant portion of the block is also utilized for agricultural activities by the local inhabitants, where seasonal cultivation is practiced depending on the availability of rainfall and soil conditions. Overall, the terrain and land-use pattern of the area are conducive to the execution of exploration activities with minimal topographic constraints.

4.3.0 MINERAL(S) UNDER INVESTIGATION

4.3.1 The block has been explored for Bauxite and associated minerals at G-3 Stage exploration.

CHAPTER-5

PHYSIOGRAPHY AND ENVIRONMENT

5.1.0 RELIEF OF THE AREA WITH MINIMUM AND MAXIMUM ELEVATION, DRAINAGE PATTERN, NATURAL WATER COURSES, RESERVOIRS, ETC.

5.1.1 Topographically, the area is characterized by gently undulating plains interspersed with mounds, hillocks, and low to moderately elevated isolated flat-topped hills (refer Text Figure No. 2). These geomorphic features represent erosional remnants developed over the underlying basaltic formations and associated sedimentary units. The highest elevations in the area rise to about 118 m above Mean Sea Level (MSL), while the lowest elevation within the study area is approximately 84 m above MSL, indicating a moderate local relief.

The northern part of the block forms part of the Matanomadh open scrub-jungle terrain, developed over exposures of basaltic rocks, which impart a slightly rugged topographic expression compared to the surrounding plains. The location of the block as depicted on Google satellite imagery is presented in Text Figure No. 2.

Text Figure No. 2: Google-earth Imagery map with respect to Dhrang and Julrai block explored by MECL, District: Kachchh, Gujarat.

5.2.0 ROADS, RAILWAY TRACK, ELECTRIC TRANSMISSION LINE, TELEPHONE LINE, ETC.

5.2.1 The Block is located to the west of Mata no Madh village in Lakhpat Taluka of Kutch District, Gujarat. The nearest towns to the block are Dayapar and Nakhatrana, while Bhuj serves as the district headquarters and the principal administrative centre. The block is well connected by metalled and all-weather roads, with the main access provided through the Mata no Madh road, facilitating convenient transportation of personnel, equipment, and materials to the exploration area.

5.2.2 The nearest railhead is Bhuj railway station, situated at a distance of approximately 110 km from the block. From the railway station, the area is accessible towards the southeast via metalled roads, primarily through the Mata no Madh–Bhuj road network, ensuring reliable connectivity for logistical support during exploration activities.

5.2.3 The nearest airport is Bhuj Airport, located about 105 km to the southeast of the block, providing air connectivity to major cities in Gujarat and other parts of India. The nearest seaport is Mundra Port, situated approximately 146 km to the south of the block, which serves as an important maritime gateway for the region.

5.2.4 The study area is traversed by a 33 kV electric transmission line, ensuring the availability of power infrastructure in the vicinity. In addition, wind energy installations (windmills) are present in and around the area, reflecting the region's suitability for renewable energy generation. Basic communication facilities, including telephone and mobile network connectivity, are available in nearby villages and towns, supporting field operations and coordination during exploration activities.

5.3.0 HOST POPULATION (LOCAL TRIBES), HUMAN SETTLEMENTS WITHIN AND NEARBY AREA

5.3.1 The population inhabiting the area surrounding the Dhrang Block is predominantly rural in nature, with livelihoods largely dependent on agriculture and animal husbandry. The local communities mainly belong to traditional agrarian and pastoral groups commonly found in the Kachchh region. Farming and livestock rearing constitute the principal sources of livelihood, with villagers maintaining cattle, sheep, and goats as an integral part of their socio-economic activities. In addition to agriculture and pastoral practices, some sections of the local population are also engaged in traditional handicrafts and small-scale cottage activities, which supplement household incomes.

5.3.2 The block falls in and around the villages of Dhrang, Denma, and Matanomadh in Lakhpat Taluka of Kutch District, Gujarat (refer Text Figure 3). The region is characterized by scattered rural settlements comprising small clusters of houses surrounded by agricultural fields. The settlement pattern reflects a typical rural landscape of the Kachchh region, where villages are interspersed with cultivated lands and grazing areas. Agriculture forms the backbone of the local economy, with crops such as cotton, millet, pulses, and seasonal vegetables being cultivated depending on rainfall and soil conditions. In addition, livestock rearing is widely practiced, contributing significantly to the subsistence and income of the local inhabitants. The overall settlement pattern and socio-economic profile of the area reflect a close-knit rural community with strong dependence on land-based activities.

5.3.4 Lakhpat Tehsil map is given below.

TEXT FIGURE-3

5.3.3 **Population:** As per the Census of India, 2011, Lakhpat Taluka of Kutch District, Gujarat recorded a total population of 62,552, which is entirely rural in character and distributed across 100 villages within the taluka. The total population comprises 32,274 males and 30,278 females, spread over a geographical area of approximately 2,190 km². The population in the age group of 0–6 years accounts for 10,966 individuals, indicating a significant young demographic. In terms of social composition, the Scheduled Castes population is 6,379, while the Scheduled Tribes population is 508 within the taluka. Matanomadh, one of the prominent villages located in Lakhpat Taluka and situated near the block area, comprises 411 households. As per the 2011 Census, the village has a total population of 2,259, including 1,151 males and 1,108 females. The child population (0–6 years) in the village is 342, constituting approximately 15.14% of the total population, reflecting the demographic structure typical of rural settlements in the region.

5.3.4 **Literacy:** The overall literacy rate of Lakhpat Taluka is 62.09%, reflecting the educational status of the predominantly rural population. The male literacy rate stands at 59.87%, while the female literacy rate is 41.96%, indicating a noticeable gender disparity in literacy levels within the taluka. In comparison, Matanomadh village records a relatively higher literacy rate of 65.94%, of which 76.30% pertains to male literacy and 55.50% to female literacy. These figures highlight a moderate level of educational attainment in the village, though a gap between male and female literacy continues to persist, reflecting broader socio-economic patterns prevalent in rural parts of the Kachchh region.

5.4.0 SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

5.4.1 The Dhrang Block is situated approximately 6 km west of Matanomadh village, which falls under Lakhpat Taluka of Kutch District, Gujarat. The region is predominantly rural in character, with the local population largely dependent on agriculture, livestock rearing, and other traditional occupations for their livelihood.

5.4.2 The overall literacy rate of Matanomadh village is recorded as 65.94%, indicating a moderate level of educational attainment among the inhabitants. Mining activities in the surrounding region have played a significant role in improving the socio-economic conditions of the area, particularly by generating employment opportunities for the local population. In addition, such activities have contributed to the development of basic infrastructure and social facilities, including educational institutions, healthcare services, and drinking water supply, thereby enhancing the overall quality of life of the local inhabitants.

5.4.3 Furthermore, the occurrence of lignite deposits in the Kachchh region has facilitated the establishment of several thermal power plants by the Government of Gujarat, which has strengthened the regional power infrastructure. As a result, electricity supply has been extended to most villages of Lakhpat Taluka, contributing to rural development and improved living standards in the area.

5.5.0 HISTORICAL SITES AND ARCHAEOLOGICAL MONUMENTS, PLACES OF WORSHIP, PUBLIC UTILITIES ETC.

The region surrounding the Dhrang Block possesses several historical, cultural, and religious sites of significance, reflecting the rich heritage of the Kachchh region.

5.5.1 One of the most prominent religious centers near the study area is the Ashapura Mata Temple, Mata no Madh, a major shrine dedicated to Goddess Ashapura, who is regarded as the presiding deity of the Kachchh region. The temple holds great religious importance and attracts large numbers of devotees and pilgrims, particularly during major festivals such as Navratri, when the site becomes a significant center of pilgrimage activity.

5.5.2 Another important pilgrimage site in the vicinity is Narayan Sarovar, located in Lakhpat Taluka of Kutch District, Gujarat near the Kori Creek. Narayan Sarovar is considered one of the sacred pilgrimage destinations for Hindus. The ancient Koteshwar Temple, situated about 4 km to the northwest, is an important temple associated with the Vaishnavite tradition and is recognized among the 108 Abhimana Kshethrams.

5.5.3 The historic town of Lakhpat also holds archaeological and religious importance. The Lakhpat Fort represents a significant historical structure reflecting the region's maritime and trading past. Within the fort premises lies the Gurudwara Shri Nanak Darbar, Lakhpat, a revered Sikh shrine associated with the visit of Guru Nanak during his fourth missionary journey (Udasi) between 1519–1521 AD, while travelling to and returning from Mecca. The site has been preserved with historical reverence, and the heritage value of the monument has been recognized with an UNESCO Heritage Award.

5.5.3 In terms of civic infrastructure, essential public utilities such as banking services (both public and private sector banks), educational institutions, and medical facilities are available at Dayapar town, which is located approximately 15 km from the study area. These facilities provide necessary support for both the local population and field personnel engaged in exploration activities in the region.

5.6.0 FORESTS, SANCTUARIES, NATIONAL PARK AND WILD LIFE SANCTUARIES ETC.

The region surrounding the Dhrang Block is characterized by semi-arid ecological conditions, supporting sparse vegetation, thorny scrub forests, and localized habitats of ecological significance.

5.6.1 One of the notable ecological sites in the vicinity is the Guneri Inland Mangrove Site, located near Guneri village. This site covers an area of approximately 32.78 hectares and is recognized for its unique inland mangrove ecosystem, where mangrove species grow on dry soil without direct contact with seawater, a rare ecological phenomenon. The area supports a variety of avian species, including migratory birds such as Greater Flamingo and Harrier, making it an important habitat for birdlife.

5.6.2 Another significant protected area in the region is the Narayan Sarovar Wildlife Sanctuary, situated in Lakhpat Taluka of Kutch District, Gujarat. The sanctuary is characterized by arid and semi-arid ecosystems, comprising thorn forests, scrublands, and grassland patches typical of the Kachchh landscape. It serves as an important habitat for several species of wildlife, notably the Chinkara (Indian Gazelle), along with other fauna adapted to the desert and semi-desert environment.

5.6.3 No reserved forests, national parks, or major wildlife sanctuaries fall directly within the Dhrang Block area; however, the presence of ecologically significant habitats in the broader region highlights the environmental importance of the surrounding landscape.

5.7.0 FLORA AND FAUNA WITHIN AND NEARBY

5.7.1 The Matanomadh–Dhrang region falls within the arid to semi-arid ecological zone of western Kachchh, where vegetation is predominantly composed of xerophytic thorny scrub and drought-resistant grasses adapted to conditions of low rainfall, saline soils, and high evapotranspiration. The natural vegetation is typically sparse and discontinuous, reflecting the harsh climatic conditions of the region. Common plant species occurring in the area include Acacia nilotica (Desi Babul) and Acacia senegal (Kumat), along with other hardy shrubs and grasses that are well adapted to the semi-arid environment.

5.7.2 The broader Kachchh region supports vegetation consisting mainly of thorny bushes, scrublands, and scattered grasslands, interspersed with drought-tolerant species such as cacti and wild grasses. Despite the arid climate, the region hosts a variety of wildlife adapted to desert and semi-desert ecosystems. Notable fauna found in the region include the Asiatic wild ass, Chinkara (Indian Gazelle), Desert fox, Indian pangolin, and Desert cat.

5.7.2 In addition to wild fauna, the local population maintains several domestic animals, which form an integral part of the rural economy. Common domesticated animals in the area include horses, camels, oxen, cows, buffaloes, sheep, goats, and donkeys, which are primarily reared for agricultural operations, transport, and livestock-based livelihoods.

5.8.0 WATER BODIES SUCH AS RIVER, NALA, STREAM, RESERVOIR, ETC

5.8.1 The drainage pattern in and around the Block is represented mainly by ephemeral streams and seasonal nalas typical of the semi-arid environment of the Kachchh region. The Kakdi Nadi and Kotawadi Nadi constitute the principal drainage channels of the area. These seasonal streams form the major surface drainage outlets, exhibiting a gentle gradient towards the north-west, and primarily carry runoff during the monsoon season. For most of the year, these channels remain dry or carry very limited surface flow, reflecting the low rainfall conditions prevalent in the region.

5.8.2 Groundwater in the area occurs mainly within weathered and fractured zones of the basaltic formations and associated sedimentary units. However, the groundwater regime has been influenced by sustained extraction for industrial and power generation activities. Continuous withdrawal of groundwater, initially by Gujarat Mineral Development Corporation (GMDC) and subsequently by Gujarat State Electricity Corporation Limited (GSECL) in the surrounding region, has resulted in a progressive decline in groundwater levels. Consequently, the present groundwater conditions of the area are governed by a combination of local hydrogeological characteristics and anthropogenic interventions related to industrial and mining activities.

5.9.0 CLIMATIC CONDITIONS

5.9.1 The Kachchh region experiences a hot and arid to semi-arid desert climate for most part of the year, characterized by high temperatures, low humidity, and scanty rainfall. The temperature in the region generally ranges between 10°C during winter months and up to about 45°C during peak summer, reflecting the extreme seasonal variation typical of desert environments. The summer season extends from March to June, during which temperatures rise significantly, often reaching 45°C, accompanied by hot and dry winds. The winter season generally prevails from November to February, when temperatures drop considerably and may fall to around 10°C, resulting in comparatively cooler and more pleasant climatic conditions.

5.9.2 Rainfall in the region is limited and erratic, with an average annual precipitation of approximately 350 mm. The area receives rainfall primarily during the Southwest Monsoon, which occurs between June and September and contributes nearly 90% of the total annual rainfall. A minor portion of rainfall may also occur during the Northeast Monsoon, though its contribution is relatively insignificant. Overall, the climatic conditions of the region are characterized by high evaporation rates and prolonged dry periods, which significantly influence the hydrology, vegetation, and land use patterns of the area.

5.10.0 OTHER PHYSIOGRAPHIC, SOCIAL AND ENVIRONMENTAL FACTOR

5.10.1 The Kachchh district, particularly Lakhpat Taluka, is characterized by an arid to semi-arid physiographic setting marked by gently undulating plains, low rocky uplands, and isolated lateritic remnants. The terrain gradually merges into marginal saline tracts adjoining the Great Rann of Kutch to the north, while the Arabian Sea lies towards the southwest of the district. The geomorphological features of the area are largely controlled by the underlying volcanic and sedimentary formations, together with prolonged weathering and erosional processes under arid climatic conditions. The drainage system of the region is predominantly ephemeral in nature, with seasonal streams carrying water mainly during the monsoon period. For the remainder of the year, most channels remain dry due to the low rainfall and high evaporation rates characteristic of the region. Groundwater generally occurs at considerable depths and is often saline in quality, which limits its suitability for drinking and irrigation purposes. Consequently, the local population relies significantly on rainfall and localized water-harvesting structures such as ponds, tanks, and check dams for meeting their water requirements.

5.10.2 The region also possesses significant mineral resources, particularly gibbsitic bauxite deposits, occurring in areas such as Gadhsisa, Ratadia-Nagrecha, Mothala-Balachod, Nana Goniyasar, and Naredi-II within Kachchh district. Several mining leases for bauxite are operated by Gujarat Mineral Development Corporation (GMDC) in these areas. In addition, bentonite deposits occur widely in the region, and a number of mining leases operated by the Ashapura Group are active in the surrounding areas for the extraction of bentonitic clay. These mineral resources contribute significantly to the industrial and economic development of the region, while also influencing the local socio-economic landscape.

CHAPTER-6
INFRASTRUCTURE

6.1.0 LOCAL INFRASTRUCTURE, HOST POPULATION, HISTORICAL SITES, FORESTS, SANCTUARIES, NATIONAL PARK AND ENVIRONMENTAL SETTING OF THE AREA.

6.1.1 The Lakhpat town, located in Lakhpat Taluka of Kutch District, Gujarat, serves as an important administrative centre in the region. Basic civic and infrastructural facilities are available in nearby towns such as Dayapar, which functions as a local service centre for the surrounding villages. The area is supported by essential amenities including a government primary health centre, private dispensaries, educational institutions, banking facilities, post office services, bus transport facilities, and local markets, which cater to the needs of the local population as well as personnel engaged in exploration and mining activities.

The region also has an established mining presence, particularly related to lignite extraction, with mining operations being carried out in the vicinity of the explored block by Gujarat Mineral Development Corporation (GMDC). These activities contribute to the regional economy and provide employment opportunities to the local population.

Details pertaining to the host population, historical and cultural sites, forest and ecological features, wildlife sanctuaries, and the overall environmental setting of the area have been described in Chapter 5.0.0 (Physiography and Environment) of this report. These aspects collectively provide an overview of the socio-environmental framework and ecological context within which the exploration activities in the Dhrang Block are undertaken.

6.1.2 Lakhpat Tehsil is located in the north-western part of Kachchh district of Gujarat and forms part of the arid desertic terrain adjoining the Great Rann of Kachchh and the coastal tract of the Arabian Sea. The region is characterized by sparse vegetation, saline flats, coastal plains and low hillocks forming a distinctive desert–coastal ecosystem. Climatically, the area falls under a hot arid zone with extreme temperature variations. Summers are hot with temperatures often exceeding 40°C, while winters remain mild. The average annual rainfall is low and erratic, generally around 300–350 mm, mostly received during the southwest monsoon. The drainage is poorly developed and consists mainly of ephemeral streams that remain dry for most of the year and discharge into the Rann or nearby creeks such as the Kori Creek.

6.1.3 Vegetation in the area is generally sparse and comprises thorny scrub, desert grasses and xerophytic shrubs adapted to saline and arid conditions. The natural vegetation belongs predominantly to the desert thorn forest type. Common species observed in the region include *Prosopis juliflora*, *Salvadora persica*, *Capparis decidua*, *Ziziphus nummularia* and various species of *Euphorbia*. Much of the land surface is covered by scrubland, saline wasteland and grass patches which provide suitable habitat for desert fauna.

6.1.4 An important protected area within Lakhpat Tehsil is the Narayan Sarovar Wildlife Sanctuary located in the western part of the taluka. The sanctuary represents a typical desert ecosystem consisting of thorn forest, grassland and seasonal wetland habitats and supports several species of wildlife including chinkara (Indian gazelle), desert fox, Indian wolf, hyena, caracal and nilgai. The sanctuary is ecologically significant as it conserves several rare and threatened species adapted to the arid conditions of Kachchh. In the broader Kachchh region, the Kutch Bustard Sanctuary also represents an important habitat for the endangered Great Indian Bustard and other migratory bird species associated with desert grasslands.

6.1.5 The region also possesses historical and cultural importance. The historic town of Lakhpat, situated near the Kori Creek, is surrounded by an old fortification wall constructed during the nineteenth century and represents one of the prominent historical landmarks of western Kachchh. Several monuments of cultural significance are present within the town including the Gurudwara Guru Nanak Darbar, which commemorates the visit of Guru Nanak, and the tomb of the Sufi saint Pir Ghaus Muhammad. The nearby area of Patgadh contains archaeological remains of an ancient settlement associated with early regional dynasties and indicates long-standing human occupation in the region.

6.1.6 Overall, the environmental setting of Lakhpat Tehsil is characterized by an arid desert landscape with sparse vegetation, saline soils and unique desert wildlife habitats. The presence of protected areas such as the Narayan Sarovar Wildlife Sanctuary along with the historical heritage of Lakhpat town adds ecological and cultural significance to the region.

CHAPTER-7

GEOLOGY

7.1.0 REGIONAL GEOLOGY

7.1.1 The Kachchh Basin of western India represents a well-developed east–west trending peri-cratonic rift basin, preserving a nearly continuous stratigraphic succession from the Middle Jurassic to Recent (Holocene). The basin records a complex geological history of marine and continental sedimentation, tectonism, volcanism and erosion, making it one of the most significant basins for understanding the evolution of the western continental margin of India.

The Mesozoic sedimentary succession, deposited over a Precambrian basement (exposed in the Nagar Parkar Hills), comprises marine sequences ranging from Bathonian to Tithonian, followed by Cretaceous non-marine sediments. These were formed under shallow marine to deltaic environments, representing major transgressive and regressive depositional cycles. A major geological break towards the end of the Cretaceous, marked by tectonism, erosion and Deccan Trap volcanism, separates the Mesozoic and Cenozoic sequences.

The basin subsequently witnessed emplacement of Deccan Trap volcanic flows (Late Cretaceous–Early Palaeocene), followed by deposition of Palaeocene volcaniclastic sediments and Eocene marine sequences, which filled structural lows and peripheral depressions. The Tertiary succession of the basin is economically important and hosts mineral deposits such as limestone, clay, lignite and bauxite.

Structurally, the basin is asymmetrical, bounded by the Nagar Parkar Fault in the north and the North Kathiawar Fault in the south, with its eastern extension limited by the Radhanpur–Barmer Arc. The sedimentation is largely syn-rift in nature, reflecting active tectonism during the Mesozoic.

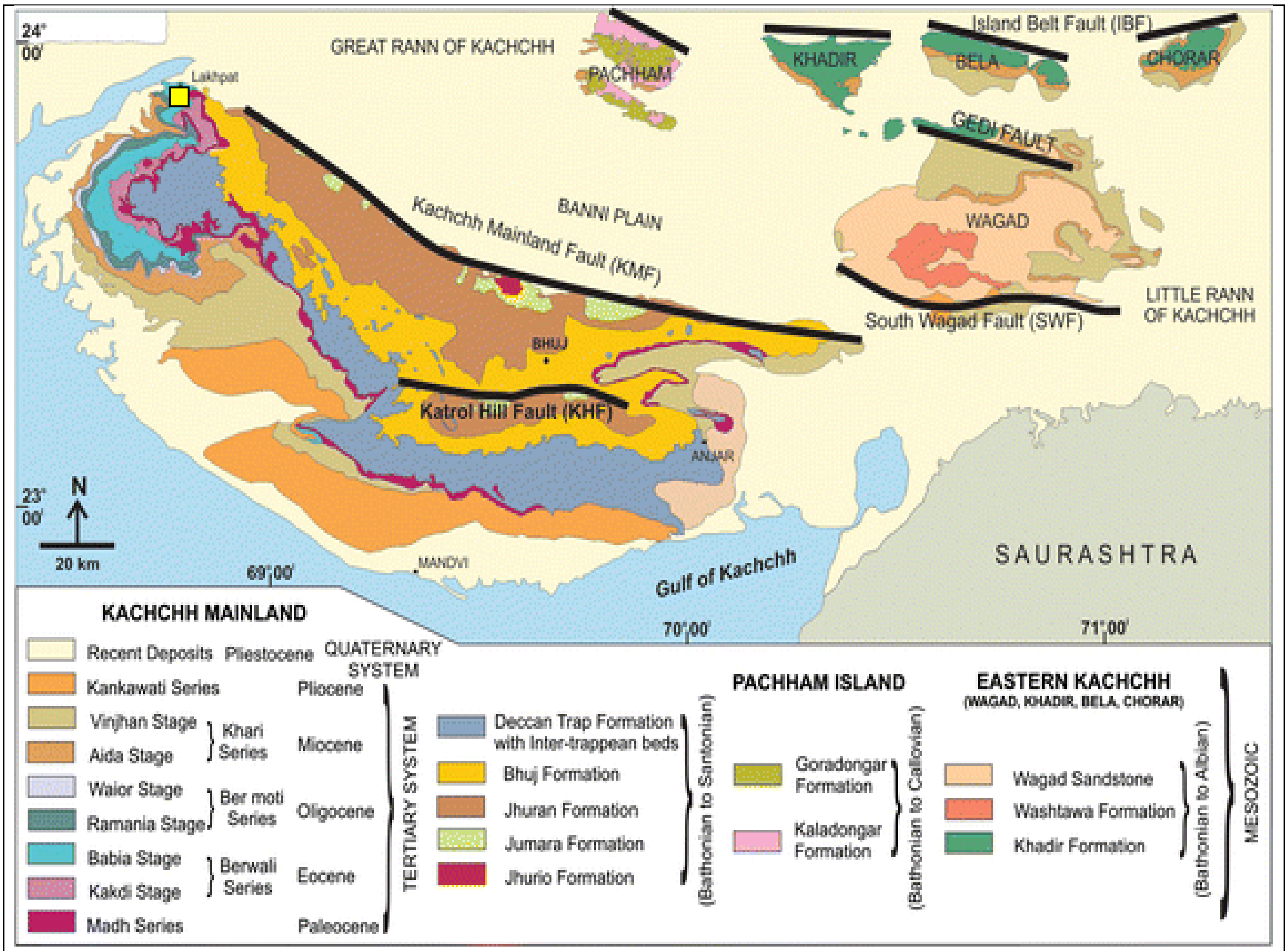
The stratigraphy of the basin includes the well-known Patcham, Chari, Katrol and Umia Groups (Waagen, 1875), later revised by Biswas (1971) into formations such as Jhurio, Jhumara, Jhuran and Bhuj. These lithological units predominantly represent nearshore marine environments ranging from neritic to lagoonal and littoral settings.

Overall, the Kachchh Basin comprises Jurassic to Recent formations overlain by Deccan Trap volcanics and younger sediments, providing a favourable geological environment for the development of lateritic bauxite deposits and associated mineralization in the region.

7.1.2 Regional Geological Map is given as Text figure- 4and Regional Stratigraphy is given below. Regional Geological map of NGDR is presented in Plate-II.

Table-7.1
Geological Succession of the Kachchh Dist, Topo-sheet no 41A/14
(After GSI 2001)

Age	Formation	
Cretaceous	Bhuj	
	Umia	Ukra beds-Marine calcareous shales
		Umia beds: Barren sandstones and shales
		Trigonia beds; Barren Sandstones
		Umia ammonite bed
		Up. Katrol Shales
Upper Jurassic to Lower Cretaceous	Katrol	Gajansar Beds
		Upper Katrol (Barren sandstone)
		Middle Katrol (red sandstones)
		Lower Katrol (Sandstone, shale, marl)
		Kantkote Sandstone
Upper Jurassic to Middle Jurassic	Chari	Dhosa oolite
		Athleta beds (marls and gypseous shales)
		Anceps beds (limestone and shales)
		Rehmanni beds (yellow limestone)
Middle Jurassic	Patcham	Macrocephalus beds
		Patcham coral bed
		Patcham shell limestone



Text Figure-4

7.1.3 **Deccan volcanics**

The Deccan Trap Volcanics constitute an important geological unit in the Kutch Basin, where they are exposed predominantly in the southern part of the Kachchh mainland as a 10–20 km wide belt trending in a NW–SE direction. These volcanic flows unconformably overlie the Bhuj Formation of Mesozoic age and represent the terminal phase of volcanic activity associated with the Late Cretaceous–Early Palaeogene Deccan volcanism.

The lava flows are generally represented by plateau-type basalts, which are predominantly tholeiitic in composition in the western parts around Dayapar and Matanomadh, while alkaline basaltic compositions have been reported from areas such as Baladia, Anjar, and Bhachau. In addition to the basaltic flows, occurrences of highly alkaline intrusive rocks such as nephelinite, essexite, and olivine–analcite basalt have been reported within the Mesozoic sedimentary sequence at a few locations (Mukherjee et al., 1988; Melluso et al., 2006).

Geological investigations have indicated that nine lava flows occur in the southern part of the Kachchh mainland, with the total thickness of the trap sequence ranging between 140 and 150 m (GSI, 2001). At many places, the basaltic lava displays pahoehoe-type flow structures, indicating emplacement under relatively fluid volcanic conditions. Numerous alkaline and tholeiitic intrusive bodies are also recorded within the Mesozoic sediments as well as within the Deccan Trap flows.

Prominent alkaline intrusive complexes occur at Nirwandh and Kuran, where the intrusive bodies are primarily composed of gabbroic rocks and pyroxenites, occasionally containing disseminations of metallic sulphides. Around the margins of these intrusive bodies, dykes and apophyses of hornblendite, ankaramite, granophyre, trachyte, andesite, and syenite are observed. In certain locations within the Kachchh mainland, mantle-derived peridotite nodules have also been reported from alkaline plugs occurring at Bhuj, Vithonia, and Dhinodhar (Mukherjee et al., 1988).

Petrographically, the basalt is typically fine- to medium-grained, commonly displaying vesicular and fractured textures, with the cavities often filled by secondary minerals such as silica, zeolites, and calcite. Exfoliation and spheroidal weathering are characteristic features observed in many basalt exposures. The presence of well-developed chilled margins is helpful in identifying individual lava flow units within the Deccan Trap sequence.

Variations in the flow direction of magma observed at different locations indicate the multiple phases of volcanic eruptions that contributed to the development of the Deccan volcanic province. In weathered exposures, concentric rings of yellow, brown, and cherry-red coloration, produced due to limonitization and intense weathering, are commonly observed in exfoliated basalt surfaces. Additionally, porphyritic varieties of basalt are locally developed in certain parts of the area, further reflecting the complex nature of Deccan volcanic activity in the Kachchh region.

7.1.4 Supta-trappean horizon

The Supta-Trappean horizon represents the sedimentary and weathered stratigraphic interval developed immediately beneath the Deccan Trap lava flows, marking the transitional phase between the pre-volcanic sedimentary sequence and the subsequent Deccan volcanic activity. This horizon generally overlies the older sedimentary formations and forms the basal weathering surface upon which the Deccan Trap basalts were emplaced.

Lithologically, the Supta-Trappean sequence comprises lithomarge, greyish to greenish bentonitic clays, ferruginous sandstones, aluminous clays (kaolin), laterite and bauxite horizons, along with yellowish to reddish laminated shales, occasionally associated with volcanic ash layers and gypseous partings. The laterite–bauxite horizons commonly contain interstratified coarse, current-bedded gritty ferruginous sandstones, micaceous siltstones and shale, indicating episodes of sedimentary reworking during the development of the weathering profile.

In certain parts of the region, particularly along the western flank, trap flows are observed immediately above the laterite–bauxite horizons, suggesting that the bauxitization and lateritization processes took place prior to the emplacement of the Deccan Trap lavas. The development of this Supta-Trappean weathering profile reflects prolonged subaerial exposure, intense chemical weathering and leaching, which favoured the formation of lateritic and gibbsitic bauxite deposits in the region.

7.1.5 Matanomadh Formation

The Matanomadh Formation represents an important lithostratigraphic unit in and around the study area and is chiefly characterized by the occurrence of bauxite, laterite, and associated clay horizons developed over the basaltic terrain. The bauxite deposits are interpreted to have formed through intense chemical weathering and alteration of the underlying basalt, followed by processes of desilicification and secondary silicification under favourable climatic and geomorphological conditions.

Macroscopically, the bauxite commonly exhibits oolitic and pisolitic textures, which are characteristic features of lateritic bauxite deposits. Field observations indicate that kaolinitisation, lateritisation, and bauxitisation processes occur together within a NW–SE trending belt, reflecting progressive stages of weathering and enrichment of aluminium within the weathering profile.

Petrographic and microscopic studies reveal the presence of alumina-rich minerals such as Gibbsite and Boehmite, along with titanium-bearing minerals including Ilmenite and Titanomagnetite. The assemblage also contains iron-bearing minerals such as Hematite, Magnetite, and Goethite, which contribute to the ferruginous character of the lateritic profile.

In hand specimen, the bauxite varies in colour from light brown and pale pink to greyish white, often displaying a clayey appearance, particularly in the lower portions of the bauxite zone. The bauxite horizon is commonly associated with small lateritic patches and cavities filled with ferruginous materials, imparting a patchy and variegated appearance to the deposit. Alternating bands and patches of cherry red, yellow, white, and brown colours are frequently observed due to the presence of laterite and ferruginous constituents.

The bauxite occurrences in the area are typically pocket-type deposits, occurring between laterite and clay horizons and forming small, discontinuous bodies. These deposits are generally scattered and localized, commonly occurring along the crests of flat-topped hills and ridges. In addition to the bauxite–laterite assemblage, the Matanomadh Formation also includes variegated bentonitic clays, which constitute an important lithological component of the formation and reflect post-volcanic weathering and sedimentary processes in the region.

7.1.6 Kakdi Nadi Formation

The Kakdi Nadi Formation is represented by a sequence of variegated to mottled siltstones, grey to olive-green shales, and micaceous siltstones, intercalated with fossiliferous marlite bands. These lithological assemblages indicate deposition under shallow marine to marginal marine conditions, reflecting fluctuating sedimentary environments during the early stages of the Palaeogene period.

Palaeontological evidence from this formation includes the occurrence of marine fossils such as Oysters, Turritella, and occasional Echinoids, which further support its marine depositional setting.

Within the proposed block area, the Kakdi Nadi Formation is primarily represented by variegated gypseous shale and clay horizons intercalated with limestone bands, which are assigned to the Palaeocene age. These lithological characteristics reflect periodic marine incursions and evaporitic conditions, resulting in the deposition of gypsiferous clay and shale associated with carbonate horizons.

7.1.6 Laterite & Bauxite

The laterite and bauxite horizons in the area occur as discontinuous pocket-type deposits, generally capping the lateritic profile of the Matanomadh Formation. These deposits are typically developed along the crests of flat-topped hills and elevated ridges, where favourable conditions for prolonged weathering and leaching prevailed.

The genesis of these deposits is attributed to the in-situ lateritization and bauxitization of the underlying Deccan Trap basalts and associated pyroclastic materials. Intense chemical weathering under suitable climatic conditions led to the progressive removal of silica (desilicification) and enrichment of alumina, resulting in the formation of laterite and subsequently bauxite within the weathering profile.

The bauxite formation process involved alteration of basaltic parent material, followed by desilicification and secondary silicification, which facilitated the concentration of aluminium-bearing minerals. In hand specimen, the bauxite commonly exhibits oolitic and pisolitic textures, which are characteristic features of lateritic bauxite deposits and indicate chemical precipitation and concretionary growth during weathering and diagenetic processes.

7.2.0 REGIONAL STRUCTURE

7.2.1 Structurally, the study area represents a tectonically stable volcanic plateau, characterized by minimal structural deformation. The Deccan Trap lava flows occurring in the region are generally horizontal to gently dipping, reflecting the overall post-eruptive tectonic stability of the area. No major structural disturbances such as folding, faulting, or metamorphism have been observed within the block area.

The bedding planes are well developed in the sedimentary units and can be recognized by variations in texture, grain size, and colour. These features are particularly conspicuous within the Bhuj Formation and Kakdi Nadi Formation, where feldspathic and ferruginous sandstones are distinguishable on the basis of their colour and mineralogical composition. In several exposures, laminations are observed within feldspathic sandstones, siltstones, and shale horizons, indicating deposition under relatively low-energy sedimentary environments. The beds generally exhibit horizontal to sub-horizontal attitudes across the area.

Several primary sedimentary structures are also present within the sedimentary formations. Cross-bedding, which is typical of the Bhuj sandstone, is commonly observed and reflects deposition under fluvial to shallow marine conditions. Additionally, ripple marks have been recorded within the Bhuj Formation, indicating the influence of wave or current action during sedimentation. Evidence of biogenic activity is also observed in the form of vertical burrows and trails, representing trace fossils formed by organisms inhabiting the sediment during deposition.

In addition to primary structures, secondary structural features developed after lithification are also present. These include joints, fractures, minor faults, and slickensides, which formed due to tectonic adjustments over geological time. Joints and fractures are particularly conspicuous within the Bhuj Formation as well as in the basaltic flows of the Deccan Traps, and they play an important role in controlling weathering patterns, groundwater movement, and local geomorphology in the region.

7.3.0 GEOLOGY OF THE BLOCK

7.3.1 The Dhrang Block, covering an area of approximately 4.86 sq. km, is located in the Matanomadh region of Kutch District, Gujarat. Geologically, the block forms part of the Deccan Trap volcanic province, where the basaltic terrain has undergone intense tropical weathering, resulting in the development of laterite, bauxite, bauxitic clay, lithomargic clay, and bentonitic clay horizons.

7.3.2 Physiographically, the Deccan basalt surface exhibits a gentle southward slope, whereas the northern and north-western parts of the block are characterized by relatively steep gradients and cliff-like hillock faces. In contrast, the southern part of the block is comparatively flat to gently undulating, with relatively lower elevation.

7.3.3 The highest elevation within the block reaches about 118 m RL, while the lowest elevation in the southern portion is approximately 84 m above Mean Sea Level (MSL). The geology of the block is heterogeneous in nature, largely controlled by topography, geomorphological position, and the varying degree of weathering of the basaltic parent rock. The geological framework of the block has been interpreted based on detailed geological mapping at 1:4000 scale, supported by systematic field traverses, bedrock sampling, nala section observations, examination of old workings, pitting, core drilling, and integration of subsurface data through geological cross-sections.

7.3.4 Detailed mapping reveals that the north-western part of the block, which occupies relatively higher elevation, shows well-developed bauxite horizons of pisolitic to conglomeratic nature occurring along the crests of hillocks. The slopes of these hillocks are generally represented by laterite grading downward into clay horizons. The central part of the block, which lies at relatively lower elevation, shows moderately developed bauxite occurrences, while the eastern part is characterized by clayey varieties of bauxite, largely restricted to nala sections and narrow exposures. The southern part of the block is mostly devoid of natural outcrops, and portions of this area are presently covered by existing bentonite mining operations of the Ashapura Group, along with several old mine workings, some of which have been partially backfilled. Geological mapping has established a lithological succession comprising bauxite, laterite, bauxitic clay, lithomargic clay, bentonitic clay, and saprolitic zones developed over the basaltic basement.

7.3.4 The area predominantly exposes Tertiary lithological units represented by the Matanomadh Formation and Kakdi Nadi Formation, along with basaltic lava flows of the Deccan Volcanics and recent unclassified alluvial deposits. The supra-trappean sequence is represented by oolitic and pisolitic bauxite, which is locally conglomeratic due to reworking, associated with laterite, lithomarge, and aluminous clay horizons of varied colours.

7.3.5 The Deccan Trap basalt forms the basement lithology of the area and is typically fine- to medium-grained, dark grey to black in colour, and locally porphyritic with feldspar phenocrysts. Amygdaloidal structures filled with secondary minerals are common, particularly in the northern sector, and the basalt exhibits variable degrees of weathering ranging from fresh massive rock to highly altered clayey material.

7.3.6 Overlying the basalt is a well-developed lateritic–bauxitic profile belonging to the Matanomadh Formation. The upper laterite horizon occurs mainly in the north-western part of the block, commonly limonitized, clay-filled, and locally in direct contact with the parent basalt. The bauxite horizon is predominantly pisolitic to oolitic, typically greyish-pink to off-white in colour, and moderately to well indurated. Pisolites occur as concentric circular to elliptical bodies, in some cases enriched by iron-bearing fluids, and are especially well developed along hill crests. Conglomeratic bauxite boulders are locally observed along hill slopes, indicating reworking and downslope transport processes.

