GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3 STAGE) FOR GLAUCONITIC SANDSTONE IN

JHARI BLOCK

(Area-5.1 Sq Km)

TEHSIL-MAJHGAWAN, DISTRICT- SATNA, MADHYA PRADESH

(Under NMET Programme)

Parts of Toposheet no. 63D13 & 63D09

TEXT, ANNEXURE AND PLATES

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MECL

MINERAL EXPLORATION AND CONSULTANCY LIMITED

(Formerly known as Mineral Exploration Corporation Limited)

A Government of India Enterprises

CORPORATE OFFICE, NAGPUR

DECEMBER-2025

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GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3 STAGE) FOR GLAUCONITIC SANDSTONE IN JHARI BLOCK TEHSIL-MAJHGAWAN, DISTRICT- SATNA, MADHYA PRADESH

SALIENT FEATURES

1.	Name of the block	Jhari Block Tehsil- Majhgawan District – Satna, State – Madhya Pradesh
2.	Mineral	Glauconitic Sandstone
3.	Total Area	5.1 sq.km.
4.	Area covered under present scheme	5.1 sq.km.
5.	Period of Exploration	July 2024 to August 2025.
6.	Meterage drilled by MECL	Total 160.00 m
7.	No. of Boreholes drilled by MECL	Total 05 Nos
8.	Thickness of Different Grade Glauconite	Average thickness of glauconitic sandstone is 15.27 m
9.	Cut-off grade	As per end use grade classification recommended by IBM cutoff grade of K_2O> 5%
10.	Resources	1. **104.20 million tonnes** of Net in-situ Inferred Resources (333 category) with **6.04% K_2O,** 49.16% SiO_2, 13.47% Al_2O_3, 15.10% Fe_2O_3 2. **25.85 million tonnes** of Net in-situ Reconnaissance Resources (334 category) with **6.18% K_2O,** 49.19% SiO_2, 13.56% Al_2O_3, 15.23% Fe_2O_3
11.	Grade	Glauconite with K_2O>5%
12.	UNFC Category	Inferred Category (333)
13.	Report Submission	December 2025

झारी ब्लॉक में ग्लौकोनाइटिक बलुआ पत्थर हेतु प्रारंभिक गवेषण (जी-3 चरण)
पर भूवैज्ञानिक रिपोर्ट
तहसील-मझगवां, जिला- सतना, मध्य प्रदेश

अध्याय 1

1.0.0 कार्यकारी सारांश

1.1.0 प्रस्तावना

1.1.1 ग्लौकोनाइट, एक पोटेशियम से भरपूर हरित सिलिकेट खनिज है जो प्राकृतिक रूप से उर्वरक (फर्टिलाइज़र), मृदा कंडिशनर बनाने और पोटाश के संभावित स्रोत के तौर पर उपयोग के लिए बहुत ज़रूरी है। यह इस इलाके में विंध्य सुपरग्रुप के सैंडस्टोन होराइज़न में पाया जाता है।

1.1.2 नाइट्रोजन और फॉस्फोरस के साथ पोटैशियम, पौधों की सेहत और कृषि की पैदावार के लिए ज़रूरी तीन मुख्य मैक्रोन्यूट्रिएंट्स बनाता है। यह कई फिजियोलॉजिकल प्रक्रियाओं में अहम भूमिका निभाता है; जिसमें एंजाइम एक्टिवेशन, पानी का रेगुलेशन, फोटोसिंथेसिस और प्रोटीन सिंथेसिस शामिल हैं। फसल की पैदावार और क्वालिटी में इसके अहम योगदान के कारण, टिकाऊ कृषि के तरीकों के लिए पोटैशियम की काफी मात्रा में ज़रूरत होती है।

1.1.3 पौधों के पोषण में पोटैशियम की ज़रूरी भूमिका के बारे में बढ़ती जागरूकता ने ग्लोबल पोटाश इंडस्ट्री के उभरने और तेज़ी से विकास को बढ़ावा दिया, जो पोटैशियम-बेस्ड फर्टिलाइज़र का एक मुख्य सप्लायर है। ऐतिपासिक अभिलेख बताते हैं कि 1921 तक दुनिया भर में पोटाश का प्रोडक्शन लगभग 1 मिलियन टन तक पहुँच गया था । तब से, प्रोडक्शन में लगातार और मज़बूती से बढ़ोतरी देखी गई है।

1.1.4 यूनाइटेड स्टेट्स जियोलॉजिकल सर्वे (U.S. जियोलॉजिकल सर्वे, मिनरल कमोडिटी समरीज, जनवरी 2025) के डेटा के मुताबिक, 2024 में दुनिया की वार्षिक पोटाश प्रोडक्शन कैपेसिटी 65.2 मिलियन टन थी और 2028 तक इसके बढ़कर लगभग 76.0 मिलियन टन K_2O होने का अनुमान है। यह बढ़ती मांग ग्लोबल फूड सिक्योरिटी चुनौतियों का सामना करने में पोटेशियम के स्ट्रेटेजिक महत्व को दिखाती है और इसने ग्लौकोनाइटिक सैंडस्टोन सहित पोटाश के दूसरे स्रोत के गवेषण की कोशिशों को और तेज़ कर दिया है।

1.1.5 अभी, पोटाश की दुनिया भर में मांग ज़्यादातर बेडेड मरीन इवैपोराइट डिपॉज़िट और पोटाश से भरपूर ब्राइन स्रोत की माइनिंग से पूरी होती है। इन नेचुरल डिपॉज़िट में पानी में घुलने वाले पोटेशियम वाले खनिज जैसे सिल्वाइट (KCl), कार्नेलाइट ($KMgCl_3 \cdot 6H_2O$), केनाइट ($KMg(SO_4)Cl \cdot 3H_2O$), और पॉलीहैलाइट ($K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$) होते हैं। ये या तो

स्ट्रेटिफाइड खनिज बेड के रूप में या सब-सरफेस और सरफेस ब्राइन रिज़र्वॉयर के रूप में होते हैं और इन्हें ज़्यादातर पोटेशियम क्लोराइड (म्यूरिएट ऑफ़ पोटाश यानी MOP) और सल्फेट ऑफ़ पोटेशियम (SOP) निकालने के लिए प्रोसेस किया जाता है, जो दो सबसे ज़्यादा प्रयोग होने वाले पोटाश फर्टिलाइज़र हैं।

1.1.6 दुनिया भर में, इन हाई-ग्रेड पारंपरिक पोटाश संसाधन का डिस्ट्रीब्यूशन बहुत ज़्यादा स्थानीय है, जिसमें 90% से ज़्यादा प्रोडक्शन सिर्फ़ कुछ देशों में ही होता है, जैसे कनाडा, रूस, बेलारूस, ब्राज़ील, चीन, चिली, जर्मनी और यूनाइटेड स्टेट्स। ये देश न सिर्फ़ बड़े रिज़र्व को कंट्रोल करते हैं, बल्कि ग्लोबल एक्सपोर्ट मार्केट पर भी हावी हैं, जिससे बाकी दुनिया, खासकर भारत जैसे पोटाश इंपोर्ट करने वाले देशों में सप्लाई पर निर्भरता बढ़ जाती है, जो कृषि पर निर्भर है।

1.1.7 लंबे समय तक कृषि की पैदावार बनाए रखने और इम्पोर्ट पर निर्भरता कम करने के लिए, पोटेशियम के दूसरे स्रोत को गवेषित करना ज़रूरी है। पोटेशियम के दूसरे स्रोत K-धारित सिलिकेट और नॉन-सिलिकेट खनिज हैं, जो इवैपोराइट खनिज की तरह आसानी से घुलते नहीं हैं, लेकिन सही एक्सट्रैक्शन टेक्नोलॉजी से पोटेशियम निकालने के लिए प्रोसेस किए जा सकते हैं। हाल के शोध से पता चलता है कि सही जियोकेमिकल और टेक्नोलॉजिकल कंडीशन में पोटेशियम वाले एल्युमिनोसिलिकेट, जैसे फेल्डस्पार, ग्लौकोनाइट और माइका, पोटाश के अच्छे स्रोत के तौर पर काम कर सकते हैं। ये दूसरे स्रोत उन देशों के लिए आत्मनिर्भरता का एक संभावित रास्ता देते हैं जिनके पास हाई ग्रेड इवैपोराइट डिपॉजिट नहीं हैं।

1.1.8 भारत दुनिया में पोटाश फर्टिलाइजर के सबसे बड़े कंज्यूमर में से एक है, फिर भी यहां सस्ते में निकाले जा सकने वाले इवैपोराइट पोटाश डिपॉजिट की कमी है। इस कमी ने ग्लौकोनाइटिक सैंडस्टोन, पोटाश से भरपूर शेल्स और फेल्डस्पैथोइड्स जैसे गैर-पारंपरिक, देसी स्रोत के गवेषण को बढ़ावा दिया है। दुनिया भर के उदाहरण ऐसे विकल्पों की संभावना और पुराने USSR में ग्लौकोनाइट के बड़े पैमाने पर प्रयोग को दिखाते हैं। भारत के सेडिमेंटरी बेसिन में इसके बड़े पैमाने पर पाए जाने को देखते हुए, ग्लौकोनाइटिक सैंडस्टोन एक स्ट्रेटेजिक रूप से महत्वपूर्ण संसाधन के रूप में उभर रहा है जो न्यूट्रिएंट सिक्योरिटी को सपोर्ट करने और इम्पोर्ट पर निर्भरता को कम करने में सक्षम है।

1.1.9 ग्लौकोनाइटिक सैंडस्टोन एक अवसादीय चट्टान है जिसमें हरे रंग का खनिज ग्लौकोनाइट होता है, जो समुद्री शेल्फ की स्थितियों में बनता है। पारंपरिक रूप से इसे स्ट्रेटीग्राफिक स्टडीज़, पैलियोएनवायरनमेंटल रिकंस्ट्रक्शन और पेट्रोलियम गवेषण के लिए महत्व दिया जाता है,

लेकिन इसे पोटैशियम फर्टिलाइज़र के स्रोत के तौर पर अपनी आर्थिक क्षमता के लिए भी पहचाना जा रहा है। भारत के रिज़र्व, जो 3,000 मिलियन टन से ज़्यादा हैं और जिनमें K_2O की मात्रा 4% से 8% तक है, उत्तर प्रदेश, बिहार, मध्य प्रदेश, राजस्थान और गुजरात में क्रेटेशियस से लेकर पैलियोजीन फॉर्मेशन में बताए गए हैं। ये डिपॉज़िट इम्पोर्टेड पोटाश का एक सस्टेनेबल विकल्प पेश करते हैं, जो न्यूट्रिएंट सेल्फ-रिलाएंस के राष्ट्रीय विज़न से मेल खाते हैं।

1.1.10 माइंस एंड मिनरल्स (डेवलपमेंट एंड रेगुलेशन) अमेंडमेंट एक्ट, 2023 के ज़रिए पॉलिसी को और मज़बूत किया गया है, जिसमें ज़रूरी मिनरल्स की स्ट्रेटेजिक अहमियत को समझने के लिए सेक्शन 1D लाया गया। ग्लौकोनाइट को नेशनल क्रिटिकल खनिज मिशन में शामिल किया गया है, जिसका मकसद कृषि, क्लीन एनर्जी, इलेक्ट्रॉनिक्स, स्पेस, डिफेंस और इंडस्ट्री के लिए ज़रूरी मिनरल्स की सुरक्षित और आत्मनिर्भर आपूर्ति पक्का करना है। यह मिशन लक्षित गवेषण, NMET फंडिंग सपोर्ट और कमर्शियल प्रयोग के लिए ब्लॉक ऑक्शन की सुविधा को बढ़ावा देता है, जिससे ग्लौकोनाइट देश के खनिज डेवलपमेंट फ्रेमवर्क में एक प्रायोरिटी के तौर पर मार्क हो गया है।

1.1.11 ज़रूरी खनिज ज़रूरतों को पूरा करने के लिए, भारत सरकार स्ट्रेटेजिक खनिज ब्लॉक्स की ट्रांच-बेस्ड नीलामी करती है। इसके पाँच ट्रांच पूरे हो चुके हैं और छठा ट्रांच चल रहा है। इन नीलामियों में लिथियम, दुर्लभ मृदा तत्व (REEs), ग्लौकोनाइट, ग्रेफाइट, वैनेडियम, निकल, कोबाल्ट और फॉस्फोराइट संसाधन शामिल हैं जो क्लीन एनर्जी टेक्नोलॉजी और फर्टिलाइज़र सिक्योरिटी के लिए ज़रूरी हैं। ट्रांसपेरेंट एलोकेशन, प्राइवेट सेक्टर की भागीदारी और एमईसीएल जैसी एजेंसियों की एक्टिव भागीदारी डीकार्बोनाइज़ेशन की कोशिशों को मज़बूत करती है, मज़बूत आपूर्ति श्रृंखला बनाती है और सस्टेनेबल इकोनॉमिक ग्रोथ को आगे बढ़ाती है। ग्लौकोनाइट जैसे खनिज को सुरक्षित करना 2070 तक भारत के नेट-ज़ीरो एमिशन टारगेट का ज़रूरी हिस्सा है, जिससे सोलर, विंड, EV, बैटरी स्टोरेज और ग्रीन हाइड्रोजन प्रोडक्शन में तरक्की हो सकेगी।

1.1.12 झारी जी-3 ब्लॉक को पिंडरा दक्षिण-पश्चिम विस्तार ब्लॉक (39.23 वर्ग किमी) से अलग किया गया है और इसमें विंध्य सुपरग्रुप की चट्टानों के रीवा समूह की प्रोटेरोज़ोइक युग की लिथो-इकाइयाँ शामिल हैं, जो ग्लौकोनाइटिक बलुआ पत्थर के लिए अपनी खनिज क्षमता के लिए प्रसिद्ध है।

1.1.13 एमईसीएल ने पिंडरा साउथ-वेस्ट एक्सटेंशन ब्लॉक में एक आवीक्षण सर्वेक्षण किया है। एमईसीएल ने इस ब्लॉक में 1,918 मिलियन टन ग्लौकोनाइटिक सैंडस्टोन के संसाधन का

अनुमान लगाया है, जिसका एवरेज ग्रेड 6.96% K_2O (334) और एवरेज मोटाई लगभग 25 मीटर है। झारी G-3 ब्लॉक को पिंडा साउथ वेस्ट एक्सटेंशन ब्लॉक से अलग किया गया है, जिसका उद्देश्य ज़्यादा भरोसे के साथ संसाधन और नीलामी के लिए ब्लॉक की सूटेबिलिटी का पता लगाना है।

1.1.14 मध्य प्रदेश के सतना के झारी ब्लॉक में ग्लौकोनाइटिक सैंडस्टोन के लिए प्रारंभिक गवेषण का प्रस्ताव 63वीं **TCC** में प्रस्तुत किया गया। मार्च**,** 2024 को और विचार-विमर्श के बाद समिति ने **NMEDT** की कार्यकारी समिति की मंजूरी के लिए सिफारिश की।

1.1.15 35वीं कार्यकारी समिति (**EC**) ने 17 मई 2024 के पत्रांक- 23/453/2024-NMET/78 के ज़रिए परियोजना को 09 महीने के समयावधि के साथ अनुमोदित की गई।

1.2.0 स्थान और पहुंचने की सुविधा

1.2.1 झारी जी -3 ब्लॉक सर्वे ऑफ इंडिया टोपोशीट नंबर 63 डी / 09 और 63 डी 13 के कुछ हिस्सों में आता है और यह 24 ° 56′ 1.39″ उत्तर से 24 ° 57′ 21.74″ उत्तर अक्षांश और 80 ° 44′ 45.95″ पूर्व से 80 ° 46′ 28.88″ पूर्व रेखांश के बीच स्थित है और मध्य प्रदेश के सतना जिले के मझगवां तहसील के झारी , पिंडरा, लालपुर पड़री और सदा गांवों में और उसके आसपास के 5.1 वर्ग किलोमीटर क्षेत्र को कवर करता है।

1.2.2 गवेषण ब्लॉक तक सतना से लगभग 44 km दूर सतना-चित्रकूट (स्टेट हाईवे 11) के ज़रिए पहुँचा जा सकता है। स्टेट हाईवे 11 और NH-135BG के ज़रिए इस इलाके की अच्छी कनेक्टिविटी है, जो इसे सतना, मैहर , उमरिया और उत्तर प्रदेश से जोड़ती है।

1.2.3 जियोडेटिक और UTM दोनों में ब्लॉक एरिया के कार्डिनल पॉइंट्स के कोऑर्डिनेट्स नीचे दिए गए हैं:

तालिका संख्या-1.1

ग्लौकोनाइटिक सैंडस्टोन के लिए झारी जी-3 ब्लॉक की ब्लॉक सीमा के मुख्य बिंदुओं के निर्देशांक, जिला-सतना, मध्य प्रदेश

कार्डिनल पॉइंट्स	यूटीएम ज़ोन-44(मी)		भौगोलिक निर्देशांक WGS-84	
	ईस्टिंग(m)	नाथिंग (एम)	अक्षांश (डीएमएस)	देशान्तर (डीएमएस)
क	474365.063	2757669.697	24° 56′ 2.60″	80° 44′ 45.95″
ख	474372.551	2760099.531	24° 57′ 21.60″	80° 44′ 46.06″
ग	475851.349	2760101.346	24° 57′ 21.74″	80° 45′ 38.79″

घ	476465.601	2759097.464	24° 56′ 49.14″	80° 46′ 0.76″
ङ	477254.177	2759093.323	24° 56′ 49.05″	80° 46′ 28.88″
च	476123.106	2757629.439	24° 56′ 1.39″	80° 45′ 48.64″

1.3.0 ब्लॉक का भूविज्ञान और संरचना

1.3.1 झारी G-3 ब्लॉक , मध्य प्रदेश के सतना ज़िले के उत्तरी हिस्से में मौजूद मझगवां – पहाड़ीखेड़ा पोटाश बेल्ट का हिस्सा है। जियोलॉजिकली, इस ब्लॉक के नीचे विंध्यन सुपरग्रुप से जुड़े रीवा ग्रुप की चट्टानें हैं, जो विंध्यन बेसिन के इस सेक्टर में अच्छी तरह से दिख रही हैं। ब्लॉक के लिए स्ट्रेटीग्राफिक नाम, मझगवां , पहाड़ीखेड़ा और सोहावल जैसे आस-पास के क्षेत्र में मौजूद रीजनल स्ट्रेटीग्राफिक सक्सेशन के साथ लिथोलॉजिकल यूनिट्स के लैटरल कोरिलेशन के आधार पर अपनाया गया है।

ब्लॉक एरिया में लिथो यूनिट्स का स्ट्रेटीग्राफिक सीक्वेंस (GSI के बाद) नीचे दिया गया है:

तालिका 1.2
झारी जी-3 ब्लॉक का स्ट्रेटीग्राफिक अनुक्रम
(जीएसआई के बाद)

आयु	सुपरग्रुप/ग्रुप/कॉम्प्लेक्स	शृंखला	गठन	लिथोलॉजी	
हाल ही में हाल ही में			जलोढ़/मिट्टी/लैटेराइट		
प्रोटेरोज़ोइक	विंध्यन सुपर ग्रुप	रीवा	गहादरा बलुआ पत्थर	क्वार्ट्ज एरेनाइट	
			झिरी शेल	ऊपरी शेल	हरा और लाल शेल
				ऊपरी सफेद बलुआ पत्थर	मध्यम दानेदार क्वार्ट्ज एरेनाइट
				मध्य ग्लौकोनाइटिक बलुआ पत्थर	
				निचला सफेद बलुआ पत्थर –	मध्यम दानेदार क्वार्ट्ज एरेनाइट
				निचली शेल	समूह के साथ हरे और लाल शेल
				रोहनिया बलुआ पत्थर	दानेदार समूह के साथ क्वार्ट्ज एरेनाइट

आयु	सुपरग्रुप/ग्रुप/कॉम्प्लेक्स	श्रृंखला	गठन	लिथोलॉजी	
			इटवा बलुआ पत्थर गठन	पिंडरा शेल	अंतर्बंध के साथ हरे और लाल शेल
				भुलवा चूना पत्थर	भूरे चर्ट के साथ क्रीम रंग का चूना पत्थर
				बनबिहा बलुआ पत्थर	ग्लौकोनाइटिक चूना पत्थर
			पन्ना शेल	इंटरबैंड के साथ शेल	
		कैमूर	बघैन बलुआ पत्थर	मीडियम से मोटा सैंडस्टोन, सिल्टस्टोन और शेल इंटरबैंड्स के साथ महीन सैंडस्टोन । मध्यम से मोटा बलुआ पत्थर, कोणीय बजरी वाला रेतीला समूह	
		स्तरक्रम में असंगति			
	विंध्यन सुपर ग्रुप	सेमरी		पालकवान शेल डोलोमाइटिक चूना पत्थर पांडवाफॉल बलुआ पत्थर	
			पांडवा फॉल गठन	बाणसागर बलुआ पत्थर (ऊपरी ग्लौकोनिटिक बलुआ पत्थर) कोहारी चर्ट (डोलोमिटिक लिमिटेशन चर्ट और चर्ट ब्रेकिया) कुदवारी बलुआ पत्थर (निचला ग्लौकोनाइटिक बलुआ पत्थर)	
	स्तरक्रम में असंगति				
प्रोटेरोज़ोइक	बुंदेलखंड नीस्सिक जटिल			ग्रेनाइट नीस ग्रेनाइट	

1.3.2 ब्लॉक के अंदर, सतह पर दिखने वाली सबसे पुरानी बनावट पन्ना शेल है, जो रीवा ग्रुप की सबसे पुरानी बनावट को दिखाती है, जिसके ऊपर बनबिहा सैंडस्टोन, भुलवा लाइमस्टोन, पिंडरा शेल और इटवा सैंडस्टोन बनावट के रोहनिया सैंडस्टोन हैं।

1.3.3 लिथोस्ट्रेटिग्राफिक सक्सेशन, इटवा सैंडस्टोन फॉर्मेशन से लेकर रीवा ग्रुप के पन्ना शेल फॉर्मेशन तक एक पूरा और एक जैसा सीक्वेंस दिखाता है, जो मिट्टी के मिट्टी वाले से रेत वाले फेशियस तक एक ट्रांज़िशनल सेडिमेंटरी माहौल दिखाता है, जिससे पता चलता है कि डिपॉज़िशन धीरे-धीरे कम एनर्जी से ज़्यादा एनर्जी वाली कंडीशन में बदल गया, जैसे कि कम गहरा समुद्री माहौल, जो ग्लौकोनाइट/पोटाश मिनरलाइज़ेशन के लिए एक अच्छी कंडीशन है।

1.3.4 इस ब्लॉक की टोपोग्राफी हल्की ढलान वाली है, जो 1°–2° है, जिसमें थोड़ी टेढ़ी-मेढ़ी और जोड़दार बनावट है, जो विंध्य के सेडिमेंट्री क्षेत्र की खासियत है। यह बनावट NE-SW की नतिलंब है और दक्षिण-पूर्व की ओर नति हुई है, जिसमें कोई बड़ी टेक्टोनिक गड़बड़ी या मेटामॉर्फिज्म नहीं देखा गया है, जो निक्षेपण के बाद से एक स्थिर क्रेटोनिक सेटिंग दिखाता है।

1.4.0 खनिजीकरण

1.4.1 झारी G-3 ब्लॉक में ग्लौकोनाइट मिनरलाइज़ेशन विंध्यन सुपरग्रुप के रीवा ग्रुप में होता है, खासकर इटवा सैंडस्टोन (लोअर रीवा सैंडस्टोन) फॉर्मेशन में। सेडिमेंट्री सीक्वेंस में अलग-अलग प्राइमरी स्ट्रक्चर दिखते हैं जैसे बेडिंग वेरिएशन, क्रॉस-बेडिंग, रिपल मार्क्स, लेमिनेशन और मड क्रैक्स, जो एक डायनामिक डिपॉज़िशनल एनवायरनमेंट को दिखाते हैं जो कम गहरे समुद्री से लेकर किनारे के पास की स्थितियों के बीच बदलता रहता है, जो कम से मीडियम एनर्जी वाले एनवायरनमेंट में डिपॉज़िशन का संकेत देता है।

1.4.2 बनबिहा सैंडस्टोन मेंबर, जो इटवा सैंडस्टोन फॉर्मेशन का बेसल हिस्सा बनाता है, मुख्य ग्लौकोनाइटिक होराइजन को दिखाता है जो सभी ड्रिल किए गए बोरहोल में इंटरसेप्टेड है। इसकी खासियत फ्लेजर बेडिंग, ट्रफ क्रॉस-बेडिंग, और अल्टरनेटिंग शेल-सैंडस्टोन लैमिनाई हैं, जो समय-समय पर एनर्जी में उतार-चढ़ाव और एपिसोडिक सेडिमेंट सप्लाई को दिखाते हैं। ग्लौकोनाइटिक सैंडस्टोन लेयर्स के अंदर चर्ट इंटरबेड (2 mm–1.5 cm मोटे) की मौजूदगी बेसिन के अंदर डिपॉज़िशनल एनर्जी और केमिकल कंडीशन में धीरे-धीरे होने वाले बदलावों को और दिखाती है।

