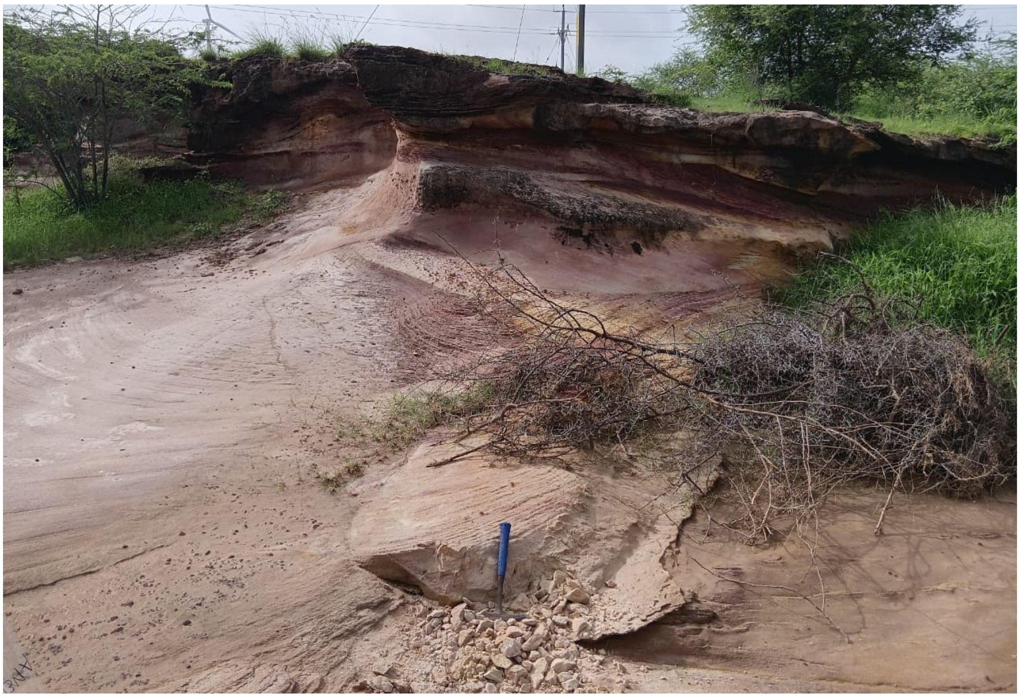
GEOLOGICAL REPORT ON RECONNAISSANCE SURVEY (G-4 STAGE) FOR GLAUCONITE, PHOSPHORITE AND REE IN

AMBARA MARU BLOCK

(Area-94.25 Sq Km)

TEHSIL-NAKHATARANA, DISTRICT- KACHCHH, GUJARAT

(Under NMEDT Programme)



Photograph showing bedded glauconitic sandstone exposed along a river section near Ambara Village.

Parts of Toposheet no. 41 E/02 and 41 E/03

TEXT, ANNEXURE AND PLATES

MECL

MINERAL EXPLORATION AND CONSULTANCY LIMITED

(Formerly known as Mineral Exploration Corporation Limited)

A Government of India Enterprises

CORPORATE OFFICE, NAGPUR

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अम्बारा मारू ब्लॉक में ग्लॉकोनाइट, फॉस्फोराइट एवं REE हेतु टोही सर्वेक्षण (G-4 स्तर) पर भूवैज्ञानिक प्रतिवेदन

(क्षेत्रफल – 94.25 वर्ग किमी) तहसील – नखत्राणा, जिला – कच्छ, गुजरात

कार्यकारी सारांश

1.1.1 ग्लॉकोनाइट एक पोटैशियम युक्त हरित सिलिकेट खनिज है, जो सामान्यतः कच्छ बेसिन के मेसोज़ोइक अनुक्रम (कच्छ सुपरग्रुप/ग्रुप) के समुद्री बलुआ पत्थर एवं शेल स्तरों में पाया जाता है। अम्बारा मारू क्षेत्र में यह कट्रोल संरचना के ग्लॉकोनाइटिक बलुआ पत्थर स्तरों में विद्यमान है। ग्लॉकोनाइट को पोटैशियम का एक महत्वपूर्ण प्राकृतिक स्रोत माना जाता है तथा इसका उपयोग मृदा सुधारक एवं धीमी गति से पोटाश प्रदान करने वाले उर्वरक के रूप में किया जाता है। पोटैशियम पौधों के तीन प्रमुख आवश्यक मैक्रोन्यूट्रिएंट्स (N–P–K) में से एक है तथा यह एंजाइम सक्रियण, जल विनियमन, प्रकाश संश्लेषण एवं प्रोटीन संश्लेषण में महत्वपूर्ण भूमिका निभाता है, जिससे फसल उत्पादन एवं पौधों के स्वास्थ्य में सुधार होता है।

1.1.2 कृषि में पोटैशियम के महत्व के कारण वैश्विक पोटाश उद्योग में निरंतर वृद्धि हुई है। संयुक्त राज्य भूवैज्ञानिक सर्वेक्षण (USGS, Mineral Commodity Summaries, 2025) के अनुसार, वर्ष 2024 में वैश्विक पोटाश उत्पादन क्षमता लगभग 65.2 मिलियन टन (K_2O) थी, जो वर्ष 2028 तक लगभग 76 मिलियन टन (K_2O) तक बढ़ने का अनुमान है। पोटैशियम उर्वरकों की बढ़ती मांग के परिणामस्वरूप ग्लॉकोनाइट युक्त बलुआ पत्थरों जैसे वैकल्पिक पोटैशियम संसाधनों के अन्वेषण को प्रोत्साहन मिला है, विशेषकर पश्चिमी भारत के कच्छ बेसिन जैसे अवसादी बेसिनों में।

1.1.3 वर्तमान में वैश्विक पोटाश आपूर्ति मुख्यतः समुद्री वाष्पीकृत निक्षेपों (marine evaporite deposits) एवं पोटाश-समृद्ध ब्राइन संसाधनों से प्राप्त होती है। प्रमुख पोटाश खनिजों में सिल्वाइट (KCl), कार्नालाइट ($KMgCl_3·6H_2O$), कैनाइट ($KMg(SO_4)Cl·3H_2O$) तथा पॉलीहेलाइट ($K_2Ca_2Mg(SO_4)_4·2H_2O$) शामिल हैं, जो परतबद्ध वाष्पीकृत स्तरों के रूप में अथवा उपसतही ब्राइन में घुलित अवस्था में पाए जाते हैं। इन निक्षेपों का प्रसंस्करण कर पोटैशियम क्लोराइड (Muriate of Potash – MOP) एवं पोटैशियम सल्फेट (SOP) का उत्पादन किया जाता है, जो सर्वाधिक प्रचलित पोटाश उर्वरक हैं। वैश्विक उत्पादन कुछ सीमित देशों जैसे कनाडा, रूस, बेलारूस, चीन, जर्मनी, चिली एवं संयुक्त राज्य अमेरिका में केंद्रित है, जिसके परिणामस्वरूप अनेक पोटाश आयातक देशों में आपूर्ति निर्भरता बनी हुई है।

1.1.4 भारत पोटाश उर्वरकों का एक प्रमुख उपभोक्ता है, किन्तु यहाँ आर्थिक रूप से खनन योग्य वाष्पीकृत पोटाश निक्षेपों का अभाव है, जिसके कारण देश आयात पर अत्यधिक निर्भर है। इस निर्भरता को कम करने हेतु ग्लॉकोनाइट, फेल्डस्पार एवं माइका जैसे स्वदेशी पोटैशियम स्रोतों के अन्वेषण को महत्व दिया जा रहा है। इनमें ग्लॉकोनाइटिक बलुआ पत्थर, जो कच्छ बेसिन सहित भारत के विभिन्न अवसादी बेसिनों में पाया जाता है, एक संभावित गैर-पारंपरिक पोटाश स्रोत माना जाता है। ग्लॉकोनाइट एक पोटैशियम-युक्त हरित खनिज है, जो समुद्री शेल्फ परिस्थितियों में बनता है तथा बलुआ पत्थर एवं शेल स्तरों में पाया जाता है। भारत में 4–8%

K_2O युक्त ग्लॉकोनाइटिक बलुआ पत्थर के व्यापक निक्षेप उत्तर प्रदेश, बिहार, मध्य प्रदेश, राजस्थान एवं गुजरात राज्यों में अभिलिखित हैं। ऐसे निक्षेपों का अन्वेषण पोटाश आयात निर्भरता को कम करने तथा दीर्घकालिक कृषि पोषक तत्व सुरक्षा को सुदृढ़ करने के राष्ट्रीय उद्देश्य के अनुरूप है तथा हाल की नीतिगत पहलों के अंतर्गत इसे प्रोत्साहन प्राप्त हुआ है।

1.1.5 महत्वपूर्ण खनिज आवश्यकताओं की पूर्ति हेतु भारत सरकार द्वारा रणनीतिक खनिज ब्लॉकों की चरणबद्ध (tranche-based) नीलामी की जाती है, जिसमें 6 चरण पूर्ण हो चुके हैं तथा 7^{th}चरण प्रगति पर है। इन नीलामियों में लिथियम, REEs, ग्लॉकोनाइट, ग्रेफाइट, वैनाडियम, निकेल, कोबाल्ट एवं फॉस्फोराइट जैसे खनिज शामिल हैं, जो स्वच्छ ऊर्जा प्रौद्योगिकी एवं उर्वरक सुरक्षा के लिए आवश्यक हैं। पारदर्शी आवंटन प्रक्रिया, निजी क्षेत्र की भागीदारी तथा MECL जैसी संस्थाओं की सक्रिय भूमिका डिकार्बोनाइजेशन प्रयासों को सुदृढ़ करती है, आपूर्ति श्रृंखला को मजबूत बनाती है तथा सतत आर्थिक विकास को प्रोत्साहित करती है।

1.1.6 अम्बारा मारू ब्लॉक गुजरात राज्य के कच्छ बेसिन के उत्तरी भाग में स्थित है। कच्छ बेसिन का स्तरीय अनुक्रम पच्छम, चारी, कट्रोल एवं उमिया संरचनाओं से निर्मित है। कच्छ का रण एवं कच्छ प्रायद्वीप मिलकर भारत के उत्तर-पश्चिमी भाग में लगभग 45,612 वर्ग किमी क्षेत्र को आच्छादित करते हैं। भौतिक भौगोलिक दृष्टि से कच्छ क्षेत्र प्रमुख पर्वतीय श्रेणियों, मृदु ढाल वाले परिधीय तटीय क्षेत्र, अपक्षयित तटीय मैदान तथा नवीन भू-आकृतिक इकाइयों जैसे डेल्टाई मैदान, ज्वारीय समतल (tidal flats), स्पिट्स एवं सीमांत अभिवृद्धि क्षेत्रों द्वारा अभिलक्षित है। यह बेसिन कच्छ सुपरग्रुप की शैलों द्वारा अधोस्थित है, जो विशेषतः ग्लॉकोनाइटिक बलुआ पत्थर के लिए अपनी खनिज संभाव्यता के लिए प्रसिद्ध है।

1.1.7 ग्लॉकोनाइटिक बलुआ पत्थर की उपस्थिति उमिया (भुज) संरचना तथा कट्रोल संरचना दोनों में अभिलिखित की गई है। 94.25 वर्ग किमी क्षेत्र में विस्तृत अम्बारा मारू ब्लॉक में MECL द्वारा टोही सर्वेक्षण संपादित किया गया। ब्लॉक क्षेत्र मुख्यतः कट्रोल संरचना की लिथो-इकाइयों से आच्छादित है, जिन्हें लेट जुरासिक से अर्ली क्रेटेशियस आयु का अभिगणित किया गया है। ब्लॉक के अंतर्गत कट्रोल संरचना सुविकसित है तथा इसमें विभिन्न लिथोलॉजी का समूह पाया जाता है, जिसमें ग्लॉकोनाइटिक बलुआ पत्थर, फेल्डस्पैथिक बलुआ पत्थर, फेरीजिनस बलुआ पत्थर, कैल्केरियस बलुआ पत्थर युक्त शेल, काओलिनाइटिक मृत्तिका तथा पादप जीवाश्म युक्त शेल सम्मिलित हैं।

1.1.8 अम्बारा मारू ब्लॉक, कच्छ जिला, गुजरात के क्षेत्रीय ग्लॉकोनाइटिक बलुआ पत्थर क्षितिज पट्टी (horizon belt) का भाग है तथा यह सर्वे ऑफ इंडिया के टोपोशीट सं. 41E/02 एवं 41E/03 के अंतर्गत आता है। अम्बारा मारू ब्लॉक में वर्तमान टोही सर्वेक्षण GSI की रिपोर्ट “कच्छ जिला, गुजरात के गुनेरी ग्राम के आसपास ग्लॉकोनाइट युक्त शेल एवं बलुआ पत्थर में पोटाश हेतु विस्तृत अन्वेषण (Detailed Investigation)” के दक्षिण-पूर्व भाग में प्रस्तावित किया गया है। उक्त G-4 स्तर (FSP 2014-15) के अंतर्गत यह अभिलिखित है कि कच्छ बेसिन की कट्रोल एवं भुज (उमिया) संरचनाओं में ग्लॉकोनाइट युक्त शेल एवं बलुआ पत्थर पाए जाते हैं। GSI की रिपोर्ट के अनुसार, इन संरचनाओं में ग्लॉकोनाइट युक्त शेल एवं बलुआ पत्थर विद्यमान

हैं, जिनमें फेरीजिनस बलुआ पत्थर, ग्लॉकोनाइटिक बलुआ पत्थर (कठोर, सघन, रेतीला से मृत्तिकायुक्त) तथा फेल्डस्पैथिक बलुआ पत्थर सम्मिलित हैं, जो उर्वरक खनिज अन्वेषण की दृष्टि से उच्च संभाव्यता को दर्शाते हैं।

1.1.9 अम्बारा मारू ब्लॉक, कच्छ जिला, गुजरात में ग्लॉकोनाइट, फॉस्फोराइट एवं REE हेतु टोही सर्वेक्षण का प्रस्ताव NMEDT की TCC-II बैठक में अनुशंसित किया गया तथा 24 जनवरी 2025 को आयोजित NMEDTकी 39वीं EC बैठक में अनुमोदित किया गया। स्वीकृति आदेश (Sanction Order) दिनांक 24 फरवरी 2025 को जारी किया गया। इस कार्यक्रम की अवधि 10 माह (23 दिसम्बर 2025 तक) निर्धारित की गई थी, जिसे बाद में तीन माह की अवधि (31 मार्च 2026 तक) के लिए विस्तारित किया गया।

1.1.10 अन्वेषण ब्लॉक का क्षेत्रफल 94.25 वर्ग किमी है। MECL द्वारा क्षेत्रीय कार्य 30 मार्च 2025 को प्रारंभ किया गया, जिसमें 1:12500 पैमाने पर भूवैज्ञानिक मानचित्रण, पिटिंग तथा तत्पश्चात ड्रिलिंग कार्य संपादित किया गया। यह भूवैज्ञानिक प्रतिवेदन मार्च 2026 में प्रस्तुत किया जा रहा है।

1.1.11 अम्बारा मारू ब्लॉक, गुजरात राज्य के कच्छ जिले के नखत्राणा तहसील में स्थित है तथा यह सड़क मार्ग से सुगम रूप से जुड़ा हुआ है। इस क्षेत्र तक भुज से नखत्राणा–रावापर–माता नो माध मार्ग द्वारा पहुँचा जा सकता है तथा राष्ट्रीय राजमार्ग NH-754K ब्लॉक से लगभग 3 किमी दूरी पर स्थित है। रावापर ग्राम से माता नो माध की दिशा में पक्की सड़क द्वारा ब्लॉक क्षेत्र तक पहुँचा जा सकता है। जिला मुख्यालय भुज ब्लॉक के दक्षिण-पूर्व दिशा में लगभग 100 किमी दूरी पर स्थित है, जहाँ निकटतम रेलवे स्टेशन एवं हवाई अड्डा उपलब्ध हैं, जो ब्लॉक क्षेत्र को क्षेत्रीय संपर्क प्रदान करते हैं।

1.1.12 अम्बारा मारू ब्लॉक में सामान्यतः हल्की उतार-चढ़ाव वाली स्थलाकृति पाई जाती है, जिसका सामान्य ढाल उत्तर एवं उत्तर-पूर्व दिशा की ओर है। ब्लॉक क्षेत्र में ऊँचाई लगभग 20 मीटर से 115 मीटर के मध्य समुद्र तल से ऊपर पाई जाती है। क्षेत्र का अपवाह मुख्यतः गजांसर नदी एवं अन्य छोटी मौसमी जलधाराओं द्वारा नियंत्रित है, जो डेंड्रिटिक से स्थानीय रूप से ट्रेलिस प्रकार के अपवाह प्रतिरूप का निर्माण करती हैं। भूवैज्ञानिक दृष्टि से यह ब्लॉक कच्छ बेसिन के उत्तरी भाग में स्थित है तथा यह कट्रोल फॉर्मेशन (जुरासिक) एवं भुज फॉर्मेशन (क्रेटेशियस) की अवसादी शैलों द्वारा अधोस्थित है। शैल स्तर सामान्यतः क्षैतिज से मृदु प्रवण होते हैं तथा क्षेत्रीय संरचनात्मक प्रवृत्तियाँ गुनेरी डोम जैसी संरचनाओं से प्रभावित होती हैं।

1.1.13 कच्छ बेसिन के कट्रोल फॉर्मेशन में ग्लॉकोनाइट खनिजीकरण मुख्यतः सूक्ष्म से मध्यम कण आकार वाले बलुआ पत्थरों तथा धूसर शेल में पाया जाता है, जो स्थानीय रूप से फेरीजिनस एवं फेल्डस्पैथिक प्रकृति के होते हैं। ग्लॉकोनाइट सामान्यतः हरित कणों एवं दानों के रूप में बलुआ पत्थर के मैट्रिक्स में प्रसारित अवस्था में उपस्थित होता है तथा कुछ विशिष्ट स्तरीय स्तरों में संकेंद्रित पाया जाता है।मेजबान शैलोंमें संस्तरण, क्रॉस-संस्तरण एवं रिपल मार्क्स जैसी सामान्य अवसादी संरचनाएँ पाई जाती हैं, जो तरंगों, ज्वार-भाटा एवं आंशिक तूफानी गतिविधियों से प्रभावित उथले समुद्री शेल्फ निक्षेपण परिवेश को इंगित करती हैं। ग्लॉकोनाइट

का निर्माण सामान्यतः धीमी अवसादन दर एवं अवसादों तथा समुद्री जल के दीर्घकालिक परस्पर क्रिया से संबंधित होता है, जो स्वजनित (authigenic) ग्लॉकोनाइट के विकास हेतु अनुकूल परिस्थितियाँ प्रदान करता है। कच्छ बेसिन की क्षेत्रीय स्तरिकी में कट्रोल फॉर्मेशन लेट जुरासिक काल के समुद्री सिलिसीक्लास्टिक निक्षेपण का प्रतिनिधित्व करता है, जहाँ ग्लॉकोनाइटिक स्तर बेसिन में समुद्री अभिगमन (marine transgression) के चरणों को सूचित करते हैं।

1.1.14 अम्बारा मारू ब्लॉक में ग्लॉकोनाइट खनिजीकरण कट्रोल फॉर्मेशन के अंतर्गत स्तरीय रूप से नियंत्रित स्तरों तक सीमित है। ये स्तर ब्लॉक स्तर पर पार्श्व सततता प्रदर्शित करते हैं तथा पुरापर्यावरणीय व्याख्या (paleoenvironmental interpretation)के लिए महत्वपूर्ण हैं। पोटाश-युक्त ग्लॉकोनाइटिक संसाधन के रूप में इनकी आर्थिक संभाव्यता का मूल्यांकन विस्तृत अन्वेषण, ग्रेड आकलन एवं beneficiation अध्ययनों के माध्यम से किया जाना अपेक्षित है।

1.1.15 अम्बारा मारू ब्लॉक में ग्लॉकोनाइट, फॉस्फोराइट एवं REE स्तरों तथा उनसे संबंधित संरचनात्मक विशेषताओं की अभिसीमन (delineation) हेतु 1:12,500 पैमाने पर भूवैज्ञानिक एवं संरचनात्मक मानचित्रण संपादित किया गया। इसका उद्देश्य सतही अभिव्यक्तियों की पहचान करना तथा खनिजीकृत क्षेत्रों की पार्श्व एवं ऊर्ध्वाधर सततता को समझना था। भू-रासायनिक सैम्पलिंग के दौरान 135 बेडरॉक नमूने, 74 पिट नमूने तथा 119 बोरहोल नमूने एकत्रित कर आठ प्रमुख ऑक्साइड (major oxides) हेतु विश्लेषित किए गए। कुल 328 प्राथमिक नमूनों के साथ 34 बाह्य जाँच सतही नमूनों का विश्लेषण NABL मान्यता प्राप्त बाह्य प्रयोगशालाओं में किया गया। इसके अतिरिक्त, 44 चयनित प्राथमिक नमूनों (18 बेडरॉक, 5 पिट तथा 21 बोरहोल नमूने) का 34 ट्रेस एलिमेंट्स हेतु विश्लेषण MECL प्रयोगशाला में किया गया।

1.1.16 सभी प्राथमिक नमूनों का विश्लेषण आठ प्रमुख रासायनिक अवयवों, जिनमें K_2O भी सम्मिलित है, हेतु मिनरल एक्सप्लोरेशन एंड कंसल्टेंसी लिमिटेड(MECL), नागपुर (महाराष्ट्र) की रासायनिक प्रयोगशाला में किया गया। सभी बाह्य जाँच नमूनों का विश्लेषण जवाहरलाल नेहरू एल्यूमिनियम रिसर्च डेवलपमेंट एंड डिज़ाइन सेंटर, नागपुर में, जो कि NABL मान्यता प्राप्त प्रयोगशाला है, संपादित किया गया।

1.1.17 अम्बारा मारू ब्लॉक में ड्रिलिंग कार्य 15 दिसम्बर 2025 से 12 जनवरी 2026 के मध्य संपादित किया गया, जिसके अंतर्गत चार स्काउट बोरहोल (MAMB-01 से MAMB-04) ड्रिल किए गए तथा कुल 160 मीटर ड्रिलिंग की गई। बोरहोलों का विन्यास लगभग 1600 मीटर अंतराल पर किया गया, जो खनिज (खनिजअंतर्स्वतुका साक्ष्य) नियम, 2015के अनुसार G-4 (Reconnaissance) स्तर के अन्वेषण हेतु उपयुक्त है। ड्रिलिंग कार्यक्रम से कुल 119 प्राथमिक कोर नमूने एवं 12 चेक नमूने प्राप्त हुए। प्राथमिक नमूनों का विश्लेषण MECLरासायनिक प्रयोगशाला, नागपुर में आठ प्रमुख ऑक्साइड हेतु किया गया, जबकि चेक नमूनों का विश्लेषण NABL मान्यता प्राप्त प्रयोगशाला, जवाहरलाल नेहरू एल्यूमिनियम रिसर्च

डेवलपमेंट एंड डिज़ाइन सेंटर,नागपुर में किया गया। बोरहोलों द्वारा कट्रोल फॉर्मेशन के अंतर्गत ग्लॉकोनाइट युक्त स्तर (>3% K_2O कट-ऑफ) प्रतिच्छेदित किए गए। भूवैज्ञानिक संसाधनों का आकलन क्रॉस-सेक्शनल विधि (मुख्य) एवं पॉलीगोनल विधि (जांच) द्वारा किया गया, जिसमें भूवैज्ञानिक अनिश्चितताओं को ध्यान में रखते हुए सकल in-situ संसाधन से 20% की कटौती की गई।

1.1.18 क्रॉस-सेक्शनल विधि द्वारा कुल 129.22 मिलियन टन श in-situ Reconnaissance Resources (334 श्रेणी) का आकलन किया गया है, जिसका औसत ग्रेड 3.10% K_2O है। जबकि पॉलीगोनल विधि द्वारा कुल 114.69 मिलियन टन in-situ Reconnaissance Resources (334 श्रेणी) का आकलन किया गया है, जिसका औसत ग्रेड भी 3.10% K_2O है।

1.1.19 क्रॉस-सेक्शनल विधि एवं पॉलीगोनल विधि द्वारा आकलित संसाधनों की तुलना संसाधन अनुमान की विश्वसनीयता के मूल्यांकन हेतु की गई। जांच विधि के रूप में प्रयुक्त पॉलीगोनल विधि द्वारा प्राप्त संसाधन अनुमान, मुख्य विधि क्रॉस-सेक्शनल विधि की तुलना में 5.95% कम पाया गया। यह अंतर स्वीकार्य सीमा के अंतर्गत है, जिससे संसाधन आकलन की विश्वसनीयता एवं सटीकता की पुष्टि होती है।

1.1.20 वर्तमान अन्वेषण कार्यक्रम के परिणामों के आधार पर यह ब्लॉक ग्लॉकोनाइट खनिजीकरण की दृष्टि से संभावनाशील है तथा चिन्हित सकारात्मक क्षेत्रों में इसे उच्च स्तर के अन्वेषण हेतु उन्नत किए जाने योग्य माना जा सकता है। इस ब्लॉक को आगे चलकर केंद्रीय सरकार द्वारा क्रिटिकल एवं स्ट्रेटेजिक मिनरल फ्रेमवर्क के अंतर्गत नीलामी हेतु प्रस्तावित किया गया है। विस्तृत अन्वेषण के अंतर्गत Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM–EDS) तथा द्विमोडीय कण आकार विश्लेषण (bimodal grain size analysis) किए जाने की अनुशंसा की जाती है, जिससे ग्लॉकोनाइट को संबद्ध फेल्डस्पार एवं माइका चरणों से पृथक एवं प्रमाणित किया जा सके।

GEOLOGICAL REPORT ON RECONNAISSANCE SURVEY (G-4 STAGE) FOR GLAUCONITE, PHOSPHORITE & REE IN AMBARA MARU BLOCK (Area-94.25 Sq Km) TEHSIL-NAKHATARANA, DISTRICT- KACHCHH, GUJARAT

CHAPTER-1

EXECUTIVE SUMMARY

1.1.1 Glauconite is a potassium-bearing green silicate mineral commonly occurring in marine sandstone and shale horizons of the Mesozoic succession of the Kachchh Basin (Kutch Supergroup/Group). In the Ambara Maru area it occurs within glauconitic sandstone horizons of the Katrol Formation. Glauconite is considered an important natural source of potassium and is used as a soil conditioner and slow-release potash fertilizer. Potassium is one of the three essential plant macronutrients (N–P–K) and plays a critical role in enzyme activation, water regulation, photosynthesis, and protein synthesis, thereby improving crop yield and plant health.

1.1.2 The importance of potassium in agriculture has led to the steady growth of the global potash industry. According to the United States Geological Survey (USGS, Mineral Commodity Summaries, 2025), the global potash production capacity was about 65.2 million tonnes of K_2O in 2024, and it is projected to increase to approximately 76 million tonnes of K_2O by 2028. This increasing demand for potassium fertilizers has encouraged exploration for alternative potassium resources such as glauconite-bearing sandstones, particularly in sedimentary basins like the Kachchh Basin of western India.

1.1.3 At present, the global supply of potash is mainly derived from marine evaporite deposits and potash-rich brine resources. The principal potash minerals include sylvite (KCl), carnallite ($KMgCl_3 \cdot 6H_2O$), kainite ($KMg(SO_4)Cl \cdot 3H_2O$), and polyhalite ($K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$), which occur as bedded evaporite layers or dissolved in subsurface brines. These deposits are processed to produce potassium chloride (Muriate of Potash – MOP) and potassium sulphate (SOP), the most widely used potash fertilizers. Global production is highly concentrated, with the majority of potash supplied by a few countries such as Canada, Russia, Belarus, China, Germany, Chile, and the United States, resulting in supply dependence for many potash-importing nations.

1.1.4 India is one of the largest consumers of potash fertilizers, but it does not have economically workable evaporite potash deposits, making the country largely dependent on imports. To reduce this dependence, exploration of alternative indigenous potassium sources such as glauconite, feldspar, and mica has gained importance. Among these, glauconitic sandstone occurring in several Indian sedimentary basins, including the Kachchh Basin, is considered a promising non-conventional source of potash. Glauconite is a potassium-bearing green mineral formed under marine shelf conditions and occurs within sandstone and shale horizons. In India, large resources of glauconitic sandstone with K_2O generally ranging between about 4–8% have been reported from states such as Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan, and Gujarat. The exploration of such deposits supports the national goal of reducing potash import dependence and strengthening long-term agricultural nutrient security, and has received policy support under recent initiatives promoting exploration of critical and strategic minerals.

1.1.5 To meet critical mineral needs, the Government of India conducts tranche-based auctions of strategic mineral blocks, having completed five tranches with a sixth underway. These auctions encompass lithium, REEs, glauconite, graphite, vanadium, nickel, cobalt, and phosphorite—resources essential for clean energy technologies and fertilizer security. Transparent allocation, private sector participation, and active involvement of agencies like MECL strengthen decarbonization efforts, build resilient supply chains, and advance sustainable economic growth.

1.1.6 The Ambara Maru Block is located in the northern part of the Kachchh Basin, Gujarat. The stratigraphic succession of the Kachchh Basin comprises the Pachcham, Chari, Katrol, and Umia Formations. The Rann of Kachchh and the Kachchh Peninsula together cover an area of approximately 45,612 sq km in the north-western part of India. Physiographically, the Kachchh region is characterized by prominent hill ranges, gently sloping peripheral coastal tracts, dissected coastal erosional plains, and younger geomorphic units such as deltaic plains, tidal flats, spits, and marginal accretionary zones. The basin is underlain by the Kachchh Supergroup of rocks, which is well known for its mineral potential, particularly for glauconitic sandstone.

1.1.7 Occurrences of glauconitic sandstone have been reported from both the Umia (Bhuj) Formation and the Katrol Formation. The Ambara Maru Block, covering an area of 94.25 sq km, was subjected to Reconnaissance Survey by MECL. The block area is predominantly occupied by lithounits of the Katrol Formation, assigned to the Late

Jurassic to Early Cretaceous age. Within the block, the Katrol Formation is well developed and comprises a varied assemblage of lithologies, including glauconitic sandstone,Feldspathic sandstone, Ferruginous sandstone, shale with calcareous sandstone, Kaolinitic clay, and shale with plant fossils.

1.1.8 The Ambara Maru Block forms part of the regional glauconitic sandstone horizon belt of Kachchh District, Gujarat, and falls within the Survey of India Toposheet Nos. 41E/02 and 41E/03. The present Reconnaissance survey in Ambara Maru Block has been proposed in the SE of GSI's report titled "Detailed Investigation for Potash in Glauconite Bearing Shale and Sandstone around Guneri Village of Kachchh District, Gujarat. G-4 block (FSP 2014-15) for potash, where the glauconite bearing shale and sandstone of Katrol and Bhuj Formations of Kachchh basin is found to be present. As per GSI's report, glauconite-bearing shale and sandstone occur within the Katrol and Bhuj (Umia) formations, consisting of ferruginous sandstone, glauconitic sandstone (hard, compact, sandy to clayey), and feldspathic sandstone—indicating strong potential for fertilizer mineral exploration.

1.1.9 The Reconnaissance survey proposal for Glauconitic, Phosphorite and REE in Ambara Maru Block, Kachchh District, Gujarat was submitted in was recommended in TCC-IIMeeting of NMEDTand was approved by 39th EC meeting of NMEDT on 24thJanuary 2025. Sanction Order was issued on 24thFebruary 2025. The program was scheduled for 10 months (up to 23rdDecember 2025), later extended by three months (up to 31st March 2026).

1.1.10 The area of the exploration block is 94.25sq. km, Field operation was initiated by MECL on30th March 2025, carried out geological mapping on 1:12500 scale, pitting and subsequently carriedout drilling. The Geological Report is being submitted in March 2026.

1.1.11 The Ambara Maru Block, in Nakhatrana Tehsil of Kachchh District, Gujarat, is well connected by road. The area can be reached from Bhuj via Nakhatrana–Rawapar–Mata no Madh road, and National Highway NH-754K passes about 3 km from the block. Rawapar village provides the nearest approach to the block through a metalled road towards Mata no Madh. The district headquarters Bhuj lies about 100 km to the south-east, which also hosts the nearest railway station and airport, providing regional connectivity to the block area.

1.1.12 The Ambara Maru Block shows gently undulating terrain with a general slope towards the north and northeast. The elevation within the block ranges from about 20 m to 115 m above mean sea level. The area is mainly drained by Gajansar Nadi and several small seasonal streams, forming a dendritic to locally trellis drainage pattern. Geologically, the block lies in the northern part of the Kachchh Basin and is underlain by sedimentary rocks of the Katrol Formation (Jurassic) and Bhuj Formation (Cretaceous). The strata are generally horizontal to gently dipping, with regional structural trends influenced by features such as the Guneri Dome.