7.3.7 Associated lithologies include clayey bauxite and bauxitic clay, which occur in alternating sequences with lithomargic clay and are commonly developed in relatively low-elevation basaltic terrain, particularly in the central and southern parts of the block. The lithomargic clay forms the lowermost unit of the lateritic weathering profile and is exposed in pits and old mine workings, representing advanced kaolinization and leaching of the basaltic parent rock. Overlying or laterally associated with the lateritic sequence is the supra-trappean bentonite horizon, which occurs as light-yellow, soft to moderately compact material, occasionally showing secondary vesicular structures, indicating alteration of volcanic ash or tuffaceous material. Sedimentary units of the Kakdi Nadi Formation are represented by limestone horizons with clay infillings, exposed in small patches in the eastern part of the block, suggesting localized shallow marine to lagoonal depositional environments. In addition, minor exposures of ferruginous sandstone belonging to the Bhuj Formation have been reported from the central to southern parts of the block.

The stratigraphy sequence is given in **Table No. 7.2**. The Geological map of the block is presented as **Plate No.-IVA** and **Text Figure-5.**

Table No. 7.2: The Local Stratigraphic Succession of the Dhrang block

Recent	Alluvium
Tertiary to Recent	Laterite (1.0-4.50m) Bauxite and aluminous laterite (0.0 to 14.0m) Variegated Clay and other Clay (2.10 to 11.50m) Lithomarge (0.5-1.0m) Saprolite (0.90-3.0m)

7.4.0 DESCRIPTION OF DIFFERENT LITHO UNITS IS GIVEN BELOW

The lithological succession within the block comprises soil, laterite, bauxite, variegated clay, and lithomargic clay, developed as a result of intense weathering and alteration of the underlying basaltic parent rock. These litho-units have been encountered in boreholes at varying depths and thicknesses, reflecting the heterogeneous nature of the weathering profile and local geomorphological controls.

The colour, texture, and chemical composition of these lithological units exhibit considerable variation, indicating different stages and intensities of lateritization, bauxitization, and clay alteration processes within the weathering sequence. A detailed description of the lithology and petrographic characteristics of the rock units exposed in the field as well as intersected in the boreholes is presented in the following paragraphs.

1. **Soil:** The soil profile is well developed in most part of the block. The Soil is brownish to Reddish in colour (Photograph 7.1). The thickness of soil cover is around 0.0 to 0.8m.

Photograph No 7.1: Soil Cover is observed at bentonite quarry at block.

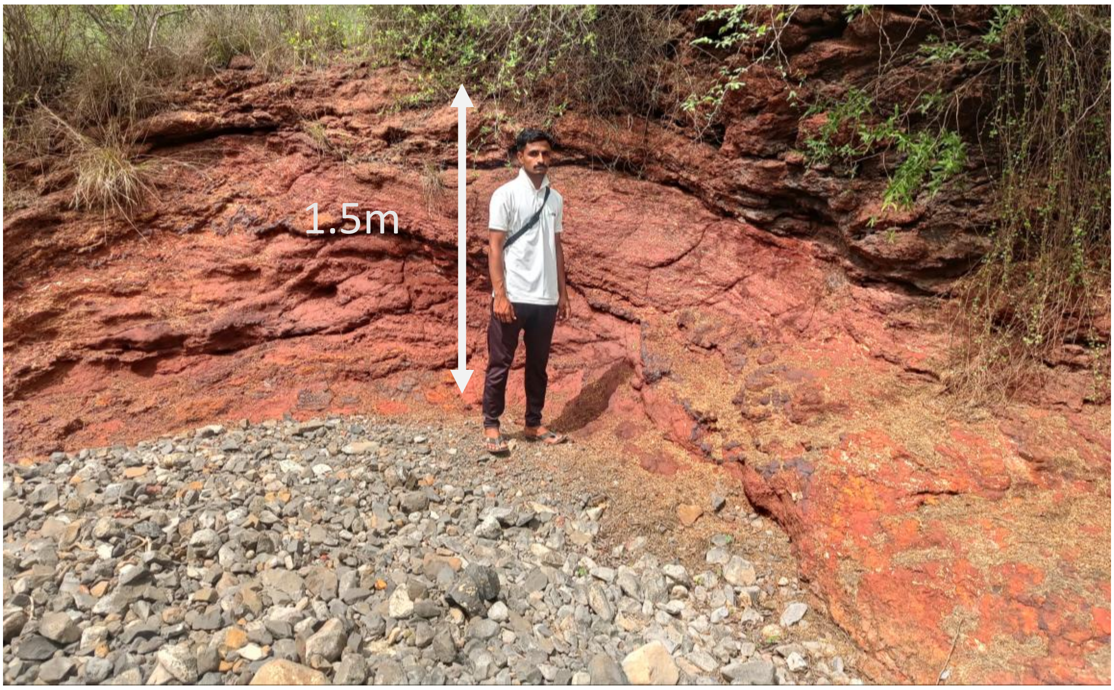
2. **Limestone**: Limestone belonging to the Fulra Formation is observed in the south eastern part of the study area. This stratigraphic relationship indicates a transition from the older clastic sedimentary sequence to younger carbonate deposition within the regional geological succession.

   Megascopically, the limestone is friable to moderately compact in nature and is generally clayey, white to cream coloured, reflecting the presence of fine carbonate material admixed with minor clay content. The rock is predominantly foraminiferal in character, indicating its deposition in a shallow marine environment where the accumulation of calcareous microfossils contributed significantly to the formation of the limestone.

3. **Laterite/Aluminous laterite:** The laterite/Aluminous horizon represents the uppermost part of the lateritic–bauxitic profile within the study area and is predominantly developed in the north-western portion of the block. In this sector, laterite commonly occurs with clay infilling and shows pronounced limonitization, often retaining the relict textures and structural signatures of the parental basaltic rock (Photograph – 7.2). At certain locations, the laterite is observed to be in direct contact with the parent basalt, indicating in-situ weathering and alteration processes.

Within the block, laterite generally occurs as irregular bodies associated with lateritic clay, and its thickness varies from about 1.0 m to 4.50 m. Stratigraphically, the laterite horizon typically overlies the bauxite zone and, at places, is overlain by lateritic soil. Megascopically, the laterite is reddish in colour, hard, compact, and massive, displaying characteristic vesicular, scoriaceous, and ferruginous textures. In some occurrences, the lateritic masses exhibit aluminous vesicles, indicating partial enrichment of aluminium during the weathering process. A segregation of bauxite is commonly observed immediately beneath the pisolitic laterite horizon, marking the transition from laterite to bauxite within the weathering profile.

In several locations, the laterite occurs with clay-filled cavities and fractures, and the colour varies from cherry red to off-white. The laterite is generally hard and compact in the north-western part of the block, whereas in the central and slope regions of the hillocks, it tends to be relatively friable due to increased weathering and clay alteration. This variation reflects differences in topographic position, intensity of weathering, and local geomorphological conditions across the block.



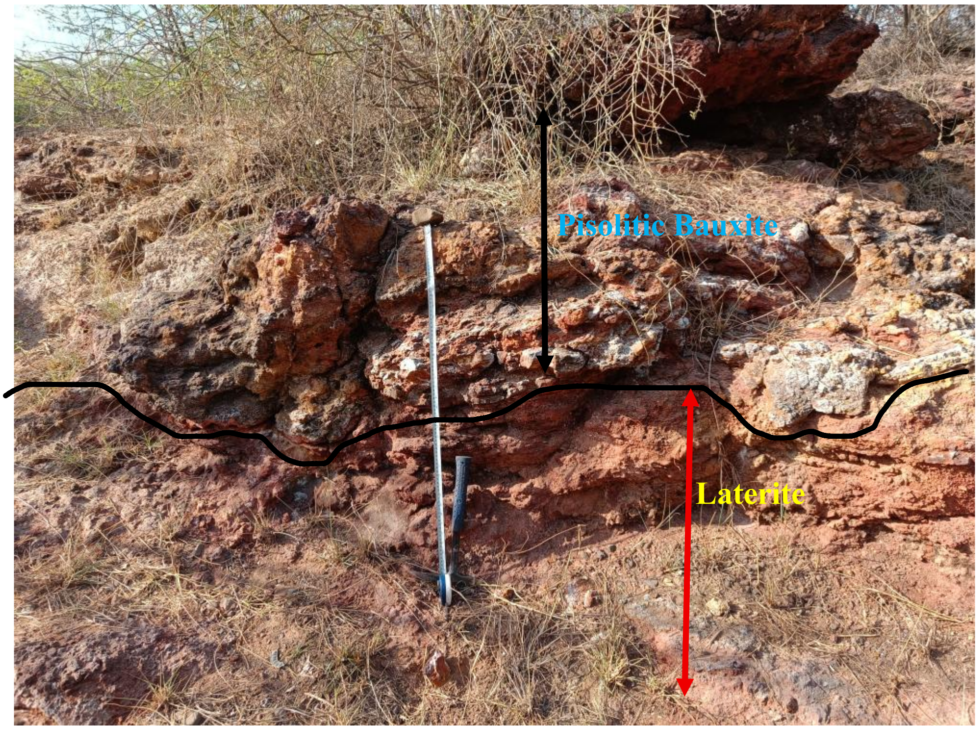
Photograph No. 7.2: Laterite profile as observed and mapped along dry nala in NW part of the block with transported Basalt Boulders (on bank of river).

4. **Bauxite**: Bauxite within the study area occurs as part of a lateritic profile developed over the Deccan Trap basalts and is mainly associated with the Mata-no-Madh Formation. Structurally, the lateritic–bauxitic band shows a general NE–SW trend in the western and central parts of the block, which gradually swings to NNW–ENE in the eastern part. Stratigraphically, the Mata-no-Madh Formation overlies the Deccan Trap basalts in the northern part of the block and is overlain by the Kakdi Nadi Formation in the central part, indicating a well-developed lateritic weathering horizon separating the volcanic basement from the younger sedimentary succession. Lithologically, the Mata-no-Madh Formation in the block is dominantly composed of laterite with localized occurrences of pisolitic bauxite, clayey bauxite, and bauxitic clay. These bauxitic horizons are generally preserved along the crest and upper slopes of hillocks where the lateritic profile is well developed. Based on field characteristics, particularly the degree of pisolitic development and the proportion of clay in the rock unit, the lateritic sequence has been classified into bauxite (bauxite-bearing laterite), clayey bauxite, bauxitic clay, and lithomargic clay.

The bauxite is typically greyish-pink to off-white in colour, moderately to well indurated, and exhibits well-developed pisolitic to oolitic textures. The pisolites are generally sub-spherical to elliptical and show distinct concentric internal structures, indicative of in-situ lateritic processes. The pisolitic bauxite is prominently developed along the crests of hillocks, whereas along the slopes, conglomeratic bauxite boulders are locally encountered, suggesting reworking, downslope transport and subsequent deposition of bauxitic material under gravity-controlled processes. Megascopically, some pisolitic bodies (Photograph – 7.3 and 7.4) exhibit ferruginous impregnation by iron-bearing fluids, while others remain relatively free from iron enrichment.

The formation of laterite and bauxite in the area is attributed to prolonged tropical weathering under conditions of intense rainfall and strong chemical leaching. During lateritization, relatively mobile elements such as calcium, sodium, potassium, and magnesium are progressively removed from the parent rock, whereas relatively immobile elements including aluminium, iron, titanium, and zirconium become concentrated in the residual material. Continued weathering over extended geological periods results in the development of lateritic profiles, which may evolve into iron-rich laterite or aluminium-rich bauxite depending on the degree of leaching and geochemical conditions.

Photograph No. 7.3: Exposure of pisolitic–oolitic lateritic bauxite characterized by rounded ferruginous concretions embedded in a clayey lateritic matrix.



Photograph No. 7.4: Exposure of pisolitic–oolitic lateritic bauxite characterized by rounded ferruginous concretions embedded in a clayey lateritic matrix and contact with laterite.

Photograph No. 7.5: Conglomeratic Type of Pisolitic Bauxite.

In the lateritic sequence, aluminous laterite occurs in association with the bauxite horizon and typically appears light pink to grey in colour, containing rounded to ellipsoidal aluminous fillings dispersed within the matrix. The bauxite encountered in the block is identified as gibbsitic-type bauxite, occurring as hard and compact masses with well-developed pisolitic structures composed predominantly of gibbsite and boehmite.

Petrographic examination indicates that the bauxite is derived from intense lateritization of basaltic parent rock. The pisolites are fine to medium grained and consist of very fine aggregates of gibbsite and boehmite forming concentric structures. In several instances, these pisolitic bodies are rimmed or infilled by carbonate minerals. Cliachitic pisolites showing partial replacement by gibbsite–boehmite aggregates are also observed, indicating progressive alumina enrichment during lateritic alteration. Gibbsite and boehmite also occur as cavity fillings within the pisolitic matrix.

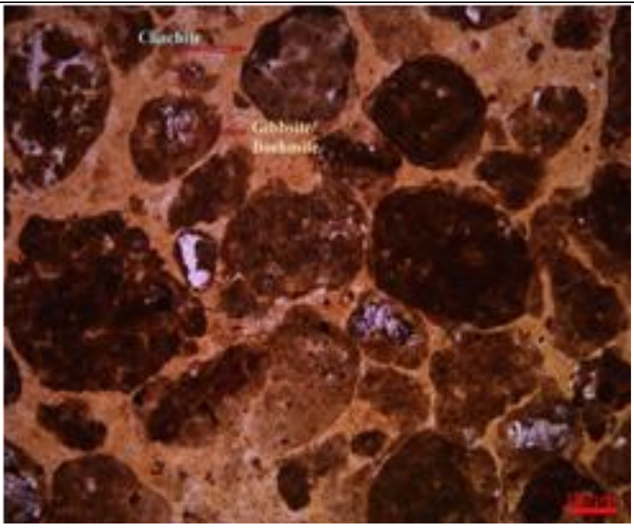
The basaltic remnants associated with the lateritic profile show porphyritic to vesicular textures, characterized by plagioclase phenocrysts embedded within a fine-grained groundmass composed of augite and plagioclase laths. Vesicles are occasionally filled with volcanic glass and opaque minerals. Secondary iron oxide minerals such as goethite and limonite occur as cavity fillings and amorphous aggregates, reflecting strong ferruginization during weathering. Accessory minerals including rutile/anatase and skeletal ilmenite are also observed as disseminated grains within the altered matrix.

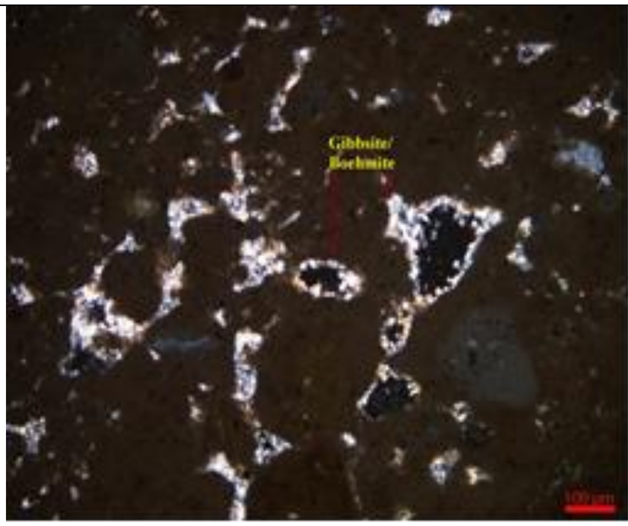
The bauxite horizon exhibits several pisolitic facies reflecting variable intensities of weathering and mineralogical alteration. Elongated aluminous pisolites showing localized infillings of goethite and hematite indicate secondary iron enrichment. Ferruginous pisolitic bauxite is characterized by fine pisolites coated with iron-oxide films, whereas massive pisolitic bauxite comprises well-sorted, spheroidal concretions embedded within a lateritic matrix. In certain sections, brecciated pisolitic bauxite is observed, reflecting syn- to post-lateritization fragmentation and subsequent re-cementation within the weathering profile. Such features may indicate localized post-depositional disturbances, possibly related to minor tectonic adjustments or mass-movement processes, rather than significant tectonic deformation. These features collectively indicate cyclic iron mobilization, progressive silica depletion, and fluctuating redox conditions during the evolution of the lateritic bauxite profile.

Microscopic examination of bauxite samples reveals whitish-grey coloured weathered rock displaying pores, cavities, fine pisolites, and ferruginous patches. Gibbsite occurs as segregated patches composed of fine prismatic aggregates(Pmg-2 and 3), while ferruginous matter occurs as reddish amorphous aggregates and stains. Opaque minerals appear as fine disseminations and anhedral patches. Carbonates occur as thin to moderately thick cavity fillings. Cliachite is observed as traces of pisolites undergoing replacement by gibbsite.

In bauxite-bearing laterite, the rock appears reddish-brown and highly weathered, containing pores, cavities, and fine whitish pisolites (Pmg-1). Clay minerals occur as medium to moderately coarse patches and pisolites. Ferruginous matter occurs as very fine amorphous aggregates forming irregular patches. Boehmite and gibbsite occur as microcrystalline aggregates forming pisolitic structures often rimmed by carbonate fillings. Opaque minerals occur as very fine relic grains within ferruginous patches.

Overall, the lithological and petrographic characteristics indicate that the bauxite of the study area represents a well-developed lateritic bauxite profile formed through prolonged chemical weathering and lateritization of basaltic parent rock, resulting in enrichment of alumina predominantly in the form of gibbsite and boehmite with associated ferruginous and accessory mineral phases.





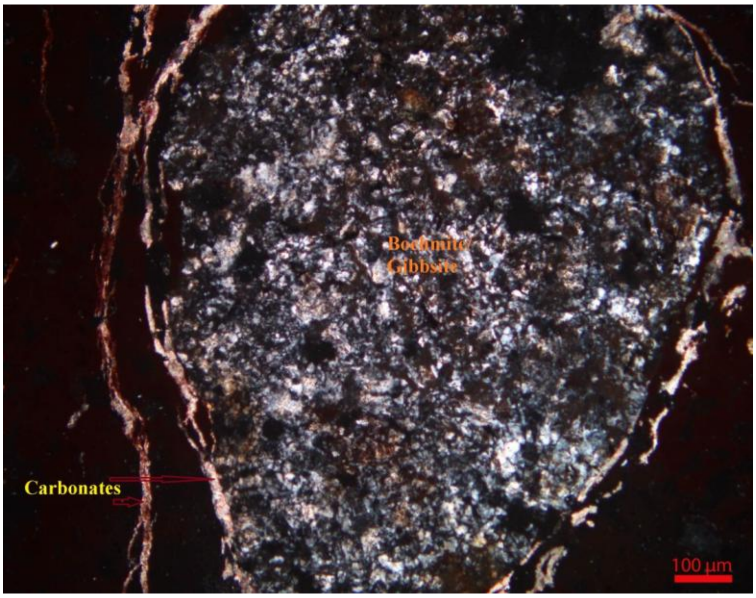
Pmg – 1: **Pmg – 2:**

Pmg – 1: Photomicrograph showing fine to medium pisolites of cliachite being replaced by gibbsite/ boehmite in areas as seen under plane polarized light.

Specimen No.: MBD/P/07 Magnification: 100X

Pmg – 2: Photomicrograph showing very fine cavity fillings of gibbsite/ boehmite as seen under crossed nicols.

Specimen No. : MBD/P/04 Magnification : 100X



Pmg – 3: Photomicrograph showing pisolite comprising very fine aggregates of boehmite/ gibbsite and is rimmed by carbonate fillings as seen under crossed nicols.

Specimen No.: MBD/P/03 Magnification: 100X

Biopedological observations reveal the presence of Commiphora genus shrubs (Photograph – 7.6) over the lateritic and bauxitic terrain in the vicinity of the Mata-no-Madh region. These xerophytic plants show strong ecological adaptation to highly weathered, ferruginous, and aluminium-rich soils typical of lateritic terrains. Such soils are generally porous, well drained, nutrient deficient, and subjected to seasonal moisture fluctuations, favouring drought-tolerant thorn-scrub vegetation. The occurrence of Commiphora therefore indicates prolonged geomorphic stability and sustained lateritic weathering within the upland terrain.

Photograph No. 7.6: Commiphora genus shrubs over the lateritic and bauxitic terrain.

In general, the bauxite horizon occurs immediately beneath the soil cover in the western, south-western, and north-western parts of the block. The bauxite is typically hard, dense, and compact, forming a well-developed lateritic horizon. The thickness of the bauxite layer shows considerable variation across the block, ranging from 0.50 m to about 9.50 m, reflecting differential lateritic development and localized geomorphological control.

(i) Exploratory drilling carried out by MECL has established the occurrence of Metallurgical Grade–II bauxite within the block. The average thickness of the metallurgical grade bauxite intercepted in five boreholes is 3.28 m. The minimum thickness of 1.55 m has been recorded in borehole MBD-05, whereas the maximum thickness of 5.00 m has been encountered in borehole MBD-01. The depth of intersection of the bauxite horizon ranges from surface exposure (0.00 m) in borehole MBD-01 to a maximum depth of 1.00 m in borehole MBD-

05, indicating that the bauxite horizon generally occurs near the surface beneath a thin soil cover.

(ii) Chemical analysis of the demarcated bauxite zones indicates that Al_2O_3 content varies from 40.49% (MBD-01) to 56.89% (MAP-01), while SiO_2 content ranges from 3.24% (MBD-01) to 3.45% (MBD-05). The relatively high alumina content coupled with low silica values confirms the metallurgical grade quality of the bauxite, making it suitable for alumina extraction and other metallurgical applications.

These results collectively indicate that the bauxite horizon in the block exhibits moderate thickness with favourable chemical characteristics of the deposit.

(a) **Clayey Bauxite:** Clayey bauxite within the block occurs interbedded with lithomargic clay, forming an alternating sequence within the lateritic weathering profile. This unit is characterized by the presence of pisolitic structures embedded within a clay-rich matrix, indicating partial lateritic alteration and incomplete alumina concentration compared to well-developed pisolitic bauxite.

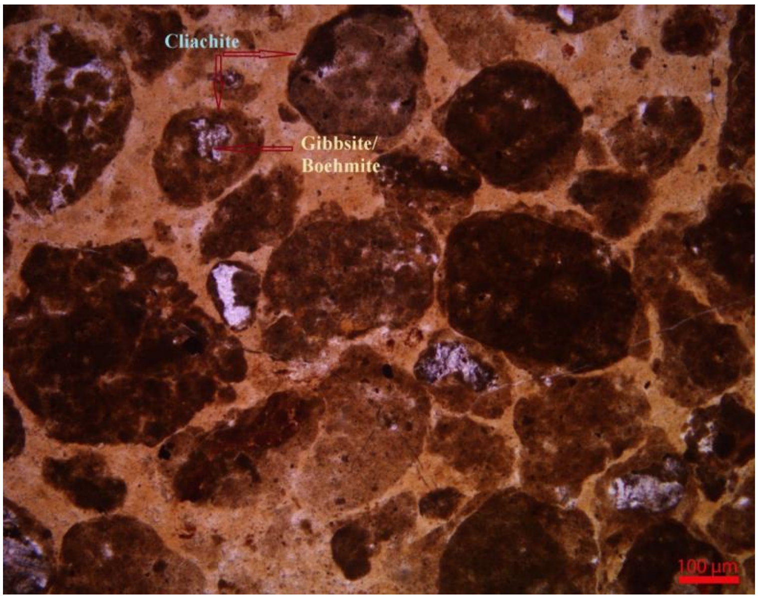
Megascopically, the clayey bauxite exhibits off-white to pinkish-white coloration (Photograph -7.7). The pinkish tint is primarily attributed to the presence of pisolitic constituents and ferruginous staining, whereas the whitish colour reflects the dominance of clayey material within the rock matrix. The material is relatively soft and friable in nature and commonly soils the hand upon handling, reflecting its high clay content and comparatively low degree of induration.

Field observations indicate that clayey bauxite is frequently encountered in measured stratigraphic sections where it occurs in alternating bands with lithomargic clay, representing transitional horizons within the lateritic profile. This lithological association suggests progressive alteration and gradation from clay-rich horizons to more aluminous bauxite zones.

Clayey bauxite is widely observed in several sections across the block, particularly in the eastern part of the study area, where it often exhibits relict textures and signatures of the parent basaltic rock, indicating incomplete lateritization and preservation of primary lithological features.

Exploratory drilling has revealed that the thickness of the clayey bauxite horizon varies locally, with a thickness of approximately 4.00 m recorded in borehole MBD-03 and 3.00 m in borehole MBD-04 (Photograph-7). The occurrence of this horizon within the lateritic sequence indicates transitional stages of weathering and alumina enrichment within the bauxite-bearing profile of the block.

Photograph No.7.7: Core Photograph of MBD-03 showing Clayey Bauxite intercepted between 0 to 4.00m



Pmg – 4: Photomicrograph showing fine to medium pisolites of cliachite being replaced by gibbsite/ boehmite in areas as seen under plane polarized light.

Specimen No. : MBD/P/07 **Magnification : 100X**

a. **Bauxitic clay:** Bauxitic clay occurs as small discontinuous patches within the clayey bauxite horizon and is distinguished by its relatively higher proportion of clay content compared to the surrounding clayey bauxite. This unit represents a transitional lithology within the lateritic profile, reflecting advanced weathering and partial alumina enrichment.

Megascopically, the bauxitic clay appears reddish white in colour under dry conditions and reddish when moist, indicating variations in moisture content and clay mineral composition (Photograph- 7.8). The rock mass commonly contains minor relict pisolitic structures, suggesting derivation from earlier pisolitic bauxite horizons that have undergone further alteration and clay enrichment. At several locations, ferruginous material are observed, indicating secondary iron mobilization and precipitation during lateritic weathering processes.

Spatially, the bauxitic clay horizon is mainly developed in the central and southern parts of the mapped area, where it occurs both as surface exposures and within borehole sections. The unit is also exposed as isolated patches within the basaltic terrain at relatively lower elevations, reflecting localized weathering and accumulation within depressional zones of the landscape. In addition, bauxitic clay has been identified in pit sections within the study area, presence within the lateritic stratigraphic sequence.

Photograph No.7.8: Core Photograph of MBD-04 showing Bauxitic Clay intercepted between 15.00 to 17.00m

(b) **Lithomargic Clay:** Lithomargic clay constitutes the lowermost unit of the lateritic–bauxite sequence within the study area. This unit is well exposed in pit sections and in the old workings of Ashapura Mines located in the southern part of the mapped area, where the complete lateritic weathering profile is preserved.

Megascopically, lithomargic clay is fine grained, soft, and typically grey to white in colour (Photograph- 7.9). The material exhibits a characteristic soapy feel and readily soils the hand, reflecting its high clay mineral content and advanced stage of chemical weathering. In several exposures, lithomargic clay is observed to occur in repeated sequences with clayey bauxite, indicating transitional stages within the lateritic alteration profile and progressive modification of the parent basaltic rock.

The whitish colour of the lithomargic clay is interpreted to be primarily due to the dominance of kaolinite and associated clay minerals, which form through intense chemical weathering and leaching processes under lateritic conditions. The development of this horizon therefore represents the initial stage of lateritic alteration of the basaltic parent rock, preceding the formation of overlying clayey bauxite and pisolitic bauxite horizons within the lateritic profile.

Photograph No.7.9: Core Photograph of MBD-05 showing Lithomergic clay intercepted between 4.71m to 5.50m

(c) **Bentonitic Clay:** Bentonite within the study area occurs as light yellow coloured, soft to moderately compact material, typically displaying a fine-grained and plastic nature. It is occur below the lithomarge clay. The unit locally exhibits secondary vesicular structures, indicating post-depositional alteration and diagenetic processes within the clay-rich horizon.

This bentonitic horizon has been observed in the southern part of the block, particularly within the existing mining lease area of Ashapura Bentonite Mines (Photograph–7.10). Field observations indicate that the bentonite occurs at a depth of approximately 25 m to 30 m below the surface, suggesting its occurrence as part of the sedimentary sequence underlying the lateritic and bauxitic horizons.

The occurrence of bentonite in the area is interpreted by GSI to be related to the alteration of volcanic ash or tuffaceous material, resulting in the formation of smectite-rich clay minerals. Its presence within the subsurface stratigraphy further indicates favourable geological conditions for the development of bentonitic clay deposits within the basin sequence of the region.

Photographs No. 7.10: Bentonite Stockyard of Ashapura Bentonite Mines**.**

5. **Basalt:** Basalt forms the basement lithology of the study area and represents the volcanic flows of the Deccan Trap sequence. Field observations indicate the presence of both phenocrystic and non-phenocrystic varieties of basalt, reflecting variations in cooling history and textural development within the lava flows.

The phenocrystic basalt is characterized by the presence of distinct plagioclase phenocrysts embedded within a fine-grained groundmass, imparting a typical porphyritic texture (Photograph – 7.11). In several exposures, this basalt displays well-developed columnar jointing, which is indicative of contractional cooling structures formed during the solidification of basaltic lava. At certain locations, the basalt also exhibits spheroidal weathering, resulting from progressive chemical weathering along joints and fractures leading to concentric exfoliation of the rock.

In addition to the phenocrystic variety, fine-grained massive basalt is also observed across the study area. Megascopically, the basalt is generally dark grey to black in colour and fine to medium grained in nature. Feldspar phenocrysts are commonly visible in hand specimens. Amygdaloidal structures, formed by the infilling of vesicles by secondary mineral phases, are particularly well developed in the northern part of the block. The basalt shows varying degrees of weathering, ranging from fresh and compact exposures to partially altered varieties. Representative field photographs illustrating these features are provided below (Photograph- 11). In some places calcite are found as fracture filling within basalt.

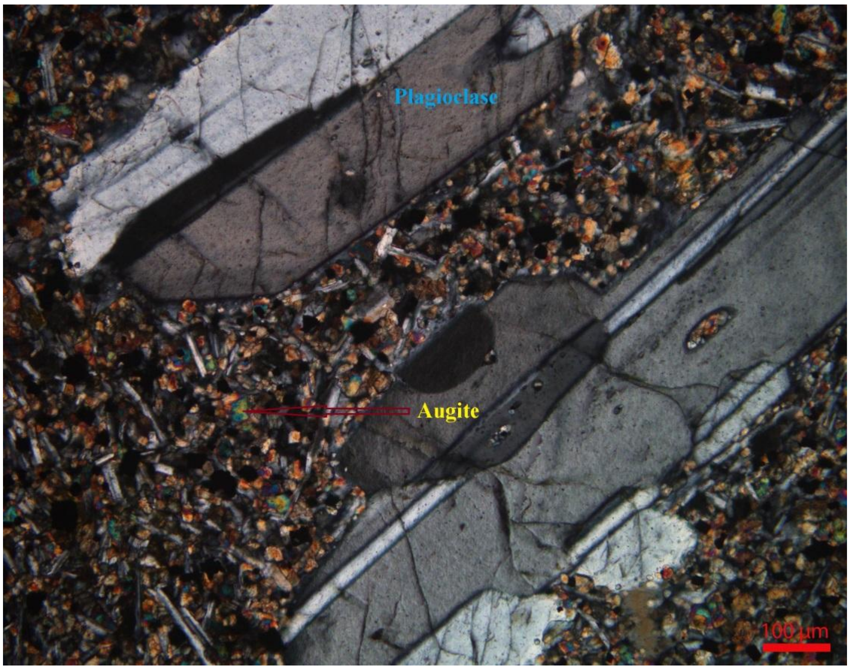
Microscopic studies reveal that the basalt exhibits a porphyritic texture and represents a very fine-grained mafic rock composed mainly of plagioclase, augite, opaque minerals, and occasionally biotite/chlorite. Plagioclase occurs as medium to fine subhedral prismatic phenocrysts and also as very fine laths within the groundmass. Augite is present as very fine granular disseminations within the groundmass, while opaque minerals occur as very fine subhedral grains dispersed throughout the matrix (Pmg-5). Biotite and chlorite occur as fine patchy aggregates of very fine amorphous material, possibly derived from the devitrification and alteration of volcanic glass.

Another textural variety observed under the microscope is vesicular basalt, which is a very fine-grained melanocratic massive rock characterized by the presence of pores, vesicles, and amygdaloids. Mineralogically, it is composed of plagioclase, augite, volcanic glass, and opaque minerals. Plagioclase occurs as very fine prismatic laths and occasionally as fine to medium prismatic phenocrysts. Augite is present as very fine subhedral to anhedral grains within the groundmass. Volcanic glass is commonly observed as fine to medium sub-rounded grains, typically brownish to reddish in colour, and in many instances, it is partially altered and replaced by patchy chlorite. Opaque minerals occur as very fine aggregates and disseminated patches throughout the rock matrix. Vesicles are frequently filled with very fine microcrystalline chert and micrite, indicating secondary mineral deposition during post-emplacement alteration processes.

The basaltic units occurring within the study area display similar mineralogical composition and textural characteristics, suggesting that they likely belong to a single basaltic lava flow. Typically, the central part of the flow exhibits porphyritic basalt, while the outer portions of the flow are represented by vesicular and fine-grained basalt, reflecting differences in cooling rate and degassing conditions during lava emplacement. This vertical variation in texture within the basalt flow provides important insights into the cooling history and emplacement dynamics of the Deccan Trap volcanism in the region.

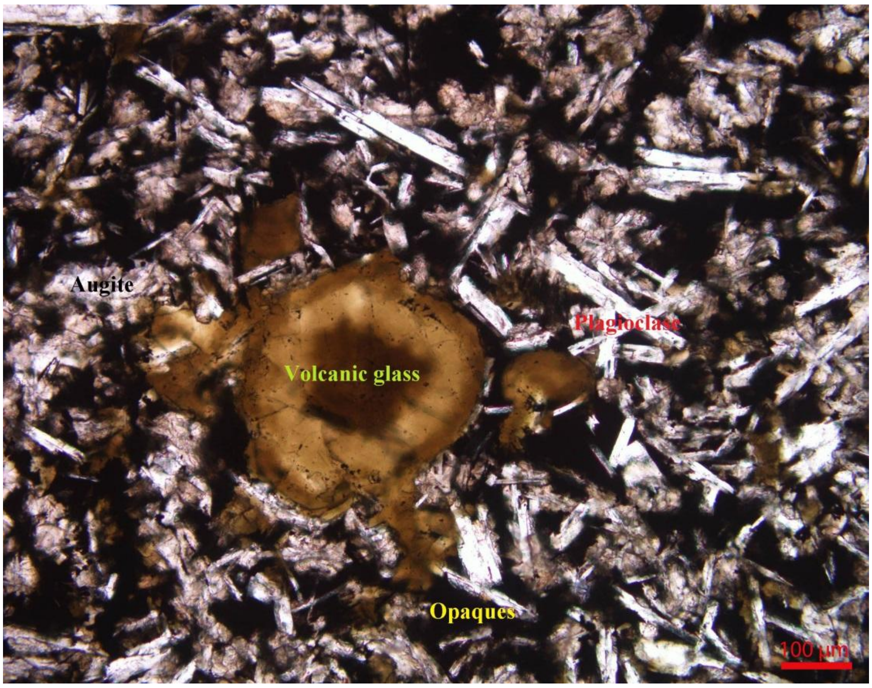

Photographs No. 7.11A & B: Porphyritic Basalt and Amygdaloidal Basalt

Photographs No. 7.12: Development of calcite layer within massive basalt.



Pmg – 5: Photomicrograph showing medium sized phenocrysts of plagioclase and very fine granular augite and plagioclase laths in porphyritic basalt as seen under crossed nicols.

Specimen No. : MBD/P/05 **Magnification : 100X**



Pmg – 6: Photomicrograph showing association of augite, plagioclase, opaques and volcanic glass in vesicular basalt as seen plane polarized light.

Specimen No. : MBD/P/10 **Magnification : 100X**

6. **Ferruginous Sandstone:** Ferruginous sandstone occurs in the study area. Megascopically, these rocks are iron-rich, reddish coloured, and comparatively heavy with high specific gravity, reflecting the dominance of ferruginous cement within the sandstone matrix. In the field, these rocks are generally classified based on their degree of compactness and specific gravity, which vary depending on the proportion of iron oxide cementation.

In the mapped area, ferruginous sandstone occupies a limited exposure in the central–southern part of the block (Photograph- 7.13), where it occurs as discontinuous patches within the stratigraphic sequence. The rock typically appears reddish to dark reddish-brown in colour, compact to moderately indurated in nature, and exhibits a massive to poorly sorting appearance.

Microscopic studies indicate that the ferruginous sandstone is fine to medium grained and displays a granular texture. Mineralogically, the rock is composed predominantly of quartz grains embedded within a ferruginous matrix, with minor amounts of feldspar and lithic fragments. Quartz occurs as fine sand to very coarse sand-sized clasts, generally subrounded to subangular in shape, and appears to float within a reddish ferruginous cementing material. The grains are typically poorly sorted and loosely packed, suggesting limited sedimentary sorting prior to deposition.

Feldspar occurs as medium to fine subangular clasts, which in many cases show partial alteration to clay minerals, indicating post-depositional chemical weathering. Lithic fragments are present as fine to medium well-rounded clasts, predominantly quartzite in composition, reflecting derivation from older siliciclastic or metamorphic source rocks.

Overall, the petrographic characteristics indicate that the ferruginous sandstone represents a quartz-rich clastic sediment strongly cemented by iron oxides, which imparts the characteristic reddish colour and high density to the rock. The ferruginous cementation suggests post-depositional iron enrichment under oxidizing conditions, likely associated with weathering and diagenetic processes within the sedimentary sequence of the Kakdi Nadi Formation.

Photograph No. 7.13: Outcrop of Ferruginous Sandstone at Southern part of the block.