1.4.3 खनिज विज्ञान के अनुसार से, ग्लौकोनाइटिक सैंडस्टोन में पाइराइट का फैलाव और पपड़ी जमी होती है, जो कम करने वाली, हल्की एल्कलाइन कंडीशन में निक्षेपण होने की पुष्टि करता है। क्वार्ट्ज़ (वेन, स्मोकी और नॉर्मल वैरायटी), फेल्डस्पार, मस्कोवाइट और क्लोराइट जैसे जुड़े हुए खनिज एसिड इग्नियस प्रोवेंस से निकलने का संकेत देते हैं। क्रॉस-बेड से पैलियोकरंट इंडिकेटर उत्तर-पश्चिम से उत्तर की ओर सेडिमेंट ट्रांसपोर्ट दिखाते हैं, जो कम-एनर्जी वाले मरीन शेल्फ सेटिंग को डेट्राइटल मटीरियल सप्लाई करने वाले एक पास के स्रोत एरिया का सुझाव देते हैं। कुल मिलाकर, झारी ब्लॉक के ग्लौकोनाइटिक हॉराइज़न स्थिर, कम करने वाली और उथली मरीन कंडीशन में बने ऑथिजेनिक मिनरलाइज़ेशन को दिखाते हैं, जो विंध्य सेडिमेंटरी बेसिन के अंदर ग्लौकोनाइट और उससे जुड़े पोटाश एनरिचमेंट के लिए बहुत अच्छी स्थिति को दिखाते हैं।

1.5.0 मौजूदा जांच के दौरान की गई गवषण

1.5.1 झारी ब्लॉक में जुलाई 2024 में गवेषण कार्य प्रारंभ हुआ और 1:4000 स्केल पर जियोलॉजिकल मैपिंग 30 सितंबर, 2024 तक पूरी हो गई। मैप की गई मुख्य लिथोलॉजिकल यूनिट्स में इटवा सैंडस्टोन फॉर्मेशन और पन्ना साहले फॉर्मेशन के सदस्य शामिल हैं। ब्रंटन कंपास का प्रयोग करके रिकॉर्ड किए गए स्ट्रक्चरल डेटा से पता चला कि यह NE–SW से ENE–WSW की ओर एक समान्य नतिलंब दिखाता है, जिसमें बेड दक्षिण-पूर्व की ओर धीरे-धीरे (1°-2°) नति हैं।

1.5.2 ड्रिलिंग 27 जून 2025 को शुरू हुई और 05 बोरहोल (MJHR-01 से MJHR- 05) ड्रिल किए गए, जिससे 160.00 mts का मीटरेज पूरा हुआ और कुल 101 प्राइमरी और 13 चेक सैंपल तैयार किए गए। सभी प्राइमरी सैंपल का 4 रेडिकल्स यानी K_2O, SiO_2, Al_2O_3, और Fe_2O_3 के लिए एमईसीएल केमिकल लेबोरेटरी, नागपुर, महाराष्ट्र में एनालिसिस किया गया और बाहरी चेक सैंपल जवाहरलाल नेहरू एल्युमिनियम रिसर्च डेवलपमेंट एंड डिज़ाइन सेंटर, (JNARDDC) नागपुर (एक NABL एक्रेडिटेड लेबोरेटरी) भेजे गए । सभी ड्रिलिंग एक्टिविटी 15 अगस्त, 2025 को पूरी हो गईं।

1.5.3 बोरहोल 800×800m ग्रिड इंटरवल पर रखा गया है जो मिनरल्स एविडेंस ऑफ़ खनिज कंटेंट रूल्स, 2015 के मुताबिक है, जो G-3 लेवल गवेषण के लिए डेटा डेंसिटी तय करता है। पिंडरा साउथ वेस्ट ब्लॉक के पहले ड्रिल किए गए एक बोरहोल को ग्लौकोनाइटिक सैंडस्टोन संसाधन के कोरिलेशन और कैलकुलेशन के लिए ध्यान में रखा गया था।

1.5.4 अनुमोदित किए गए कार्य बनाम वास्तविक लक्ष्य की मात्रा और प्रकृति की जानकारी नीचे दी गई है:

तालिका – 1.3

ग्लौकोनाइटिक सैंडस्टोन के लिए झारी जी-3 ब्लॉक में एमईसीएल द्वारा स्वीकृत कार्य की मात्रा बनाम वास्तविक उपलब्धि, जिला: सतना, मध्य प्रदेश

क्रम संख्या	कार्य का वर्णन	इकाई	स्वीकृत मात्रा	प्राप्त क्वांटम
I	**जियोलॉजिकल मैपिंग (1:4000 स्केल पर मैप को अपडेट करना)**	हे.	510	510
2	स्थलाकृतिक सर्वेक्षण बीएच निर्देशांक	हे. नग	510 05	510 05

क्रम संख्या	कार्य का वर्णन	इकाई	स्वीकृत मात्रा	प्राप्त क्वांटम
II	**गवेषणात्मक ड्रिलिंग**	एम	250	160
III	**प्रयोगशाला अध्ययन**			
	प्राथमिक और जाँच नमूने			
1	4 रेडिकल K_2O, SiO_2, Al_2O_3 और Fe_2O_3 के लिए प्राइमरी सैंपल एनालिसिस	नग	125	101
2	4 रेडिकल K_2O, SiO_2, Al_2O_3 और Fe_2O_3 के लिए एक्सटर्नल चेक सैंपल (प्राइमरी का 10%) एनालिसिस	नग	13	13
IV	**भौतिक अध्ययन**			
1	थोक घनत्व निर्धारण	नग	04	04
V	**भूवैज्ञानिक रिपोर्ट तैयार करना**	**नग.**	**1**	**1**

1.6.0 क्षेत्रों का परिसीमन

1.6.1 एमईसीएल ने 800m के गैप पर बने 05 बोरहोल में कुल 160.00 मीटर की ड्रिलिंग की। इन बोरहोल में, ग्लौकोनाइट ज़ोन (>5% K2O कटऑफ पर दिखाया गया) बनबिहा सैंडस्टोन में MJHR-01 में 2.50 m गहराई से MJHR-04 में 19.35 m गहराई तक मिला है और मोटाई 10.50 m (MJHR-01, K2O 5.47%) से 19.20 m (MJHR-05, K2O 6.12%) के बीच है।

1.7.0 संसाधन और ग्रेड का अनुमान

1.7.1 संसाधन एस्टिमेशन दो तरीकों से कैलकुलेट किया गया है: क्रॉस-सेक्शनल मेथड (मुख्य मेथड) और पॉलीगोनल मेथड (चेक मेथड)।

1.7.2 नेट जियोलॉजिकल संसाधन, ग्रॉस इन-सीटू संसाधन के आंकड़ों में से 20% घटाने के बाद आते हैं, जिसका प्रयोग कैविटी, गुफाओं और दूसरी स्ट्रक्चरल गड़बड़ियों जैसे अनदेखे जियोलॉजिकल फैक्टर्स को ध्यान में रखने के लिए किया गया था।

1.7.3 कुल 104.20 मिलियन टन नेट इन-सीटू अनुमानित संसाधन (333 श्रेणी) औसत ग्रेड 6.04% K_2O और 6.18% औसत ग्रेड के साथ 25.85 मिलियन टन नेट इन-सीटू आवीक्षण संसाधन (334 श्रेणी) K_2O क्रॉस सेक्शनल तरीके से अनुमान लगाया गया है । क्रॉस-सेक्शन तरीके से कुल नेट इन-सीटू संसाधन (333+334) 130.05 मिलियन टन एवं औसत ग्रेड 6.06% के साथ K_2O है।

1.7.4 हालाँकि, कुल 144.25 मिलियन टन शुद्ध इन-सीटू आवीक्षण संसाधन (334 श्रेणी) औसत ग्रेड 6.07% के साथ K_2O का अनुमान पॉलीगोनल तरीके से लगाया गया है ।

1.7.5 अनुमान के कॉन्फिडेंस लेवल का पता लगाने के लिए क्रॉस-सेक्शनल मेथड और पॉलीगोनल मेथड से अनुमानित संसाधन की तुलना की गई। चेक अप्रोच के तौर पर प्रयोग किए गए पॉलीगोनल मेथड से, मुख्य मेथड क्रॉस-सेक्शनल मेथड की तुलना में 10.35% ज़्यादा संसाधन अनुमान मिला। यह अंतर तय लिमिट के अंदर आता है, जो संसाधन अनुमान के भरोसेमंद और सटीक होने की पुष्टि करता है।

1.7.0 सिफारिश

1.7.1 एमईसीएल ने 130.05 मिलियन टन (333 +334 श्रेणी) स्थापित किया है औसत ग्रेड 6.06% के साथ K_2O मौजूदा खोज के काम के नतीजे के आधार पर 5.1 वर्ग. किमी. एरिया में संसाधन के ब्लॉक को CL/ML पर नीलाम किया जा सकता है। डिटेल्ड खोज के दौरान फेल्डस्पार और माइका से ग्लौकोनाइट की मौजूदगी को वैलिडेट करने और अलग करने के लिए SEM-EDS और बाइमोडल स्टडी करने की भी सलाह दी जाती है।

GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3 STAGE) FOR GLAUCONITIC SANDSTONE IN JHARI BLOCK

TEHSIL-MAJHGAWAN, DISTRICT- SATNA, MADHYA PRADESH

CHAPTER-1

1.0.0 EXECUTIVE SUMMARY

1.1.0 INTRODUCTION

1.1.1 Glauconite, a potassium-rich green silicate mineral of significant importance for use as a natural fertilizer, soil conditioner, and potential source of potash, occurs within the sandstone horizons of the Vindhyan Supergroup in this region.

1.1.2 Potassium, alongside nitrogen and phosphorus, forms the trio of primary macronutrients essential for plant health and agricultural productivity. It plays a vital role in various physiological processes; including enzyme activation, water regulation, photosynthesis, and protein synthesis. Due to its significant contribution to crop yield and quality, potassium is required in substantial quantities for sustainable agricultural practices.

1.1.3 The growing awareness of potassium's critical role in plant nutrition spurred the emergence and rapid development of the global potash industry, a key supplier of potassium-based fertilizers. Historical records indicate that global potash production reached approximately 1 million tonnes by 1921. Since then, production has witnessed a steady and robust upward trajectory.

1.1.4 According to data from the United States Geological Survey (U.S. Geological Survey, Mineral Commodity Summaries, January 2025), world annual potash production capacity was 65.2 million tons in 2024 and projected to increase to about 76.0 million tons of K_2O by 2028. This rising demand underscores the strategic importance of potassium in meeting global food security challenges and has further intensified exploration efforts for alternative potash sources, including glauconitic sandstone.

1.1.5 Currently, the global demands of potash are predominantly made through mining of bedded marine evaporite deposits and potash-rich brine sources. These natural deposits comprise a suite of water-soluble potassium-bearing minerals such as sylvite (KCl), carnallite ($KMgCl_3 \cdot 6H_2O$), kainite ($KMg(SO_4)Cl \cdot 3H_2O$), and polyhalite ($K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$). They occur either as stratified mineral beds or in the form of sub-surface and surface brine reservoirs and are predominantly processed to extract potassium chloride (Muriate of Potash i.e. MOP) and sulfate of potassium (SOP), the two most widely used potash fertilizers.

1.1.6 Globally, the distribution of these high-grade conventional potash resources is highly localized, with over 90% of production concentrated in just a few countries notably Canada, Russia, Belarus, Brazil, China, Chile, Germany, and the United States. These nations not only control large reserves but also dominate the global export markets, creating supply dependence for the rest of the world, especially in potash-importing countries like India which relies on agriculture.

1.1.7 To sustain long-term agricultural productivity and reduce dependence on imports, it is essential to explore alternative potassium resources. Alternating potassium sources are K-bearing silicate and non-silicate minerals, which, though not readily soluble like evaporite minerals, can be processed to release potassium through suitable extraction technologies. Recent research suggests that potassium-bearing aluminosilicates, such as feldspar, glauconite, and mica could serve as viable sources of potash under the right geochemical and technological conditions. These alternative sources offer a potential pathway for self-sufficiency for countries lacking high grade evaporite deposits.

1.1.8 India is among the world's largest consumers of potash fertilizers, yet it lacks economically mineable evaporite potash deposits. This shortfall has driven the exploration of non-conventional, indigenous sources such as glauconitic sandstone, potash-rich shales, and feldspathoids. Global precedents demonstrate the viability of such alternatives and extensive glauconite use in the former USSR. Given its widespread occurrence in India's sedimentary basins, glauconitic sandstone emerges as a strategically important resource capable of supporting nutrient security and reducing import dependence.

1.1.9 Glauconitic sandstone is a sedimentary rock enriched in the greenish mineral glauconite, formed under marine shelf conditions. While traditionally valued for stratigraphic studies, paleoenvironmental reconstruction, and petroleum exploration, it is increasingly recognized for its economic potential as a source of potassium fertilizer. India's reserves, exceeding 3,000 million tons with K_2O content ranging from 4% to 8%, are reported across Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan, and Gujarat in Cretaceous to Paleogene formations. These deposits present a sustainable alternative to imported potash, aligning with the national vision of nutrient self-reliance.

1.1.10 Policy recognition has been reinforced through the Mines and Minerals (Development and Regulation) Amendment Act, 2023, which introduced Section 1D to address the strategic importance of critical minerals. Glauconite has been included under the National Critical Mineral Mission, which aims to ensure a secure and self-reliant supply of minerals vital to agriculture, clean energy, electronics, space, defence, and industry. This mission promotes targeted exploration, NMET funding support, and block auction facilitation for commercial utilization, marking glauconite as a priority in the country's mineral development framework.

1.1.11 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. Securing minerals like glauconite is integral to India's Net-Zero Emission Target by 2070, enabling progress in solar, wind, EV, battery storage, and green hydrogen production.

1.1.12 The Jhari G-3 block (5.1 sq. km) has been carved out from Pindra South-West Extension Block (39.23 sq. km) and it consist of Proterozoic age litho-units of Rewa Group of the Vindhyan Supergroup of rocks, which is well-known for its mineral potentiality for glauconitic sandstone.

1.1.13 MECL has conducted a Reconnaissance Survey in the Pindra South-West Extension block. MECL has estimated a resource of 1,918 million tonns of glauconitic sandstone in this block, with an average grade of 6.96% K_2O (334) and average thickness of about 25 meters. The Jhari G-3 block is delineated from Pinda South West Extension Block, which aims to establish resources with higher confidence and block suitability for auction.

1.1.14 The Preliminary exploration proposal for Glauconitic sandstone in Jhari block, Satna, Madhya Pradesh was submitted in 63th TCC held on March, 2024 and after deliberation committee recommended for approval of Executive committee of NMEDT.

1.1.15 35th Executive Committee (EC) approved the project vide letter no. 23/453/2024-NMET/78, dated 17th May 2024, with time duration of 09 months.

1.3.0 LOCATION AND ACCESSIBILITY

1.3.1 The Jhari G-3 block falls in parts of the Survey of India Toposheet No. 63D/09 and 63D13 and it lies between 24° 56′ 1.39″ N to 24° 57′ 21.74″ N latitudes and 80° 44′ 45.95″ E to 80° 46′ 28.88″ E longitudes and covers an area of 5.1 sq.km, in and around Jhari, Pindra, Lalpur Padari, and Sada villages of Majhgawan Tehsil, Satna district, Madhya Pradesh.

1.3.2 The exploration block can be accessed at about 44 km from Satna along the Satna–Chitrakoot (State Highway 11). The area has good connectivity through State Highway 11 and NH-135BG, linking it with Satna, Maihar, Umaria, and the Uttar Pradesh.

1.3.3 The co-ordinates of the cardinal points of the block area both in geodetic and in UTM are given below:

Table No.-1.1

Co-ordinates of Cardinal Points of Block Boundary of Jhari G-3 Block for Glauconitic Sandstone, District-Satna, Madhya Pradesh

CARDINAL PONTS	UTM Zone-44(m)		Geographic Co-ordinate WGS-84	
	Easting (m)	Northing (m)	LATITUDE (DMS)	LONGITUDE (DMS)
A	474365.063	2757669.697	24° 56′ 2.60″	80° 44′ 45.95″
B	474372.551	2760099.531	24° 57′ 21.60″	80° 44′ 46.06″
C	475851.349	2760101.346	24° 57′ 21.74″	80° 45′ 38.79″
D	476465.601	2759097.464	24° 56′ 49.14″	80° 46′ 0.76″
E	477254.177	2759093.323	24° 56′ 49.05″	80° 46′ 28.88″
F	476123.106	2757629.439	24° 56′ 1.39″	80° 45′ 48.64″

1.4.0 GEOLOGY AND STRUCTURE OF THE BLOCK

1.4.1 The Jhari block forms part of the Majhgawan–Paharikhera Potash Belt, located in the northern part of Satna District, Madhya Pradesh. Geologically, the block is underlain by the rocks of the Rewa Group belonging to the Vindhyan Supergroup, which is well exposed in this sector of the Vindhyan Basin. The stratigraphic nomenclature for the block has been adopted based on the lateral correlation of lithological units with the established regional stratigraphic succession in adjoining areas such as Majhgawan, Paharikhera, and Sohawal.

The stratigraphic sequence of litho units in the Block area (After GSI) is given below:

Table 1.2
Stratigraphic sequence of the Jhari G-3 Block
(After GSI)

AGE	SUPERGROUP/ GROUP / COMPLEX	SERIES	FORMATION	LITHOLOGY	
Recent to sub-recent			Alluvium/soil/laterite		
Proterozoic	Vindhyan Super Group	Rewa	Gahadara sandstone	Quartz arenite	
			Jhiri Shale	Upper shale	Green & Red shale
				Upper White sandstone	medium grained quartz arenite
				Middle Glauconitic sandstone	
				Lower White sandstone –	medium grained quartz arenite
				Lower shale	green and red shale with conglomerate
				Rohania sandstone	quartz arenite with granular conglomerate
			Itwa sandstone formation	Pindra Shale	green and red shale with limestone interbands
				Bhulwa limestone	cream colour limestone with brown chert
				Banbiha Sandstone	glauconitic limestone
			Panna Shale	Shale with limestone interband	
		Kaimur	Baghain Sandstone	Medium to Coarse Sandstone, fine sandstone with siltstone and shale interbands. Medium to coarse sandstone, angular gravel bearing sandy conglomerate	
		Unconformity			
	Vindhyan Super Group	Semri		Palkwan Shale Dolomitic limestone Pandwafall sandstone	
			Pandwa fall formation	Bansagar sandstone (Upper glauconitic sandstone) Kohari chert (dolomitic limitation	

AGE	SUPERGROUP/ GROUP / COMPLEX	SERIES	FORMATION	LITHOLOGY
				chert and chert breccia) Kudwari sandstone (Lower glauconitic sandstone)
	Unconformity			
Proterozoic	Bundelkhand Gneissic Complex			Granite gneiss Granite

1.4.2 Within the block, the oldest formation exposed on the surface is the Panna Shale, representing the oldest Formation of Rewa Group overlain by Banbiha Sandstone, Bhulwa Limestone, Pindra Shale and Rohania Sandstone members of Itwa Sandstone formation.

1.4.3 The lithostratigraphic succession of the Jhari block displays a complete and conformable sequence from the Itwa Sandstone Formation through Panna Shale Formation of Rewa Group, indicating a transitional sedimentary environment from argillaceous to arenaceous facies which indicated deposition gradually changed from low energy to high energy condition such as shallow marine environment, which is a favorable condition for glauconite/ potash mineralization.

1.4.4 The block has gentle sloping topography of 1°–2°, with minor warping and jointing, characteristic of the Vindhyan sedimentary terrain. The formation strikes NE-SW with dip due southeast, with of no major tectonic disturbances or metamorphism are observed, indicating a stable cratonic setting since deposition.

1.5.0 MINERALIZATION

1.5.1 The glauconite mineralization in the Jhari block occurs within the Rewa Group of the Vindhyan Supergroup, particularly in the Itwa Sandstone (Lower Rewa Sandstone) Formation. The sedimentary sequence exhibits diverse primary structures such as bedding variations, cross-bedding, ripple marks, lamination, and mud cracks, reflecting a dynamic depositional environment that fluctuated between shallow marine to nearshore conditions suggest deposition under a low to moderate energy environment.

1.5.2 The Banbiha Sandstone Member, forming the basal part of the Itwa Sandstone Formation, represents the principal glauconitic horizon which is intercepted in all the drilled boreholes. It is characterized by flaser bedding, trough cross-bedding, and alternating shale–sandstone laminae, indicating periodic energy fluctuations and episodic sediment supply. The presence of chert interbeds (2 mm–1.5 cm thick) within glauconitic sandstone layers further reflects gradational transitions in depositional energy and chemical conditions within the basin.

1.5.3 Mineralogically, the glauconitic sandstone hosts pyrite disseminations and encrustations, confirming deposition under reducing, mildly alkaline conditions. Associated minerals such as quartz (vein, smoky, and normal varieties), feldspar, muscovite, and chlorite indicate derivation from an acid igneous provenance. Paleocurrent indicators from cross-beds show north-westerly to northerly sediment transport, suggesting a proximal source area supplying detrital material to a low-energy marine shelf setting. Overall, the glauconitic horizons of the Jhari block represent authigenic mineralization formed under stable, reducing, and shallow marine conditions, marking an environment highly conducive for glauconite and associated potash enrichment within the Vindhyan sedimentary basin.

1.6.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

1.6.1 In Jhari block exploratory operations in the block commenced July 2024 with geological mapping on 1:4000 scale was completed by 30th September 2024. The key lithological units mapped include members of Itwa Sandstone Formation and Panna Sahle Formation. Structural data recorded using a Brunton compass revealed a general strike of NE–SW to ENE–WSW, with beds gently dipping (1°-2°) towards the southeast.

1.6.2 Drilling commenced on 27th June 2025 and 05 nos. of boreholes (MJHR-01 to MJHR-05) were drilled completing meterage of 160.00 mts. and in total 101 primary and 13 check samples were generated. All the primary samples were analyzed for 4 radicals viz. K_2O, SiO_2, Al_2O_3, and Fe_2O_3, at MECL chemical laboratory, Nagpur, Maharashtra and external check samples were sent to Jawaharlal Nehru Aluminum Research Development and Design Centre, (JNARDDC) Nagpur (A NABL accredited Laboratory). All the drilling activities were completed on 15th August 2025.

1.6.3 The borehole placed at 800×800m grid interval which conform to the Minerals Evidence of Mineral Content Rules, 2015, which prescribe the data density for G-3 level exploration. One previously drilled borehole of Pindra South West Block was taken into consideration for correlation and calculation of glauconitic sandstone resources.

1.6.4 The details of the nature and quantum of work approved vs actual achievement is given below:

Table – 1.3
Approved Quantum of Work vs. Actual achievement by MECL in Jhari G-3 Block for Glauconitic Sandstone, District: Satna, Madhya Pradesh

Sl. No	Description of Work	Unit	Approved quantum	Achieved quantum
I	**Geological mapping (updating of map at 1:4000 scale)**	Ha	510	510
2	Topographical Survey BH co-ordinates	Ha Nos	510 05	510 05
II	**Exploratory Drilling**	M	250	160
III	**Laboratory Studies**			
	Primary and Check samples			
1	Primary sample analysis for 4 radicals K_2O, SiO_2, Al_2O_3 & Fe_2O_3	Nos	125	101
2	External Check Samples (10% of Primary) analysis for 4 radicals K_2O, SiO_2, Al_2O_3 & Fe_2O_3	Nos	13	13
IV	**Physical studies**			
1	Bulk Density determination	Nos	04	04
V	**Geological Report preparation**	**Nos.**	**1**	**1**

1.7.0 DELINIATION OF ZONES

1.7.1 MECL carried out a total 160.00 meters of drilling in 05 nos. of borehole, vertically drilled, which are spaced in 800m interval. In these boreholes, the glauconite zone (demarcated at >5% K_2O cutoff) is intersected in Banbiha Sandstone at depth ranging from 2.50 m depth in MJHR-01 to 19.35 m depth in MJHR-04 and thickness varies between 10.50 m (MJHR-01, K_2O -5.47%) to 19.20 m (MJHR-05, K_2O - 6.12%).

1.8.0 ESTIMATION OF RESOURCE AND GRADE

1.8.1 The resource estimation has been calculated using two methods: the Cross-Sectional Method (principal method) and the Polygonal Method (check method).