1.1.13 Glauconite mineralisation in the Katrol Formation of the Kachchh Basin occurs mainly within fine- to medium-grained sandstones and grey shales, which are locally ferruginous and feldspathic. The glauconite is typically present as green pellets and grains dispersed within the sandstone matrix and concentrated in certain stratigraphic horizons. The host rocks show common sedimentary structures such as bedding, cross-bedding and ripple marks, indicating deposition in a shallow marine shelf environment influenced by waves, tides and occasional storm activity. The formation of glauconite is generally associated with slow sedimentation and prolonged interaction between sediments and seawater, conditions favourable for authigenic glauconite development. In the regional stratigraphy of the Kachchh Basin, the Katrol Formation represents Late Jurassic marine siliciclastic sedimentation, with glauconitic layers marking phases of marine transgression within the basin.

1.1.14 In the Ambara Maru Block, glauconite mineralization is confined to stratigraphically controlled horizons within the Katrol Formation. These horizons show lateral continuity at the block scale and are significant for palaeoenvironmental interpretation. Their economic potential as a potash-bearing glauconitic resource requires further evaluation through detailed exploration, grade assessment, and beneficiation studies.

1.1.15 Geological and structural mapping was carried out in the Ambara Maru Block on a 1:12,500 scale to delineate the Glauconite, Phosphorite and REE horizon and associated structural features. The objective was to identify surface manifestations and understand the lateral as well as vertical continuity of the mineralized zones. During geochemical sampling, 135 bedrock samples, 74 pit samples, and 119 borehole samples were collected and analysed for eight major radicals (major oxides). In total, 328 primary samples, along with 34 external check surface samples, were analysed for major oxides at NABL-accredited external laboratories.Additionally, 44 selected primary samples (comprising 18 bedrock samples, 5 pit samples, and 21 borehole samples) were analysed for 34 trace elements at the MECL Laboratory.

1.1.16 All primary samples were analysed for eight chemical radicals, including K_2O, at the chemical laboratory of Mineral Exploration & Consultancy Limited (MECL), Nagpur, Maharashtra. All the external check samples were analysed at the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory.

1.1.17 Drilling in the Ambara Maru Block was carried out between 15 December 2025 and 12 January 2026, during which four scout boreholes (MAMB-01 to MAMB-04) were drilled with a total meterage of 160 m. The boreholes were laid out at an approximate spacing of about 1600 m, suitable for G4 (Reconnaissance) level exploration as per the Minerals (Evidence of Mineral Content) Rules, 2015. From the drilling programme, 119 primary core samples and 12 check samples were generated. The primary samples were analysed for eight major oxides at the MECL Chemical Laboratory, Nagpur, while the check samples were analysed at the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory. The boreholes intersected glauconite-bearing horizons (>3% K_2O cut-off) within the Katrol Formation. Geological resources were estimated using both the cross-sectional method (principal) and the polygonal method (check), with 20% deduction applied to the gross in-situ resource to account for geological uncertainties.

1.1.18 A total of **129.22 million tonnes** of Net in-situ Reconnissance Resources (334 category) with average grade of **3.10%K_2O**have been estimated by cross sectional method.However**,** total of **114.69 million tonnes** of Net in-situ Reconnaissance Resources (334 category) with average grade of **3.10% K_2O** has been estimated by polygonal method.

1.1.19 The resource estimated through the Cross-Sectional Method and Polygonal Method were compared to assess the confidence level of the estimation. The polygonal Method, used as the check approach, yielded a resource estimate 5.95% lower as compare to the Cross-Sectional Method which is principal method. This variance falls within the permissible limits, confirming the reliability and accuracy of the resource estimation.

1.1.20 Based on the outcome of the current exploration program, the block demonstrates promising glauconite mineralization and may be considered for upgradation to a higher level of exploration in identified positive zones. The block is subsequently planned for auction by the Central Government under the critical and strategic mineral framework. It is recommended that detailed exploration include Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM–EDS) and bimodal grain size analysis to validate and distinguish glauconite from associated feldspar and mica phases.

CHAPTER-2

2.0.0 DETAILS OF THE QUALIFIED PERSON(S) / EXPLORATION AGENCY

2.1.0 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

Maharashtra, India.

2.2.0 PERSONNEL ASSOCIATED WITH EXPLORATION

Exploration agency: Mineral Exploration and Consultancy Limited

Experience: 51 Years, Since 1972

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

Sl.No.	Name of the Person	Designation	Qualification	Experience
1	Shri Shrikant Sharma	HOD (Exploration)	M.Sc. Geology	23 Years
2	Shri P. Ravindran	GM (Exploration) Rtd.	M.Sc. Geology	35 Years
3	Shri Naveen Pala	Sr. Manager (Geology)	M.Sc. Geology	21Years
4	Shri Bhuneshwar Kumar	Manager (Geology)	M.Sc. Geology	20 Years
5	Shri J. Madhu Babu	Manager (Geology)	M.Sc. Geology	10 Years

CHAPTER-3

3.0.0 TITLEAND OWNERSHIP

3.1.0 Report Title: Geological Report on Reconnaissance Survey (G-4 Stage) For Glauconite, Phosphorite and REE in Ambara Maru Block (Area-94.25Sq Km), Tehsil-Nakhatrana, District- Kachchh, Gujarat

Ownership: Governmentof Gujarat

Name of 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

Address of Prospector: Dr. Babasaheb Ambedkar Bhavan, High Land Drive Road, Seminary Hills, Nagpur, Pin- 440006, Maharashtra, India

E-mail of Prospector: cmd@mecl.gov.in; gm-exploration@mecl.gov.in

Telephone numbers of Prospector: 0712-2510289; 0712-2511829

3.2.0 DETAILS ABOUT PERIOD OF PROSPECTING

The exploration programme in the block commenced on 30th March 2025 with geological mapping at a 1:12,500 scale. This was followed by pitting and exploratory drilling, during which DGPS surveying and borehole core sampling were undertaken in parallel to support accurate documentation. Analytical and laboratory investigations were then carried out in MECL laboratories and other NABL-accredited laboratories to generate reliable geochemical and petrological data.

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

3.3.1 **Exploration Agency:** Mineral Exploration and Consultancy Limited
(Formerly Mineral Exploration Corporation Limited)
A Govt. of India Enterprise-A Miniratna-ICPSE

3.3.2 Qualification : M.Sc. /M. Sc. Tech. (Geology)

3.3.3 Experience: Experience: Since 1972

CHAPTER-4

4.0.0 DETAILS OF THE AREA

4.1.0 LOCATION AND ACCESSIBILITY OF THE BLOCK

4.1.1 The Ambara MaruBlock is located in Nakhatrana Taluka, Kachchh District, Gujarat, on the western part of the Kachchh mainland. It lies near the villages of Ambara, Maru, Ludbay, Deshalpur, Jinjay, Taraf Manjali (OG), Vigodi, and Ratadiya villages. The total area of the block is about 94.25sq km.

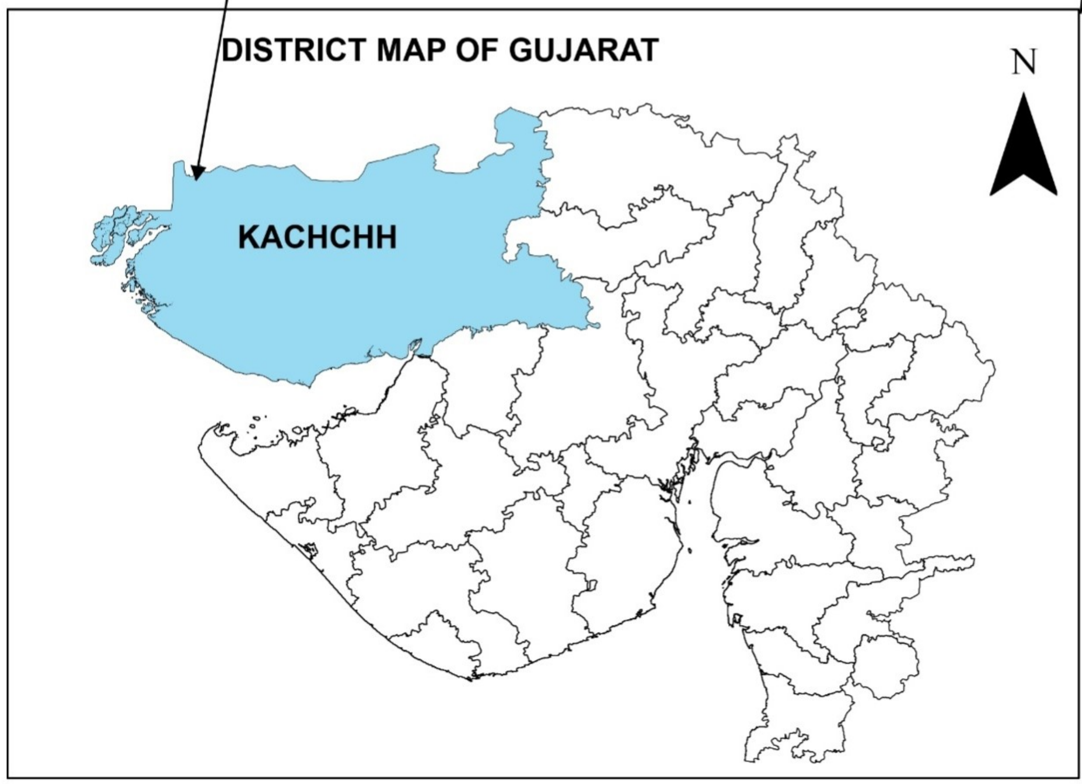
4.1.2 The Exploration blockfalls in parts of the Survey of India Toposheet No. 41E/02 and 41E/03and it lies between 23°29′04.03″to 23°35′16.66″latitudes and 69°05′25.56″to 69°11′36.02″longitudes.The Location Map is given in Plate-I and Text Fig. 4.1. The co-ordinates of the corner points of the block area given in table No.- 4.1 and in Annexure IA.

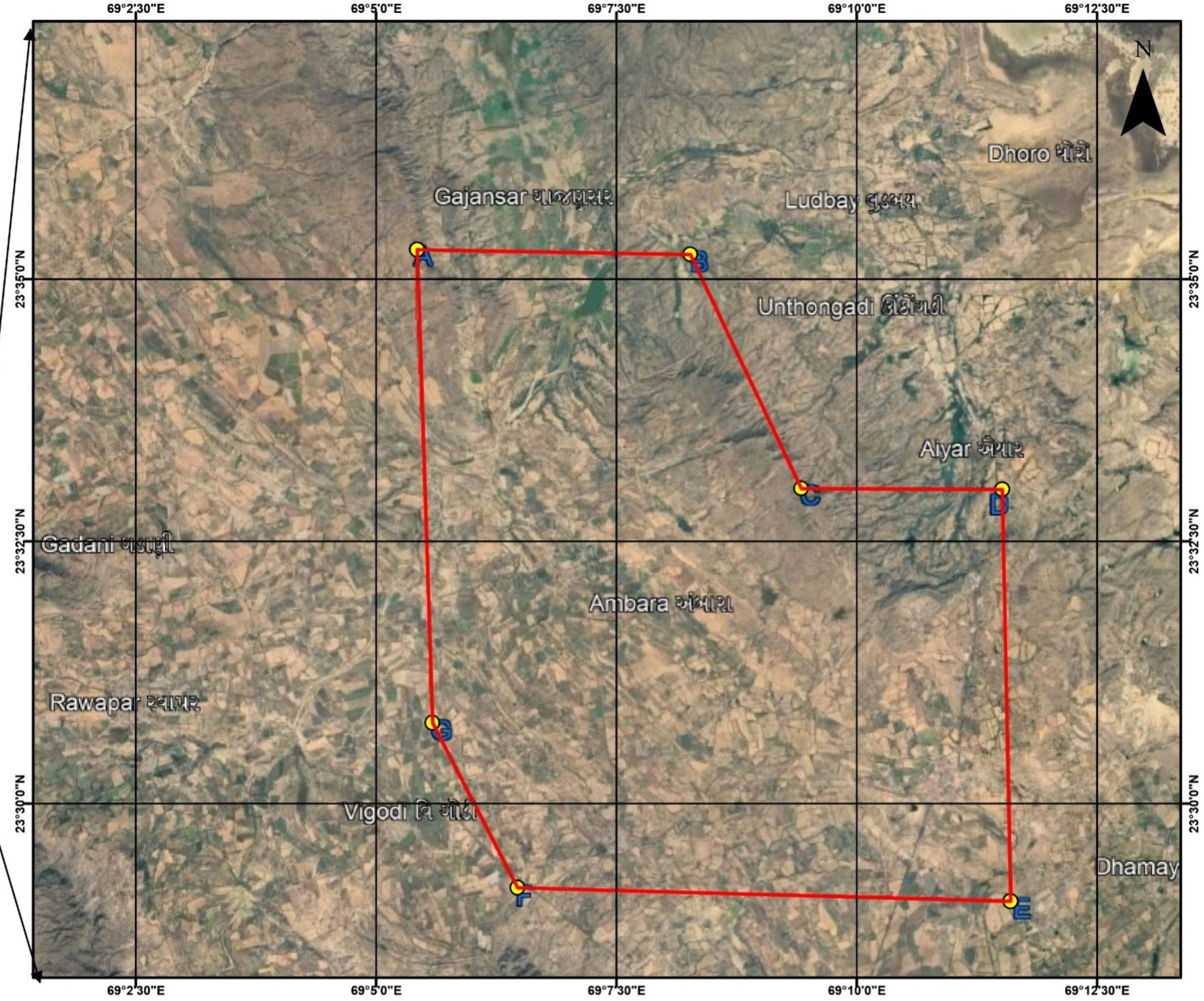
Table No.-4.1
Co-ordinates of cardinal points of block boundary of Ambara Maru Block for Glauconite, Phosphorite and REE, District: Kachchh, Gujarat

Points	Latitude	Longitude
A	23°35'16.66"	69°05'25.56"
B	23°35'13.95"	69°08'16.09"
C	23°33'00.19"	69°09'25.38"
D	23°32'59.44"	69°11'30.61"
E	23°29'04.03"	69°11'36.02"
F	23°29'11.63"	69°06'28.29"
G	23°30'45.97"	69°05'35.28"

4.1.3 The block is accessible from Bhuj, the district headquarters, via Devpar, Nakhatrana, and Ugedi through National Highway (NH)-754K, which provides direct connectivity to the block area. Nakhatrana Tehsil is situated approximately 28 km from the block, while Bhuj town lies about 100 km to the southeast. The nearest railway station is Bhuj, located around 100 km southeast of the block. Bhuj Railway Station is a Class-A station under the Western Railway network. The nearest airport is Bhuj Airport, also approximately 100 km southeast of the block.

LOCATION MAP OF PROPOSED AMBARA MARU BLOCK (AREA:94.25 Sqkm),TEHSIL: NAKHATRANA DISTRICT:KACHCHH, GUJARAT





NOT TO SCALE

INDEX

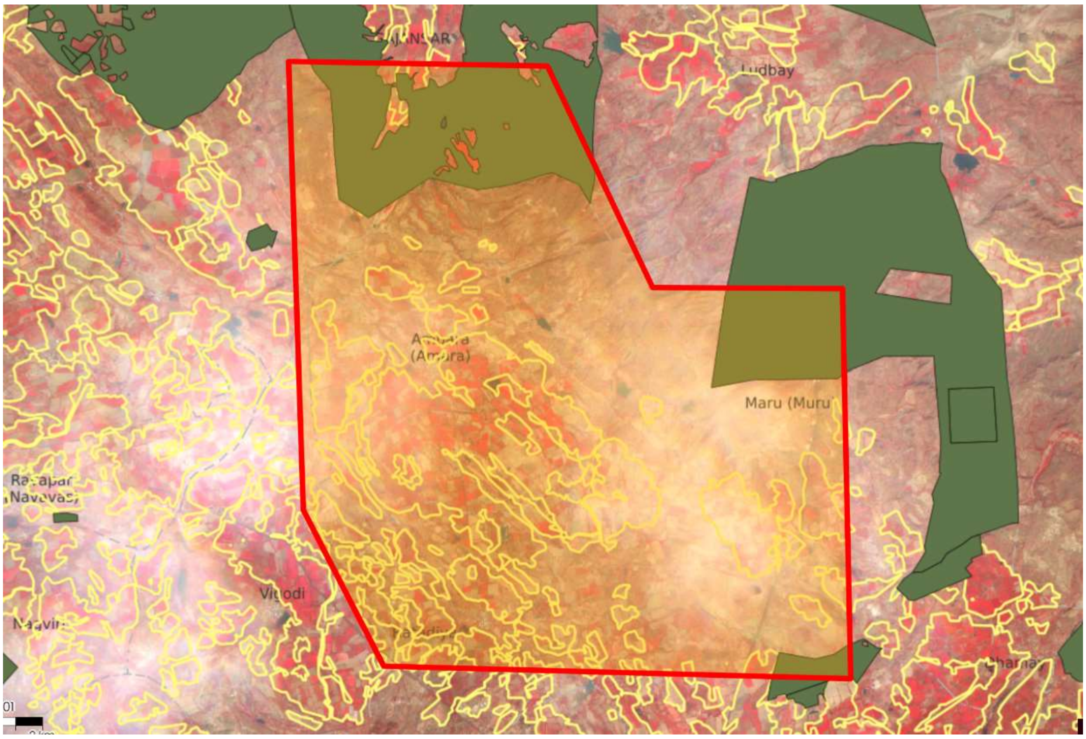
- Ambara Maru Block_Boundary
- Cardinal Points of Ambara Maru Block Boundary

Cardinal Points	Northing (m)	Easting (m)	Latitude	Longitude
A	2608612.343	509227.1079	23°35'16.66"	69°05'25.56"
B	2608532.862	514060.4133	23°35'13.95"	69°08'16.09"
C	2604421.206	516028.891	23°33'00.19"	69°09'25.38"
D	2604402.679	519579.1981	23°32'59.44"	69°11'30.61"
E	2597163.564	519742.3847	23°29'04.03"	69°11'36.02"
F	2597388.087	511013.394	23°29'11.63"	69°06'28.29"
G	2600288.275	509508.0633	23°30'45.97"	69°05'35.28"

Text Figure-4.1: Location Map of Ambara Maru Block, District: Kachchh, Gujarat

4.2.0 DETAILS OF THE AREA WITH LAND USE

4.2.1 The block area includes agricultural land (yellow colour)and a small portion of forest (green colour), with agriculture being the dominant land use across the region.



Text Figure-1.1 Map showing the Land-use for the Ambara Maru Block and surrounding area (Source: PM Gatishakti Portal)

4.3.0 MINERAL(S) UNDER INVESTIGATION

4.3.1 Block was explored for glauconite, phosphorite, and rare earth elements (REE). Based on the results of the present exploration, glauconite mineralization has been identified within the block area. However, no promising zones for phosphorite and REE mineralization have been identified at the current stage of investigation.

CHAPTER-5

5.0.0 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 The Ambara Maru Block, covering an area of about 94.25 sq km and falling in Nakhatrana Taluka of Kachchh District, is situated in the western part of the Kachchh Mainland. The terrain is characterized by gently undulating surfaces with intervening rocky uplands and Quaternary plains, typical of the stable mainland uplift of Kachchh. Based on interpretation of regional satellite data, the area shows a general north to northeastward regional slope. The block area exhibits gently undulating topography with a general regional slope towards the north and northeast. The highest elevation within the block is 115 m in the north eastern part, while the lowest elevation is 20 m in the northern part of the block.

5.1.2 The area is drained by the Gajansar Nadi along with several second- and third-order streams. The drainage pattern is predominantly dendritic, with local development of a trellis pattern. The presence of trellis drainage suggests structural control in parts of the area, likely influenced by alternating resistant and less resistant lithological units and/or joint and fracture systems. The sub-parallel alignment of tributaries indicates that stream courses are guided by structural discontinuities such as bedding planes, faults, or fractures.

5.1.3 No major perennial rivers or large reservoirsare present within the block boundary. Surface water bodies are limited to seasonal streams, minor check dams, and village ponds (talavs) developed for rainwater harvesting in nearby habitations. During the monsoon season, temporary water accumulation occurs along stream channels and low-lying depressions, while most channels remain dry during the summer months. Overall, the area represents a semi-arid fluvial landscape with moderate relief and structurally influenced drainage characteristics.

5.2.0 ROADS, RAILWAY TRACK, ELECTRIC TRANSMISSION LINE, TELEPHONE LINE, WIND FARMS, SOLAR FARMS ETC.

5.2.1 The block is well connected by road network. National Highway NH-754K passes in proximity to the area and provides connectivity from Bhuj to Nakhatrana and adjoining villages. From the highway, the block can be accessed through a network of metalled district roads and village roads. Internal access within the block is facilitated by kutcha tracks and cart roads connecting agricultural fields and settlements.

5.2.2 No railway track passes through the block area. The nearest railway station is located at Bhuj, approximately 100 km to the southeast, which lies on the Western Railway network. Bhuj railway station serves as the nearest railhead for transportation of heavy equipment and bulk materials required for mining activities.

5.2.3 Electric power infrastructure is available in the surrounding villages. Overhead electric transmission and distribution lines, including 11 kV and higher-capacity lines, pass through or near habitation areas adjoining the block. Power supply is presently utilized for domestic and agricultural purposes. Extension of electricity for exploration or future mining operations can be facilitated from the existing grid network.

5.2.4 Telecommunication facilities are available in the region. Mobile network coverage is present in and around the block area, and telephone lines are established in nearby villages as part of the regional communication infrastructure. Internet connectivity is accessible through mobile networks, ensuring adequate communication facilities for field operations.

5.2.5 The Ambara-Muru-Aiyar cluster in Bhuj, Gujarat, serves as a high-density renewable energy hub, hosting an estimated 80–120 wind turbines with a combined capacity of 250–300 MW. Major developers, including Suzlon, Adani Green, and Alfanar

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

5.3.1 The Ambara–Maru Block lies within the rural administrative jurisdiction of Nakhatrana Taluka, Kachchh District, Gujarat. According to the Census of India 2011, Nakhatrana Taluka comprises entirely rural habitation with a total population of approximately 146,367 persons residing across 132 villages, and a sex ratio of 968 females per 1,000 males. Scheduled Castes constitute about 17.3 % of the total taluka population, while Scheduled Tribes account for approximately 1 %.

5.3.2 Within and adjacent to the block boundary, several medium-to-large villages serve as the primary host population centres. Ambara village, which lies near the northern sector of the block, had a total population of 1,637 persons in 2011, with Scheduled Castes accounting for 6.3 % and no resident Scheduled Tribe population recorded. Devpar village, located to the west, had 3,005 inhabitants, with SC representing 15.5 % and a small ST component of about 0.37 %. Maru village in the southern vicinity had 1,138 persons with a high SC proportion of approximately 43.2 %, and no ST population reported.

5.3.3 These villages are predominantly rural agricultural settlements with traditional livelihoods focussed on farming, livestock rearing and related activities. No major urban centre exists within the block; the nearest significant rural centre is Nakhatrana village (population ~17,478), which functions as the taluka headquarters and main service hub for surrounding habitations. The demographic composition indicates a mixed socio-cultural population, with Scheduled Castes forming a significant local segment and a small presence of Scheduled Tribes consistent with the broader taluka profile.

5.4.0 SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

5.4.1 The Ambara–Maru Block lies in a predominantly rural region of Nakhatrana Taluka. As per Census 2011, Nakhatrana Taluka has a total population of approximately 1.46 lakh persons distributed across more than 130 revenue villages. The population is entirely rural in character, with agriculture, livestock rearing, and allied activities forming the principal sources of livelihood. Rain-fed farming and pastoral practices are common due to semi-arid climatic conditions.

5.4.2 The sex ratio of the taluka is approximately 968 females per 1,000 males, which is comparable to the district average. The literacy rate is moderate, with male literacy higher than female literacy, reflecting the general rural demographic pattern of western Kachchh. Educational facilities are available at the village and taluka headquarters level, while higher education and specialized institutions are located at Bhuj.

5.4.3 Scheduled Castes (SC) constitute a significant proportion of the population in the taluka, accounting for roughly 17–18 percent of the total population as per Census 2011. Scheduled Tribes (ST) form a relatively small component (around 1 percent) of the taluka population. In villages located near the block boundary, SC population percentage varies, while ST presence is minimal. The demographic structure reflects a mixed rural social composition typical of Kachchh district.

5.4.4 The villages situated within and around the block area are small to medium-sized nucleated settlements. Housing patterns are generally compact within village limits, surrounded by agricultural fields and grazing land. Basic civic amenities such as primary schools, drinking water supply, electricity, and rural road connectivity are available in most villages as per government village directory records. Healthcare and administrative facilities are primarily concentrated at Nakhatrana town, which serves as the nearest taluka headquarters and service centre.

5.4.5 No major urban settlement, industrial township, or densely populated habitation falls within the block boundary. The overall population density in the immediate block vicinity is low to moderate, and the area does not fall under any notified metropolitan or urban agglomeration. From a socio-economic perspective, the region represents a stable rural setting with limited industrial development and dependence on primary sector activities.

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

5.5.1 As per records of the Archaeological Survey of India (ASI) and the State Department of Archaeology, no centrally protected monument or ASI-notified archaeological site is located within the immediate boundary of the Ambara–Maru Block. The block area primarily comprises agricultural land, scrub terrain, and small village habitations.

5.5.2 Places of worship within the block are limited to local village temples and community shrines maintained by the resident population; no nationally or state-notified pilgrimage centre or protected religious monument falls within the block limits as per district records and village directories. These village religious structures are small in scale and centred on the nucleated habitations at the block margins.

5.5.3 Public utilities in and around the block are limited to basic rural facilities as recorded in government village directories. These include primary schools in villages, primary health sub-centres in larger settlements, drinking water supply through tube wells, hand pumps, and village tanks, and electricity supply under rural electrification schemes. Higher-level facilities such as sub-district hospitals, major administrative offices, secondary and higher educational institutions are available at Nakhatrana (taluka headquarters) and Bhuj (district headquarters). No major industrial establishment, large public utility infrastructure, or central government installation is located within the block boundary.

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

5.6.1 The block area falls in a semi-arid region characterized by sparse vegetation, scrubland, and revenue wasteland. No National Park is located within or adjoining the block boundary. The nearest notified protected areas in Kachchh District include the Kachchh Desert Wildlife Sanctuary, the Narayan Sarovar Wildlife Sanctuary, and the Kachchh Bustard Sanctuary. These protected areas are situated at considerable distances from the block and do not overlap with the block area.

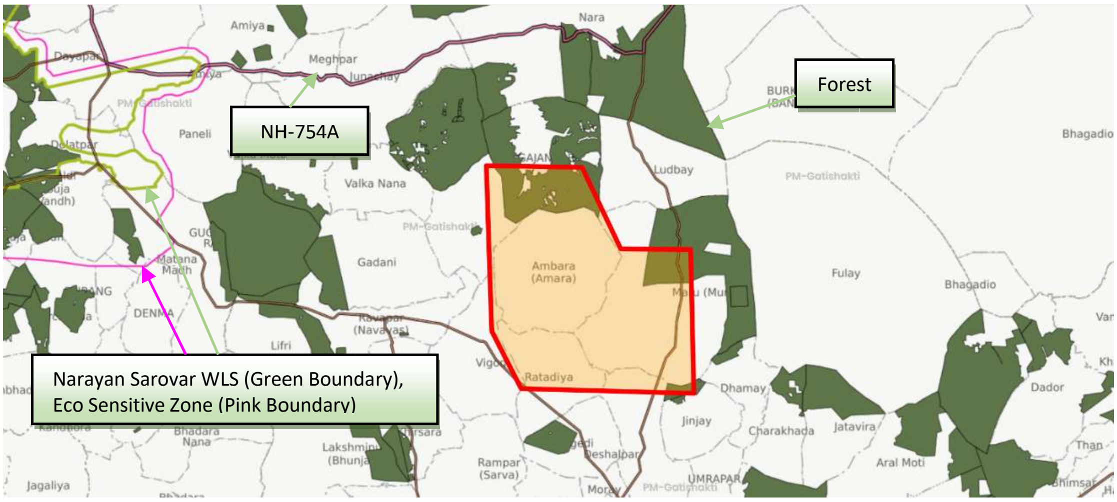
The block lies in proximity to two major protected areas:

- **Narayan Sarovar Wildlife Sanctuary:**The Narayan Sarovar Wildlife Sanctuary, located to the southwest of the Ambara Maru Block, is a notified Protected Area under the Wildlife Protection Act and covers approximately 444 sq km. The sanctuary represents a typical arid–desert ecosystem with dominant vegetation comprising desert thorn scrub, Euphorbia scrub, and dry savannah communities. The principal flora includes species of Acacia (notably Acacia nilotica), Salvadora, Ziziphus, Capparis, various Euphorbia species, and scattered patches of Prosopis which has been recorded as invasive in parts of the sanctuary. The fauna is characteristic of the arid biome and includes

Chinkara (Indian Gazelle), Blackbuck, Nilgai (Bluebull), Indian Fox, Desert Fox, Striped Hyena, Caracal, Indian Wolf, Indian Hare, Porcupine, Wild Boar, and small carnivores such as the Indian Grey Mongoose. The sanctuary also supports rich avifaunal diversity, with more than 160 species reported, including raptors, bustards, migratory waterbirds, and other desert-adapted bird species. Recent survey records (2020–2023) from the Gujarat Forest Department, ZSI, and regional checklists confirm continuing presence of these species groups within the protected area.

- **Kachchh Desert Wildlife Sanctuary:**The Kutch Desert Wildlife Sanctuary is situated approximately 25–30 km east of the Ambara Maru Block and forms India's largest protected saline wetland, spanning nearly 7,506 sq km. The landscape comprises extensive seasonal wetlands, saline plains, mudflats, and desert scrub. Vegetation is dominated by halophytic and xerophytic species such as Prosopis (primarily P. juliflora), Commiphora wightii (Gugal), Euphorbia ("Thor"), Salvadora, Capparis decidua, and Dichrostachys/Senegalia ("Gorad"), representing a typical dry scrub–thorn ecosystem. The fauna includes desert ungulates and carnivores such as the Indian Gazelle, Nilgai, Desert/Indian Fox, Striped Hyena, and occasional Caracal sightings. The sanctuary is internationally known for its large congregations of migratory and resident waterbirds, including Greater and Lesser Flamingos, Pelicans, Cranes, Avocets, and numerous wader and gull species that utilize the seasonal wetland habitats; "Flamingo City" within the sanctuary continues to be a major breeding site during favourable years. Reptilian fauna such as the Spiny-tailed Lizard and other desert-adapted species are also well documented. The ecological influence of this protected wetland extends across the wider Lakhpat–Kutch desert landscape, even though it lies outside the immediate buffer zone of the Ambara Maru Block.

5.6.2 The block does not fall within any notified National Park, Wildlife Sanctuary, Conservation Reserve, or Eco-Sensitive Zone as per district-level protected area maps. There is no record of critical wildlife habitat or designated tiger/elephant corridor within the block limits. (Text Figure-5.1).



Text Figure-5.1 Map showing the status of nearby ESZ and National Park in the vicinity of the Ambara Maru Block (Source – PM Gatishakti Portal)

5.7.0 FLORA AND FAUNA WITHIN AND NEARBY

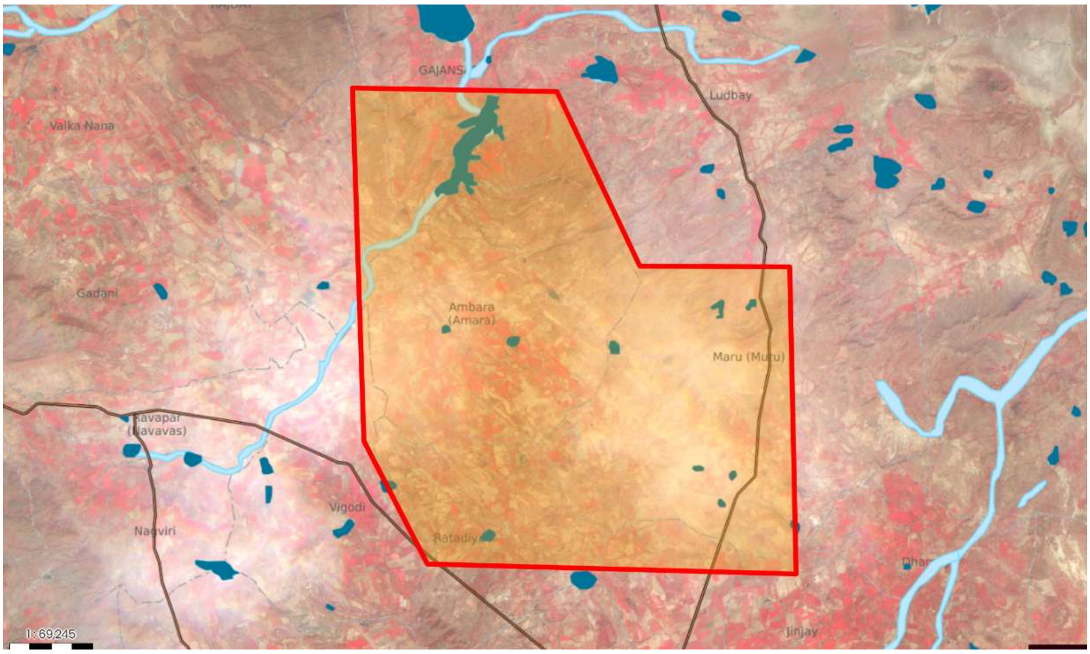
5.7.1 The block area falls within the semi-arid climatic zone of Kachchh District and is characterized by sparse natural vegetation. The predominant vegetation type corresponds to tropical thorn forest and scrub, typical of arid and semi-arid regions of western Gujarat. Common plant species reported in district forest records include Acacia species (e.g., Acacia nilotica, Acacia senegal), Prosopis juliflora (locally introduced), Capparis species, Ziziphus species, Salvadora persica, and various xerophytic shrubs and grasses. Vegetation cover within the block is generally discontinuous and largely confined to scrub patches, field boundaries, and uncultivated wasteland areas. Agricultural land within and around the block supports seasonal crops depending on monsoon rainfall. No National Park, Wildlife Sanctuary, or notified Conservation Reserve is located within the block.