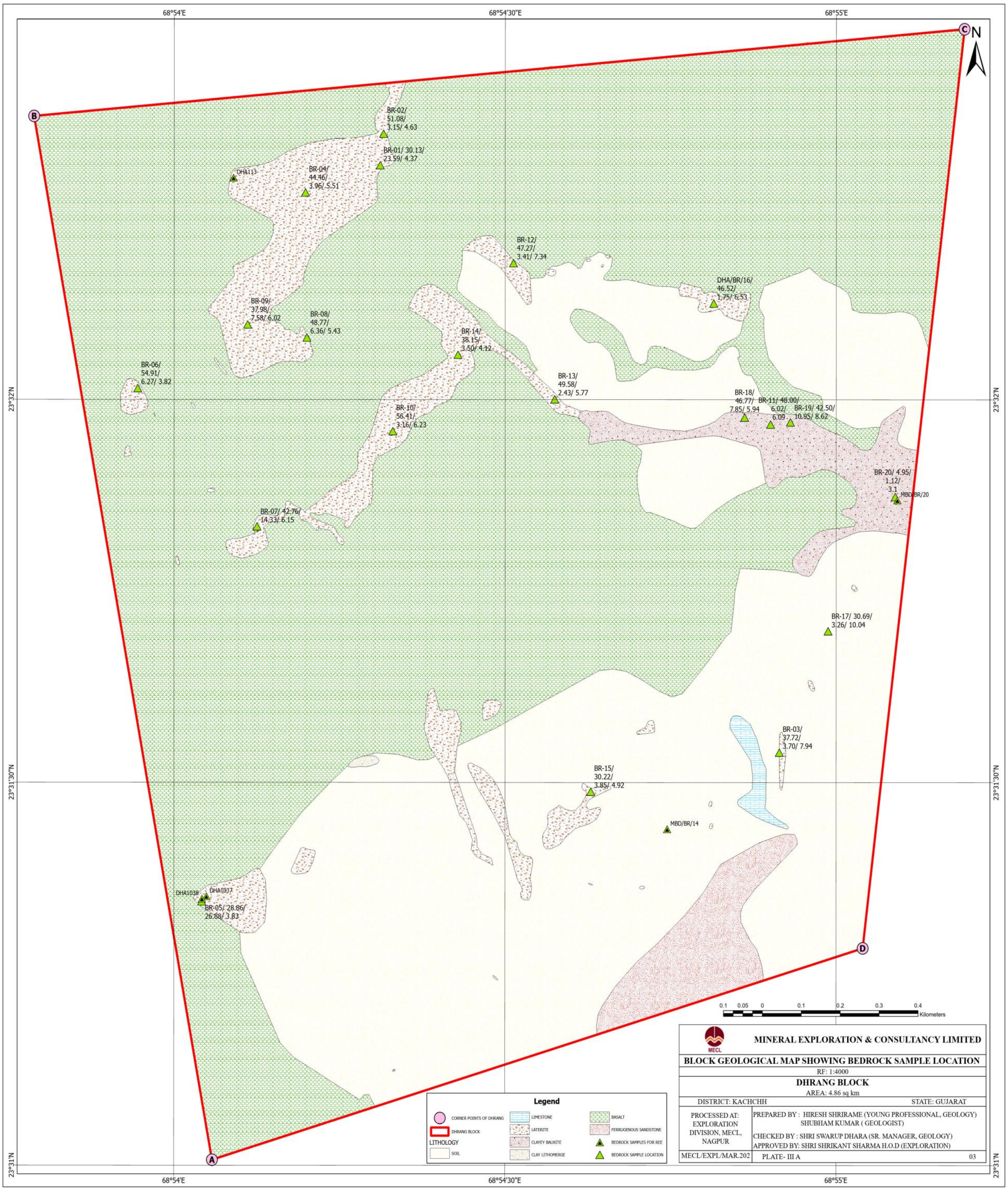
7.5.0 VERTICAL LATERITIC WEATHERING PROFILE

7.5.1 The lateritic profile developed within the Dhrang Block represents a typical residual weathering sequence formed over basaltic parent rocks. The vertical succession generally consists of soil cover at the top followed by laterite, pisolitic bauxite, clayey bauxite, lithomargic clay and unaltered basalt at depth.

The uppermost layer comprises reddish to brown soil containing ferruginous nodules derived from weathering of lateritic material. This is followed by a compact laterite horizon characterized by ferruginous matrix and vesicular texture. The laterite horizon commonly overlies the bauxite zone and acts as a protective cap over the mineralised layer.

The bauxite horizon is generally pisolitic in nature and consists of rounded nodules embedded within a ferruginous or aluminous matrix. The pisolites display concentric structures indicating chemical precipitation during lateritization. Below the pisolitic bauxite zone occurs clayey bauxite and lithomargic clay which represent transitional weathering products formed due to partial alteration of basaltic parent rocks.

The development of this vertical profile indicates prolonged chemical weathering under stable geomorphological conditions which favoured the formation and preservation of bauxite deposits in the study area.



TEXT FIGURE- 5

7.6.0 STRUCTURE OF THE BLOCK

The structural features observed during geological mapping of the study area have been broadly categorized into primary (non-diastrophic) structures and secondary (diastrophic) structures. Primary structures are those formed during the deposition or emplacement of the rock units, whereas secondary structures developed subsequently due to tectonic stresses, cooling, weathering, or post-emplacement processes.

7.6.1 Primary Structures

Primary structures in the study area are represented mainly by pisolitic structures within the bauxite and lateritic horizons, as well as igneous structures within the basaltic rocks. The bauxite and lateritic bauxite commonly exhibit well-developed pisolitic textures, where the pisolites range in diameter from approximately 0.10 mm to 0.40 mm. These pisolites occur in variable shapes and sizes and are occasionally observed to contain grey-coloured clay infillings, reflecting localized alteration and clay enrichment within the lateritic profile.

Within the basaltic rocks, the primary igneous structures are characterized by columnar jointing, particularly well developed in the phenocrystic basalt exposures. These columnar structures are formed due to contractional stresses during the cooling and solidification of basaltic lava flows and represent typical primary igneous features associated with Deccan Trap volcanism.

In addition to these features, traces of burrows and trails are locally observed within certain sedimentary horizons, indicating minor biogenic activity during or shortly after deposition.

7.6.2 Secondary Structures

Secondary structures in the area are primarily represented by vesicular and amygdaloidal features as well as joints and fractures. The basaltic rocks display well-developed vesiculation resulting from the escape of volatile gases during the later stages of lava solidification. In several exposures, these vesicles are subsequently filled with secondary minerals forming amygdaloidal structures.

In many sections, the basalt exhibits a massive, compact, and fine-grained character, representing the dense interior portion of the lava flow where gas escape was minimal during solidification. Laterally and vertically, this massive basalt gradually transitions into vesicular and amygdaloidal basalt, characterized by numerous cavities formed due to volatile exsolution during the late stages of cooling. These cavities are commonly filled by secondary mineral phases. The transition from massive basalt to amygdaloidal facies within the same flow unit reflects the degassing behaviour, cooling dynamics, and subsequent mineral infilling processes associated with basaltic lava emplacement.

Apart from vesicular features, sparse joints and fractures are also observed within the basaltic rocks of the Deccan Trap sequence, although they are relatively sparse in occurrence within the study area. The joints generally exhibit a dominant NE–SW trend, which may reflect regional tectonic stress patterns and cooling-induced fracturing within the basaltic flow units.

Overall, the structural features observed in the area provide important insights into the volcanic emplacement processes, lateritic weathering, and subsequent tectonic and weathering modifications affecting the rock units of the study area.

7.7.0 MINERALISATION

7.7.1 The lateritic profile of the study area is developed directly over the Deccan Trap basalts and associated pyroclastic rocks, with the laterite–bauxite sequence resting unconformably over the volcanic basement. In certain parts of the region, the lateritic horizon is also observed in proximity to the Bhuj Formation, indicating a complex stratigraphic association within the basin framework. Field investigations suggest that the laterite–bauxite deposits of the area have formed through intense lateritization and bauxitization of basaltic and pyroclastic rocks belonging to the Deccan Volcanics.

The laterite horizon is generally massive and compact, though in several exposures it retains relict textures of the parent basalt, indicating in-situ alteration during lateritization. These relict features are typically characterized by plagioclase phenocrysts embedded within a fine-grained groundmass, occasionally displaying flow alignment of plagioclase laths that reflect the original volcanic fabric of the basaltic parent rock. Such preserved textures clearly demonstrate that the bauxitic horizon represents the residual product of intense chemical weathering of the Deccan Trap volcanics.

The Dhrang block is characterized by a relatively subdued topography with elevations ranging from approximately 118 m to 84 m above mean sea level (MSL). Within this geomorphic setting, laterite and bauxite horizons are developed over the basaltic country rocks of the Deccan Volcanic Province, forming a typical lateritic weathering profile.

The bauxites of the Mata-no-Madh Formation are interpreted to have formed by alteration of the pyroclastic facies of the Deccan basaltic flows under prolonged tropical weathering conditions. The lateritic sequence comprises ferruginous laterite resting over the Deccan Trap basalts, which in turn is overlain by Eocene gypseous shale beds, indicating the evolution of the lateritic profile prior to the deposition of younger sedimentary units. The formation of these deposits is attributed to long-term chemical weathering, leaching of mobile elements, and enrichment of relatively immobile components such as aluminium, iron, and titanium.

Mineralization within the study area occurs predominantly as bauxite-rich lateritic cappings, forming pocket- to blanket-type deposits. These deposits are mainly developed in the north-western part of the block, where favourable geomorphological and lithological conditions have facilitated the accumulation of aluminous laterite and pisolitic bauxite.

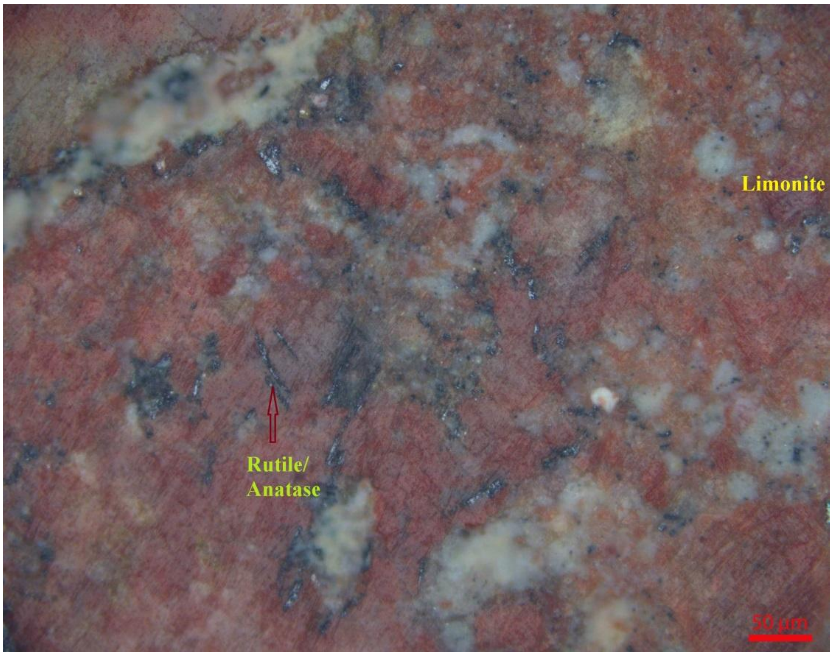
The bauxite horizon is chiefly characterized by fine- to medium-grained pisolites composed of very fine aggregates of gibbsite and boehmite, often arranged in concentric structures. In several instances, the pisolites are rimmed or partially filled by carbonate minerals, reflecting secondary mineral deposition within the lateritic profile. Petrographic observations indicate that cliachitic pisolites undergo partial replacement by very fine granular aggregates of gibbsite–boehmite, suggesting progressive lateritic alteration and alumina enrichment. Gibbsite and boehmite are also commonly observed as very fine cavity fillings within the pisolitic matrix, further confirming the supergene origin of the bauxite.

Associated mineral phases within the lateritic bauxite include several iron oxides, titanium-bearing minerals, and minor sulphides. Limonite commonly occurs as very fine reddish amorphous aggregates, patches, and stains dispersed throughout the specimen, reflecting intense ferruginization during weathering. Goethite is observed as fine dendritic fillings, patchy aggregates, and cavity infillings, often occurring together with hematite within the ferruginous matrix. Hematite occurs as very fine subhedral to anhedral grains and relic patches within goethitic zones, indicating progressive oxidation and alteration within the lateritic environment.

Titanium-bearing minerals are represented by anatase and rutile, which occur as very fine amorphous to microcrystalline particles, subhedral grains, and bladed crystals disseminated throughout the specimen. In several instances, anatase occurs as fine segregations within clay-rich and bauxite-rich zones, suggesting residual concentration during lateritization. Ilmenite is also observed as very fine skeletal and bladed grains disseminated within the matrix, which in many cases show partial replacement by goethite due to secondary alteration.

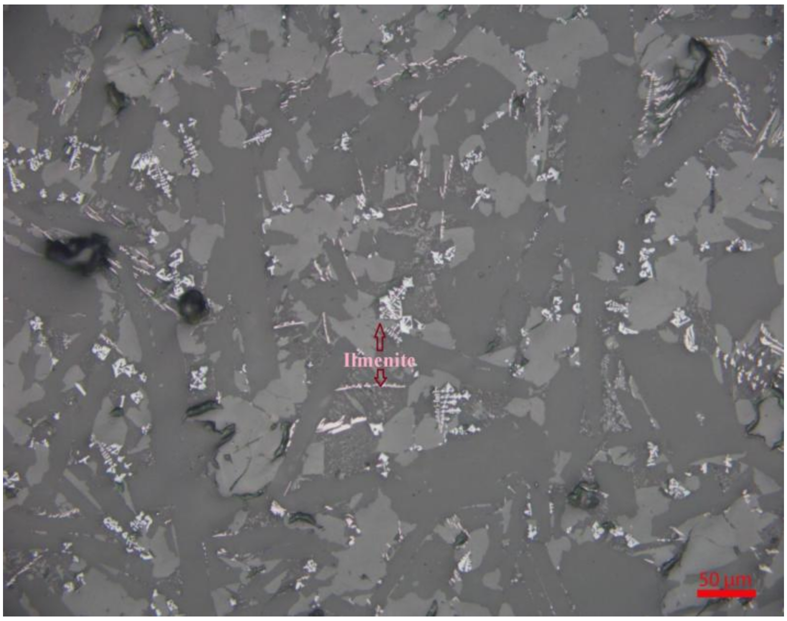
Minor sulphide minerals are present only in trace amounts, typically occurring as very fine specks of pyrite, pyrrhotite, pentlandite, and chalcopyrite within the rock matrix. These sulphides occur as isolated disseminations and are generally associated with accessory mineral phases within the basaltic parent material.

Overall, the mineral assemblage and petrographic characteristics indicate that the bauxite mineralization of the study area is primarily of supergene origin, resulting from prolonged tropical weathering and lateritic alteration of the Deccan Trap basalt and associated pyroclastic rocks. The resulting lateritic profile is characterized by enrichment of alumina in the form of gibbsite and boehmite, accompanied by ferruginous minerals and accessory titanium-bearing phases, forming economically significant bauxite deposits within the Mata-no-Madh Formation.



Pmg – 7: Photomicrograph showing very fine bladed grains of rutile/ anatase and reddish amorphous aggregates of limonite as seen under reflected light.

Specimen No. : MBD/M/03 **Magnification : 200X**



Pmg – 8: Photomicrograph showing very fine dissemination of skeletal and bladed ilmenite as seen under reflected light.

Specimen No. : MBD/M/07 **Magnification : 200X**

7.8.0 GENETIC MODEL OF BAUXITE FORMATION

7.8.1 The bauxite mineralisation in the Dhrang Block represents a typical lateritic type deposit formed through prolonged chemical weathering of basaltic parent rocks. The formation of bauxite is primarily controlled by intense tropical weathering processes that resulted in progressive leaching of silica and enrichment of aluminium and iron oxides.

7.8.2 During the lateritization process, basaltic rocks undergo intense alteration under conditions of high temperature and seasonal rainfall, leading to breakdown of primary silicate minerals such as feldspar and pyroxene. The leaching of silica and mobile elements results in residual concentration of aluminium hydroxides mainly in the form of gibbsite along with iron oxides and hydroxides. Over time, this process leads to the development of a characteristic vertical weathering profile consisting of soil, laterite, pisolitic bauxite, clayey bauxite and lithomargic clay horizons.

7.8.3 The pisolitic texture observed within the bauxite horizon indicates repeated cycles of weathering, re-precipitation and concretionary growth of aluminium-rich nodules. The development of bauxite horizons is strongly influenced by geomorphological stability, gentle slopes and efficient drainage conditions which favour removal of silica and enrichment of aluminium.

Thus, the bauxite deposits of the Dhrang Block can be interpreted as residual lateritic bauxite formed over basaltic parent rocks under prolonged tropical weathering conditions during post-Deccan geological evolution of the Kachchh region.

7.9.0 MODE OF OCCURRENCE

7.9.1 In the study area, lateritic bauxite occurs as three distinct bands forming capping over flat-topped hillocks, representing the residual products of intense lateritization and bauxitization of the Deccan Trap basalt. These bauxite-bearing horizons are typically preserved on elevated geomorphic surfaces where prolonged weathering and leaching have resulted in the development of a well-defined lateritic profile.

The lateritic bauxite sequence in the area generally exhibits a well-developed vertical zonation consisting of five lithological units arranged from top to bottom. These zones represent progressive stages of chemical weathering, alumina enrichment, and clay formation within the lateritic profile.

The uppermost zone is represented by laterite, which occurs as a hard, compact, and massive ferruginous unit forming a protective cap over the underlying bauxite-bearing horizons. This lateritic crust is typically resistant to erosion and therefore forms the prominent capping over the hillocks.

Below the laterite occurs the pisolitic bauxite horizon, which constitutes the principal aluminous zone of the profile. This unit is characterized by well-developed pisolitic structures displaying concentric rings composed predominantly of aluminium-bearing minerals such as gibbsite and bauxite, along with ferruginous minerals including hematite and magnetite and minor clay minerals. The pisolitic texture indicates intense lateritic alteration and concentration of alumina during the weathering process.

Underlying the pisolitic bauxite is the clayey bauxite horizon, which develops where pisolites occur within a clay-rich matrix, indicating partial alteration and incomplete concentration of alumina. This horizon represents an intermediate stage between fully developed pisolitic bauxite and clay-dominated lithologies.

The bauxitic clay zone occurs below the clayey bauxite and is typically exposed as small discontinuous patches within the clayey bauxite horizon. It is distinguished by a higher proportion of clay relative to alumina-bearing minerals. Megascopically, this unit appears white when dry and grey when wet, and locally preserves relict pisolitic or oolitic structures, indicating derivation from altered bauxite.

The lowermost unit of the lateritic profile is lithomargic clay, which is fine grained, grey to white in colour, and exhibits a characteristic soapy feel that readily soils the hand. In many exposures, lithomargic clay occurs in alternating sequences with clayey bauxite, suggesting fluctuating environmental conditions during the lateritic weathering process. This alternating sequence is interpreted to reflect periodic variations between relatively dry and wet climatic conditions during the evolution of the lateritic profile.

Below the lithomargic clay horizon, the unaltered Deccan Trap basalt or locally the sandstone of the Bhuj Formation forms the basement lithology. In many sections, the mineralogical composition of the underlying bedrock indicates extensive alteration of the original parent rock into laterite and bauxite through prolonged weathering.

Based on physical appearance, degree of pisolitic development, and proportion of clay content, the lateritic sequence of the study area has been classified into laterite, pisolitic bauxite, clayey bauxite, bauxitic clay, and lithomargic clay. The bauxite-bearing bands exhibit a general NE–SW trend in the north-western and southern parts of the block, while clayey bauxite occurrences in the eastern part show an E–W trend. The mineralized band attains a strike length of approximately 1 km, with a width ranging from about 60 m to 110 m, and the thickness of the lateritic–bauxitic profile varies between 10 m and 20 m.

Within the mapped area, the Mata-no-Madh Formation is predominantly composed of laterite, with only a few localized pockets of pisolitic bauxite, clayey bauxite, and bauxitic clay. In the south-western part of the block, ferruginous sandstone belonging to the Kakdi Nadi Formation forms the topmost lithological unit. The lateritic profile of the area generally rests directly over the Deccan Trap basalt, although in certain localities it occurs in association with sediments of the Bhuj Formation.

In several exposures, the laterite exhibits limonitization, imparting characteristic reddish to yellowish surface coloration due to the formation of hydrated iron oxides during weathering.

During the process of bauxitization, primary minerals such as plagioclase feldspar and other hydrous silicate minerals are progressively altered and converted into aluminium hydroxide minerals, which constitute the principal ore minerals of bauxite. In the present area, the dominant ore mineral is gibbsite, while accessory minerals include iron oxides (Fe_2O_3), rutile (TiO_2), and kaolinite. Due to intense leaching within the lower parts of the lateritic profile, the bauxitic clay and lithomargic clay horizons show enrichment in kaolinite.

The formation of bauxite in the region is closely related to tropical to sub-tropical climatic conditions characterized by intense weathering, heavy rainfall, and in-situ leaching of pre-existing rocks. Bauxitization represents the extreme stage of lateritization, wherein prolonged chemical weathering leads to the removal of soluble constituents and the residual concentration of relatively immobile elements such as aluminium, iron, and titanium.

The Mata-no-Madh Formation, therefore, represents a lateritic bauxite horizon formed through in-situ weathering and lateritization of Deccan Trap basalt, occurring stratigraphically between the older Bhuj Formation and the younger Kakdi Nadi Formation. The alternating sequence of lithomargic clay and clayey bauxite observed within the profile further indicates periodic climatic fluctuations and variations in drainage conditions during the evolution of the lateritic weathering system.

i) Factors Controlling Bauxitization

The process of bauxitization involves the neoformation of hydroxides, hydrated oxides, and oxides of aluminium, iron, and titanium, while silicate minerals and quartz may persist as residual phases. The liberation and redistribution of these minerals from the parent rock are influenced by several factors, including the bond strength within mineral crystal lattices, solubility of secondary mineral phases, redox potential (Eh) and pH of the circulating solutions, oxidation state of elements, temperature and concentration of the weathering fluids, and the presence of other dissolved ions within the weathering environment.

ii) Genesis

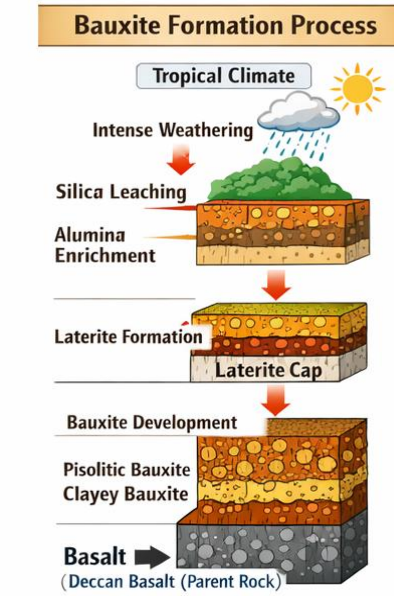
The genesis of bauxite and laterite is strongly controlled by the geochemical behaviour of aluminium, iron, silica, and titanium in aqueous solutions, together with the prevailing Eh–pH conditions of the weathering environment. Dissolution and removal of silica represent a critical step in the development of bauxite deposits. Iron is also gradually mobilized and redistributed during lateritization, although it commonly accumulates in upper parts of the profile forming ferruginous caps.

Titanium is typically enriched within bauxitic profiles and occurs mainly as anatase, rutile, or ilmenite. Although titanium may partially substitute for silica within certain mineral structures, its incorporation is limited due to differences in ionic radius. The bauxite and laterite profile significanly enriched with Vanadium and Galium also.

During weathering, hydrolysis reactions generate colloidal systems containing negatively charged silica (SiO_2) and ferric hydroxide [$Fe(OH)_3$] as well as positively charged aluminium hydroxide [$Al(OH)_3$], although aluminium hydroxide may also acquire negative charges in alkaline conditions. Titanium ions may play a role in modifying charge balance within these systems. The formation of clay minerals results from reactions between silica and amorphous aluminium hydroxides, and the resulting mineral assemblage is strongly influenced by drainage conditions that regulate silica availability.

The pH of the weathering environment is typically alkaline in the case of mafic source rocks such as basalt, which, when combined with effective drainage, favours the precipitation of aluminium hydroxides. Iron, once mobilized in solution, tends to precipitate under oxidizing surface conditions, resulting in the formation of ferruginous caps. In deeper parts of the profile where reducing conditions prevail and drainage becomes sluggish; iron may be removed while clay minerals accumulate.

Collectively, these chemical, climatic, and geomorphological processes lead to the development of the distinct vertical zonation observed in the lateritic bauxite profile of the study area, ultimately resulting in the formation of economically significant bauxite deposits within the Mata-no-Madh Formation.



Text Figure 6: Bauxite formation conceptual model of Dhrang Block.

7.10.0 MINERAGRAPHIC AND PETROGRAPHIC STUDIES OF MINERALISED CORE SAMPLES

7.10.1 A total of 5nos. of XRD samples were collected from different bauxite/laterite zones and sent for mineralogical studies in Chemical lab of MECL, Nagpur. X-ray diffraction (XRD) analysis of samples reveals a mineral assemblage typical of lateritic bauxite developed over basaltic parent rock. The mineralogical composition is dominated by aluminium hydroxide minerals, accompanied by clay minerals, iron oxides, and minor accessory phases. The major bauxite-forming minerals identified include Gibbsite. Clay minerals such as kaolinite occur as significant constituents, suggesting intense chemical weathering and alteration of feldspathic and mafic minerals from the parent basaltic rock. The presence of chlorite group minerals such as chamosite and clinochlore further supports derivation from mafic volcanic rocks and subsequent weathering-related alteration. Iron oxide and hydroxide minerals including goethite, hematite, and magnetite are also recorded in the samples, reflecting strong ferruginization and oxidation processes associated with the development of lateritic profiles. Accessory heavy minerals such as rutile and ilmenite occur in minor quantities and represent residual resistant phases that persist after prolonged weathering and leaching processes. Mica group minerals including muscovite and biotite are also identified in trace amounts and may represent relict minerals from the original parent rock or detrital contributions within the weathering profile.

A total 10 no of samples were subjected to Petrographical studies which confirmed the samples as bauxite/ laterite. The sample wise details of the petrographic studies are presented as Annexure-VIIA and the photomicrographs of the polished sections are given as pmg-1.

7.10.2 **Available Alumina and Reactive Silica:** A total of six representative samples (MBD-01 to MBD-05) collected from the bauxite horizon were subjected to chemical analysis to determine Total Hydratable Alumina at 40°C (THA-40°C), Monohydrate Alumina at 240°C (MHA-240°C), and Reactive Silica, which are critical parameters for assessing the suitability of bauxite for metallurgical, refractory, and cement-grade applications.

The analytical results indicate that THA-40°C values range from 24.77% to 48.54%, whereas MHA-240°C values vary between 0.99% and 10.40%. The Reactive Silica content ranges from 1.60% to 6.49%. These variations reflect the mineralogical heterogeneity of the bauxite horizon and the varying degrees of lateritization and clay enrichment within the deposit.

The geochemical data reveal moderate variability in alumina content across the sampled horizon, suggesting the presence of localized zones of alumina enrichment within an otherwise heterogeneous bauxite profile. Among the analysed samples, sample MBD-05.02 records the highest THA value of 48.54%, representing a comparatively higher-grade pocket within the deposit. Most of the remaining samples exhibit moderate alumina content ranging approximately between 26% and 38%, indicating moderate-grade bauxite.

The MHA-240°C values are generally low to moderate, except for sample MBD-01.04, which shows a comparatively higher value. This variation likely reflects localized mineralogical differences within the bauxite horizon, particularly variations in the proportions of gibbsite and boehmite.

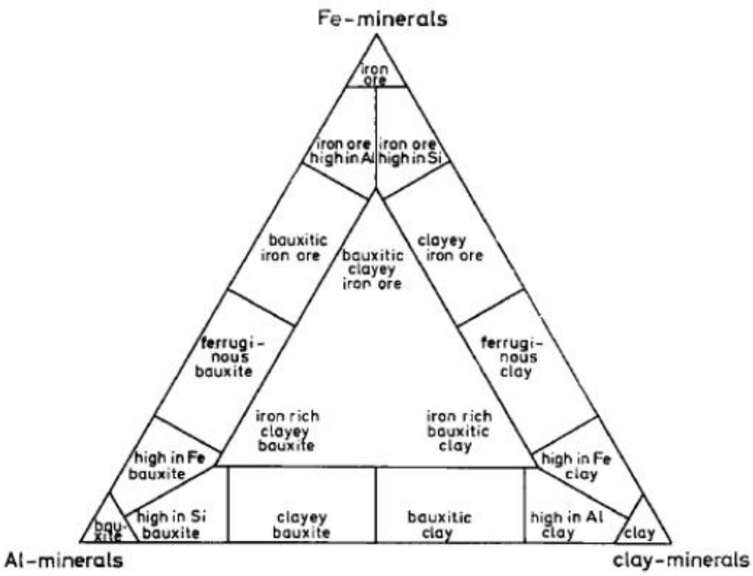
The Reactive Silica content shows a range between 1.60% and 6.49%, with sample MBD-03.05 displaying relatively higher reactive silica values. Elevated reactive silica is considered detrimental for alumina extraction processes, as it may lead to increased soda consumption and reduced recovery efficiency during beneficiation and refining.

Overall, the analytical results indicate that while certain samples exhibit favourable alumina content coupled with relatively low reactive silica, the presence of localized high-silica zones within the deposit acts as a limiting factor for ore quality and processing efficiency. Based on the present dataset, approximately 30–35% of the analysed samples may be classified as relatively higher-grade bauxite, whereas the remaining samples fall within the moderate- to low-grade category. The detailed analytical results are presented in Annexure–X.

7.11.0 GEOCHEMISTRY OF BAUXITE

7.11.1 The classification proposed by Valeton (1972), modified from Bardossy (1963), is based primarily on genesis (mode of formation) and parent rock type, reflecting the geological and geochemical processes involved in bauxite formation.

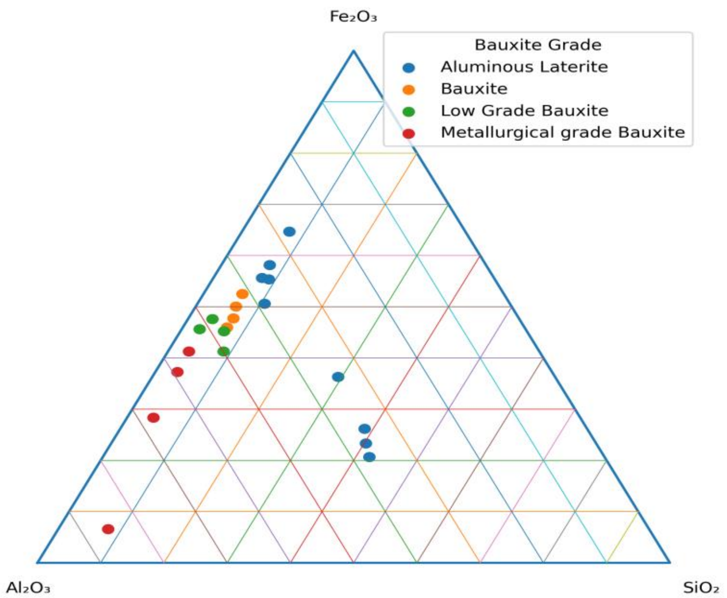
Classification scheme proposed by Valeton, modified from BARDOSSY(1963) is shown below,



TEXT FIGURE- 7

7.11.2 All the core sample data of Metallurgical grade bauxite, low grade bauxite and Bauxitic clay are plotted on Ternary diagram and based on the Al_2O_3–Fe_2O_3–SiO_2 ternary diagram, bauxites along with its transition varieties (Fig. 7).

TEXT FIGURE No. 8 – Al_2O_3–Fe_2O_3–SiO_2 ternary diagram of Samples analysed in Dhrang block.



7.11.3 The Al_2O_3–Fe_2O_3–SiO_2 ternary plot of the analysed samples indicates a compositional spread from aluminous laterite to metallurgical grade bauxite. Metallurgical grade bauxite samples cluster close to the Al_2O_3 apex, reflecting high alumina enrichment with comparatively low ferruginous and siliceous constituents. Low-grade bauxite occupies an intermediate position, showing moderate alumina enrichment with variable Fe_2O_3 and SiO_2 contents. Samples classified as bauxite plot between the ferruginous and aluminous fields, whereas aluminous laterite samples are concentrated toward the Fe_2O_3-rich and partly SiO_2-rich sectors of the diagram. The overall trend suggests progressive bauxitization through desilicification and relative alumina enrichment from lateritic precursors, with localized persistence of ferruginous and clay-rich domains within the profile.

7.12.0 Geochemical Characteristics of Bauxite and Associated Elements

7.12.1 Geochemical analysis of the samples from the Dhrang Block indicates significant enrichment of aluminium within the bauxite horizons accompanied by varying concentrations of iron and titanium. The enrichment of alumina reflects the residual concentration of aluminium hydroxides following leaching of silica during the lateritization process.

7.12.2 Trace element analysis reveals the presence of critical elements such as scandium (Sc), vanadium (V) and gallium (Ga) within the bauxite and lateritic horizons. These elements are commonly associated with lateritic bauxite deposits and are derived from the basaltic parent rocks during weathering.

7.12.3 The presence of titanium within the bauxite zone indicates the concentration of resistant titanium-bearing minerals such as anatase and ilmenite during weathering processes. The geochemical association between aluminium, titanium and trace elements suggests that the enrichment of these elements is closely linked with the lateritic weathering processes.

The distribution pattern of trace elements also indicates that the lateritic profile may represent a potential secondary source of strategic and critical metals in addition to aluminium.

7.12.4 The geochemical association of Scandium (Sc), Gallium (Ga), Vanadium (V) and Titanium (Ti) in lateritic bauxite deposits reflects the behaviour of these elements during intense tropical weathering and lateritization of basaltic parent rocks. During chemical weathering, mobile elements such as silica are leached out, while relatively immobile elements such as aluminium, iron, titanium and certain trace metals become progressively enriched within the residual lateritic profile.

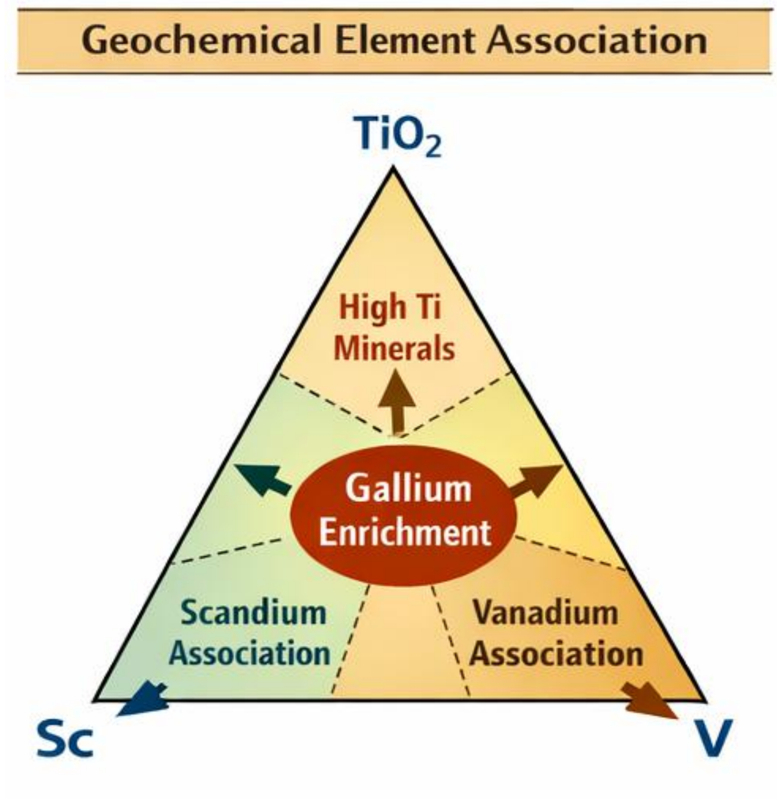
Titanium (Ti) is typically concentrated within resistant minerals such as anatase, rutile and ilmenite, which remain stable during weathering processes. As a result, TiO_2 enrichment commonly occurs within the bauxite–laterite horizon. Titanium phases also act as geochemical traps for several trace elements.

Scandium (Sc) is mainly associated with iron oxide phases and can be incorporated into the crystal lattice of goethite and hematite formed during lateritization. The enrichment of scandium in lateritic bauxite deposits is therefore often correlated with iron-rich zones within the profile.

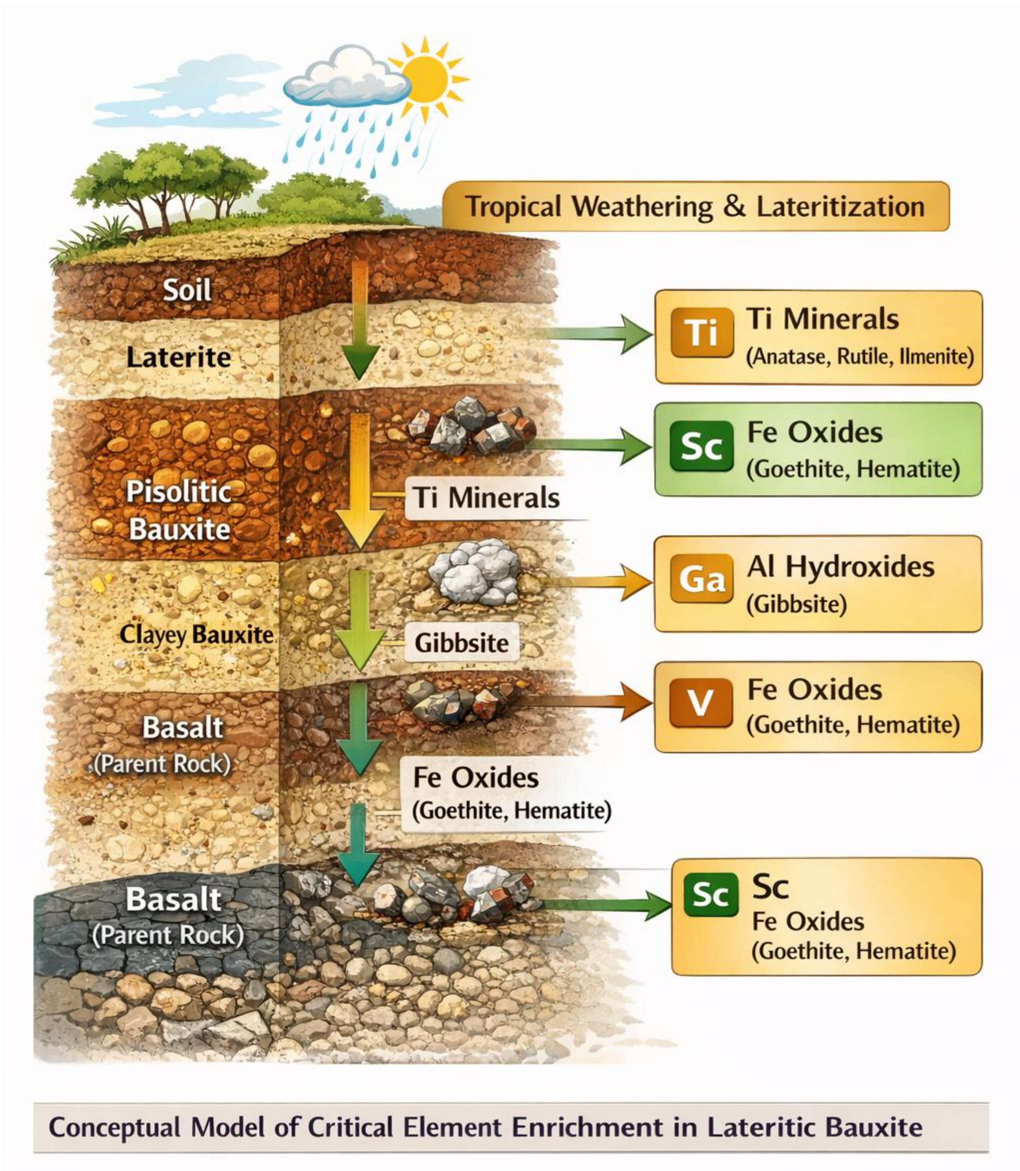
Gallium (Ga) displays a strong geochemical affinity with aluminium and commonly substitutes for aluminium within the lattice of gibbsite and other aluminium hydroxide minerals present in bauxite. Consequently, gallium enrichment is generally observed within the aluminous portion of the bauxite horizon.