1.8.2 The Net geological resources are arrived after a deduction of 20% from the gross in-situ resource figures, which was applied to account for unseen geological factors such as, cavities, caverns, and other structural irregularities.

1.8.3 A total of **104.20 million tonnes** of Net in-situ Inferred Resources (333 category) with average grade of **6.04% K_2O** and **25.85 million tonnes** of Net in-situ Reconnaissance Resources (334 category) with average grade of **6.18% K_2O** have been estimated by cross sectional method. The cumulative **Net in-situ Resources (333+334)** by cross-section method is **130.05 Millon tonnes** with average grade of **6.06% K_2O.**

1.8.4 However**,** total **144.25 million tonnes** of Net in-situ Reconnaissance Resources (334 category) with average grade of **6.07% K_2O** has been estimated by polygonal method.

1.8.5 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 10.35% higher 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.

1.9.0 RECOMMENDATION

1.9.1 MECL has established **130.05 million tons (333 +334** category) with average grade of **6.06% K_2O** of resources over 5.1 sq. km. area based on the outcome of the current exploration work the block may be auctioned at CL/ML. It is also recommended to carry out SEM-EDS and bimodal study to validate and distinguish the presence of glauconite from feldspar and mica during detailed exploration.

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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 PRELIMINARY 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 Kumar Pala	Sr. Manager (Geology)	M.Sc. (Tech.), Applied Geology	21 Years
4	Shri Peeyush Kumar	Assistant Manager (Geology)	M.Sc., Geology	08 Years
5	Shri Aditya Chodhury	Sr. Geologist	M.Sc., Geology	05 Years
6	Shri Rajnikant Singh	PM Manager (Drilling)	B. tech	10 Years
7	Shri Dushyant Singh	Sr. Drilling Engineer	B. tech	12 Years
8	Shri Rohit Kumar Sharma	Manager (Chemical Lab)	M.Sc., Chemistry	15 Years
9	Shri Sayantan Pal	Manager (Geology)	M.Sc., Applied Geology	12 Years

CHAPTER-3

3.0.0 TITLE AND OWNERSHIP

3.1.0 TITLE OF THE REPORT

GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3 STAGE) FOR GLAUCONITIC SANDSTONE IN JHARI BLOCK (5.1 sq km) TEHSIL-MAJHGAWAN, DISTRICT- SATNA, MADHYA PRADESH

Ownership: Government of Madhya Pradesh

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 exploratory programme in the block commenced in July 2024 with topographical surveying and geological mapping conducted on a 1:4,000 scale. Subsequently, exploratory drilling operations were undertaken. Associated field activities were executed in parallel to ensure efficiency. In addition, analytical and laboratory investigations were carried out concurrently in MECL laboratories as well as other NABL accredited laboratories.

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

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

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

3.3.3 Experience: Established in 1972

CHAPTER-4

4.0.0 DETAILS OF THE AREA

4.1.0 LOCATION AND ACCESSIBILITY OF THE BLOCK

4.1.1 The Jhari G-3 block falls in parts of the Survey of India Toposheet No. 63D/09 and 63D13 and it lies between 24° 56′ 1.39″ N to 24° 57′ 21.74″ N latitudes and 80° 44′ 45.95″ E to 80° 46′ 28.88″ E longitudes.

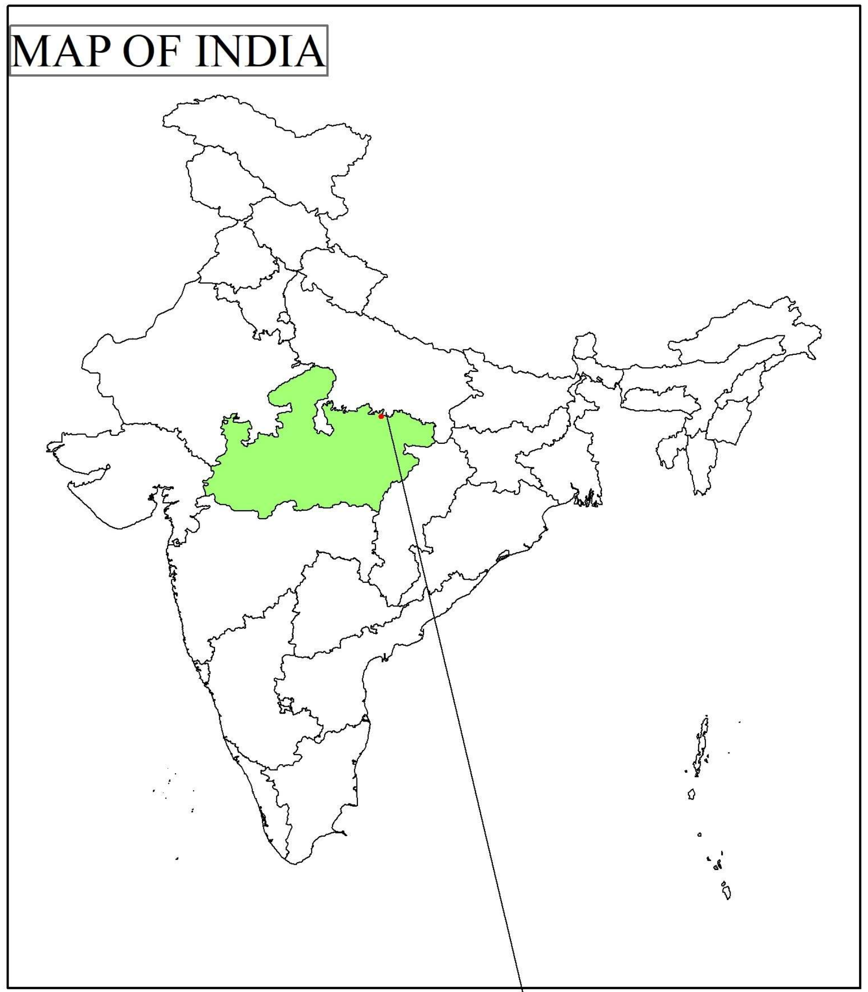
4.1.2 The block covers an area of 5.1 sq.km, in and around Jhari, Pindra, Lalpur Padari, Padari, and Sada villages of Majhgawan Tehsil, Satna district, Madhya Pradesh. The Location Map is given in Plate-I and Text Fig. 4.1. The co-ordinates of the corner points of the block area both in geodetic and in UTM are given in table No.- 4.1 and in Annexure IA.

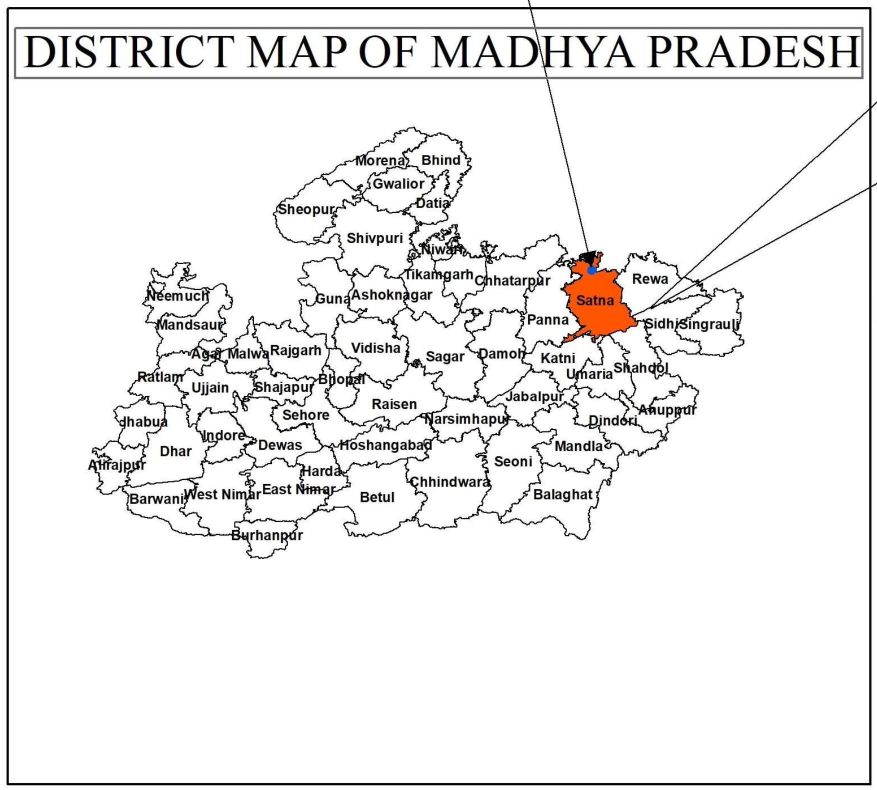
Table No.-4.1
Co-ordinates of cardinal points of block boundary of Jhari (G-3) block for Glauconitic sandstone etc., Distt-Satna, Madhya Pradesh

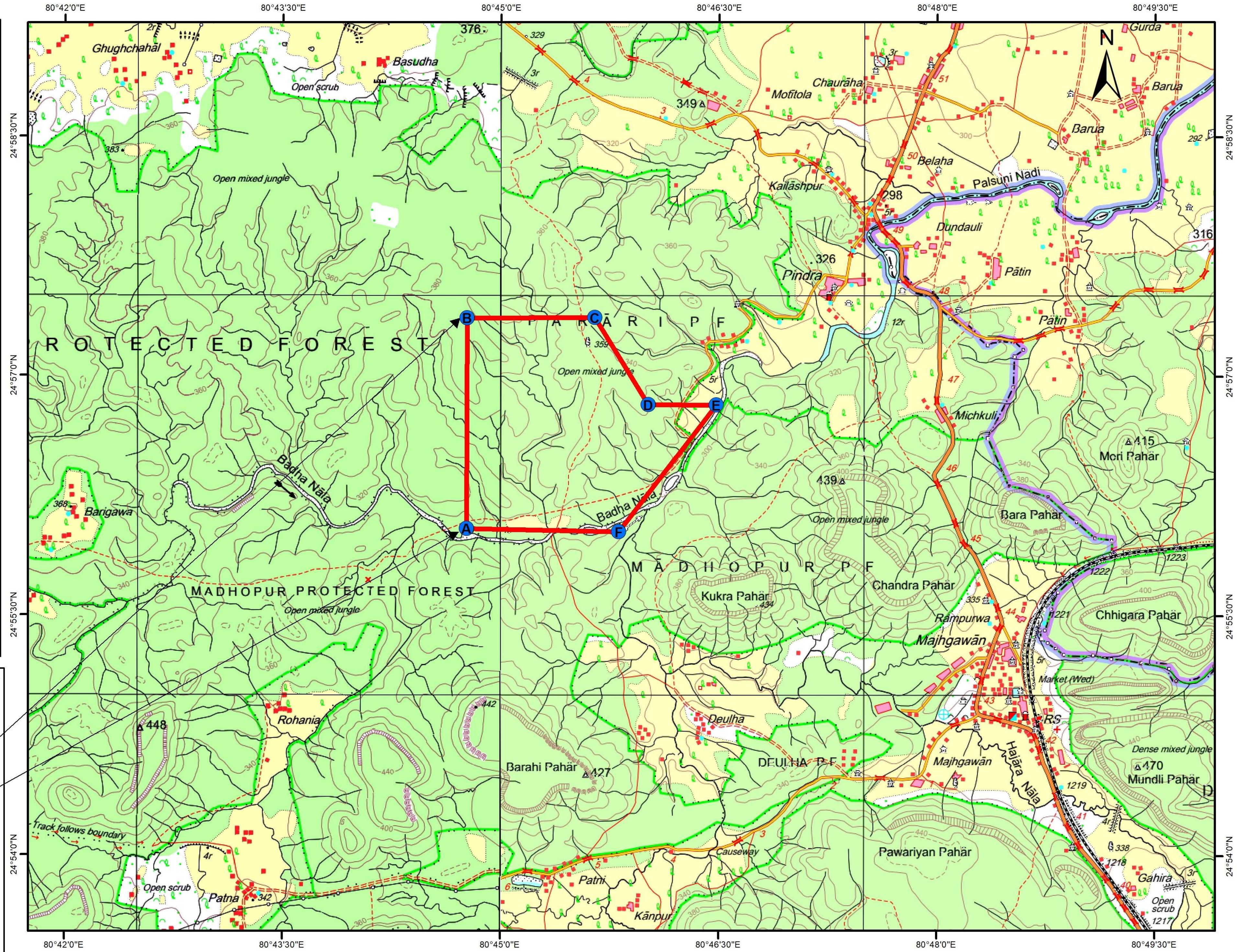
CARDINAL PONTS	UTM Zone-44(m)		Geographic Co-ordinate WGS-84	
	Easting (m)	Northing (m)	LATITUDE (DMS)	LONGITUDE (DMS)
A	474365.063	2757669.697	24° 56′ 2.60″	80° 44′ 45.95″
B	474372.551	2760099.531	24° 57′ 21.60″	80° 44′ 46.06″
C	475851.349	2760101.346	24° 57′ 21.74″	80° 45′ 38.79″
D	476465.601	2759097.464	24° 56′ 49.14″	80° 46′ 0.76″
E	477254.177	2759093.323	24° 56′ 49.05″	80° 46′ 28.88″
F	476123.106	2757629.439	24° 56′ 1.39″	80° 45′ 48.64″

4.1.3 The exploration block is located in Majhgawan Tehsil of Satna District in Madhya Pradesh. It falls on State highway no. 11 and is about 37 km from Chitrakoot town on Satna– Chitrakoot road. The road network around Jhari, Pindra and Majhgawan consists of a mix of highways, district roads, and rural village roads. The nearest National Highway (NH-39/NH-30) is approximately 30-40 km from Jhari. District-level roads like the Kotar–Mahuti–Majhgawan Road and a bypass further improve regional access. Pindra village is located about 2 km from block area and linked through smaller gravel and murram village roads, which provide local connectivity but are less developed and often seasonal in quality. Overall, the area has excellent connectivity to town and highways while intra-village connections remain basic. Majhgawan railway station is 10 Km away in South- Eastern direction from the southern boundary of the block and is located on Mumbai-Jabalpur-Allahabad line, lies between Satna and Manikpur stations of Western Central Railway. Khajuraho, Madhya Pradesh (125 KM in WSW direction) and Prayagraj, Uttar Pradesh (168 KM in NE direction) are the nearby airport from the block.

Text Figure-4.1: Location Map of Jhari (G-3 stage) block explored for Glauconitic sandstone, District- Satna, Madhya Pradesh







LABEL	UTM (WGS84) - ZONE 44 R		GCS (DMS)		Elevation
	EASTING (m)	NORTHING (m)	LATITUDE (N)	LONGITUDE (E)	
A	474365.063	2757669.697	24° 56′ 2.60″	80° 44′ 45.95″	311.486
B	474372.551	2760099.531	24° 57′ 21.60″	80° 44′ 46.06″	372.723
C	475851.349	2760101.346	24° 57′ 21.74″	80° 45′ 38.79″	363.226
D	476465.601	2759097.464	24° 56′ 49.14″	80° 46′ 0.76″	343.899
E	477254.177	2759093.323	24° 56′ 49.05″	80° 46′ 28.88″	302.594
F	476123.106	2757629.439	24° 56′ 1.39″	80° 45′ 48.64″	329.583

Cardinal Points

Jhari G-3 Block

4.2.0 DETAILS OF THE AREA WITH LAND USE

4.2.1 Nearly 98% of the block area of 5.1 sq. km. falls within the Parari protected forest land of Chitrakoot Range of Rewa circle, while remaining area falls under habitat land.

4.2.2 The cadastral details of the area are not obtained.

4.3.0 MINERAL(S) UNDER INVESTIGATION

4.3.1 Block was explored for Glauconitic Sandstone.

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 exploration block lies on the undulating Vindhyan/central Indian plateau terrain: low hills, hill-slopes and inter-hill valleys with patches of reserve/forest cover in the entire block. This gives a landscape of gentle to moderate relief rather than steep mountains. Highest elevation in the area is around 378m in the northwestern part of the exploration block and gradually elevation reduces towards Southeastern part of the block and it goes down to 300m. General slope is towards South-East.

5.1.2 Satna district falls in Ganga basin, The Yamuna, the Tons and the Son are Sub-basins of the Ganga basin, which are draining the area. Except in small southern part, the district is mainly drained by river Tons and its tributaries. Tons is a perennial river, which flows in north and north-east direction. Its main tributaries are westerly flowing Seranji Nala, north-easterly flowing Lilji Nala, Barua Nala and Beehar Nadi, northerly flowing Magardaha Nala, and easterly flowing Satna, Simrawal and Asrawal rivers. The "Paisuni or Mandakni" or "Bandha Nala" sacred river, which is a tributary of the river Yamuna drains northern part of the district (Chitrakoot area).

5.1.3 Groundwater in the Jhari area of Satna district occurs mainly in weathered and fractured Vindhyan sandstones and local alluvium, with movement controlled by joints and fractures in hard rock. The water table ranges from 6–22 m below ground level before monsoon and rises to 1–6 m after it, though many wells dry up in summer. Yields are moderate and seasonal, with borewells in fractured zones giving more dependable output. Water quality is generally fit for domestic and agricultural use, except in some areas with high fluoride. Recharge is mainly from rainfall and village tanks, causing sharp declines in dry seasons, thus emphasizing the need for rainwater harvesting, check-dams, farm ponds, and restoration of village tanks.

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

5.2.1 National Highway 135BG, a spur road of National Highway 35. NH 135BG traverses the states of Madhya Pradesh and Uttar Pradesh in India connecting Maihar and Chitrakoot. This highway falls within 10km from Jhari block.

5.2.2 Majhagawan (MJG), is the nearest railway station which belongs to Jabalpur division of West Central Railway. The railway station is about 10km in eastern direction of the explored block.

5.2.3 There are no major Electric transmission lines in the block, however 132KV transmission line connecting Majhgawan is available along the NH 135BG.

5.2.4 Khajuraho airport serving Khajuraho is nearest airport, located at 125km in western direction from the explored block, Prayagraj Airport also known as Allahabad Airport serving Prayagraj, Uttar Pradesh is another airport located 168km in north eastern direction from the block.

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

5.3.1 The Jhari block is located in Majhgawan Tehsil of Satna district, Madhya Pradesh. Majhgawan is one of ten tehsils in the district and includes 193 villages and two towns—Chitrakoot and Majhgawan—making it largely rural. According to the 2011 Census, the tehsil had a population of 150,362, with 79,158 males and 71,204 females, resulting in a sex ratio of 900 females per 1,000 males, which is lower than the state average.

Census details of Jhari and Pindra villages population lying in close proximities of block is given below:

Village name	Male Population	Female Population	Sex Ratio (Female/Male)	Literacy Rate	Total Families	Scheduled Tribe Population
Jhari	708	654	924/1000	69.87%	285	223
Pindra	3370	3031	899/1000	58.63%	1461	2676

5.4.0 SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

5.4.1 The population in Majhgawan tehsil is centred on rainfed farming, agricultural labour, livestock, and seasonal migration, with only limited access to higher education, healthcare, and organized employment. Basic infrastructure like roads, electricity, and hand-pump for water exists, but gaps remain in sanitation, quality education, and health services, making the area socio-economically vulnerable and in need of targeted, community-sensitive development interventions.

5.4.2 Majority of the Population speaks Bagheli and Hindi.

5.4.3 The major occupation of the people of Satna district as well as Majhgawan tehsil people is agriculture, 50% of Majhgawan area is covered by forest and 50000 ha is under cultivation.

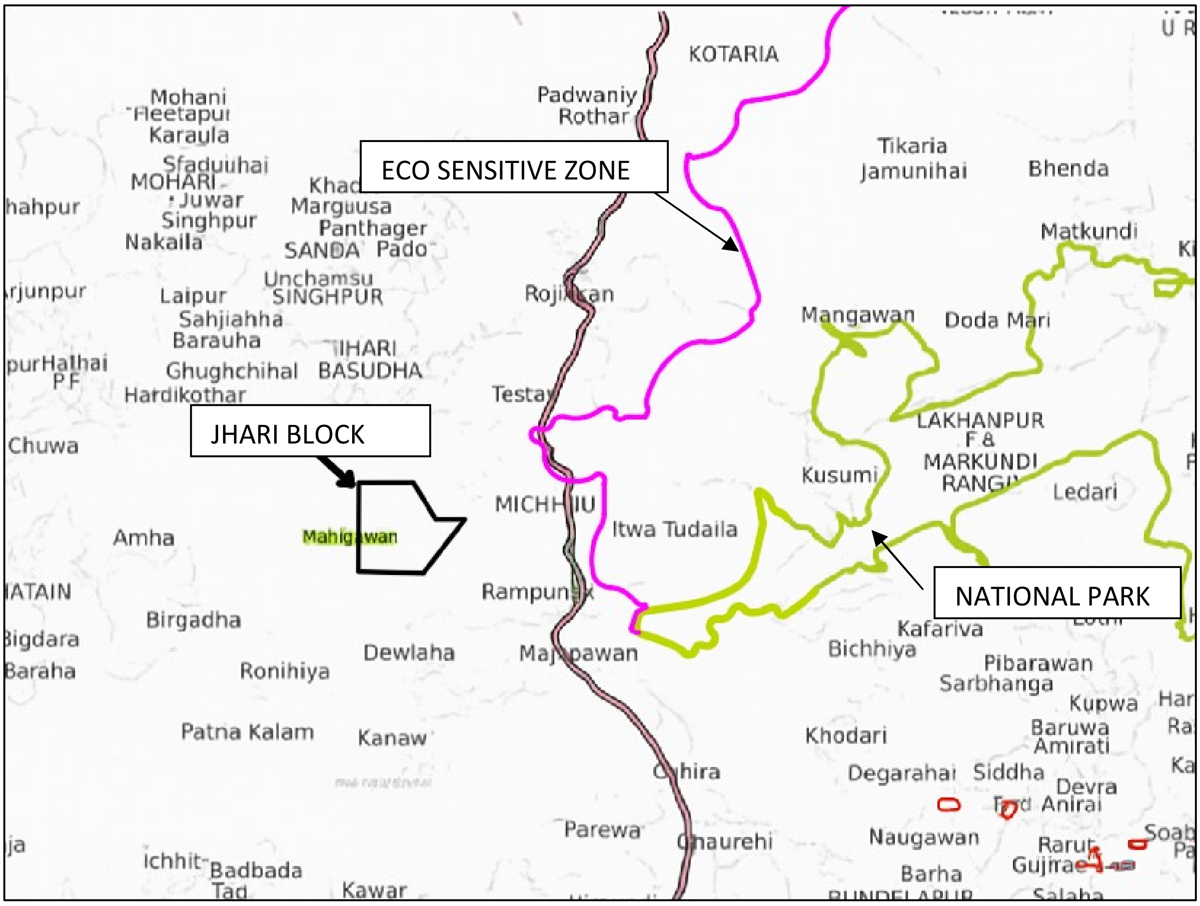
5.5.0 HISTORICAL SITES AND ARCHAEOLOGICAL MONUMENTS, PLACES OF WORSHIP, PUBLIC UTILITIES ETC.

5.5.1 Satna district has two major religious tourist places viz., Chitrakoot (~37km in northern direction from block) & Maihar (~74km in southern direction from block), along with an ancient city of Buddhist culture named 'Bharhut', whose archaeological remains have been gifted to the major museums in the country and the world. Tulsi museum at Ram Van has many unique artistic sculptures of ancient times found in this area. Lord Shiva Temple at Birsinghpur is also a famous and old temple in the region.

5.5.2 Public utilities around Majhgawan town and Satna city include essential civic infrastructure such as banks, hospitals, educational institutes, Aadhaar enrolment centers, local government offices, and water points often linked with temples or ashrams. These major utilities like electricity and roads serve the villages, while smaller community facilities such as village ponds, tanks, and meeting spaces play vital roles in daily life. These smaller utilities are often intertwined with local religious and cultural institutions, reflecting the community-centric nature of public services in the area.

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

5.6.1 95% of the Jhari block is situated in Parari Protected Forest. The southeastern boundary of the block shares the boundary of Madhopur Protected Forest range. There is no Eco Sensitive Zone in the block. Ranipur (Kaimur) Wildlife Sanctuary Area is the nearest Eco Sensitive Zone and Wildlife Sanctuary Area (Text Figure-5.1).



Text Figure-5.1 Map showing the status of nearby ESZ and National Park in the vicinity of the Jhari exploration block (Source – PM Gatishakti Portal)

5.7.0 FLORA AND FAUNA WITHIN AND NEARBY

5.7.1 The area surrounding Jhari block is rich in biodiversity, owing to its proximity to several protected forest areas and its location within the Satpura-Maikal bio-geographic region. The forests within and around Jhari are characterized by a mix of tropical dry deciduous and sal-dominated ecosystems. Common tree species include sal (Shorea robusta), teak (Tectona grandis), bamboo, tendu (Diospyros lotus), mahua (Madhuca longifolia), chironji (Buchanania lanzan), and kardhai (Anogeissus latifolia). These forests support a variety of medicinal plants, such as Aegle marmelos, Azadirachta indica, Withania somnifera, and Terminalia bellirica, which are utilized by local communities for traditional healing practices.