5.7.2 In the surrounding region, two major notified wildlife habitats influence the ecological setting. To the southwest lies the Narayan Sarovar Wildlife Sanctuary (~444 km²), hosting desert-thorn forest with Acacia, Ziziphus, Salvadora, Euphorbia, gugal, and savannah scrub supporting Chinkara, Bluebull, Blackbuck, Caracal, Desert Fox, Striped Hyena, and over 180–200 bird species including desert bustards, harriers, and seasonal waterbirds. Around 25–30 km east of the block lies the Kutch Desert Wildlife Sanctuary (~7,506 km²), characterised by saline wetlands, "bets," and desert scrub with Prosopis, Euphorbia, Commiphora (gugal), Capparis, and halophytes, supporting large congregations of Greater/Lesser Flamingos, pelicans, cranes, waders, Chinkara, Bluebull, foxes, hyenas and desert reptiles. These sanctuaries lie outside the block limits but form the nearest significant ecological receptors, representing sensitive arid-ecosystem biodiversity relevant for regional environmental assessment.

5.8.1 WATER BODIES SUCH AS RIVER, NALA, STREAM, RESERVOIR, ETC., WITHIN OR NEARBY AND CLIMATIC CONDITIONS

5.8.1 The area is drained by the Gajansar Nadi and several second- and third-order seasonal streams. The drainage pattern is predominantly dendritic with localized trellis development, indicating structural control influenced by alternating resistant and less resistant lithologies and associated joints, fractures, or bedding planes. Sub-parallel tributary alignment suggests guidance by structural discontinuities. No major perennial rivers or large reservoirs occur within the block boundary. Surface water is limited to seasonal streams, minor check dams, and village ponds (talavs), with water flow mainly during the monsoon and most channels remaining dry in summer. The area thus represents a semi-arid fluvial terrain with moderate relief and structurally controlled drainage.

5.8.2 The climate in the Ambara Maru Block region is arid to semi-arid, characteristic of the wider Kachchh district. According to long-term climatological data at Bhuj (nearest meteorological station), the annual mean temperature is approximately 26.4 °C. Summers are extremely hot, with peak temperatures reaching about 39–40 °C (sometimes higher), whereas winter temperatures may drop to around 10–12 °C during the coldest nights. Annual rainfall is low and erratic: long-term records suggest an average annual precipitation in the range of ~300–400 mm, with most rainfall concentrated during the southwest monsoon months (June to September). Humidity also shows wide seasonal variation: during pre-monsoon and peak summer the relative humidity may drop to ~25–30%, whereas during monsoon and early mornings it may climb to ~65–75%, leading to average/hypothetical annual humidity around 50–55%.



Text Figure-5.2 Map showing the status of nearby water bodies, streams/ river in the vicinity of the Ambara Maru Block (Source – PM Gatishakti Portal)

5.9.0 OTHER PHYSIOGRAPHIC, SOCIAL AND ENVIRONMENTAL FACTOR

5.9.1 The Ambara–Maru Block, located in Nakhatrana Taluka of Kachchh District, Gujarat, forms part of the semi-arid physiographic terrain of western Kachchh. The area is characterized by gently undulating topography with moderate relief and sandy to sandy-loam soils, with clayey patches in low-lying areas. The climate is hot and dry, with most rainfall received during the southwest monsoon. Surface runoff during monsoon and wind erosion during dry months are the dominant geomorphic processes. Groundwater occurs in weathered and fractured formations and is mainly utilized for domestic and limited agricultural purposes.

5.9.2 Land use within and around the block is predominantly agricultural and grazing. Rain-fed cultivation of millets, pulses, and other seasonal crops is practiced depending on monsoon conditions. The area also includes scrubland and revenue wasteland interspersed with cultivated fields. There is no major industrial activity within the block boundary, and the region retains a predominantly rural and agrarian character.

5.9.3 From a social and environmental perspective, the surrounding villages have a stable rural population dependent on agriculture and animal husbandry. Basic civic amenities such as rural roads, electricity, drinking water supply, and primary education facilities are available in nearby settlements. The block does not fall within any notified national park, wildlife sanctuary, biosphere reserve, or major industrial zone.

CHAPTER-6

6.0.0 INFRASTRUCTURE AND ENVIRONMENT

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

6.1.1 No railway line passes through the block area. The nearest railway station is Bhuj, located approximately 100 km to the southeast, forming part of the Western Railway network. Bhuj railway station functions as the nearest railhead for transportation of heavy machinery, construction materials, and bulk supplies required for exploration or mining operations.

6.1.2 Port infrastructure is available at Kandla Port, situated at an approximate distance of 180 km southeast, and Mundra Port, about 160 km southeast of the block. Both ports are major handling centres for bulk minerals, industrial raw materials, and exports, thereby enhancing logistical viability.

6.1.3 Electric power supply to the area is available through medium- and high-voltage transmission lines aligned along district roads, with substations located at Dayapar and Ghaduli, ensuring reliable power distribution for exploration and ancillary activities. Water availability is limited due to the semi-arid climatic conditions of the region; water requirements are largely met through village talavs, check dams, and borewells, supplemented by transported water from regional sources during dry periods. There is no Eco-Sensitive Zone (ESZ) within the block area. The nearest notified ESZ and Wildlife Sanctuary is the Narayan Sarovar Wildlife Sanctuary.

6.1.4 Telecommunication facilities are available in and around the block area. Mobile network coverage is generally available, and basic telephone connectivity exists in nearby villages. Internet services are accessible through mobile data networks, providing adequate communication support for field operations and project activities.

6.1.5 The Kachchh region hosts several mineral-based and allied industries, including cement plants, ceramic units, fertilizer blending facilities, and salt-based chemical industries, primarily concentrated around Gandhidham, Mundra, and Bhuj.

Glauconite, owing to its potassium and iron content, has potential applications in fertilizer manufacturing, soil conditioning, and ceramic products. The presence of fertilizer units in Gandhidham and ceramic clusters around Bhuj indicates potential regional demand. Additionally, proximity to Mundra and Kandla ports enhances prospects for movement to national and international markets.

CHAPTER-7

7.0.0 GEOLOGY OF THE AREA

7.1.0 REGIONAL GEOLOGY

7.1.1 Regionally, the Ambara MaruBlock is situated in the northern part of the Kachchh Basin, a pericratonic rift basin of western India. Lithostratigraphically, the block forms part of the Katrol Formation, which belongs to the Late Jurassic–Early Cretaceous age. The Kachchh Peninsula and the adjoining Rann of Kachchh cover an area of approximately 45,612 sq km, and are physiographically divided into hill ranges, dissected coastal erosional plains, gently sloping peripheral tracts, tidal flats, deltaic plains, and marginal accretionary zones.

7.1.2 The Kachchh Basin preserves a complete sedimentary sequence from Middle Jurassic to Holocene, with a major unconformity between the Mesozoic and Cenozoic rocks due to non-deposition, tectonism, and volcanism at the close of the Cretaceous. The Mesozoic succession of the Kachchh Basin comprises predominantly marine Jurassic sediments ranging in age from Bajocian–Bathonian to Tithonian, overlain by largely continental Cretaceous deposits of the Bhuj Formation. These sediments were deposited in shallow-marine shelf to deltaic environments and record two major depositional cycles: a Middle Jurassic transgressive cycle followed by a Late Jurassic–Early Cretaceous regressive cycle (Biswas, 1981). The sedimentary sequence rests on a Precambrian granitic basement, which is exposed in the Nagar Parkar Hills of Pakistan and is inferred to underlie the basin elsewhere.

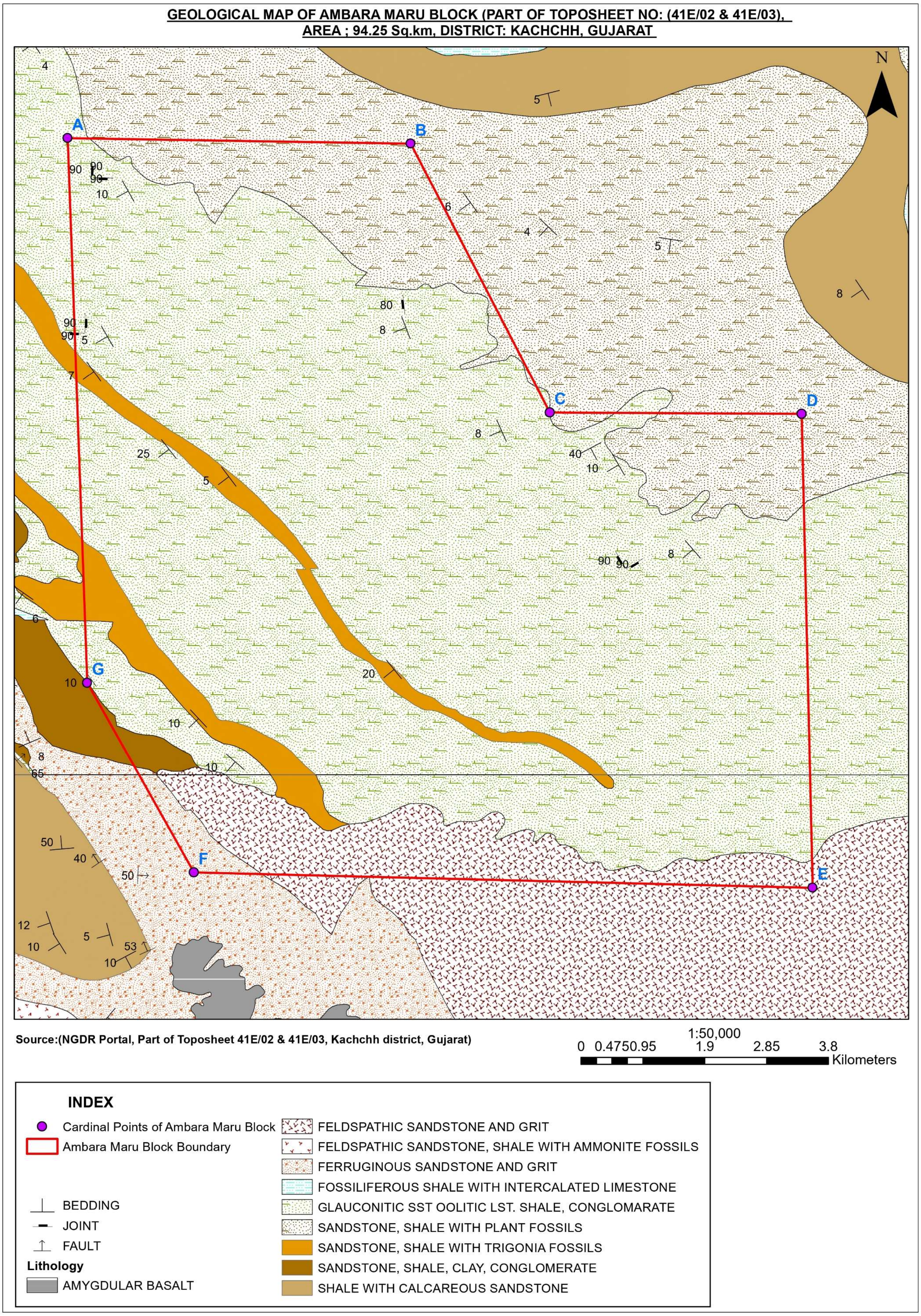
7.1.3 The stratigraphy of the basin is well established, with the Mesozoic units comprising the Pachchham, Chari, Katrol, and Umia Formations. The Katrol Formation, which hosts the Ambara Maru Block, includes red and brown sandstones, shales, and marl, deposited in marginal marine settings. The overlying Umia Formation contains glauconitic sandstones and fossiliferous shales, while the underlying Chari and Pachchham Formations consist of oolitic limestones, marl, and calcareous shales. The Deccan Traps of Late Cretaceous–Early Palaeocene age overlie the Mesozoic units in parts of the basin, followed by Palaeogene and Neogene sediments filling peripheral lows.

7.1.4 The Mesozoic sediments of Kachchh are represented by Pachchham, Chari, Katrol and Umia Formations (after Krishnan, 1982). Krishnan (1982) classified the Mesozoic succession of Kachchh as presented in the below table 7.1-

Table 7.1: Regional Stratigraphic sequence of Litho units (after Krishnan, 1982)

Kachchh Supergroup

Age	Unit	Sub-division	Lithology
Post-Aptian	UMIA (1000 m)	Bhuj beds (Umia Plant beds)	Sandstone and shale
Aptian		Ukra beds	Marine calcareous shale
Upper Neocomial		Umia beds	Barren sandstone and shale
Valanginian		Trigonia beds	Barren sandstone
Upper Tithonian		Umia ammonite beds	Shale and sandstone
Middle Tithonian	KATROL (300 m)	Upper Katrol Shales	Shale
Middle Tithonian		Gajansar beds	Shale
Lower Tithonian		Upper Katrol (Barren)	Sandstone
Middle Kimmeridgian		Middle Katrol	Red sandstone
Upper Oxfordian		Lower Katrol	Sandstone, shale, marl
Oxfordian	CHARI (360 m)	Dhosa Oolite	Green and brownoolitic limestone
U. Callovian		Athleta beds	Marl and gypseous shale
Middle Callovian		Anceps beds	Limestone and marl
Middle Callovian		Rehmani beds	Yellow limestone
Lower Callovian	PACHCHHAM (300 m)	Macrocephalus beds	Shales with calcareous bands and golden oolites
Lower Callovian		Coral bed	Shale and limestone
Lower Callovian to Bathonian		Pachchham shell limestone Patcham basal beds (Kuar Bet beds)	Limestone, shale and marl



Text Figure 7.1: Regional Geological map showing the Ambara Maru Block

MECL

7.2.0 REGIONAL STRUCTURE

7.2.1 The Ambara Maru Block lies within the Kachchh Basin, a pericratonic rift basin along the western continental margin of India, whose structural evolution is governed by basement-controlled extensional tectonics. The basin is dissected by a series of E–W to ENE–WSW and NW–SE trending deep-seated faults, resulting in a mosaic of uplifted structural highs and intervening subsiding depocentres. These basement lineaments exert a first-order control on sediment thickness, facies distribution, and depositional environments of the Mesozoic sedimentary succession.

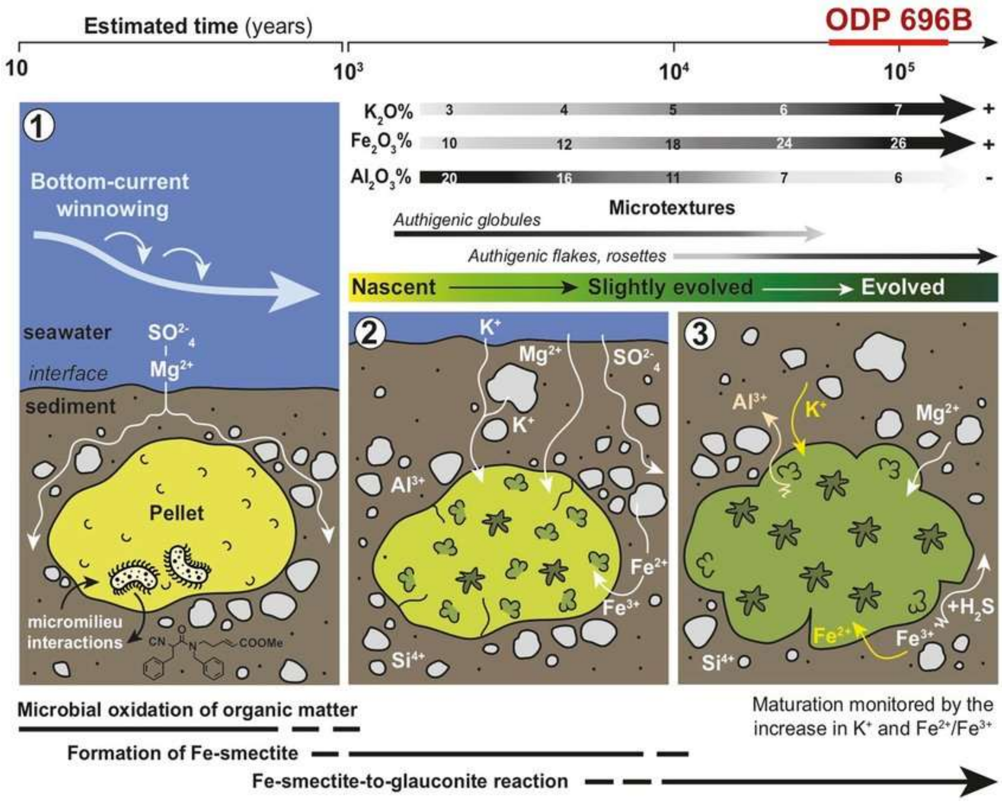
7.2.2 The Mesozoic sequence, including the Katrol Formation, is gently deformed and exhibits low-angle dips with broad open warps. Regional bedding strikes vary from NE–SW to E–W and NW–SE, reflecting the influence of basin-scale structural elements such as domes, flexures, and fault-controlled blocks. Faulting is predominantly normal to oblique-slip, with many faults interpreted as syn-sedimentary growth faults active during Jurassic–Early Cretaceous sedimentation. Post-Mesozoic tectonic events include emplacement of Deccan Trap volcanics during the Late Cretaceous–Early Palaeocene and mild Cenozoic reactivation of older structures, resulting in gentle warping without intense folding or structural disruption.

7.3.0 REGIONAL MINERALIZATION

7.3.1 Glauconite mineralisation in the Ambara Maru Block does not exhibit any direct structural control such as fault-hosted mineralisation or structurally remobilised concentrations. Instead, the mineralisation is stratabound and stratiform, occurring within specific horizons of the Katrol Formation. Regional structural elements have influenced the mineralisation only indirectly, primarily by controlling basin subsidence, accommodation space, sediment supply, and marine transgressive–regressive cycles that governed the depositional environment of glauconite-bearing sediments (after S. K. Biswas, 1981; M. S. Krishnan, 1982).

7.3.2 The sedimentary sequence in the block is gently deformed, with only low-angle dips and broad open warps, and shows no evidence of major post-depositional faulting. This structural simplicity has helped preserve primary bedding features and resulted in good lateral continuity of glauconite-bearing horizons.

7.3.3 Glauconite formation in the Katrol Formation is interpreted to have occurred in shallow marine shelf environments under conditions of slow sedimentation or sediment starvation, typical of condensed sedimentary sequences, where prolonged interaction between seawater and iron-rich clay precursors promotes glauconitisation (after H. Odin & A. Matter, 1981).



7.4.0 Block Geology

7.4.1 The Ambara–Maru Block, falls within the central part of the Kachchh Mainland Basin, Gujarat. The block is underlain predominantly by Mesozoic sedimentary sequences comprising lithounits of the Katrol Formation (Late Jurassic–Early Cretaceous) and the overlying Bhuj Formation (Early Cretaceous).

7.4.2 The Katrol Formation occupies the major part of the block area and represents shallow marine to marginal marine depositional environments. It is characterized by alternating sequences of sandstone and shale, with reported occurrences of glauconitic sandstone horizons. The sandstones are generally fine- to medium-grained, compact to moderately indurated, and at places ferruginous. Shale units are grey to dark grey, occasionally fossiliferous, indicating marine depositional conditions.The presence of glauconitic sandstone within the Katrol sequence is significant from the mineralization perspective and aligns with earlier GSI investigations in adjoining areas.

7.4.3 Glauconite mineralisation within the Katrol Formation of the Kachchh Basin occurs in fine- to medium-grained sandstones and grey shale, locally ferruginous and feldspathic, forming distinct glauconitic horizons. The mineral typically appears as greenish pellets and peloids disseminated within sandy to silty matrices and concentrated along specific stratigraphic levels. Primary sedimentary structures such as parallel bedding, cross-bedding, ripple marks, graded bedding, and laminations indicate deposition in a shallow marine shelf to nearshore environment influenced by waves, tides, and occasional storm activity. The glauconite formed through slow sedimentation and prolonged sediment–seawater interaction under sub-oxic to mildly reducing conditions, representing marine transgressive or condensed horizons within the Late Jurassic sedimentary succession.

7.4.4 The southern part of the block is marked by exposures of the Bhuj Formation (Early Cretaceous), which unconformably overlies the Katrol Formation. The Bhuj Formation is dominantly composed of feldspathic sandstone, grit (silicious sandstone), and ferruginous sandstone, representing fluvio-deltaic to near-shore depositional environments. These sandstones are typically coarse-grained, moderately sorted, and occasionally cross-bedded. Bhuj Formation in this sector also includes glauconitic intercalations, particularly near transitional zones with underlying marine units.

7.4.5 Structurally, the area forms part of the gently dipping sedimentary succession of the Kachchh Basin, with beds generally exhibiting low to moderate dips. No major structural discontinuities are reported, although minor fractures and joints are common in sandstone units. The regional strike of bedding planes is showing NW–SE directions. The rock beds are generally horizontal to gently dipping, with low-angle dips towards the southwest.

7.4.6 Contacts between successive lithounits are predominantly gradational, indicating continuous sedimentation without major structural breaks. No major faults or folds have been identified within the block area at the reconnaissance scale; however, gentle warping related to basin-scale tectonism is evident.

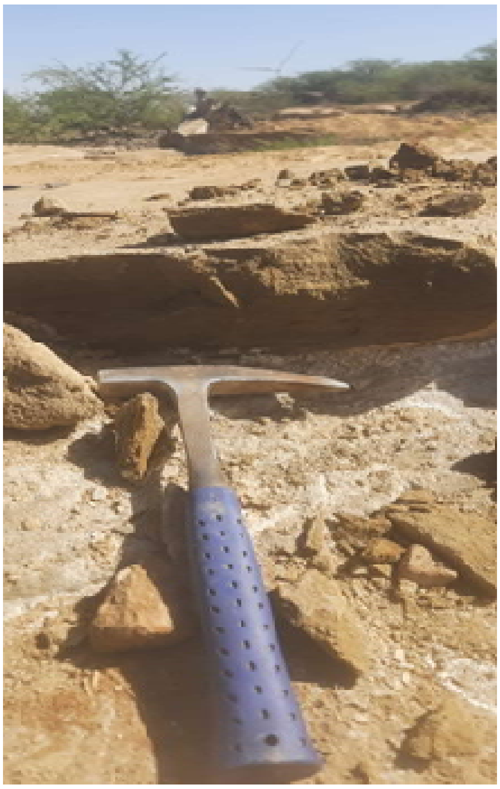


Photo 7.1 Photograph showing Glauconite Horizons in river bed of near Ambara village.

Photo 7.2 Photogra [illegible] hari Riverconnectd [illegible]

Photo 7.3 Photograph showing Sand stone bedding uderlaying by locally deformed shale formation.

Photo 7.4 Photograph showing ferruginous sandstone exhibiting well-developed iron pisolite concretions.

Photo 7.5 Photograph showing bedded glauconitic sandstone exposed along a river section near Ambara Village.

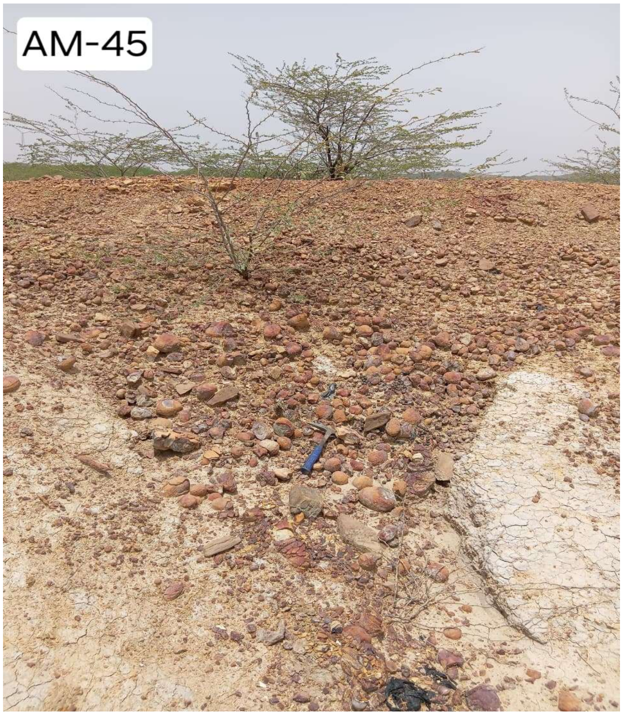


Photo 7.6 Photograph showing ferruginous nodules developed on the upper surface of shale near the Muru Village.

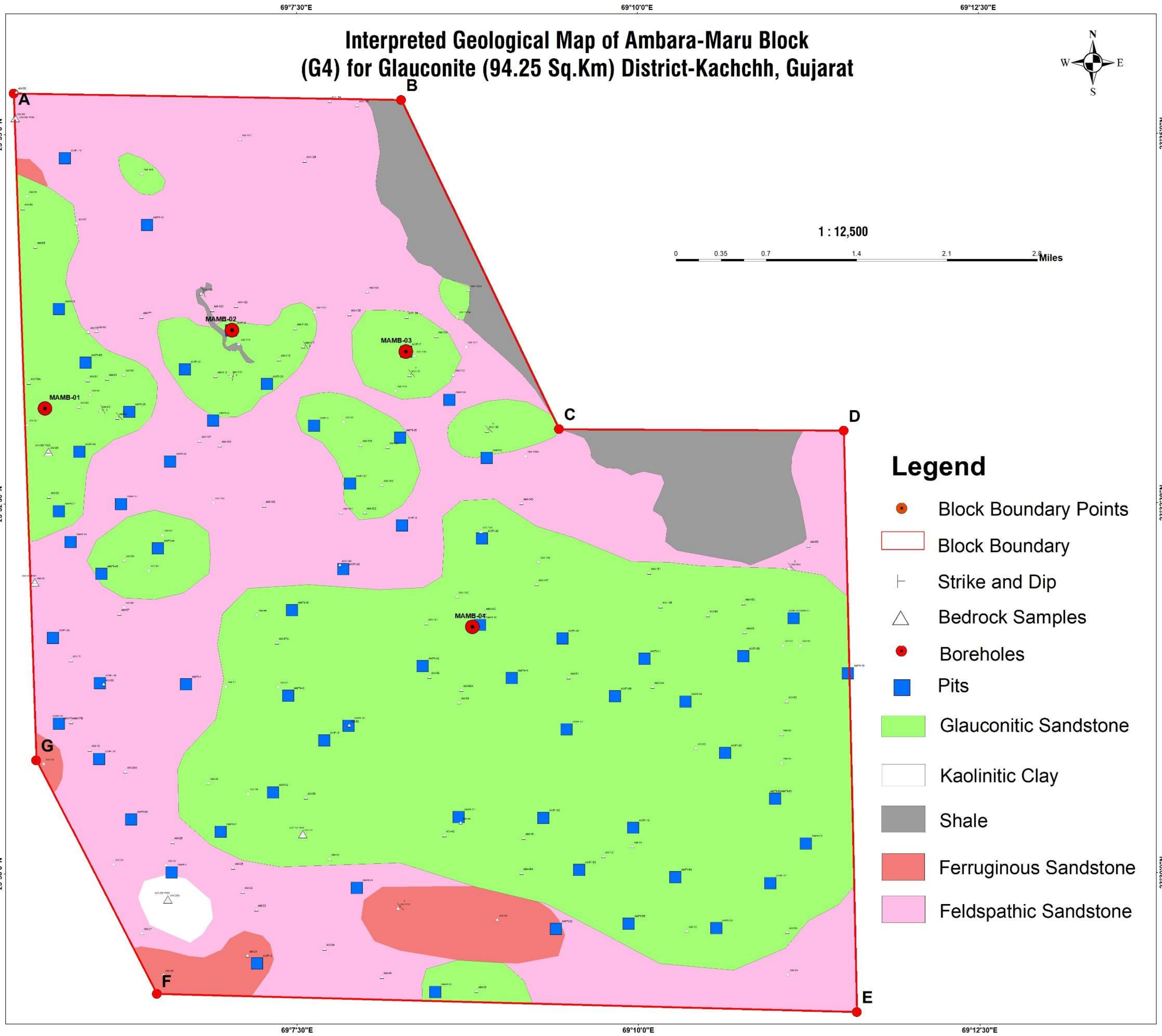
Photo 7.7 Photograph showingSandstone with Marl on small hillock near Ratadiya village.

7.4.7 The local stratigraphic sequence of litho units exposed in the Ambara MaruBlock area is given in Table 7.2.

Table 7.2
Stratigraphic Sequence of Ambara Maru Block (After,GSI)

Age	Formation	Lithology
Recent to Sub-Recent	Alluvium / Soil Cover	Unconsolidated sand, silt and clay
Early Cretaceous	Bhuj Formation	Feldspathic sandstone, medium- to coarse-grained sandstone, grit, ferruginous sandstone; locally clayey sandstone and kaolinitic clay horizons
Late Jurassic – Early Cretaceous	Katrol Formation	Glauconitic sandstone; interbedded sandstone and shale with minor micaceous minerals; fossiliferous shale

7.4.8 The Geological plan is presented in Text fig. 7.2 and Plate –III.



Text Figure.7.2 Interpreted Geological Map of Ambara Maru Block

7.5.0 DESCRIPTION OF ROCKTYPES PRESENT IN AMBARA MARU BLOCK:

7.5.0.1 **SOIL:**Most of the Ambara-Maru Block is covered by a thin mantle of sandy to clayey soil, mainly sandy and feldspathic, derived from the weathering of underlying Mesozoic sedimentary rocks. The soil is generally light brown to brown, with occasional reddish patches due to iron oxide enrichment under semi-arid weathering conditions. At some places, a yellowish-green tint is observed, which likely indicates the presence of glauconite-bearing detrital material derived from underlying glauconitic sandstone horizons.

7.5.0.2 The soil cover is generally thin and widespread, with an average thickness ranging from about 0.25 m to 1.0 m. Thickness varies depending on topography and drainage, being thinner on elevated or sloping areas due to erosion and relatively thicker in low-lying or depressional zones where fine sediments accumulate.

7.5.1 LITHOLOGIES BELONGING TO BHUJ FORMATION

7.5.1.1 **<u>Feldspathic Sandstone</u>-**In the Ambara-Maru Block, lithounits of the Bhuj Formation are exposed predominantly in the northern to central part of the area. The Bhuj Sandstone is characterized by medium- to coarse-grained, feldspathic sandstone, Ferruginous sandstone indicating derivation from a continental to cratonic provenance, as widely documented for the Bhuj Formation in the Kachchh Basin. The sandstone is moderately sorted, ferruginous at places, and displays well-developed cross-bedding, which is the dominant sedimentary structure observed in the field.

7.5.1.2 These cross-bedded units indicate deposition under moderate- to high-energy conditions, consistent with fluvio-deltaic to shallow marginal-marine environments reported in earlier studies. Structurally, the sandstone beds exhibit a general NW–SE strike with very gentle dips towards the southwest, reflecting the regional structural grain parallel to the Guneri structural high.

7.5.1.3 The gentle attitude of bedding, absence of deformation, and preservation of primary sedimentary structures suggest deposition in a relatively stable tectonic regime during Early Cretaceous time. The feldspathic composition of the sandstone further supports rapid sediment supply from uplifted source areas with limited transport, a characteristic feature of the Bhuj Formation across western Kachchh.

7.5.1.4 **<u>Iron-Rich Sandstone</u> -** The sandstone exposed at this locality represents a distinct iron-rich sandstone facies within the Bhuj Formation. In hand specimen and field exposure, the rock is medium- to coarse-grained, moderately sorted, and composed predominantly of quartz grains set in a ferruginous matrix, giving it a characteristic reddish-brown to rusty colour. The sandstone is noticeably iron-cemented, with iron oxide coatings enveloping individual sand grains and locally masking primary sedimentary textures.

7.5.1.5 The massive to poorly bedded character observed locally, combined with a dominance of authigenic ferruginous cement, suggests post-depositional iron enrichment and oxidation; these features likely developed under conditions of intermittent subaerial exposure or fluctuating redox environments. Furthermore, the absence of fossiliferous horizons implies that this sandstone represents a high-energy or chemically restrictive depositional micro-environment, where conditions were unfavorable for the taphonomic preservation of benthic fauna. Due to its distinct ferruginous chemistry, unique textural maturity, and lack of biotic content, this sandstone is classified as a discrete lithological variant within the Bhuj Formation.

7.5.1.6 **Ferruginous sandstone:** Within the northern and northwestern sectors of the block, the Bhuj Formation is represented by prominent exposures of ferruginous sandstone. This unit is characterized as a medium- to coarse-grained, moderately sorted feldspathic arenite. Its distinctive reddish-brown hue is attributed to pervasive iron-oxide cementation. The rock varies from compact to moderately indurated and frequently displays well-defined planar and cross-stratification, reflecting a moderate- to high-energy depositional regime.