Vanadium (V) is typically derived from the alteration of mafic minerals present in basaltic parent rocks. During weathering, vanadium becomes mobilized and subsequently adsorbed onto iron oxide phases or incorporated within secondary minerals formed in the lateritic profile.

The combined enrichment of Sc–Ga–V–Ti therefore reflects the interplay of residual concentration, adsorption processes and mineral substitution mechanisms operating during lateritic weathering. The geochemical association of these elements indicates that lateritic bauxite deposits such as those observed in the Dhrang Block may represent potential secondary sources of strategic and critical metals, in addition to aluminium.



TEXT FIGURE No. 9 – Geochemical association of enriched strategic trace elements in Lateritic bauxite.



TEXT FIGURE No. 10 – Conceptual model showing enrichment of Sc, Ga, V and Ti within lateritic bauxite profiles developed over basaltic parent rocks during prolonged tropical weathering and lateritization.

CHAPTER-8

PREVIOUS WORK

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

8.1.1. The geology and mineral potential of the Kachchh region have been investigated by several workers of the Geological Survey of India (GSI), Oil and Natural Gas Commission (ONGC), and other institutions over the past several decades. These studies encompass geological mapping, stratigraphic classification, palaeontological investigations, geophysical surveys, and exploration of economically important minerals such as lignite, bentonite, glauconite, potash and lateritic bauxite.

8.1.2 The earliest documented investigation of the mineral resources of the region was carried out by Roy (1948), who studied the mineral resources of the Lakhpat–Nakhatrana area of Kachchh district, Gujarat, and documented his findings in an unpublished progress report of the Geological Survey of India. Subsequently, Poddar and Venkatappayya (1953) investigated the occurrence of coal and lignite deposits in Kachchh district, providing one of the first systematic descriptions of the lignite-bearing stratigraphic units of the basin.

8.1.3 A major contribution to the stratigraphic framework of the basin was made by Biswas (1971) of ONGC, who proposed a revised litho-chronostratigraphic classification of the Tertiary rocks of the Kachchh Basin. In his work, the Tertiary sequence was subdivided into eight distinct lithostratigraphic units, a classification that continues to be widely followed in geological studies of the basin.

8.1.4 Occurrences of glauconite in the Mesozoic and Tertiary sedimentary sequences of Kachchh were reported by several researchers including Kulkarni and Agarwal (1963–64), Kulkarni and Desikan (1965–66), Ghevariya (1980–81), Vijaya Sarathi and Sable (1984–85), and Ghevariya and Srikarni (1990–91). These studies highlighted the presence of glauconitic horizons within the sedimentary sequences and emphasized their stratigraphic and economic significance.

8.1.5 Bhattacharya (1978–79) investigated the lignite deposits of the north-western part of Kachchh district, identifying six major deposits namely Panandhro, Metanomadh-Lefri, Umarsar, Ghuneri, Akri and Jhulrai-Waghpadhar.

8.1.6 Subsequently, Ghevariya (1979–82) carried out investigations for bentonite deposits in parts of Toposheet Nos. 41A/10, 41A/11, 41A/13, 41A/14 and 41A/15. The investigation involved regional traverse mapping on 1:50,000 scale followed by detailed mapping on 1:2,000 scale for delineation of bentonite deposits. During the course of the study, reworked bentonite and associated white clay horizons within the Tertiary sedimentary sequence were also identified. In particular, white clay deposits with thickness ranging from 1.5 m to 2 m were reported from the Guneri area, associated with Mesozoic formations.

8.1.7 Vijaya Sarathi (1981–82) carried out geological mapping over approximately 400 sq km on 1:50,000 scale in parts of Toposheet Nos. 41A/9, 41A/10, 41A/13, 41A/14 and 41A/15 with the objective of delineating the Tertiary stratigraphy of the region. Based on palaeontological evidence and lithological characteristics, four lithostratigraphic units were delineated, representing marine depositional environments ranging in age from Paleocene to Oligocene.

8.1.8 Geophysical investigations were subsequently carried out by Baranwal, Chattopadhyay and Ray (1989–90) in the Umarasar–Pranpur area using magnetic, electrical resistivity and seismic refraction techniques to delineate the configuration of basement trap rocks and thickness of the overlying sedimentary formations.

8.1.9 Gandhi (1990–91) carried out regional exploration for lignite in the Umarsar area of Kachchh district covering an area of about 19 sq km. A total of 2618.20 m of drilling was completed in 18 boreholes (GLK-81 to GLK-98) with an inter-borehole spacing of approximately 750 m. The investigation established that lignite seams occur within the Lakhpat and Fulra Dam Formations of Paleocene to Lower Eocene age, which overlie the Deccan Trap or Bhuj Formation.

8.1.10 In a palaeontological investigation, Prasad (1992–93) carried out systematic collection of invertebrate fossils from Middle Jurassic to Lower Cretaceous sediments exposed in the Ghuneri, Maudhan and Lakhapar areas, contributing to the establishment of biostratigraphic zones and regional correlations within the Kachchh mainland.

8.1.11 Jain (1994–95) investigated the potash potential of glauconite-bearing shale and sandstone formations over an area of 100 sq km at 1:25,000 scale in Kachchh district. Based on the occurrence of a glauconite-bearing band with cumulative thickness of about 1.5 m and strike continuity of 3–4 km, approximately 0.02 million tonnes of glauconite reserves containing about 5.33% K_2O were estimated.

8.1.12 Later, Saxena and Fulzele (2002–03) carried out seismotectonic studies along the Kachchh Mainland Fault (KMF) involving geological mapping over about 250 sq km at 1:25,000 scale, trenching and trench face mapping. Their investigations revealed significant neotectonic activity and palaeoseismic features, including soft-sediment deformation structures and east–west trending faults within Holocene fluvial sediments.

8.1.13 Sarkar and Banerjee (2011) suggested an authigenic origin of glauconite within the Naredi Formation, contributing to the understanding of glauconite genesis in the basin. Subsequently, Basheer and Kumar (2014–15) carried out detailed investigation for potash in glauconite-bearing formations around Guneri village, during which two samples of lateritic bauxite analysed yielded 20–22 wt.% Al_2O_3.

8.1.14 More recently, Sahu et al. (F.S. 2016–18) carried out laterite-bauxite investigations in Toposheet No. 41A/13. The lateritic profile was classified into bauxite, clayey bauxite, bauxitic clay and lithomargic clay based on physical characteristics and pisolitic texture. The profile typically consists of laterite at the top, bauxite in the middle and lithomargic clay at the base. The laterite thickness ranges from 1–2 m, while bauxite varies from 0.5 m to 7 m and lithomargic clay from 0.3 m to 5 m. The laterite-bauxite belt exhibits a strike continuity of about 6 km with width ranging from 1 m to 350 m. Based on reconnaissance investigations during F.S. 2016–17, 744,313.18 tonnes of bauxite resources with an average grade of 42.84% Al_2O_3 and 36,549 tonnes of lithomargic clay with an average grade of 36.52% Al_2O_3 were estimated. Additionally, detailed investigation at 1:2000 scale by Z.G. Ghevariya in the Gaduli and Chhuger areas reported the occurrence of bentonite deposits over about 6,800 sq m area with an average thickness of approximately 1 m.

8.1.15 In the Umarsar–Guneri area, Gujarat Mineral Development Corporation Limited (GMDC) operates lignite mines and represents the principal lignite mining activity in the region. Geological Survey of India carried out several phases of geological investigations between 1981–82 and 2014–15, including detailed exploration involving drilling for lignite deposits. Subsequently, GMDC acquired mining leases in the vicinity of Umarsar village and commenced commercial mining operations. In addition, Ashapura Bentonite Clay Mines are operating in the southern part of the mapped area, exploiting bentonite deposits associated with the Tertiary sedimentary formations.

Table 8.1: Chronological Summary of Previous Investigations

Year / Period	Investigator / Organization	Nature of Work	Key Outcome
1948	Roy, B.C. (GSI)	Mineral resource study	Initial assessment of mineral resources in Lakhpat–Nakhatrana area
1953	Poddar & Venkatappayya (GSI)	Coal and lignite investigation	Documentation of lignite occurrences
1971	Biswas (ONGC)	Stratigraphic classification	Eight lithostratigraphic units of Tertiary rocks defined
1963–1991	Various workers	Glauconite studies	Identification of glauconite horizons in Mesozoic–Tertiary rocks
1978–79	Bhattacharya (GSI)	Lignite investigation	Identification of six lignite deposits
1979–82	Ghevariya (GSI)	Bentonite exploration	Mapping and delineation of bentonite and white clay deposits
1981–82	Vijaya Sarathi (GSI)	Geological mapping	Delineation of Tertiary lithostratigraphic units
1989–90	Baranwal et al.	Geophysical survey	Basement configuration and sediment thickness studied
1990–91	Gandhi (GSI)	Lignite exploration drilling	2618 m drilling in Umarsar area
1992–93	Prasad (GSI)	Palaeontological study	Biostratigraphic zonation of Jurassic–Cretaceous rocks
1994–95	Jain (GSI)	Potash investigation	Estimation of glauconite reserves
2002–03	Saxena & Fulzele (GSI)	Seismotectonic study	Neotectonic features along KMF identified
2011	Sarkar & Banerjee	Glauconite genesis	Authigenic origin of glauconite proposed
2014–15	Basheer & Kumar (GSI)	Potash investigation	Identification of glauconite and lateritic bauxite samples
2016–18	Sahu et al. (GSI)	Laterite–bauxite exploration	Bauxite resource estimation

Table 8.2: Mineral Exploration Summary in the Region

Mineral / Commodity	Area	Organization	Status
Lignite	Umarsar–Guneri	GSI / GMDC	Active mining
Bentonite	Guneri–southern block	GSI / Ashapura Mines	Active mining
Glauconite / Potash	Guneri region	GSI	Investigated
Laterite–Bauxite	TS 41A/13	GSI	Resource estimated

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.

9.1.1. During the current exploration program, no Aerial/Geophysical surveys were not carried out.

CHAPTER-10

EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 INTRODUCTION

10.1.1 The importance of bauxite is well known in the production of Aluminium metal and also in other industries viz. abrasives, refractory, chemical and cement. The properties like lightness of metal aluminium, its high resistance to atmospheric corrosion and good electrical conductivity makes it a popular metal and is being used for making household utensils and therefore known as 'poor man's gold'. The aluminium metal being a good substitute for nonferrous metals like copper, zinc which are scarce and costly metals has further necessitated the development of aluminium industry throughout the world.

10.1.2 Resources of bauxite in the country as on 01.04.2020 as per Indian Mineral Year book 2022 are placed at 4,958 million tonnes. These resources include 646 million tonnes reserves and remaining 4,311 million tonnes remaining resources. By grades, about 79% resources are of Metallurgical grade (I, II & Mixed). The resources of Refractory and Chemical grades are limited and together account for about 4 %. States, Odisha alone accounts for 41% of country's resources of bauxite followed by Chhattisgarh 20%, Andhra Pradesh (12%), Gujarat (8%), Jharkhand (6%), Maharashtra (5%) and Madhya Pradesh (4%). Major bauxite resources are concentrated in the East Coast bauxite deposits in Odisha and Andhra Pradesh

10.1.3 The production of bauxite is 22,494 thousand tonnes in 2021-22 increased by 10% as compared to previous year (IBM Year BooK). There are 126 reporting mines in 2021-22 as against to 134 in the previous year. Ten principal producers having 41 mines contributed 91.40% of total production. NALCO is the leading producer and contributed 33% of the total production.

10.1.4 In view of the enactment of the MMDR Amendment Act-2015 and Mineral Auction Rule- 2015 by the Govt. of India, Commissioner of Geology and Mining (CGM), Gujarat had discussed with MECL to take up exploration work for Bauxite blocks in Kachchh district of Jharkhand for upgradation of these areas as per the MMDR Amendment Act and Mineral Auction Rule, 2015 which shall enable the state government for auctioning of the Bauxite blocks.

10.1.5 Based on the mineral potentiality of the prospect and previous work carried out by GSI and CGM Gujarat in the area, MECL formulated G-3 stage Exploration proposal and presented in the 5th meeting of TCC-II, NMET held on 27th – 29th January 2025. The Technical Cost committee has technically evaluated and recommended the exploration proposal for approval Executive Committee (EC) of NMET.

10.1.6 Consequently, the project was approved by 40th EC, NMET held on 21st February 2025 and the same was intimated to MECL vide MoM letter No. F.NO.23/583/2025-NMET/951 dated 5th March, 2025. Project was approved with the title "Preliminary Exploration (G-3) for Bauxite and associated minerals in Dhrang Block, District Kachchh, Gujarat", with estimated cost of Rs 1.51 Cr including GST in time schedule of 14 months for carrying out the proposed work (Annexure XI) and submission of report.

10.1.7 The present phase of exploration drilling in the Dhrang Block was initiated following detailed geological mapping, with drilling commencing at Borehole No. MBD-04 on 14.10.2025 and concluding with the completion of Borehole No. MBD-01 on 07.11.2025. As per the approved quantum of work, a total of 77.00 m of drilling was completed through 05 boreholes during the first phase. All boreholes were advanced up to the lithomargic clay horizon, marking the base of the lateritic weathering profile. The bauxitic/aluminous lateritic horizon is moderately developed, with thickness generally varying between 10 m and 14 m across the drilled locations. The borehole locations were strategically selected in areas showing favourable surface geochemical indications, particularly where bedrock samples (BRS) exhibited elevated Al_2O_3 values, in order to effectively delineate the subsurface continuity and grade of the bauxitic horizon. As per the approved scope of work, the objective was to delineate the bauxitic horizon and assess its lateral and depth extension through a combination of pitting, bedrock sampling and limited exploratory drilling in a scattered pattern. Accordingly, drilling in the first phase was carried out on a non-grid basis, targeting geochemically favourable zones identified from surface investigations. A second phase of drilling, envisaged to establish a systematic grid in accordance with the provisions of the MEMC Rules, 2015, could not be undertaken, as the lateral continuity, depth and areal extent of the bauxitic zones were found to be limited during the initial phase of exploration.

10.1.8 The allied field-works including Borehole survey, topographical survey, sampling and analytical work were completed simultaneously. The laboratory studies including chemical analysis and physical analysis i.e. petrographic and bulk density studies were carried out simultaneously in laboratories of MECL and other Govt. / NABL accredited laboratories.

10.1.9 The progress of the block, along with the analytical results of the core samples generated during the course of exploration, was reviewed in the 24th TCC-II meeting held on 2nd and 3rd March 2026. After due consideration of the analytical results and the overall exploration status, the Technical-cum-Cost Committee (TCC) observed that the extension of the bauxitic zones within the block is very limited with good value of TiO2 and, accordingly, recommended to estimate the resources and closure of the exploration programme and submission of the Geological Report. TCC-II committee revised the project cost of Rs. 0.58 Cr., considering the reduced scope of drilling along with the corresponding decrease in sampling and chemical analysis (Annexure- XII).

10.1.10 The details of the nature and quantum of work proposed Vs actual achievement is given in **Table-10.1.**

Table – 10.1
Approved Quantum of Work vis a vis Achievement by MECL in Dhrang block, District: Kachchh, State: Gujarat

S. No	Item details	Unit	Proposed Quantum	Achieved Quantum	Remarks
1	Geological Mapping (1:4000 scale)	Sq. Km.	4.86	4.86	
2	Topographic Survey (Contour interval 2m) at 1:4000 scale	Sq. Km.	4.86	5.86	
3	Pitting	cu. m	100	50.08	
4	Trenching	cu. m	50	0	
5	Bore Hole Fixation and determination of co-ordinates & Reduced Level (RL) of the boreholes and demarcation of lease hold boundary points by DGPS	Nos.	15+4=19	9	
6	Core drilling (400m x 400m grid).	m	450	77	5 Nos BH in phase I drilling
7	**Sampling & Chemical Analysis**				

A)	Primary samples to be analyzed for 7 radicals viz. Al_2O_3, SiO_2, Fe_2O_3, TiO_2, V, Ga, Sc & LOI				
i.	Bedrock samples	Nos.	20	20	
ii.	Trench/ Pit samples	Nos.	20	20	
iii.	Borehole Core samples	Nos.	300	54	
iv.	For Each additional Trace Element viz.V, Ga, Sc. (from BH Core Sample)	Nos.	300	54	
v.	Check samples (10% external)	Nos.	34	16	
8	**Physical Studies**				
a)	ICP-AES/ICPMS (sequential technique) for 34 elements i.e. 16 other elements viz. Li, Ga, In, Be, Ge, Mo, Ni, Cr, Ta, W, Ba, Co, Rb, Sr, Zr, Nb ;16 REE viz. La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc, Y; 02 Actinides viz. U, Th.	Nos.	15	15	
b)	X-RD studies for mineral identification	Nos.	10	5	
9	Petrographic Studies	Nos.	10	6	
10	Mineragraphic Studies	Nos.	10	4	
11	Preparation of Polished Section & Thin Section (05+05)	Nos.	10		
12	Bulk density	Nos.	10	2	
13	Combined determination of Trihydrate Alumina (THA-140°C), Monohydrate Alumina (MHA-240°C) & Reactive Silica	Nos.	10	5	
14	Geological Report Preparation {As per Mineral (Evidence of mineral contents) Rule-2015}	Nos.	1	1	

10.2.0 OBJECTIVES OF INVESTIGATION

10.2.1. The present investigation at the G-3 stage of exploration has been planned with the objective of systematically evaluating the occurrence, distribution, thickness and grade characteristics of bauxite and associated lateritic formations within the study block. The exploration programme has been formulated in accordance with the provisions of the Minerals (Evidence of Mineral Contents) Rules, 2015, Mineral (Auction) Rules, 2015, and the MMDR Act, 2015, with the ultimate aim of establishing mineral resources and facilitating the auction of the block by the Government of Gujarat.

The specific objectives of the investigation are as follows:

1. To prepare a detailed geological map on 1:4000 scale for delineation of various litho-units such as bauxite, laterite, Deccan basalt (Deccan volcanics), limestone, sandstone and associated formations, along with their structural attributes and geomorphological expressions.
2. To collect approximately 80 bedrock / chip samples from bauxite and aluminous laterite bearing horizons for geochemical analysis and characterization of the mineralized zones.
3. To carry out pitting operations at approximately 400 m × 400 m grid interval in order to delineate the lateral extent and continuity of bauxite and aluminous laterite horizons prior to undertaking drilling operations.
4. To conduct a detailed topographical survey on 1:4000 scale to generate accurate base maps for geological mapping, drilling site selection and resource estimation.
5. To establish the occurrence, lateral continuity and depth persistence of bauxite horizons through systematic exploratory drilling of 15 boreholes at 400 m × 400 m grid spacing, in accordance with the provisions of the MEMC Rules, 2015.
6. To drill two boreholes up to the basement rock (Deccan basalt) in order to establish the complete lateritic profile and confirm the depth of the underlying bedrock.
7. To evaluate the thickness, grade and quality of the bauxite horizons and delineate bauxite resources at G-3 (333) level in accordance with the United Nations Framework Classification (UNFC) system.
8. In addition to bauxite, to assess the potential occurrence of associated elements such as Titanium, Gallium, Vanadium and other economically significant minerals, and to report their resources where encouraging analytical values are encountered.
9. To carry out exploration activities in conformity with the Minerals (Evidence of Mineral Contents) Rules, 2015, Mineral (Auction) Rules, 2015, and the MMDR Act, 2015, thereby facilitating the scientific assessment of the block and enabling its auction by the Government of Gujarat.

10.3.0 DETAILS OF PITTING, TRENCHING, DRILLING, ETC.

10.3.1 The approved scheme of Preliminary Exploration (G-3) work in Dhrang Block includes geological mapping, Survey, drilling, core logging, Pitting, core sampling and associated laboratory studies

10.3.2 **Geological Mapping:** Geological mapping has been carried out in the block for the entire area of 4.86 sq. km on 1:4000 scale depicting the lithology, structure and mineralization signatures such as mineralised zones. Identification and demarcation of mineralized zones, thus helped in marking the geochemical sampling locales for channel sampling. Lithological units and litho-contacts have been mapped with the help of handheld GPS. Attitude and structural features of rocks like bedding, and joints has been recorded by Brunton Compass. The readings recorded in the field were plotted and produced in the form of geological map given as Plate IVA.

10.3.4 **Surface bed rock sampling:** During geological traverses, exposures with aluminous mineralisation/ aluminous laterites bands were identified. The sampling was carried out by chipping across the mineralized body of fresh surface exposures of 1m radius. The area was cleaned to remove the dusts before collection of samples.

During, geological traverses, MECL has carried out surface sampling and collected a total of 20 Primary bedrock samples. Location of the bedrock alongwith the Maximum values of SiO_2 and Al_2O_3 in each bedrock sample has been displayed on geological map is represented in Plate-IVB. All 20 channel samples were analysed for Al_2O_3, SiO_2, Fe_2O_3, TiO_2 and LOI (Annexure-IIIA). Out of 20 channel samples Al2O3 varies from > 30% to 56.41% and silica values ranging between 2.43%-23.59. % .

10.3.3 **Pitting:** During the course of detailed geological mapping, a total of 20 bedrock samples were collected from the exposed litho-units for geochemical analysis. Based on the analytical results and field observations, pitting was undertaken to further examine the occurrence and continuity of laterite–bauxite horizons within the block. Against the proposed 100 cu. m of pitting, a total of 50.8 cu. m of 20 nos. pitting was carried out, as the exposure of laterite and bauxite within the block was found to be limited, making it difficult to precisely identify potential bauxitic zones Photograph – 10.1 o 10.16 and Fig. 10.1 to 10.19).

The pits were excavated at approximately 400 m horizontal intervals upto a depth of maximum 2m, guided by the analytical results of bedrock samples and the prevailing lithological conditions. A total of 20 pits were excavated and sampled during the investigation. Most of the pits were located within laterite and basalt units with the objective of exposing the laterite–bauxite interface as well as the basal portion of the bauxite horizon, in order to understand the vertical extent and continuity of the mineralized zone. The location of pits showing on geological map presented in Plate- IVC.

In addition, a few pits were excavated in soil-covered areas to verify the possible subsurface occurrence of bauxite horizons in areas lacking surface exposure. The pitting programme thus aided in assessing the presence and vertical disposition of lateritic and bauxitic horizons within the mapped area. The details of pits and analysis is given in Annexure- IIIB.

Dhrang G3 Block Bauxite and Associated Minerals

Photograph No. 10.1: Pit No.39

	
Demarcating the Dimension of Pit	Excavated Pit
	
Lithology of Pit	Altered Basalt at the bottom of pit

Closing of Pit

Photograph No. 10.2: Pit No.11

Demarcation of Pit

Excavated Pit

Full View

Closing Pit

Photograph No. 10.3: Pit No.08

	
Demarcation of Pit	Excavation of Pit
	
Closing Pit	

Photograph No. 10.4: Pit No.09

	
Demarcation Pit	Excavated Pit
	
Closing Pit	

Photograph No. 10.5: Pit No.24	
	
Demarcation Pit	Excavation of Pit

Photograph No. 10.6: Pit No.41

	
Demarcation of Pit	Excavated Pit
	
Full view	Closing Pit

Photograph No. 10.7: Pit No.28

Demarcation Pit

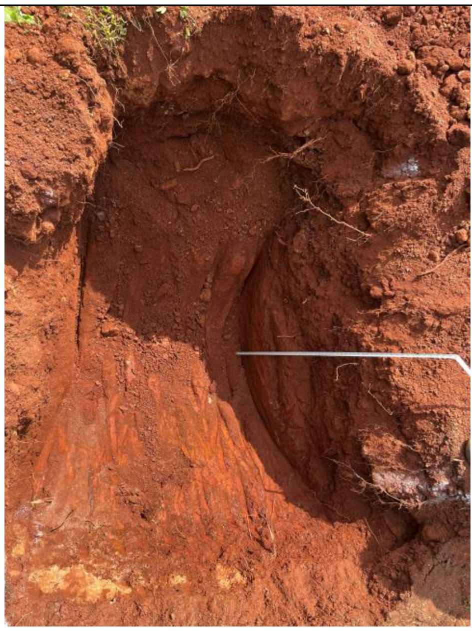
Excavated Pit

Closing Pit

Photograph No. 10.8: Pit No.41

Demarcation Pit

Excavated Pit



Full view

Closing of pit

Photograph No. 10.9: Pit No.29

Demarcation of Pit

Excavated Pit measurement

Closing of Pit

Photograph No. 10.10: Pit No.33

	
Demarcation Pit	Pit Measurement
	
Clayey bauxite at Bottom	Closing of Pit

Photograph No. 10.11: Pit No.23

	
Demarcation of Pit	Excavated Pit
	
Closing of Pit	

Photograph No. 10.12: Pit No-5

Demarcation of Pit

Excavated Pit

Measurment of Pit

Closing of Pit

Photograph No. 10.13: Pit No. 30

	
Demarcation Pit	Excavated Pit
	

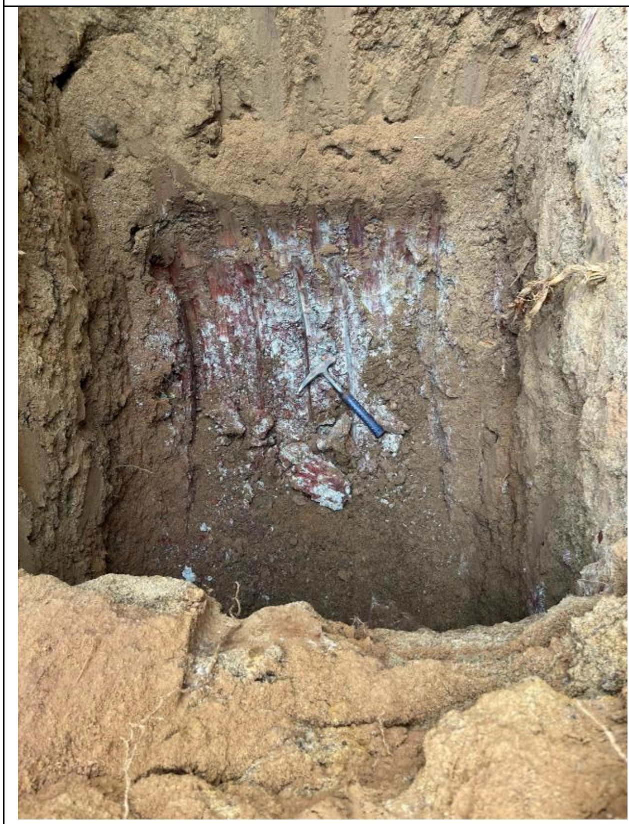
Showing measurement of Pit

	
Closing of pit	

Photograph No. 10.14: Pit No.31

Demarcation Pit

Excavated Pit



Clayey Bauxite at bottom

Closing of Pit

Photograph No. 10.15: Pit No. No.3

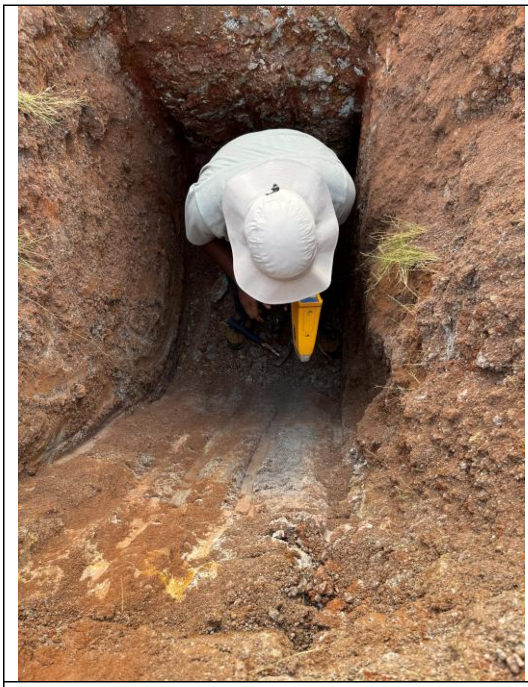
	
Demarcation Pit	Excavated Pit
	
Full view of pit with measurement	

Closing of Pit

Photograph No. 10.16: Pit No.26

Demarcation of Pit

Channel Sample collection

	
Using handheld XRF	Collection of channel samples from Pit
	
Closing of Pit	

PITTING RECORDS

Name of the Investigation Lateritic Bauxite	Date of Commencement: 14.09.2025
Pit No. - 39	Date Of Completion: 14.09.2025
Location (Coordinates): Easting: 490400.00 Northing: 2602786.00	Elevation:
Pit Measurements(mtrs):	
Top Measurement	Bottom Measurement
a. Length – 1.0m b. Width – 1.0m	a. Length – 1.0m b. Width – 1.0m c. Depth -2.0m
Recorded By: Shubham Kumar	
Lithology Details: 0-0.6m is soil, 0.6m -2m Altered Basalt, Pit Floor Altered Basalt.	
Structural Details:Nil	
Log of Pit: A, B, C, D are side section and E plan view is bottom of the pit.	
Samples: One sample was collected from bottom of pit. Sample No - MBD/PT/39	

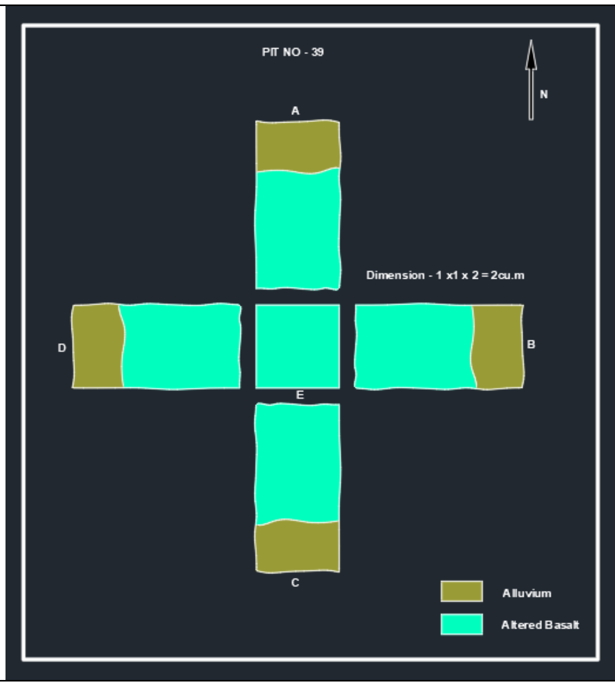
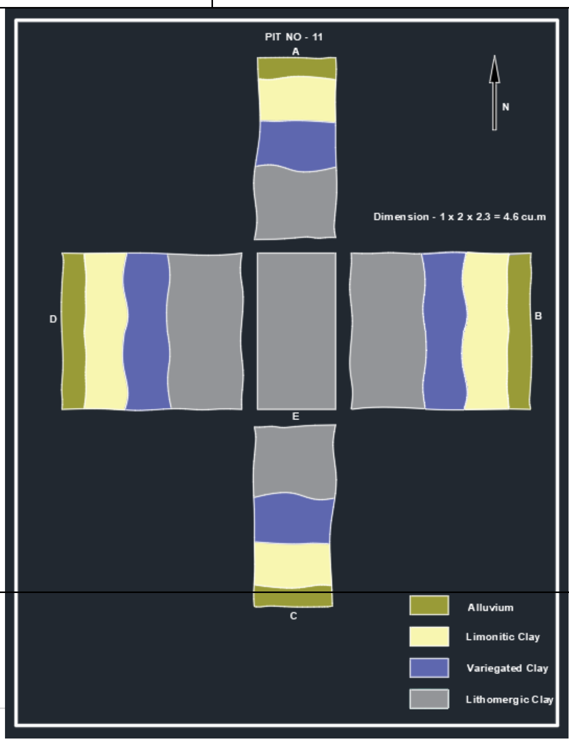


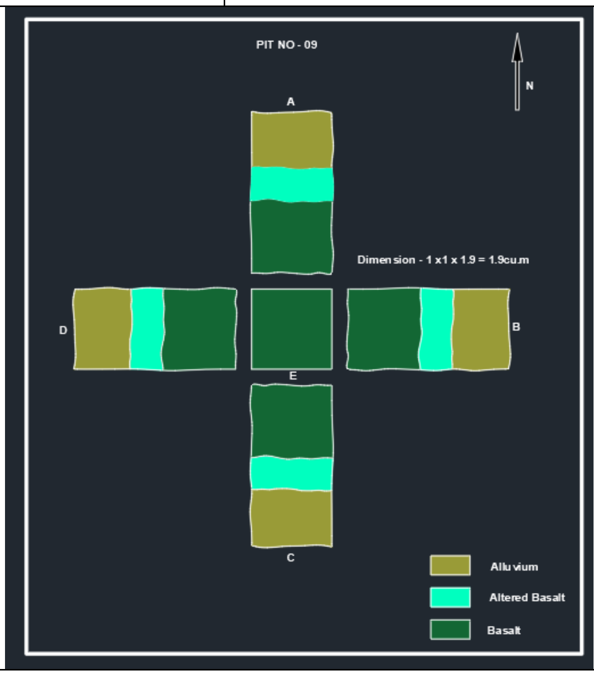
Fig.10.1: Details log of pit PT-39

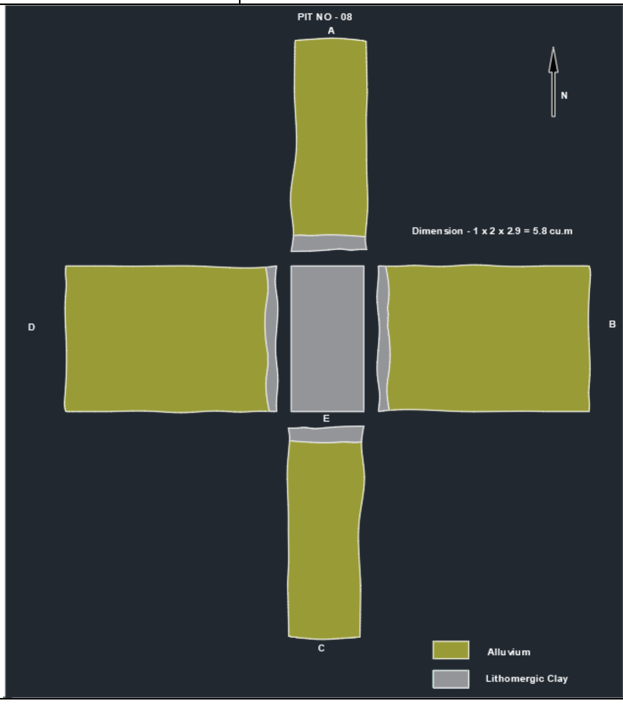
PITTING RECORDS

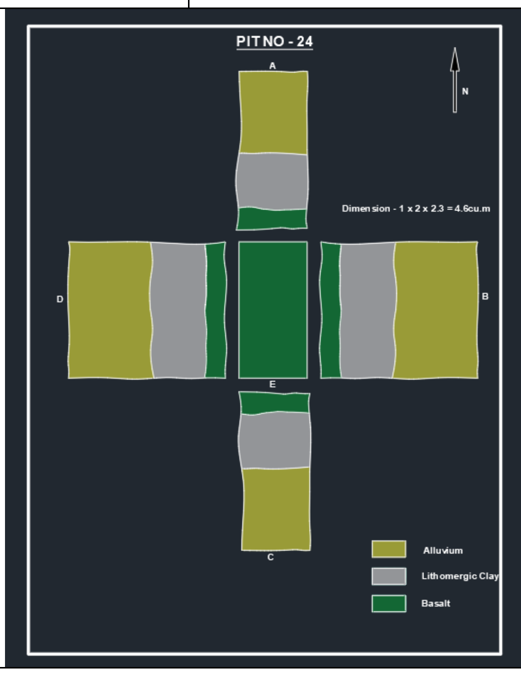
Name Of the Investigation Lateritic Bauxite	Date of Commencement: 14.09.2025
Pit No. - 11	Date Of Completion: 14.09.2025
Location (Coordinates): Easting: 490556.01 Northing: 2602734.2	
Pit Measurements(mtrs):	
Top Measurement	Bottom Measurement
c. Length – 2.0m d. Width – 1.0m	d. Length – 2.0m e. Width – 1.0m f. Depth – 2.3m
Recorded By: Utkarsh Singh & Hiresh Shrirame	
Lithology Details: 0-0.28m -soil, 0.28-0.83 is Limonitic clay, 0.83-1.40m Aluminous Clay/Varigated Clay, 1.40m-2.30 – Lithomergic Clay	
Structural Details:	



Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.	
Samples: Samples were collected from walls of Pit. MBD/PT/11A, MBD/PT/11B & MBD/PT/11C	Fig.10.2. Details log of pit PT11

PITTING RECORDS			
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 14.09.2025		
Pit No. - 09	Date Of Completion: 14.09.2025	 	
Location (Coordinates): Easting: 490686.17 Northing: 2602398.44			
Pit Measurements(mtrs):			
Top Measurement	Bottom Measurement		
e. Length – 1.0m f. Width – 1.0m	g. Length – 1.0m h. Width – 1.0m i. Depth – 1.9m		
Recorded By: Hiresh Shrirame			
Lithology Details: Top Soil is 0-0.7m and below 0.7-1.10m is Altered Basalt;1.10 – 2.0 - Basalt			
Structural Details:			
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.			
Samples: One sample was collected from bottom of pit MBD/PT/09A		Fig.10.3. Details log of pit PT09	

PITTING RECORDS			
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 14.09.2025		
Pit No. - 08	Date Of Completion: 14.09.2025		
Location (Coordinates): Easting: 489886.20 Northing: 2602348.30			
Pit Measurements(mtrs):			
Top Measurement	Bottom Measurement		
g. Length – 2.0m h. Width – 1.0m	j. Length – 2.0m k. Width – 1.0m l. Depth – 2.9m		
Recorded By: Utkarsh Singh			
Lithology Details: Soil is 0-2.7m , 2.7-2.9m limonitic Clay/Ferrugenous Clay/Lithomargic Clay.			
Structural Details:			
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.			
Samples: Samples were collected from Bottom. MBD/PT/08A		Fig.10.4. Details log of pit PT08	