5.7.2 The district has rich forest resources. Fauna present in district are mainly herbivorous in dense forest with some carnivorous animals; some common fauna of this area are antelope, Nilgai, Gazelle, wild cats, fox, wolf, jackal, boar, stripped hyena, monkey, reptiles and birds like peacock, parrot, crows and doves.

5.8.0 CLIMATIC CONDITIONS

5.8.1 The climate of this district is tropical monsoon type. It is characterized by hot and dry summer from March to May, rainy season from July to October and winter from November to February.

5.8.2 The monsoon begins in first week of July and continues up to September-October and winter season starts from November and continues till middle to end of February in which December and January are the coolest months. The maximum and minimum temperature may go down to the coolest point on individual days in January and December. The maximum and minimum temperature for this district are 41.90°C (May) and 8.70°C (January), respectively. Mean annual temperature is 32.2°C and 19.00°C and annual rainfall received by Satna district is 1046.00mm.

5.9.0 OTHER PHYSIOGRAPHIC, SOCIAL AND ENVIRONMENTAL FACTOR

5.9.1 Satna district, a part of Rewa division is a district of Madhya Pradesh with its administrative headquarters located at Satna town. The district got its name from the river Satna which is flowing through the region. Satna district is under the Baghelkhand region and earlier, a huge portion of the place was under the rule of the Rewa.

5.9.2 Almost entire Satna district lies on the Vindhyan plateau, which extends from the Kaimur hill range in the south to the edge of the Ganga valley in the north. It is traversed by three prominent hill ranges from south-south west to north-north east and is occupied by a higher plateau in the south-western part of the district known as "Parasmania Pahar" which is part of Bhander series. Maximum elevation of the district is 704 m above mean sea level, which is recorded near "Papra Reserve Forest" on Kaimur hill range on southern part of the district. The southern and northern fringes of the district lie low in the respective valleys of the Son and the Yamuna rivers.

5.9.3 The economy of the district is mainly based on agriculture. The chief agricultural products in the district are paddy, maize, black gram, green gram, soyabean, pigeon pea, etc. The district is scantily industrialized but some small industries of handloom weaving, flour, oilseed milling, fabric products, etc., are available in the district. The district is well known for its dolomite and limestone deposits. Several cement plants are established in Satna.

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 The district comprises several culturally and historically significant centers that attract both national and international visitors. Among these, the Bharhut Stupa, an early Buddhist monument erected during the 3rd century BC and discovered by Sir Alexander Cunningham in 1873, represents an essential archaeological site of considerable heritage value. The Tulsi Archaeological Museum located at Ram Van houses an extensive collection of ancient artifacts and sculptures, contributing to the preservation of the region's cultural legacy. Chitrakoot Dham, a prominent pilgrimage site with strong Puranic associations, serves as a religious focal point, drawing a substantial number of devotees annually. In the vicinity of Jhari and Pindra villages, several smaller archaeological remnants, ancient shrines, and traditional cultural nodes reflect the continuity of rural settlement patterns and socio-cultural identity.

6.1.2 The district possesses an advanced educational framework anchored by Mahatma Gandhi Chitrakoot Gramoday Vishwavidyalaya (established in 1991), India's first rural university. Additionally, a number of institutions operate under the affiliation of Awdhesh Pratap Singh University, Rewa. Notable among these are Indira Gandhi Government Girls College, Government Polytechnic College, Shri Rama Krishna College, Rajiv Gandhi Computer College, Mahatma Gandhi College, Vindhya Institute of Technology and Science, and Sadguru Institute of Paramedical Sciences. Primary and secondary education facilities are available within adjacent settlements, ensuring basic educational access for the resident population.

6.1.3 Banking operations and financial institutions are available at Majhgawan Tehsil headquarters. Markets, repair workshops, and small-scale commercial establishments provide routine economic and logistic support to the surrounding villages. Medical infrastructure, including hospitals and primary health centers, along with modest hospitality services such as lodges and rest houses, are operational in Majhgawan.

Jhari and Pindra villages are interconnected by all-weather roads that facilitate movement of personnel and equipment between the villages and the nearest administrative centers. Basic civic amenities such as drinking water supply, electricity, and communication networks are functional but limited in capacity, consistent with rural standards within the region.

6.1.4 The host population primarily dependent on agriculture, forest produce collection, and ancillary occupations such as livestock rearing and wage-based labor. The environmental setting is defined by mixed deciduous forest cover interspersed with agricultural lands and seasonal streams. The region lies in proximity to designated forest reserves and wildlife habitats that contribute to maintaining ecological stability and biodiversity. These include state-managed sanctuaries and protected areas supporting a range of terrestrial and avian fauna. Comprehensive descriptions of population dynamics, ecological components, physiography, forest distribution, and environmental sensitivity zones are provided in Chapter-5 (Physiography and Environment) of this report.

CHAPTER-7

7.0.0 GEOLOGY OF THE AREA

7.1.0 REGIONAL GEOLOGY

7.1.1 Regionally, the lithological units exposed in the Satna district range in age from the Archaean to the Cainozoic. The Archaean sequence, represented by granites and gneisses, occurs only in the northwestern part of the district. The Vindhyan Supergroup, comprising the Semri, Kaimur, Rewa, and Bhander Groups, occupies a major part of the area. The Semri Group consists of alternating sandstone and shale horizons with intercalations of porcellanitic and limestone beds, mainly exposed in the southern and northern parts of the district. The Rohtas Limestone of the Semri Group is typically light to grey in colour, fine-grained, compact, and well-bedded. The Kaimur Group, predominantly composed of fine-grained, massive, and thickly bedded sandstone, is exposed in both northern and southern regions. The Rewa Group mainly consists of sandstone, shale, and conglomerate, and it is exposed chiefly in the northern part of the district.

7.1.2 Regional Stratigraphy of the Satna district is given in Table 7.1

Table 7.1 Regional Stratigraphic Sequence of lithology (After GSI, 1988)

AGE	SUPERGROUP/ GROUP / COMPLEX	FORMATION/ SERIES	LITHOLOGY
Recent to sub-recent			Alluvium
Proterozoic	Vindhyan Super Group	Rewa	Upper Rewa Sandstone Jhiri Shales Itwa Sandstone, Banbiha sandstone (Glauconitic sandstone) Panna Shales Diamondiferous Conglomerate beds
		Kaimur	Baghain Sandstone
	Unconformity		
	Vindhyan Super Group	Semri	Palkwan Shale Dolomitic limestone Pandwafall sandstone
		Semri Pandwa fall formation	Bansagar sandstone (Upper glauconitic sandstone) Kohari chert (dolomitic limitation chert and chert breccia) Kudwari sandstone (Lower glauconitic sandstone)
Unconformity			
Proterozoic	Bundelkhand Gneissic		Granite gneiss Granite

AGE	SUPERGROUP/ GROUP / COMPLEX	FORMATION/ SERIES	LITHOLOGY
	Complex		

7.1.3 **Bundelkhand Gneissic complex:**

7.1.3.1 Bundelkhand gneissic complex is represented by pink-coarse granite which are intruded with pegmatite and dolerite, these are exposed in north western part of the Satna dist. Coarse granite is rich in potash feldspar, often occurring as subhedral to euhedral phenocrysts; biotite as subordinate. Acid intrusions in some instances become aplitic. Basic and mafic dykes are common and younger than acidic veins.

7.1.4 **Vindhyan Super group**

The Vindhyan Basin is the largest Proterozoic intra-continental basin in central India that occupies an area of ca. 1,20,000 sq. km. and attains a huge thickness of ~ 4500-5000 m. In addition, about 80,000 sq km is overlain by the Deccan traps in the southern and south-western region and in the north about 10,000 sq.km is covered by the Gangetic alluvium (Mathur, 1986). The rocks are characteristically developed in the Son Valley and in parts of Rajasthan, Madhya Pradesh, Telangana and Andhra Pradesh.

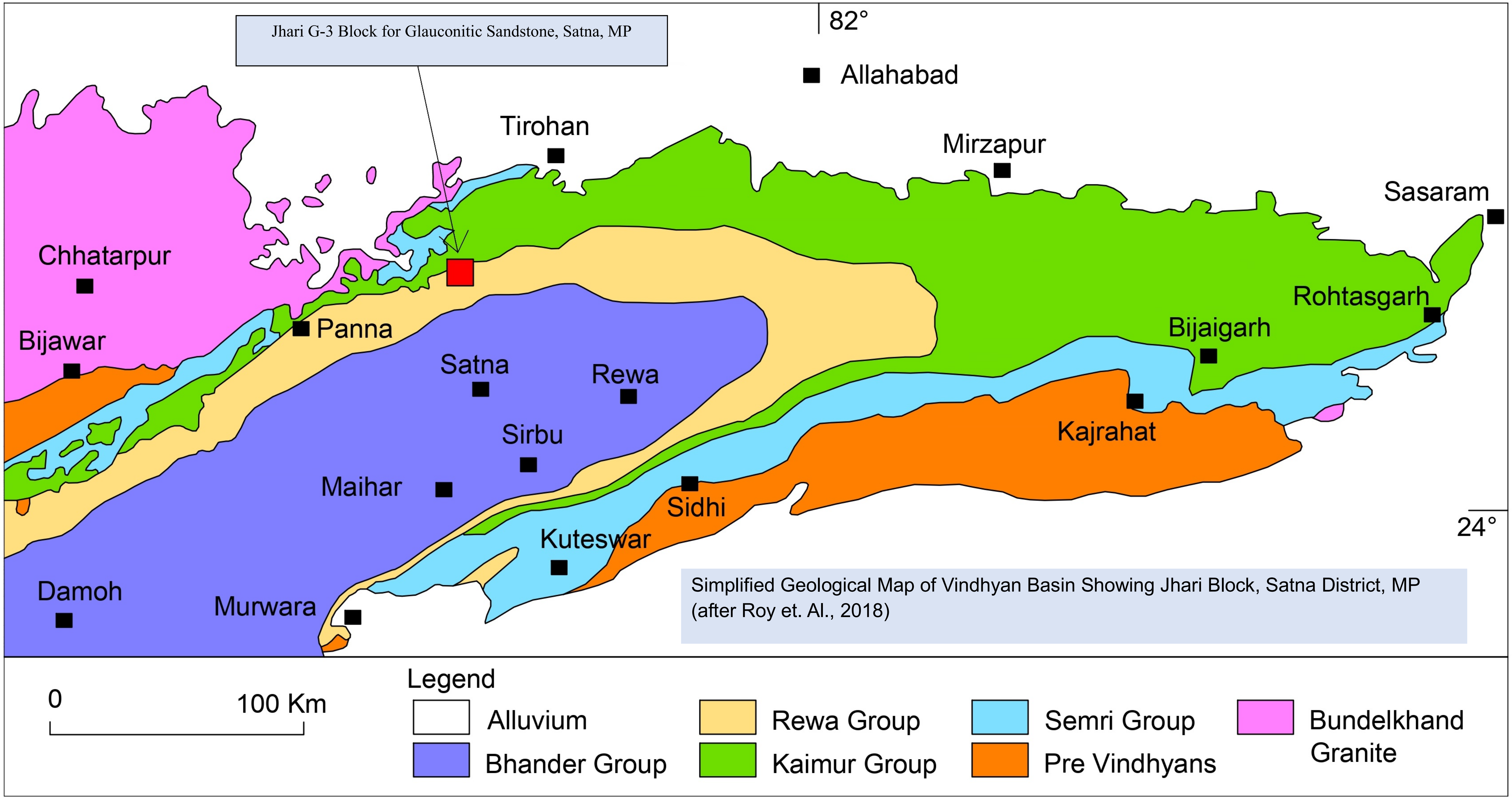
Vindhyan Super group is divided into upper and lower Vindhyan super group separated by unconformity Bhander, Rewa and Kaimur belong to upper Vindhyan and Semri series belongs to lower Vindhyan group.

7.1.4.1 **Rewa Group:** The name Rewa is derived from Rewa town in Madhya Pradesh in Central India. The Rewa Series occupies the middle position in the Upper Vindhyan. The rocks of the Rewa Series are exposed all along the synclinal exposure belt of the Vindhyan Supergroup in the Son Valley. This Series is composed of sandstone and shale. It contains kimberlite derived diamondiferous conglomerate (Bose et al., 2001). Sandstone and shale of this series have been subdivided into the Panna Shale, the Itwa Sandstone, the Jhiri Shale and the Gahadra Sandstone. The Panna Shale conformably overlies the Baghain Sandstone. It mainly comprises purple to olive green (khaki), thinly laminated flaggy shale with thin siltstone and fine sandstone. Itwa Sandstone conformably overlies the Panna Shale with a gradational contact. It forms a prominent stratigraphic division between the Panna Shale and the overlying Gahadra Sandstone. The Itwa Sandstone comprises Banbiha Sandstone (Glauconitic), Bhulwa Limestone, Pindra Shale and Rohania Sandstone members in order of superposition. The Jhiri Shale is purple, greenish grey, khaki and chocolate coloured, thinly laminated with wavy to lenticular bedding. Sedimentary structures such as halite casts, load casts, flute casts, bounce marks, small scale cross bedding and ripple marks are commonly exhibited by silty and sandy units. The Gahadara Sandstone comprises a thickly bedded, current bedded and massive sandstone succession. It is compact and pink, light reddish brown and purple coloured, medium to fine grained, rarely gritty. A conglomerate (oligomictic type), comprising pebbles, cobbles and even boulder size fragments of vein quartz and sandstone, has yielded diamonds in the Sakaria area.

7.1.4.2 **Kaimur Group:** It is named after Kaimur hills in M.P. There is well marked unconformity between Kaimur and Semri Series. This group attains a thickness of 400 m and is characterized by argillo-arenaceous rocks. The sequence begins with conglomerate (containing pebbles of Jasper) and shale which is succeeded by the Susnai breccias, upper Kaimur sandstone and quartzite, the Bijaigarh Shale, Upper Kaimur Sandstone, scarps of sandstone and conglomerate and finally Dhandraul quartzite. This is the only horizon which can be traced from the eastern to the western part of the Vindhyan Basin. Thus, it can be considered as marker horizon.

7.1.4.3 **Semri Group:** The Semri series is the oldest of the Vindhyan System and is best exposed in the Son Valley area, Central India where it unconformably overlies the phyllites of the Bijawar Series. Auden (1933) divided it into four stages as the Basal Stage, the Porcellanite Stage, the Kheinjua Stage and the Rohtas Stage. The thickness of this group is about 3694 m. Semri series is further divided into Bansagar sandstone which is marked as upper glauconitic sandstone which is underlain by Kohari chert i.e. dolomitic chert breccia which is underlain by Kudwari sandstone the lower glauconitic sandstone formation.

Text Figure 7.1: Regional Geological map showing the Jhari G-3 block



7.2.0 REGIONAL STRUCTURE

7.2.1 The Vindhyan sequence as a whole exhibit a mild southeasterly tilt, with a low dip of approximately 3°–5°, giving rise to the successive appearance of younger formations toward the southeast. Lithological contacts generally trend northeast–southeast, although the northeast–southwest trend may reflect either the original basin alignment or the orientation of the tilt axis. This gentle southeasterly dip is locally disturbed by minor deformations, resulting in variations in structure and thickness. Mild diastrophism has produced rare domes and low-plunging to non-plunging warps, which, due to their localized nature, do not significantly affect the overall map pattern. A consistent orientation of such warps—northwest–southeast and north-northeast–south-southwest—has been observed.

7.2.2 In several instances, bedding exhibits apparently moderate to steep dips due to the sliding of jointed blocks. Numerous sub-vertical joints, ranging from lengths observable in aerial photographs to as short as 20 meters, are present. Many nala and stream courses are controlled by these joints. These joint planes are non-penetrative and show variable trends, with northwest–southeast sets being the most prominent, followed by northeast-trending sets. Joint sets are particularly well-developed in the southwest and are less common in north–south and east–west directions. Notably, dykes and quartz veins in the Bundelkhand Granite generally trend northeast–southwest or northwest–southeast, mimicking the structural trends of the basement.

7.2.3 Localized sub-vertical faults have been observed at Gupt Godavari (northeast–southwest trend, northwestern block down-thrown), Pathra (east–west trend, northern block down-thrown), and east of Hanuman Dhara (east–west trend, northern block down-thrown). Additionally, the nala courses south and west of Jateri Baba are aligned along linear zones of disturbance, likely associated with these faults.

7.3.0 REGIONAL MINERALIZATION

7.3.1 Vindhyan rocks are rich in economic minerals like limestone, Glauconite, diamond, pyrite, dolomite and building stones etc. The Vindhyan basin, containing more than 5000 m thick sequence of sandstone, shale and limestone, occupies an area of about 1,62,000 sq.km of which about 80,000 Sq.km extends into the Ganga valley in the north and northeast beneath the Tertiary sediment of the Himalayan foredeep.

7.3.2 The Vindhyan Supergroup is noted primarily for its sediment-hosted diamond occurrences, with the Upper Vindhyan containing two significant diamond-bearing horizons, notably at Panna and the historic Golconda mines. The diamondiferous conglomerates are associated chiefly with the Rewa Group, where they manifest as oligomictic conglomerates containing vein quartz and sandstone clasts. Diamond extraction in these horizons has a long mining history in central India.

7.3.3 Sulphide mineralization, including pyrite, chalcopyrite, pyrrhotite, arsenopyrite, and specks of gold, is documented within the Middle Porcellanite Member of the Porcellanite Formation, Semri Group, particularly around the Amrora-Barwari-Kupa sectors in Garhwa district, Jharkhand. These sulphide occurrences are linked to faulting and shearing and are observed as disseminated grains and specks across zones up to 750 meters long and 300 meters wide. Petrographic studies reveal mineral inclusions of quartz, feldspar, plagioclase, perthite, sericite, calcite, and chlorite in these mineralized zones.

7.3.4 Limestone is a major economic mineral throughout the basin, especially in the Lower Vindhyan (Semri Group, Rohtas Limestone), and is exploited for various industrial uses including cement production. High-purity glass-making sandstone and ornamental stones are also widespread and actively quarried within the Vindhyan sequence, further contributing to the economic significance of these rocks.

7.3.5 Coal occurrences are reported in limited areas within the Vindhyan succession, though deposits are not extensive or of major commercial value. Pyrite has also been identified as an accessory mineral in certain horizons, but no significant metalliferous mineralization is noted in the basin. Vindhyan Supergroup is largely devoid of extensive base metal ore bodies or metallic mineral deposits.

7.3.6 Hydrocarbon potential is present due to favourable source rock conditions, with step faults and anticlinal structures creating possible traps, particularly in sandstone and limestone of both the Lower and Upper Vindhyan. Areas with structural highs such as the Jabera dome in the Son Valley and anticlines near Chittorgarh in the Chambal valley have been investigated for oil and gas, with ongoing exploration activity in such zones.

7.4.0 BLOCK GEOLOGY

7.4.1 The Jhari G-3 block forms a part of the Majhgawan–Paharikhera Potash Belt, situated in the northern part of Satna District, Madhya Pradesh. This belt represents one of the most significant sedimentary basins within the Vindhyan Supergroup, known for its potential for glauconite and associated potash mineralization. The Jhari block occupies the central portion of this belt and exhibits a well-preserved stratigraphic succession of the Rewa Group, providing valuable insights into the depositional history and basin evolution of the region.

7.4.2 Geologically, the area is occupied by rocks of the Rewa Group belonging to the Upper Vindhyan Supergroup, which unconformably overlie the Kaimur Group of the Lower Vindhyan. The lithostratigraphic nomenclature has been established through lateral correlation of the lithounits with the standard stratigraphic sequences mapped in adjoining areas such as Majhgawan, Paharikhera, Sohawal, and Chitrakoot. The Vindhyan Supergroup in this part of Satna district displays an extensive spread of sandstone–shale alternations, reflecting shallow marine to nearshore depositional conditions during the Proterozoic period.

7.4.3 The oldest formation exposed within the Jhari block is the Panna shale, oldest Formation of the Rewa Group. It consists of grey, fissile, and locally carbonaceous shale, occasionally containing thin interbeds of fine-grained sandstone. It is conformably overlain by Banbiha sandstone member of Itwa Sandstone formation.

7.4.4 The Panaa Shale overlies the Baghain Sandstone of the Kaimur Group, which exposed 3 km north of Jhari block, marking the transitional boundary between the Kaimur and Rewa Groups. The presence of these lithounits indicates a gradual shift from fluvial to marginal marine sedimentation.

7.4.5 Towards the upper part of the succession, Rohania sandstone member, represent the youngest exposed lithounit within the Jhari block which is the youngest member of Itwa Sandstone Formation. It is characterized by thin- to thick-bedded, white to dirty yellow, fine- to medium-grained sandstone, interbedded with thin shale layers in the lower part.

7.4.6 Overall, the lithostratigraphic succession of the Jhari block displays a complete and conformable sequence from the Itwa Sandstone Formation through Panna Shale Formation of Rewa Group, indicating a continuous phase of sedimentation under varying energy regimes. The glauconitic sandstone horizons, mainly within the Itwa Sandstone formations, form the principal mineralized zones of economic significance. These glauconitic units suggest slow sedimentation rates in a shallow marine shelf environment, conducive to the authigenic formation of glauconite.

7.4.7 Structurally, the area exhibits gentle dips (1°–2°) towards the southeast, with minor warping and jointing, typical of the Vindhyan sedimentary terrain. No major tectonic disturbances or metamorphism are observed, indicating a stable cratonic setting since deposition. The combination of favorable lithology, stratigraphic continuity, and minimal structural deformation renders the Jhari block highly prospective for systematic exploration and resource evaluation of glauconite and potash-bearing formations.