Photo 7.8 Photograph showing interbedded Reddish brown coloured Sandstone with brown colour sandstone.

7.5.1.7 The preservation of primary sedimentary structures, combined with the sub-horizontal bedding geometry observed in situ, indicates a fluvio-deltaic to marginal marine depositional setting. These features reflect fluctuating hydraulic energy and episodes of subaerial exposure. As a prominent lithounit within the Bhuj Formation, this ferruginous sandstone serves as the parent material for the characteristic sandy, iron-rich regolith and soil profile observed across the study area.

7.5.1.8 **Kaolinitic Clay:**A localized and discrete body of kaolinitic clay is exposed near Ratadiya village in the southern sector of the block within the Bhuj Formation of the Kachchh Basin. This litho-unit is geochemically significant, yielding Total Rare Earth Element (TREE) concentrations exceeding 1000 ppm.Out of the analysed samples, two pit samples (AMPI-40 and AMPI-30)show enrichment of total rare earth elements (TREE + Y) exceeding 1000 ppm, with values ranging from ~1004 ppm to ~1055 ppm. The remaining samples show lower REE concentrations (<1000 ppm), indicating that REE enrichment is localized rather than widespread within the analysed horizons.The formation of this deposit is attributed to intense chemical weathering and hydrolysis of feldspathic precursor minerals present in the sandstones of the Bhuj Formation.The enrichment is interpreted to result from intense weathering and kaolinization of feldspathic sandstones, where alteration of feldspar and mica released REEs that were subsequently adsorbed and retained within kaolinite-rich clay horizons. The kaolinitic clay locally occurs with glauconitic sandstone layers, reflecting marginal marine to deltaic depositional conditions with intermittent marine influence and fluctuating sedimentation energy during deposition of the Bhuj Formation.

7.5.2 LITHOLOGIES BELONGING TO KATROL FORMATION

7.5.2.1 **GLAUCONITIC SANDSTONE:** Glauconitic sandstone forms an important lithological unit within the Katrol Formation in the Ambara-Maru Block. In the field, the unit is observed to be predominantly fine-grained, friable, and greenish to dark green in colour, reflecting a high glauconite content. The sandstone is generally poorly to moderately indurated, locally sandy to silty, and easily disaggregates on weathering. Structurally, the beds exhibit a consistent NW–SE strike with very gentle dips towards the southwest, indicating a simple and undisturbed sedimentary disposition.Based on the geochemical plots and interpretations, the glauconite in the block area represents a nascent to moderately evolved maturity stage. The moderate K_2O enrichment with relatively high Fe_2O_3 content indicates Fe-rich glauconite formed during early diagenesis, rather than highly mature glauconite. The bivariate relationships (especially K_2O–Fe_2O_3 and K_2O–MgO) suggest that potassium incorporation has begun through glauconitization, but the mineral has not reached full maturation. Plot details have been mentioned in paragraph no-7.7.8 (Genesis of Glauconite Mineralization).

7.5.2.2 The glauconitic sandstone commonly occurs in association with glauconitic shale and alternate bands of grey shale, forming a rhythmic alternation of arenaceous and argillaceous lithologies. The glauconitic shale is fine-grained, fissile, and greenish grey, whereas the grey shale is compact and non-glauconitic, suggesting short-term variations in sediment supply and depositional conditions. Field mapping indicates that the glauconitic horizons are predominantly developed in the central portion of the block, where they show better continuity and thickness compared to the marginal areas.

7.5.2.3 The intimate association of glauconitic sandstone with shale units indicates deposition under low-energy shallow marine conditions, where slow sedimentation favoured the formation and preservation of glauconite. The lateral persistence of these lithologies, combined with their gentle bedding attitude and minimal deformation, highlights the stratabound nature of the glauconitic horizons within the Katrol Formation.

7.5.2.4 The summarized lithologs and average geochemical analysis of the Glauconitic Sandstone characterised by moderate K_2O enrichment (~2.6–4.2%), with SiO_2 ranging ~52–75%, Al_2O_3 ~9–24%, and Fe_2O_3 ~5–16%. CaO is generally low to moderate (~0.2–6.9%). This reflects the presence of glauconite pellets within a quartz–clay matrix.

Photo 7.9 Photograph showing glauconitic sandstone underlain by shale exposed along the Khari River section.

Photo 7.10 Photograph showing Bedrock sample of glauconite AM-16 (5.46% K2O)

7.5.2.5 **Ferruginous shale Nodules:**Shale nodules occur as a distinctive lithological feature within the Bhuj Formation of the Ambara-Maru Block and are spatially associated with shale-dominated horizons interbedded with sandstone. These nodules are typically calcareous to ferruginous, spherical to irregular in shape, and are embedded within compact shale. Their development is attributed to early diagenetic processes, involving localized chemical precipitation around nucleation centers under low-energy depositional conditions.

Photo 7.11 Photograph showing ferruginous shale nodules (iron concretions) developed within shale near Muru Village.

7.5.2.6 The occurrence of nodular shale is well documented in Bhuj strata across western Kachchh and is indicative of periods of reduced clastic input, allowing chemical differentiation within fine-grained sediments. The presence of shale nodules in the block further supports deposition in a shallow marine to deltaic setting, with alternating phases of sediment starvation and accumulation.

7.5.2.7 **Ferruginous sandstone:** Ferruginous sandstone is well exposed within the block, mainly in the northern to north-western part, and belongs tothe Bhuj Formation. In the field, the sandstone is observed to be medium- to coarse-grained, moderately sorted, and feldspathic in composition, with a characteristic reddish to brown coloration imparted by iron oxide cement. The rock is compact to moderately indurated and commonly exhibits well-developed cross-bedding and planar bedding, indicating deposition under moderate- to high-energy conditions.

7.5.2.8 The ferruginous nature of the sandstone is attributed to iron enrichment during early diagenesis, followed by oxidation under subaerial or near-surface conditions, which is reflected in the pervasive iron staining along bedding planes and fractures.

7.5.2.9 The preservation of primary sedimentary structures, coupled with the gentle attitude of bedding observed in the field, suggests deposition in a fluvio-deltaic to marginal marine environment, with fluctuating energy conditions and periodic exposure. The ferruginous sandstone forms a distinctive and easily identifiable lithounit within the

Bhuj Formation and contributes significantly to the sandy and iron-rich soil cover developed over the area.The summarized lithologs and average geochemical analysis of the ferruginous sandstone indicate a wide variation in SiO_2 (~43–91%) with elevated Fe_2O_3 (~2–18%) due to iron oxide enrichment. K_2O generally ranges ~0.9–2.6%, and CaO may vary ~2–14% where carbonate or alteration is present.

Photo 7.12 Photograph showing dark reddish ferruginous sandstone exposed near the Aiyer Village.

7.5.2.10 **Interbbeded Shale with sandstone(Shaly Sandstone):**The presence of shale with rhythmic, thin-bedded sandstone intercalations in the Katrol Formation represents a heterolithic shelf facies deposited under storm-influenced shallow marine conditions. The dominant shale records background suspension settling of fine silt and clay in a low-energy offshore shelf environment. The thin sandstone layers are interpreted as event beds formed by currents, wave reworking, deposited during episodic higher-energy conditions. This rhythmic alternation of shale and sandstone reflects fluctuating depositional energy on a shallow marine shelf with increasing accommodation space due to basin subsidence.

7.5.2.11 Based on the petrographic observations in the attached report, the shaly sandstone is described as a very fine-grained, dark grey, thinly laminated clastic rock composed predominantly of silt- to fine sand-sized quartz and feldspar grains segregated along lamination planes. The rock contains abundant biotite occurring as fine flakes and patches, often aligned parallel to the laminations, along with minor opaques and sericite. Accessory minerals include glauconite, tourmaline, and chlorite, occurring as very fine pellets or grains within the matrix. The presence of thin laminations, segregation of biotite and clastic grains, and the admixture of clay material indicate deposition under low-energy marine conditions, where fine clastic sediments accumulated with a significant shale component, imparting the characteristic shaly nature to the sandstone.

7.5.2.12 The summarized lithologs and average geochemical analysis of the characterised by moderate SiO_2 (~44–53%) and high Al_2O_3 (~13–22%), reflecting significant clay content. K_2O ranges ~2.4–3.3%, while CaO is generally ~1–7%, depending on carbonate admixture.

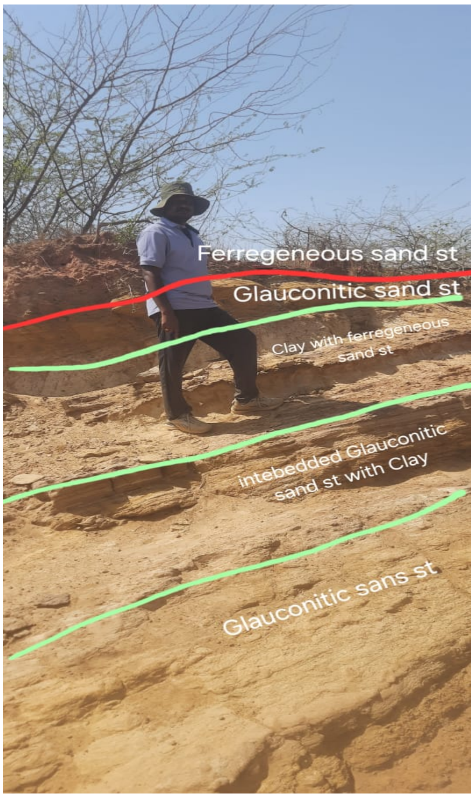


Photo 7.13 Photograph showingLight Green to greenish coloured Glauconitic Sandstone and other lithologies

7.6.0 STRUCTURAL DETAILS OF THE AREA SUCH AS DIP, STRIKE, FOLDS, FAULTS, ETC.

7.6.1 The Ambara-Maru Block is situated within a structurally stable segment of the Kachchh Basin; however, regional geological interpretation indicates the presence of major fault systems in the surrounding areas, as depicted in the regional geological map. These faults are predominantly basin-bounding and intra-basinal normal faults, which trend mainly NW–SE to NE–SW, consistent with the extensional tectonic framework of the Kachchh rift basin.

7.6.2 Although these fault planes are not directly exposed or traceable within the Ambara-Maru Block, their regional influence is reflected in the broad structural grain, gentle tilting of strata, and local variations in lithological distribution. The absence of visible fault displacement within the block suggests that the area occupies a relatively undisturbed fault block or inter-fault domain, where sedimentation and preservation of lithounits occurred with minimal tectonic disruption. Consequently, the fault systems have exerted a regional structural control on basin development and sedimentation patterns, while the Ambara-maru Block itself remains largely unaffected by direct faulting, favouring continuity of stratigraphic units, particularly the glauconitic sandstone horizons.

7.7.0 MINERALIZATION

7.7.1 The Ambara Maru Block has been explored at the G4 (Reconnaissance) stage for glauconite, phosphorite, and rare earth element mineralisation. Based on geological mapping, core logging, lithological studies, chemical analyses of borehole, bedrock, and pit samples, and petrographic investigations, the mineralisation encountered in the block is interpreted to be sedimentary in origin and stratigraphically controlled.

7.7.2 Field and subsurface investigations indicate that the lithological assemblage mainly comprises sandstone, sub-arkose, arkosic wacke, shale, shaly sandstone, and impure micritic limestone. Petrographic examination shows that the rocks are predominantly quartz–feldspar rich clastics with carbonate and clay matrices, accompanied by limonite, ferruginous matter, opaques, biotite, and sericite, with accessory minerals such as tourmaline and monazite. Some samples (e.g., AM-05 and AM-89) are classified as arkosic wacke, while AM-06 and AM-29 correspond to limonitic sub-arkose, and MAMB-2 and MAMB-3 represent biotite-rich shale or shaly sandstone. The presence of impure micritic limestone containing calcitic peloids (MAMB-4) further supports deposition under shallow marine conditions.

Interpretation ofGlauconite mineralisation:

7.7.3 Glauconite is observed petrographically as fine to very fine sub-rounded pellets and relict grains, commonly occurring within sandy or micritic matrices and locally altered to limonite and clay minerals. The occurrence of glauconite pellets along with ferruginous alteration patches indicates authigenic formation under marine conditions. Its association with micritic limestone, laminated shale, and sub-arkosic sandstone suggests sedimentation in a shallow marine shelf to marginal marine environment, where relatively slow sedimentation rates and mildly reducing conditions favoured glauconitisation. The K_2O enrichment observed in chemical analyses further supports the presence of glauconitic minerals in the mineralised horizons.

7.7.4 The major oxide analysis of bedrock, pit, and borehole samples indicates the presence of glauconite-bearing horizons characterised by moderate enrichment of K_2O. The K_2O values generally range from about ~3.0% to ~6.3% in the mineralised samples, which is consistent with the geochemical signature of glauconitic sandstone.Higher K_2O values are observed in several samples such as AM-63 (~6.39%), AMPI-54A (~5.60%), AMPI-53 (~4.98%), AM-65 (~4.78%) and AM-61 (~4.56%), indicating relatively stronger glauconite concentration in these horizons. In the borehole samples, glauconitic intervals are also indicated by K_2O values exceeding ~3%, such as MAMB-01/05 (~3.13%), MAMB-01/11 (~3.74%), and MAMB-04/14 (~3.98%).

7.7.5 Overall, the K_2O distribution shows sporadic but consistent enrichment within specific stratigraphic horizons, suggesting that glauconite occurs as stratabound layers within the sandstone–shale sequence. Geochemical data indicate moderate glauconite mineralisation typical of marine glauconitic sandstones, rather than any high-grade potassium mineral deposit.

Interpretation of Phosphorite mineralisation:

7.7.6 Block was also assessed for phosphorite mineralisation through lithological examination and evaluation of P_2O_5 content in analysed samples (add samples and value range). Petrographic studies do not reveal the presence of discrete phosphatic nodules, apatite-rich horizons, or phosphorite beds. The major oxide analysis of bedrock, pit, and borehole samples indicates that P_2O_5 values are generally low and irregularly distributed across the block.

7.7.7 In the bedrock samples, P_2O_5 values mostly range from about 0.03% to 0.54%, with relatively higher values observed in samples such as AM-15 (~0.70%) and AM-104 (~0.42%), while most other samples show values below 0.20%. In the borehole core samples, P_2O_5 values generally range between ~0.05% and ~0.93%, with the highest value recorded in sample MAMB-01/23 (~0.93%). Most of the borehole samples show P_2O_5 below 0.30%, indicating only minor phosphatic content.

7.7.8 The pit samples also show low to moderate P_2O_5 values, generally ranging from ~0.01% to ~2.80%, with comparatively higher values in samples such as AMPI-48A (~2.80%) and AMPI-64 (~0.31%). Overall, the P_2O_5 distribution suggests sporadic and low-grade phosphatic enrichment, most likely related to detrital or minor phosphatic material within the sedimentary sequence. The observed values are well below the typical economic grade for phosphorite deposits, indicating no significant phosphorite mineralisation within the investigated horizons of the Ambara Maru Block.

Interpretation of REE mineralisation:

7.7.9 Multi-element geochemical analysis carried out to evaluate REE mineralisation indicates no significant enrichment of total REE (TREE). Although trace amounts of accessory monazite grains were observed in some thin sections, their occurrence is sparse and does not indicate any economically viable REE mineralisation. No primary or secondary REE enrichment zones were identified within the investigated stratigraphic units.The trace element analysis indicates that the Total Rare Earth Elements (TREE = La–Lu) show moderate enrichment in the analysed samples. In the bedrock samples, TREE values generally range from approximately ~120 ppm to ~650 ppm. Higher TREE values are observed in samples such as AM-23, AM-29, AM-45B and AM-78, whereas comparatively lower values occur in samples like AM-09 and AM-18. In the pit samples, the TREE content is relatively higher, ranging from approximately ~150 ppm to ~1050 ppm. The highest enrichment is observed in samples AMPI-40 (~1054 ppm) and AMPI-30 (~1004 ppm), while other samples such as AMPI-45 and AMPI-34 show moderate TREE values.The REE distribution pattern indicates enrichment of Light Rare Earth Elements (LREE: La–Nd) relative to Heavy Rare Earth Elements (HREE: Gd–Lu), which is typical of siliciclastic sedimentary rocks containing accessory minerals such as monazite and zircon.

7.7.10 Some samples also show notable enrichment of Zr (up to ~952 ppm in AM-78), suggesting the presence of detrital zircon grains, while high Ba values (locally >700 ppm in samples such as AM-57B and AM-60B) indicate possible association with feldspar or clay minerals. Overall, the trace element data suggest localized and moderate REE enrichment without any continuous or economically significant REE mineralisation within the studied horizons.

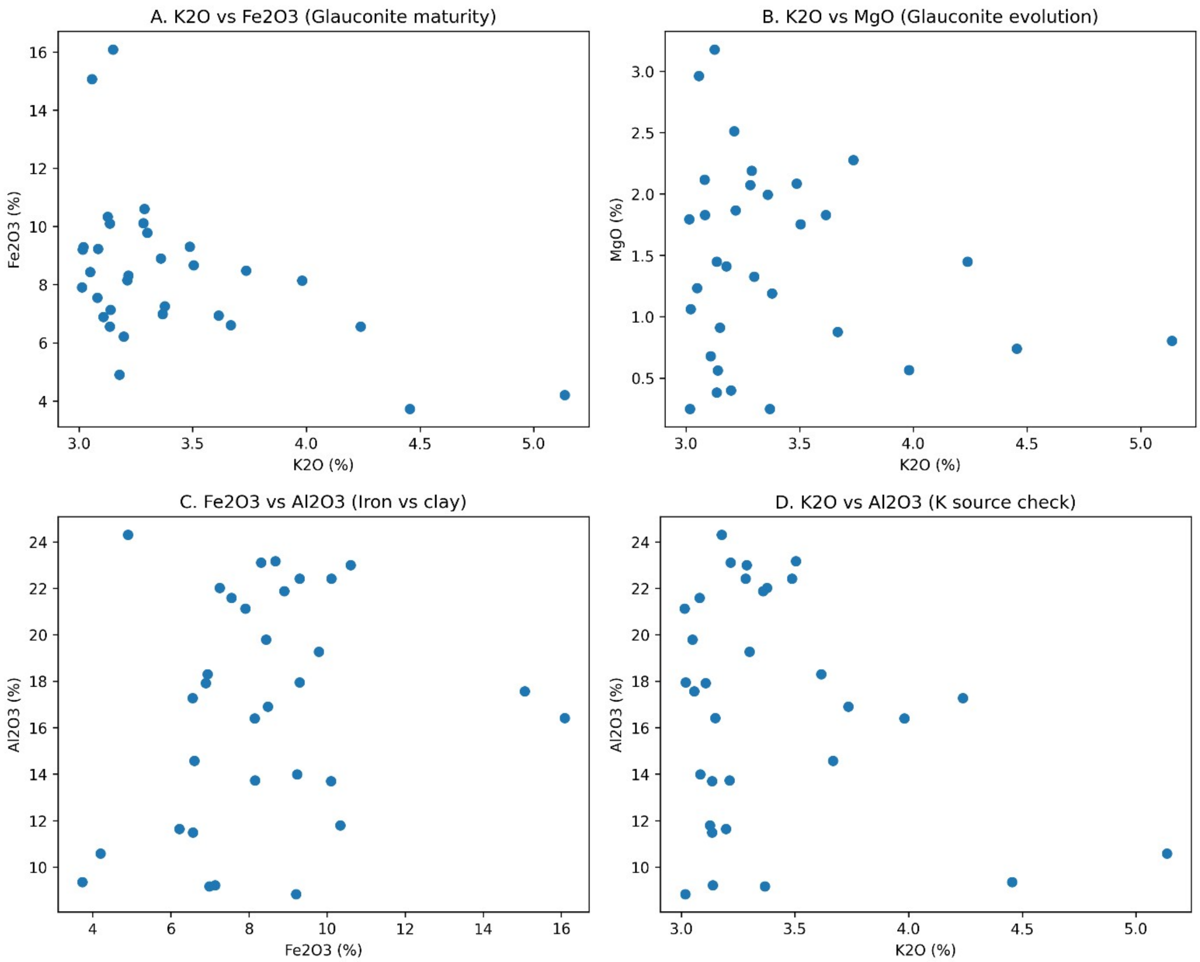
7.7.11 Integrated geological, geochemical, and petrographic evidence indicates that the Ambara Maru Block hosts stratabound glauconite mineralisation of marine sedimentary origin. The deposit represents a greensand-type system formed under shallow marine shelf conditions. However, no economically significant zones of phosphorite or REE mineralisation have been delineated at the G4 reconnaissance stage of exploration.

7.7.12 Genesis of Glauconite Mineralization

7.7.13 The genesis of glauconite mineralization in the Ambara Maru Block is interpreted as authigenic, controlled primarily by depositional environment and early diagenetic processes. The elevated K_2O and Fe_2O_3 contents in both pit and bedrock samples indicate progressive potassium fixation and iron enrichment within clay precursors during early burial. Localized enrichment of P_2O_5 in few samples suggests episodic phosphatic conditions associated with condensed sedimentation horizons, further supporting slow sedimentation rates. The chemical association of iron enrichment with low Na_2O and moderate MgO implies formation under sub-oxic to mildly reducing marine pore-water conditions, which are favourable for glauconite maturation. Variations in glauconite grade across the block reflect differential degrees of diagenetic evolution, quartz dilution, and carbonate influence rather than changes in genetic processes. The mineralization is therefore interpreted as autochthonous, formed in situ within marine sediments during early diagenesis, with subsequent chemical stabilization during burial.

7.7.14 The petrogenetic and mineralization characteristics identified for glauconite in the Ambara Maru Block, based on major oxide geochemistry, are consistent with authigenic, diagenetic glauconite formation under shallow marine shelf conditions, a model that aligns with widely documented glauconite occurrences in the Kachchh Basin of Gujarat.

7.7.11. Bivariate Diagrams:



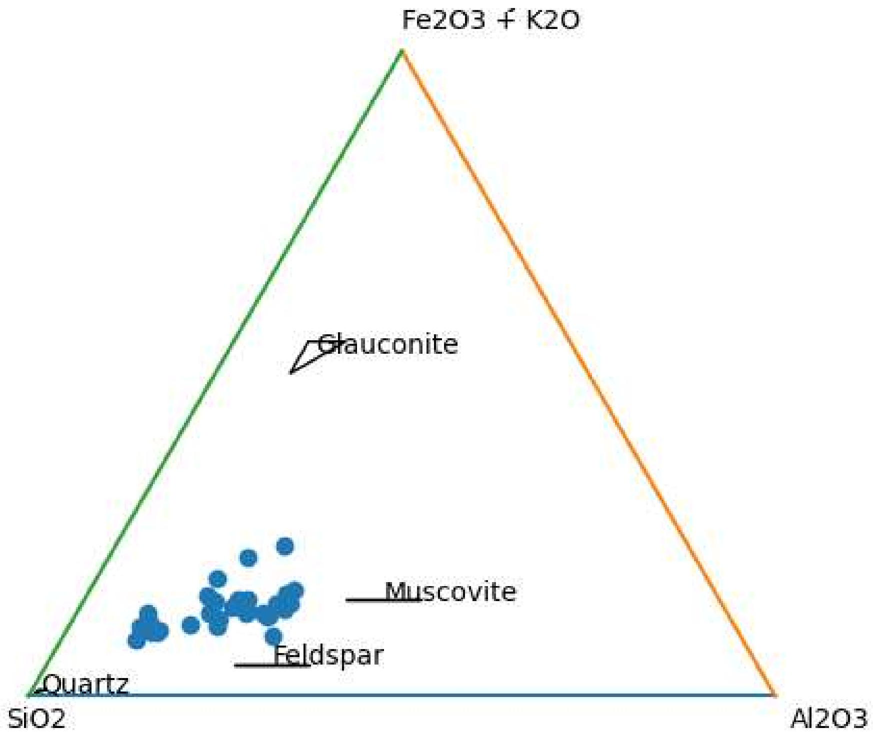
These four plots together help determine:

- Glauconite maturation
    - K_2O increases with maturation.
- Cation exchange during diagenesis
    - Mg tends to decrease as K increases.
- Mineral association
    - Fe_2O_3 vs Al_2O_3 shows glauconite vs clay contribution.
- Source of potassium
    - K_2O vs Al_2O_3 distinguishes glauconite-derived K vs feldspar-derived K.

7.7.12 Interpretation of Bivariate Diagrams

The bivariate relationships among major oxides provide important insights into the geochemical behavior and maturation of glauconite within the Ambara-Maru sediments. The K_2O–Fe_2O_3 diagram indicates moderate potassium enrichment associated with relatively high iron content, which is characteristic of Fe-rich glauconite minerals formed during early diagenesis. The distribution of samples within the moderate K_2O range suggests the presence of nascent to slightly evolved glauconite. The K_2O–MgO relationship reflects the cation exchange processes involved in glauconitization, where potassium is progressively incorporated into the mineral structure during maturation. The Fe_2O_3–Al_2O_3 relationship indicates the coexistence of iron-rich glauconite with aluminous clay minerals in the sediment matrix. Furthermore, the K_2O–Al_2O_3 plot shows that potassium enrichment does not correspond to strong alumina enrichment, suggesting that the potassium is primarily associated with glauconite rather than detrital K-feldspar. Overall, the bivariate geochemical trends indicate that the studied sediments contain moderately evolved glauconite within a siliciclastic sandstone matrix.

SiO_2–Al_2O_3–(Fe_2O_3+K_2O) Ternary Diagram:



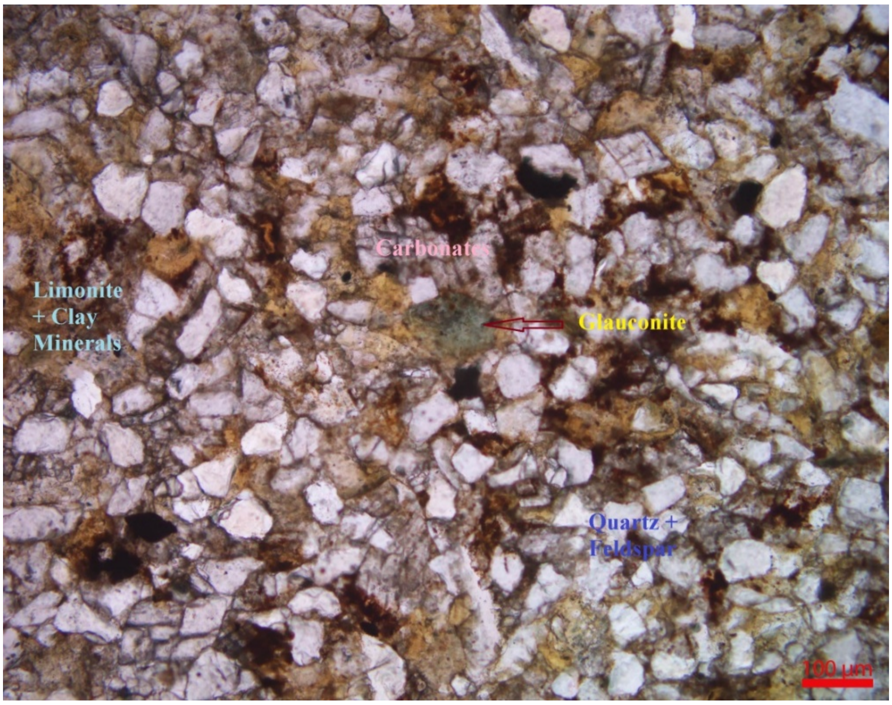
7.7.13 Interpretation of SiO_2–Al_2O_3–(Fe_2O_3+K_2O) Ternary Diagram:

The SiO_2–Al_2O_3–(Fe_2O_3+K_2O) ternary diagram illustrates the relative contribution of quartz, clay/feldspar, and glauconite components in the Ambara-Maru samples. Most of the data points cluster close to the SiO_2 apex and along the SiO_2–Al_2O_3 join, indicating that the sediments are dominated by quartz with a subordinate clay or feldspathic matrix. The distribution of samples away from the $Fe_2O_3+K_2O$ apex suggests that glauconite is present but does not represent the dominant mineral phase within the bulk composition. Instead, glauconite occurs as discrete pellets dispersed within a quartz-rich sandstone framework. The slight tendency of samples toward the $Fe_2O_3+K_2O$ component reflects the contribution of Fe-rich glauconite, which accounts for the observed potassium enrichment. Therefore, the ternary distribution indicates that the Ambara-Maru sediments can be classified as quartz-rich glauconitic sandstones formed in a marine shelf environment where glauconite developed as an authigenic mineral within a siliciclastic sedimentary system.

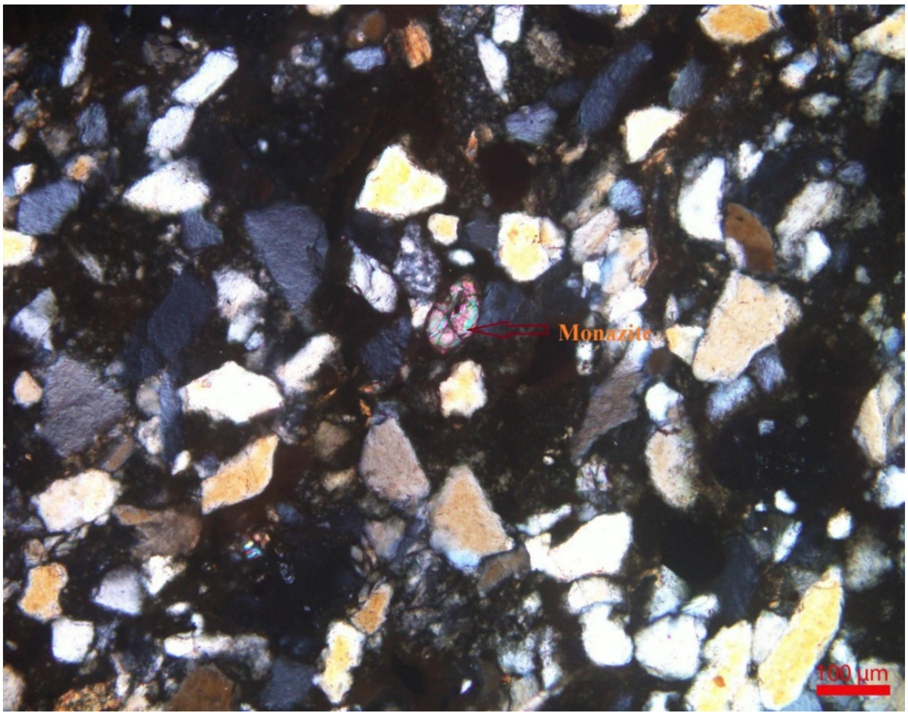
7.7.14 Petrological Studies

7.7.15 Petrological studies were carried out on the major lithological units encountered in the Ambara Maru Block. A total of eight representative samples from different lithological types were selected for petrographic analysis and examined at the MECL Laboratory, Nagpur. The petrographic study of eight representative samples indicates that the rocks are predominantly quartzo-feldspathic sandstones and shaly lithologies, with compositions ranging from arkosic wacke and limonitic sub-arkose to biotite-rich shale and impure micritic limestone. The framework grains are mainly quartz and feldspar, occurring as fine to very fine subrounded to subangular clasts, commonly supported by carbonate, clayey, or ferruginous matrices. Accessory minerals such as biotite, muscovite/sericite, tourmaline, monazite, and opaques are present in minor to trace amounts. In several samples, limonite and ferruginous matter occur as patches, pellets, and fillings, commonly indicating alteration of primary minerals and post-depositional iron enrichment.