PITTING RECORDS			
Name Of the Investigation Laterite Bauxite	Date of Commencement: 15.09.2025		
Pit No. - 24	Date Of Completion: 15.09.2025		
Location (Coordinates): Easting: 490283.17 Northing: 2601694.24			
Pit Measurements(mtrs):			
Top Measurement	Bottom Measurement		
i. Length – 1.0m j. Width – 1.0m	m. Length – 1.0m n. Width – 2.0m o. Depth – 2.3m		
Recorded By: Hiresh Shrirame			
Lithology Details: Soil 0-1.20m, Lithomargic Clay - 1.20m-2.00m, 2.0 m–2.30m Basalt.			
Structural Details:			
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.			
Samples: No Samples were collected		Fig.10.5. Details log of pit PT24	

PITTING RECORDS		
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 15.09.2025	
Pit No. – 22	Date Of Completion: 15.09.2025	
Location (Coordinates): Easting: 490986.89 Northing: 2601378.49		
Pit Measurements(mtrs):		
Top Measurement	Bottom Measurement	
k. Length – 1.0m l. Width – 1.0m	p. Length – 1.0m q. Width – 1.0m r. Depth – 1.0m	
Recorded By: Shubham Kumar		
Lithology Details: 0.0 – 0.30- Soil,0.30 – 1.00 – Altered Basalt.		
Structural Details:		
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.		
Samples: MBD/PT/22 OR MBD/PT/05		Fig.10.6. Details log of pit PT22

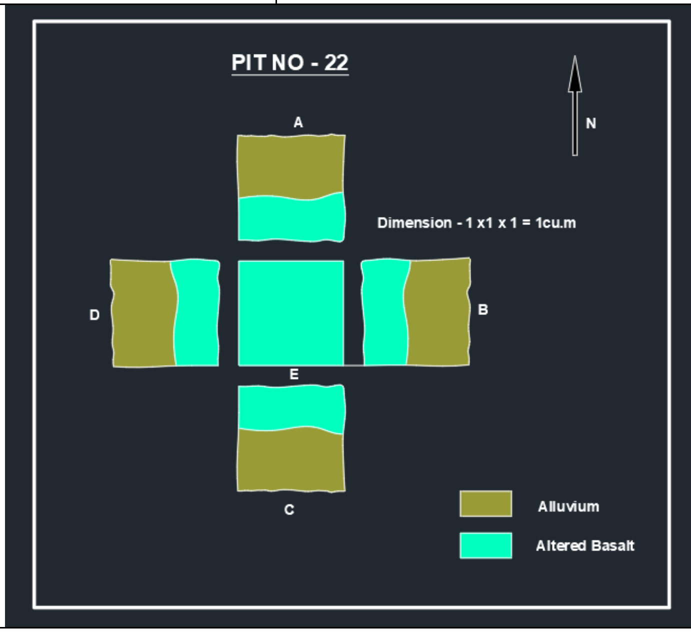


Fig.10.6. Details log of pit PT22

PITTING RECORDS		
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 15.09.2025	
Pit No. – 41	Date Of Completion: 15.09.2025	
Location (Coordinates): Easting: 490249.49 Northing: 2603098.99		
Pit Measurements(mtrs):		
Top Measurement	Bottom Measurement	
m. Length – 1.0m n. Width – 1.0m	s. Length – 1.0m t. Width – 1.0m u. Depth – 1.50m	
Recorded By: Hiresh Shrirame & Utkarsh Singh		
Lithology Details: Soil 0-0.28m, Weather Basalt/Altered Basalt is 0.28m-0.60m, Laterite is 0.60m-1.50m		
Structural Details:		
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.		
Samples: One sample was Collected from wall and Bottom - MBD/PT/41		Fig.10.7. Details log of pit PT41

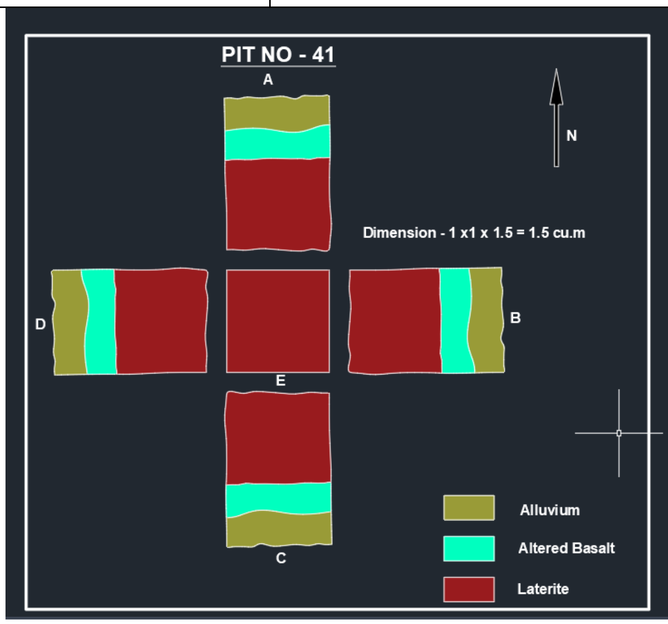


Fig.10.7. Details log of pit PT41

PITTING RECORDS	
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 15.09.2025
Pit No. - 28	Date Of Completion: 15.09.2025
Location (Coordinates): Easting: 490908.94 Northing: 2602076.12	
Pit Measurements(mtrs):	
Top Measurement	Bottom Measurement
o. Length – 1.0m p. Width – 1.0m	v. Length – 1.0m w. Width – 1.0m x. Depth – 2.0m
Recorded By: Utkarsh Singh & Hiresh Shrirame	
Lithology Details: Top Soil is 0-0.50m, Altered Basalt is 0.50m-1.50m, Basalt - 1.50-2.0	
Structural Details:	
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.	
Samples: Sample not collected	

Fig.10.8. Details log of pit PT28

PITTING RECORDS	
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 16.09.2025
Pit No. - 29	Date Of Completion: 16.09.2025
Location (Coordinates): Easting: 491503.11 Northing: 2602144.46	
Pit Measurements(mtrs):	
Top Measurement	Bottom Measurement
q. Length – 1.0m r. Width -1.0m	y. Length – 1.0m z. Width – 1.0m aa. Depth – 1.9 m
Recorded By: Shubham Kumar & Utkarsh Singh	
Lithology Details: Soil 0-1.0m, Altered Basalt 1.0-1.30, Basalt 1.30m – 2.0m	
Structural Details:	
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.	
Samples: One Sample was collected from wall and bottom - MBD/PT/29	

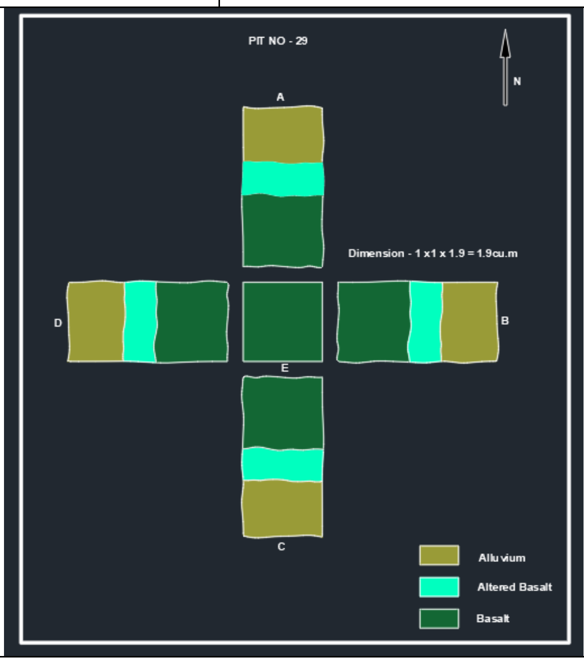
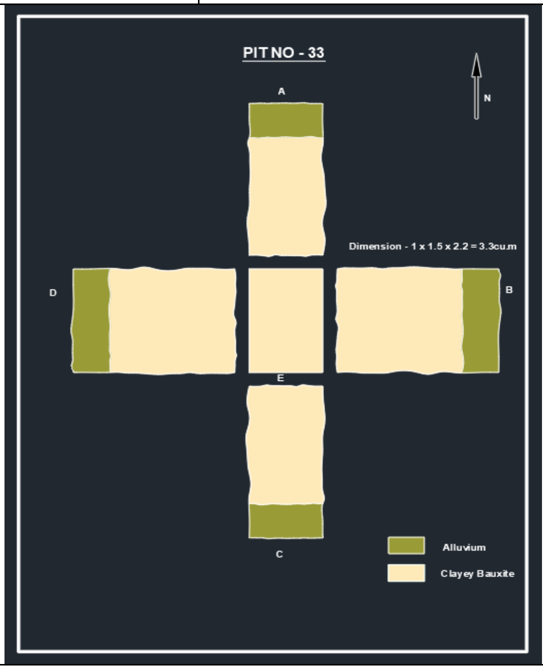
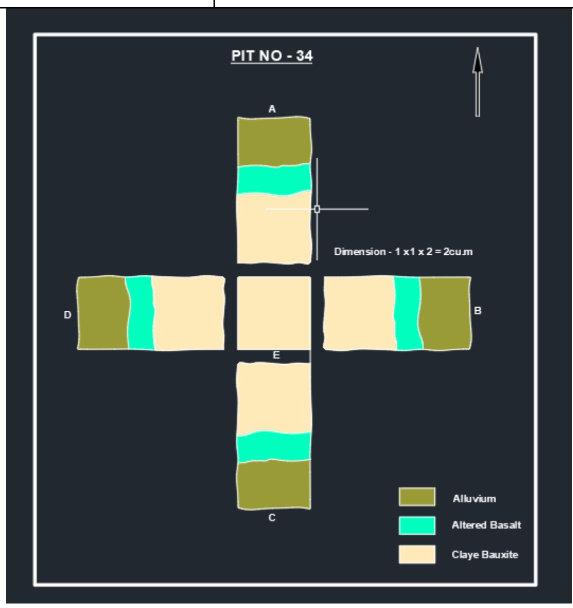


Fig.10.9. Details log of pit PT29

PITTING RECORDS		
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 16.09.2025	
Pit No. - 33	Date Of Completion: 16.09.2025	
Location (Coordinates): Easting: 491155.45 Northing: 2602494.84		
Pit Measurements(mtrs):		
Top Measurement	Bottom Measurement	
s. Length -1.5m t. Width – 1.0m	bb. Length – 1.5m cc. Width – 1.0m dd. Depth – 2.2m	
Recorded By: Utkarsh Singh & Hiresh Shrirame		
Lithology Details: Soil 0-0.50m, Clayey bauxite 1.0m-2.2m		
Structural Details:		
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.		
Sample: - MBD/PT/33		Fig.10.10. Details log of pit PT33

PITTING RECORDS		
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 16.09.2025	
Pit No. - 34	Date Of Completion: 16.09.2025	
Location (Coordinates): Easting: 491528.36 Northing: 2602485.43		
Pit Measurements(mtrs):		
Top Measurement	Bottom Measurement	
u. Length – 1.0m v. Width – 1.0m	ee. Length – 1.0m ff. Width – 1.0m gg. Depth – 2.0m	
Recorded By: Shubham Kumar & Hiresh Shrirame		
Lithology Details: Soil is 0-0.64m, Altered Basalt 0.64m-1.0m, Clayey Bauxite - 1.0m-2.0m.		
Structural Details:		
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.		
Sample: MBD/PT/34		Fig.10.11. Details log of pit PT34

PITTING RECORDS	
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 16.09.2025
Pit No. - 23	Date Of Completion: 16.09.2025
Location (Coordinates): Easting: 490575.14 Northing: 2601534.07	
Pit Measurements(mtrs):	
Top Measurement	Bottom Measurement
w. Length – 2.0m x. Width – 1.0m	hh. Length – 2.0m ii. Width – 1.0m jj. Depth – 2.50m
Recorded By: Shubham Kumar	
Lithology Details: Soil is 0-0.90m, Altered/Weather Basalt is 0.90m-2.50m	
Structural Details:	
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.	
Samples: No Samples were collected	

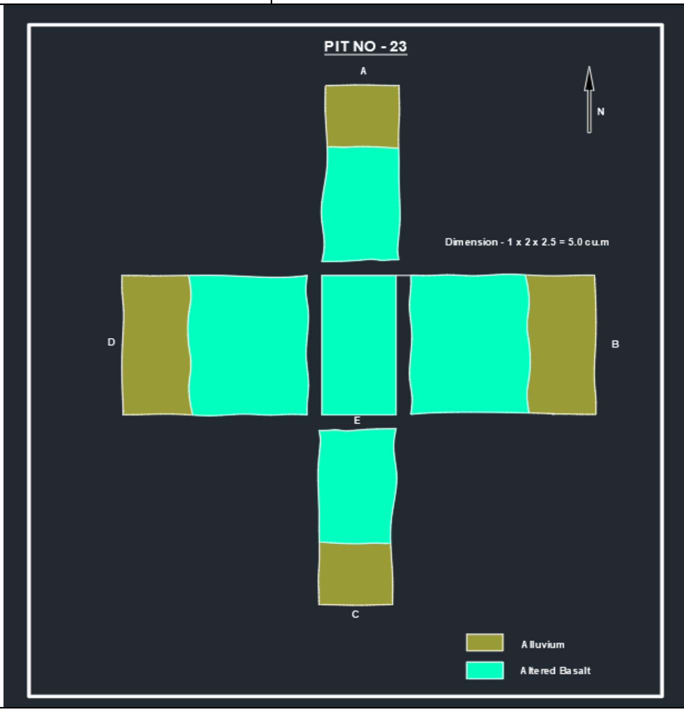


Fig.10.12. Details log of pit PT23

PITTING RECORDS	
Name Of the Investigation Lateritie Bauxite	Date of Commencement: 17.09.2025
Pit No. - 05	Date Of Completion: 17.09.2025
Location (Coordinates): Easting: 491475.46 Northing: 2601574.95	
Pit Measurements(mtrs):	
Top Measurement	Bottom Measurement
y. Length – 2.0m z. Width – 1.0m	kk. Length – 2.0m ll. Width – 1.0m mm. Depth – 2.39m
Recorded By: Shubham Kumar & Hiresh Shrirame	
Lithology Details: Soil 0-2.39m	
Structural Details: Nil	
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.	
Samples: No Samples were collected	

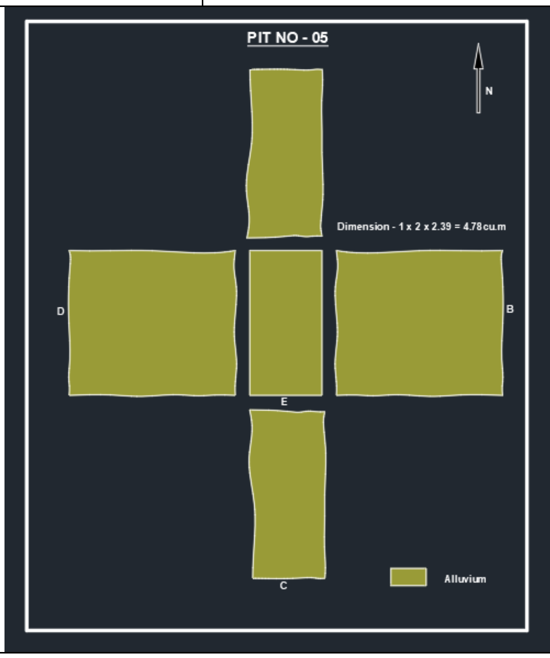
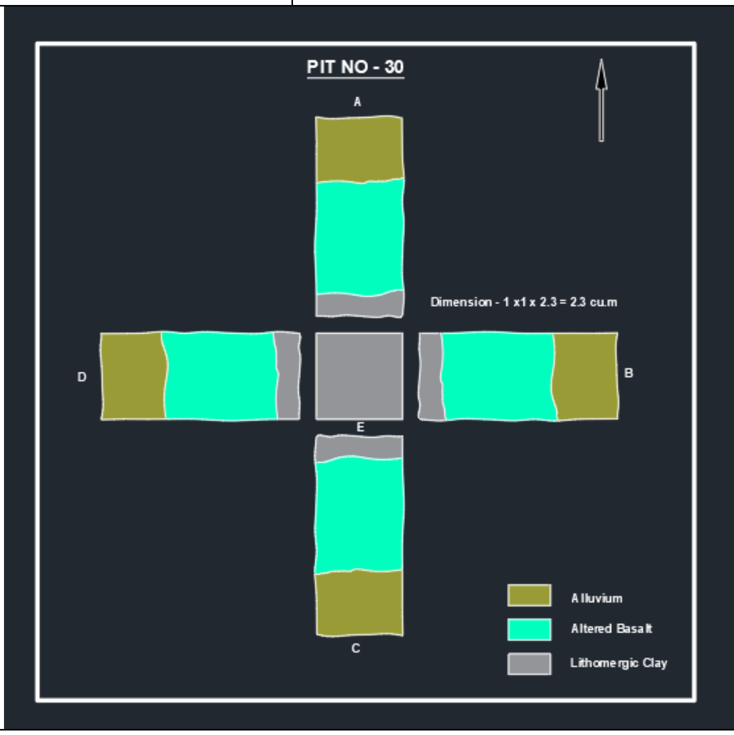
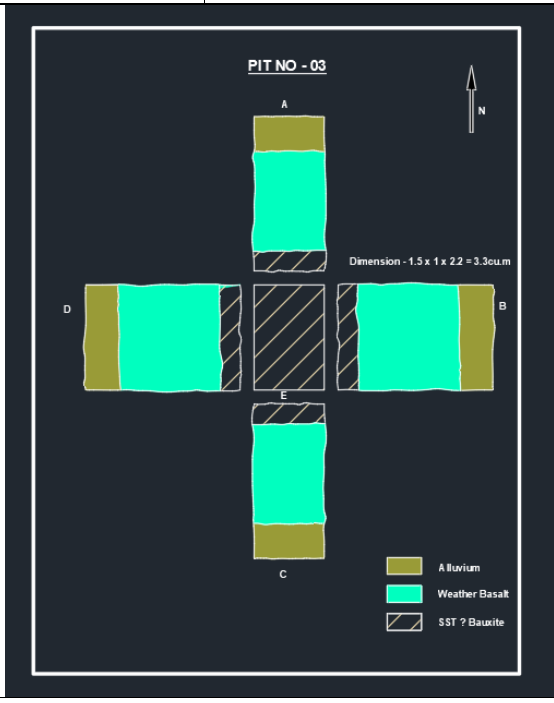
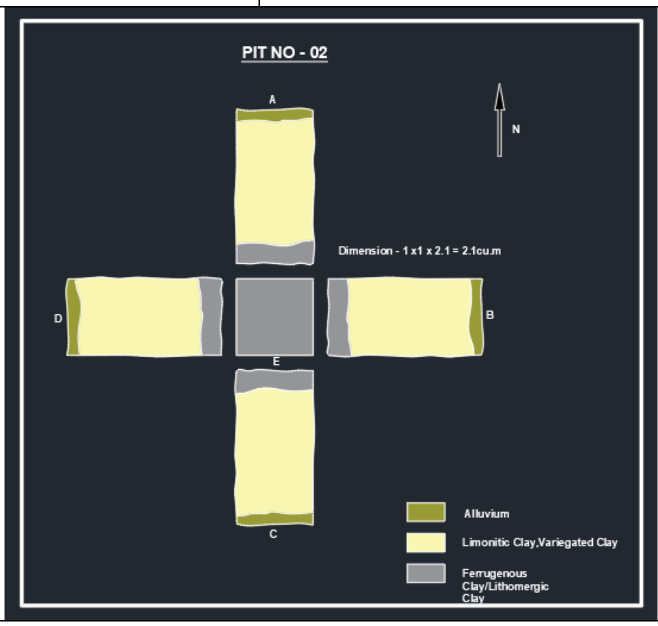


Fig.10.13. Details log of pit PT05

PITTING RECORDS			
Name Of the Investigation Laterite Bauxite	Date of Commencement: 17.09.2025		
Pit No. - 30	Date Of Completion: 17.09.2025		
Location (Coordinates): Easting: 490020.82 Northing: 2602815.93			
Pit Measurements(mtrs):			
Top Measurement	Bottom Measurement		
a. Length - 1.0m b. Width – 1.0m	ma. Length – 1.0m nb. Width – 1.0m oc. Depth – 2.30m		
Recorded By: Utkarsh Singh			
Lithology Details: Soil 0-0.70m, Clayey Bauxite/Altered Basalt - 0.70-2.10m, Bottom Clay.			
Structural Details:			
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.			
Samples: MBD/PT/30A & MBD/PT/30B		Fig.10.14. Details log of pit PT30	

PITTING RECORDS			
Name Of the Investigation Laterite Bauxite	Date of Commencement: 17.09.2025		
Pit No. - 19	Date Of Completion: 17.09.2025		
Location (Coordinates): Easting: 490012.08 Northing: 2601302.62			
Pit Measurements(mtrs):			
Top Measurement	Bottom Measurement		
c. Length - 1.0m d. Width – 1.0m	md. Length – 1.0m ne. Width – 1.0m of. Depth – 2.0m		
Recorded By: Shubham Kumar & Hiresh Shirrame			
Lithology Details: Soil 0.0m-0.45m, Laterite - 1.10m-1.60m, 1.60 – 2.0m Clay.			
Structural Details:			
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.			
Samples: Two Samples were collected. Sample No - MBD/PT/19A & MBD/PT/19B		Fig.10.15. Details log of pit PT19	

PITTING RECORDS		
Name Of the Investigation Laterite Bauxite	Date of Commencement: 17.09.2025	
Pit No. - 03	Date Of Completion: 17.09.2025	
Location (Coordinates): Easting: 490982.20 Northing: 2601002.84		
Pit Measurements(mtrs):		
Top Measurement	Bottom Measurement	
e. Length - 1.5m f. Width – 1.0m	mg. Length – 1.5m nh. Width – 1.0m oi. Depth – 2.20m	
Recorded By: Hiresh Shrirame & Utkarsh Singh		
Lithology Details: Soil 0-0.37, Altered/Weathered basalt - 0.45m – 1.90m, Sandstone - 1.90m – 2.20m.		
Structural Details:		
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.		
Samples: MBD/PT/03		Fig.10.16. Details log of pit PT03

PITTING RECORDS		
Name Of the Investigation Laterite Bauxite	Date of Commencement: 18.09.2025	
Pit No. - 02	Date Of Completion: 18.09.2025	
Location (Coordinates): Easting: 490668.98 Northing: 2601137.06		
Pit Measurements(mtrs):		
Top Measurement	Bottom Measurement	
g. Length - 1.0m h. Width – 1.0m	mj. Length – 1.0m nk. Width – 1.0m ol. Depth – 2.10m	
Recorded By: Shubham Kumar		
Lithology Details: Soil is 0-0.10m, Limonitic/Lateritic Clay 0.10m-1.70m, Lithomarge Clay is 1.70m-2.10m		
Structural Details:		
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.		Fig.10.17. Details log of pit PT02
Sample: MBD/PT/02		

PITTING RECORDS	
Name Of the Investigation Laterite Bauxite	Date of Commencement: 18.09.2025
Pit No. - 37	Date Of Completion: 18.09.2025
Location (Coordinates): Easting: 491084.98 Northing: 2602897.66	
Pit Measurements(mtrs):	
Top Measurement	Bottom Measurement
i. Length - 1.0m j. Width – 1.0m	mm. Length – 1.0m nn. Width – 1.0m oo. Depth – 2.0m
Recorded By: Hiresh Shrirame & Utkarsh Singh	
Lithology Details: Soil 0-0.50m, Basalt is 0.50-2.0m	
Structural Details:	
Log Of Pit: A, B, C, D are side section and E plan view is bottom of the pit.	
Samples: Sample not collected	

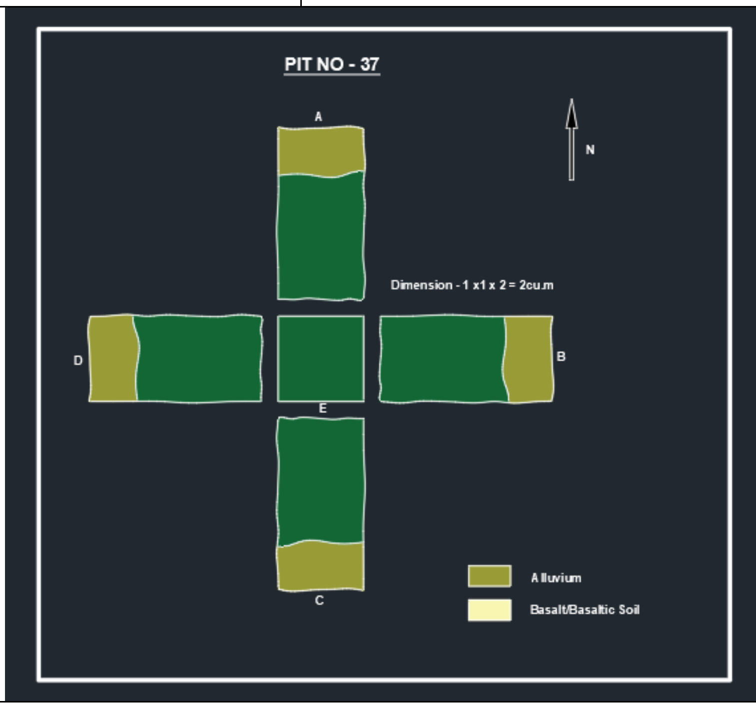


Fig.10.18. Details log of pit PT37

PITTING RECORDS	
Name Of the Investigation Dhrang Block	Date of Commencement: 18.09.2025
Pit No. - 26	Date Of Completion: 18.09.2025
Location (Coordinates): Easting: 491440.73 Northing: 2601900.34	
Pit Measurements(mtrs):	
Top Measurement	Bottom Measurement
k. Length - 1.0m l. Width – 1.0m	mp. Length – 1.0m nq. Width – 1.0m or. Depth – 2.0m
Recorded By: Utkarsh Singh	
Lithology Details: Soil is 0-0.5m, Weathered Basalt 0.5m-2.0m	
Structural Details:	
Log Of Pit:	
Samples: MBD/PT/26	

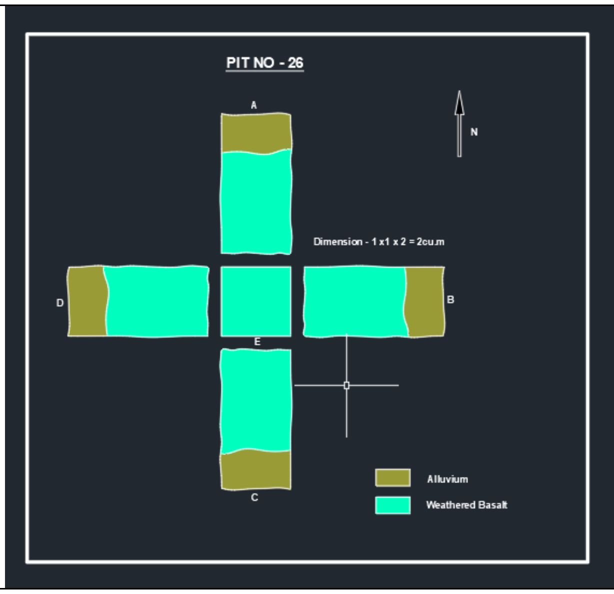
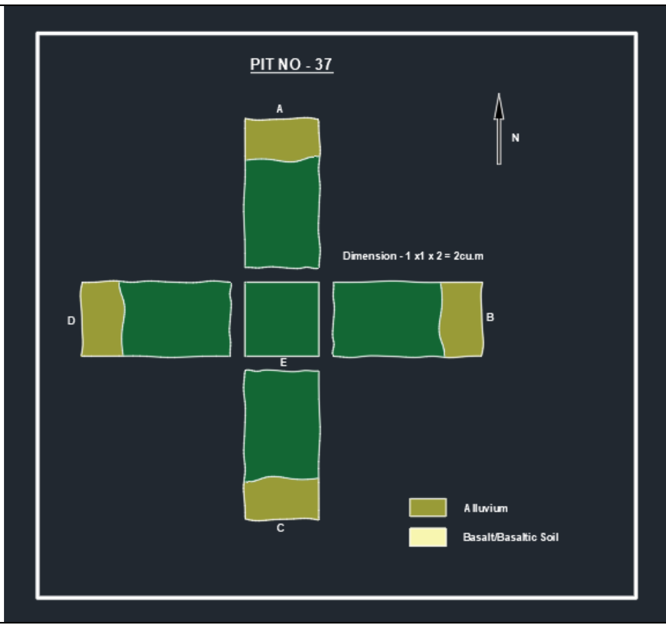


Fig.10.19. Details log of pit PT26

<table>
<tr><td colspan="3">PITTING RECORDS</td></tr>
<tr><td>Name Of the Investigation
Dhrang Block</td><td>Date of Commencement:
18.09.2025</td><td></td></tr>
<tr><td>Pit No. - 37</td><td>Date Of Completion:
18.09.2025</td><td rowspan="8">
</td></tr>
<tr><td>Location (Coordinates):
Easting: 490290.885
Northing: 2602135.296</td><td></td></tr>
<tr><td>Pit Measurements(mtrs):</td><td></td></tr>
<tr><td>Top Measurement</td><td>Bottom Measurement</td></tr>
<tr><td>a. Length - 1.0m
b. Width – 1.0m</td><td>mp. Length – 1.0m
nq. Width – 1.0m
or. Depth – 1.0m</td></tr>
<tr><td colspan="2">Recorded By:
Utkarsh Singh</td></tr>
<tr><td colspan="2">Lithology Details:
Soil is 0-0.5m, Basalt is 0.5m-1.0m</td></tr>
<tr><td colspan="2">Structural Details:

Log Of Pit:</td></tr>
<tr><td colspan="2">Samples: No Sample was collected</td><td>Fig.10.20. Details log of pit PT37</td></tr>
</table>

10.3.3 **Exploratory Drilling:** During the present exploration program, total 05 no of vertical boreholes on 200 to 400m spacing as given in para no 10.4.1, involving a total of 77.00 m of drilling was carried out in the block to check the strike and depth continuity of Bauxite bearing ore zones in the block area. All borehole cores were logged and mineralized zones were identified and samples were prepared from the mineralized zones and analysed for five oxides viz. Al_2O_3, SiO_2, Fe_2O_3, TiO2 & LOI and Elements Scandium, Vanadium and Gallium. Lithomarge/saprolite samples were analysed for Total Rare Earth Elements at MECL Chemical Laboratory, Nagpur. During the review in 24^{th} TCC-II meeting, it was suggested to conclude the block and submit the Geological Report as Bauxite occurrences are discrete and patchy in nature.

10.3.4 The summarised details of the boreholes drilled in the block are presented in Table 10.2, while detailed borehole information is furnished in Annexure-IB. The locations of the boreholes are shown on the topographical map and geological map in Plate-III and Plate-IVD respectively.

Table-10.2
Details of Boreholes drilled by MECL in Dhrang block, District: Kachchh, State: Gujarat

Sl. No.	BH.No.	UTM (42N)		RL (m)	Date of Commencement	Date of Closure	Total Depth (m)
		Northing (m)	Easting (m)				
1	MBD-01	490104.099	2603114.148	118.536	01-11-2025	07-11-2025	24.00
2	MBD-02	490044.776	2602694.366	105.132	25-10-2025	27-10-2025	14.00
3	MBD-03	490212.852	2602306.105	95.118	22-10-2025	24-10-2025	11.00
4	MBD-04	491285.401	2602502.510	88.391	14-10-2025	20-10-2025	22.00
5	MBD-05	490497.140	2601658.022	84.305	29-10-2025	30-10-2025	6.00
						Total:	**77.00**

10.3.5 Geological logging of borehole cores were properly done along with all the structural, lithological and mineralogical observations.(Annexure IIA and IIB). The associated laboratory studies i.e., chemical and physical have been completed simultaneously. In almost all the boreholes, we have encountered Bauxite, Aluminous laterites, Lithomergic Clay and Bentonite clay. As far as Al_2O_3 values are concerned, results are encouraging for BH samples and getting anamoulus values for Al_2O_3, TiO_2, V, Sc and Ga. But bauxite zones are limited in nature ranges from 5.00m to 9.50m encountered in all boreholes MBD-1 to 5. While in all borehole bauxitic and aluminous laterite zones of 3-16m thickness for Gallium, Scandium and TiO_2 has been found. The TiO_2, V, Sc and Ga cut-off is considered as 2%, 500 ppm, 50 ppm and 50ppm respectively.

10.3.6 A total of 54 Primary BH samples from 5 boreholes were collected and analyzed for five oxides viz. Al_2O_3, SiO_2, Fe_2O_3, TiO2 & LOI and Elements Scandium, Vanadium and Gallium (Annexure-IIIC). The analytical results of the core samples obtained from different boreholes indicate considerable variation in the major oxides and trace element concentrations, reflecting the vertical transition from bauxite to aluminous laterite and ferruginous laterite horizons within the lateritic profile.

Borehole MBD-01 shows Al_2O_3 values ranging from 21.22% to 52.38%, indicating the presence of both metallurgical grade bauxite and aluminous laterite horizons. SiO_2 content varies from 2.13% to 33.88%, generally increasing downward in the profile. Fe_2O_3 ranges between 4.03% and 49.32%, suggesting progressive ferruginisation towards the basal lateritic zones. TiO_2 values range from 3.51% to

6.70%, while LOI varies from 12.69% to 28.77%, reflecting hydration characteristics of the lateritic material. Trace element concentrations show Sc ranging from 21.78 to 62.90 ppm, V from 456.46 to 1499.93 ppm, and Ga from 46.02 to 74.43 ppm, indicating moderate enrichment of these elements within the bauxitic horizons.

In Borehole MBD-02, Al_2O_3 values vary from 20.23% to 39.04%, representing predominantly aluminous laterite to low-grade bauxite horizons. SiO_2 ranges between 1.62% and 21.78%, while Fe_2O_3 varies from 26.41% to 49.83%, indicating ferruginous enrichment in the lower parts of the profile. TiO_2 content ranges from 2.66% to 6.74%, and LOI values range between 11.49% and 20.67%. Trace elements show Sc ranging from 23.72 to 58.55 ppm, V from 349.60 to 939.56 ppm, and Ga from 39.23 to 69.05 ppm.

Borehole MBD-03 represents relatively higher-grade bauxite horizons in the upper sections, with Al_2O_3 values ranging from 22.27% to 50.91%. SiO_2 varies from 2.66% to 23.09%, whereas Fe_2O_3 ranges between 5.05% and 52.03%, indicating gradational transition into ferruginous laterite. TiO_2 content ranges from 4.59% to 7.45%, and LOI varies from 13.69% to 27.92%. The trace element concentrations indicate Sc values between 12.82 and 59.94 ppm, V between 439.12 and 1373.87 ppm, and Ga between 47.71 and 84.40 ppm, with notable enrichment of vanadium in certain intervals.

Samples from Borehole MBD-04 show Al_2O_3 values ranging from 22.18% to 50.39%, while SiO_2 varies widely between 2.20% and 34.27%. Fe_2O_3 content ranges from 4.70% to 37.43%, and TiO_2 varies from 2.86% to 8.36%, indicating variable titania enrichment within the lateritic profile. LOI ranges from 11.01% to 33.21%. Trace elements show Sc values between 19.48 and 83.15 ppm, V from 581.50 to 2157.27 ppm, and Ga between 42.76 and 78.36 ppm, with locally high vanadium values suggesting secondary enrichment within ferruginous horizons.

Borehole MBD-05 exhibits comparatively higher Al_2O_3 values ranging from 23.58% to 57.03%, indicating the presence of high-grade bauxite horizons in the upper part of the lateritic profile. SiO_2 values range between 3.10% and 33.30%, while Fe_2O_3 varies from 2.42% to 20.72%, suggesting relatively lower ferruginisation in the upper sections. TiO_2 content ranges from 4.05% to 5.08%, and LOI varies between 15.25% and 30.83%. Trace element concentrations show Sc values ranging from

13.33 to 44.66 ppm, V from 264.31 to 632.98 ppm, and Ga from 41.33 to 52.35 ppm.

Overall, the geochemical data indicate a typical lateritic bauxite profile characterized by higher Al_2O_3 and lower Fe_2O_3 in the upper horizons and progressively increasing iron content downward towards the ferruginous laterite zone. Trace elements such as Sc, V and Ga show moderate enrichment within the lateritic profile, reflecting their association with alumina and iron-bearing phases. Graphic lithologs of the drilled boreholes presented in Plate-V.

10.3.5 The lateritic bauxite horizon was observed in four bands in the mapped area. For the ease of having a comparative understanding of behaviour of the various elements in block, the results are discussed in this section.

10.3.6 General weathering trends for the major and minor elements during laterite formation show strong depletion of alkalis, alkaline earths and silica and accumulation of iron, titanium and aluminium. The most strongly depleted elements were calcium, sodium and potassium, which were probably released into solution during the breakdown of plagioclase feldspar. Also strongly depleted were magnesium and manganese, which were most likely released from the initial breakdown of the ferromagnesian minerals specially the pyroxenes. The analytical results obtained from the core samples of different boreholes indicate a typical lateritic geochemical profile characterized by significant variation in alumina, silica, iron and associated trace elements. The variations reflect the vertical evolution of the laterite profile from high-grade bauxite in the upper horizons to aluminous and ferruginous laterite towards the basal part. The Al_2O_3 content in the analysed samples ranges from about 20.23% to 57.03%, indicating the presence of metallurgical grade-II bauxite, low-grade bauxite and aluminous laterite horizons within the profile. The higher alumina values (>45%) are generally observed in the upper portions of the lateritic profile, representing relatively pure bauxitic zones developed due to intense lateritization and leaching of silica and iron. The SiO_2 content varies widely from about 1.62% to 34.27%, reflecting the degree of silica removal during lateritization. Low silica values (<5%) are typically associated with higher grade bauxite zones, whereas higher silica values occur in transitional horizons and lower parts of the lateritic profile, indicating the presence of clay minerals and relict parent rock components. The Fe_2O_3 content ranges from about

2.42% to 52.03%, showing a progressive increase towards the lower part of the lateritic profile. This enrichment of iron is characteristic of ferruginous laterite zones developed due to residual accumulation of iron oxides during intense weathering of the parent basaltic rocks. TiO_2 values range from approximately 2.66% to 8.36%, which is consistent with the presence of titanium-bearing minerals such as anatase and ilmenite commonly associated with lateritic profiles developed over basaltic parent rocks. The Loss on Ignition (LOI) values range between about 11.01% and 33.21%, reflecting the combined water content associated with hydroxyl-bearing minerals such as gibbsite, goethite and other hydrated iron oxides present within the lateritic profile.

10.3.7 The analytical results of the core samples indicate a well-developed lateritic weathering profile developed over the basaltic parent rock (Deccan Volcanics) in the study area. The lateritic profile exhibits distinct vertical geochemical zonation, which is reflected in the systematic variation of Al_2O_3, SiO_2, Fe_2O_3 and associated trace elements from top to bottom of the profile.