7.4.8 The local stratigraphic sequence of litho units exposed in the Jhari block area is given below:

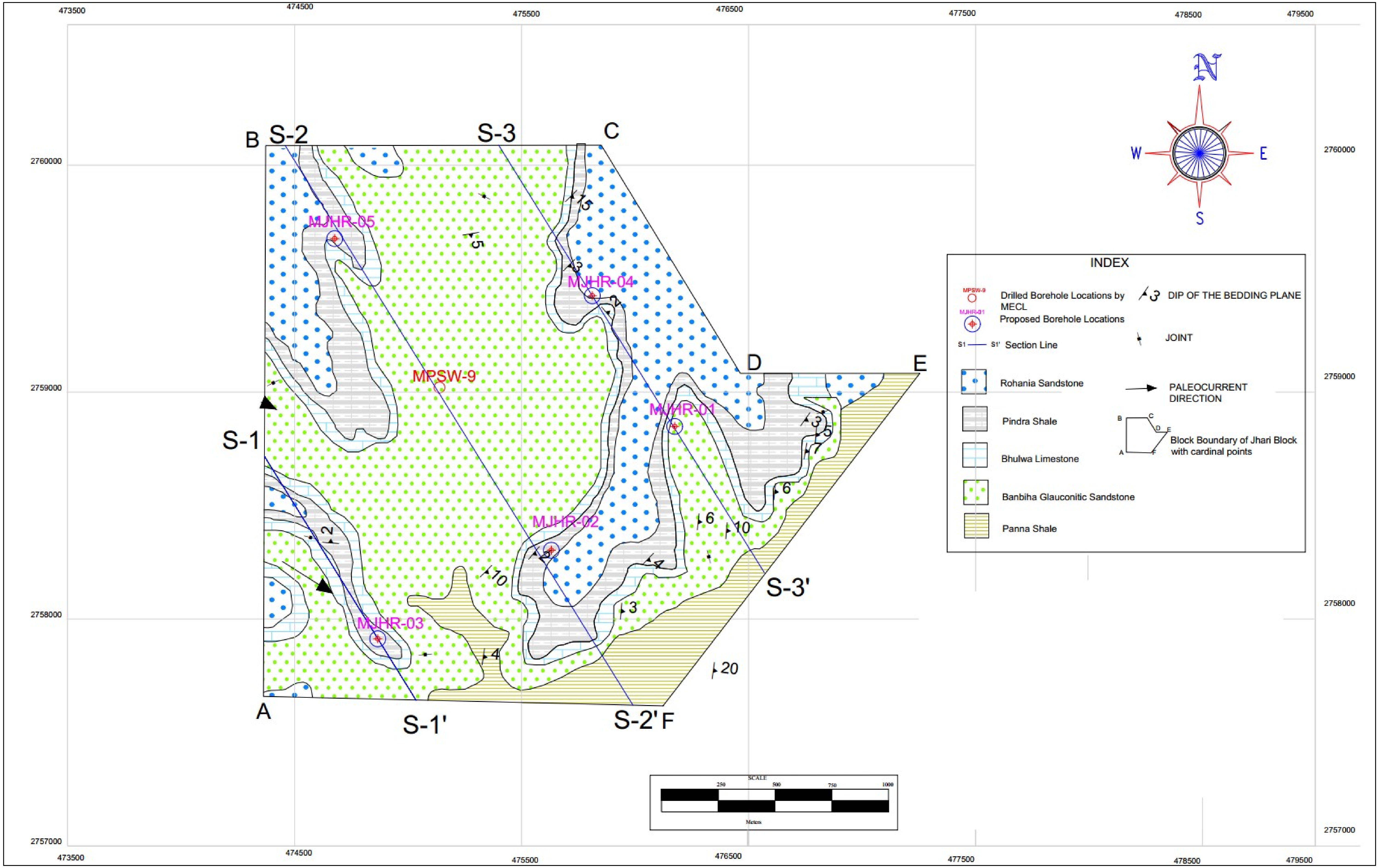
Table 7.2
Stratigraphic Sequence of Jhari Block, Dist: Satna, Madhya Pradesh (After,GSI)

AGE	SUPERGROUP/ GROUP / COMPLEX	SERIES	FORMATION	LITHOLOGY	
Recent to sub-recent			Alluvium/soil/laterite		
Proterozoic	Vindhyan Super Group	Rewa	Gahadara sandstone	Quartz arenite	
			Jhiri Shale	Upper shale	Green & Red shale
				Upper White sandstone	medium grained quartz arenite
				Middle Glauconitic sandstone	
				Lower White sandstone –	medium grained quartz arenite
				Lower shale	green and red shale with conglomerate
				Rohania sandstone	quartz arenite with granular conglomerate
			Itwa sandstone formation	Pindra Shale	green and red shale with limestone interband
				Bhulwa limestone	cream colour limestone with brown chert
				Banbiha Sandstone	glauconitic limestone
			Panna Shale	Shale with limestone interband	
		Kaimur	Baghain Sandstone	Medium to Coarse Sandstone, fine sandstone with siltstone and shale interbands. Medium to coarse sandstone, angular gravel bearing sandy conglomerate	

AGE	SUPERGROUP/ GROUP / COMPLEX	SERIES	FORMA-TION	LITHOLOGY
		Unconformity		
	Vindhyan Super Group	Semri		Palkwan Shale Dolomitic limestone Pandwafall sandstone
			Pandwa fall formation	Bansagar sandstone (Upper glauconitic sandstone) Kohari chert (dolomitic limitation chert and chert breccia) Kudwari sandstone (Lower glauconitic sandstone)
	Unconformity			
Proterozoic	Bundhelkhand Gneissic Complex			Granite gneiss Granite

7.4.9 The Geological plan is presented in Text fig. 7.2.

Text Figure.7.2 Surface Geological Plan of Jhari Block, Dist: Satna, Madhya Pradesh



7.5.0 DESCRIPTION OF ROCK TYPES PRESENT IN JHARI BLOCK:

7.5.1 **SOIL:** Most of the area within the block is covered by a layer of clayey to sandy soil, exhibiting brown to light brown coloration, which reflects varying degrees of oxidation and organic content. The average thickness of this soil horizon is about 2 meters, suggesting moderate soil development across the terrain. However, subsurface data obtained from boreholes reveal noticeable local variations in the thickness of this soil layer, ranging between 1.00 meters and 2.70 meters. Such variation may be attributed to differences in topography, degree of weathering, and sediment accumulation in low-lying or depressional areas. In gently sloping or elevated zones, the soil tends to be thinner due to erosional removal, whereas in flat or valley portions, the thickness increases as a result of depositional processes and accumulation of fine-grained materials.

7.5.2 LITHOLOGIES BELONGING TO REWA GROUP

7.5.2.1 The Rewa Group stratigraphically consists of four distinct formations arranged in ascending order—Panna Shale, Itwa Sandstone, Jhiri Shale, and Gabadra Sandstone Formations. Within the present block, rock types belonging to the middle and lower part of the Rewa Group viz. Itwa Sandstone and Panna Shale Formation are prominently exposed. The stratigraphic relationship among these units demonstrates a well-developed sequence of alternating arenaceous and argillaceous lithologies, indicative of repeated shifts between high-energy and low-energy depositional regimes, such as fluvial to shallow marine or deltaic environments.

7.5.2.2 Topographic and geological survey data further reveal that the Rohania Sandstone member, the youngest member of Itwa Sandstone Formation, occupies the highest elevations within the block, reaching a maximum reduced level (RL) of approximately 378.00 meters. In contrast, the Panna shale Formation is exposed at the lowest elevation, around 300.00 meters RL.

7.5.2.3 **ITWA FORMATION:** The Itwa Formation comprises a sequence of glauconitic sandstone, shale, limestone, chert, and quartz arenite horizons, displaying well-defined lithological variability and stratigraphic organization. Based on lithological characteristics and their order of superposition, the formation has been subdivided into four distinct members, each representing a specific phase of sedimentation and depositional environment within the stratigraphic succession.

7.5.2.3.1 **ROHANIA SANDSTONE MEMBER:** The Rohania Sandstone forms the uppermost unit of the Itwa Sandstone Formation and is composed of thin to thick-bedded, white to dirty yellow, fine to medium grained sandstone with intercalations of thin shale layers towards bottom (Fig. 7.1 & 7.2). This unit predominantly comprises well-sorted quartz arenite, showing moderate degree of compaction and containing sub-angular to sub-rounded quartz grains. Occasional ferruginous staining present along bedding planes, joints, and fractures. Regionally, the diamondiferous Itwa Conglomerate, an important horizon within the Panna Diamond Belt, is spatially associated with this sandstone; however, within the present block, the conglomeratic bed is absent. It has been intersected in two drilled boreholes viz. MJHR-04 and MJHR-05, the thickness varies between 1.35 and 2.30 meters with a depth range of 3.00 mt to 5.00 mt. On surface it is exposed along the NW-SE and NE-SW running highland region, resistant to erosion contributes to the prominence of these hilltops in the block.

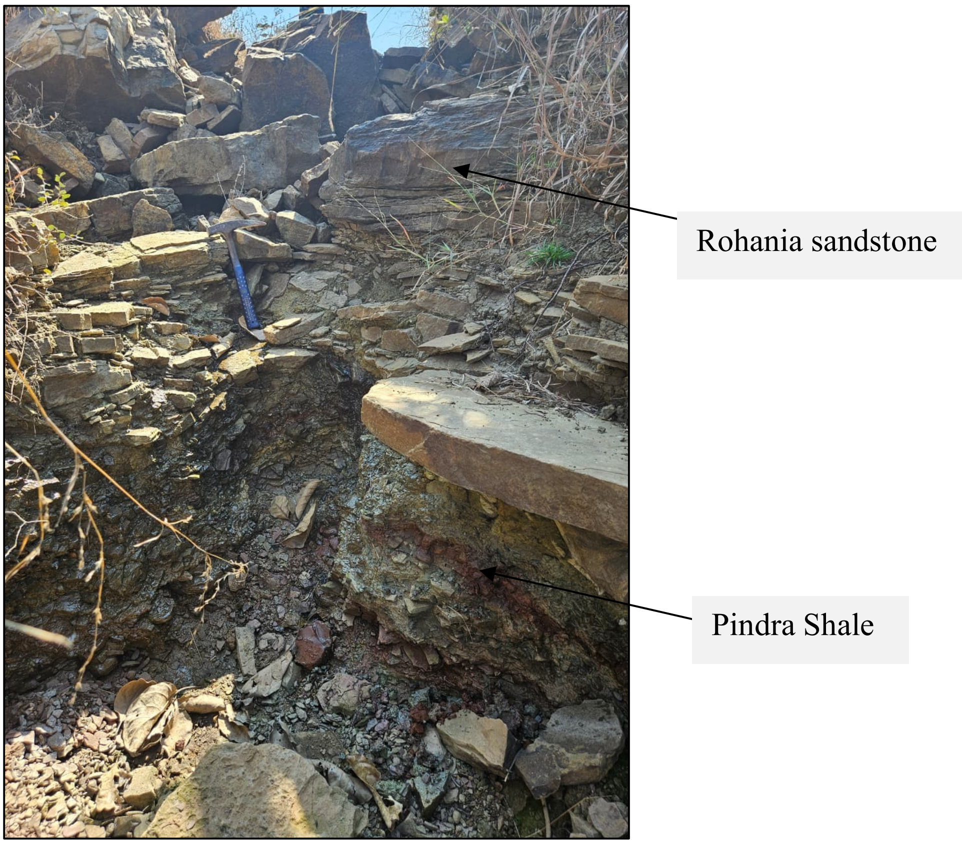


Fig.7.1: Surface exposure of Rohania Sandstone and Pindra Shale

MJHR-05 From 0.00m to 7.00m

Fig.7.2: Core photograph showing Rohania Sandstone in borehole MJHR-05

7.5.2.3.2 **PINDRA SHALE MEMBER:** The Pindra Shale Member represents a transitional facies between the underlying Bhulwa Limestone and the overlying Rohania Sandstone (Fig. 7.1). It consists of greenish, calcareous shale interbedded with thin layers of limestone, reflecting a gradual shift from carbonate to clastic sedimentation in its basal part. Upwards, the shale becomes non-calcareous and exhibits chocolate brown, pink, and grey coloured bands, with well-developed lamination and intercalations of fine sandstone beds (Fig. 7.3). This indicates progressive shallowing of the depositional environment. The member shows uniform lithological characteristics and consistent thickness in the block. On surface it is exposed along the escarpment following the similar trend of overlying Rohaina sandstone. It has been intersected in three boreholes viz. MJHR-02, MJHR-04 and MJHR-05, the thickness varies between 4.67 mt. to 14.03 mt. with a depth range of 5.67 mt. to 18.80 mt.

MJHR-05 From 7.00m to 14.00m

Fig.7.3: Core photograph showing Pindra shale, Borehole no. MJHR-05

7.5.2.3.3 **BHULWA LIMESTONE MEMBER:** The calcareous shale of Pindra shale overlies the grey and cream coloured, compact, fine grained limestone unit of the Bhulwa Limestone Member. Chert breccia or brecciated chert horizon reported at few places in the block. The lower chert breccia unit conformably overlies the Banbiha Sandstone. This chert layer gradually transits into a brecciated chert zone composed of angular fragments of chert and glauconitic sandstone, eventually giving rise to a massive chert bed in the upper part (Fig. 7.4). The chert horizon varies in thickness from 10 cm to 50 cm, displaying local pinching and swelling but maintaining good lateral persistence across the area. The overlying limestone is fine-grained, compact, and often shows disseminated pyrite stringers, suggesting mildly reducing depositional conditions. It exposed along the escarpment in the block with an average thickness of 2.00mt to 4.00 mt., overlying green coloured glauconitic sandstone of Banbiha sandstone member (Fig. 7.5). Thickness of this unit varies between 0.55 mt. to 2.33 mt. with a depth range of 3.00 m to 19.35 m in the drilled boreholes.

MJHR-04 From 17.70m to 20.50m

Photo.7.4: Core photograph showing Bhulwa Limestone and Banbiha Sandstone contact, Borehole-MJHR-04

7.5.2.3.4 **BANBIHA SANDSTONE MEMBER:** Banbiha Sandstone member is the lowermost member of the Itwa Sandstone Formation, conformably overlies the Panna Shale Formation, with a distinct lithological break. The sandstone is green to dark green in colour, fine to medium grained, and comprises thick cross-bedded units of glauconitic sandstone intercalated with quartz-rich sandstone and thin shale bands towards the lower part. The upper sequence is reddish-green due to intense ferruginous staining resulting from oxidation, while the lower portion is dominantly green to dark green. Mineralogically, the unit consists mainly of glauconite, quartz, feldspar, mica, and subordinate ferro-magnesian minerals. The cementing material is primarily glauconitic mud, although local variations with siliceous and ferruginous cement are also observed. Banbiha Sandstone is exposed across nearly half of the block, predominantly within the low-relief areas of the region. It has been intersected in all five drilled boreholes (Fig. 7.6) in the Jhari Block and in one previously drilled borehole of the Pindra South-West Block. The maximum thickness of 19.20 meters, with 6.12% K_2O, was recorded in borehole MJHR-05, while the minimum thickness of 10.50 meters with 5.47% K_2O was noted in MJHR-01. The average thickness calculated from 06 boreholes (5 from Jhari Block and 1 from Pindra South-West Block) is 15.72 meters with an average K_2O content of 6.01%. The deepest intersection of this unit was observed in borehole MJHR-05, from 19.30 m to 38.50 m depth, whereas the shallowest intersection occurred in borehole MJHR-01, between 2.50 m to 13.00 m.

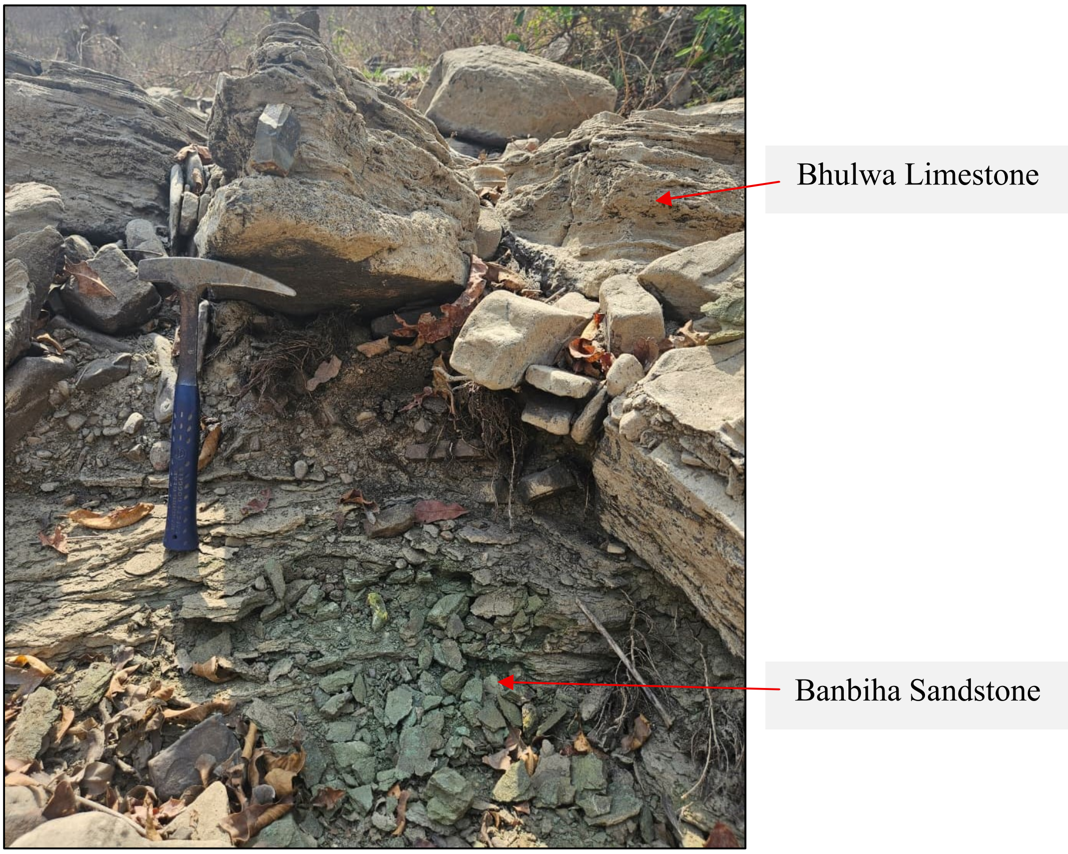


Fig.7.5: Surface exposure of Bhulwa Limestone and Banbiha Sandstone

MJHR-04 From 27.30 to 32.30m

Fig.7.6: Core photograph showing Glauconitic sandstone of Banbiha sandstone member in borehole -MJHR-04 (27.30 to 32.30m)

7.5.2.3.5 **PANNA SHALE FORMATION:** The Panna Shale Formation is represented by red, grey, and greyish-black argillaceous shale (Fig 7.8). The shale is thinly bedded to finely laminated, displaying rhythmic alternations that reflect quiet-water depositional conditions. In the upper part of the sequence, the shale becomes distinctly calcareous, comprising alternating beds of greyish calcareous shale and thin bluish-grey argillaceous limestone, indicating intermittent carbonate sedimentation. The formation exposed in the south-eastern part of the block where it forms a continuous band around the tablelands capped by the overlying Banbiha Sandstone (Fig.7.7). All exploratory boreholes were terminated after intersecting the Panna Shale Formation. Depth range varies from 20.00 m to 42.00 m with a maximum thickness of 4.50 meters in MJHR-02.

Fig.7.7: Surface exposure of Panna Shale

MJHR-04 From 36.70m to 41.30m

Banbiha Sandstone

Panna Shale

Photo.7.8: Core photograph showing of Banbiha sandstone member (36.70 m to 37.60 m) and Panna shale formation (37.60 m to 41.30 m) in borehole -MJHR-04

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

7.6.1 The rock units of the Majhgawan–Paharikheda Belt constitute a part of the northern limb of the Vindhyan Syncline. The regional strike trends predominantly NNE–SSW with minor local variations, while the bedding generally dips gently, ranging from nearly horizontal to about 1° towards the SSE. The drainage pattern, controlled by structure, shows nalas aligned along synformal troughs, where they have deeply incised into the comparatively softer Banbiha Sandstone Member in the central region of the block. Along the south-eastern boundary a segment of the Bandha Nala follows the axial region of a mild antiformal warp trending ENE–WSW.

7.6.2 Structural interpretation based on borehole data indicates that bedding within the block is almost flat, with minor local dips ranging between 1° and 2°, towards the south-east. Four prominent joint sets have been identified in and around the block, trending (i) ENE–WSW, (ii) NW–SE, (iii) NE–SW, and (iv) E–W. Within the present block, however, the joints are relatively minor, closely spaced, and show no significant structural displacement.

7.6.3 Various primary sedimentary structures such as parallel lamination, parallel bedding, ripple marks, cross-bedding, and clay galls have been observed within the block (Fig.7.9 a & b). The presence of ripple marks and cross-bedding suggests deposition under shallow-water conditions influenced by oscillatory and unidirectional currents. The occurrence of clay galls and mud pellets within the sandstone and shale horizons indicates intermittent subaerial exposure and reworking of semi-consolidated sediments, characteristic of a tidal mudflat or shallow marine depositional environment. These sedimentary features collectively suggest that the sediments were laid down in a near-shore to marginal marine setting with periodic fluctuations in energy and water depth.

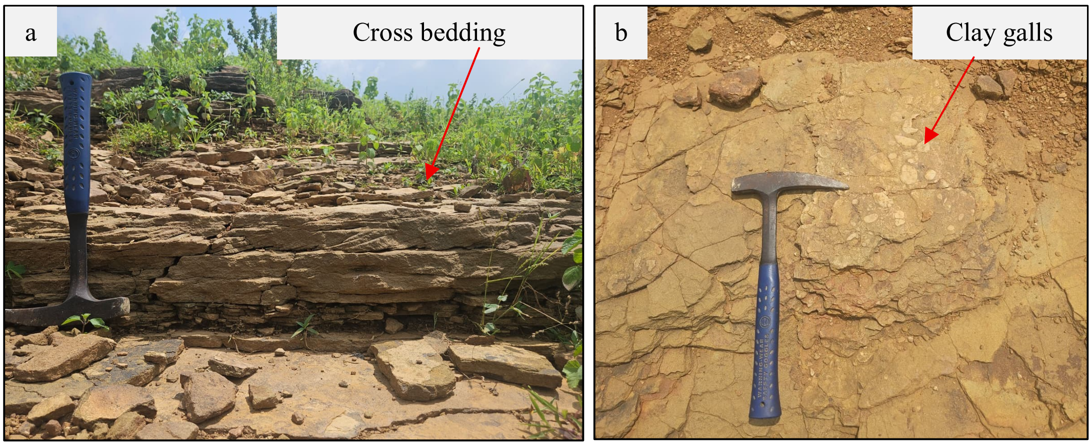


Fig.7.9 (a) and (b): Surface exposure showing cross beddings and clay gale in Banbiha Sandstone

7.7.0 GLAUCONITE MINERALIZATION

7.7.1 Glauconite mineralization predominantly occurs in marine sedimentary environments, particularly within glauconitic sandstone, shale, and marine limestone, reflecting authigenic formation processes under specific geochemical and depositional conditions.

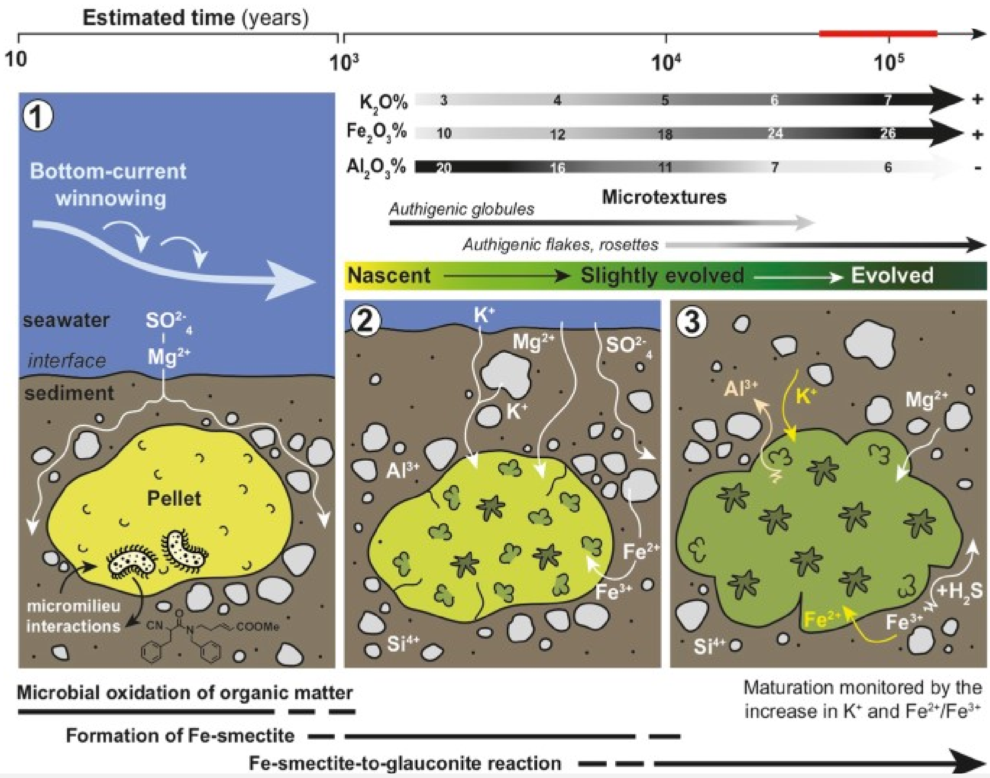
7.7.2 Globally, glauconite-bearing sediments are recognized as important stratigraphic markers of low sedimentation rate continental shelf marine settings, often associated with condensed sections formed during transgressive events.

7.7.3 Glauconite forms via anthogenesis through alteration of fecal pellets, detrital clays (illite and biotite), and direct precipitation from marine porewaters rich in iron and potassium. It is generally found in sands and silt-sized peloidal grains, occasionally replacing or infilling skeletal bioclasts (Text Fig 7.3).

7.7.4 Glauconite mineralization tends to occur in marine settings characterized by slow sediment accumulation, normal marine salinity and pH, and subtoxic to mildly reducing redox conditions often induced by organic matter decay within fecal pellet microenvironments.

7.7.5 Deposits of glauconitic sandstone can vary in thickness from a few meters to over 50 meters, typically forming laterally extensive, tabular horizons that may cover tens to hundreds of square kilometres in continental shelf environments.

7.7.6 Geochemically, glauconite is an iron-rich potassium phyllosilicate mica mineral with compositions varying in Fe and K content depending on maturity and diagenetic alteration. Higher potassium grades (up to 8-9% K_2O) reflect mature glauconite and are indicative of favourable depositional and diagenetic regimes.