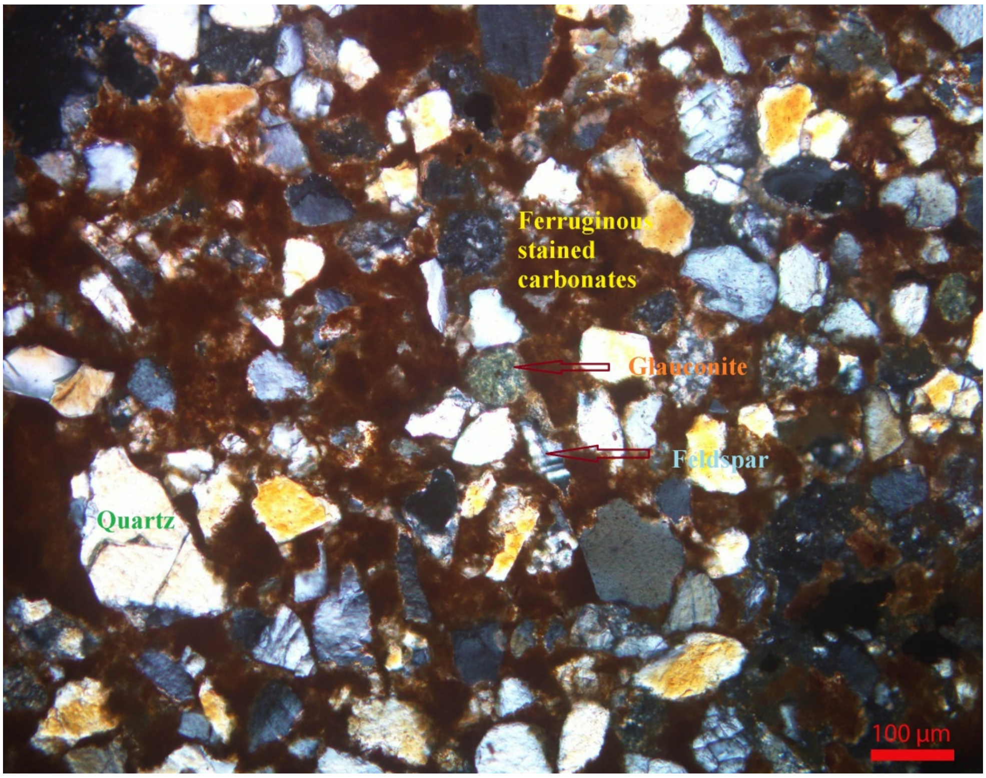
7.7.16 Glauconite occurs in many samples as fine to very fine greenish pellets and relicts, commonly disseminated within sandy or silty matrices and occasionally associated with limonitic patches, suggesting partial alteration of glauconitic grains to iron oxides and clay minerals. Carbonate components occur locally as micritic matrix, peloids, intra-clasts, and sparry patches, while thin laminations and fine clastic segregation in shale samples indicate low-energy sedimentary conditions. The presence of clayey lenses, micritic matrix, and carbonate reaction with dilute HCl further confirms mixed siliciclastic–carbonate sedimentation. The details of sample locations and corresponding lithologies are provided in the Annexure-VI.



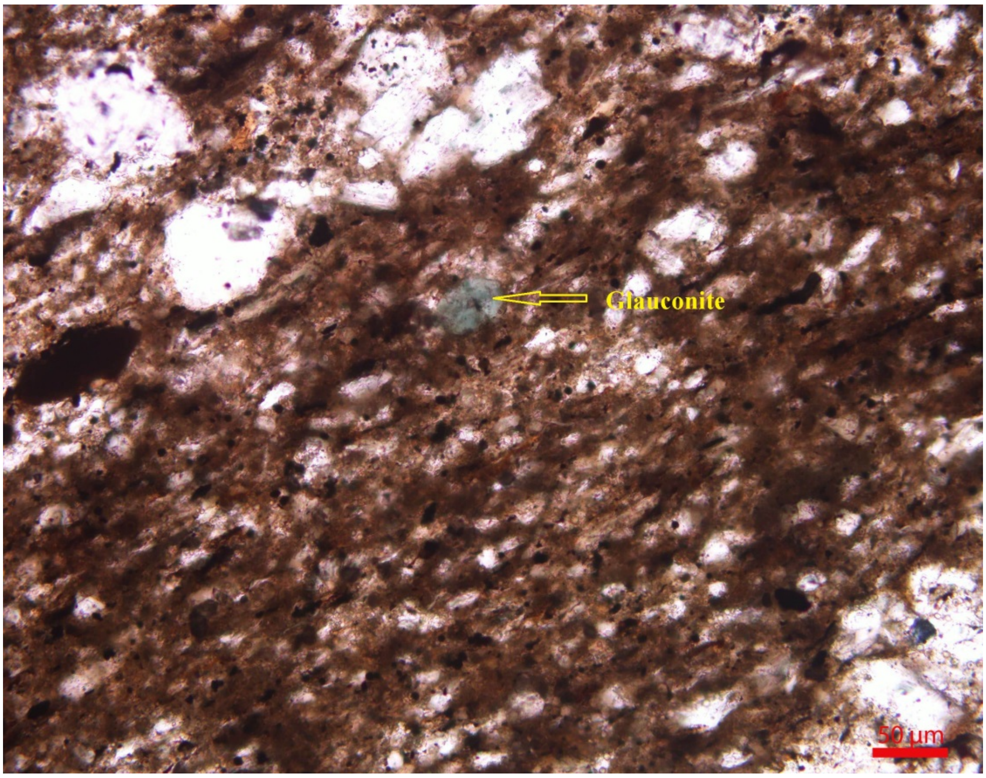
Pmg – 1: Photomicrograph showing presence of glauconite in arkosic wacke as seen under plane polarized light.**Specimen No. : AM-05/ PG1, Magnification : 100X**



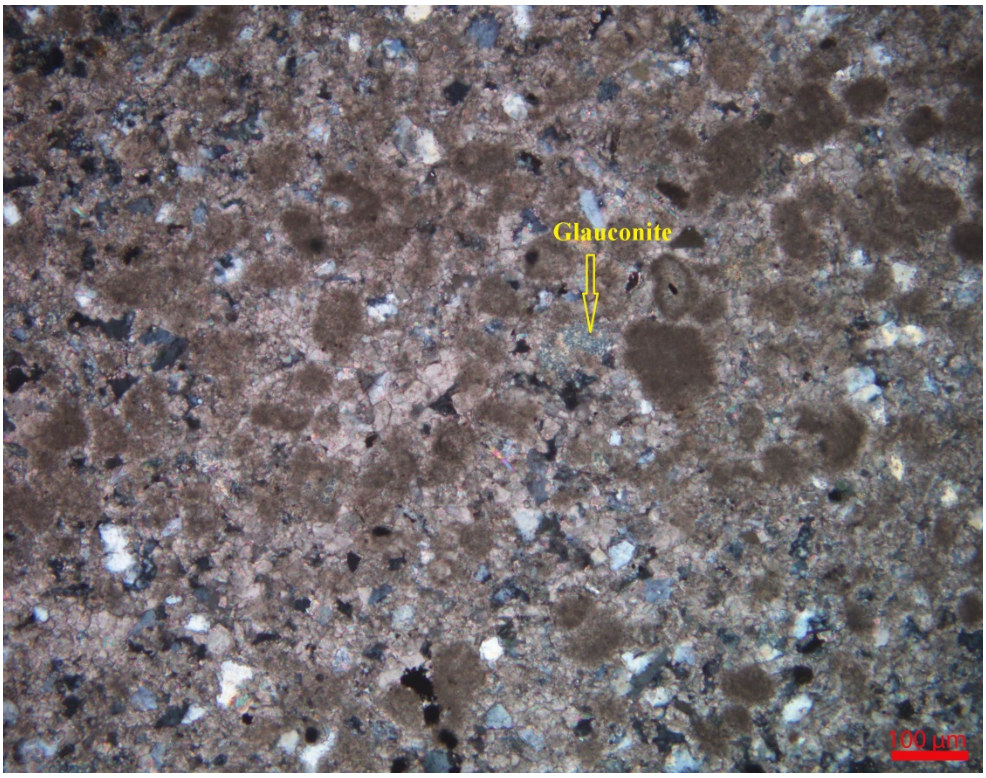
Pmg – 2: Photomicrograph showing presence of detrital monazite in limonitic sub-arkose as seen under crossed nicols.**Specimen No. : AM-29/ PG3, Magnification : 100X**



Pmg – 3: Photomicrograph showing presence of glauconite in arkosic wacke as seen under crossed nicols.**Specimen No. : AM-89/ PG5, Magnification : 100X**



Pmg – 4: Photomicrograph showing presence of glauconite in biotite rich shale as seen under plane polarized light.**Specimen No. : MAMB-2/ PG1 , Magnification : 200X**



Pmg – 5: Photomicrograph showing presence of glauconite in impure micritic limestone/ shaly limestone as seen under crossed nicols.**Specimen No. : MAMB-4/ PG1, Magnification : 100X**

7.8.0 EXTENT OF MINERALIZATION

7.8.1 The Ambara Maru Block, encompassing an area of 94.25 sq km and situated in Nakhatrana Talukas of Kachchh District, occupies the western part of the Kachchh Mainland. During the Reconnaissance Stage (G-4) exploration, systematic investigations were undertaken, comprising detailed geological mapping at 1:12,500 scale, collection of 135 bedrock samples, excavation of approximately 135 cubic metres of exploratory pits with 74 pit samples, and exploratory drilling of 04 boreholes aggregating 160 metres of 140 Core samples.

7.8.2 Integration of lithological mapping, surface sampling, pitting, and subsurface borehole data establishes the presence of stratiform, stratabound glauconite mineralisation hosted within marine siliciclastic units of the Katrol Formation. All boreholes intersected glauconite-bearing sandstone horizons, with cumulative mineralised thicknesses ranging from approximatel1m (MAMB-03) to 10.00 m(MAMB-02), indicating persistence of mineralisation in the subsurface. The mineralised horizons are encountered at shallow sub-surface levels, with the upper contact occurring close to the surface and extending downwards to depths corresponding to the maximum borehole penetration.

7.8.3 Based on the correlation of surface and subsurface data, and considering the bedded geometry, lateral persistence, and stratigraphic control of the glauconitic horizons, an area of approximately 6.8 km^2 is interpreted to be mineralised at the present reconnaissance level of confidence (G4). The glauconite-bearing horizons are stratabound and laterally persistent, showing a predominant NW–SE trend, broadly conformable with the regional structural grain of the Kachchh Basin.

CHAPTER-8

8.1.0 PREVIOUS WORK

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

8.1.1 The Geological Survey of India (GSI) has carried out various geological, mineral investigation, and reconnaissance studies in different parts of the Kachchh Basin, including areas proximal to the Ambara Maru Block. The salient contributions relevant to glauconite and associated minerals are listed below.

8.1.2 Early regional investigations by GSI focused on industrial and fertilizer minerals in Kachchh District. Z. G. Ghevariya carried out investigations for bentonite deposits in Kachchh District during FS 1978–80, covering Survey of India Toposheet Nos. 41R/10, 41R/11, 41R/14, and 41R/15, and documented the geological framework of sedimentary formations hosting industrial minerals.

8.1.3 Occurrences of glauconite in the Mesozoic and Tertiary formations of the Kachchh Basin were reported by several workers, including Kulkarni and Agarwal (1963–64), Kulkarni and Desikan (1965–66), Vijaya Sarthi and Sable (1984–85), Ghevariya (1980–81), and Ghevariya and Srikarni (1990–91). These studies established the widespread presence of glauconite within sandstone and shale units of the basin.

8.1.4 Jain, R. L. (1994–95) carried out investigations for potash in glauconite-bearing shale and sandstone over an area of about 100 sq km on 1:25,000 scale in Kachchh District, Gujarat. Based on a glauconite-bearing band with a cumulative thickness of ~1.5 m, strike continuity of 3–4 km, and exploration up to 2 m depth, a tentative reserve of 0.02 million tonnes of glauconite with an average K_2O content of 5.33% was estimated.

8.1.5 Sarkar and Banerjee (2011) suggested an authigenic origin for glauconite occurring in the Naredi Formation. Rathore, S. S. et al. (1999) carried out K–Ar dating of glauconite from the Ukra Member, and reported ages of approximately 105.2 ± 1.3 Ma, indicating glauconite formation during Early Cretaceous time.

8.1.6 Ajaya Kumar Sahu, Dhananjai Verma, et al. (FS 2016–17) conducted a G-4 Reconnaissance Survey for lateritic bauxite and lithomargic clay around Umarsar and

Guneri areas (Toposheet No. 41A/13), Western Kachchh. The study estimated a reconnaissance mineral resource of 3.04 million tonnes of bauxite at 30% Al_2O_3 cut-off, with an average grade of 38.40% Al_2O_3, and 101,840.92 tonnes of lithomargic clay with an average 36.62% Al_2O_3. During this investigation, two glauconite samples were also analysed, reporting K_2O values ranging from 5.07% to 7.27%, indicating the presence of potassic glauconite in the region.

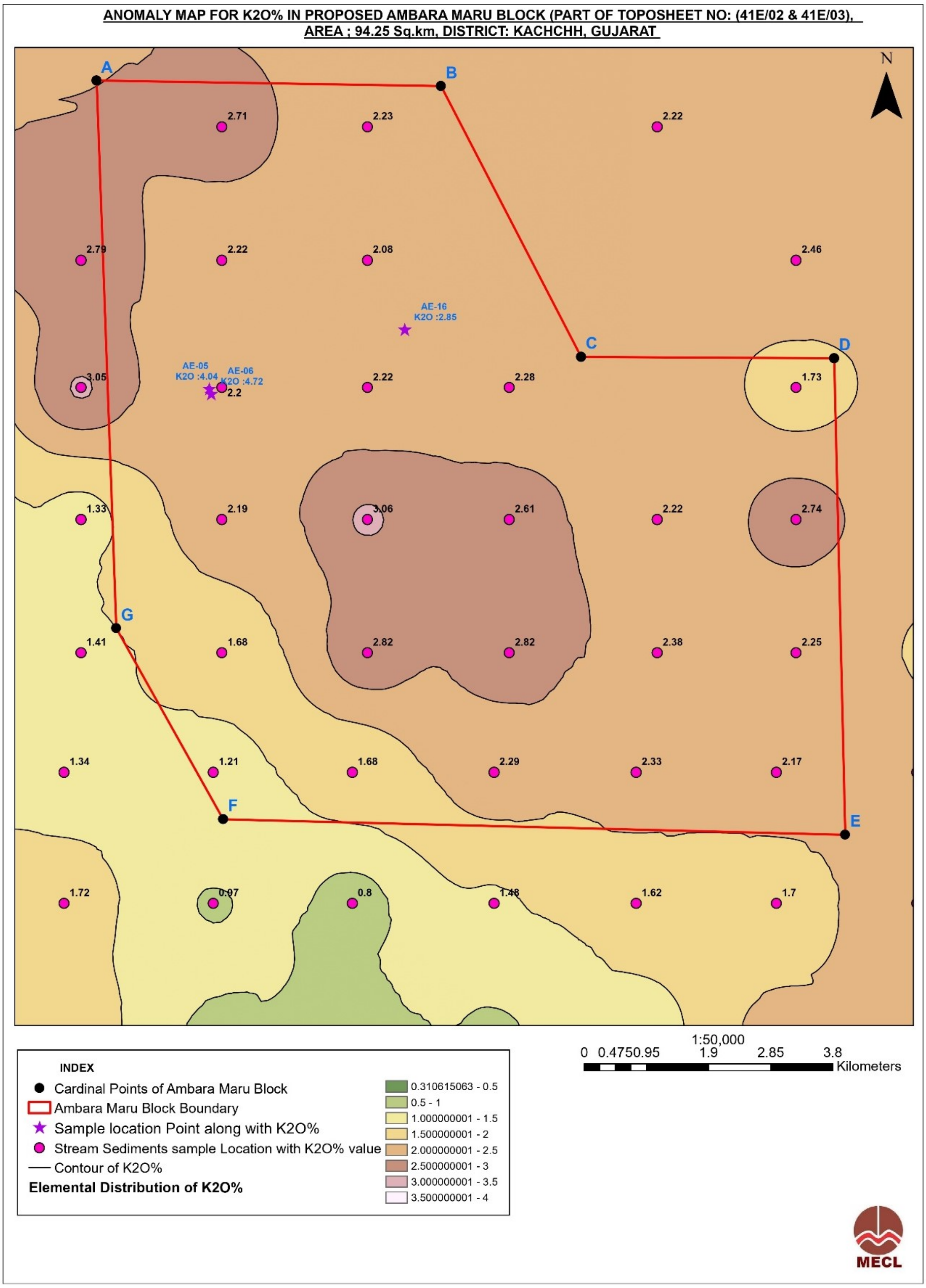
8.1.7 Basheer, H. K. and Kumar, A. (FS 2014–15) carried out detailed investigations for potash in glauconite-bearing shale and sandstone around Guneri village, Kachchh District. The study estimated glauconite resources in different grade brackets, with K_2O contents ranging from <2% to >4%, and based on the exploration results, the Guneri block was placed on the auction platform.

8.1.8 The present Reconnaissance Survey for glauconite in the Ambara Maru Block has been proposed in the south-eastern extension of GSI's explored Guneri Block (FS 2014–15). The extension area is inferred to host glauconite-bearing sandstone and shale units of the Katrol Formation, as established by regional stratigraphic continuity. As per GSI records, the Bhuj (Umia) Formation in the region comprises ferruginous sandstone, glauconitic sandstone (hard, compact, intercalated, sandy to clayey), and feldspathic sandstone, supporting the regional prospectivity for glauconite-hosted fertilizer minerals.

8.1.9 As part of the Geological Survey of India's National Geochemical Mapping Programme (NGCM), systematic stream sediment sampling was carried out in and around the Ambara Maru Block on a 2 km × 2 km grid pattern, following standard NGCM protocols. The objective of this regional geochemical survey was to identify elemental dispersion patterns and delineate areas favourable for mineralisation.

8.1.10 Within the Ambara–Maru Block, a total of 23 NGCM stream sediment samples fall inside the block boundary. The analytical results show that K_2O values range from 1.21% to 3.06%. Such potassium values are significant in the regional geological setting of the Kachchh Basin and indicate the likely presence of potassium-bearing minerals in the source rocks.

8.1.11 Since glauconite is a potassium-rich mineral commonly found in sandstone and shale of the Katrol and Bhuj Formations, the elevated K_2O values in stream sediments suggest that glauconite-bearing horizons may be present in the upstream areas within the block. The consistency of these values across multiple samples further supports the possibility of glauconite mineralization rather than isolated occurrences. (Text Figure 8.1)



Text Figure 8.1: K_2O Anomaly Map with Proposed Ambara Maru Block, Nakhatrana Taluka, Kachchh District, Gujarat

CHAPTER-9

9.1.0 AREAL OR GROUND GEOPHYSICAL OR GEO-CHEMICAL DATA

9.1.1 The present exploration has been carried out for Glauconite, Phosphorite and REE in Ambara Maru Block (Area-94.25 Sq Km), Tehsil-Nakhatrana, District- Kachchh, Gujaratfor which Areal or geophysical survey has not been carried out.

CHAPTER-10

10.0.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 INTRODUCTION

10.1.1 The reconnaissance survey proposal for glauconite in the Ambara Maru Block, Kachchh District, Gujarat, was submitted during the 3rd Meeting of the Technical-cum-Cost Committee-II of NMEDT held on 5th–6th December 2024 and was subsequently approved in the 39th Executive Committee meeting of NMEDT held on 24th January 2025. The Sanction Order was issued on 24th February 2025. The exploration programme was initially scheduled for a period of 10 months (up to 23rd December 2025) and was later extended by three months up to 31st March 2026.

10.1.2 The Ambara–Maru Block is situated within the Kachchh Basin, a geologically significant peri-cratonic basin characterized by a well-developed Mesozoic sedimentary succession and established occurrences of industrial and fertilizer minerals. The basin comprises diverse lithological units including sandstone, shale, limestone, and associated clastic sequences, forming a favourable geological setting for glauconite bearing horizons along with phosphorite and REE mineralization.

10.1.3 Mineral Exploration & Consultancy Limited (MECL) commenced field operations on 30th March 2025. The exploration programme included systematic geological mapping on 1:12,500 scale, followed by pitting and exploratory drilling to investigate the subsurface continuity and disposition of mineralized horizons. Detailed core logging, systematic sampling, and laboratory-based chemical analyses were undertaken to evaluate lithological characteristics and grade parameters.

10.1.4 The present investigation was carried out to assess the glauconite, phosphorite, and REE potential of the block. Considering the strategic and agricultural importance of these minerals, the programme was designed to delineate glauconite-, phosphorite-, and REE-bearing horizons through integrated geological and subsurface studies. The work has generated baseline geological and analytical data necessary for preliminary resource appraisal and evaluation of the economic potential of mineralization within the Ambara–Maru Block.

10.1.5 **OBJECTIVES OF INVESTIGATION**On approval of EC, NMEDT, the exploration programme in AmbaraMaru Block has been formulated to fulfil the following objectives:

a. To carry out systematic geological and structural mapping on 1:12,500 scale for delineation of glauconitic horizons, including associated structural features, and to establish the surface expressions as well as lateral and vertical disposition of mineralised zones.
b. To evaluate the surface quality and grade characteristics of glauconite, phosphorite, and REE horizons through collection of surface samples comprising bedrock, channel, and pit samples, thereby guiding the subsequent stages of exploration.
c. To establish the surface continuity of potential mineralisation concealed beneath soil and overburden cover through systematic pitting.
d. Based on the outcomes of geological mapping, sampling, and pitting, to undertake systematic exploratory drilling in a grid pattern to establish the vertical and lateral continuity of mineralisation, along with its qualitative and quantitative attributes.
e. To estimate mineral resources in accordance with UNFC norms and the Minerals (Evidence of Mineral Contents) Amendment Rules, 2021.
f. To generate adequate geological and exploratory data to facilitate upgradation of the block to a higher level of exploration.

10.1.6 The quantum of work proposed vis-à-vis quantum of work carried out is furnished in Table no 10.1.

Table No 10.1

Details of Exploratory Work carried out by MECL in Ambara Maru Block, Kachchh District, Gujarat

Sl. No.	Item of Work	Unit	Approved Quantum	Achievement
1	Geological Mapping (1:12500 scale)	Sq. Km	94.25	94.25
2	Surface Geochemical sampling	Nos.	200	135
3	Exploratory Mining (Pitting)	Cu M.	150	135
4	DGPS Survey for Borehole fixation	Nos	20	4
5	Drilling (Core)	m.	800	160*
6	Surface samples (Bedrock/Channel/Pit/ BH Samples)			

Sl. No.	Item of Work	Unit	Approved Quantum	Achievement
	i) Primary samples for 8 radicals (K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3& Fe_2O_3)	Nos.	900	328
	ii) 10% External check samples for 8 radicals (K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3& Fe_2O_3)	Nos.	90	34
	iii) Trace Element (34 element)	Nos.	220	44
7	Petrological Studies (10 samples)	Nos	10	8
8	XRD Study	Nos.	5	3
9	Determination of Bulk Density	Nos.	5	3
10	Geological Report preparation	Nos.	1	1

** During evaluation of the exploration proposal, the Technical-cum-Cost Committee-II (TCC-II) initially approved 20 boreholes for the Ambara Maru Block. Subsequently, after completion of bedrock sampling, pitting, and analysis of the collected samples, the progress and results of the exploration work were reviewed by TCC-II. Based on the outcomes of these investigations, the committee recommended drilling of only 04 boreholes with a total meterage of 160 m as a preliminary assessment. It was further advised that release of the remaining boreholes would be considered in a subsequent TCC meeting based on the results obtained from these initial boreholes.After completion of the four boreholes, the drilling results were again reviewed by TCC-II, which advised closure of the exploration programme with the already completed four boreholes and submission of the Geological Report. Accordingly, as the programme was concluded at this stage, the collection and analysis of primary and check samples under the originally proposed drilling programme could not be undertaken.*

10.2.0 DETAILS OF EXPLORATION ACTIVITIES TAKEN UP

10.2.1 LARGE SCALE GEOLOGICAL MAPPING:

Large-scale geological mapping of the Ambara Maru Block was carried out on a 1:12,500 scale, covering an area of 94.25 Sq Km. The mapping provided a comprehensive regional base map that serves as the foundation for exploration and resource evaluation. During geological fieldwork, lithological boundaries, stratigraphic contacts, and structural elements were critically examined, and the geological map was prepared at the same scale. This representation incorporates the latest field observations and structural interpretations, ensuring that the geology of the Ambara Maru Block is precisely depicted and provides a reliable basis for subsequent exploration programs.

Photo.10.1 Photograph showing geologist involved in geological mapping in the block

10.2.2 Exploratory operations in the Ambara Maru Block commenced in 30th March 2025and were successfully completed in 12thJanuary 2026. The mapping programme involved systematic field observations, including the documentation of lithological contacts, stratigraphic boundaries, geomorphological features, and structural elements. Major lithological units mapped in the area comprise ferruginous sandstone, feldspathic sandstone, glauconitic sandstone, kaolinitic clay, alternating bands of sandstone and shale (shaly sandstone), and shale. The delineation of these units was carried out based on field characteristics, fossil occurrences, and mineralogical composition.

10.2.3 Lithological boundaries and contacts were established with the aid of handheld GPS instruments, ensuring spatial precision in plotting and reducing positional errors. Structural data, including the attitude of bedding planes, cross bedding patterns, were systematically recorded using a Brunton Compass, enabling a clear understanding of the overall structural disposition of the block.

10.2.4 The general strike of the litho-units was observed to be NW–SE, with sub-horizontal dips ranging between 1° to5° towards the southwest. This structural orientation provides insights into the tectonic regime and depositional environment of the area. The integration of lithological and structural data allowed for the preparation of a comprehensive geological map (Plate–III and IV), which represents the up-to-date field observations and interpretations.

10.2.5 This geological map serves as a reliable baseline for subsurface correlation, stratigraphic reconstruction, and mineral resource evaluation. It provides a scientifically robust framework for guiding exploratory drilling and future development activities within the Ambara Maru Block.

10.2.6 Large-scale geological mapping of the Ambara Maru Block was carried out on a 1:12,500 scale to document lithological variations, stratigraphic relationships, and structural features, with particular emphasis on the delineation of glauconite, phosphorite and REE-bearing horizons. The Ambara–Maru Block is predominantly underlain by the Katrol Formation (Late Jurassic–Early Cretaceous), which represents shallow marine to marginal marine depositional environments. It comprises alternating sandstone and shale sequences, including glauconitic sandstone horizons of mineralization significance. The sandstones are fine- to medium-grained, compact, and locally ferruginous, while shales are grey to dark grey and occasionally fossiliferous, containing marine fauna such as Trigonia. Oolitic limestone and localized conglomerate bands are also reported, along with plant fossil-bearing shale indicating intermittent continental influence.

10.2.7 The southern part of the block exposes the Bhuj Formation (Early Cretaceous), unconformably overlying the Katrol Formation. It consists mainly of feldspathic sandstone, grit (silicious sandstone) and ferruginous sandstone deposited under fluvio-deltaic to near-shore conditions, with occasional glauconitic intercalations. Structurally, the area forms part of the gently dipping sedimentary succession of the

Kachchh Basin, with no major structural disturbances reported within the block boundary.

10.2.8 **Bedrock sampling:**During systematic geological traverses in the Ambara Maru Block, glauconite, phosphorite and REE-bearing horizons were carefully delineated and representative bedrock samples were collected to characterize the nature and extent of mineralisation. Sampling was carried out by chipping fresh, unweatheredmaterial from exposed glauconitic sandstone and associated shale and clay units, ensuring adequate representation of the mineralized horizons.

10.2.9 Prior to sample collection, weathered and altered surfaces were removed using a geological hammer to expose fresh glauconitic bands, typically exhibiting greenish to olive-grey coloration. Sample chips were collected along the strike of the exposures and across the width of the mineralized bands to minimize localized bias and to capture lithological and textural variations within the horizons.

10.2.10 This systematic and uniform sampling methodology ensured that the collected samples are representative of the average glauconite content, textural characteristics, and mineralogical distribution of the bedrock. In total, 153 bedrock samples were collected from the block area. The samples constitute a reliable dataset for subsequent petrographic studies, geochemical analysis, and grade evaluation, and form the basis for assessing the glauconite resource potential of the Ambara Maru Block.

10.2.11 The trace element analysis of bedrock samples (18 nos) shows that the Total Rare Earth Elements (TREE) range approximately from ~150 ppm to ~600 ppm. Relatively higher TREE values are observed in samples such as AM-23, AM-29, AM-38B, AM-41B and AM-45B, while lower values occur in samples like AM-09 and AM-78. The overall REE concentration is moderate and irregularly distributed, indicating that REEs are mainly present as trace accessory minerals (e.g., monazite) rather than forming any economic mineralisation.

10.2.12 The data also show higher Light REE (La–Nd) compared to Heavy REE (Gd–Lu), which is typical for siliciclastic sedimentary rocks. Some samples show high Zr values (up to ~900 ppm) indicating the presence of zircon grains, and moderately high Ba values likely related to feldspar or clay minerals. Overall, the trace element data suggest no significant REE mineralisation in the studied horizons.

10.2.13 **Pitting:** A total of 67 pits, involving a cumulative excavation volume of about 135 m^3, pits were excavated along strike of glauconitic horizons to determine true thickness and grade variation in the Ambara Maru Block to assess the distribution, thickness, and grade of near-surface glauconitic, phosphorite and REE mineralisation. Pitting was undertaken in glauconitic sandstone and glauconitic shale/clay horizons, based on the results of prior bedrock sampling and reconnaissance-scale geological mapping. Pit locations were selected systematically in areas showing surface glauconite indications, with additional infill pits excavated in anomalous zones to refine the understanding of lateral continuity and enrichment patterns. The locations of all pits were recorded using GPS, and each pit was excavated to expose fresh, unweathered bedrock.

10.2.14 The pits were generally 1.0 m × 1.0 m in plan dimensions and were excavated to depths ranging from 2.0 m to 2.5 m, depending on lithological conditions and depth to competent bedrock. All pit locations have been plotted on the geological map (Plate–III and IV) for spatial reference. From the excavated pits, a total of 74 pit samples were collected and analysed for major oxide constituents, namely K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 (Annexure–IVB). Analytical results indicate that 29 out of 74 samples contain more than 3% K_2O, confirming K_2O enrichment in several parts of the block. The K_2O values range from 0.12 % to 6.39 %, with Pit Sample No. AMPI-63 recording the highest grade of 6.39 % K_2O.

10.2.15 The enriched horizons identified through pitting are interpreted to represent primary glauconite concentrations within relatively less-weathered sandstone units, and constitute priority targets for further evaluation of mineral resources in the Ambara Maru Block.

10.2.16 The details of pit samples sample values for K_2O% are tabulated below in Table 10.2.

Table 10.2
Details of pit sample values for K_2O%, P_2O_5 in Ambara Maru Block, Kachchh District, Gujarat.