The upper part of the lateritic profile is generally characterized by high Al_2O_3 content and comparatively low Fe_2O_3 and SiO_2 values, representing the bauxite horizon formed due to intense lateritization and leaching of silica and iron during prolonged subaerial weathering. The enrichment of alumina in this zone is mainly attributed to the accumulation of aluminium hydroxide minerals such as gibbsite and boehmite, which form as residual products during the chemical weathering of the parent basaltic rocks.

Below the bauxite horizon, the profile gradually grades into aluminous laterite, where Al_2O_3 values decrease while Fe_2O_3 and SiO_2 contents increase. This transitional zone represents a partially altered lateritic horizon where iron oxides and clay minerals begin to dominate over alumina-bearing minerals.

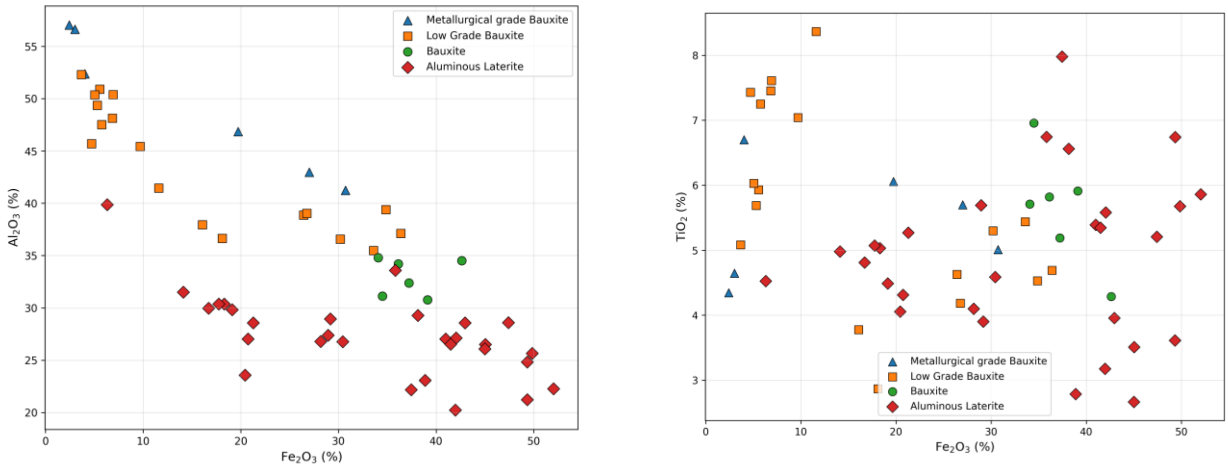
The lower part of the profile is dominated by ferruginous laterite, characterized by higher Fe_2O_3 content and comparatively lower Al_2O_3 values. This zone represents the residual accumulation of iron oxides such as hematite and goethite, which remain after progressive leaching of silica and aluminium during lateritization. In several boreholes, the increase in Fe_2O_3 towards the basal portion of the profile clearly reflects this ferruginous enrichment. The SiO_2 content shows an irregular but generally increasing trend downward, which may be attributed to the presence of relict silicate minerals, clay minerals and partial preservation of the parent rock texture within the lower lateritic zones. In some intervals, localized higher silica values may also indicate siliceous contamination or transitional horizons between bauxite and underlying weathered basalt.

Overall, the observed geochemical pattern clearly indicates that the lateritic bauxite deposits of the study area have evolved through intense lateritic weathering of basaltic parent rocks, resulting in the development of distinct bauxite, aluminous laterite and ferruginous laterite zones. The vertical geochemical zonation observed in the boreholes is consistent with typical tropical lateritic weathering profiles developed over basaltic terrains.

10.3.8 The Al_2O_3 vs Fe_2O_3 plot shows a clear inverse trend, with metallurgical and low-grade bauxite plotting in the high alumina–low iron field, whereas aluminous laterite shifts toward lower alumina and higher iron values. This pattern reflects the progressive transition from bauxitic to ferruginous lateritic horizons within the weathering profile.

The TiO_2 vs Fe_2O_3 plot indicates that TiO_2 remains moderate to high across the profile, with several aluminous laterite samples showing relatively elevated Fe_2O_3. This suggests that titanium is retained during lateritization and is commonly associated with iron-rich lateritic horizons derived from the basaltic parent rock.

The Al_2O_3 vs SiO_2 binary diagram (Text Figure- 10) shows a clear negative relationship between alumina and silica contents. Samples classified as Metallurgical Grade Bauxite plot in the high Al_2O_3–low SiO_2 field, reflecting intense lateritization and effective leaching of silica during bauxite formation. Low Grade Bauxite and Bauxite samples occupy the intermediate field, indicating transitional zones within the lateritic profile where silica removal is incomplete. In contrast, Aluminous Laterite samples plot toward higher SiO_2 and lower Al_2O_3 values, suggesting increased clay and silicate mineral content within the lower lateritic horizons. The overall distribution pattern reflects the progressive vertical geochemical evolution from bauxite to aluminous laterite within the lateritic weathering profile developed over basaltic parent rocks.



Text Figure No. 11: Binary diagrams showing the relationship between Al_2O_3 vs Fe_2O_3 and TiO_2 vs Fe_2O_3 for samples from the Dhrang Block. The diagrams illustrate the geochemical transition from high-grade bauxite to aluminous laterite within the lateritic profile

10.3.9 The Al_2O_3 vs SiO_2 binary plot of the analyzed samples clearly shows geochemical differentiation between metallurgical grade bauxite, low-grade bauxite, bauxite, and aluminous laterite.

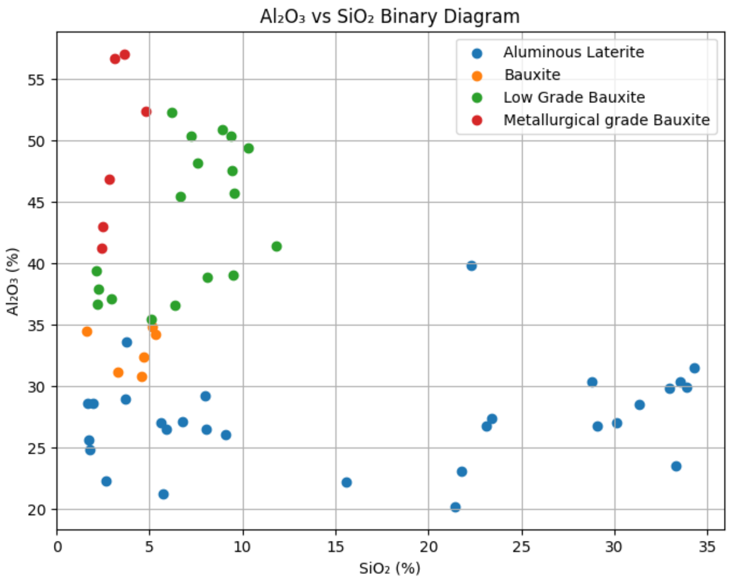
The metallurgical grade bauxite samples plot in the high Al_2O_3 and low SiO_2 field, typically characterized by Al_2O_3 > 45–55% and SiO_2 < 5%. This indicates strong desilication and enrichment of alumina, which is a key requirement for metallurgical-grade bauxite suitable for alumina extraction.

The low-grade bauxite samples occupy an intermediate position with moderately high Al_2O_3 (≈36–50%) and slightly higher SiO_2 (≈6–12%). The increased silica suggests partial lateritization and incomplete removal of silica during weathering, reducing metallurgical quality.

The bauxite samples generally fall in the moderate Al_2O_3 (≈30–36%) and low to moderate SiO_2 range, representing transitional compositions between high-grade bauxite and aluminous laterite.

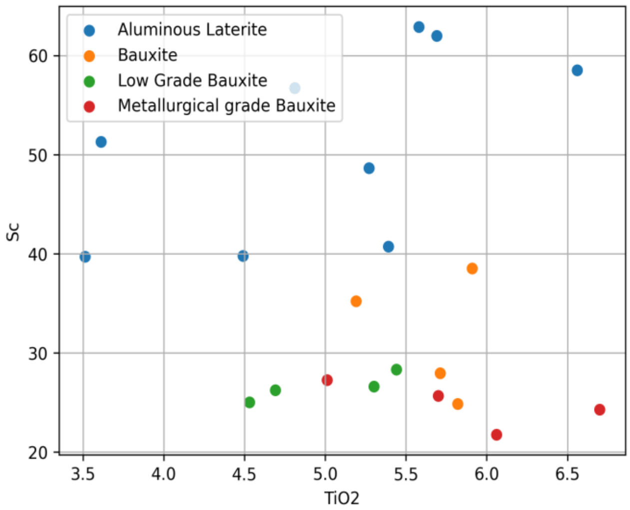
The aluminous laterite samples plot in the low Al_2O_3 and high SiO_2 domain, with Al_2O_3 mostly 20–30% and SiO_2 reaching up to ~30–35%. These compositions reflect advanced lateritic weathering with silica enrichment and relatively lower alumina concentration, indicating that they represent the weathered upper lateritic zone rather than economic bauxite horizons.

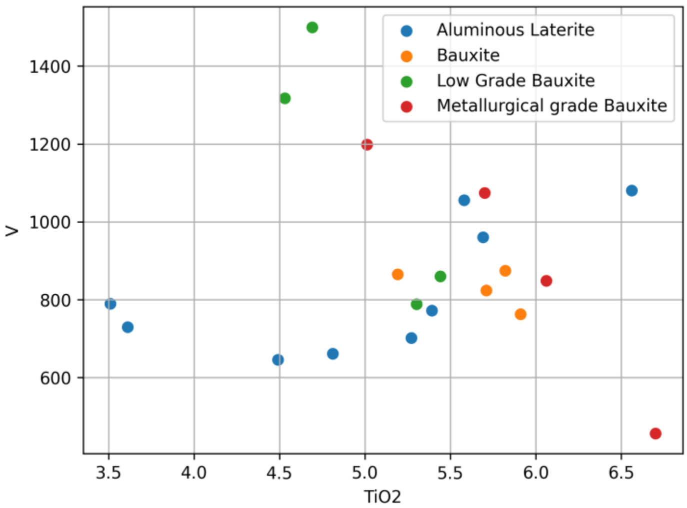
Overall, the binary diagram demonstrates a clear geochemical trend from aluminous laterite → bauxite → metallurgical grade bauxite, reflecting progressive silica removal and alumina enrichment during lateritization of the parent rock (Text Figure- 11) . This trend is consistent with typical lateritic bauxite profiles developed over basaltic or aluminous parent rocks, where economic bauxite forms in zones of maximum desilication and alumina concentration.

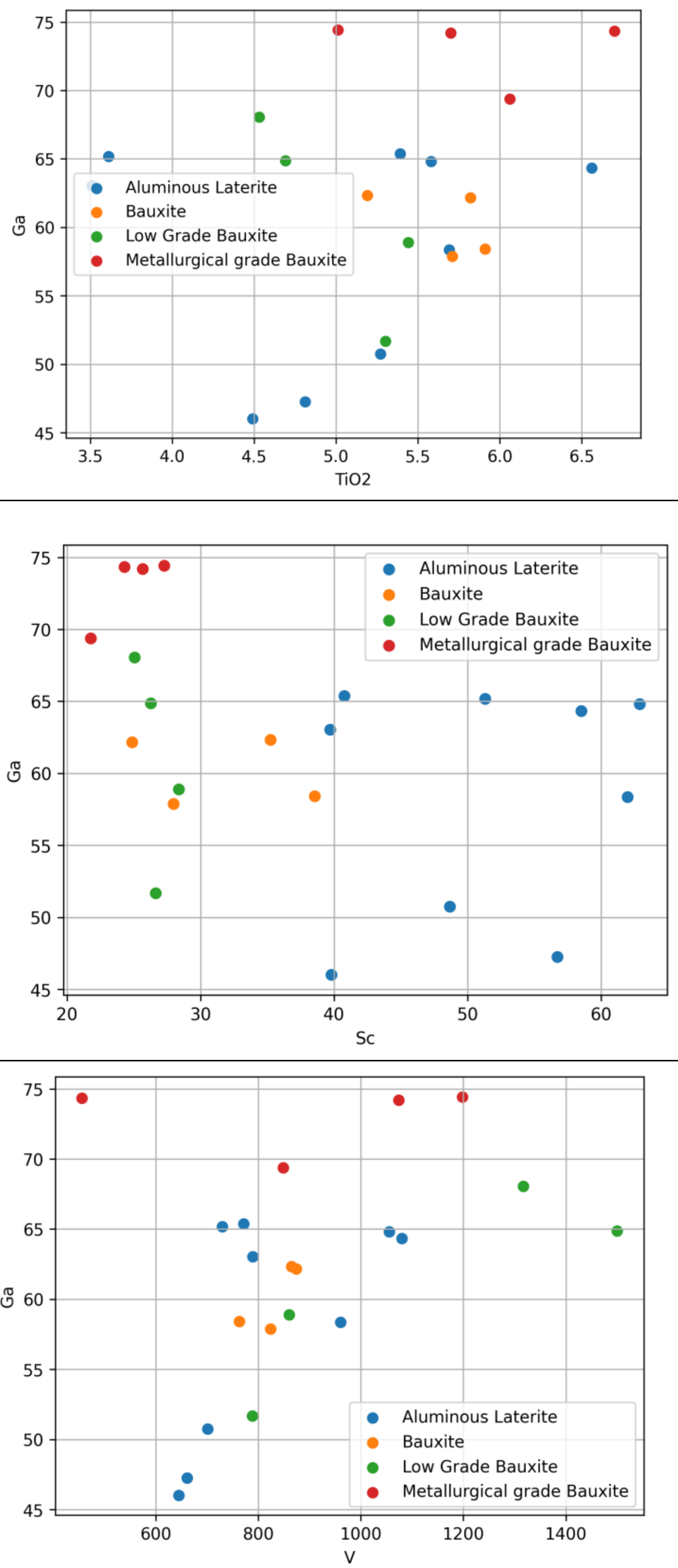


Text Figure No. 12: Binary diagrams showing the relationship between Al_2O_3 vs SiO_2 for samples from the Dhrang Block. The diagrams illustrate the geochemical transition from high-grade bauxite to aluminous laterite within the lateritic profile

10.3.10 The binary plots indicate that Sc and Ga show a tendency of relative enrichment in the aluminous laterite portion of the profile, reflecting their affinity with alumina-bearing phases during lateritization (Text Figure- 12). TiO_2 does not exhibit a strong systematic correlation with V or Ga, suggesting that these elements are not primarily controlled by Ti-bearing minerals and may be associated with other mineral phases such as Fe-oxides or clay components. Vanadium displays comparatively wide dispersion across the plots, indicating variable geochemical behaviour within the profile. Overall, the distribution pattern suggests that trace element concentration is largely influenced by lateritic weathering processes and mineralogical controls rather than a simple dependence on TiO_2 content within the studied bauxite–laterite sequence.







Text Figure No. 13: Binary diagrams showing the relationships between **TiO_2 (%) and Sc, V and Ga (ppm)**, as well as **Sc–Ga and V–Ga**, for analysed samples from the studied bauxite–laterite profile. The plots illustrate the distribution of trace elements across metallurgical grade bauxite, low grade bauxite, bauxite and aluminous laterite.

10.4.0 DATA SPACING FOR REPORTING OF EXPLORATION RESULTS

10.4.1 Out of 05 BH's 03 boreholes are drilled on 400 m spacing in NW part and remaining 2 were in spacing of 800m to identify the vertical depth and quality of the bauxite within limited exposure of bauxitic laterite. Owing to plateau conditions borehole spacing varies at places. However, all the boreholes were drilled at 400m interval.

10.4.2 Extract of MEMC Part III is as below

Exploration Norms for different types of deposits for **I. Bedded Stratiform and tabular deposits of regular and irregular habit:**

For limestone, bauxite, potash and salt beds the grid spacing of bore holes may be 800m or closer for deposits of regular habit and 400m or closer for irregular habit; for others the spacing may be 400m or closer for regular and 200m or closer for irregular habit.

Or

Provided that for deposits specified in Schedule II, 3 bore holes drilled so as to form a polygon in blocks of less than 100 hectares and 5 bore holes in blocks of more than 100 hectares may be sufficient. The lateral influence beyond the bore hole spacing may be limited to a maximum of 50 per cent. of the spacing depending on the results of surface geological mapping.

10.4.2 The mineral resources within the block have been estimated using the polygon method. For the purpose of resource estimation, an influence zone of 200 m radius around each borehole has been considered. The resources falling within this zone of influence have been classified under the Inferred Mineral Resource (333) category in accordance with the UNFC guidelines. The areas lying beyond the borehole influence zones, where geological continuity is inferred primarily from surface indications and limited exploration data of pits and bed rock samples, have been considered under the Reconnaissance Mineral Resource (334) category as per the UNFC classification system.

CHAPTER-11

LOCATION OF DATA POINTS

11.1.0 ACCURACY AND QUALITY OF SURVEY USED TO LOCATE DRILL HOLES

11.1.1 The surveyed block area is located near Mata na Madh village, lies in the Kachchh District. Dhrang block covers an area of 4.86 sq.km, and falls in part of Survey of India Toposheet No. 41 A/14. Survey site is located 8km west from Mata no Madh village and approximately 105 km from Bhuj, District headquarters, Gujarat.

Table no 11.1

Block Boundary coordinates of corner points for Dhrang block, District - Kachchh, Gujarat as per DGPS Survey

BOUNDARY POINTS	UTM (WGS84) - ZONE 42 N		D M S		REDUCED LEVEL (M)
	EASTING (m)	NORTHING (m)	LATITUDE (N)	LONGITUDE (E)	
A	489889.693	2600733.131	23° 31' 00.42775" N	68° 54' 03.47071" E	75.998
B	489432.97	2603248.049	23° 32' 22.19781" N	68° 53' 47.30088" E	114.334
C	491823.51	2603456.821	23° 32' 29.03644" N	68° 55' 11.61104" E	107.294
D	491561.615	2601242.28	23° 31' 17.01879" N	68° 55' 02.41888" E	78.951

11.1.2 All the Borehole Drilled in Dhrang block were surveyed in respect of their location with the help of DGPS Instrument for surveying.

11.1.2.1 TECHNICAL SPECIFICATION OF DGPS

MAKE	**Trimble GNSS**
MODEL	**DA-2 Catalyst**
YEAR OF PURCHASE	**2025**

11.1.2.2 **MEASUREMENT ACCURACY**:

- Static Mode

  Horizontal: 10 mm + 0.1 ppm or better

  Vertical: 20 mm + 0.4 ppm or better

- RTX Mode

Horizontal: 20 mm + 0.1 ppm or better

Vertical: 30 mm + 0.4 ppm or better

11.1.3 A detailed contour survey of the Dhrang Block was carried out to generate an accurate topographic base for geological mapping, borehole location fixing and resource estimation. The survey was conducted using a Differential Global Positioning System (DGPS), specifically the Trimble GNSS System (DA-2 Catalyst) operating in RTX correction mode, which enables high positional accuracy through satellite-based real-time correction services. In this mode, the receiver obtains correction data from the Trimble RTX global reference station network, which is supported by a network of continuously operating reference stations (CORS), including those maintained by the Survey of India, and other international reference stations. These base stations continuously track GNSS satellites and transmit correction data to the RTX system, which is then relayed via satellite to the field receiver, thereby enabling precise positioning without the requirement of establishing a local base station within the survey area.

During the survey, the GNSS receiver was connected to a field data collection device and positioned at predetermined locations across the block. At each survey point, the instrument recorded latitude, longitude and elevation data after achieving stable satellite lock and receiving RTX correction signals. The points were systematically collected to represent the terrain configuration of the block. The acquired DGPS data were subsequently processed using GIS and survey software to generate contour maps and digital elevation models (DEM) of the area. The resultant contour map served as the topographic framework for detailed geological mapping, and borehole location fixing, and integration of exploration data within the Dhrang Block. Particulars of DGPS data are given as Annexure- IB.

11.1.4 During the survey, surface features i.e., roads, Mining area, etc. have been picked up and the same have been depicted on topographical map of the block given as **Plate-III**. Topographical survey with 4m Contouring interval was carried out on 1:4000 scale in the block.

11.1.5 Total 05 boreholes were drilled by MECL i.e. MBD-01 to MBD-05 and all the boreholes were fixed by DGPS survey instrument. Borehole location co-ordinates & Reduced level (RL) of the borehole along with boundary pillar in Dhrang block area were surveyed by DGPS survey instrument. The borehole location and block boundary corner points are given in **Table no 11.1 and as Plate-III.**

11.2.0 QUALITY AND ADEQUACY OF TOPOGRAPHIC CONTROL

11.2.1 The topographic control for the Dhrang Block was established using a Trimble GNSS System (DA-2 Catalyst) operating in RTX correction mode, ensuring high positional accuracy suitable for geological mapping and exploration activities at the G-3 stage of investigation. The system receives real-time satellite correction signals from the Trimble RTX global reference station network, supported by continuously operating reference stations including those maintained by the Survey of India, thereby providing reliable differential corrections without the requirement of a local base station. The survey points were recorded after achieving stable satellite lock and RTX convergence, ensuring accurate horizontal and vertical positioning. The generated coordinate data were used to prepare contour maps and digital elevation models, which served as the topographic base for geological mapping, borehole fixing and resource estimation. The accuracy and spatial distribution of the collected data are considered adequate and reliable for the scale of investigation (1:4000) at G-3 level.

CHAPTER-12

SAMPLING TECHNIQUE

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

12.1.1 The sampling and analysis were carried out for entire laterite/Bauxite zones intersected in the boreholes drilled. Borehole cuttings, the material which was obtained by dry drilling, was dried in sun and sampled for a uniform length of 1.00 m to 50cm keeping in view irregular and discontinuous nature of the deposit, the sampling was carried out according to lithological changes. Each sample thus obtained, was crushed to (-) 200 mesh size and its quantity further reduced to 500 grams by progressive coning and quartering. The material was further crushed to (-) 200 mesh size. Two representative samples weighing about 100 grams each was taken from this, one of which was sent for primary analysis for five oxides Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI, Elements Vanadium (V), Scandiium (Sc) and Gallium (Ga) at Chemical Laboratory of MECL, Nagpur. The remaining 300 gms sample was used for preparation of composite samples for analysis of XRD, and reactive silica etc. for future reference. The details are attached as Annexure-VI & X respectively.

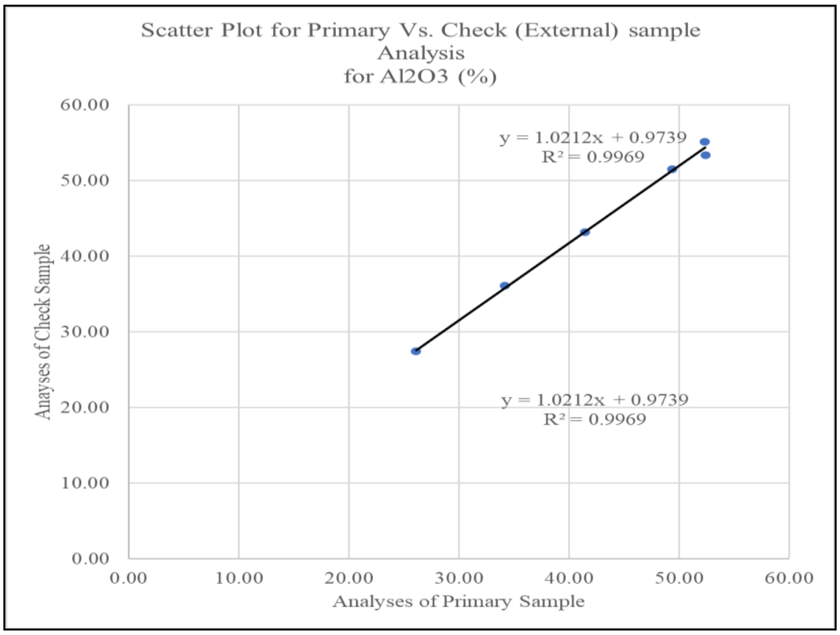
12.1.2 During the present exploration, a total of 54 nos. of primary core samples were been generated and analysed for Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI, Elements Vanadium (V), Scandium (Sc) and Gallium (Ga). In addition to this, total 15 nos. of primary core samples collected from Saprolite/lithomarge were analyzed for TREE by ICP-MS method. The details of analysis of primary core samples for Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI and TREE, Elements Vanadium (V), Scandium (Sc) and Gallium (Ga) are given in Annexure III-C.

12.1.3 In order to check analytical bias if any, external (10%) check analysis have been carried out at external NABL accredited laboratories. Total 16 nos. of external check samples analyzed for Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI. Out of 16 samples six core samples are analysed. The details of External check analysis are submitted as Annexure-IV**.** Scatter plots of Al2O3, TiO2, Sc, V and Ga pertaining to core samples given below:

12.1.4 Scatter plot of primary vs external check analysis for core samples for Al_2O_3% is provided in the Text figure-13. The comparison between Primary and Check analyses of Total Al_2O_3 for six paired samples shows very strong agreement and consistency. The arithmetic means are 42.63% (Primary) and 44.51% (Check) with almost identical standard deviations (~9.69) and variances, indicating similar data dispersion in both datasets.

The very high correlation coefficient (0.998) demonstrates an excellent linear relationship between the two analyses (Text Figure- 13). The mean absolute error (0.035) and very small deviation indicate minimal analytical difference between the paired results.

The F-test value (1.004) suggests no significant difference in variances, confirming comparable precision. Although the paired t-value (-17.275) indicates a statistical difference between means, the overall extremely high correlation and negligible error show that the primary and check analyses are highly consistent and reliable for Al_2O_3 determination.



Text Figure 14: Scatter Plot of Primary vs Check (External) sample analysis of Trench samples for Al_2O_3

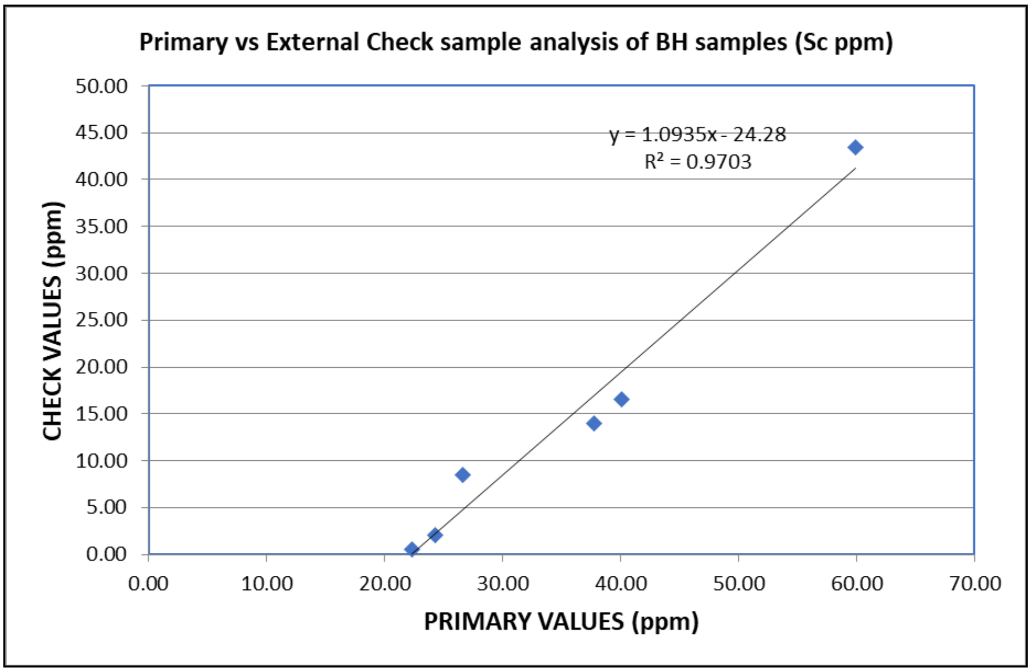
Table-12.1
Statistical comparison of Primary and External Check sample analysis for Al_2O_3%
(Core samples)

Comparison Index	Total Al_2O_3%	
	Primary	Check
No. of sample pairs	6	
Arithmetic mean	42.629	44.508
Standard Deviation	9.669	9.690
Standard error of mean	3.947	3.956
Variance	93.489	93.893
Mean of deviation	-0.035	
Standard Deviation (Error)	0.267	
Correlation Co-efficient	0.998	
Mean absolute error	0.035	
Paired T-value	-17.275	
F- test value	1.004	

12.1.5 The comparison of Primary and Check analyses for Total Fixed Sc based on six paired samples shows a strong positive correlation (r = 0.985), indicating that both datasets follow a very similar trend (Text Figure- 14). However, the arithmetic mean of Primary samples (35.16 ppm) is considerably higher than that of the Check samples (14.17 ppm), suggesting a systematic difference between the two analyses.

The standard deviations (12.67 and 14.20) and F-test value (1.257) indicate comparable variability and precision between the datasets. The mean absolute error (0.390) and small deviation suggest generally consistent analytical behaviour, although the paired t-value (17.985) indicates a statistically significant difference in the mean values.

Overall, while the high correlation confirms good analytical consistency in trend, the difference in mean values suggests possible analytical bias or methodological variation between Primary and Check determinations of Sc.



Text Figure 15: Scatter Plot of Primary vs Check (External) sample analysis of Trench samples for Scandium

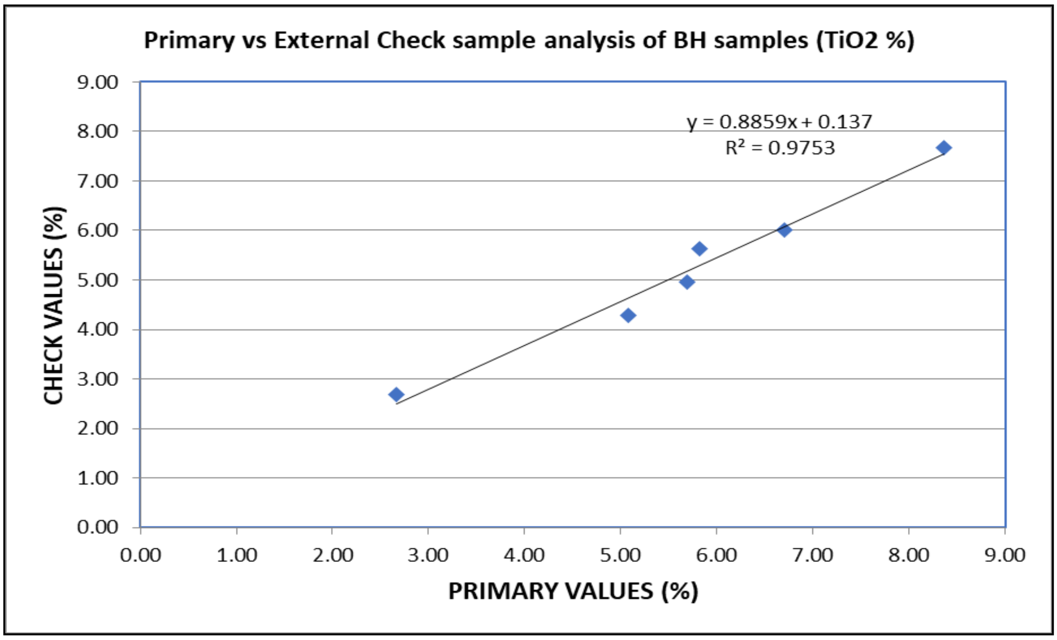
Table-12.2
Statistical comparison of Primary and External Check sample analysis for Sc ppm (Core samples)

Comparison Index	Sc (ppm)	
	Primary	Check
No. of sample pairs	6	
Arithmetic mean	35.161	14.167
Standard Deviation	12.668	14.204
Standard error of mean	5.172	5.799
Variance	160.469	201.740
Mean of deviation	0.390	
Standard Deviation (Error)	2.859	
Correlation Co-efficient	0.985	
Mean absolute error	0.390	
Paired T-value	17.985	
F- test value	1.257	

12.1.6 The comparison of Primary and Check analyses for Total TiO_2 based on six paired samples indicates very strong agreement and consistency between the two datasets. The arithmetic means (5.72% for Primary and 5.21% for Check) are closely comparable, and the standard deviations (1.86 and 1.63) indicate similar variability in both analyses.

The very high correlation coefficient (0.988) demonstrates a strong linear relationship between Primary and Check values (Text Figure- 15). The mean deviation and mean absolute error (0.010) along with the very small standard deviation of error (0.082) indicate minimal analytical difference between the paired results.

The F-test value (1.302) suggests no significant difference in variances, confirming comparable precision of the analyses. Although the paired t-value (15.489) indicates a statistical difference in means, the overall high correlation and very small analytical error confirm that the Primary and Check analyses show good reliability and consistency for TiO_2 determination.



Text Figure 16: Scatter Plot of Primary vs Check (External) sample analysis of Trench samples for TiO_2

Table-12.3
Statistical comparison of Primary and External Check sample analysis for TiO_2%
(Core samples)

Comparison Index	TiO2 (%)	
	Primary	Check
No. of sample pairs	6	
Arithmetic mean	5.721	5.205
Standard Deviation	1.856	1.626
Standard error of mean	0.758	0.664
Variance	3.445	2.645
Mean of deviation	0.010	
Standard Deviation (Error)	0.082	
Correlation Co-efficient	0.988	
Mean absolute error	0.010	
Paired T-value	15.489	
F- test value	1.302	

CHAPTER-13

DRILLING TECHNIQUES AND DRILL SAMPLING EMPLOYED

13.1.0 DRILLING TYPES AND DETAILS

13.1.1 During the present investigation, MECL drilled total 05 no of boreholes with 77.0 m and the details of boreholes drilled by MECL are given in Annexure-IB and summary of borehole is given in **Table-10.2**.

13.1.2 All boreholes were laid on 200m spacing as given in para no 10.4.1 and all boreholes are vertically drilled. Drilling operations were carried out by conventional wireline drill rig RD-60. Drilling in NQ size by dry coring method was the main tool for sub surface exploration. The length of individual run was generally kept as short as 50cm and sometimes till one meter depending on lithological variations and avoid contamination of different lithological units.

13.1.3 Drilling was carried out by dry coring method using RD-60 drill (Photograph – 13.1) with NX and BX size of TC casing and TC shoe bit. The length of individual run was generally less than one meter and was essentially 20 to 50cm, depending on lithological variations. The core recovery was around 98 to 100%.

13.1.4 The core recovery in the mineralized zones is about 98-99% which is satisfactory. After closure, all the boreholes were properly plugged and sealed with cement pillars and its DGPS survey has been completed (Photograph- 13.2).

Photograph No.13.1: RD60 drill Rig used for drilling operations

Photograph No.13.2: Pillars constructed on boreholes drilled in Dhrang block by MECL.

13.1.5 The borehole cores were geologically logged recording textural, lithological, mineralogical and structural details. Each lithology was identified based on accepted nomenclature. Their colour, grain size, mineral variations and lithological changes etc meticulously recorded. Depth parameters of zones of weathering, oxidation and fracturing etc are recorded. Similarly, mineralisation zones, various physically identifiable ore minerals and their megascopic characteristics are identified. The core recovery figures, changes in recovery percentage with changes in lithology, weathering characteristics of respective rocks etc are also noted. Core samples have been logged, the mineralisation zones relogged after splitting of the core for additional information, that can support resource estimation.

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

13.2.1 The material obtained by way of dry drilling was stored in polythene bags (Photograph No. 13.3 and 13.4). The admixture of cuttings and powder was carefully examined and the details like colour, physical nature, and mineral constituents were recorded. The details of run wise log thus generated were consolidated and are presented in Annexure- II A.

Photograph No.13.3: Drilled core by dry drilling

Photograph No.13.4: Drilled core by dry drilling

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

13.3.1 The short runs were made during drilling for optimum core recovery.

13.4.0 WHETHER THE RELATIONSHIP EXISTS BETWEEN SAMPLE RECOVERY AND GRADE

13.4.1 The core recovery is about 98-99% approximately. The entire bauxite/laterite mineralized zones / length were recorded during the geological logging on visual basis. Since, the recovery percentage in the mineralized zones is high there is no any negative effect from the core recovery.

13.5.0 CORE LOGGING

13.5.1 Sub surface drilling reveals presence of lateritic soil, laterite, bauxite, red clay, variegated clay and Basalt in the order of stratigraphic sequence**.**

13.5.2 The logging was carried out run-wise for boreholes and the variation of lithounits i.e., Laterite, Bauxite and Saprolite/lithomarge were marked meticulously and detailed litholog is submitted as annexure IIA

CHAPTER-14

SUB SAMPLING TECHNIQUES AND SAMPLE PREPARATION

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

14.1.1 The details of sampling procedure are described in Para 12.1.0. Borehole cuttings, the material which was obtained by dry drilling, was dried in sun and sampled for a uniform length of 1.00 m to 50cm keeping in view irregular and discontinuous nature of the deposit, the sampling was carried out according to lithological changes. Each sample thus obtained, was crushed to (-) 200 mesh size and its quantity further reduced to 500 grams by progressive coning and quartering. The material was further crushed to (-) 200 mesh size. Two representative samples weighing about 100 grams each was taken from this, one of which was sent for primary analysis for five oxides Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI, Elements Scandium (Sc) Vanadium (V) and Gallium (Ga) at Chemical Laboratory of MECL, Nagpur.

14.2.0 NATURE, QUALITY AND APPROPRIATENESS OF THE SAMPLE PREPARATION TECHNIQUE

14.2.1 The sampling and analysis have been carried out for entire laterite/Bauxite zones intersected in the boreholes drilled on visual basis. The primary samples have been marked in the mineralized zones intersected in the borehole based on type and concentration of bauxite zone and in general the sample length has been kept as 1.0 m which varied in some instances because of variation in lithology and type and concentration of mineralisation.

14.3.0 QUALITY CONTROL PROCEDURES ADOPTED

14.3.1 Standard sampling procedure in supervision of qualified sampling technician has been adopted and the samples have been prepared at project sampling unit. Total 94 nos. of primary samples including bedrock, pits and core samples have been prepared and analysed for Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI at Chemical Laboratory of MECL, Nagpur. In order to check the sampling and analytical bias if any, a total of 16 numbers of external checks submitted to NABL accredited lab i.e., JNARDDC in Nagpur.

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

14.4.1 All the primary samples have been marked and prepared from Bauxite/laterite mineralised cores. During the preparation of primary samples, the mineralised cores have been studied meticulously and samples have been marked properly. The proper marking of primary samples from drilled cores and following standard procedure for primary and composite 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

14.5.1 The primary samples have been prepared in (–) 200 mesh size. As per the present practice for bauxite exploration, the (–) 200 mesh size is fitting for the liberation of mineral grains and analysis for Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI and associated elements in the block area.