Text Fig 7.3: Figure showing maturation stages in glauconite formation

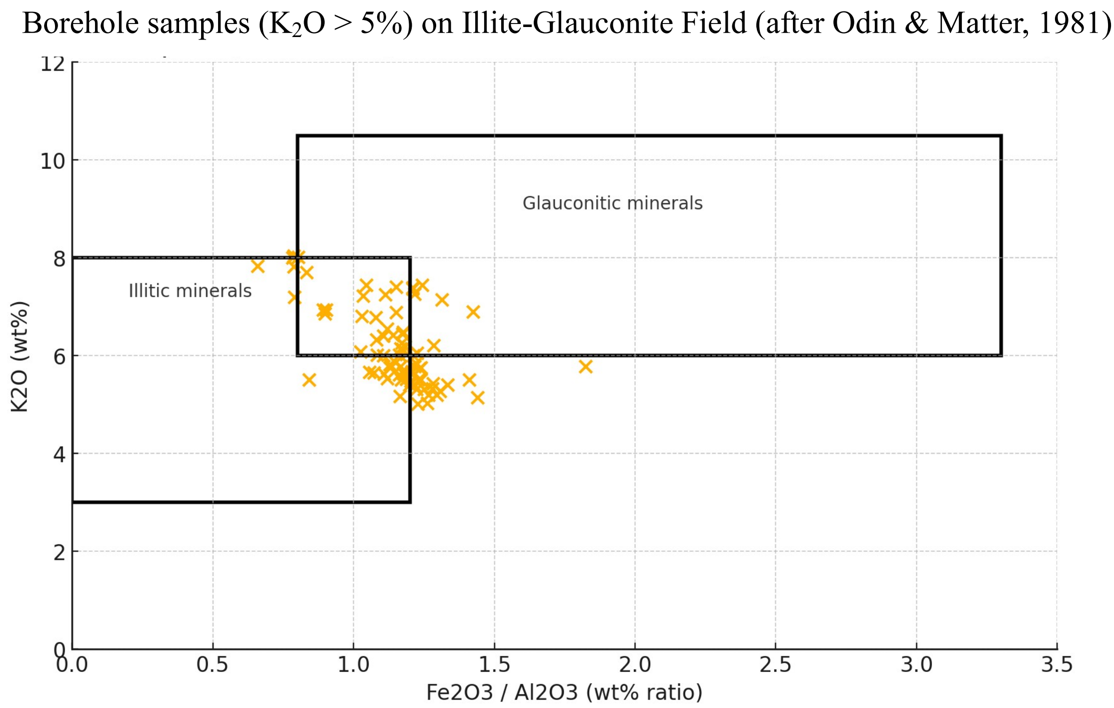
7.7.7 Glauconitic sandstone is generally greenish due to iron content, often displaying interbedded chert, shale, and limestone. Mineral assemblages include quartz, feldspar, muscovite, and ferromagnesian minerals, with glauconite acting both as clasts and cement.

7.7.8 Economic potential of glauconitic mineralization lies in its significant potassium content (K_2O ranging 4–9%), representing a non-traditional potash source in regions lacking evaporite deposits. Large-scale reserves such as those in the Vindhyan basin of India underscore its strategic importance.

7.8.0 GLAUCONITE MINEROLOGY IN THE BLOCK

7.8.1 The Banbiha Sandstone Member forms the principal glauconitic horizon in the block. The lower part of the sandstone contains alternating thin shale interbeds, whereas the upper part includes thin chert laminae and intercalations. These vertical variations signify a gradual shift in depositional environment from moderately reducing, glauconite-bearing marine settings to more oxygenated shallow-water conditions.

7.8.2 To differentiate detrital illitic clays from authigenic glauconite and to evaluate the maturity stage of glauconitic minerals within the present block, all samples exhibiting K_2O contents exceeding 5% were plotted on the Illite–Glauconite Composition Field Diagram (Text Fig 7.4) proposed by Odin and Matter (1981). In this plot, the K_2O content is indicative of the degree of interlayer potassium fixation, whereas the Fe_2O_3/Al_2O_3 ratio reflects the extent of iron substitution within the clay mineral lattice. Typically, illitic minerals occupy the field characterized by lower K_2O and Fe_2O_3/Al_2O_3 values, while glauconitic minerals plot within the domain of higher K_2O and moderate to high Fe_2O_3/Al_2O_3 ratios. Such compositional attributes are diagnostic of authigenic origin and represent progressive diagenetic maturation of glauconitic phases.



Text Fig 7.4: Cross Plot between K_2O and Fe_2O_3/Al_2O_3 from borehole samples

7.8.3 The illitic mineral field on this diagram is characterized by relatively low K_2O and low Fe_2O_3/Al_2O_3 ratios, representing detrital clays or early-stage glauconite precursors that have not undergone significant chemical reorganization. In contrast, the glauconitic mineral field is defined by higher K_2O and elevated Fe_2O_3/Al_2O_3

ratios, indicating authigenesis and progressive maturation under suitable diagenetic conditions. Movement from the illitic field toward the glauconitic field therefore represents increasing levels of K-enrichment and Fe-substitution, corresponding to the slightly evolved to well-evolved stages of glauconite formation.

7.8.4 The filtered dataset ($K_2O > 5$ %) plots predominantly within the glauconitic mineral domain, confirming the presence of true authigenic glauconite rather than detrital clay admixture. These compositions suggest formation under sub-oxic to reducing porewater conditions, associated with low sedimentation rates and prolonged residence time at the sediment-water interface. Overall, the geochemical signatures support a marine depositional environment with conditions favourable for glauconite maturation, consistent with condensed sections, transgressive shelf settings, or slow siliciclastic input.

7.9.0 EXTENT OF MINERALIZATION

7.9.1 Glauconitic sandstone of Banbiha Sandstone member extends over entire exploration area i.e. 5.1 sq.km, it is a bedded deposit with NE-SW strike and almost horizontal to gentle dip of 1-2 degrees towards south east.

CHAPTER-8

8.0.0 PREVIOUS WORK

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

8.1.1 The regional geological mapping of the Majhgawan-Jhari area was initially carried out by Sanyal and Chakraborty (1982), with adjoining areas mapped earlier by Rao (1980). Stratigraphic aspects of the glauconite-bearing horizons and associated rocks were discussed in these studies. Adjoining regions to the east, falling within Uttar Pradesh, were examined by Kedar Narayan (1960), Safaya (1963–66), Hukku (1971), and Srivastava et al. (1977). Later, Kalsotra and Sheo Prasad (1980), while drilling along the ASMARA lineament in the neighboring UP area, intersected glauconitic horizons and analyzed samples of glauconitic sandstone. Subsequently, the Geological Survey of India (GSI), Uttar Pradesh Circle, conducted detailed exploration of glauconitic sandstone in the region during 1980–82.

8.1.2 In 1987, GSI drilled a total of 23 boreholes in the Pindra North Block to calculate glauconite reserves. Additionally, two boreholes (GMP-22 & GMP-23) were drilled to study the regional distribution of glauconitic sandstone and its potash (K_2O) content. The total drilling depth of the 23 boreholes was 456.90 m. The glauconitic sandstone thickness varied between 10 m and 19.40 m, with an average thickness of 15.89 m. In boreholes where the upper portion of the sandstone was eroded, thickness ranged from 10 to 15 m. The upper 5 m of the sandstone is ferruginous and brown due to iron oxidation, whereas the lower portion is bluish-green and non-ferruginous. The sandstone also contains thin bands, laminae, and chert fragments in the upper part, with thin grey shale bands in the lower part. Quartz-rich sandstone bands, ranging from 2 cm to 14 cm, occur within the horizon and dilute the K_2O content.

8.1.3 Detailed exploration of approximately 12 sq. km in Pindra North Block has indicated proved category reserves of around 266 million tonnes of glauconitic sandstone with an average grade of 4.90% K_2O. A substantial portion of this horizon carries more than 5% K_2O, making it a significant potash resource in the region.

8.1.4 M/s Nagur Minerals Pvt. Ltd. conducted exploration in the Chitrakoot-2 prospecting lease block, including geological mapping, surface sampling, pitting/trenching, and drilling of 16 boreholes. These investigations estimated a proved mineable resource of approximately 50.46 million tonnes of glauconitic sandstone, highlighting the commercial potential of the deposit.

8.1.5 MECL carried out a reconnaissance survey in the Pindra South-West extension block during 2023-24, covering an area of 39.23 sq. km. A total of 10 exploratory boreholes were drilled on a 1600 × 1600 m grid, totaling 472 m in depth. The survey established an extensive horizon of glauconitic sandstone across the block, with an average width of 2.5 km. The glauconitic sandstone is underlain by younger sediments, and its average thickness is 24.65 m. Based on its thickness and areal extent, reconnaissance resources of approximately 1918 million tonnes with an average grade of 6.96% K_2O have been estimated, confirming the area's potential as a major potash resource.

8.1.6 Two blocks were carved out from above Pindra south west extension block i.e. Deulha and Jhari blocks.

8.1.7 MECL carried out exploration at G-3 stage in Deulha Block during 2024-26, covering an area of 8.5 sq.km. lying in the south direction of present Jhari block. A total 8 exploratory boreholes were drilled at 800 m interval, with 393 m of drilling in the glauconitic horizons of Jhari Shale and Banbiha sandstone. The average thickness of glauconitic sandstone varies between 22.00 to 24.00 m. in Banbiha Sandstone. A total of 317.04 million tonnes of net in-situ Inferred Resources (333 category) with an average grade of 6.80% K_2O have been estimated.

CHAPTER-9

9.0.0 AREAL OR GROUND GEOPHYSICAL OR GEO-CHEMICAL DATA

9.1.0 The present exploration has been carried out for Glauconitic sandstone etc. in Jhari G-3 stage block for which geophysical survey has not been carried out.

9.2.0 "Regional Geochemical Sampling of Stream sediment and soil in some selected blocks in Bundelkhand Granite Terrain, Panna Diamond Belt, Madhya Pradesh.", (Field season 1985-86, 1986-87, 1987-88 & 1988-89) was carried out by GSI which covers the present exploration block.

CHAPTER-10

10.0.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 INTRODUCTION

10.1.1 The Preliminary exploration for Glauconitic sandstone in Jhari block (G-3 stage), Satna, Madhya Pradesh was recommended in 63th TCC held on 22nd, 26th, 27th March, 2024 and was subsequently approved in 35th EC held on 17.05.2024.

10.1.2 The Jhari block, covering an area of about 5.1 sq. km, is situated in Majhgawan tehsil of Satna district, Madhya Pradesh, and is represented in Survey of India Toposheet No. 63D/9 and 63D/13. The area lies within the Vindhyan Basin, which is regionally significant for its diverse lithological units and mineral occurrences. The block is well connected by approach roads and lies in proximity to Majhgawan railway station, ensuring accessibility for exploration activities and logistical support.

10.1.3 The present investigation was carried out to evaluate the potentiality of glauconitic sandstone within the block. Considering the strategic importance of glauconite in agriculture and industry, the exploration programme was designed to delineate glauconite-bearing horizons through geological mapping, exploratory drilling, core logging, sampling, and laboratory studies. This stage of investigation provides baseline data for resource estimation and helps establish the economic significance of glauconitic sandstone in the Jhari block, forming the basis for future exploration and development.

10.1.4 **OBJECTIVES OF INVESTIGATION**

The exploration Programme in Jhari G-3 block has been formulated to fulfil the following objectives:

a. To carry out Geological & structural mapping on 1:4,000 scale for demarcation of glauconitic sandstone with the structural features to identify the surface manifestations and lateral and vertical disposition of the mineralized zones.

b. To conduct a topographical survey at 2 m contour interval on 1:4,000 scale.

c. To establish the depth continuity of glauconitic sandstone formations within the block.

d. To estimate the mineral resources (333 category) and determine the grade (K_2O content) of glauconite as per the guidelines of the UNFC and MEMC Rules, 2015 (amended up to 2021).

10.1.5 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 Jhari block area, Dist. Satna, Madhya Pradesh

Sl. No	Description of Work	Unit	Approved quantum	Achieved quantum
I	**Geological mapping (updating of map at 1:4000 scale)**	Ha	510	510
2	Topographical Survey BH co-ordinates	Ha Nos	510 05	510 05
II	**Exploratory Drilling**	M	250	160
III	**Laboratory Studies**			
	Primary and Check samples			
1	Primary sample analysis for 4 radicals K_2O, SiO_2, Al_2O_3 & Fe_2O_3	Nos	125	101
2	External Check Samples (10% of Primary) analysis for 4 radicals K_2O, SiO_2, Al_2O_3 & Fe_2O_3	Nos	13	13
IV	**Physical studies**			
1	Bulk Density determination	Nos	04	04
V	**Geological Report preparation**	**Nos.**	**1**	**1**

10.2.0 DETAILS OF EXPLORATION ACTIVITIES TAKEN UP

10.2.1 LARGE SCALE GEOLOGICAL MAPPING:

10.2.1.1 Large-scale geological map of the parent Pindra South West Block was already available on 1:12,500 scale covering an area of 39.23 sq. km which serves as a comprehensive regional base map. Since the Jhari block forms an integral part of this larger mapped area, the existing geological framework has been utilized and further refined for the present study. Lithological boundaries, structural elements, and stratigraphic contacts were critically examined in the field. The map was updated on 1:4,000 scale to capture local-scale variations with greater accuracy and precision. This updated mapping ensures that the geological representation of the

Jhari block reflects the most recent field observations and structural interpretations, providing a reliable basis for subsequent exploration and resource evaluation.

10.2.1.2 Major lithological units such as, Rohania Sandstone, Pindra Shale, Bhulwa Limestone, Banbiha Sandstone member and Panna Shale Formation were carefully identified and mapped. Lithological boundaries and contacts were established with the aid of a handheld GPS and topographical survey, ensuring spatial precision in plotting. Structural data, including attitude of bedding planes and joint orientations, were recorded using a Brunton Compass to understand the overall structural disposition of the area. The general strike of the litho-units is observed to be NE–SW to ENE–WSW, with sub-horizontal dips (1°-2°) towards the southeast. All field data and observations were systematically compiled and represented in the geological map, which forms the basis for subsequent subsurface correlation and interpretation.

10.2.2 Surface / Bedrock sampling: No surface samples were taken owing to the previous exploration in the present area.

10.2.3 EXPLORATORY DRILLING:

10.2.3.1 During the present exploration program, drilling was planned by placing 05 nos. of boreholes in 800 x 800 m grid interval, 03 nos. of NW-SE trending section lines placed 800m apart, to check the extent, depth and calculation of resources.

10.2.3.2 Exploratory core drilling for G-3 level of exploration commenced on 27th June 2025 and concluded on 15th August 2025, thus completing meterage of 160.00 m in 05 number of boreholes (MJHR-01 to MJHR-05). The coordinates and reduced levels (RLs) of all boreholes were determined using DGPS in the WGS-84 Datum. The borehole locations along with section lines over the block's geological map are presented in PLATE-IV.

10.2.3.3 One borehole (MPSW-09) drilled in previous phase (Pindra South-West G-4 Block) are considered for correlation and resource evaluation of Glauconite horizon of Jhari block.

10.2.3.4 Details of boreholes drilled in Jhari block (2025-26) and previously drilled boreholes in Pindra South West block (2023-24) with total depth are summarized below and submitted as Annexure No. IIA and IIB respectively.

Table- 10.2
Details of Boreholes in Jhari G-3 block for glauconitic sandstone, District-Satna, Madhya Pradesh

Sl.No.	BH.No.	RL (m)	Northing (m)	Easting (m)	Date of Commencement	Date of Closure	Total Depth(m)
1	MJHR-01	323.559	2758861.904	476174.536	27.06.2025	30.06.2025	20
2	MJHR-02	334.870	2758316.045	475630.970	30.06.2025	05.07.2025	31
3	MJHR-03	334.021	2757925.839	474866.255	06.07.2025	09.07.2025	25
4	MJHR-04	356.324	2759438.056	475811.439	24.07.2025	01.08.2025	42
5	MJHR-05	366.071	2759689.726	474676.471	06.08.2025	15.08.2025	42

Table- 10.3
Details of Boreholes in Pindra South West Block (G-4) for glauconitic sandstone, District-Satna, Madhya Pradesh

Sl.No.	BH.No.	RL (m)	Northing (m)	Easting (m)	Date of Commencement	Date of Closure	Total Depth(m)
1	MPSW-09	338.834	2759042.570	475149.309	08.10.2023	12.10.2023	29.00

10.3.0 Data spacing for reporting of exploration results:

10.3.1 The boreholes were spaced at 800m interval approximately which is sufficient to establish glauconitic sandstone resources at G-3 stage (preliminary exploration) as per the exploration norms of Minerals (Evidence of Mineral Content) Rule-2015, The estimated resources in the block area may be placed under Inferred Mineral Resource (333) category as per UNFC code.

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 DA 2 Catalyst (Annexure-IB). The photograph of instrument is given in Photo-11.1.

Photo-11.1: DGPS survey in the block using DGPS DA 2 Catalyst System)

11.1.2 The SOI base station was utilized 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 was **V740 (SOI BASE)**. The coordinates of the SOI base station are provided below.

Table-11.1
Coordinates of the SOI CORS Base Point for DGPS Survey of Jhari Block (Glauconitic Sandstone), District Satna, Madhya Pradesh

Base Station	Latitude	Longitude	Easting (m)	Northing (m)	RL (m)
(SOI BASE)	N24°57'08.32800"	E80°44'56.90800"	474676.088	2759690.875	427.554

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**

After completion of the field survey work, raw data was downloaded from the GNSS Rover. The data was subsequently processed using the CORS-based subscription service provided by SOI, which falls under region 1. A point list was then generated in the form of a summary along with a report. The baseline processing results are also enclosed with this report.

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 In the drill core sampling, representative borehole samples were systematically collected from glauconite-bearing zones encountered in the boreholes. To maintain the integrity of the samples, all visibly weathered and altered surfaces were avoided in sampling, ensuring that only fresh, unaltered portions of the cores were considered. Sampling was carried out by cutting the core in two equal halves using core splitter, out of which one half was sampled and another half was stored. Each sample weighed approximately 1.0–1.5 kg and was immediately placed in clean, high-quality cotton bags, which were securely tied and appropriately labelled to maintain proper sample identification and traceability.

12.1.2 Strict adherence to standard operating procedures (SOPs) was maintained to ensure data reliability and analytical accuracy. Glauconite-bearing rock samples were initially reduced in size using a sample crusher, followed by fine grinding in a pulveriser and further homogenization with a mortar and pestle until a uniform powder of -200 mesh size was obtained. After processing each sample, all equipment including the crusher, pulveriser, mortar, pestle, sample trays, brushes, and associated tools was thoroughly cleaned to prevent cross-contamination.

12.1.3 Representative portions of approximately 100 g were obtained through successive reduction by the coning and quartering method. In this procedure, the bulk powdered sample was poured onto a clean, flat surface to form a conical heap, which was then flattened and divided into four equal quadrants. Two diagonally opposite quadrants were retained for further processing, while the others were discarded. This process was repeated until the desired sample weight was achieved, ensuring statistical representativity of the final sample. Approximately 300 g of prepared sample was then divided into three equal packets of 100 g each—one for primary analysis, one for check analysis, and one for laboratory reference. The surplus powdered sample was securely stored in sealed, labelled containers under controlled conditions to prevent mixing or degradation. All tools and accessories used during sampling, reduction, and packaging were thoroughly cleaned between samples to eliminate any risk of cross-contamination.

Photo-12.1 Photograph showing sample crusher used in sample processing

Photo-12.2: Photograph showing pulveriser used in sample processing

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

12.2.0 PRIMARY AND CHECK SAMPLE STUDIES

12.2.1 A total of 101 nos. of borehole samples were generated and analysed for K_2O, SiO_2, Al_2O_3, and Fe_2O_3 at Chemical Laboratory of MECL, Nagpur. Total 13 nos. of external check samples were prepared and analysed at Jawaharlal Nehru Aluminium Research Development and Design Centre, (JNARDDC) Nagpur (A NABL accredited Laboratory. The details of analysis are given in Annexure-IV, and Annexure-VI respectively.

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 05 no of boreholes with 160.00m and carried out other associated geological and analytical work. The details of boreholes drilled by MECL are given in Annexure-IA and summary of borehole is given in Table-10.2 at page no. 50.

13.1.2 Core drilling was carried out by two conventional wire line drill rigs viz. RD-100 (MEC-354) & RD-100 (MEC-355). All the boreholes in the block were drilled in NQ size with single barrel / wire line, wet core drilling method. Diamond impregnated NQ bit (outer diameter 75.7 mm and inner diameter 47.6 mm) and TC bit had been used during drilling operation. At the initial depths, all the boreholes have been used with HW and NW casing to control falling of soil cover and loose friable weathered formation. The polymer was used as drilling fluid to flush out the cuttings and stabilize the borehole wall. The drilling fluid also works as a coolant to avoid burning of drill bits. All the precautions had been taken to maintain quality of drilling and to achieve maximum core recovery. The core recovery varies from minimum 87.62% (MJHR-01) and maximum 92.08% (MJHR-05) with an average core recovery is about 89.52%.

13.1.3 The recovery in the mineralized zone is about 94.79% which is satisfactory. 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 Owning to the bedded nature of the deposit, drilling was drilling was planned vertically by placing 05 nos. of boreholes in 800 x 800 m grid interval

13.2.2 Details of boreholes drilled by MECL in Jhari block 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 in the block are vertical with depth ranging from 20.00m to 42.00m. There is no necessity for carrying out deviation for these vertical and shallow depth boreholes. Hence, no deviation survey has been done 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 have been logged in detail, viz., lithology, grain size, colour, nature and type of mineralisation along with structural details viz. foliation, fracture, fracture fillings and rock quality designation. Major lithology intersected in the boreholes is shale, sandy shale, sandstone, limestone and glauconitic sandstone.

13.4.2 The detailed run wise litholog and summarized litholog for 05 boreholes drilled by MECL in Jhari block and 01 boreholes in Pindra South West block are given in Annexure- III A, IIIB and Annexure- III C respectively.

13.4.3 Core recovery in glauconitic sandstone zones is 94.79% which is satisfactory. Samples were marked based on glauconitic sandstone zone based on visual basis, in general, the sample length has been kept at 1.00 m interval which varied in some instances because of variation in lithology and type and concentration of mineralization.

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

13.5.1 The short runs were drilled as per necessity so that optimum core recovery is maintained. Whenever core recovery is less, the grade of the recovered portion has been extrapolated over the non-recovered section. The quality of drilling was ensured during the operation.

13.6.0 ROCK QUALITY DESIGNATION (RQD)

13.6.1 Rock Quality Designation (RQD) is a modified measure of the degree of jointing and the fracture in a rock mass, measured as a percentage of drill core in lengths if 10cm or more. High quality rock has RQD more than 75%, Low quality rock has RQD of less than 50%. D.U. Deere in 1963 define the RQD as the ratio of the sum of the total length of the core pieces of length 10cm and length recovered from drilling of one run (3.0 m) drilling.

13.6.2 The Rock Quality Designation (RQD) has been calculated using the standard formula:

RQD (%) = (Total length of the core in pieces of 10cm or more) / Length of the run) X100

13.6.3 During detailed geological core logging, RQD values were measured for the entire length of the core column, including the mineralized zones. The run-wise RQD data have been systematically recorded and incorporated into the corresponding lithological logs, providing a comprehensive assessment of rock mass quality across different litho-units.

13.6.4 The average RQD of all boreholes is less than 50% owing to fissile nature of shaly horizon, however in the glauconitic sandstone zone the RQD is 57.56%, hence all the formation falls in Low quality rock category.

13.7.0 BOREHOLE CORE SAMPLING

13.7.1 A total 101 no of primary samples are generated from borehole core obtained after drilling by MECL. Samples were marked considering variation of glauconitic sandstone zone as well as lithology. In general, the sample length has been kept at 1.00 m interval which varied in some instances because of variation in lithology and type and concentration of mineralization. Hence, the overall sample length is varying with minimum 0.50 m to maximum 1.00 m.

13.7.2 Sample as demarcated during core logging by geologist, based on visual basis. Sample has been prepared by splitting of core into two equal halves by using core splitter identical half is crushed to 100mesh and remaining half split core is stored in core box for future reference. The crushed 100mesh sample was further grounded to fine powder and was passed through -200 mesh size sieve. Powdered material was mixed thoroughly and about 100 grams of samples taken for chemical analysis by successive coning and quartering as primary samples and rest of the material (-200 mesh size) kept as duplicate half for future reference.

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 carried out for the entire mineralized zones or lengths intersected in the drilled boreholes. Sampling was conducted systematically to ensure complete and representative coverage of glauconite-bearing horizons. Each sample was precisely marked on the core, with depth intervals clearly indicated before extraction. Special emphasis was given to glauconite-bearing sandstone and associated shale units, covering both high-grade and marginal zones to evaluate vertical and lateral grade variations. This ensured that all significant lithological variations within the mineralized sequence were represented in the analytical dataset.

14.1.2 The mineralized core was split into two equal halves using a core splitter (Photo 14.1), ensuring uniform ore mineral distribution in both portions. One half was crushed to (-) 200 mesh, and a ~500 g representative sample was obtained by the coning and quartering method using a crusher and pulveriser (Photos 12.2 and 12.3). From this, two 100 g samples were prepared, one sent to MECL Chemical Laboratory, Nagpur, for primary chemical analysis (K_2O, SiO_2, Al_2O_3, Fe_2O_3) and the other retained for check analysis. The remaining 300 g was preserved for future studies.