Sr. No.	Pit No.	Primary Sample No.	Easting (m)	Northing (m)	K_2O%	P_2O_5%
1	AMPI-1	AMPI-1	511378	2601234	2.98	0.07
2	AMPI-2	AMPI-2A	512462	2599888	2.59	0.04
3	AMPI-2	AMPI-2B	512462	2599888	5.03	0.06
4	AMPI-2	AMPI-2C	512462	2599888	2.61	0.04
5	AMPI-2	AMPI-2D	512462	2599888	3.69	0.06
6	AMPI-3	AMPI-3	512262	2597766	1.03	0.43
7	AMPI-5	AMPI-5B	512971	2604464	3.80	0.07
8	AMPI-6	AMPI-6B	511937	2605656	4.34	0.14
9	AMPI-7	AMPI-7A	514123	2605387	2.97	0.07
10	AMPI-8	AMPI-8B	515127	2604063	0.72	0.04
11	AMPI-10	AMPI-10A	515045	2601978	3.52	0.04
12	AMPI-11	AMPI-11A	517093	2601555	1.75	0.05
13	AMPI-11	AMPI-11B	517093	2601555	0.20	0.02
14	AMPI-11	AMPI-11C	517093	2601555	0.64	0.04
15	AMPI-12	AMPI-12A	516123	2600676	3.07	0.08
16	AMPI-15	AMPI-15	512700	2602162	2.82	0.11
17	AMPI-16B	AMPI-16B	513402	2600720	4.15	0.14
18	AMPI-17	AMPI-17	514776	2599582	3.32	0.04
19	AMPI-19	AMPI-19	519632	2601373	1.32	0.47
20	AMPI-20	AMPI-20A	518099	2600379	3.08	0.03
21	AMPI-20	AMPI-20B	518099	2600379	2.73	0.03
22	AMPI-21	AMPI-21A	519107	2599250	2.86	0.02
23	AMPI-21	AMPI-21B	519107	2599250	2.37	0.01
24	AMPI-24	AMPI-24	513505	2598701	1.57	0.72
25	AMPI-25	AMPI-25	514483	2597411	1.85	0.04
26	AMPI-26	AMPI-26	510293	2600307	0.71	0.13
27	AMPI-28	AMPI-28A	509792	2605922	3.62	0.06
28	AMPI-28	AMPI-28B	509792	2605922	3.26	0.08
29	AMPI-28	AMPI-28C	509792	2605922	4.03	0.08
30	AMPI-29	AMPI-29A	510668	2604638	1.90	0.06
31	AMPI-29	AMPI-29B	510668	2604638	2.18	0.06
32	AMPI-30	AMPI-30	511178	2604018	2.79	0.07
33	AMPI-31	AMPI-31	511363	2605170	3.11	0.06
34	AMPI-33	AMPI-33	512386	2604986	3.49	0.07
35	AMPI-34	AMPI-34B	315995	2604849	0.35	0.08
36	AMPI-35	AMPI-35	514047	2604313	0.76	0.07
37	AMPI-39	AMPI-39	513336	2602673	2.80	0.12
38	AMPI-40	AMPI-40	516070	2601807	2.36	0.25
39	AMPI-41	AMPI-41	515441	2601313	2.60	0.02
40	AMPI-42	AMPI-42	514327	2601464	4.23	0.10

Sr. No.	Pit No.	Primary Sample No.	Easting (m)	Northing (m)	K_2O%	P_2O_5%
41	AMPI-43	AMPI-43A	512650	2601092	5.39	0.07
42	AMPI-43	AMPI-43B	512650	2601092	3.23	0.10
43	AMPI-44	AMPI-44B	511026	2602935	3.50	0.02
44	AMPI-45	AMPI-45	510322	2602615	2.95	0.09
45	AMPI-46	AMPI-46A	509935	2603015	2.73	0.08
46	AMPI-46	AMPI-46B	509935	2603015	3.18	0.07
47	AMPI-47	AMPI-47A	510567	2603487	2.24	0.08
48	AMPI-47	AMPI-47C	510567	2603487	2.26	0.04
49	AMPI-48	AMPI-48A	509719	2601813	1.64	2.80
50	AMPI-48	AMPI-48B	509719	2601813	3.13	0.13
51	AMPI-49	AMPI-49A	510302	2601252	2.46	0.09
52	AMPI-51	AMPI-51	513100	2600536	1.56	0.02
53	AMPI-52	AMPI-52	515833	2599571	2.99	0.07
54	AMPI-53	AMPI-53	516280	2598924	4.98	0.04
55	AMPI-54	AMPI-54A	517480	2598834	5.60	0.05
56	AMPI-54	AMPI-54B	517480	2598834	2.66	0.02
57	AMPI-55	AMPI-55	516897	2598257	2.88	0.11
58	AMPI-56	AMPI-56A	518952	2602063	3.33	0.31
59	AMPI-57	AMPI-56BC	518952	2602063	2.86	0.09
60	AMPI-57	AMPI-57B	518324	2601585	4.65	0.06
61	AMPI-58	AMPI-57C	518324	2601585	2.88	0.03
62	AMPI-58	AMPI-58	517571	2599929	2.73	0.03
63	AMPI-59	AMPI-59	517605	2601021	4.98	0.08
64	AMPI-60	AMPI-60A	516726	2601086	4.45	0.03
65	AMPI-60	AMPI-60B	516726	2601086	3.26	0.22
66	AMPI-60	AMPI-60C	516726	2601086	2.88	0.02
67	AMPI-61	AMPI-61	518664	2598760	3.25	0.05
68	AMPI-62	AMPI-62A	518724	2599811	2.46	0.08
69	AMPI-63	AMPI-62B	518724	2599811	1.99	0.08
70	AMPI-63	AMPI-63	512983	2605507	6.39	0.06
71	AMPI-64	AMPI-64	510045	2604136	2.05	0.03
72	AMPI-65	AMPI-65	510124	2605253	0.12	0.10
73	AMPI-66	AMPI-66	510692	2599552	2.05	1.92
74	AMPI-67	AMPI-67	511807	2599397	2.73	0.06

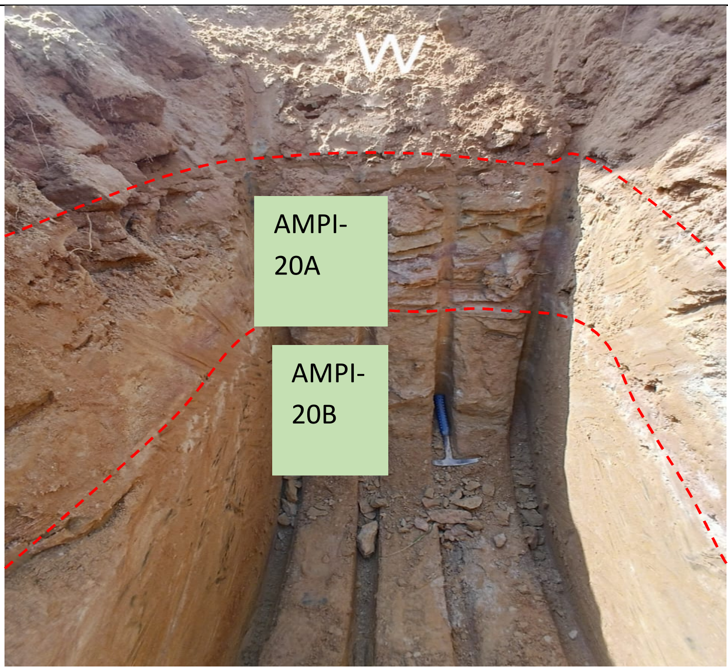


Photo 10.2 Photograph showing Pitting and sampling in Pit Sample no: AMPI-20A near village Ambara (K_2O-3.08%)

Pit exposure in the Ambara Maru Block showing The lithological sequence.

Pit Face/Orientation	Pit sample no.	From (m)	To (m)	Thick	Lithology
Face-1 (360°)		0.00	0.50	0.50	Light brown sandy soil
All faces have the same lithology	AMPI-20A	0.50	1.10	0.60	Greenish Grey, Soft, highly Friable Glauconitic
	AMPI-20B	1.10	2.00	0.90	Greenish Grey, Soft, Friable Glauconitic Sandstone

Location geo-coordinates:

Easting:518099
Northing:2600379
Elevation: 116.00m

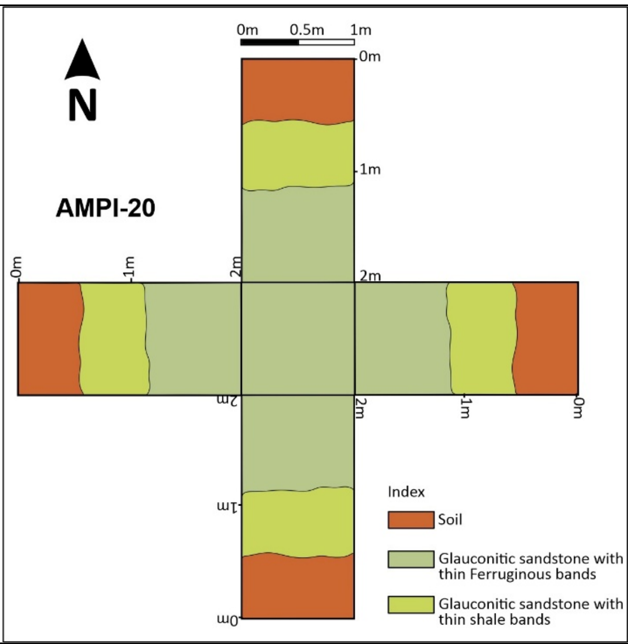
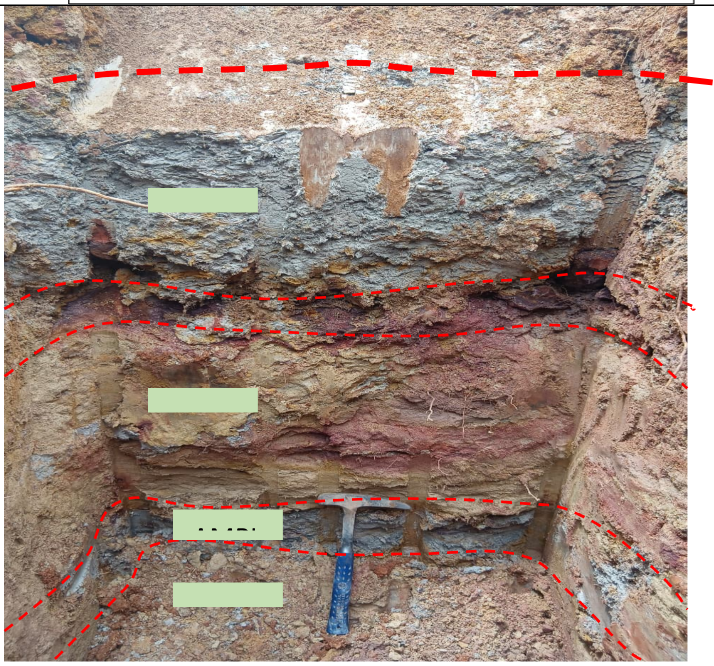


Photo 10.3:Photograph showing lithological variations exposed in Pit AMPI-20.



Location geo-coordinates:

Easting:512462
Northing:2599888
Elevation: 67.00m

Photo 10.4 Photograph showing Pitting and sampling in Pit No: AMPI-02 near village Ambara (Sample no: AMPI-02B (K_2O-5.03%)).
Pit exposure in the Ambara Maru Block showing the lithological sequence.

Pit Face/Orientation	Pit sample no.	From (m)	To (m)	Thick	Lithology
Face-1 (360°)		0.00	0.20	0.20	Soil cover
	AMPI-02A	0.20	0.30	0.10	Grey Shale
All faces have the same lithology	AMPI-02B	0.30	1.07	0.77	Yellowish Glauconitic Sandstone with thin ferruginous sanstone thin bands and shale bands
	AMPI-02C	1.07	1.19	0.12	Grey shale
	AMPI-02D	1.19	2.00	0.81	Glauconite with thin band of ferruginoussandstone

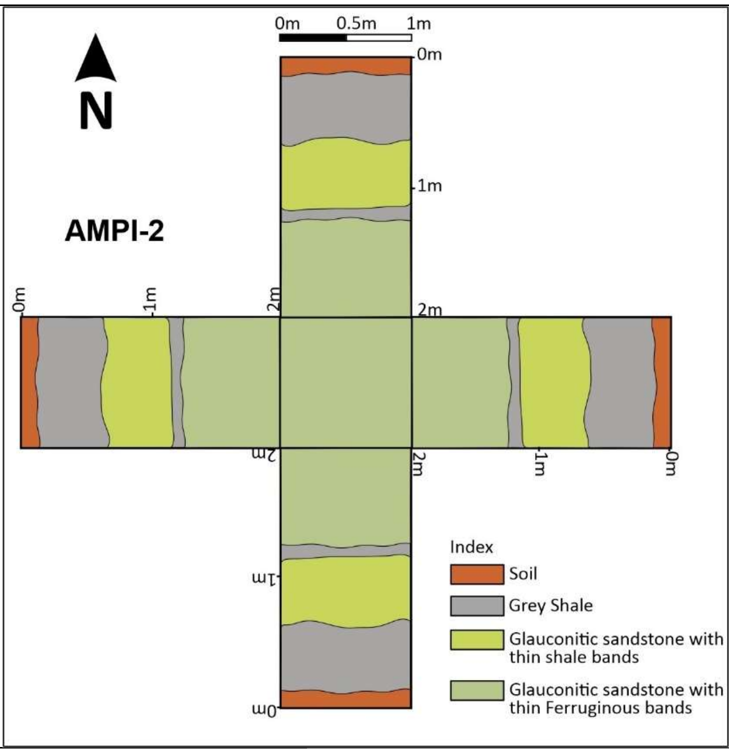
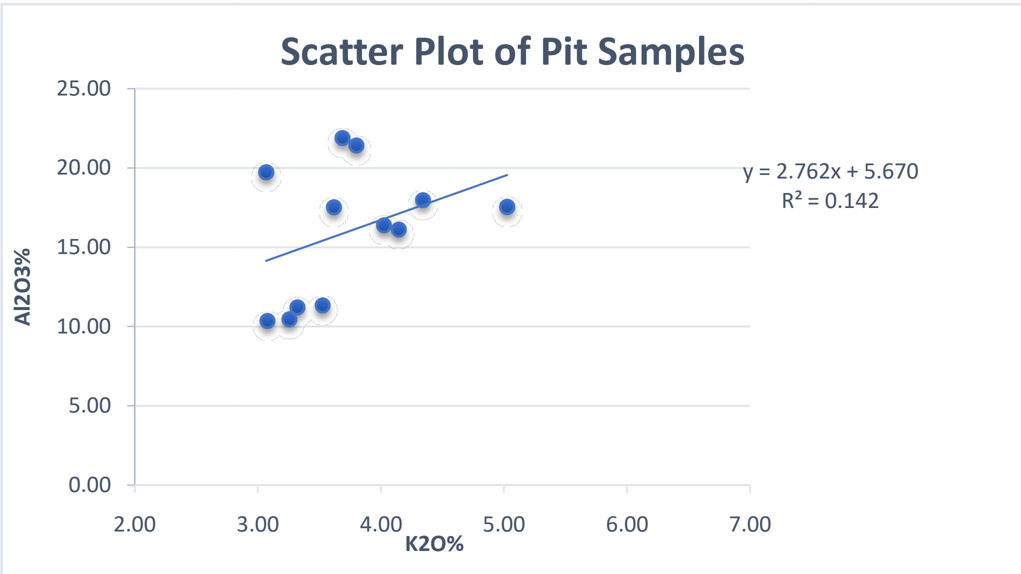


Photo 10.5Photograph showing lithological variations exposed in Pit AMPI-2.

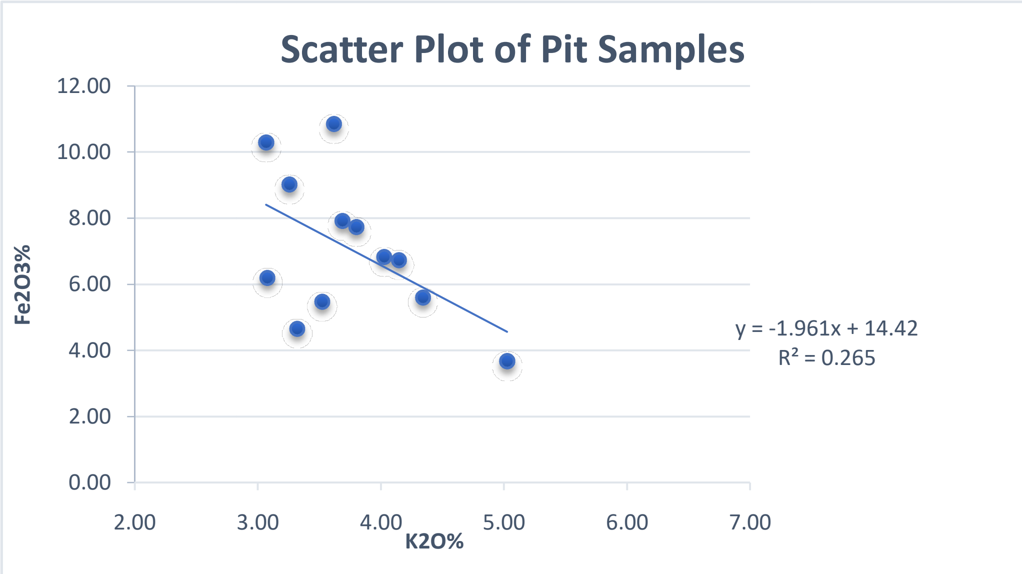
10.2.17 Based on the scatter plots of pit samples, the correlations between K_2O and major oxides can be interpreted as follows.

K_2O vs Al_2O_3:



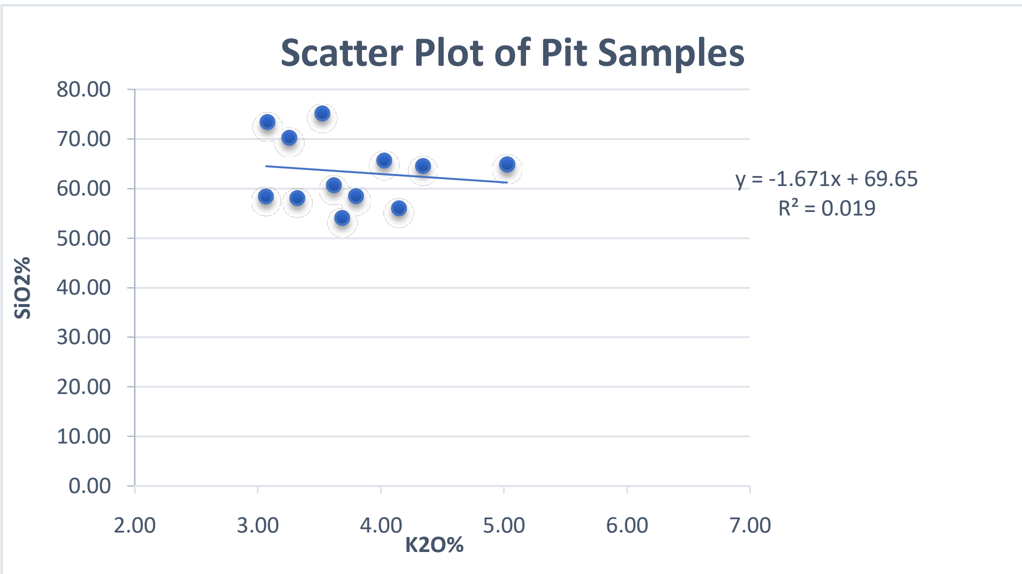
The plot shows a weak to moderate positive correlation with the regression equation $y = 2.762x + 5.6709$ and $R^2 = 0.1428$. This indicates that Al_2O_3 tends to increase slightly with increasing K_2O, indicating that potassium enrichment is partly associated with alumino-silicate minerals such as glauconite, feldspar, and clay minerals present in the sediments. However, the low R^2 value indicates that other mineral phases also influence the alumina content.

K_2O vs Fe_2O_3:



A moderate negative correlation is observed with the regression equation $y = -1.9619x + 14.428$ and $R^2 = 0.2657$. This suggests that Fe_2O_3 tends to decrease with increasing K_2O content. The relationship implies that iron oxides and ferruginous components are partly independent of glauconite formation, and in some horizons iron may occur as secondary limonitic coatings rather than within glauconitic minerals.

K_2O vs SiO_2:



The plot shows very weak negative correlation with the regression equation $y = -1.6718x + 69.652$ and $R^2 = 0.0196$. The very low R^2 value indicates almost no systematic relationship between K_2O and SiO_2. This shows that quartz content (SiO_2) is largely independent of potassium enrichment, reflecting the detrital quartz framework of the sandstone matrix.

Based on the pit sample geochemical analysis, samples containing >3% K_2O were plotted on scatter diagrams to examine the statistical relationships between K_2O and major oxides. The plots show a weak positive correlation between K_2O and Al_2O_3, suggesting that potassium enrichment is partly associated with glauconitic and clay-rich aluminosilicate components. In contrast, SiO_2 exhibits negligible correlation with K_2O, indicating that quartz occurs largely as a detrital framework mineral independent of potassium enrichment. Similarly, Fe_2O_3 shows a weak negative relationship with K_2O, suggesting that ferruginous phases are not directly linked with glauconite concentration. Overall, these relationships support the interpretation that glauconite occurs as discrete pellets within a quartz-rich sandstone matrix rather than being uniformly distributed throughout the rock.

10.2.18 **Exploratory Drilling:**

10.2.18.1 As part of the present exploration programme, exploratory core drilling was undertaken in the Ambara Maru Block at the G4 (Reconnaissance) level to assess the lateral continuity and depth persistence of glauconite, phosphorite, and REE mineralisation. Following completion of the initial phase of exploration work, the progress and results were reviewed in the Technical-cum-Cost Committee-II (TCC-II) meeting, which recommended the execution of four scout boreholes for preliminary subsurface assessment. Accordingly, four boreholes with a total drilling meterage of approximately 160 m were drilled on an approximate 1600 m grid pattern, in accordance with the provisions of the Minerals (Evidence of Mineral Contents) Rules, 2015.The boreholes were aligned along NE–SW trending section lines with an inter-borehole spacing of about 1600 m, providing representative subsurface coverage of the block area for reconnaissance-level evaluation.

10.2.18.2 Drilling operations commenced on 15 December2025 and were completed on 12 January 2026, achieving a cumulative drilled meterage of 160 m. The boreholes were designated MAMB-01 to MAMB-04.

10.2.18.3 The coordinates and Reduced Levels (RLs) of all boreholes were determined using Differential Global Positioning System (DGPS) under the WGS-84 datum, ensuring accurate and consistent positioning. The borehole locations, along with the corresponding section lines, have been plotted on the geological map of the block for spatial reference.

Table- 10.3

Details of Boreholes in Ambara Maru Block for Glauconite, Phosphorite and REE in Tehsil-Nakhatrana, District- Kachchh, Gujarat

BOREHOLE CO-ORDINATES OF AMBARA MARU BLOCK IN UTM ZONE42N(WGS84)

BH NO	Latitude	Longitude	Easting	Northing	RL (m)
MAMB-01	23° 33' 08.80443" N	69° 05' 39.25951" E	509617.984	2604680.646	48.677
MAMB-02	23° 33' 40.51393" N	69° 07' 01.49362" E	511948.522	2605657.499	47.072
MAMB-03	23° 33' 31.73247" N	69° 08' 17.95531" E	514116.325	2605389.381	81.911
MAMB-04	23° 31' 39.89415" N	69° 08' 47.15647" E	514947.648	2601950.938	74.484

Details of Boreholes Drilled in Ambara Maru Block

Sl. No.	BH.No.	Date of Commencement	Date of Closure	Total Depth(m)
1	MAMB-01	15.12.2025	28.12.2025	40.00
2	MAMB-02	24.12.2025	30.12.2025	40.00
3	MAMB-03	29.12.2025	01.01.2026	40.00
4	MAMB-04	01.01.2026	12.01.2026	40.00

10.2.19 Detailed geological logging of all borehole cores was carried out, incorporating systematic observations on structural features, lithological variations, and mineralogical characteristics (Annexure-II). Core sampling was undertaken at 1.0 m and 2.0m intervals, with minor adjustments where lithological changes warranted closer control. In nearly all boreholes, horizons of glauconitic sandstone and glauconitic shale/clay were encountered, confirming the occurrence of glauconite-bearing strata within the block.

Photo 10.6 Photograph showing Borehole Site (MAMB-01)

10.2.20 Associated laboratory investigations were carried out concurrently with core logging. The results of chemical analyses of borehole samples are presented in Annexure-IVC. These analyses provide quantitative data on major oxide composition, with particular emphasis on K_2O enrichment, which is a key parameter for assessing the grade and resource potential of glauconite mineralization. The block was also evaluated for phosphorite and rare earth elements (REE); however, no significant mineralized zones have been delineated at the present stage of investigation.

10.2.21 Table 10.4 summarises the delineated lithologies identified within the Ambara Maru Block, Kachchh District, Gujarat, based on subsurface exploration through boreholes. The cut-off grade of 3% K_2O has been adopted for the present study based on the guidelines and practices followed by the Indian Bureau of Mines for evaluation of glauconite-bearing sandstones. Glauconite is a potassium-bearing mineral, and K_2O content serves as the primary indicator of glauconite concentration in the host rock. Accordingly, a minimum threshold of 3% K_2O is considered suitable at the reconnaissance (G4) stage to delineate glauconite-bearing horizons and to identify zones with potential for further exploration and resource assessment.

10.2.22 The table records the depth intervals of glauconitic horizonstogether with the average K_2O grades calculated for each mineralised zone. This dataset offers a concise overview of the spatial distribution, thickness, and grade characteristics of glauconite-bearing horizons, forming a reliable basis for subsurface correlation, grade estimation, and resource categorisation.

10.2.23 Most boreholes display several mineralised intervals at varying depths, indicating a consistent presence of potash mineralisation across the area.Give one line each for lithology wise`

Table- 10.4

Summarised Litholog of Boreholes in Ambara Maru Block for Glauconite, Phosphorite and REE, District-Kachchh, Gujarat

BH No-MAMB-01											
From (m)	To (m)	Thickness (m)	Lithology	K2O %	SiO2 %	MgO%	CaO%	Na2O %	P2O5%	Al2O3%	Fe2O3%
0.00	4.40	4.40	Ferruginous Sandstone	0.89	90.82	0.10	2.14	0.06	0.05	1.77	2.32
4.40	5.00	0.60	Calcareous Sandstone	0.65	74.24	0.74	9.16	0.04	0.03	1.54	6.46
5.00	7.00	2.00	Glauconitic Sandstone	3.12	67.96	0.53	0.44	0.24	0.07	14.70	6.73
7.00	9.00	2.00	Calcareous Sandstone	2.14	43.23	2.50	7.26	0.24	0.33	13.80	13.52
9.00	12.00	3.00	Shaly Sandstone	2.83	51.51	2.40	7.18	0.27	0.16	13.19	9.32
12.00	13.00	1.00	Calcareous Sandstone	2.83	51.51	2.40	7.18	0.27	0.16	13.19	9.32
13.00	15.00	2.00	Glauconitic Sandstone	3.74	52.71	2.28	4.65	0.30	0.05	16.91	8.48
15.00	40.00	25.00	Shaly Sandstone	3.32	50.92	2.21	4.03	0.30	0.17	17.08	9.03

BH No-MAMB-02											
From (m)	To (m)	Thickness (m)	Lithology	K2O %	SiO2 %	MgO%	CaO%	Na2O%	P2O5%	Al2O3%	Fe2O3%
0.00	10.00	10.00	Glauconitic Sandstone	2.90	49.20	1.93	2.47	0.52	0.33	21.47	8.78
10.00	18.00	8.00	Shaly Sandstone	2.79	50.26	1.97	1.36	0.24	0.09	22.14	8.24
18.00	20.00	2.00	Glauconitic Sandstone	3.01	52.39	1.79	1.24	0.23	0.47	21.13	7.91
20.00	24.00	4.00	Shaly Sandstone	2.95	52.48	1.85	1.51	0.19	0.10	22.36	7.11
24.00	26.00	2.00	Glauconitic Sandstone	3.18	54.68	1.41	0.33	0.15	0.09	24.31	4.90
26.00	29.00	3.00	Calcareous Sandstone	2.39	47.49	4.02	9.08	0.14	0.08	13.44	7.40
29.00	31.00	2.00	Shaly Sandstone	2.91	50.29	1.50	1.02	0.17	0.16	21.59	7.74
31.00	33.00	2.00	Siliceous sandstone	1.37	84.26	0.56	1.18	0.13	0.07	5.69	3.43
33.00	40.00	7.00	Shaly Sandstone	2.43	50.40	2.38	4.63	0.22	0.11	18.10	7.59

BH No-MAMB-03											
From (m)	To (m)	Thickness (m)	Lithology	K2O %	SiO2 %	MgO%	CaO %	Na2O%	P2O5%	Al2O3%	Fe2O3%
0.00	4.00	4.00	Glauconitic Sandstone	2.84	55.08	0.99	6.89	0.20	0.17	10.87	13.39
4.00	5.00	1.00	Ferruginous Sandstone	2.08	42.79	2.98	14.10	0.16	0.43	6.51	16.32

BH No-MAMB-03											
From (m)	To (m)	Thickness (m)	Lithology	K2O %	SiO2 %	MgO%	CaO %	Na2O%	P2O5%	Al2O3%	Fe2O3%
5.00	6.00	1.00	Glauconitic sandstone	3.15	52.97	0.91	1.42	0.39	0.41	16.42	16.09
6.00	10.00	4.00	Ferruginous Sandstone	2.62	50.87	1.83	5.24	0.22	0.34	11.78	16.28
10.00	11.00	1.00	Glauconitic sandstone	3.14	58.20	1.45	3.70	0.19	0.31	13.69	10.10
11.00	14.00	3.00	Ferruginous Sandstone	2.02	43.43	3.27	9.32	0.11	0.22	8.35	18.37
14.00	15.00	1.00	Glauconitic sandstone	3.02	58.37	1.06	0.92	0.15	0.16	17.95	9.30
15.00	18.00	3.00	Ferruginous Sandstone	2.42	49.42	2.22	6.13	0.12	0.28	12.45	14.28
18.00	19.00	1.00	Calcareous Sandstone	2.52	50.41	2.54	7.41	0.13	0.15	13.80	8.34
19.00	24.50	5.50	Shaly Sandstone	2.59	50.67	1.95	4.09	0.18	0.30	15.88	10.52
24.50	27.00	2.50	Calcareous sandstone	2.52	51.36	2.34	6.36	0.26	0.13	13.97	9.62
27.00	40.00	13.00	Shaly Sandstone	2.46	50.11	1.74	3.59	0.32	0.15	18.70	8.91

BH No-MAMB-04											
From (m)	To (m)	Thickness (m)	Lithology	K2O%	SiO2%	MgO%	CaO%	Na2O%	P2O5%	Al2O3%	Fe2O3%
0.00	5.00	5.00	Glauconitic Sandstone	2.60	66.74	0.51	6.64	0.13	0.06	9.05	7.72
5.00	7.00	2.00	Calcareous Sandstone	2.32	62.38	0.49	10.30	0.09	0.04	7.02	9.01
7.00	9.00	2.00	Glauconitic Sandstone	3.19	74.93	0.25	0.22	0.23	0.10	9.00	8.10
9.00	12.00	3.00	Ferruginous sandstone	2.62	52.33	2.61	11.43	0.14	0.39	8.28	10.44
12.00	14.00	2.00	Glauconitic Sandstone	3.55	56.08	1.87	5.53	0.20	0.12	14.10	9.24
14.00	22.00	8.00	Shaly Sandstone	2.87	52.67	1.89	2.92	0.16	0.12	18.36	9.04
22.00	26.00	4.00	Siliceous Sandstone	2.88	70.79	1.25	1.73	0.21	0.08	10.44	5.75
26.00	28.00	2.00	Glauconitic Sandstone	4.24	61.00	1.45	0.61	0.26	0.06	17.27	6.55
28.00	31.00	3.00	Calcareous Sandstone	2.42	46.81	2.94	8.18	0.18	0.23	12.66	13.74
31.00	40.00	9.00	Shaly Sandstone	2.87	44.53	2.24	2.26	0.30	0.33	21.32	13.24

10.2.24 The borehole data from MAMB-01 to MAMB-04 indicate a heterolithic siliciclastic succession comprising glauconitic sandstone, shaly sandstone, calcareous sandstone, ferruginous sandstone and minor siliceous sandstone. Among these, glauconitic sandstone constitutes the principal mineralised horizon, characterized by K_2O values generally ranging from about 2.6% to 4.24%, reflecting the presence of glauconite pellets dispersed within a quartz–clay matrix. Shaly sandstone forms a major part of the sequence and shows moderate K_2O and relatively high Al_2O_3, indicating a significant clay and aluminosilicate component. Calcareous sandstone horizons are distinguished by elevated CaO content, indicate carbonate cementation under marine conditions, whereas ferruginous sandstone units show high Fe_2O_3 values associated with iron oxide enrichment and weathering effects. Siliceous sandstone horizons display high SiO_2 values, indicating quartz-dominated mature sediments. Overall, the lithological association and geochemical characteristics indicate deposition within a shallow marine siliciclastic system where glauconite developed authigenically under conditions of slow sedimentation and periodic marine influence, resulting in stratabound glauconitic horizons within the sandstone–shale sequence.

10.3.0 Data spacing for reporting of exploration results:

10.3.1 The boreholes were spaced at an interval of approximately 1600 m, which is considered adequate for establishing glauconite resources at the G-4 stage (Reconnaissance Exploration) in accordance with the provisions of the Minerals (Evidence of Mineral Content) Rules, 2015. Based on the present level of exploration and the available geological data, the estimated resources of the Ambara Maru Block may be classified under the Reconnaissance Mineral Resource (UNFC Code: 334) category.

CHAPTER-11

11.0.0 LOCATION OF DATA POINTS

11.1.0 ACCURACY AND QUALITY OF SURVEY

11.1.1 The survey of boreholes drilled in the block has been carried out by the DGPS Trimble GNSS (Annexure-IB). The photograph of instrument is given in Photo-11.1.

Photo-11.1: DGPS survey in the block using DGPS (Trimble GNSS)

11.1.2 The SOI base station was utilised for fixing the borehole positions on the ground as well as for obtaining the reduced levels of the boreholes. The base station used from the SOI India CORS network. The coordinates of the SOI base station are provided in Table-11.1.

Table-11.1

Coordinates of the SOI CORS Base Point for DGPS Survey of Ambara Maru Block for Glauconite, Phosphorite and REE in Tehsil-Nakhatrana, District- Kachchh, Gujarat

Base Station	Latitude	Longitude	Easting (m)	Northing (m)	RL (m)
Survey of India (Bhrindiyara)	N23°39'43.70026"	E69°42'27.97850"	572176.176 m	2617000.363 m	7.717 m

11.1.3 **Technical Specifications of DGPS**

Make: Trimble GNSS

- **Model:**DA-2 Catalyst
- **Year:**2025

a) Measurement Accuracy:

- Static Mode
  - Horizontal: 10 mm + 0.1 ppm or better
  - Vertical: 20 mm + 0.4 ppm or better

b) Baseline Processing Results

Total 4 boreholes were drilled in the block by MECL as part of present G4 stage exploration have been fixed by DGPS survey instrument. Borehole locational co-ordinates & Reduced level (RL) of the borehole are given in Annexure-IB and also shown in Plate-III and IV.

11.2.0 **QUALITY AND ADEQUACY OF TOPOGRAPHIC CONTROL**

The survey work has been carried out with the help of DGPS(GNSS) for higher level measurement accuracy. A point list was then generated as .csv file for topographical points and summary was attached along with report. The baseline processing results are also enclosed with this report. Survey work carried out by the experienced qualified surveyor as per the prevailing standard procedures.

CHAPTER-12

12.0.0 SAMPLING TECHNIQUE

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

12.1.1 Drill core samples were collected systematically from glauconite-bearing zones intersected in boreholes. Care was taken to avoid weathered or altered portions, and only fresh, unoxidised core segments were sampled. Each core was split lengthwise into two halves using a core splitter: one half was preserved for record, while the other half was used for sampling. Individual samples weighed about 1.0–1.5 kg and were placed in clean cotton bags, securely tied and labelled to ensure proper identification and traceability.

12.1.2 Sample preparation followed standard geological protocols to maintain accuracy. The collected core samples were first crushed, then ground in a pulveriser, and finally homogenised with mortar and pestle to achieve a fine powder of -200 mesh size. After each sample, all equipment—including crusher, pulveriser, trays, and tools—was thoroughly cleaned to prevent contamination.