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 chemical analysis of primary samples for bauxite was carried out under WD-XRF method with Primus-IV model machine and details are given below.

Make: Rigaku

Model: Primus-IV (WD-XRF)

Analytical range: Wavelength Dispersive X-ray Fluorescence spectrometer (WD-XRF) is capable of analyzing major, minor and trace elements in rocks/ores/minerals and geological materials as solid samples (pressed pallets and fusion beads) in % to ppm range

Accuracy and precision (standard deviation) for major oxides is excellent (<1%). For testing of the samples, pressed pallets of the powdered samples were made using hydraulic press. The XRF instrument was calibrated using suitable matrix matching CRMs. After calibration of the instrument the samples were analyzed and the values of the SiO_2, Al_2O_3, Fe_2O_3, TiO_2 were obtained. The Loss on Ignition was determined by calculating the loss in weight of the sample after igniting the sample taken in a Pt crucible at 1000°C in a muffle furnace.

The following **Precautions** were followed in the laboratory while doing chemical analysis.

(a) PPEs were used to avoid any contamination to the samples.

(b) Label all containers to identify their contents.

(c) Avoid touching hot objects. Be careful when using hot objects. Use suitable tongs to remove hot containers from the furnace.

(d) Properly dispose of waste chemicals.

15.2.0 NATURE OF QUALITY CONTROL PROCEDURES ADOPTED

15.2.1 The standard procedure for chemical analysis as per provision made in the proposal for QA/QC has been followed. All the primary samples have been analyzed in the Chemical Laboratory of MECL, Nagpur. In order to assess the bias and inaccuracies in analytical determination,

(i) Analysis of Certified reference materials/measurement standards (BCS CRM-395, GBAP-14, GBAP-16, NCSHC-28811)

(ii) Analysis of blind samples

(iii) Use of QC samples and control charts

(iv) Analysis in duplicates & Internal Check standards.

15.3.0 CHECK ANALYSIS FROM THIRD PARTY NABL ACCREDITED LABORATORY

15.3.1 The third-party external check samples analyses being carried out at JNARDDC, (NABL Accredited lab) Nagpur. Total of 49 numbers of external check samples for Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI, results are submitted as Annexure-IV. Details of check samples discussed in chapter 12.

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

15.4.1 The samples were prepared at the project sampling unit with proper labelling and tag packed in sealed polythene bags sent to chemical laboratory in supervision of qualified sampling technician. At the sampling unit, standard procedure was followed and all the precautionary measures were taken to avoid the contamination. The sampling unit is a separate unit from the chemical laboratory, so there is no possibility of contamination.

CHAPTER-16

MOISTURE

16.1.0 All the analysis for oxides i.e., Al_2O_3, SiO_2, Fe_2O_3, TiO_2 & LOI were carried out with natural moisture. However, Moisture analysis has not been done at this stage. Hence, no information can be provided.

CHAPTER-17

BULK DENSITY

17.1.0 BULK DENSITY ANALYSIS DETAILS

17.1.1 Bulk density (BD), in conjunction with volume, is a critical parameter for the accurate estimation of mineral resources and reserves. It is governed by both the intrinsic density of the constituent mineral particles and their spatial arrangement within the ore body, including the presence of inter-particulate voids and fractures. Bulk density is defined as the mass of material per unit volume, where the volume encompasses both solid material and associated pore spaces. It is typically expressed in grams per cubic centimeter (g/cm^3) or tones per cubic meter (t/m^3) and is an essential input parameter in tonnage calculations for resource evaluation.

17.2.0 BULK DENSITY DETERMINATION PROCEDURE

17.2.1 A total of two representative core samples was selected for bulk density determination to evaluate the physical characteristics of the Bauxite. The objective of this study was to obtain reliable bulk density values, which constitute a critical input parameter for resource estimation and tonnage calculations. The methodology and procedural steps adopted for bulk density measurement are described below.

17.2.2 **Applicability:** This method shall be applicable in hard litho units, where regular solid cylindrical drill cores are obtained during the course of drilling. The drill core samples to be used for the study should be of NQ or larger diameter.

17.2.3 **Sample Preparation:** Take a full cylindrical drill core sample of minimum ten (10) centimeters - length with both ends trimmed smoothly at right angle to the core axis using a mechanical core cutter to form a regular cylinder.

17.2.4 **Measurement:** Measure the length of the sample, at-least at four locations along its axis by suitably rotating the sample. Measure the diameter of the sample using a caliper scale, at least at four locations, preferably at regular interval. Weigh the air-dried sample in a platform balance.

17.2.5 **Calculation:** Take mean average of all the readings for length and diameter. Divide the average mean value of diameter by two to arrive at the radius of the sample. The volume of a core sample is obtained by using formulae: $V = \pi r^2 h$ (where V = volume, r = radius and h = height or length of the cylindrical core). The bulk density of the sample is determined by using the formula:

$$D = M/V$$

where B. D= bulk density, M= mass (weight) of the sample and V= volume of the sample.

17.2.6 **Number of Samples studied:** A total of two observations is carried out for each sample. The average of these observations results for each sample may be taken as the final bulk density for the purpose of estimation of resources of Bauxite and aluminous laterite. Bulk density determination results are mentioned below:

Sl.No.	Sample No.	Bulk Density (gm/cc)
1	MBD/BD/01	2.13
2	MBD/BD/02	2.50
Average Specific Gravity		**2.32**

17.2.7 Average Bulk density as calculated is 2.32 g/cm^3, which is considered for calculation of ore resources of Bauxite and aluminous laterite.

CHAPTER-18

BENEFICIATION STUDIES

18.1.0 Beneficiation studies were not carried out as there is no scope of work in the present stage exploration stage.

MECL

CHAPTER-19
RESOURCE ESTIMATION TECHNIQUE

19.1.0 DISCUSSION ON DATA DENSITY TO ASSURE CONTINUITY OF MINERALISATION

19.1.1 Kachchh Basin is one of the main topographic units in the area with altitudes rising from 60m to 150 m MSL. On basin region laterite/bauxite is developed over the basaltic rock belonging to Deccan trap rocks.

19.1.2 Dhrang block is over an area of 4.86 sq.km, The Dhrang Block exhibits supergene bauxite mineralization developed over the Deccan Trap basement through prolonged tropical weathering and lateritization. Mineralization occurs as a capping of bauxite-rich laterite characterized by pocket- to boulder-type deposits along the crest of hillocks localized along the north western sector of the Block area.

19.1.2 In accordance with the provisions of the Minerals (Evidence of Mineral Contents) Rules, 2015 (MEMC Rules, 2015) and based on the recommendations of the Technical-cum-Cost Committee (TCC), MECL has carried out exploratory drilling of 05 boreholes with a cumulative meterage of 77 m within the block. The drilling data generated during the present investigation have been utilized for geological interpretation, lithological correlation and resource estimation of bauxite and associated minerals in the area.

For the purpose of resource estimation, the bauxite resources have been classified following the Indian Bureau of Mines (IBM) end-use grade classification, wherein Metallurgical Grade-II Bauxite corresponds to Al_2O_3 > 40% and SiO_2 < 4% (total), Low Grade Bauxite corresponds to Al_2O_3 between 35–40% and SiO_2 < 10%, and Aluminous Laterite corresponds to Al_2O_3 > 20%. The analytical data obtained from drilling and sampling have been interpreted accordingly to delineate the resource categories within the block.

19.2.0 WHETHER PREVIOUS EXPLORATION DATA HAS BEEN USED

19.2.1 There is no previous data available on bauxite mineralization in the Dhrang block. Abandoned adjacent mines were considered for correlation purpose associated minerals.

19.3.0 THE NATURE AND APPROPRIATENESS OF THE ESTIMATION TECHNIQUE(S) APPLIED AND KEY ASSUMPTIONS

19.3.1 All boreholes were drilled as per MEMC rules 2015, amended upto 14th December 2021. Extract of Part III of MEMC rules is given below

Exploration Norms for different types of deposits for **I. Bedded Stratiform and tabular deposits of regular and irregular habit:** For **bauxite, limestone etc.** through **systematic exploratory drilling** at **800 m × 800 m grid spacing for depost of regular habit and** at **400 m × 400 m grid spacing for deposit of irregular habit**.

Provided that for deposits specified in Schedule II, 3 bore holes drilled so as to form a polygon in blocks of less than 100 hectares and 5 bore holes in blocks of more than 100 hectares may be sufficient. The lateral influence beyond the bore hole spacing may be limited to a maximum of 50 per cent. of the spacing depending on the results of surface geological mapping.

19.3.2 Accordingly, Bauxite, Titanium Oxide and other associated mineral resources are estimated by "**Polygon Method**".

19.4.0 THE BASIS FOR CLASSIFICATION OF THE MINERAL RESOURCES

19.4.1 As per MEMC rules 2015, amended upto 14th December 2021. Part III and given in para 19.3.1, the mineral resource in the block area is categorized as inferred Mineral Resource (333) code as per UNFC system.

19.5.0 THE ASSUMPTIONS MADE REGARDING RECOVERY OF BY PRODUCTS

19.5.1 During diagenesis, epigenesis and weathering processes leaching and dislocation of Si and Fe leads to continuous aluminium enrichment in lateritic bauxites and in bauxites formed over parent rock in duricrust and bauxite zones. The trace elements present in parent rock displaced several times during this process. In saprolite zone certain trace elements like Ti, Sc, Ga and V may become enriched to such an extent that they form deposits and are minable as by products. Elements like Cr and Zr become enriched in basal Saprolite horizon due to their association with weathering resistant chromites and zircon of parent rock, while Ni, Co and P concentrate via solution. Ga in particular precipitates in reducing environment and become enriched

19.5.2 Scandium, Vanadium (V) and Gallium (Ga) anomalous zones were demarcated based on >50ppm Sc, >500ppm V and >50ppm Ga, however samples below these anomalous values are also considered where zone is demarcated. Thus, from primary analytical data Scandium (Sc) has thickness ranging between Max 3.70m in BH MBD-01 and Min 1.00 in MBD-02, Vanadium (V) anomalous zones have thickness ranging between Max 3.70m in BH MBD-01 and Min 1.00 in MBD-02 and for Gallium (Ga) anomalous zones has thickness ranging between Max 15.00 m in BH MBD-01 and Min 1.00 in MBD-05.

19.5.3 About 15 nos. of samples from lithomarge have been submitted for analysed for REE elements by ICPMS method, Total REE in these samples range from Min 28.47 and Max 640.14 ppm, out of 15 nos of samples only 2 samples show more than 500ppm. Details are submitted as Annexure -IIID.

19.6.0 DETAILED DESCRIPTION OF THE METHOD USED AND THE ASSUMPTIONS MADE TO ESTIMATE TONNAGE AND GRADES

19.6.1 The Bauxite ore resource and grade have been estimated by "**Polygon Method**", and estimated resources placed under inferred (333) category of UNFC considering the following parameters and assumptions.

1. **Cut-off Grade**: This is the most significant artificial boundary demarcating low grade mineralization and techno economically viable ore that can be exploited at a profit**.** The cut off of bauxite was considered as per IBM End use classification.
2. **By products**: TiO_2, 2% is considered as a byproduct with bauxite/clay. Resource of Sc, Ga, V have been estimated at 50, 50 and 500ppm cut off criteria.
3. **Minimum Stopping Width and Maximum Parting:** For bulk minerals such as bauxite, the minimum stoppable thickness is generally considered to be 2 m. However, in the present study area, the bauxite horizons occur with comparatively lesser thickness and show irregular and discontinuous distribution. In view of these geological characteristics, the minimum stoppable thickness has been considered as 1.5 m for the purpose of resource estimation in the block.
4. **Correlation of ore lodes:** Correlation of ore lodes were done along NS and EW section lines.
5. **Description of lodes:** The mineralised zones occur as i) irregular bedded and ii) boulder type with varying thickness.
6. **Preparation of LV sections:** Not Applicable
7. **Preparation of Level Plan:** Not Applicable
8. **Bulk Density: as given in chapter 17,** Average Bulk density i.e., 2.32 g/cm^3, is considered for calculation of bauxite ore resources
9. An overall deduction factor of 10% has been applied to the total gross tonnage to derive the net in-situ geological resources of the deposit. This deduction accounts

for inherent geological uncertainties and operational limitations associated with the exploration data. The factors considered include variations in core recovery during drilling, irregular and discontinuous nature of the bauxite horizons, and abrupt lateral and vertical changes in the thickness of the mineralized zones. Application of this deduction ensures a conservative and realistic estimation of resources, in accordance with standard geological resource estimation practices and UNFC-based reporting.

10. All boreholes were laid on scattered manner depending on Bedrock and pit samples as given in para no 10.4.1 and all boreholes are vertically drilled. The area of influence is taken as 50% where adjacent boreholes are positive or bauxite occurs as outcrop or nala or cliff sections or local quarry is present. Area of influence is taken as 25% in case of corner bore holes and where adjacent boreholes are negative. So, the influence area for each Boreholoe and sample location is taken as 200 m and 200 m along strike direction and along the direction perpendicular to strike respectively on either side of the location point. Wherever the mineralised zone is not continuing further, the area of influence is considered as the actual distance from the sample location measured. The area of influence is taken as the area of the polygon from which the sample has been collected.

11. Since the aluminous laterite and bauxite band is exposed on the surface with no overburden, the thickness of the bauxite band is measured from the exposed section in some place where only bed rock sample analysis available with no boreholes. Where ever the base of bauxite is not exposed, pits at the base are excavated to know the vertical continuity as well as thickness. The band with thickness less than 1 m thick has been discarded from resource calculation.

12. An intermediate bauxite zone exhibiting slightly higher silica content (>4%) and marginally lower Al_2O_3 values (<40%) has also been considered during resource estimation under the Metallurgical Grade-II bauxite category, wherever the average grade of the cumulative sample intervals within a borehole satisfies the prescribed grade criteria. Such intermediate grade material is considered mineable and can be suitably blended with higher grade bauxite occurring within the block to achieve the desired metallurgical specifications.

13. Similarly, for Low Grade Bauxite, zones exhibiting Al_2O_3 values marginally below 35% and silica slightly exceeding 10% have been included in the resource estimation where the average grade of the cumulative sample intervals conforms broadly to the classification limits. These zones have been considered on the basis

that grade variation within lateritic bauxite deposits is often gradual and selective mining and blending practices can optimize the overall ore quality during beneficiation or utilization.

14. In areas where surface exposures of bauxite or aluminous laterite are present but no boreholes have been drilled, the resources and grade characteristics have been estimated based on data obtained from pits and bedrock/chip samples collected during detailed geological mapping and pitting operations. The thickness of the respective bauxite or aluminous laterite horizon in such areas has been inferred from the nearest boreholes or available geological sections in the adjoining areas. The lithological continuity observed in the field, together with the analytical results of these samples, has been used to reasonably infer the presence, thickness and quality of bauxite/aluminous laterite horizons for the purpose of resource estimation.

19.6.2 **Exploration Data for Resource Estimation:** During the present investigation, Geological Map prepared on 1:4000 scale, a total of 77.0 m drilling in 05 Boreholes was taken into consideration for evaluation of resources in the block.

19.6.3 Analysis of total 54 no of samples indicated that

(a) The average thickness of Metallurgical Grade-II bauxite intersected in the five drilled boreholes is 1.60 m, with a minimum thickness of 1.55 m in borehole MBD-05 and a maximum thickness of 3.00 m in borehole MBD-01. The depth of intersection of the bauxite horizon ranges from surface (0.00 m in MBD-01) to about 1.00 m below ground level (in MBD-05).

(b) In the Metallurgical Grade II bauxite zones demarcated, Al_2O_3 varies from Min 43.71% (MBD-01) and Max 56.89% (MBD-05) and SiO_2 varies from Min 2.81% (MBD-01) and Max 3.45% (MBD-05).

(c) In the Low-Grade bauxite zones demarcated, Al_2O_3 varies from Min 35.62% (MBD-01) and Max 52.30% (MBD-05) and SiO_2 varies from Min 5.55% (MBD-01) and Max 8.84% (MBD-04).

(d) Average thickness of Aluminous Laterite is intercepted in the 05 no boreholes drilled by MECL is 4.20 m, with Min thickness of 2.00m (MBD-03) and maximum 6.00m (MBD-01). Depth of intersection of these zones varies from 0.00m (MBD-02) and max of 3.20m (MBD-04).

(e) In the Aluminous Laterite zones demarcated, Al_2O_3 varies from Min 24.41% (MBD-03) and Max 32.10% (MBD-04) and SiO_2 varies from Min 2.43% (MBD-02) and Max 6.02% (MBD-01)

(f) TiO_2 is present in all the lithologies intercepted, hence 2% cut-off is considered for demarcating the zone.

(g) SC, V, Ga is present in all the lithologies intercepted, hence >50ppm,>50ppm and >500ppm cut-off is considered for demarcating the zone.

(h) Details of Zone are given below.

(i) Table-19.1

(j) Details Of Metallurgical Grade II Bauxite zones from exploratory boreholes drilled by MECL in Dhrang block, district - Kachchh, Gujarat

(k) Zones demarcated based on Al_2O_3>40**%** and SiO_2 ≤04**%**

Borehole	From (m)	To (m)	Thickness (m)	Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	Sc (ppm)	V (ppm)	Ga (ppm)
MBD-01	0.00	5.00	5.00	40.49	3.34	29.62	5.35	19.76	25.14	1095.98	68.25
MBD-05	1.00	2.55	1.55	56.89	3.45	2.64	4.45	30.79	13.98	266.12	43.15
Cumulative			**6.55**	**44.37**	**3.37**	**23.24**	**5.14**	**22.37**	**22.50**	**899.60**	**62.31**

Table-19.2

Details of Low-Grade Bauxite zones from exploratory boreholes drilled by MECL in Dhrang block, district - Kachchh, Gujarat

Zones demarcated based on Al_2O_3 35% to 40% and SiO2≤10%

Borehole	From (m)	To (m)	Thickness (m)	Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	Sc (ppm)	V (ppm)	Ga (ppm)
MBD-01	5.00	8.00	3.00	35.62	5.55	32.6	5.48	18.89	27.66	824.13	56.15
MBD-02	5.50	7.50	2.00	37.59	7.37	28.85	5.05	19.84	43.26	679.97	52.16
MBD-03	0.00	5.00	5.00	44.94	7.41	12.33	6.62	26.00	30.84	675.39	72.79
MBD-04	0.00	3.20	3.20	46.39	8.84	6.67	7.62	26.34	30.86	913.22	67.17
MBD-05	0.00	1.00	1.00	52.30	6.18	3.68	5.08	29.40	22.31	316.95	52.35
Cumulative			**14.20**	**42.78**	**7.25**	**17.06**	**6.28**	**23.95**	**31.32**	**735.81**	**63.66**

Table-19.3

Details of Aluminous Laterite zones from exploratory boreholes drilled by MECL in Dhrang block, district - Kachchh, Gujarat

(Zones demarcated based on Al_2O_3 ≥20%)

Borehole	From (m)	To (m)	Thickness (m)	Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	Sc (ppm)	V (ppm)	Ga (ppm)
MBD-01	8.00	14.00	6.00	27.86	6.02	41.55	5.10	17.57	47	883	63.61
MBD-02	0.00	5.50	5.50	28.22	2.43	46.30	4.95	15.89	36.66	743.65	58.83
MBD-03	5.00	7.00	2.00	24.41	5.35	46.75	5.60	16.29	52	990	64.97
MBD-04	3.20	6.50	3.30	32.10	2.81	26.16	3.39	29.39	72	1252	48.51
Cumulative			**16.80**	**28.40**	**4.14**	**40.70**	**4.78**	**19.19**	**49.12**	**922.57**	**59.24**

Table-19.4
Details of TiO_2 zones from exploratory boreholes drilled by MECL in Dhrang block, district - Kachchh, Gujarat
Zones demarcated based on Zones demarcated based on TiO_2 >2%

Borehole	From (m)	To (m)	Thickness (m)	Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	Sc (ppm)	V (ppm)	Ga (ppm)
MBD-01	0.00	16.00	16.00	33.35	7.86	33.96	5.25	17.94	37.16	928.60	62.23
MBD-02	0.00	9.50	9.50	28.81	7.51	41.39	4.55	15.87	41.36	667.78	53.60
MBD-03	0.00	8.50	8.50	36.00	10.36	23.74	5.83	21.30	38.65	728.40	65.54
MBD-04	0.00	8.50	8.50	35.82	9.41	20.25	5.46	24.56	56.55	1143.43	58.76
MBD-05	0.00	3.15	3.15	52.19	7.90	3.67	4.67	29.15	20.50	324.92	46.00
Cumulative			**45.65**	**34.66**	**8.54**	**28.96**	**5.21**	**20.14**	**40.77**	**835.76**	**59.28**

Table-19.5
Details of Scandium zones from exploratory boreholes drilled by MECL in Dhrang block, district - Kachchh, Gujarat
Zones demarcated based on Zones demarcated based on Sc >50ppm

Borehole	From (m)	To (m)	Thickness (m)	Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	SC (ppm)	V (ppm)	Ga (ppm)
MBD-01	10.30	11.00	0.70	21.22	5.72	49.32	3.61	17.67	51.31	729.56	65.19
MBD-01	12.00	15.00	3.00	27.93	12.70	36.37	5.94	15.65	61.13	1032.01	62.50
MBD-02	7.50	8.50	1.00	9.09	3.88	13.24	11.42	27.01	93.54	1550.98	96.80
MBD-03	4.00	7.00	3.00	26.65	4.67	42.67	6.06	18.06	54.46	1117.73	71.44
MBD 04	0.00	3.15	3.15	29.38	9.61	28.39	4.13	24.01	72.06	1285.64	53.68
Cumulative			**10.85**	**25.83**	**8.32**	**34.50**	**5.80**	**19.92**	**64.81**	**1157.66**	**65.75**

Table-19.6
Details of Vanadium zones from exploratory boreholes drilled by MECL in Dhrang block, district - Kachchh, Gujarat
Zones demarcated based on Zones demarcated based on V >500ppm

Borehole	From (m)	To (m)	Thickness (m)	Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	SC (ppm)	V (ppm)	Ga (ppm)
MBD-01	10.30	11.00	0.70	21.22	5.72	49.32	3.61	17.67	51.31	729.56	65.19
MBD-01	12.00	15.00	3.00	27.93	12.70	36.37	5.94	15.65	61.13	1032.01	62.50
MBD-02	7.50	8.50	1.00	9.09	3.88	13.24	11.42	27.01	93.54	1550.98	96.80
MBD-03	4.00	7.00	3.00	26.65	4.67	42.67	6.06	18.06	54.46	1117.73	71.44
MBD 04	0.00	3.15	3.15	29.38	9.61	28.39	4.13	24.01	72.06	1285.64	53.68
Cumulative			**10.85**	**25.83**	**8.32**	**34.50**	**5.80**	**19.92**	**64.81**	**1157.66**	**65.75**

Table-19.7
Details of Gallium zones from exploratory boreholes drilled by MECL in Dhrang block, district - Kachchh, Gujarat
Zones demarcated based on Zones demarcated based on Ga > 50ppm

Borehole	From (m)	To (m)	Thickness (m)	Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	SC (ppm)	V (ppm)	Ga (ppm)
MBD-01	0.00	15.00	15.00	35.58	8.39	36.22	5.60	19.14	39.64	990.51	66.38
MBD-02	0.00	7.00	7.00	30.13	3.34	42.71	5.03	16.77	38.85	738.11	58.17
MBD-03	0.00	7.50	7.50	38.25	7.91	22.71	6.22	22.59	36.70	758.41	69.03
MBD-04	0.00	3.20	3.20	46.39	8.84	6.67	7.62	26.34	30.86	913.22	67.17
MBD-04	5.00	8.50	3.50	25.34	13.41	34.16	4.57	19.31	71.94	1416.58	58.85
MBD 05	0.00	1.00	1.00	52.30	6.18	3.68	5.08	29.40	22.31	316.95	52.35
Cumulative			**37.20**	**35.51**	**7.79**	**31.11**	**5.68**	**20.30**	**40.72**	**911.55**	**64.35**

19.7.0 METHODOLOGY ADOPTED IN POLYGON METHOD OF RESOURCE ESTIMATION

19.7.1 Following methodology has been adopted while computation of various grades of laterite/bauxite ore zones.

19.7.2 **POLYGON METHOD:**

The polygon method has been adopted for estimation of bauxite and aluminous laterite resources in the block. The principal objective of this method is to delineate the area of influence of each borehole intersecting the aluminous laterite/bauxite horizons and to estimate the corresponding resource within that defined influence zone.

The area of influence around each borehole has been determined by constructing polygons through perpendicular bisectors drawn between adjoining boreholes, thereby forming triangular networks that define the limits of influence for each drilling point. In areas where boreholes were not drilled, the analytical data from bedrock and pit samples collected during detailed mapping and pitting operations have been utilized to infer the presence and grade characteristics of the lateritic bauxite horizons. The areas of influence of individual boreholes and sample points were calculated using AutoCAD software, ensuring accurate determination of polygonal blocks.

Within each polygonal block, the cumulative thickness of the bauxite horizon intercepted in the corresponding borehole has been considered for resource estimation. In zones where borehole control is absent, the thickness of the lateritic bauxite horizon has been inferred from nearby geological sections, pits, or surface exposures. The boundary of each polygonal block has been restricted within the outer limits of the mapped laterite–bauxite bodies, thereby avoiding extrapolation beyond the geological continuity of the deposit.

The grade assigned to each polygon block corresponds to the weighted average grade of the bauxite samples obtained from the respective borehole. In areas where the influence of boreholes is absent, the analytical results of pit and bedrock samples have been considered for assigning grade values. Based on these parameters, the resources of bauxite and aluminous laterite have been estimated using the polygon method, applying the standard formula for resource calculation as given below:

R= P_A X Th X Bulk Density

Where, P_A = Area of Polygon

Th= Thickness of bauxite zone/ Aluminous Laterite

R= Resource/ Tonnage

19.8.0 DESCRIPTION OF THE GEOLOGICAL INTERPRETATION USED TO CONTROL THE RESOURCE ESTIMATES

19.8.1 The resource has been estimated by Polygon method as per MEMC Rules 2015. An overall deduction of 10% is applied to the total gross tonnage to arrive at the geological net in-situ resource of Various Bauxite ores to account for data gaps, irregular nature of deposit and abrupt change in zone thickness etc.

19.8.2 The lateritic bauxite horizon in the study area occurs as surface exposures, generally devoid of significant overburden, except for a thin veneer of ironstone observed locally at a few places. The lateritic bauxite band is manifested as a series of elevated linear ridges within the block. These ridges exhibit variable orientation across different parts of the area, trending NNE–SSW in the north-western and western sectors, E–W in the eastern sector, and nearly N–S in the south-central part of the block.

19.8.3 In the north-western part of the block, the lateritic bauxite band extends for a strike length of approximately 800 m to 1.0 km, with a width ranging between 70 m and 176 m. The thickness of the bauxite horizon varies from about 2.00 m to 7.50 m, locally attaining a maximum thickness of up to 9.50 m in certain section.

19.8.4 In the eastern part of the block, the lateritic bauxite band exhibits a strike length of about 860 m, with the width varying from 63 m to 140 m. The thickness of the bauxite horizon in this sector ranges from 2.00 m to 5.00 m. Overall, the bauxite occurs as a lateritic cap forming low ridge-like geomorphological features, reflecting its resistance to erosion and its development over the underlying lithological units.

CHAPTER-20

REPORTING OF RESOURCES

20.1.0 RESOURCE AND GRADE

20.1.1 Assessment **of Bauxite:** The mineralized zones occur as i) irregular bedded with varying thickness type. Details of mineralized zone thickness are summarized in the table- 19.1 to 19.2. The resource estimated at IBM End use classification grade by Polygon method.

20.1.2 Metallurgical Grade II Bauxite net resources of **0.95 MT is estimated with an average grade of alumina 42.21% and SiO_2 3.35%, Fe_2O_3 26.79% TiO_2 5.26%, Sc 23.96 ppm, V 1008.84** ppm and ***Ga 65.61 ppm*** **(Table 20.1).** The resource estimated at $Al_2O_3 \geq$ 40 % and SiO2$\leq$ 4% cut-off under Inferred Resource (333) category.

20.1.3 Low Grade Bauxite net resources of **1.26 MT is estimated with an average grade of alumina 40.55% and SiO_2 6.89%, Fe_2O_3 21.76% TiO_2 6.05%, Sc 31.27 ppm, V 770.74** ppm and **Ga 60.70 ppm (Table 20.2).** The resource estimated at Al_2O_3 $\geq$35 to 40% and SiO2 to $\leq$ 10% cut-off under Inferred Resource (333) category.

20.1.3 Aluminous Laterite resources of **1.85 MT is estimated with an average grade of alumina 35.53% and SiO_2 9.43%, Fe_2O_3 30.25% TiO_2 4.35%, Sc 47.71 ppm, Ga 73.22** ppm and **V 830.22 ppm (Table 20.3).** The resource estimated at $Al_2O_3 \geq$ 20% cut-off under Inferred Resource (333) category.

20.1.4 Metallurgical Grade II Bauxite net resources of **0.44 MT is estimated with an average grade of alumina 43.24% and SiO_2 3.03%, Fe_2O_3 12.39% TiO_2 5.05%, Sc 5.99 ppm, V 247.79** ppm and ***Ga 16.09*** *ppm* **(Table 20.3).** The resource estimated at $Al_2O_3 \geq$ 40 % and SiO2$\leq$ 4% cut-off under Reconnaissance mineral resource (334) category.

20.1.5 Low Grade Bauxite net resources of **0.69 MT is estimated with an average grade of alumina 44.04% and SiO_2 8.14%, Fe_2O_3 13.09% TiO_2 6.81%, Sc 32.62 ppm, V 830.43** ppm and **Ga 62.55 ppm (Table 20.5).** The resource estimated at Al_2O_3 $\geq$35 to 40% and SiO2 to $\leq$ 10% cut-off under Reconnaissance mineral resource (334) category.

20.1.6 Aluminous Laterite resources of **0.99 MT is estimated with an average grade of alumina 34.68% and SiO_2 10.11%, Fe_2O_3 31.39% TiO_2 4.45%, Sc 54.62 ppm,**

Ga 68.12 ppm and **V 802.45 ppm (Table 20.6).** The resource estimated at $Al_2O_3 \geq$ 20% cut-off under Reconnaissance mineral resource (334) category.

20.1.7 **Assessment of TiO_2:** TiO_2 has been recorded in all lithounits viz. Metallurgical Grade II bauxite, Low Grdae bauxite, aluminous laterite and clay horizons. The average TiO_2% is 5.26 % in Metallurgical grade II bauxite Zone, 6.05% in low grade bauxite zone and 4.35% in Aluminous Laterite zone. A resource of **4.03 MT** has been estimated for TiO_2% cutoff of 2%, with average grade of 5.01% in the Bauxite, Laterite and clay zone which has average alumina 37.74%, SiO_2 7.92% **(Table: 20.7).**

20.1.8 **Gallium (Ga)** resources of **4.21 MT is estimated with an average grade of Ga 64.57 ppm, Vanadium 934.36 ppm, Scandium 40.67 ppm, alumina 35.04% and silica 7.81%,** TiO_2 5.30% **(Table: 20.8).** The resource estimated at Ga≥ 50ppm cutoff.

20.1.9 **Scandium (Sc)** resources of **1.12 MT is estimated with an average grade of Sc 66.79 ppm, alumina 27.27% and silica 10.14%,** TiO_2 5.69% **(Table: 20.9).** The resource estimated at Sc≥ 50ppm cutoff.

20.1.10 **Vanadium (V)** resources of **1.12 MT is estimated with an average grade of V 1129.02 ppm, Ga 66.75 ppm, Sc 66.79 ppm, alumina 27.27% and silica 10.14%,** TiO_2 5.69% **(Table: 20.10).** The resource estimated at V≥ 500 ppm cutoff under Inferred (333) category.

Table No.20.1

SUMMARY OF ESTIMATED POLYGON WISE, BOREHOLE WISE INFERRED CATEGORY OF RESOURCES (333) OF METALLURGICAL GRADE-II BAUXITE (POLYGONAL METHOD) IN DHRANG BLOCK, DISTRICT - KUCHCHH, GUJARAT.

(at IBM cut off for bauxite >40% Al2O3% and ≤4% SiO2%)

							Bulk Density: 2.32							
Sl. No.	BH No.	Polygon Area (m^2)	Thickness (m)	Volume (m^3)	Gross Geological Resources (tonnes)	Net Geological Resources (tonnes)	Average Quality							
							Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	SC (ppm)	V (ppm)	Ga (ppm)
1	MBD-01	81183.98	5.00	405919.88	941734.13	847560.71	40.49	3.34	29.62	5.35	19.76	25.14	1095.98	68.25
2	MBD-05	23812.55	2.00	47625.10	110490.23	99441.20	56.89	3.45	2.64	4.45	30.79	13.98	266.12	43.15
Total Geological resources of Bauxite with grade in tonnes					**1052224.35**	**947001.92**	**42.21**	**3.35**	**26.79**	**5.26**	**20.92**	**23.96**	**1008.84**	**65.61**
Total Geological resources for Bauxite with grade in million tonnes					**1.05**	**0.95**								

Table No.20.2

SUMMARY OF ESTIMATED POLYGON WISE, BOREHOLE WISE INFERRED CATEGORY OF RESOURCES (333) OF LOW-GRADE BAUXITE (POLYGONAL METHOD) IN DHRANG BLOCK, DISTRICT - KUCHCHH, GUJARAT.
(at IBM cut off for bauxite 35% to 40% Al2O3% and ≤10% SiO2%)

Polygon No.	BH No.	Polygon Area (m^2)	Thickness (m)	Volume (m^3)	Gross Geological Resources (tonnes)	Net Geological Resources (tonnes)	Average Quality							Bulk Density: 2.32
							Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	SC (ppm)	Ga (ppm)	V (ppm)
1	MBD-01	81183.98	3.00	243551.93	565040.48	508536.43	35.62	5.55	32.61	5.48	18.89	27.66	824.13	56.15
2	MBD-02	49605.81	2.00	99211.61	230170.94	207153.85	37.59	7.37	28.85	5.05	19.84	43.26	679.97	52.16
3	MBD-03	22489.61	5.00	112448.05	260879.46	234791.52	44.94	7.41	12.33	6.62	26.00	30.84	675.39	72.79
4	MBD-04	38449.87	3.20	123039.59	285451.84	256906.66	46.39	8.84	6.67	7.62	26.34	30.86	913.22	67.17
5	MBD-05	23812.55	1.00	23812.55	55245.11	49720.60	52.30	6.18	3.68	5.08	29.40	22.31	316.95	52.35
Total Geological resources of Aluminous Laterite with grade in tonnes					**1396787.83**	**1257109.05**	**40.55**	**6.89**	**21.76**	**6.05**	**22.31**	**31.27**	**770.74**	**60.70**
Total Geological resources for Aluminous Laterite with grade in million tonnes					**1.40**	**1.26**								

Table No.20.3

SUMMARY OF ESTIMATED POLYGON WISE, BOREHOLE WISE INFERRED CATEGORY OF RESOURCES (333) OF ALUMINOUS LATERITE (POLYGONAL METHOD) IN DHRANG BLOCK, DISTRICT - KACHCHH, GUJARAT.
(at IBM cut off for Aluminous laterite min 20%)

							Bulk Density: 2.32							
Sl. No.	BH No.	Polygon Area (m^2)	Thickness (m)	Volume (m^3)	Gross Geological Resources (tonnes)	Net Geological Resources (tonnes)	Average Quality							
							Al_2O_3 %	Fe_2O_3 %	SiO_2 %	TiO_2 %	LOI %	SC (ppm)	V (ppm)	Ga (ppm)
1	MBD-01	81183.98	6.00	487103.86	1130080.95	1017072.86	35.80	30.01	9.42	4.63	19.25	47.36	78.21	884.98
2	MBD-02	49605.81	5.50	272831.93	567490.42	510741.38	37.68	29.35	8.19	3.28	20.74	36.66	65.64	705.71
3	MBD-03	22489.61	2.00	44979.22	93556.77	84201.10	39.19	23.26	11.01	5.90	20.05	51.72	102.71	1031.00
4	MBD-04	38449.87	3.30	126884.57	263919.91	237527.92	30.76	35.65	11.56	4.91	16.61	71.55	57.67	792.33
Total Geological resources of Aluminous Laterite with grade in tonnes					**2055048.06**	**1849543.25**	**35.83**	**30.25**	**9.43**	**4.35**	**19.36**	**47.71**	**73.22**	**830.22**
Total Geological resources for Aluminous Laterite with grade in million tonnes					**2.06**	**1.85**								

Table No.20.4

STATEMEMT SHOWING BOREHOLE WISE RECONNAISSANCE CATEGORY OF RESOURCES (334) OF METALLURGICAL GRADE II BAUXITE ESTIMATED BY POLYGONAL METHOD IN DHRANG BLOCK, DISTRICT - KACHCHH, GUJARAT

{at IBM cut off for Metallurgical Grade II Bauxite Al2O3≥ 40 % and SiO2≤ 4% CUT OFF}

Sl. No.	BH No.	Polygon Area (m^2)	Thickness (m)	Volume (m^3)	Gross Geological Resources (tonnes)	Net Geological Resources (tonnes)	Average Quality							
							Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	Sc (ppm)	V (ppm)	Ga (ppm)
1	MBD-01	9192.5665	5.00	45962.83	106633.77	95970.39	40.49	3.34	29.62	5.35	19.76	25.14	1095.98	68.25
2	Pit-26	2830.5622	1.50	4245.84	9850.36	8865.32	49.58	2.43	3.29	5.77	30.53	22.31	316.95	52.35
3	BRS-13& 14	31702.9088	5.00	158514.54	367753.74	330978.37	43.87	2.96	7.64	4.94	29.12			
Total Geological resources of Bauxite with grade in tonnes					**484237.87**	**435814.08**	**43.24**	**3.03**	**12.39**	**5.05**	**27.09**	**5.99**	**247.79**	**16.09**
Total Geological resources for Bauxite with grade in million tonnes					**0.48**	**0.44**								

Table No.20.5

STATEMEMT SHOWING BOREHOLE WISE RECONNAISSANCE CATEGORY OF RESOURCES (334) OF LOW GRADE BAUXITE ESTIMATED BY POLYGONAL METHOD IN DHRANG BLOCK, DISTRICT - KACHCHH, GUJARAT