14.1.3 During the present exploration, a total of 101 primary borehole (BH) core samples were prepared for chemical analysis. The primary BH core samples were analysed for K_2O, SiO_2, Al_2O_3, and Fe_2O_3 at the Chemical Laboratory of MECL, Nagpur, following standard analytical procedures.

14.1.4 To ensure analytical accuracy and reproducibility, a set of 13 external check samples were analysed at the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), Nagpur, a NABL-accredited laboratory. The comparative analysis of these check samples provided an independent verification of the primary laboratory results, thereby strengthening the reliability of the dataset.

Photo-14.1: Photograph showing core splitter used to split borehole core

14.2.0 NATURE, QUALITY AND APPROPRIATENESS OF THE SAMPLE PREPARATION TECHNIQUE

14.2.1 The sampling procedure for primary samples is described in detail in Para 14.1.0. To maintain the quality and integrity of the samples, strict QA/QC protocols were followed during preparation. All equipment used for crushing, sieving, and splitting was thoroughly cleaned before and after processing each sample to prevent contamination. Regular maintenance of the equipment was carried out to ensure consistent performance.

14.2.2 Samples were reduced to the required size fraction using proper crushing and sieving techniques, followed by the coning-and-quartering method to obtain representative splits. These operations were performed by trained and experienced personnel, ensuring that the prepared samples were homogeneous and free from bias. The adherence to proper technique and procedural discipline throughout the preparation process ensured that the samples remained representative of the in-situ material, thereby enhancing the reliability of subsequent analytical results.

14.3.0 QUALITY CONTROL PROCEDURES ADOPTED

14.3.1 The primary core samples were collected from the entire mineralised zones or lengths intersected in the drilled boreholes and subsequently prepared at the centralised mechanised sampling unit. Standardised sampling procedures, in accordance with established protocols, were followed under the direct supervision of qualified sampling technicians to ensure the quality and representativeness of the samples. Similarly, the external check samples were prepared at the same facility, also under the supervision of qualified sampling technicians, adhering strictly to the standard sampling procedures to maintain consistency and reliability in the analytical dataset.

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

14.4.1 All primary samples were marked and prepared from mineralised cores. During sample preparation, the cores were examined in detail, and sampling intervals were accurately marked to ensure proper representation of the mineralised zones. The preparation of primary samples followed the procedure outlined in Para 14.1.0, ensuring uniformity and quality control. The combination of precise core marking and adherence to standard preparation protocols ensured that the collected primary samples were truly representative of the in-situ material.

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

14.5.1 For the determination of K_2O, SiO_2, Al_2O_3, and Fe_2O_3 by X-ray fluorescence (XRF) analysis, the core samples were first reduced to a particle size of (–)200 mesh to ensure homogeneity and reproducibility of results. The fine pulverisation to this size facilitates uniform mixing of mineral constituents, minimises analytical errors caused by particle-size variation, and enhances the precision of XRF measurement. The prepared powder was thoroughly homogenised before being used for pellet or fused bead preparation, as per standard analytical protocols, to obtain accurate and representative elemental concentrations.

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 Preliminary exploration (G-3 stage) for glauconitic sandstone in the Jhari Block, Satna District, Madhya Pradesh, included comprehensive laboratory analyses covering borehole samples. These samples were analyzed for K_2O, SiO_2, Al_2O_3, and Fe_2O_3 using wavelength dispersive X-ray fluorescence (WD-XRF). Detailed descriptions of the analytical methods adopted are provided in the subsequent paragraphs.

15.2.0 ANALYSIS OF GLAUCONITE BEARING SAMPLES BY XRF

15.2.1 **WD XRF (Wavelength Dispersive X-ray Fluorescence)**

Wavelength Dispersive X-ray Fluorescence (WD-XRF) is a non-destructive analytical technique employed for the determination of major oxides in glauconitic samples. In the present study, WD-XRF was used to analyzed four key oxides K_2O, SiO_2, Al_2O_3, and Fe_2O_3; utilising a RIGAKU make ZSX Primus IV XRF instrument. This method offers high precision and accuracy for elemental quantification while preserving the integrity of the original sample.

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 pelletized 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 analyzed for K_2O, SiO_2, 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 The third-party sample analyses were conducted at the Jawaharlal Nehru Aluminum Research Development and Design Centre (JNARDDC), Nagpur a NABL accredited laboratory.

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

15.4.1 The security and chain of custody for samples from the field unit to the sampling unit and subsequently to the chemical laboratory were maintained through a meticulous and well-organized process. All samples were prepared at the centralized mechanized sampling unit under the supervision of qualified sampling technicians. Each sample was carefully labelled and tagged prior to dispatch, and transported to the chemical laboratory in securely sealed bags. The integrity of the seals was verified at the sampling unit before opening.

15.4.2 Standard operating procedures and robust precautionary measures were strictly followed to prevent any possibility of contamination, ensuring the reliability of analytical results. The sampling unit operates independently from the chemical laboratory, eliminating the risk of cross-contamination. Remaining sample portions were properly preserved, labelled, and stored for future reference, ensuring a secure and traceable chain of custody under the company's control.

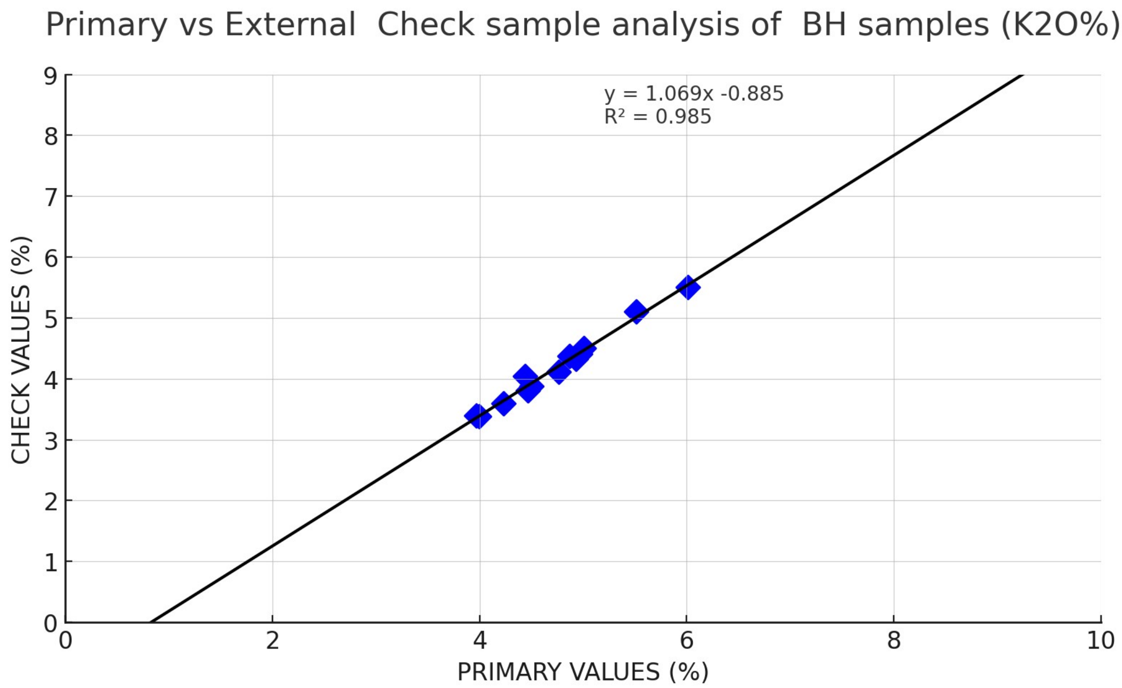
15.5.0 NATURE OF QUALITY CONTROL PROCEDURES ADOPTED

15.5.1 In order to ensure the accuracy of the analyzed samples, NCSDC-16006 has been used as certified reference material. The Certified Reference Material (CRM) was processed under similar conditions as samples and run after every 20 samples.

15.5.2 A total of 13 nos. of external check BH samples analyses has been carried out at chemical laboratory of JNARDDC, Nagpur. Comparison of primary and external check borehole sample results are furnished as Annexure-VI

15.5.3 **STATISTICS OF CHECK SAMPLE**

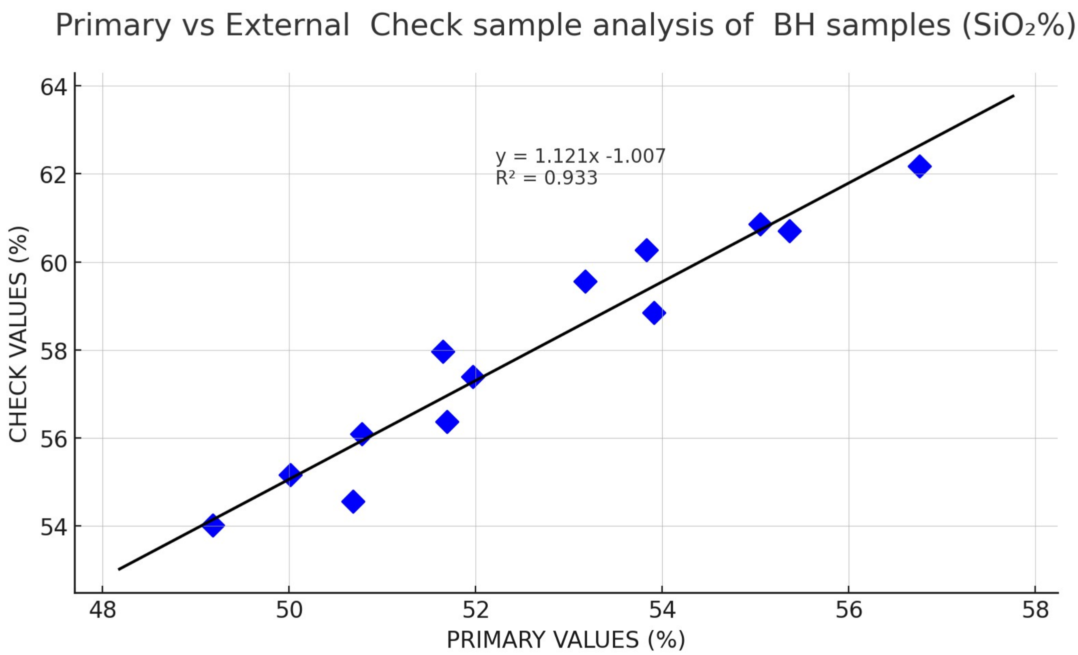
15.5.3.1 The statistical analysis of primary and external check analysis data has been carried out on K_2O, SiO_2, Al_2O_3 and Fe_2O_3. It has been observed from the correlation coefficient which is the measure of strength of a linear relationship between two data set. The correlation coefficient for K_2O is 0.993. This indicates that the Primary and Check assays are co-relatable with each other. Further the Scatter plot of the primary Vs check assay in respect of four radicals (Text Fig No 15.1 to 15.5) shows scatter of values are closely following the bisector. The arithmetic mean of the primary and check data set are close to each other. Thus, it can be opined that the chemical analysis of the samples shows the repeatability and reliability of the analysis and also prove that the homogeneity of the samples.



Text Fig. 15.1: Scatter Plot of Primary Vs External Check samples for K_2O

Table no 15.1
COMPARISON OF PRIMARY Vs. EXTERNAL CHECK ANALYSIS

Comparison Index	Total Fixed K_2O%	
	Primary	Check
No. of sample pairs	13	13
Arithmetic mean	4.744	4.188
Standard Deviation	0.579	0.623
Standard error of mean	0.161	0.173
Variance	0.335	0.389
Mean of deviation	0.556	
Standard Deviation (Error)	0.086	
Correlation Co-efficient	0.993	
Mean absolute error	0.556	
Mean relative random error (%)	11.729	
Paired T-value	23.37	
F-test value	1.161	

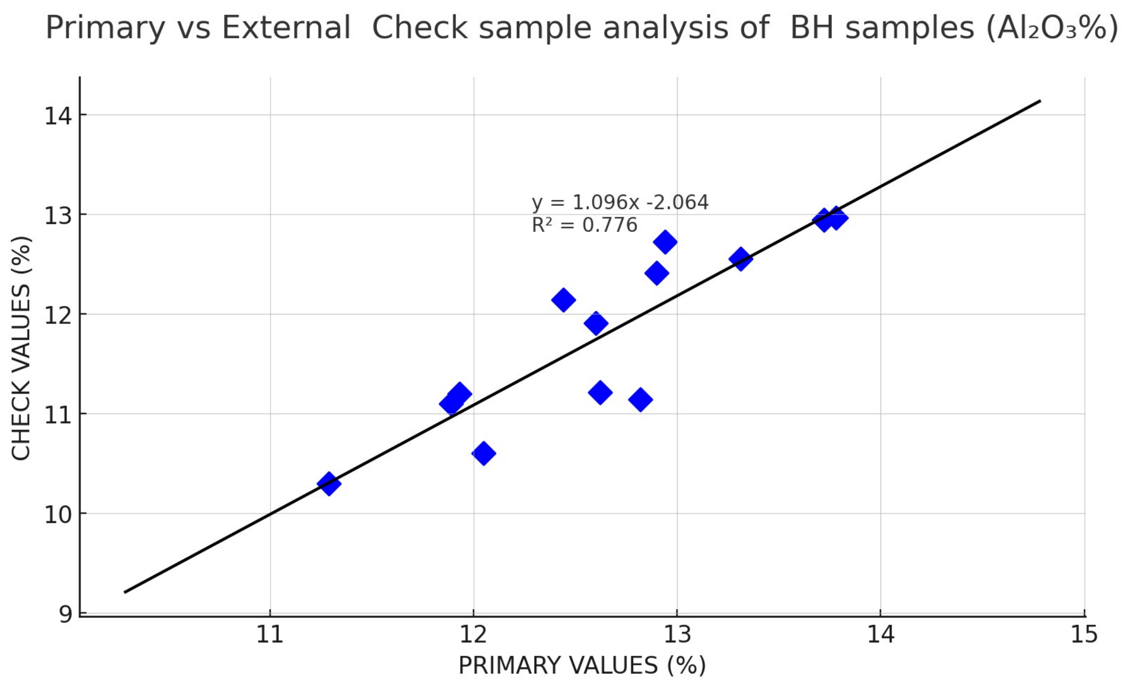


Text Fig. 15.2: Scatter Plot of Primary Vs External Check samples for SiO_2

Table no 15.2

COMPARISON OF PRIMARY Vs. EXTERNAL CHECK ANALYSIS

Comparison Index	Total Fixed SiO_2%	
	Primary	Check
No. of sample pairs	13	13
Arithmetic mean	52.6185	52.6185
Standard Deviation	2.27	2.64
Standard error of mean	0.63	0.73
Variance	5.17	6.96
Mean of deviation	-5.38	
Standard Deviation (Error)	0.74	
Correlation Co-efficient	0.96	
Mean absolute error	5.38	
Mean relative random error (%)	10.23	
Paired T-value	-26.40	
F-test value	1.35	

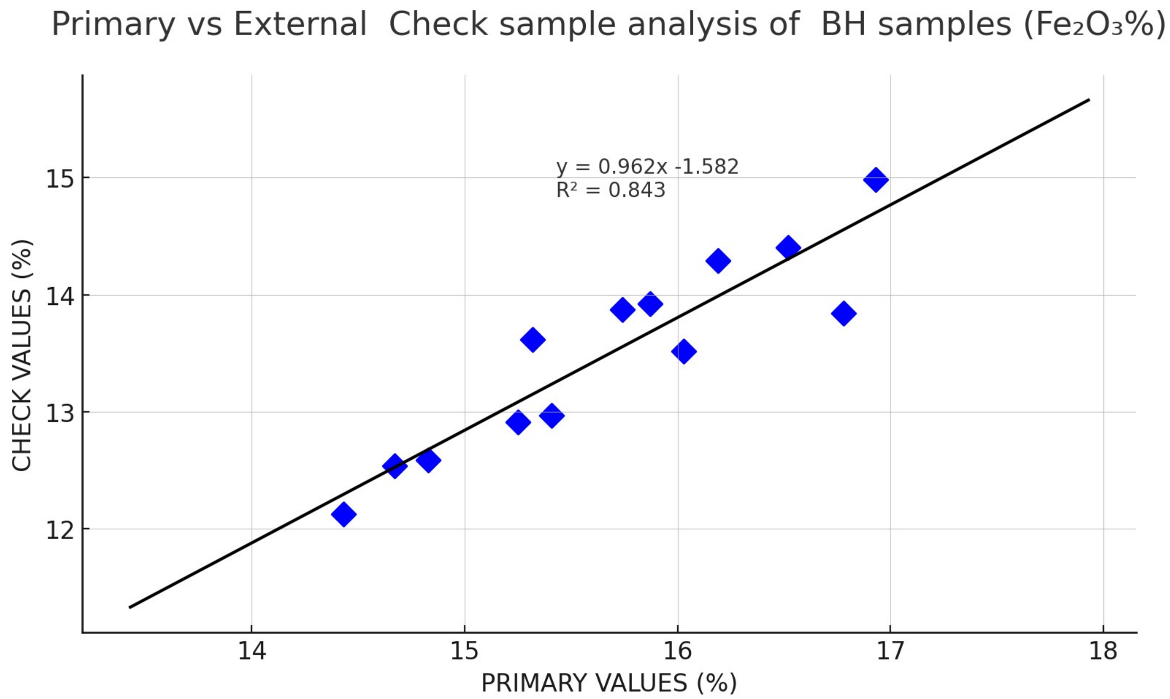


Text Fig. 15.3: Scatter Plot of Primary Vs External Check samples for Al_2O_3

Table no 15.3

COMPARISON OF PRIMARY Vs. EXTERNAL CHECK ANALYSIS

Comparison Index	Total Fixed Al_2O_3%	
	Primary	Check
No. of sample pairs	13	13
Arithmetic mean	12.48	11.87
Standard Deviation	0.708	0.914
Standard error of mean	0.1964	0.2536
Variance	0.5014	0.8354
Mean of deviation	0.6062	
Standard Deviation (Error)	0.7279	
Correlation Co-efficient	0.8809	
Mean absolute error	0.6285	
Mean relative random error (%)	5.0350	
Paired T-value	3.0231	
F-test value	1.6667	



Text Fig. 15.4: Scatter Plot of Primary Vs External Check samples for Fe_2O_3

Table no 15.4
COMPARISON OF PRIMARY Vs. EXTERNAL CHECK ANALYSIS

Comparison Index	Total Fixed Fe_2O_3%	
	Primary	Check
No. of sample pairs	13	13
Arithmetic mean	15.69	13.5062
Standard Deviation	0.7954	0.8328
Standard error of mean	0.2206	0.2310
Variance	0.6326	0.6936
Mean of deviation	2.1838	
Standard Deviation (Error)	0.3309	
Correlation Co-efficient	0.9184	
Mean absolute error	2.1838	
Mean relative random error (%)	13.9187	
Paired T-value	23.7923	
F-test value	1.0964	

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) is a critical parameter, along with volume, for accurately estimating the tonnage of mineral resources and reserves. It depends on both the density of individual particles and their spatial arrangement within the ore body. Bulk density is defined as the ratio of the mass of a material to its volume, including the contribution of inter-particulate void spaces. It is commonly expressed in grams per cubic centimetre (g/cm^3) or tonnes per cubic meter (T/m^3).

17.2.0 BULK DENSITY DETERMINATION PROCEDURE

17.2.1 A total of four core samples were selected and subjected to bulk density determination to assess the physical characteristics of the glauconitic sandstone. The objective of this study was to obtain accurate bulk density values, which are essential for resource estimation The detailed procedure adopted for bulk density measurement is 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) centimetres - 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 of the sample. The volume of a core sample is obtained by using formulae: $V = \pi r^2 h$ (where V = volume, r = radius and h = height or length of the cylindrical core). The bulk density of the sample is determined by using the formula: 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 glauconitic mineralization for Jhari (G-3 stage) block, Satna, Madhya Pradesh

Sl. No.	Sample no.	Borehole no.	From (m)	To (m)	Bulk Density (gm/cm^3)
1	MJHR/BD01	MJHR-01	9.89	10.00	2.62
2	MJHR/BD02	MJHR-03	17.87	18.00	2.58
3	MJHR/BD03	MJHR-04	32.50	32.60	2.67
4	MJHR/BD04	MJHR-05	29.87	30.00	2.62
				Average Bulk Density	**2.62**

CHAPTER-18

18.0.0 BENEFICIATION STUDIES

18.1.0 In the present exploration beneficiation study has not been carried out.

CHAPTER-19

19.0.0 RESOURCE ESTIMATION TECHNIQUE

19.1.0 GENERAL

19.1.1 MECL carried out a Preliminary Exploration (G-3 stage) in the Jhari block for glauconitic sandstone. The exploration programme comprised detailed geological mapping on a 1:4,000 scale, Topographical survey with contouring at 2m interval and drilling through 05 vertical boreholes at 800m x 800m spacing. Through this integrated approach, MECL thoroughly evaluated the exploration block, delineated zones of glauconite mineralization, and subsequently estimated the Inferred Resources under UNFC Category 333.

19.1.2 In these boreholes, the glauconite zone (demarcated at >5% K_2O cutoff) is intersected in Banbiha Sandstone at depth ranging from 2.50 m depth in MJHR-01 to 19.35 m depth in MJHR-04 and thickness varies between 10.50 m (MJHR-01, K2O -5.47%) to 19.20 m (MJHR-05, K2O -6.12%).

19.1.3 Apart from that, one borehole (MPSW-09) drilled during exploration in Pindra SW Extension G-4 block was also taken into consideration while estimating the resource of Jhari G-3 Block.

19.1.4 All these 06 boreholes are plotted on 3 Section lines (S1–S1′ to S3–S3′) which are aligned at N30°W-S30°E.

19.1.5 Geological cross-sections were prepared based on the interpretation of sub-surface borehole data, incorporating both the grade of mineralization and integrated surface-subsurface geological information. Applying a cut-off grade of 5% K_2O, mineralized zones ranging in thickness from 10.50 m to 19.20 m were delineated and plotted on the geological cross-sections.

19.1.6 Zone data of the mineralized zone from Jhari block and Pindra South West block taken into consideration has been given below:

Table 19.1.

Table showing mineralized zone and average grade for boreholes drilled in Jhari G-3 block, Satna, Madhya Pradesh

Sl. No.	BH. No.	Section line	From (m)	To (m)	Thickness (m)	K_2O %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %
1	MJHR-01	S3–S3′	2.50	13.00	10.50	5.47	47.53	13.48	17.02
2	MJHR-02	S2–S2′	8.00	24.00	16.00	6.34	49.21	13.73	15.42
3	MJHR-03	S1–S1′	3.00	18.00	15.00	6.49	48.98	13.90	15.84
4	MJHR-04	S3–S3′	19.35	35.00	15.65	6.27	49.95	13.38	14.99
5	MJHR-05	S2–S2′	19.30	38.50	19.20	6.12	50.96	13.22	15.14

Table 19.2.
Table showing mineralized zone and average grade for boreholes drilled during Pindra SW extension block falling in Jhari G-3 block, Satna, Madhya Pradesh

Sl. No.	BH. No.	Section line	From (m)	To (m)	Thickness (m)	K_2O%	SiO_2%	Al_2O_3%	Fe_2O_3%
1	MPSW-09	S2–S2′	8.00	26.00	18.00	5.63	47.52	13.44	13.67

19.2.0 PARAMETER AND ASSUMPTIONS FOR RESOURCE ESTIMATION

19.2.1 The resource is estimated by Cross-sectional method as principal method and the Polygonal as check method. While applying these techniques, certain axiomatic assumptions were inherently considered to determine the overall grade and resource potential of the deposit. These assumptions, which form the basis of the estimation process, are outlined below:

19.2.2 A total of 101 nos. of primary core samples and 1 no borehole data of Pindra SW extension block have been considered for evaluation of glauconitic zones

19.2.3 The zones of K_2O have been demarcated from the values of primary sample analysis, Cut-off grade of 5% K_2O is considered (as per IBM) for estimating the resources and delineation of mineralized zone. The minimum thickness of 1.00m of K_2O zone has been considered for resource calculation in both methods.

19.2.4 All the boreholes were placed at 800m strike interval, Hence, strike influence for all the sections has been considered up to the midpoint (half of the distance) of the next section on correlation and along the down dip and up dip, 400m has been considered from the mineralization intersection.

19.2.5 A total of four borehole core samples from the K_2O rich horizon were analyzed to determine bulk density. The measured values are considered representative of the K_2O rich mineralization in the area, thereby enhancing the accuracy of resource estimation and providing a reliable basis for tonnage calculations. The average bulk density has been computed as 2.62 g/cm³.

19.2.6 A deduction of 20% from gross in-situ resources has been made to arrive at net-in-situ resources by geological cross-section and, polygon method for unseen geological factors i.e. nature of cavities/caverns and other structural features.

19.3.0 METHODOLOGY ADOPTED FOR CROSS SECTIONAL METHOD (PRINCIPAL) FOR RESOURCE ESTIMATION

19.3.1 Following methodology has been adopted while computation of glauconite resource by Geological Cross-Section Method.