12.1.3 Representative portions were obtained using the coning and quartering method. The powdered sample was heaped, flattened, and divided into four quadrants; two opposite quadrants were retained and the process repeated until the required weight was achieved. About 300 g of homogenised powder was prepared and split into three packets of 100 g each: one for primary analysis, one for check analysis, and one for laboratory reference. Remaining material was stored in sealed, labelled containers under controlled conditions.

12.1.4 These procedures ensured that the samples were representative of the glauconite-bearing zones. Avoidance of altered material preserved geological integrity, systematic splitting maintained archival record, fine grinding ensured uniform particle size, and coning and quartering provided statistical representativity. Triplicate division of samples supported analytical reliability, while strict cleaning and secure packaging eliminated risks of contamination and ensured traceability.

Photo-12.1 Photograph showing samplesample crusher used in sample processing

Photo-12.2: Photograph showing pulveriser used in sample processing

Photo-12.3: Photograph showing coning-qurtering equipment used in sample processing

12.2.0 PRIMARY AND CHECK SAMPLE STUDIES

12.2.1 During the exploration work, a total of 160.00 m of core drilling was carried out targeting the glauconitic zones. A total of 119 nos. of borehole samples, 135 nos. of bedrock samples, and 74 nos. of pit samples were collected and analyzed for eight major oxides, namely K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 (Annexure-IVA,B,C). In addition to the 18 bedrock samples, 5 pit samples, 21 borehole samples were analysed 34 element analysis (trace element)-(Annexure-IVD)..Further, the primary samples were analyzed at the Chemical Laboratory, MECL, Nagpur, while the external check samples were analyzed at the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory. The analytical results of the primary borehole samples and the external check borehole samples are presented in Annexure-IV and Annexure-VI, respectively.

12.2.2 A total of three samples were subjected to X-ray Diffraction (XRD) analysis at the MECL Laboratory for the identification and confirmation of constituent mineral phases. The XRD analysis of selected borehole samples from the Ambara Maru Block indicates that the rocks are predominantly composed of quartz and feldspar (microcline, orthoclase) with associated clay minerals such as kaolinite, illite, and dickite, along with minor muscovite, dolomite, and siderite. The presence of clay minerals and mica suggests diagenetic alteration of glauconitic material within the sandstone matrix. Accessory minerals such as pyrite, magnetite, and biotite indicate deposition under reducing marine conditions, which are favourable for glauconite formation. Overall, the mineral assemblage supports the occurrence of glauconite-bearing siliciclastic sediments with partial alteration to clay minerals. The details of the analysis report are attached as Annexure-V.

CHAPTER-13

13.0.0 DRILLING TECHNIQUES AND DRILL SAMPLING EMPLOYED

13.1.0 DRILLING TYPES AND DETAILS

13.1.1 During the present investigation, MECL drilled a total of 4 boreholes aggregating to 120 m of core drilling and carried out other associated geological and laboratory analytical works in the study area. The exploration programme was executed to evaluate the lithological characteristics, mineralization pattern, and subsurface continuity of the targeted horizons. Detailed information on the boreholes drilled by MECL, including their locations, depths, coordinates, and drilling particulars, is provided in Annexure-IB. A consolidated summary of the borehole data, highlighting key parameters and drilling outcomes, is presented in Table-10.2 and Table-10.4.

13.1.2 Core drilling was carried out using two conventional wireline drill rigs, RD-100 (Rig Nos. MEC-364, MEC-333, and MEC-349). All boreholes in the block were drilled in NQ size using the single barrel wireline wet core drilling method. During drilling operations, diamond impregnated NQ bits (outer diameter 75.7 mm and inner diameter 47.6 mm) and TC bits were used.At the initial depths, HW and NW casing were inserted in all boreholes to prevent the collapse of soil cover and loose, friable weathered formations. Polymer-based drilling fluid was used to flush out drill cuttings and stabilize the borehole walls. The drilling fluid also acted as a coolant to prevent overheating and burning of drill bits.All necessary precautions were taken to maintain the quality of drilling operations and to achieve maximum core recovery.

13.1.3 The quality of drilling was ensured during the operation. After closure, all the boreholes have been properly sealed with cement pillars.

13.2.0 EXPLORATORY DRILLING

13.2.1 Owing to the bedded nature of the deposit, the drilling programme was planned with vertical boreholes. Accordingly, 4 boreholes were laid out on approximately 1600 m × 1600 m grid pattern along 4nos. of NE–SW trending section lines, spaced at 800m to 1600 m intervals, to evaluate the lateral continuity, depth persistence, and thickness of the mineralized horizons.

Photo-13.1 Photograph showing Drilling work under progress in Ambra Maru block near Village of Ambara.

13.2.2 This drilling pattern was designed to systematically assess the extent and depth of mineralization, establish stratigraphic continuity, and generate subsurface geological data essential for resource evaluation and future exploration planning.

13.2.3 Details of boreholes drilled by MECL in Ambara MaruBlock are given in table no 10.2 in chapter 10.

13.3.0 DEVIATION SURVEY IN DRILLING

13.3.1 All the exploratory boreholes drilled within the block are vertical, with depths ranging up to 40.00 m. Owing to the shallow depth and vertical nature of these boreholes, no deviation was observed during drilling. Accordingly, deviation surveys were not carried out for the boreholes in the block.

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

13.4.1 The drill cores obtained from the Ambara Maru Block have been logged in detail, covering lithology, grain size, colour, nature and type of mineralisation, as well as structural attributes including foliation, fractures and fracture fillings. The major lithologies intersected in the boreholes comprise feldspathic sandstone, ferruginous sandstone, feldspathic sandstone, limestone, and glauconitic sandstone, Clay, interbedded sandstone and shale, shale. Detailed run-wise lithologs and summarized lithologs for all 04 boreholes drilled by MECL are presented in Annexure–II and III.

13.4.2 Core recovery in the glauconitic sandstone zones has been recorded at 95%, which is considered satisfactory. The recovery data were systematically documented during drilling and logging, ensuring accurate representation of the subsurface lithologies. Samples were delineated primarily on the basis of glauconitic zones identified visually. In general, the sampling interval was maintained at 1.00 m; however, variations were introduced where lithological changes, mineralisation type, or concentration warranted adjustment to capture representative material.

13.4.3 The primary core samples collected from these zones have been subjected to detailed chemical analysis, with results presented in Annexure–III. The analytical programme was designed to ensure reliability and reproducibility, with representative samples assayed to establish the grade and distribution of glauconite mineralisation. The systematic recording of core recoveries, coupled with the assay of primary samples, confirms that both recovery and analytical data have been properly documented and are suitable for resource evaluation.

13.5.0 MEASURES TAKEN TO MAXIMIZE SAMPLE RECOVERY AND ENSUREREPRESENTATIVE NATURE OF THE SAMPLES.

13.5.1 Drilling operations were carried out with due care to maintain optimum core recovery, particularly within mineralised zones. Short drill runs were adopted wherever necessary to minimise core loss and ensure that the recovered material was representative of the in-situ lithology.

13.5.2 In instances where core recovery was less than complete, the grade of the recovered portion was extrapolated over the non-recovered section, following standard geological practice. This approach ensured that the analytical dataset remained representative of the mineralised interval while accounting for unavoidable gaps in recovery.

13.5.3 The quality of drilling was closely monitored throughout the programme. Proper drilling techniques, use of suitable drilling fluids, and careful handling of cores were employed to minimise disturbance and maximise recovery. Continuous supervision and adherence to best practices ensured that the samples collected were both representative and suitable for subsequent geological and geochemical evaluation.

13.6.0 BOREHOLE CORE SAMPLING

13.6.1 A total of 140 primary samples were generated from borehole cores obtained during drilling operations carried out by MECL. The samples were demarcated considering both the variation in glauconitic sandstone zones and the associated lithological changes. In general, the sampling interval was maintained at 1.00 m; however, in certain instances, the interval was adjusted between 0.50 m and 3.00 m depending on lithological variation, mineralisation type, and concentration, to ensure representative coverage of the mineralised horizons.

13.6.2 Sample demarcation was carried out during core logging by the geologist, based on visual identification of glauconitic zones and lithological boundaries. Once marked, the cores were split into two equal halves using a core splitter. One half was retained in the core box for permanent record and future reference, while the other half was processed for analysis.The analytical half was first crushed to approximately 100 mesh size, followed by further grinding to fine powder and sieving through -200 mesh to achieve uniform particle size. The powdered material was thoroughly homogenised to eliminate bias. From this homogenised lot, about 100 g of representative sample was obtained by successive coning and quartering and designated as the primary sample for chemical analysis. The remaining portion of the -200-mesh material was securely stored as duplicate reference material for future checks and validation.

13.6.3 This systematic approach ensured that the borehole core samples were representative of the glauconitic mineralised zones, with proper archival record maintained, and reliable analytical samples prepared for geochemical evaluation.

CHAPTER-14

14.0.0 SUB SAMPLING TECHNIQUES AND SAMPLE PREPARATION

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

14.1.1 Core sampling and analytical work were undertaken across the entire mineralised zones intersected in the boreholes to ensure complete and representative coverage of glauconite-bearing horizons. Each sample was carefully marked on the core during logging, with depth intervals clearly indicated prior to extraction. Special emphasis was placed on glauconitic sandstones and associated shale units, covering both high-grade and marginal mineralised sections to evaluate vertical and lateral grade variations. This approach ensured that all significant lithological variations within the mineralised sequence were represented in the analytical dataset.

14.1.2 The mineralised cores were split into two equal halves using a core splitter (Photo 14.1), thereby maintaining uniform distribution of ore minerals in both portions. One half of the split core was retained in the core box for permanent record and future reference, while the other half was processed for analysis. The analytical half was first crushed and pulverised to (-) 200 mesh size, and a representative ~500 g sample was obtained by the coning and quartering method (Photos 12.2 and 12.3). From this homogenised lot, two 100 g samples were prepared: one was sent to the MECL Chemical Laboratory, Nagpur, for primary chemical analysis, and the other was retained for check analysis. The remaining ~300 g of powdered material was preserved under controlled conditions for future studies.

14.1.3 During the present exploration programme, a total of 140 primary borehole core samples and 12 external check samples (borehole core) were prepared for chemical analysis. Of the 140 primary samples, 119 samples were analysed for eight major oxides, while 21 samples were analysed for trace elements (34 elements). The primary samples for major oxide analysis—including K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, Fe_2O_3 and trace elements were analysed at the MECL Chemical Laboratory, Nagpur, following standard analytical procedures and quality control protocols.

Photo-14.1: Photograph showingcore splitter used to split borehole cores

14.1.4 To ensure analytical accuracy and reproducibility, 34 external check samples—comprising 15 bedrock samples, 7 pit samples, and 12 borehole core samples—were submitted to the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory, for analysis of major oxides. The results obtained from the check samples were compared with those from the primary analyses to independently validate the analytical data. This comparative evaluation enhanced the reliability and confidence of the geochemical dataset generated during the exploration programme.The detailed analytical results of the primary samplesare presented in Annexure-IVA,B,C,D, while the check sample analysis are provided in Annexure-IVE.

14.2.0 NATURE, QUALITY AND APPROPRIATENESS OF THE SAMPLE PREPARATION TECHNIQUE

14.2.1 The sampling procedure for primary borehole core samples, as detailed in Para 14.1.0, was carried out under strict QA/QC protocols to maintain the quality and integrity of the samples. All equipment used in crushing, sieving, splitting, and homogenisation was thoroughly cleaned before and after processing each sample to eliminate the risk of contamination. In addition, regular maintenance of crushers, pulverisers, and sieves was undertaken to ensure consistent performance and reliability of the preparation process.

14.2.2 Samples were reduced to the required size fraction using standardised crushing and sieving techniques. The homogenised material was further subjected to the coning-and-quartering method to obtain representative splits. This procedure ensured that the prepared samples were statistically representative of the in-situ mineralised zones.

14.2.3 All preparation work was performed by trained and experienced personnel, following established geological protocols. The systematic application of proper technique and procedural discipline ensured that the samples were homogeneous, unbiased, and suitable for chemical analysis. As a result, the prepared samples accurately reflected the mineralised horizons intersected in drilling, thereby enhancing the reliability and reproducibility of the analytical dataset generated for the Ambara Maru Block.

14.3.0 **QUALITY CONTROL PROCEDURES ADOPTED**

14.3.1 Primary core samples were collected from the entire mineralised zones intersected in the boreholes and subsequently prepared at the centralised mechanised sampling unit at MECL Nagpur. Standardised sampling protocols were strictly followed to ensure that the samples were representative of the in-situ mineralisation. Each stage of sampling and preparation was carried out under the direct supervision of qualified sampling technicians, thereby maintaining consistency and reliability in the dataset.

14.3.2 External check samples were also prepared at the same facility, following identical procedures and under the same level of supervision. This ensured uniformity in preparation and eliminated procedural bias between primary and check samples. All equipment used for crushing, pulverising, sieving, and homogenisation was regularly cleaned and maintained to prevent contamination and to guarantee reproducibility of results.

14.3.3 The adoption of these QA/QC measures ensured that both primary and external check samples were of high quality, representative of the mineralised horizons, and suitable for chemical analysis. The systematic application of controlled procedures enhanced the reliability of the analytical results and provided confidence in the geochemical dataset generated for the Ambara Maru Block.

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

14.4.1 Primary samples were systematically marked and prepared from mineralised cores, with intervals carefully selected during detailed core logging to capture lithological and mineralisation variations. Sampling followed the standardised procedure outlined in Para 14.1.0, including core splitting, crushing, pulverising, and homogenisation to (-)200 mesh. Strict QA/QC protocols ensured uniformity and eliminated bias. The combination of accurate core marking and disciplined preparation techniques produced samples that are truly representative of the in-situ mineralised horizons, providing a reliable analytical dataset for resource evaluation.

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

14.5.1 For the determination of major oxides (K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3) using X-ray fluorescence (XRF) and for the analysis of trace elements by ICP-MS, the samples were pulverized to a particle size of –200 mesh. This level of fine pulverization was adopted to ensure complete homogenization of mineral phases, minimize analytical bias, and achieve high reproducibility and accuracy of the analytical results.

14.5.2 Reduction to (–)200 mesh size is appropriate to the grain size of the glauconitic sandstone and associated lithologies, as it eliminates particle-size related bias and minimises analytical errors. The uniform fine powder facilitates thorough mixing of mineral phases and enhances the precision of XRF measurements.

14.5.3 The prepared powders were homogenised prior to pellet or fused bead preparation, following standard analytical protocols. This ensured that the elemental concentrations obtained were accurate, representative, and consistent with the in-situ mineralised material intersected in drilling.

CHAPTER-15

15.0.0 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 Reconnaissance Survey (G4 Stage) for glauconite, phosphorite, and REE in the Ambara Maru Block (Area: 94.25 sq. km), Tehsil Nakhatrana, District Kachchh, Gujarat involved systematic geochemical sampling followed by laboratory analysis. During the exploration programme, a total of 372 samples were collected, comprising 153 bedrock samples, 79 pit samples, and 140 borehole core samples.Out of these, 328 samples (135 bedrock, 74 pit, and 119 borehole core samples) were analysed for eight major oxides (K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3) using Wavelength Dispersive X-Ray Fluorescence (WD-XRF). In addition, 44 samples (18 bedrock, 5 pit, and 21 borehole core samples) were analysed for trace elements using Inductively Coupled Plasma–Mass Spectrometry (ICP-MS).

15.1.2 To ensure analytical accuracy and reliability of the results, 34 external check samples were also prepared and submitted for major oxide analysis. Prior to analysis, all samples were pulverised to –200 mesh to ensure homogeneity and minimise analytical bias caused by particle-size variations.

15.1.3 Primary samples were analysed at the MECL Chemical Laboratory, Nagpur, following established internal protocols, while external check samples were analysed at NABL-accredited laboratories to validate results and maintain QA/QC standards. The adoption of WD-XRF, combined with duplicate and external check analyses, ensured that the dataset generated is both reliable and representative of the mineralised horizons. A total of 3 glauconite samples were subjected to X-ray diffraction (XRD) analysis at the MECL Laboratory for the identification and confirmation of constituent mineral phases. Result of the same is awaited.

15.1.4 Detailed descriptions of the analytical methods, including sample preparation, homogenisation, and QA/QC procedures, are provided in the subsequent sections of this report. These measures confirm that the assaying and laboratory procedures adopted during the survey were appropriate to the nature of the material and of sufficient quality to support resource evaluation in the Ambara Maru Block.

15.2.0 ANALYSIS OF GLAUCONITE BEARING SAMPLES BY XRF

15.2.1 WD XRF (Wavelength Dispersive X-ray Fluorescence)

The glauconite-bearing core samples collected during the exploration programme were analysed using Wavelength Dispersive X-ray Fluorescence (WD-XRF), a non-destructive analytical technique widely employed for the determination of major oxides in geological materials. This method was selected for its ability to provide high precision and accuracy in elemental quantification while preserving the integrity of the original sample.

In the present study, WD-XRF was utilised to determine eight major oxides — K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 — which are critical for evaluating the chemical composition and grade of glauconitic sandstones. The analyses were carried out using a RIGAKU ZSX Primus IV XRF instrument, following standard laboratory protocols to ensure reproducibility and reliability of results.

The adoption of WD-XRF ensured that the analytical dataset generated was both accurate and representative of the mineralised horizons intersected in drilling. The precision of this technique, combined with rigorous sample preparation and QA/QC measures, provides confidence in the geochemical results used for resource evaluation in the Ambara Maru Block.

Photo 15.1 Photograph showing WD-XRF instrument (Rigaku, Japan) at Chemical Lab, MECL, Nagpur

15.2.2 PROCEDURE OF ANALYSIS BY WD XRF

Powdered samples were pelletised using a hydraulic press prior to analysis. The WD-XRF instrument (RIGAKU ZSX Primus IV) was calibrated using matrix-matched Certified Reference Materials (CRMs) to ensure accuracy and precision. After calibration, samples were analysed for eight major oxides — K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 with oxide concentrations computed using the ZSX software. Loss on Ignition (LOI) was determined separately by heating the samples at 1000 °C in a muffle furnace and recording the weight loss.

Analytical Procedure:

1. Calibrate the WD-XRF instrument using selected representative samples and CRMs.
2. Verify that the instrument is set up according to standard operating guidelines.
3. Place the prepared pellet securely in the sample holder.
4. Ensure correct positioning of the sample cup within the instrument.
5. Initiate the WD-XRF analysis through the ZSX software.
6. Allow the instrument to scan the sample, during which incident X-rays excite atoms in the sample, causing emission of characteristic fluorescence.
7. Record and tabulate results, including oxide concentrations and relevant analytical parameters.

15.3.0 CHECK ANALYSIS FROM THIRD PARTY NABL ACCREDITED LABORATORY

15.3.1 To ensure the reliability and accuracy of analytical results, third-party check analyses were carried out at the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory. During the present exploration programme, a total of 34 external check samples derived from the block were submitted for independent analysis.

15.3.2 These external check samples were analysed for eight major oxides — K_2O, SiO_2, MgO, CaO, Na_2O, P_2O_5, Al_2O_3, and Fe_2O_3 — using standard laboratory protocols. The adoption of NABL-accredited facilities for check analysis provided an independent validation of the primary laboratory results, thereby strengthening the QA/QC framework of the exploration programme.

15.3.3 The detailed analytical results of these external check samples are awaited.

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

15.4.1 The security and chain of custody of all samples — from collection in the field to preparation at the sampling unit and subsequent dispatch to the chemical laboratory were maintained through a systematic and well-organised process. All samples were prepared at the centralised mechanised sampling unit under the direct supervision of qualified sampling technicians, ensuring procedural discipline and accountability at every stage.

15.4.2 Each sample was carefully labelled, tagged, and recorded prior to dispatch. Samples were transported to the chemical laboratory in securely sealed bags, with the integrity of the seals verified at the sampling unit before opening. This procedure ensured that the identity and traceability of each sample were preserved throughout the transfer process.

15.4.3 Strict adherence to standard operating procedures and precautionary measures eliminated the possibility of contamination. The sampling unit functioned independently from the chemical laboratory, thereby preventing any risk of cross-contamination between preparation and analysis. Remaining portions of the samples were properly preserved, securely stored, and clearly labelled for future reference, ensuring a complete and traceable chain of custody under company control.

15.5.0 NATURE OF QUALITY CONTROL PROCEDURES ADOPTED

15.5.1 To ensure the accuracy and reliability of analytical results, NCSDC-16006 Certified Reference Material (CRM) was employed as part of the quality control framework. The CRM was processed under identical conditions as the borehole core samples and analysed after every batch of 20 samples. This procedure provided a consistent benchmark for validating analytical precision and detecting any instrumental or procedural deviations.

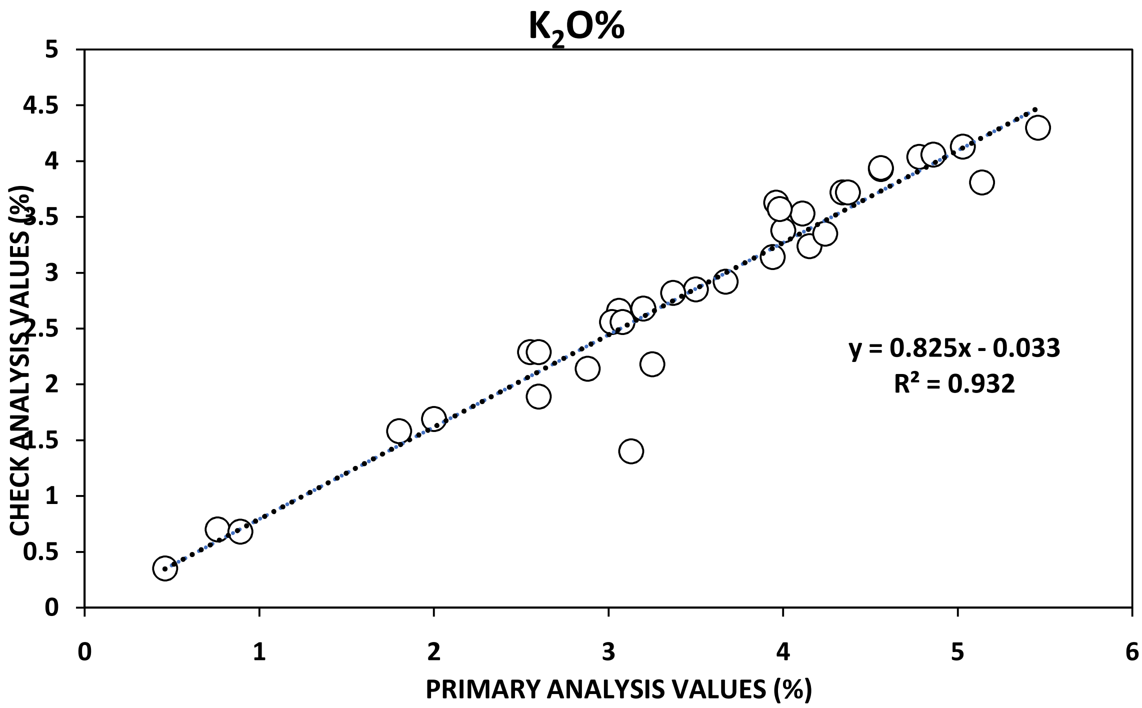
15.5.2 In addition to internal QA/QC checks, a total of 34 external check samples were analysed at the JNARDDC Chemical Laboratory, Nagpur, which is NABL-accredited. Comparative results of primary and external check borehole samples are furnished in Annexure– IVE, providing independent validation of the analytical dataset. Analysis report of external check samples is awaited.

15.5.3 A scatter plot illustrating the comparison between primary and external check analyses for K_2O (%) is presented in Text Figure–15.1. The calculated correlation coefficient of 0.966, being close to unity, demonstrates a strong positive relationship between the two datasets. This confirms good repeatability, reliability, and consistency of the analytical procedures, as well as the homogeneity of the prepared samples.

15.5.4 Furthermore, detailed statistical parameters for K_2O values in both primary and external check samples are comprehensively summarised in Table–15.1, reinforcing the robustness of the QA/QC measures adopted during the exploration programme in the Mudhan Khatiya Block.

15.5.5 The comparative statistical evaluation of K_2O between primary and check analyses demonstrates good analytical reproducibility with a small but systematic bias. The arithmetic mean of K_2O is slightly higher in the primary dataset (3.45%) compared to the check data (2.82%), indicating a consistent negative bias in the external analysis or slight overestimation in the primary measurements. The relatively low standard deviations (1.240 and 1.060) and standard errors (0.213 and 0.182) suggest good precision within both datasets. The high correlation coefficient (r = 0.966) confirms a strong linear relationship and consistency in sample behavior across both analyses, implying that the variation is predominantly systematic rather than random. This is further supported by the mean absolute error (0.634) and mean relative random error (0.185), indicating limited random analytical uncertainty.

15.5.6 However, the paired t-test value (10.584) is significantly higher than the critical value, demonstrating that the difference between primary and check means is statistically significant, thereby confirming the presence of a systematic analytical bias rather than random error. In contrast, the F-test value (1.368) indicates that the variances between the two datasets are comparable, suggesting no significant difference in analytical precision between the laboratories. Overall, these results indicate that while both datasets are internally consistent and reliable, a systematic offset exists, which should be considered during data interpretation, particularly for geochemical classification and modelling of glauconitic sandstone.



Text Figure 15.1 Scatter Plot of Primary vs Check (External) sample analysis of samples

Table-15.1

Statistical comparison of Primary and External Check sample analysis for K_2O **(samples)**

Comparison Index	K_2O%	
	Primary	Check
No. of sample pairs	34	
Arithmetic mean	3.45	2.82
Standard Deviation	1.240	1.060
Standard error of mean	0.213	0.182
Variance	1.538	1.125
Mean of deviation	0.63	
Standard Deviation (Error)	0.350	
Correlation Co-efficient	0.966	
Mean absolute error	0.634	
Mean relative random error	0.185	
Paired T-value	10.584	
F- test value	1.368	

CHAPTER-16

16.0.0 MOISTURE

16.1.0 All the analysis has been carried out with natural moisture. However, Moisture analysis has not been done at this stage. Hence, no information can be provided.

CHAPTER-17

17.0.0 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 tonnes 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 3 representative core samples were selected for bulk density determination to evaluate the physical characteristics of the glauconitic sandstone. 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 calliper 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 ofthe 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 densityofthesample is determined byusingthe formula: B.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 five 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. Bulk density determination results are mentioned below:

Table 17.1
Bulk density study results of glauconite mineralisation for Ambara Maru Block

Sl. No.	Sample no.	Borehole no.	From (m)	To (m)	Bulk Density (gm/cm^3)
1	MAMB-2/BD1	MAMB-2	38.43	38.56	2.29
2	MAMB-3/BD1	MAMB-3	37.40	37.55	2.17
3	MAMB-4/BD1	MAMB-4	11.16	11.31	2.48
Average Bulk Density					**2.31**

CHAPTER-18

18.0.0 BENEFICIATION STUDIES

18.1.0 Beneficiation studies were not carried out in the current exploration, MECL strongly recommends for beneficiation and other studies to establish its suitability as a fertilizer raw material in the next level of exploration i.e., G-3/2/1.

CHAPTER-19

19.0.0 RESOURCE ESTIMATION TECHNIQUE

19.1.0 GENERAL

19.1.1 MECL carried out Reconnaissance Stage (G-4) exploration for glauconite, phosphorite and REE in the Ambara Maru Block. The exploration programme comprised systematic geological mapping on a 1:12,500 scale, bedrock sampling, pitting, and exploratory drilling through 4 vertical scout boreholes.

19.1.2 Through this integrated surface and sub-surface exploration approach, MECL comprehensively evaluated the exploration block, delineated zones of glauconite mineralisation, and subsequently estimated Reconnaissance Mineral Resources in accordance with the UNFC classification under Category 334.

19.1.3 In the drilled boreholes, the glauconite-bearing zone, demarcated at a cut-off grade of >3% K_2O, has been intersected within the Katrol/Bhuj Formation. All the 4 boreholes have been plotted on 4 geological cross-sections (A-A′ to D-D’), which are aligned along the N45°E–S45°W direction. These cross-sections were prepared based on the interpretation of sub-surface borehole data and incorporate both the grade of mineralisation and integrated surface–subsurface geological information, enabling a coherent understanding of the geometry and continuity of the mineralised zones.

19.1.4 The cut-off grade of 3% K_2O has been adopted for the present study based on the guidelines and practices followed by the Indian Bureau of Mines for evaluation of glauconite-bearing sandstones. Glauconite is a potassium-bearing mineral, and K_2O content serves as the primary indicator of glauconite concentration in the host rock.Accordingly, a minimum threshold of 3% K_2O is considered suitable at the reconnaissance (G4) stage to delineate glauconite-bearing horizons and to identify zones with potential for further exploration and resource assessment. Few zones demarcated at less than 3% K_2O, based on the logging and confirmation of green pellets in the lithology by megascopic study.

19.1.5 The details of the mineralised glauconite zones intersected in the Ambara Maru Block are presented below.

Table 19.1.
Table showing mineralisation zone and average grade for 8 Radicalsencountered in boreholes taken into consideration for the resource estimation ofAmbara Maru Block, District-Kachchh, Gujarat

BH No.	Section Line	From (m)	To (m)	Thickness (m)	Average Quality							
					K2O%	SiO2%	MgO%	CaO%	Na2O%	P2O5%	Al2O3%	Fe2O3%
MAMB-01	A-A'	5.00	7.00	2.00	3.12	67.96	0.53	0.44	0.24	0.07	14.70	6.73
	A-A'	13.00	15.00	2.00	3.74	52.71	2.28	4.65	0.30	0.05	16.91	8.48
MAMB-02	B-B'	0.00	10.00	10.00	2.90	49.20	1.93	2.47	0.52	0.33	21.47	8.78
	B-B'	18.00	20.00	2.00	3.01	52.39	1.79	1.24	0.23	0.47	21.13	7.91
	B-B'	24.00	26.00	2.00	3.18	54.68	1.41	0.33	0.15	0.09	24.31	4.90
MAMB-03	C-C'	0.00	4.00	4.00	2.84	55.08	0.99	6.89	0.20	0.17	10.87	13.39
	C-C'	5.00	6.00	1.00	3.15	52.97	0.91	1.42	0.39	0.41	16.42	16.09
	C-C'	10.00	11.00	1.00	3.14	58.20	1.45	3.70	0.19	0.31	13.69	10.10
	C-C'	14.00	15.00	1.00	3.02	58.37	1.06	0.92	0.15	0.16	17.95	9.30
MAMB-04	D-D'	0.00	5.00	5.00	2.60	66.74	0.51	6.64	0.13	0.06	9.05	7.72
	D-D'	7.00	9.00	2.00	3.19	74.93	0.25	0.22	0.23	0.10	9.00	8.10
	D-D'	12.00	14.00	2.00	3.55	56.08	1.87	5.53	0.20	0.12	14.10	9.24
	D-D'	26.00	28.00	2.00	4.24	61.00	1.45	0.61	0.26	0.06	17.27	6.55

19.2.0 PARAMETERD AND ASSUMPTIONS FOR RESOURCE ESTIMATION

19.2.1 The mineral resources of the Ambara Maru Block have been estimated using the Geological Cross-sectional method as the principal method, with the Polygonal method applied as a check method, in accordance with accepted exploration and resource estimation practices. While applying these methods, certain axiomatic and geological assumptions were inherently considered for determining the grade continuity and overall resource potential of the deposit, as outlined below.

19.2.2 A total of 328 numbers of primary samples collected from Ambara Maru Block were analyzed at the in-house chemical laboratory of MECL, Nagpur. To ensure analytical accuracy and reliability of the primary analyses, 10% of the primary samples (i.e., 34 numbers) were sent to a NABL-accredited external laboratory, Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, for check analysis. The results of the external analyses were found to be comparable with the primary analyses, thereby validating the analytical data used for resource estimation.

19.2.3 The K_2O-bearing zones were delineated based on the results of primary sample analyses. A cut-off grade of 3% K_2O has been adopted for the present study in accordance with the exploration practices followed by the Indian Bureau of Mines for evaluation of glauconite-bearing sandstones. Since glauconite is a potassium-bearing mineral, the K_2O content is the most reliable geochemical indicator of glauconite concentration in the host rock. Further, a minimum true thickness of 1.0 m of the K_2O-bearing zone has been considered for inclusion in the resource calculation under both the cross-sectional and polygonal methods.

19.2.4 For the purpose of resource estimation, the strike influence of each geological cross-section has been considered up to the mid-point between adjacent boreholes/sections, representing half the inter-borehole distance. Along the down-dip and up-dip directions, an influence distance of about 800 m from the point of mineralisation intersection has been assumed. This assumption is based on the interpreted geological continuity derived from borehole data and its correlation with surface exposures of glauconitic horizons within the block.

19.2.5 To determine bulk density, a total of 03 borehole core samples from the K_2O-rich horizon were analyzed. The measured bulk density values are considered representative of the glauconite-bearing mineralised zone in the area. Based on these determinations, an average bulk density of 2.31 g/cm^3 has been adopted for tonnage calculations, thereby improving the reliability and accuracy of the estimated resources.