{at IBM cut off for Low Grade Bauxite Al2O3≥35% to 40% and SiO2≤10%}

							Bulk Density: 2.32							
Sl. No.	**BH No.**	**Polygon Area (m^2)**	**Thickness (m)**	**Volume (m^3)**	**Gross Geological Resources (tonnes)**	**Net Geological Resources (tonnes)**	**Average Quality**							
							Al_2O_3 %	**SiO_2 %**	**Fe_2O_3 %**	**TiO_2 %**	**LOI %**	**Sc (ppm)**	**V (ppm)**	**Ga (ppm)**
1	MBD-01	9192.5665	3.00	27577.70	63980.26	57582.24	35.62	5.55	32.61	5.48	18.89	27.66	824.13	56.15
2	MBD-02	32471.747	2.00	64943.49	150668.91	135602.02	37.59	7.37	28.85	5.05	19.84	43.26	679.97	52.16
3	MBD-04	68714.531	3.20	219886.50	510136.68	459123.01	46.39	8.84	6.67	7.62	26.34	30.86	913.22	67.17
4	MBD-05	16086.719	1.00	16086.72	37321.19	33589.07	52.30	6.18	3.68	5.08	29.40	22.31	316.95	52.35
Total Geological resources of Low-grade Bauxite with grade in tonnes					**762107.04**	**685896.33**	**44.04**	**8.14**	**13.09**	**6.81**	**24.58**	**32.62**	**830.43**	**62.55**
Total Geological resources for Low grade Bauxite with grade in million tonnes					**0.76**	**0.69**								

Table No.20.6

STATEMEMT SHOWING BOREHOLE WISE RECONNAISSANCE CATEGORY OF RESOURCES (334) OF ALUMINOUS LATERITE ESTIMATED BY POLYGONAL METHOD IN DHRANG BLOCK, DISTRICT - KACHCHH, GUJARAT

{at IBM cut off for Aluminous Laterite Al2O3 - 20%(min)}

							Bulk Density: 2.32							
Sl. No.	**BH No.**	**Polygon Area (m^2)**	**Thickness (m)**	**Volume (m^3)**	**Gross Geological Resources (tonnes)**	**Net Geological Resources (tonnes)**	**Average Quality**							
							Al_2O_3 %	**Fe_2O_3 %**	**SiO_2 %**	**TiO_2 %**	**LOI %**	**Sc (ppm)**	**Ga (ppm)**	**V (ppm)**
1	MBD-01	9192.5665	6.00	55155.40	127960.53	115164.47	35.80	30.01	9.42	4.63	19.25	47.36	78.21	884.98
2	MBD-02	32471.747	5.50	178594.61	371476.79	334329.11	37.68	29.35	8.19	3.28	20.74	36.66	65.64	705.71
3	MBD-03	31702.909	2.00	63405.82	131884.10	118695.69	39.19	23.26	11.01	5.90	20.05	51.72	102.71	1031.00
4	MBD-04	68714.531	3.30	226757.95	471656.54	424490.89	30.76	35.65	11.56	4.91	16.61	71.55	57.67	792.33
Total Geological resources of Aluminous Laterite with grade in tonnes					**1102977.95**	**992680.16**	**34.68**	**31.39**	**10.11**	**4.45**	**18.72**	**54.62**	**68.12**	**802.45**
Total Geological resources for Aluminous Laterite with grade in million tonnes					**1.10**	**0.99**								

Table No.20.7

SUMMARY OF ESTIMATED POLYGON WISE, BOREHOLE WISE INFERRED CATEGORY OF RESOURCES (333) OF TiO_2 (POLYGONAL METHOD) IN DHRANG BLOCK, DISTRICT - KACHCHH, GUJARAT.
(at IBM cut off TiO_2 >2%)

Sl. No.	BH No.	Polygon Area (m^2)	Thickness (m)	Volume (m^3)	Gross Geological Resources (tonnes)	Net Geological Resources (tonnes)	Bulk Density: 2.32 Average Quality							
							Al_2O_3 %	SiO_2 %	Fe_2O_3 %	TiO_2 %	LOI %	Sc (ppm)	V (ppm)	Ga (ppm)
1	MBD-01	81183.98	12.80	1039154.90	2410839.36	2169755.43	33.35	7.86	33.96	5.25	17.94	37.16	928.60	62.23
2	MBD-02	49605.81	5.90	292674.26	679004.27	611103.85	28.81	7.51	41.39	4.55	15.87	41.36	667.78	53.60
3	MBD-03	22489.61	2.00	44979.22	104351.79	93916.61	36.00	10.36	23.74	5.83	21.30	38.65	728.40	65.54
4	MBD-04	38449.87	1.20	46139.84	107044.44	96340.00	35.82	9.41	20.25	5.46	24.56	56.55	1145.43	58.76
5	MBD 05	23812.55	21.30	507207.29	1176720.92	1059048.82	52.19	7.90	3.67	4.67	29.15	20.50	324.92	46.00
Total Geological resources of Titanim Oxide with grade in tonnes					**4477960.78**	**4030164.70**	**37.74**	**7.92**	**26.56**	**5.01**	**20.81**	**33.92**	**730.93**	**56.65**
Total Geological resources for Titainium Oxide with grade in million tonnes					**4.48**	**4.03**								

Table No.20.8

SUMMARY OF ESTIMATED POLYGON WISE, BOREHOLE WISE INFERRED CATEGORY OF RESOURCES (333) OF GALLIUM (Ga) (POLYGONAL METHOD) IN DHRANG BLOCK, DISTRICT - KACHCHH, GUJARAT.
(at cut off Ga ≥50ppm)

									Bulk Density: 2.32					
Sl. No.	**BH No.**	**Polygon Area (m^2)**	**Thickness (m)**	**Volume (m^3)**	**Gross Geological Resources (tonnes)**	**Net Geological Resources (tonnes)**	**Average Quality**							
							Al_2O_3 %	**SiO_2 %**	**Fe_2O_3 %**	**TiO_2 %**	**LOI %**	**SC (ppm)**	**V (ppm)**	**Ga (ppm)**
1	MBD-01	81183.98	15.00	1217759.65	2825202.38	2542682.14	35.58	8.39	36.22	5.60	19.14	39.64	990.51	66.38
2	MBD-02	49605.81	7.00	347240.64	805598.29	725038.46	30.13	3.34	42.71	5.03	16.77	38.85	738.11	58.17
	MBD-03	22489.61	7.50	168672.07	391319.20	352187.28	38.25	7.91	22.71	6.22	22.59	36.70	758.41	69.03
3	MBD-04	38449.87	3.20	123039.59	285451.84	256906.66	46.39	8.84	6.67	7.62	26.34	30.86	913.22	67.17
4	MBD-04	38449.87	3.50	134574.55	312212.95	280991.66	25.34	13.41	34.16	4.57	19.31	71.94	1416.58	58.85
5	MBD 05	23812.55	1.00	23812.55	55245.11	49720.60	52.30	6.18	3.68	5.08	29.40	22.31	316.95	52.35
Total Geological resources of Gallium grade in tonnes					**4675029.77**	**4207526.79**	**35.04**	**7.81**	**33.88**	**5.60**	**19.59**	**40.67**	**943.36**	**64.57**
Total Geological resources for Gallium grade in million tonnes					**4.68**	**4.21**								

Table No.20.9

SUMMARY OF ESTIMATED POLYGON WISE, BOREHOLE WISE INFERRED CATEGORY OF RESOURCES (333) OF SCANDIUM (Sc) (POLYGONAL METHOD) IN IN DHRANG BLOCK, DISTRICT - KACHCHH, GUJARAT.
(at cut off Sc ≥50ppm)

							Bulk Density: 2.32							
Sl. No.	**BH No.**	**Polygon Area (m^2)**	**Thickness (m)**	**Volume (m^3)**	**Gross Geological Resources (tonnes)**	**Net Geological Resources (tonnes)**	**Average Quality**							
							Al_2O_3 %	**SiO_2 %**	**Fe_2O_3 %**	**TiO_2 %**	**LOI %**	**SC (ppm)**	**V (ppm)**	**Ga (ppm)**
1	MBD-01	81183.98	0.70	56828.78	131842.78	118658.50	21.22	5.72	49.32	3.61	17.67	51.31	729.56	65.19
2	MBD-01	81183.98	3.00	243551.93	565040.48	508536.43	27.93	12.70	36.37	5.94	15.65	61.13	1032.01	62.50
3	MBD-02	49605.81	1.00	49605.81	115085.47	103576.92	26.66	11.38	38.82	10.15	28.49	116.23	1695.88	114.96
4	MBD-03	22489.61	3.00	67468.83	156527.68	140874.91	26.65	4.67	42.67	6.06	18.06	54.46	1117.73	71.44
5	MBD 04	38449.87	3.15	121117.09	280991.66	252892.49	29.38	9.61	28.39	4.13	24.01	72.06	1285.64	53.68
Total Geological resources of Sc grade in tonnes					**1249488.06**	**1124539.25**	**27.27**	**10.14**	**36.96**	**5.69**	**19.22**	**66.79**	**1129.02**	**66.75**
Total Geological resources for Sc grade in million tonnes					**1.25**	**1.12**								

Table No.20.10

SUMMARY OF ESTIMATED POLYGON WISE, BOREHOLE WISE INFERRED CATEGORY OF RESOURCES (333) OF VANADIUM (V) (POLYGONAL METHOD) IN DHRANG BLOCK, DISTRICT - KACHCHH, GUJARAT.

(at cut off V ≥500ppm)

									Bulk Density: 2.32					
Polygon No.	**BH No.**	**Polygon Area (m^2)**	**Thickness (m)**	**Volume (m^3)**	**Gross Geological Resources (tonnes)**	**Net Geological Resources (tonnes)**	**Average Quality**							
							Al_2O_3 %	**SiO_2 %**	**Fe_2O_3 %**	**TiO_2 %**	**LOI %**	**SC (ppm)**	**V (ppm)**	**Ga (ppm)**
1	MBD-01	81183.98	0.70	56828.78	131842.78	118658.50	21.22	5.72	49.32	3.61	17.67	51.31	729.56	65.19
2	MBD-01	81183.98	3.00	243551.93	565040.48	508536.43	27.93	12.70	36.37	5.94	15.65	61.13	1032.01	62.50
3	MBD-02	49605.81	1.00	49605.81	115085.47	103576.92	26.66	11.38	38.82	10.15	28.49	116.23	1695.88	114.96
4	MBD-03	22489.61	3.00	67468.83	156527.68	140874.91	26.65	4.67	42.67	6.06	18.06	54.46	1117.73	71.44
5	MBD 04	38449.87	3.15	121117.09	280991.66	252892.49	29.38	9.61	28.39	4.13	24.01	72.06	1285.64	53.68
Total Geological resources of Va grade in tonnes					**1249488.06**	**1124539.25**	**27.27**	**10.14**	**36.96**	**5.69**	**19.22**	**66.79**	**1129.02**	**66.75**
Total Geological resources for Va grade in million tonnes					**1.25**	**1.12**								

20.2.0 COMPUTATION OF AVERAGE GRADE:

20.2.1 All calculations for grade estimation for bauxite zone are made by weighted average method. Since the sample interval was uniformly maintained along with different litho-units, the length of the sample was mostly maintained at 1.00m interval with the exception of litho-unit variations, and any structural implications. The, weighted average has been calculated by the following formula:

$$\text{Weighted average grade} = \frac{V1 \times G1 + V2 \times G2 + V3 \times G3 + \ldots\ldots\ldots\ldots + Vn \times Gn}{V1 + V2 + V3 + \ldots\ldots\ldots\ldots + Vn}$$

Here `V' = Volume of bauxite ore in individual borehole

`G'= Grade of the respective bauxite ore in the corresponding borehole

20.3.0 CATEGORY OF RESOURCE:

20.3.1 The bauxite in this area is relatively thin band and always not correlated with adjoining boreholes and Pit unequivocally in all the places, so the Total estimated resources in Dhrang block are placed under "Inferred Mineral Resource" (333) category of UNFC. The resource falling outside influence of boreholes is considered as Reconnaissance category of resource (334).

20.3.2 The area under investigation falls under 333 and 334 categories of resources under UNFC nomenclature. However as per the Minerals (Evidence of Mineral Contents) Rules, 2015, amended upto 14th Dec 2021, a geological study report has been prepared conforming to Part IVA of Schedule-I."

CHAPTER-21

SUMMARY AND RECOMMENDATIONS

21.1.0 DISCUSSION ON THE OUTCOME OF THE EXPLORATION WORK DETAILING THE NATURE OF THE DEPOSIT

21.1.1 The Preliminary Exploration (G-3 stage) undertaken in the Dhrang Block, District Kachchh, Gujarat, covering an area of approximately 4.86 sq. km, has successfully established the occurrence of lateritic bauxite mineralization developed over the Deccan Trap basaltic terrain. The exploration programme was carried out under the aegis of National Mineral Exploration Trust (NMET) with the objective of delineating the occurrence, thickness, grade characteristics and resource potential of bauxite and associated minerals within the block.

21.1.2 The exploration programme comprised detailed geological mapping on 1:4000 scale, topographical survey, exploratory drilling, systematic sampling, laboratory analysis, petrographic studies and bulk density determination, which collectively generated reliable geological and analytical data for interpretation of the deposit and estimation of mineral resources. As part of the approved scope of work, five boreholes were drilled with a cumulative meterage of about 77 m, along with systematic sampling of the laterite–bauxite horizons encountered during drilling.

21.1.3 Geologically, the study area forms part of the Kachchh Basin, where extensive lateritic weathering profiles have developed over the Deccan Trap basaltic basement. The bauxite mineralization in the block is of chemical weathering origin, formed through prolonged tropical weathering, de-silicification and residual enrichment processes acting upon the basaltic parent rocks. These processes have resulted in progressive removal of mobile constituents and enrichment of relatively immobile elements such as aluminium, iron and titanium, leading to the development of lateritic bauxite horizons within the weathering profile.

21.1.4 The bauxite mineralization within the block occurs predominantly as lateritic capping deposits developed over basaltic bedrock, forming ridge-like geomorphological features within the study area. The mineralized zones generally occur as irregular bedded bodies with variable thickness, reflecting the influence of geomorphology, structural controls and intensity of lateritic weathering.

21.1.5 In the north-western sector of the block, the lateritic bauxite band extends over a strike length of approximately 800 m to 1.0 km, with widths ranging between 70 m and 176 m. The thickness of the bauxite horizon in this sector varies from about 2.0 m to 7.5 m, locally attaining a maximum thickness of approximately 9.5 m. In the eastern sector, the lateritic bauxite band extends for about 860 m, with widths varying between 63 m and 140 m, and thickness ranging from 2.0 m to 5.0 m.

21.1.6 Lithologically, the lateritic weathering profile in the block comprises a sequence of laterite, bauxite, clayey bauxite, bauxitic clay, lithomargic clay and saprolitic zones, developed over the basaltic basement. The bauxite horizon generally occurs in the middle portion of the lateritic profile and represents the zone of maximum alumina enrichment.

21.1.7 Chemical analysis of the core samples indicates that the bauxite occurring within the block predominantly falls under Metallurgical Grade-II category as per IBM end-use classification, characterized by Al_2O_3 content exceeding 40% and relatively low silica content. In addition to metallurgical grade bauxite, the lateritic profile also hosts low-grade bauxite and aluminous laterite horizons, reflecting variations in the intensity of lateritization.

21.1.8 During the course of exploration, 54 primary core samples were generated and analysed for major oxides including Al_2O_3, SiO_2, Fe_2O_3, TiO_2 and LOI, along with trace elements such as Vanadium (V), Scandium (Sc) and Gallium (Ga). Analytical accuracy and data reliability were ensured through external check analysis carried out at NABL accredited laboratories, which showed excellent agreement with the primary analytical results.

21.1.9 For the purpose of resource estimation, the Polygon Method has been adopted in accordance with the provisions of the Minerals (Evidence of Mineral Contents) Rules, 2015 (MEMC Rules). The estimation considered the area of influence of individual boreholes, thickness of the mineralized horizon and average bulk density of 2.32 g/cm^3, determined from representative core samples.

21.1.10 Based on the available geological, drilling and analytical data, the total geological resources of Metallurgical Grade-II Bauxite have been estimated at approximately 1.25 million tonnes, with an average Al_2O_3 grade of about 53.68% and SiO_2 around 3.15%. After applying standard geological deductions to account for irregularity of the deposit and possible data gaps, the net in-situ geological resource is estimated at approximately 1.12 million tonnes.

21.1.11 Considering the limited borehole spacing and irregular nature of the mineralized zones, the estimated resources have been classified under Inferred Mineral Resource category (UNFC Code-333). The areas falling outside the direct influence of boreholes have been categorized under Reconnaissance Mineral Resource category (UNFC Code-334) in accordance with the provisions of the MEMC Rules, 2015.

21.1.12 The exploration carried out in the Dhrang Block thus establishes the presence of lateritic bauxite mineralization of metallurgical grade quality, occurring as residual lateritic caps developed over basaltic terrain, representing a typical lateritic bauxite deposit model.

21.1.13 The delineated bauxite mineralization within the block exhibits favourable grade characteristics and occurs in near-surface horizons with minimal overburden, which is a typical feature of lateritic bauxite deposits. The occurrence of metallurgical grade bauxite with comparatively high alumina content and moderate silica levels indicates potential suitability for alumina extraction and other industrial applications.

21.1.14 In addition, the presence of trace elements such as Scandium, Vanadium and Gallium within the lateritic profile enhances the strategic significance of the deposit, as these elements are increasingly recognized as critical minerals for advanced technologies and energy applications.

21.1.15 Net resources under Inferred Resource category (333) of Metallurgical Grade-II Bauxite of 0.95 MT have been estimated at a cut-off of Al_2O_3 >40% and $SiO_2 \leq$ 4%, with an average grade of Al_2O_3 42.21%, SiO_2 3.35%, Fe_2O_3 26.79%, TiO_2 5.26%, Sc 23.96 ppm, V 1008.84 ppm and Ga 65.61 ppm. In addition, Low Grade Bauxite resources of 1.26 MT have been estimated at Al_2O_3 35–40% and $SiO_2 \leq$10% cut-off, with an average grade of Al_2O_3 40.55%, SiO_2 6.89%, Fe_2O_3 21.76% and TiO_2 6.05%. The block also hosts 1.85 MT of Aluminous Laterite resources estimated at Al_2O_3 $\geq$20% cut-off, with an average grade of Al_2O_3 35.53%, SiO_2 9.43%, Fe_2O_3 30.25% and TiO_2 4.35%.

21.1.16 Net resources of Metallurgical Grade-II Bauxite amounting to 0.44 MT have been estimated at a cut-off of $Al_2O_3 \geq$ 40% and $SiO_2 \leq$ 4%, with an average grade of Al_2O_3 43.24%, SiO_2 3.03%, Fe_2O_3 12.39% and TiO_2 5.05%, along with trace elements such as Sc 5.99 ppm, V 247.79 ppm and Ga 16.09 ppm. In addition, Low Grade Bauxite resources of 0.69 MT have been delineated at a cut-off of Al_2O_3 35–40% and $SiO_2 \leq$ 10%, with an average grade of Al_2O_3 44.04%, SiO_2 8.14%, Fe_2O_3 13.09% and TiO_2 6.81%, and enriched in Sc 32.62 ppm, V 830.43 ppm and Ga 62.55 ppm. The block also hosts 0.99 MT of Aluminous Laterite at a cut-off of $Al_2O_3 \geq$ 20%, with an average grade of Al_2O_3 34.68%, SiO_2 10.11%, Fe_2O_3 31.39% and TiO_2 4.45%, along with Sc 54.62 ppm, Ga 68.12 ppm and V 802.45 ppm. All the above resources have been classified under the Reconnaissance Mineral Resource (UNFC Code 334) category.

21.1.17 Associated trace element enrichment has also been observed within the lateritic profile. A TiO_2 resource of about 4.03 MT has been estimated at 2% TiO_2 cut-off with an average grade of 5.01%. In addition, Gallium-bearing resources of 4.21 MT (Ga ≥50 ppm) with an average Ga grade of 64.57 ppm, Scandium resources of 1.12 MT (Sc ≥50 ppm) with an average 66.79 ppm, and Vanadium resources of 1.12 MT (V ≥500 ppm) with an average 1129.02 ppm have been delineated within the bauxite–laterite horizon.

21.1.18 Apart from aluminium, the bauxite deposits of the Dhrang Block show enrichment of several strategic elements including scandium (Sc), gallium (Ga) and vanadium (V). These elements are increasingly recognized as critical minerals due to their applications in advanced technologies, aerospace alloys, electronics and energy storage systems.

21.1.19 Scandium is widely used in high-strength aluminium alloys and solid oxide fuel cells, while gallium plays an important role in semiconductor and photovoltaic industries. Vanadium is an important component in steel alloys and vanadium redox batteries used for energy storage.

21.1.20 The presence of these elements within the bauxite-laterite profile suggests that the deposits may hold additional economic significance beyond conventional aluminium production. Detailed geochemical investigation and metallurgical studies may therefore be undertaken in future exploration stages to evaluate the potential recovery of these associated critical elements.

21.2.0 RECOMMENDATIONS

21.2.1 Considering the geological characteristics, thickness variation and grade distribution of the bauxite horizons delineated during the present investigation, the following recommendations are proposed for further evaluation of the deposit.

21.2.2 Further close-spaced exploratory drilling in G-2 level is recommended in the north-western and eastern sectors of the block where promising bauxite and aluminous lateritic horizons with decent value of TiO2, Va, Ga and Sc have been intersected. This will help in establishing the lateral continuity and thickness variation of the mineralized zones more accurately.

21.2.3 The detailed geochemical investigations by drilling may evaluate the potential of associated critical trace elements such as Scandium, Vanadium and Gallium, which may have potential economic value as critical minerals.

21.2.4 Detailed beneficiation studies may be undertaken to evaluate the metallurgical behaviour of the bauxite and to assess its suitability for alumina extraction and other industrial applications and its associated trace elements.

21.2.5 The proposed detailed investigations are expected to enhance the auction potential of the block and improve the geological confidence in the delineated deposit, thereby facilitating informed decision-making for its future development.

21.2.6 Considering the favorable geological setting and occurrence of lateritic bauxite horizons with critical minerals within the block, systematic exploration in adjoining areas of the lateritic plateau is also recommended in order to identify additional zones of bauxite mineralization associated trace elements such as Scandium, Vanadium and Gallium within the regional geological framework.

CHAPTER-22

PLATES AND MAPS

22.1.0 As mentioned in Index.

CHAPTER-23

ANNEXURE / ENCLOSURES TO THE REPORT

23.1.0 The report includes all the relevant annexure and maps/plans, sections photographs and photomicrographs etc.

CHAPTER-24

ANY OTHER INFORMATION

24.1.0 Locality Index

Sl. No.	Village	Latitude	Longitude	Toposheet
1	Kotda	23°28'56.83"N	68°54'43.74"E	41A/14
2	Mata no Madh	23°32'33.14"N	68°56'58.83"E	41A/14
3	Murchmana	23°30'41.61"N	68°52'31.78"E	41A/14
4	Suja Vandh	23°33'11.46"N	68°51'47.25"E	41A/14

CHAPTER-25

CERTIFICATE FROM THE QUALIFIED PERSON WITH NAME, DATE AND SIGNATURE

This is to certify that the Preliminary Exploration (G3) for Bauxite, Titanium and Associated Minerals in the Dhrang Block, District Kachchh, State Gujarat, has been carried out by Mineral Exploration & Consultancy Limited (MECL) in accordance with the prescribed technical standards, procedures, and guidelines laid down in: NMET/MECL-approved Exploration Methodology for G3 Stage

The exploration activities—including geological mapping, sampling, drilling, core logging, sample preparation, laboratory analysis, QA/QC validation and data processing—were executed under the supervision of qualified MECL geoscientists and technical personnel

NAME: SHRIKANT SHARMA

DESIGNATION: HoD (EXPLORATION)

DATE: 31-03-2026

LIST OF PERSONNEL ASSOCIATED WITH RECONAISSANCE SURVEY (G-4) FOR IRON, MANGANESE AND ASSOCIATED MINERALS IN TIKARIYABLOCK (33.40SQKM) DISTRICT-KATNI, MADHYA PRADESH

1	Overall guidance	Shri P. Ravindran, Retired GM (Exploration)/ Shrikant Sharma (HoD-Exploration)
2	Overall Planning, Co-ordination & Supervision	Shri Swarup Dhara, Sr. Manager (Geology)
		Shri Rajanya Roy, Asst. Manager (Geology)
3	Project Management	Shri Khusiram, Manager (Drilling) / Shri Anil Tiwary, Manager (Drilling)/ Project Manager
4	Physical Execution of work	
	Geological work	Shri Shubham Kumar, Senior Geologist Shri Hiresh Shrirame, Young Professional (Geology)
5	Sample Processing	Shri Ankush Wagh, Sampling Technician Shri Pushparaj Tiwary, Sampling Technician Smt. Shikha, Sampling Technician
6	Chemical Laboratory	Shri Rohit Sharma, Manager (Chemical Lab)
		Dr. Deepti Rahangdale, Manager (Chemical Lab)
7	Petrographic Studies	Shri Sayantan Pal, Manager (Geology)
8	Documentation	Swarup Dhara, Sr. Manager (Geology)
		Shri Shubham Kumar, Senior Geologist
		Miss. Rajanya Roy, Sr. Geologist
		Shri Uday Patil, Sr. Computer Operator
10	Reprography and Printing	Shri Pratap Negi, OIC, Survey & Map Officer
		Shri Durgesh Devarshee, Assistant Survey & Map Officer
		Shri Punit Khandale, Sr. Technician (S & D)
11	Proposal Formulation	Moumita Ghosh, Asst. Manager (Geology)
12	Hindi Translation	Shri Srikant Rai, Hindi Officer

REFERENCES

Aleva, G.J.J., 1994. Laterites: Concepts, Geology, Morphology and Chemistry. International Soil Reference and Information Centre, Wageningen, the Netherlands (169 pp.).

Andrews, J.E., Greenaway, A.M., Dennis, P.F., Barnes-Leslie, D.A., 2001. Isotopic effectson inorganic carbon in a tropical river caused by caustic discharges from bauxite processing. Applied Geochemistry 16, 197–206.

Bardossy, G., (1982). Karst Bauxites. Bauxite Deposits on Carbonate Rock. Elsevier Scientific Publishing Company, Amsterdam.

Bhattacharya, N. B., (1978-79), A report on the assessment of lignite resources of Gujarat. (Progress Report for the field season)

Biswas S.K. (1965) : A new classification of the Tertiary rocks of Kutch, western India, bult. Geol. Min. of Met. Soc. Ind. No.35

Biswas, S. K. and Deshpande S. V. (1970): Geological and tectonic map of the Kutch. Bull. ONGC, V. 7, pp. 115-116.

Biswas, S. K. (1971): Note on geology of Kutch. Quaternary Journal of Geology, Mineral Metal. Soc. India, V. 43, pp. 223-235.

Biswas, S. K. and Raju, D. S. N. (1973). The rock-stratigraphic classification on the Tertiary sediments of Kutch. Bulletin of Oil and Natural Gas Commission, v. 10 (1&2),pp.37-46.

Biswas, S. K. (1974): Landscape of Kutch – A morphotectonic analysis. Indian Journal of Earth Science, V. 1(2), pp. 177-190.

Biswas, S. K. (1977): Mesozoic Rock Stratigraphy of Kutch. Quarterly Journal of the Geological, Mining and Metallurgical Society of India, V. 49, pp.1-52.

Biswas, S. K. (1980): Structure of Kutch-Kathiwar region, Western India. Proc. 3rd Ind. Geol. Cong., Poona, pp. 255-272.

Biswas, S. K. (1981): Basin framework, paleoenvironment and depositional history of the Mesozoic sediments of Kutch. Western India, Quart. Jour. Geol., Min. Met. Soc. India, V. 53, pp. 56-85.

Biswas, S. K. (1982): Rift basins in Western India and their hydrocarbon prospects with special reference to Kutch basin. AAPG Bull., V. 66, pp. 1467-1513.

Biswas, S. K., (1987): Regional tectonic framework, structure and evolution of western marginal basins of India. Tectonophysics, V. 135, pp. 307-327.

Biswas, S.K. (1992). Tertiary Stratigraphy of Kutch. Jour. Pal. Soc.India. vol. 37, pp. 1-29.

Calagari, A.A., Abedini, A., 2007. Geochemical investigations on Permo-Triassic bauxite horizon at Kanisheeteh, east of Bukan, West-Azarbaidjan, Iran. Journal of Geochemical Exploration 94, 1–18.

Chauhan, O. S. and Almeida, F. (1993): Influences of Holocene Sea level, regional tectonics, and fluvial gravity and slope current induced sedimentation on the regional geomorphology of the continental slope off northwestern India. Mar. Geo., V. 112, pp. 313–328.

Chatterji, A. K. and Mathur, U. B. (1966). Note on the Nari Series of Kutch, Gujarat; Bull.Geol. Soc. India, v.3. pp.9-11.

Crnicki, J.; Jurkovic, I. Rare earth elements in Triassic bauxites of Croatia Yugoslavia. Travaux 1990, 19,239–248.

Desikan, N. and Kulkarni, G. R. (1970), Geological mapping of part of Bhuj Taluka Kachchh district, Gujarat" Unpublished progress report of Geol. Surv. Ind. (F.S. 1967- 68).

Gandhi, P. (1990-91), Report on regional exploration for lignite in Kachchh district-Gujarat (GSI Final Report for Field Season)

Gautam Sen, Willis E. Hames, Dalim K. Paul, Sanjib K. Biswas3, Arijit Ray, Indra S. Sen. (2016) Pre-Deccan and Deccan Magmatism in Kutch, India: Implications of New 40Ar/39Ar Ages of Intrusions, 10.17491/cgsi/2016/105422

Ghevariya, Z. G., Sable, A. B. And Rakshit, P. (1985), Geological mapping of Mesozoic rocks, Kutch district, Gujarat state, unpublished report of GSI.

Ghevariya, Z. G. (1990), Report on Geological mapping of Mesozoic rocks in parts of Kachchh district, Gujarat (toposheet no. 41 E/6 and 41 I/7) unpublished progress report of GSI.

Ghevariya, Z. G., Sabale, A. B. and Rakshit P. (1984). Geological mapping of theMesozoic Rocks, Kachchh district, Gujarat. (Unpublished report for the progress Report forthe F.S. (1981-82).

Ghevariya Z. G. (1985). Geological mapping of Mesozoic rocks around Anjar, Kachchh,Gujarat (Unpublished progress report of GSI, FS 1984-85).

Ghevariya Z.G. and Srikarni C. (1991). Systematic Geological Mapping inparts of topsheets 41A 09 of Kachchh district, Gujarat. Unpublished report of Geological Survey of India.

GSI (Geological Survey of India). (2001). Geology and Mineral Resources of Gujarat, Daman and Diu, Miscellaneous Publication, v. 30, Part XIV, 102p.

Hill, I.G., Worden, R.H., Meighan, I.G., 2000. Geochemical evolution of a palaeolaterite: The Inter basaltic Formation, Northern Ireland. Chemical Geology 166, 65–84.

Indian Mineral Yearbook 2015, IBM, Bauxite (Advance Release), 54th Edition.

Karadag, M.M., Kupeli, S., Aryk, F., Ayhan, A., Zedef, V., Doyen, A., 2009. Rare earth element (REE) geochemistry and genetic implications of the Mortas bauxite deposit (Seydisehir/Konya—Southern Turkey). Chemie Der Erde—Geochemistry 69, 143–159.

Krishnan, M.S., (1982). Geology of India and Burma (6th edition), Delhi CBS, publication.

Kuikarni, G. R. and Deslkan, N. (1965-66). GSI Progress Report of Mandvi, Nakhatrana and Bhuj Talukas, Kachchh district

Kuikarni, G.R. and Agrawal, G.C. (1963-64). GSI Progress Report on the Geology of Abdasa, Nakhatrana and Mandvi Taluka, Kachchh district, Gujarat.

Liaghat, S., Hosseini, M., Zarasvandi, A., 2003. Determination of the origin and mass change geochemistry during bauxitization process at the Hangam deposit, SW Iran. Geochemical Journal 37, 627–637.

Liu, X.; Wang, Q.; Deng, J.; Zhang, Q.; Sun, S.; Meng, J. Mineralogical and geochemical investigations of the Dajia Salento-type bauxite deposits, western Guangxi, China. J. Geochem. Explor. 2010, 105, 137–152.

Maclean, W.H., 1990. Mass change calculations in altered rock series. Mineralium Deposita 25, 44–49.

MacLean, W.H., Barrett, T.J., 1993. Lithogeochemical techniques using immobile elements. Journal of Geochemical Exploration 48, 109–133.

Maclean, W.H., Kranidiotis, P., 1987. Immobile elements as monitors of mass transfer in hydrothermal alteration; Phelps Dodge massive sulfide deposit, Matagami, Quebec. Economic Geology 82, 951–962.

MacLean, W.H., Bonavia, F.F., Sanna, G., 1997. Argillite debris converted to bauxite during karst weathering: evidence from immobile element geochemistry at the Olmedo Deposit, Sardinia. Mineralium Deposita 32, 607–616.

Maksimovic, Z.; Panto, G. Contribution to the geochemistry of the rare earth elements in the karst-bauxite deposits of Yugoslavia and Greece. Geoderma 1991, 51, 93–109.

Manishi Baranwal, Chattopadhyay, A. K. and Ray, S. (1989-90), Report on geophysical investigation to aid in exploration of lignite deposits in Umarasar and Pranpur areas, Kutch district, Gujarat (Progress Report for the Field Season)

Meiluso, L., Mahoney, J. J.and Dallai, L. (2006). Mantle sources and crustal input as recorded in high-Mg Deccan Traps basalts of Gujarat (India), Lithos, v. 89, Issues 3-4, pp.259-274.

Meshram, R.R., Randive, K.R., 2011. Geochemical study of laterites of the Jamnagar district, Gujarat, India: implications on parent rock, mineralogy and tectonics. Journal of Asian Earth Sciences 42, 1271–1287.

Mordberg, L.E., Spratt, J., 1998. Alteration of zircons: the evidence of Zr mobility duringbauxitic weathering. Goldschmidt Conference Toulouse, pp. 1021–1022.

Mukherjee, A. B., Biswas, S. (1988). Mantle derived spinel lherzolite xenoliths from theDeccan Volcanic Province (India): implication for the thermal structure of the lithosphereunderlying the Deccan Traps. J. Volcanol. Geotherm. Res., v.35, pp.269-

Özlü, N., 1983. Trace element contents of karst bauxites and their parent rocks in the Mediterranean belt. Mineralium Deposita 18, 469–476.

Panahi, A., Young, G.M., Rainbird, R.H., 2000. Behavior of major and trace elements (including REE) during Paleoproterozoic pedogenesis and diagenetic alteration ofan Archean granite near Ville Marie, Quebec, Canada. Geochimica Et CosmochimicaActa 64, 2199–2220.

Poddar, M.C. & Venkatappayya, N. (1953), Final report on coal & lignite deposits of Kutch list., (Unpublished progress report of G.S.I.). 138

Prasad, S., (1992-93) Report on the biostratigraphical studies of the middle Jurassic cretaceous sediments of Kachchh district, Gujarat (Progress Report for Field Season)

Roy, B.C. (1948), Mineral Resources of Lakhpat-Nakhatrana area, Kutch dist., Gujarat State, (Unpublished progress report of G.S.I.)

Rajnath. (1932). A contribution to the stratigraphy of Cutch. Quart.Jour. Geol. Min. Met. Soc. India, vol.4, pp. 161- 174.

Saxena, A.K., Fulzele, D. N., (2002-03), Seismotectonic study of the Kachchh mainland fault (KMF), Kachchh district Gujarat (Final Report for Field Season).

Schellmann, W., 1982. Eine neue Laterite definition. Geologisches Jahrbuch — Reihe D 58,31–47.

Schroll, E., Sauer, D., 1968. Beitrag zur Geochemie von Titan, Chrom, Nickel, Cobalt, Vanadium und Molyb din in bauxitischen Gesteinen und das Problem der stofflichen Herkunft des Aluminiums. Travaux du ICSOBA, 5 83–96.

Shukla, S.B. (2011). Late Quaternary Morphodynamic Evolution of the Northern Coast of Gulf of Kachchh Gujarat Western India, Thesis, Maharaja Sayajirao University of Baroda, 2011. http://hdl.handle.net/10603/7485.

Singh, P. K., Sahu, B. K. and Mohapatra, S. R. (2008). Geological mapping along theKachchh Mainland Fault. Unpublished Report of GSI, FS. (2005-07).

Vijayasarathi G. (1981-82), Report on geological mapping of the Tertiary rocks of Kutch (Progress Report for the Field season).

Waagen, A. B. (1872). Memoir on the geology of Kutch, to accompany the map compiled by A.B. Wynne and F. Fedden during the seasons of 1867-68 and 1868-69. Mem. Geol. Surv. India, v.9 (Pt.l), 293p.

Waagen, W. (1873-75). Jurassic fauna of Kutch - The Cephalopoda, Belemnitidae and Nautiloidae. Pal. Ind. Ser. 9, vol. 1, pp. 1-247. pl. 1-60.

Waagen et al. (1875). Jurassic fauna of Cutch. The Cephalopoda. Mem. Geol. Surv. Ind.,Pal. Ind., Ser. 9, pt. 1, pp.1-27.

Wynne, A.B. (1872). Geology of Kutch. Mem. geol. Surv. India. 9(1): 1-289.

Wynne, W. B. (1869). Rec. Geol. Surv. India, 11, pt.1, pp.1-5.

Zarasvandi, A.; Carranza, E.J.M.; Ellahi, S.S. Geological, geochemical, and mineralogical characteristics of the Mandan and Deh-now bauxite deposits, Zagros Fold Belt, Iran. Ore Geol. Rev. 2012, 48, 125–138.

ABBREVIATIONS USED

SL. No.	Abbreviation	Full form
1	m	Meter
2	Cu m	Cubic Meter
4	RL	Reduced Level
5	mRL	Reduced Level in metre
6	M.S.L.	Mean sea level
7	IBM	Indian Bureau of Mines
8	GSI	Geological Survey of India
9	NMET	National Mineral Exploration Trust
10	TCC	Technical cum Cost Committee
11	EC	Executive Committee
12	MMDR	Mines and Minerals (Development and Regulation)
13	MEMC	Minerals (Evidence of Mineral Contents)
14	MECL	Mineral Exploration and Consultancy Limited
15	NABL	National Accreditation Board for Testing and Calibration Laboratories
16	QA/QC	Quality Assessment/ Quality Checks
17	WGS-84	World Geodetic System-84
18	DMS	Degree Minute Second
19	UTM	Universal Transverse Mercator
20	F.S.P.	Field Season Programme
21	DGPS	Differential Global Positioning System
22	XRF	X-ray Fluorescence
23	ICP-MS	Inductively Coupled Plasma Mass Spectrometry
24	BDL	Below Detection Limit
25	MT	Million Tonnes