19.2.6 In order to account for unseen geological factors, such as the possible presence of cavities, caverns, minor structural disturbances, and other geological uncertainties, a uniform deduction of 20% has been applied to the gross in-situ resources estimated by both the geological cross-sectional method and the polygonal method. The resulting values represent the net in-situ resources of the block.

19.3.0 METHODOLOGY ADOPTED FOR CROSS SECTIONAL METHOD FOR RESOURCE ESTIMATION

19.3.1 The following methodology has been adopted for computation of resources in the Ambara Maru Block using the Geological Cross-Section Method.

19.3.2 A total of 4 numbers of geological cross-sections, serially numbered from A-A′ to D-D’ were prepared. These cross-sections were drawn perpendicular to the general strike of the mineralised zones. (Plate–V)

19.3.3 The geological map data and borehole collar/header data were utilized for preparation of the profiles. All vertical boreholes were plotted along the respective section lines using AutoCad software, ensuring accurate spatial positioning of borehole intersections.

19.3.4 The cross-sections were prepared and correlated by integrating both surface and sub-surface geological data, including litho-units intersected in the boreholes and their attitudes, mineralised glauconite zones with proper nomenclature, thickness, and qualitative characteristics, along with borehole lithology, thickness, and analytical data of glauconite.

19.3.5 The glauconite-bearing zone was projected up to a distance of 800 m of half of the distance of section interval from the point of mineralisation intersection along the down-dip or up-dip direction, as applicable, in cases where the adjacent borehole did not intersect mineralisation. In areas where mineralisation was continuous in adjacent boreholes, a half-way influence between the boreholes was considered. Based on these projections, the sectional area of the mineralised zone was computed for each cross-section.

19.3.6 As the boreholes are generally spaced at an interval of approximately 1,600 m along strike, the strike influence for each cross-section was considered up to the mid-point (half the distance) between two adjacent sections.This assumption is based on the interpreted geological continuity derived from borehole data and its correlation with surface exposures of glauconitic horizons within the block.

19.3.7 All measurements of sectional areas were carried out using computer-aided drafting techniques with AutoCAD Map 2025 software, ensuring precision in area calculations.

19.3.8 The sectional area thus obtained for each cross-section was multiplied by the respective strike influence to derive the sectional volume of the mineralised zone. The sectional volume was further multiplied by the average bulk density (2.31g/cm^3) to compute the resource tonnage for each section.

19.3.9 The sum of section-wise resources, estimated through the Geological Cross-Section Method, represents the total geological gross / net in-situ glauconite resource of the block, subject to applicable geological deductions as described elsewhere in the report.

19.4.0 METHODOLOGY ADOPTED FOR POLYGONAL METHOD FOR RESOURCE ESTIMATION

19.4.1 The resource estimation for K_2O-rich glauconite mineralisation in the Ambara Maru Block was carried out using the Polygonal Method as a check method to validate the resources estimated by the Geological Cross-Section Method.

19.4.2 In this method, the mineralised bodies delineated through surface and sub-surface exploration were treated as distinct mineralised zones, within which resource calculations were performed. The polygonal approach ensures systematic allocation of resources based on the spatial distribution of boreholes and the interpreted geological continuity of mineralisation.

19.4.3 The polygonal resource map, presented as Plate–VI, illustrates the area of influence of individual boreholes and their corresponding polygons. The entire glauconite-bearing zone intersected in 4 boreholes has been subdivided into 04 numbers of polygons of varying thicknesses.

19.4.4 The influence area of each borehole was determined by constructing polygons using perpendicular bisectors of lines joining adjacent boreholes, forming triangular and rectangular polygons as dictated by borehole geometry and surface exposures of the glauconitic horizons. The area of each polygon was computed using AutoCAD Map 2025 software.

19.4.5 The thickness assigned to each polygon corresponds to the cumulative thickness of glauconite-bearing horizons/bands intersected in the respective borehole within the polygon, limited by observations from surface exposures of the glauconitic horizons. The volume of mineralisation for each polygon was estimated by multiplying the polygonal area by the corresponding cumulative thickness of the mineralised zone.

19.4.6 The polygon-wise volumes were subsequently multiplied by the average bulk density adopted for the block to derive the polygon-wise resource tonnage. The summation of all polygon-wise resources represents the total geological gross / net in-situ resource estimated by the Polygonal Method, which serves as a validation of the resources estimated by the Geological Cross-Section Method.

Table- 19.2
Boreholes wise corresponding Polygon area and corresponding glauconite zone thickness inAmbara Maru Block

BH No.	Polygon Area (m^2)	From (m)	To (m)	ZoneThickness (m)
MAMB-01	1618828.50	5.00	7.00	2.00
	1618828.50	13.00	15.00	2.00
MAMB-02	1353081.86	0.00	10.00	10.00
	1353082.86	18.00	20.00	2.00
	1353083.86	24.00	26.00	2.00
MAMB-03	1392120.28	0.00	4.00	4.00
	1392120.28	5.00	6.00	1.00
	1392120.28	10.00	11.00	1.00
	1392120.28	14.00	15.00	1.00
MAMB-04	2445539.66	0.00	5.00	5.00
	2445539.66	7.00	9.00	2.00
	2445539.66	12.00	14.00	2.00
	2445539.66	26.00	28.00	2.00

19.4.7 The calculated volume for each borehole was multiplied by the respective bulk density values to arrive at the resource tonnage. The sum of resources from all boreholes provided the total in-situ geological resource for the Ambara Maru Block. The formula of resource estimation is as follows:

$$R = P_A \times Th \times \text{Average bulk density}$$

Where, P_A = Area of Polygon

R= Resource/ Tonnage

Th= Thickness of Glauconite zone

19.5.0 DATA VERIFICATION AND/OR VALIDATION PROCEDURES USED

19.5.1 The resource has been estimated by two methods i.e., Geological Cross Section (principle) and Polygonal Method (check) method. The resource estimated by both the method has been compared and found there is 5.95% of difference in estimation of resources which is under acceptable limits. The details are discussed in Para 20.3.0.

CHAPTER-20

20.0.0 REPORTING OF RESOURCES

20.1.0 RESOURCE AND GRADE

20.1.1 The resource estimation for K_2O-rich glauconite mineralisation in the Ambara MaruBlock has been carried out considering the bedded nature of the deposit and the level of geological confidence achieved through Reconnaissance Stage (G-4) exploration. Accordingly, the resources have been classified and reported in conformity with the United Nations Framework Classification (UNFC) system.

20.1.2 Resource estimation has been undertaken using the Geological Cross-Section Method as the principal method, with the Polygonal Method adopted as a check method, to ensure reliability and internal validation of the estimates. Both methods utilize geological mapping, borehole data, analytical results, and interpreted continuity of mineralisation.

20.1.3 All primary samples generated during the present exploration stage were analyzed for eight (08) chemical radicals, and the analytical results were used for delineation of mineralised zones and grade determination. The resources have been estimated at a cut-off grade of >3.0% K_2O, which has been considered appropriate for delineation of K_2O-rich glauconite mineralisation at the reconnaissance level.

20.1.4 Under the Geological Cross-Section Method, resources have been estimated on a section-wise and borehole-wise basis, while under the Polygonal Method, resources have been estimated on a borehole-wise and polygon-wise basis. The quantities and grades estimated by both methods have been reconciled to ensure consistency.

20.1.5 As per standard reporting practice, the gross geological in-situ resources have been reduced by applying a confidence factor of 20%, resulting in net in-situ geological resources. This deduction accounts for the reconnaissance level of exploration, geological uncertainties, possible recovery losses during drilling operations, and unforeseen sub-surface conditions.

20.1.6 Based on the available geological, analytical, and spatial data, the estimated resources fall under UNFC Category 334, corresponding to Reconnaissance Mineral Resources.

20.1.7 Using the Geological Cross-Section Method, a total of 129.22 million tonnes of Net in-situ Reconnaissance Mineral Resources (UNFC 334) with an average grade of 3.10% K_2O has been estimated. The section-wise and borehole-wise distribution of these resources at >3.0% K_2O cut-off is presented in Table 20.1, with detailed calculations provided in Annexure-VIII and Table 20.1.

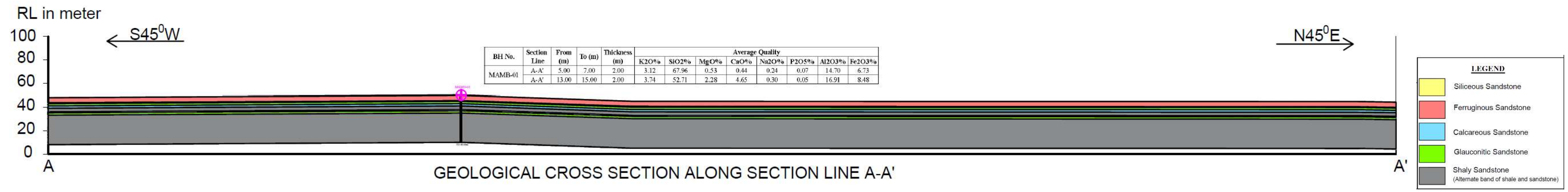
20.1.8 Using the Polygonal Method, a total of 114.69 million tonnes of Net in-situ Reconnaissance Mineral Resources (UNFC 334) with an average grade of 3.10 % K_2O has been estimated. The borehole-wise and polygon-wise distribution of these resources at >3.0% K_2O cut-off is presented in Table 20.2, with detailed calculations provided in Annexure-IX and Table 20.2.

20.1.9 Grade-wise classification of resources has been carried out at the adopted cut-off grade of >3.0% K_2O, which is considered suitable for the present stage of exploration. As glauconite is reported in terms of K_2O grade, metal content reporting is not applicable.

Table 20.1

Statement showing section wise, borehole wise Reconniassance Mineral Resources (334 category) of Glauconitic Sandstone, Estimated by Cross Sectional method, Ambara Maru Block, District-Kachchh, Gujarat

BH No.	Section Line	From (m)	To (m)	Thickness (m)	Sectional Area (m^2)	Section Influence (m)	Volume (m^3)	Specific Gravity	Gross Geological Resources (tonnes)	Net in-situ Resources (tonnes)	Average Quality							
											K2O%	SiO2%	MgO%	CaO%	Na2O%	P2O5%	Al2O3%	Fe2O3%
MAMB-01	A-A'	5.00	7.00	2.00	2306.95	1559.00	3596535.21	2.31	8307996.33	6646397.06	3.12	67.96	0.53	0.44	0.24	0.07	14.70	6.73
	A-A'	13.00	15.00	2.00	2306.95	1559.00	3596535.36	2.31	8307996.69	6646397.35	3.74	52.71	2.28	4.65	0.30	0.05	16.91	8.48
MAMB-02	B-B'	0.00	10.00	10.00	8816.01	1557.00	13726523.52	2.31	31708269.34	25366615.47	2.90	49.20	1.93	2.47	0.52	0.33	21.47	8.78
	B-B'	18.00	20.00	2.00	3200.00	1557.00	4982400.00	2.31	11509344.00	9207475.20	3.01	52.39	1.79	1.24	0.23	0.47	21.13	7.91
	B-B'	24.00	26.00	2.00	3200.00	1557.00	4982400.00	2.31	11509344.00	9207475.20	3.18	54.68	1.41	0.33	0.15	0.09	24.31	4.90
MAMB-03	C-C'	0.00	4.00	4.00	5580.08	1045.00	5831184.85	2.31	13470037.01	10776029.61	2.84	55.08	0.99	6.89	0.20	0.17	10.87	13.39
	C-C'	5.00	6.00	1.00	1600.00	1045.00	1672000.00	2.31	3862320.00	3089856.00	3.15	52.97	0.91	1.42	0.39	0.41	16.42	16.09
	C-C'	10.00	11.00	1.00	1600.00	1045.00	1672000.00	2.31	3862320.00	3089856.00	3.14	58.20	1.45	3.70	0.19	0.31	13.69	10.10
	C-C'	14.00	15.00	1.00	1600.00	1045.00	1672000.00	2.31	3862320.00	3089856.00	3.02	58.37	1.06	0.92	0.15	0.16	17.95	9.30
MAMB-04	D-D'	0.00	5.00	5.00	8009.10	1600.00	12814554.08	2.31	29601619.92	23681295.94	2.60	66.74	0.51	6.64	0.13	0.06	9.05	7.72
	D-D'	7.00	9.00	2.00	3203.64	1600.00	5125821.60	2.31	11840647.90	9472518.32	3.19	74.93	0.25	0.22	0.23	0.10	9.00	8.10
	D-D'	12.00	14.00	2.00	3203.64	1600.00	5125821.60	2.31	11840647.90	9472518.32	3.55	56.08	1.87	5.53	0.20	0.12	14.10	9.24
	D-D'	26.00	28.00	2.00	3203.64	1600.00	5125821.60	2.31	11840647.90	9472518.32	4.24	61.00	1.45	0.61	0.26	0.06	17.27	6.55
Resources in tonnes for glauconitic sandstone									**161523510.97**	**129218808.78**	**3.10**	**58.45**	**1.27**	**3.26**	**0.26**	**0.18**	**15.75**	**8.55**
Resources in Million Tonnes									**161.52**	**129.22**								



(Not to scale)

Text Figure.20.1: Representative Geological Cross section along section lines A-A' of Ambara Maru Block, District-Kachchh, Gujarat

Table 20.2

Statement showing Polygon wise, borehole wise resources of Glauconitic Sandstone by Polygon Method,Ambara Maru Block, District-Kachchh, Gujarat

Sl No.	BH No.	Polygon Area (m^2)	From (m)	To (m)	Zone Thickness (m)	Volume (m^3)	Bulk Density	Gross Geological Resources (tonnes)	Net In-situ Resources (tonnes)	Average Quality							
										K2O%	SiO2%	MgO%	CaO%	Na2O%	P2O5%	Al2O3%	Fe2O3%
1	MAMB-01	1618828.50	5.00	7.00	2.00	3237657.00	2.31	7478987.66	5983190.13	3.12	67.96	0.53	0.44	0.24	0.07	14.70	6.73
2		1618828.50	13.00	15.00	2.00	3237657.00	2.31	7478987.66	5983190.13	3.74	52.71	2.28	4.65	0.30	0.05	16.91	8.48
3	MAMB-02	1353081.86	0.00	10.00	10.00	13530818.63	2.31	31256191.04	25004952.83	2.90	49.20	1.93	2.47	0.52	0.33	21.47	8.78
4		1353082.86	18.00	20.00	2.00	2706165.73	2.31	6251242.83	5000994.26	3.01	52.39	1.79	1.24	0.23	0.47	21.13	7.91
5		1353083.86	24.00	26.00	2.00	2706167.73	2.31	6251247.45	5000997.96	3.18	54.68	1.41	0.33	0.15	0.09	24.31	4.90
6	MAMB-03	1392120.28	0.00	4.00	4.00	5568481.14	2.31	12863191.42	10290553.14	2.84	55.08	0.99	6.89	0.20	0.17	10.87	13.39
7		1392120.28	5.00	6.00	1.00	1392120.28	2.31	3215797.86	2572638.28	3.15	52.97	0.91	1.42	0.39	0.41	16.42	16.09
8		1392120.28	10.00	11.00	1.00	1392120.28	2.31	3215797.86	2572638.28	3.14	58.20	1.45	3.70	0.19	0.31	13.69	10.10
9		1392120.28	14.00	15.00	1.00	1392120.28	2.31	3215797.86	2572638.28	3.02	58.37	1.06	0.92	0.15	0.16	17.95	9.30
10	MAMB-04	2445539.66	0.00	5.00	5.00	12227698.30	2.31	28245983.08	22596786.46	2.60	66.74	0.51	6.64	0.13	0.06	9.05	7.72
11		2445539.66	7.00	9.00	2.00	4891079.32	2.31	11298393.23	9038714.58	3.19	74.93	0.25	0.22	0.23	0.10	9.00	8.10
12		2445539.66	12.00	14.00	2.00	4891079.32	2.31	11298393.23	9038714.58	3.55	56.08	1.87	5.53	0.20	0.12	14.10	9.24
13		2445539.66	26.00	28.00	2.00	4891079.32	2.31	11298393.23	9038714.58	4.24	61.00	1.45	0.61	0.26	0.06	17.27	6.55
Resources in tonnes for glauconitic sandstone								**143368404.40**	**114694723.52**	**3.10**	**58.71**	**1.25**	**3.43**	**0.27**	**0.17**	**15.33**	**8.67**
Resources in million tonnes for glauconitic sandstone								**143.37**	**114.69**								

MECL

20.2.0 COMPUTATION OF AVERAGE GRADE

20.2.1 All calculations for grade estimation for glauconite 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 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 glauconitic body in individual borehole

`G'= Grade of the respective glauconitic body in the corresponding borehole

20.3.0 COMPARISON OF ORE RESOURCE BY GEOLOGICAL CROSS SECTION AND POLYGONAL METHOD

20.3.1 The total phosphorite resources estimated by Coss section and Polygonal method at >3%K_2O cutoff respectively have been compared for reliability of estimated resources. The comparison of resources is given below table.

Table no 20.3
Comparison of Cross Sectional and Polygonal Method resources, Ambara Maru Block, District-Kachchh, Gujarat

Method	Gross Geological Resources (million tonnes)	Net In-situ Resources (million tonnes)	Average Quality							
			K2O %	SiO2 %	MgO %	CaO %	Na2O %	P2O5 %	Al2O3 %	Fe2O3 %
Polygon Method	143.37	114.69	3.10	58.71	1.25	3.43	0.27	0.17	15.33	8.67
Cross Section Method	161.52	129.22	3.10	58.45	1.27	3.26	0.26	0.18	15.75	8.55
Difference (million tonnes)	**18.16**	**14.52**								
Difference (%)	**5.95**	**5.95**								

20.3.2 The resource estimates obtained through the Cross-Sectional Method and Polygonal Method were compared to assess the confidence level of the estimation. The polygonal Method, used as the check approach, yielded a resource estimate 5.95% lower for K_2O as compare to the Cross-Sectional Method which is principal method. This variance falls within the permissible limits, confirming the reliability and accuracy of the resource estimation.

20.4.0 CATEGORY OF RESOURCES

20.4.1 The present exploration for glauconite in the Ambara Maru Block has been carried out at the Reconnaissance stage (G-4) of exploration, wherein exploratory boreholes have been drilled at an approximate strike interval of 1,600 m. The glauconite mineralisation occurs as a bedded deposit, exhibiting lateral continuity consistent with the regional geological framework.

20.4.2 Considering the nature and style of mineralisation, the borehole density, and the spacing of geological cross-sections, the exploration parameters achieved in the block are commensurate with the requirements of G-4 level exploration as prescribed under the UNFC system. Further, the exploration inputs and level of geological confidence satisfy the specifications laid down in Part III-I (Evidence of Mineral Content) of the Minerals (Evidence of Mineral Content) Rules, 2015.

20.4.3 Accordingly, based on the available geological, analytical, and spatial data generated during the present phase of exploration, the mineral resources estimated for the Ambara Maru Block have been classified as Reconnaissance Mineral Resources under UNFC Category 334.

CHAPTER-21

SUMMARY AND RECOMMENDATIONS

21.1.0 Outcome of Exploration Work

21.1.1 The Ambara Maru Block, located in the northern part of the Kachchh Basin, hosts bedded glauconite mineralisation within the Katrol Formation of Late Jurassic–Early Cretaceous age, forming part of the Kachchh Supergroup. MECL carried out Reconnaissance Stage (G-4) exploration over an area of 94.25 sq. km, comprising geological mapping on 1:12,500 scale, pitting, bedrock sampling, and exploratory drilling with 4 scout boreholes.

21.1.2 The Ambara Maru Block is underlain predominantly by Katrol Formation (Late Jurassic–Early Cretaceous) sediments, which constitute the principal host for glauconite mineralisation. Glauconitic sandstone occurs as stratigraphically controlled and laterally continuous horizons, deposited under shallow-marine to nearshore conditions during marine transgressive phases, indicating favourable geological continuity for resource evaluation. Minor exposures of the Bhuj Formation and limited Deccan Trap volcanics are present but are not associated with mineralisation. The sedimentary succession is gently deformed with gradational contacts and no major structural disruptions, supporting consistent geological interpretation at the block scale.

21.1.3 Structurally, the sedimentary succession in the Ambara Maru Block is influenced by the regional tectonic framework of the Kachchh Basin. The regional strike of bedding planes is broadly parallel to the Guneri Dome, showing variations from NE–SW, E–W, to NW–SE directions. The rock beds are generally horizontal to gently dipping, with low-angle dips towards the southeast and southwest.

21.1.4 The mineralised horizons have been intersected at shallow to moderate depths within the drilled boreholes. Exploration has established both vertical and lateral continuity of glauconite horizons within the investigated depth range. Considering the stratigraphic continuity of the Katrol Formation, there is a reasonable possibility of continuation of mineralisation beyond the explored depth and strike limits, which warrants further detailed exploration.

21.1.5 The geological, geochemical, and petrographic investigations carried out in the Ambara Maru Block indicate the presence of stratabound glauconite mineralisation within sandstone–shale horizons of the Katrol Formation. Bedrock sampling (153 samples), pitting (74 samples), and borehole drilling confirm that glauconite occurs as pellets within quartz-rich sandstone and shaly sandstone units. Major oxide analysis shows K_2O values ranging from about 0.12% to 6.39%, with 29 pit samples exceeding the adopted cut-off grade of 3% K_2O, indicating moderate enrichment of glauconite within specific stratigraphic horizons. Statistical correlations show a weak positive relationship between K_2O and Al_2O_3, suggesting association with glauconitic and clay-rich aluminosilicate phases, while SiO_2 and Fe_2O_3 show weak or negative correlations, indicating that quartz and ferruginous phases occur independently within the sandstone matrix.

21.1.6 Trace element analysis of selected bedrock samples indicates moderate Total Rare Earth Element (TREE) concentrations ranging roughly from ~150 ppm to ~600 ppm. Higher values occur in samples such as AM-23, AM-29, AM-38B, AM-41B, and AM-45B, but the enrichment is irregular and mainly associated with accessory minerals such as monazite and zircon, rather than forming any continuous REE mineralised zone. Similarly, phosphorite mineralisation was not observed in significant quantities, as petrographic and geochemical studies did not identify phosphatic nodules or horizons with appreciable P_2O_5 enrichment. XRD analysis further confirms that the rocks are mainly composed of quartz, feldspar, and clay minerals with minor mica and carbonate phases, supporting the interpretation of glauconite-bearing siliciclastic sediments formed under shallow marine conditions.

21.1.7 Exploration results indicate that the Ambara Maru Block hosts moderate glauconite mineralisation with stratigraphic control, while economically significant phosphorite and REE mineralisation has not been delineated at the present G4 (reconnaissance) stage of exploration. The identified glauconitic horizons represent potential targets for further detailed exploration and evaluation, particularly in zones where K_2O values exceed 3%, to better assess the continuity, thickness, and grade distribution of the glauconite resource within the block.

21.1.8 Future exploration is recommended through closer-spaced drilling, detailed litho-structural studies, and advanced mineralogical investigations to enhance geological confidence and upgrade the resource category.

21.2.0 Resources Estimated under Various Classes with Grade

21.2.1 Resource estimation has been carried out using the Geological Cross-Section Method as the principal method and the Polygonal Method as a check method, adopting a cut-off grade of >3.0% K_2O. A 20% deduction has been applied to gross in-situ resources to account for geological uncertainties and reconnaissance-level limitations, resulting in net in-situ resources.

21.2.2 Based on the level of exploration achieved and geological confidence, the resources have been classified as Reconnaissance Mineral Resources under UNFC Category 334.

Cross-Sectional Method:

129.22 million tonnesof Net in-situ Reconnaissance Resources (UNFC 334) with an average grade of 3.10% K_2O.

Polygonal Method:

114.69 million tonnesof Net in-situ Reconnaissance Resources (UNFC 334) with an average grade of 3.10% K_2O.

21.2.3 The variation between the estimates obtained by the two methods is within acceptable limits, confirming the reliability of the reconnaissance-level resource estimation.

21.3.0 Possibility of Economic Extraction

21.3.1 Glauconite is a potassium-bearing mineral with potential application as an alternative source of potash, particularly for use in slow-release fertilizers and soil-conditioning formulations. The bedded geometry of the mineralisation, its shallow depth of occurrence, and the lateral continuity of glauconitic horizons constitute favourable geological attributes from a mining and resource-development perspective.

31.3.2 The block is supported by existing road connectivity, is situated in a low-population-density area, and, based on reconnaissance-level observations, does not indicate any significant environmental or social constraints. Subject to systematic detailed exploration, beneficiation studies, and techno-economic evaluation, the glauconite deposit demonstrates reasonable potential for future economic extraction, contingent upon prevailing market conditions.

21.4.0 Anticipated Hindrances in Economic Extraction

21.4.1 At the present stage, the principal limitation arises from the reconnaissance level of exploration, characterised by wide drill spacing and limited depth penetration, which constrains the confidence level of resource estimation and precludes higher-category resource classification. Additional technical challenges may be associated with spatial variability in glauconite grade, mineralogical intergrowth with feldspar and mica, and the requirement for beneficiation to enhance recoverable K_2O content.

21.4.2 To address these constraints, subsequent phases of exploration should incorporate closer-spaced drilling, detailed mineralogical characterisation using SEM–EDS, and grain-size distribution studies to evaluate glauconite liberation characteristics and processing behaviour. Based on current reconnaissance-level observations, no significant statutory, environmental, or social impediments to mineral extraction are anticipated at this stage.

21.5.0 Suggested Future Plan and Strategy for Further Exploration and Mining

21.5.1 Based on the results of the present Reconnaissance Stage (G-4) exploration in the Ambara Maru Block, glauconite mineralisation is observed to be bedded, laterally continuous, and geologically favourable, indicating scope for further resource augmentation. To improve geological confidence and achieve better delineation of mineralised horizons, it is recommended that exploration be upgraded to the Prospecting Stage (G-3) in identified promising zones through closer-spaced drilling, detailed litho-structural mapping, and refined geological and 3-D modelling. These measures are expected to facilitate upgradation of resources to higher confidence categories and provide a robust geological basis for future mine planning.

21.5.2 In addition, advanced mineralogical and beneficiation studies, including SEM–EDS analysis and bimodal grain-size distribution studies, are recommended to characterise glauconite mineralogy, assess its association with feldspar and mica phases, and evaluate processing behaviour and K_2O recovery potential. Considering the shallow depth of occurrence, bedded geometry, and good accessibility, the glauconite mineralisation appears amenable to conventional open-cast mining, subject to favourable outcomes of detailed exploration and techno-economic evaluation. On the basis of the present exploration results, the block is considered prospective for glauconite mineralisation and is recommended for upgradation to a higher level of exploration in identified favourable zones, with subsequent consideration for auction under the Central Government's critical and strategic mineral framework, in accordance with applicable statutory provisions.

CHAPTER-22

22.0.0 PLATES AND MAPS

Plate–I: Location map of Ambara Maru Block, District Kachchh, Gujarat — Not to scale

Plate–II: Regional geological map showing Ambara Maru Block, District Kachchh, Gujarat — Not to scale

Plate–III: Interpreted geological map of Ambara Maru Block, District Kachchh, Gujarat — Scale: 1:12,500

Plate–IV: Outcrop map of Ambara Maru Block, District Kachchh, Gujarat — Scale: 1:12,500

Plate–V: Geological cross-sections along section lines A-A' to D-D′, Ambara Maru Block, District Kachchh, Gujarat — Scale: 1:1,000

Plate–VI: Polygon map prepared for resource calculation of glauconitic sandstone in Ambara Maru Block, District Kachchh, Gujarat — Scale: 1:4,000

CHAPTER-23

23.0.0 ANNEXURE / ENCLOSURES TO THE REPORT

23.1.0 The report includes all the relevant annexure and maps, plans, sections, photographs etc. List of annexures, tables, maps/plans/sections, photographs and Text figure etc are provided before the start of the text part of the Geological Report.

CHAPTER-24

24.0.0 ANY OTHER INFORMATION

24.1.0 ANY OTHER INFORMATION

No Such information is required to be mentioned additionally.

CHAPTER-25

25.0.0 CERTIFICATE FROM THE QUALIFIED PERSON WITH NAME, DATE AND SIGNATURE

This is to certify that the Geological Report in respect of Reconnaissance Survey (G-4 Stage) for glauconite, phosphorite and REE in the Ambara Maru Block (Area: 94.25 sq. km), Tehsil Nakhatrana, District Kachchh, Gujarat, was recommended in TCC-II Meeting of NMEDT and was approved by 39th EC meeting of NMEDT on 24th January 2025. Sanction Order was issued on 24th February 2025.

The exploration programme was initially scheduled for a period of 10 months (up to 23rd December 2025), later extended by three months (up to 31st March 2026). Field operations were initiated by MECL on 30th March 2025, which included geological mapping on 1:12,500 scale, pitting, and exploratory drilling over the entire block area of 94.25 sq. km. The Geological Report has been prepared based on the data generated during the above exploration activities and is being submitted in March 2026.

The undersigned certifies that the contents of this Geological Report are based on the data generated during the course of exploration and have been compiled and interpreted in accordance with the applicable guidelines, standards, and statutory provisions.

Name: Shri Shrikant Sharma
Designation: HoD (Exploration)
Organisation: Mineral Exploration & Consultancy Limited (MECL)

Date: 12.03.2026
Signature: …………………

LIST OF PERSONNEL ASSOCIATED WITH RECONNAISSANCE SURVEY (G-4 STAGE) FOR GLAUCONITIC SANDSTONE, PHOSPHRITE AND REE IN THE AMBARA MARU BLOCK (AREA: 94.25 SQ. KM), TEHSIL NAKHATARANA, DISTRICT KACHCHH, GUJARAT

1	Overall guidance	Shri P. Ravindran, Ex.GM (Exploration) Shri Shrikant Sharma, HoD (Exploration) Shri Naveen Pala, Sr. Manager (Geology)
2	Overall Planning, Co-ordination & Supervision	Shri S.N. Khadse, GM (Exploration)
3	Operation	Shri S.N. Khadse, GM (Exploration) Shri Jayprakash Choudhury, Sr. Manager (Geology Shri Alok Daharwal, Sr. Manager (Geology) Shri Sandeep Sarangi, Manager (Geology)
4	Project Management	Shri Khushi Ram, Manager (Drilling) Shri Anil Tiwari, Manager (Drilling)
5	Physical Execution of work	
	a) Geology b) DGPS Survey	Shri Jaladi Madhu Babu, Manager (Geology) Shri Punit Khandale, Sr. Technician (S&D)
6	Sample Processing	Manohar Walmik Raut, Technician Sampling Pramod Kumar Mahanto, Technician Sampling
7	Chemical Laboratory	Shri Shrikant Sharma, HoD (Exploration) Shri E. Kupusamy, Dy.GM (Exploration)/ Lab. in-charge
		Shri Rohit Sharma, Manager (Chemical Lab)
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8	Petrographic Studies	Shri SayantanPal, Manager (Geology)
9	Documentation	Shri BhuneshwarKumar, Manager (Geology)
		Shri Jaladi Madhu Babu, Manager (Geology)
10	Non-Coal Geological Report Cell	Shri Peeyush Kalwani, Assistant Manager (Geology)
		Mrs Moumita Ghosh, Assistant Manager (Geology)
		Shri Uday Patil, Sr. Assistant (Information Technology)
		Shri Shivanand, Sr. Assistant (Information Technology)
11	Reprography and Printing	Shri P. S. Negi, Survey & Map Officer
		Shri Durgesh Devarshee, Assistant Survey & Map Officer
		Shri Deepanjan Halder, Assistant Survey & Map Officer
12	Proposal Formulation	Shri Bhuneshwar Kumar, Manager (Geology)
13	Hindi Translation	Shri Bhuneshwar Kumar, Manager (Geology)

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ABBREVIATION

SL. No.	Abbreviation	Full form
1	UNFC	United Nation Framework Classification
2	IBM	Indian Bureau of Mines
3	DGCO	Directorate General Camp Office
4	GSI	Geological Survey of India
5	MECL	Mineral Exploration and Consultancy Limited
6	CPSE	Central Public Sector Enterprises
7	NMET	National Mineral Exploration Trust
8	TCC	Technical cum Cost Committee
9	EC	Executive Committee
10	NABL	National Accreditation Board for Testing and Calibration Laboratories
11	JNARDDC	Jawaharlal Nehru Aluminium Research Development and Design Centre
12	F.S.P.	Field Season Programme
13	MEMC	Minerals (Evidence of Mineral Contents)
14	MMDR	Mines & Minerals (Development and Regulation)
15	NH	National Highway
16	WGS-84	World Geodetic System-84
17	UTM	Universal Transverse Mercator
18	RL	Reduced Level
19	cu m	Cubic Meter
20	ICP-MS	Inductively Coupled Plasma Mass Spectrometry
21	DGPS	Differential Global Positioning System
22	DMS	Degree Minute Second
23	M / m	Meter
24	Sq. km	Square Kilometer
25	M. Sc.	Master of Science
26	M. Sc. Tech	Master of Science Technology
27	mRL	Reduced Level in metre
28	R.F.	Reserve Forest
29	QA/QC	Quality Assessment/ Quality Checks
30	WD-XRF	Wavelength Dispersive X-ray Fluorescence
31	CRM	Certified Reference Material
32	SARM	South African Reference Material
33	SoI	Survey of India