19.3.2 A total of 03 Nos. Geological Cross Sections serially numbered as S1-S1′ to S3-S3′ and were drawn perpendicular to general strike of the mineralized zones spaced at 800m interval.

19.3.3 Geological Map along with topographical survey data and boreholes header data has been considered for preparation of profiles, the vertical boreholes has been plotted along the profile with the help of GDM software.

19.3.4 The cross-sections have been prepared and correlated on the profile by marking the surface and subsurface geological data i.e., litho-units intersected in the borehole and its attitude i.e., foliation angle etc., mineralization zone along with nomenclature, thickness and qualitative data and the borehole data (lithology, nomenclature, thickness and analytical data of glauconite).

19.3.5 The Glauconite zone has been projected to 400m from intersection towards down dip or up dip direction as the case may be where the adjacent borehole has no mineralization. For the borehole with continuous mineralization in adjacent boreholes, half way influence has been considered. Accordingly, the sectional area has been calculated.

19.3.6 In general, boreholes spaced at approximately 800 m strike interval. Hence, strike influence for all the sections has been considered up to the midpoint (half of the distance) of the next section.

19.3.7 The measurements have been made with the help of computer aided Auto- CAD Map 2025 software.

19.3.8 The sectional area obtained has been multiplied by cross sectional influence (strike influence) to obtain the sectional volume.

19.3.9 The sectional volume has been multiplied by the average bulk density (2.62) to arrive at the resource tonnage.

19.3.10 The sum of Section-wise cross-sectional resource is the total geological gross/net in-situ resource.

19.4.0 METHODOLOGY ADOPTED FOR POLYGONAL METHOD (CHECK) FOR RESOURCE ESTIMATION

19.4.1 The resource estimation for glauconitic sandstone in the Jhari block was carried out using the Polygonal Method as check method to validate the resource by cross sectional method.

19.4.2 In this approach, the mineralized bodies delineated through exploration are treated as distinct zones within which the resource calculations are performed. The method ensures that the estimated resources are systematically allocated on the basis of spatial distribution and geological continuity.

19.4.3 The polygonal resource map, as depicted in Plate-VII, provides a visual representation of these borehole influences in each polygon.

19.4.4 The entire glauconite body intersected in 6 boreholes has been subdivided into six polygons (P1 to P06) of varying thickness. The influence area has been determined by constructing polygons through perpendicular bisectors of triangles and rectangles formed by adjoining boreholes. Area of each polygon has been calculated using Auto CAD 2025.

19.4.5 The thickness of each polygon represented by the cumulative thickness of glauconite horizons/bands encountered in the corresponding borehole. Area of the polygons were multiplied by the thickness of the zones encountered in each borehole.

19.4.6 Area devoid of glauconite mineralization along section lines as projected from cross sections has been carved out from polygons.

Table- 19.3
Boreholes and corresponding Polygonal area and corresponding zone thickness in Jhari G -3 block

Polygon No.	BH No.	Polygon Area (m^2)	Thickness (m)
P1	MJHR-01	651524.2000	10.50
P2	MJHR-02	661057.3200	16.00
P3	MJHR-03	696142.1400	15.00
P4	MJHR-04	761377.6304	15.65
P5	MJHR-05	738752.2485	19.20

Table- 19.4
Boreholes and corresponding Polygonal area and corresponding zone thickness in Jhari G -3 block drilled during the exploration program of Pindra South West block

Polygon No.	BH No.	Polygon Area (m^2)	Thickness (m)
P6	MPSW-09	825763.8200	18.00

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 Jhari 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 (principal) and Polygonal Method (check) method. The resource estimated by both the methods has been compared and found difference of 10.35% 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 Considering the bedded nature of deposit, the resource estimation has been conducted using two methods: the Cross-Sectional Method as the principal method and the Polygonal Method as a check method. All the primary samples generated during current exploration analyzed for K_2O, SiO_2, Al_2O_3 and Fe_2O_3.

20.1.2 The Resources have been estimated over surface area of 5.1 sq.km for mineralized zones >5% K_2O cutoff.

20.1.3 As per the standard practice, the gross geological resource has been reduced to 80% which is an empirical figure to arrive for net in-situ geological resource owing to nature of the body, recovery loss during the drilling operation and any unforeseen conditions.

20.1.4 A total of **104.20 million tonnes** of Net in-situ Inferred Resources (333 category) with average grade of **6.04% K_2O** and **25.85 million tonnes** of Net in-situ Reconnaissance Resources (334 category) with average grade of **6.18% K_2O** have been estimated by cross sectional method (Annexure-IX)**.** The cumulative **Net in-situ Resources (333+334)** by cross-section method is **130.05 Millon tonnes** with average grade of **6.06% K_2O.**

20.1.5 The summarized, borehole wise, section wise Cross sectional Inferred Resources (333 category) and Reconnaissance Resources at >5% K_2O cut-off in Jhari block (5.1 sq. km.) are given in table 20.1 and 20.2.

20.1.6 Total of **144.25 million tonnes** of Net in-situ Reconnaissance Resources (334 category) with average grade of **6.07% K_2O** has been estimated by polygonal method**.** (Annexure-X)**.**

20.1.7 The summarized, borehole wise and polygonal area wise Polygonal Reconnaissance resources at >5% K_2O cut-off in Jhari block (5.1 sq. km.) are given in table 20.3.

Table 20.1

Statement showing borehole wise, section wise Inferred Resource (333) of Glauconitic Sandstone, Estimated by Cross Sectional method, Jhari Block, District-Satna, Madhya Pradesh (Area 5.1 Sq. Km)

BH No.	Section Line	From (m)	To (m)	Thick-ness (m)	Sectional Area (m^2)	Section Influence (m)	Volume (m^3)	Specific Gravity	Gross Geological Resources (tonnes)	Net in-situ Resources (tonnes)	Average Quality			
											K_2O (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)
MJHR-03	S1-S1'	3.00	18.00	15.00	7224.97	766.38	5537086.15	2.62	14507165.72	11605732.58	6.49	48.98	13.90	15.84
MJHR-02	S2-S2'	8.00	24.00	16.00	8721.15	800.00	6976920.00	2.62	18279530.40	14623624.32	6.34	49.21	13.73	15.42
MPSW-09		8.00	26.00	18.00	14148.95	800.00	11319198.77	2.62	29656300.77	23725040.62	5.63	47.52	13.44	13.67
MJHR-05		19.30	38.50	19.20	16812.48	698.64	11745815.83	2.62	30774037.47	24619229.98	6.12	50.96	13.22	15.14
MJHR-01	S3-S3'	2.50	13.00	10.50	6763.77	789.83	5342219.92	2.62	13996616.19	11197292.95	5.47	47.53	13.48	17.02
MJHR-04		19.35	35.00	15.65	11277.56	779.50	8790820.40	2.62	23031949.46	18425559.56	6.27	49.95	13.38	14.99
Resources in tonnes									**130245600.01**	**104196480.01**	**6.04**	**49.16**	**13.47**	**15.10**
Resources in Million Tonnes									**130.25**	**104.20**				

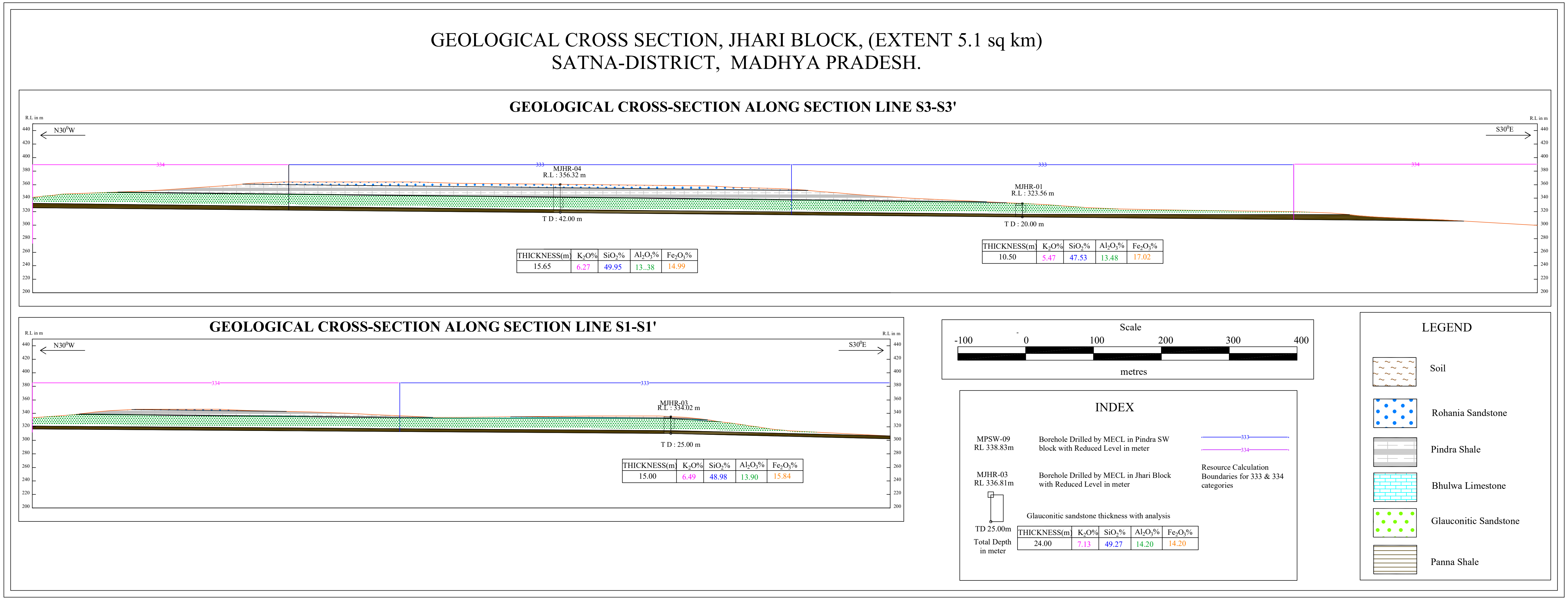
Table 20.2
Statement showing borehole wise, section wise Reconnaissance Resource (334) of Glauconitic Sandstone, Estimated by Cross Sectional method, Jhari Block, District-Satna, Madhya Pradesh (Area 5.1 Sq. Km)

BH No.	Section Line	From (m)	To (m)	Thick-ness (m)	Sectional Area (m^2)	Section Influence (m)	Volume (m^3)	Specific Gravity	Gross Geological Resources (tonnes)	Net in-situ Resources (tonnes)	Average Quality			
											K_2O (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)
MJHR-03	S1-S1'	3.00	18.00	15.00	7518.44	571.61	4297622.38	2.62	11259770.65	9007816.52	6.49	48.98	13.90	15.84
MJHR-02		8.00	24.00	16.00	42.76	683.98	29246.94	2.62	76626.97	61301.58	6.34	49.21	13.73	15.42
MJHR-02		8.00	24.00	16.00	282.48	137.12	38733.25	2.62	101481.13	81184.90	6.34	49.21	13.73	15.42
MPSW-09	S2-S2'	8.00	26.00	18.00	5765.53	325.50	1876666.41	2.62	4916865.99	3933492.79	5.63	47.52	13.44	13.67
MJHR-05		19.30	38.50	19.20	8518.91	120.58	1027230.48	2.62	2691343.86	2153075.09	6.12	50.96	13.22	15.14
MJHR-05		19.30	38.50	19.20	1235.60	208.31	257392.07	2.62	674367.22	539493.78	6.12	50.96	13.22	15.14
MJHR-01		2.50	13.00	10.50	11.34	799.99	9071.91	2.62	23768.42	19014.73	5.47	47.53	13.48	17.02
MJHR-01	S3-S3'	2.50	13.00	10.50	2380.78	322.63	768118.65	2.62	2012470.87	1609976.70	5.47	47.53	13.48	17.02
MJHR-04		19.35	35.00	15.65	5146.99	782.70	4028564.11	2.62	10554837.96	8443870.36	6.27	49.95	13.38	14.99
Resources in tonnes									**32311533.07**	**25849226.45**	**6.18**	**49.19**	**13.56**	**15.23**
Resources in Million Tonnes									**32.31**	**25.85**				

Table 20.3
Statement showing Polygon wise, borehole wise resources (333+334) of Glauconitic Sandstone by Polygonal Method, Jhari Block, District-Satna, Madhya Pradesh (Area 5.1 sq.km)

										Specific Gravity: 2.62
Polygon No.	**BH No.**	**Polygon Area (m^2)**	**Thickness (m)**	**Volume (m^3)**	**Gross Geological Resources (tonnes)**	**Net In-situ Resources (tonnes)**	**Average Quality**			
							K_2O%	**SiO_2%**	**Al_2O_3%**	**Fe_2O_3%**
P1	MJHR-01	651524.2000	10.50	6841004.10	17923430.74	14338744.59	5.47	47.53	13.48	17.02
P2	MJHR-02	661057.3200	16.00	10576917.12	27711522.85	22169218.28	6.34	49.21	13.73	15.42
P3	MJHR-03	696142.1400	15.00	10442132.10	27358386.10	21886708.88	6.49	48.98	13.90	15.84
P4	MJHR-04	761377.6304	15.65	11915559.92	31218766.98	24975013.58	6.27	49.95	13.38	14.99
P5	MJHR-05	738752.2485	19.20	14181826.91	37156386.52	29725109.21	6.12	50.96	13.22	15.14
P6	MPSW-09	825763.8200	18.00	14863748.76	38943021.75	31154417.40	5.63	47.52	13.44	13.67
Total Resources of Glauconitic Sandstone in tonnes					**180311514.94**	**144249211.96**	**6.07**	**49.14**	**13.51**	**15.20**
Total Resources for Glauconitic Sandstone in million tonnes					**180.31**	**144.25**				

Text Figure.20.1: Geological Cross section along section lines S1-S1' and S3-S3' of Jhari Block, Dist: Satna, Madhya Pradesh.



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:

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

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 have been compared for reliability of estimated resources. The comparison of resources is given below table.

Table no 20.4

Comparison of Cross Sectional and Polygonal resources, Jhari block, Tehsil-Majhgawan, District -Satna, Madhya Pradesh

Method of Resource Estimation	Gross Resource (million tonnes)	Net in situ Resource (million tonnes)	K_2O %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %
Geological Cross Section	162.56	130.05	6.06	49.17	13.49	15.12
Polygonal Method	180.31	144.25	6.07	49.14	13.51	15.20
Difference	17.75	14.20	0.01	0.03	0.02	0.08
Difference (%)	**10.35**	**10.35**	**0.15**	**0.05**	**0.15**	**0.52**

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 10.35% higher for K_2O as compared 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 Jhari block is carried out at G-3 level of Exploration where the boreholes are placed at 800m strike interval. The glauconite zone is occurring as bedded homogenous deposit. Considering the nature and style of mineralization, borehole density and geological cross section interval which fulfil the criteria of G-3 stage exploration as per UNFC system and specifications given in Part: III-I of Minerals (evidence of Mineral content) Rule-2015, mineral resource in the **Jhari block** is categorised as **inferred category (333)**.

CHAPTER-21

21.0.0 SUMMARY AND RECOMMENDATIONS

21.1.0 SUMMARY

21.1.1 The preliminary exploration for glauconitic sandstone in the Jhari Block, Satna District, Madhya Pradesh, was recommended during the 63rd Technical Coordination Committee (TCC) meetings held on 22nd, 26th, and 27th March 2024, and subsequently approved in the 35th Executive Committee (EC) meeting on 17th May 2024. MECL received formal approval from the 35th Executive Committee of NMET through letter no. 23/453/2024-NMET/78 dated 17th May 2024, with a designated project duration of nine months.

21.1.2 The Jhari exploration block (G-3 stage) for glauconitic sandstone covers an area of 5.1 sq. km, encompassing parts of the villages Pindra, Jhari, Lalpur Padar and Majhgawan, surrounding areas in Majhgawan tehsils of Satna district. The exploration block falls in the Survey of India toposheet no. 63D/9 and 63/D13. The block can be approached by State highway no. 11 and is about 50 km from Satna on Satna– Chitrakoot road. Majhgawan is well connected by State Highway 11 and NH-135BG, linking it to Satna, Maihar, Umaria, and the UP border.

21.1.3 The oldest formation exposed on the surface is the Panna Shale of Rewa Group overlain by Banbiha Sandstone, Bhulwa Limestone, Pindra Shale and Rohania Sandstone members of Itwa Sandstone formation.

21.1.4 The lithostratigraphic succession of the Jhari block displays a complete and conformable sequence from the Itwa Sandstone Formation through Panna Shale Formation of Rewa Group, indicating a transitional sedimentary environment from argillaceous to arenaceous facies which indicated deposition gradually changed from low energy to high energy condition such as shallow marine environment, which is a favorable condition for glauconite/ potash mineralization.

21.1.5 The block has gentle sloping topography of 1°–2°, with minor warping and jointing, characteristic of the Vindhyan sedimentary terrain. The formation strikes NE-SW with dip due southeast, with no major tectonic disturbances or metamorphism are observed, indicating a stable cratonic setting since deposition.

21.1.6 The glauconitic sandstone mineralization in the block primarily occurs within the Banbiha Sandstone Member of the Itwa Formation, exhibit features such as flaser and cross-bedding, ripple marks, and chert interbeds, indicating deposition under low to moderate energy, shallow marine conditions with reducing and mildly alkaline chemistry. The presence of pyrite, quartz, feldspar, muscovite, and chlorite suggests derivation from an acid igneous provenance and an environment favorable for authigenic glauconite formation and potash enrichment within the Vindhyan Basin.

21.1.7 The exploration block forms part of the Pindra South West G-4 Block. The area which was covered under a 1:12,500 scale geological map; the geological mapping was refined and updated on a larger scale of 1:4,000. This high-resolution mapping incorporated all visible changes in lithology, structure, and mineralization patterns, enabling more accurate delineation of stratigraphic contacts and glauconitic sandstone horizons significant for mineral resource evaluation. The General strike of NE–SW to ENE–WSW with gentle dips (1°–2°) towards the southeast, suggesting a relatively undisturbed sedimentary regime.

21.1.8 Exploratory operations in the block commenced in July 2024 and concluded in August 2025.

21.1.9 Topographically, the block is characterized by undulating terrains, interspersed hilly region with younger much resistant Rohania Sandstone member at top.

21.1.10 Five boreholes (MJHR-01 to MJHR-05) were drilled with a total 160.00 meters of drilling. Boreholes were placed on a systematic 800 m × 800 m grid pattern. DGPS (WGS-84) was used for precise location and elevation control, and data were plotted on the updated geological map. Additionally, one borehole (MPSW-09) drilled earlier in the adjoining Pindra South West Block were integrated for correlation and resource evaluation. The adopted borehole spacing meets the requirements of the Minerals (Evidence of Mineral Content) Rules, 2015, ensuring adequate data density for G-3 level exploration and classification of the identified glauconitic sandstone as Inferred Mineral Resource (333) under the UNFC system.

21.1.11 Apart from glauconite, other potassium-bearing minerals such as feldspar (orthoclase/microcline), illite/mica, and diagenetically altered detrital phases may also contribute to the overall K_2O content. Since XRD and EPMA analyses were not included in the NQT stage of the exploration programme, specific confirmation regarding these phases cannot be made. However, cross-plot analysis supports the presence of true authigenic glauconite rather than detrital clay admixtures.

21.1.12 A total of **104.20 million tonnes** of Net in-situ Inferred Resources (333 category) with average grade of **6.04% K_2O** and **25.85 million tonnes** of net in-situ Reconnaissance Resources (334 category) with average grade of **6.18% K_2O** have been estimated by cross sectional method (Annexure-IX). The cumulative **Net in-situ Resources (333+334)** by cross-section method is **130.05 Millon tonnes** with average grade of **6.06% K_2O.**

21.1.13 Alternatively, resource estimation by the polygonal method indicates a total of 144.25 million tonnes of Net in-situ Reconnaissance Resources (334 category) with an average grade of 6.07% K_2O, suggesting good consistency between both estimation approaches and reaffirming the significant glauconitic potential of the block.

21.1.14 The difference between the resources from Geological Cross section method and Polygonal Method is 10.35% and grade difference of K_2O is 0.15%. The variation in resources estimated by both the methods is within limit, hence the reliability of resource estimated by Geological Cross section method may be considered for all practical purposes.

21.2.0 RECOMMENDATIONS

21.2.1 Substantial glauconite potential have been reported based on the exploration data generated during the G-3 stage exploration work carried out in the block.

21.2.2 SEM-EDS and Bimodal studies are recommended in future work to validate presence of glauconite vs feldspar/mica in the area.

21.2.3 Based on the outcome of the present exploration work, the block can be auctioned as CL block under the Auction programme of GOI for Critical and strategic minerals in future tranches of Auction.

CHAPTER-22

22.0.0 PLATES AND MAPS

22.1.0 Location Map of the block showing various topographic and physiographic features on SoI toposheet is given as Plate-I on 1:50,000 scale.

22.2.0 Regional Geology Map is given as Plate-II.

22.3.0 Topography Map is given as Plate-III on 1:4000 scale.

22.4.0 Block Geological Map on 1:4,000 with BH Locations is given as Plate-IV.

22.5.0 Geological Map of Pindra-SW G-4 block showing Jhari G-3 block, Dist.-Satna, Madhya Pradesh on 1:12,500 scale is given as Plate-V

22.6.0 Geological cross section along section lines S1-S1' S2-S2' and S3-S3' on 1:1000 scale is given as Plate-VI.

22.7.0 Map for the mineralized body used for determination of polygonal resources, on 1: 10,000 scale is given as Plate-VII

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

N.A.

CERTIFICATE FROM THE QUALIFIED PERSON WITH NAME, DATE AND SIGNATURE

This is to certify that geological report in respect of Preliminary Exploration for Glauconitic sandstone in Jhari G-3 block, Satna, Madhya Pradesh was recommended–in 63th TCC held on 22nd, 26th, 27th March, 2024 and was subsequently approved in 35th EC held on 17.05.2024. MECL has received approval from the 35th Executive Committee of NMET through letter no. 23/453/2024-NMET/78, dated 17th May 2024, with the designated time duration of 09 months. The area of the exploration block is 5.1 sq. km, Field operation was initiated by MECL in July 2024, carried out geological mapping and topographical survey on 1:4,000 scale subsequently carried out drilling. MECL completes the exploration as per MEMC rules and Geological Report is being submitted.

NAME: **SHRIKANT SHARMA**

DESIGNATION: **HoD (EXPLORATION)**

DATE: December

LIST OF PERSONNEL ASSOCIATED WITH PRELIMINARY EXPLORATION (G-3) FOR GLAUCONITIC SANDSTONE IN JHARI BLOCK DISTRICT-SATNA, MADHYA PRADESH

1	Overall guidance	Shri P. Ravindran, Ex.GM (Exploration) Rtd Shri Shrikant Sharma, HoD (Exploration)
2	Overall Planning, Co-ordination & Supervision	Shri S.N. Khadse, GM (Exploration)
		Shri Naveen Kr. Pala, Sr. Manager (Geology)
3	Operation	Shri S.N. Khadse, GM (Exploration) Shri Jayprakash Choudhury, Sr. Manager (Geology)/Head (Operation) Shri Alok Daharwal, Sr. Manager (Geology) Shri Sandeep Sarangi, Manager (Geology)
4	Project Management	Shri Rajnikant, Project Manager (Manager, Drilling)
5	Physical Execution of work	
	a) Geology	Shri Peeyush Kumar, Assistant Manager (Geology) Shri Aditya Chodhury, Ex. Geologist
6	Sample Processing	Shri Ankush Wagh, Sr. Sampling Assistant
7	Chemical Laboratory	Shri P. Ravindran, Ex.GM (Exploration)/ Lab. in-charge Shri Shrikant Sharma, HoD (Exploration)/Lab in-charge
		Shri Rohit Sharma, Manager (Chemical Lab)
		Dr. Deepti Rahangdale, Manager (Chemical Lab)
8	Petrographic Studies	Shri Sayantan Pal, Manager (Geology)
9	Documentation	Shri Naveen Kumar Pala, Sr. Manager (Geology)
		Shri Peeyush Kumar, Assistant Manager (Geology)
10	Non-Coal Geological Report Cell	Shri S. K. Satpathy, Sr. Manager (Geology)
		Mrs. Saumya Anand, Assistant Manager (Geology)
		Shri Uday Patil, Sr. Computer Operator
		Shri Shivanand, Sr. Computer Operator
11	Reprography and Printing	NEM GR Cell (Exploration Division)
12	Proposal Formulation	Shri Naveen Kr. Pala, Sr. Manager (Geology)

LOCALITY INDEX

Locality	Latitude	Longitude
Pindra	24°31′20.3″N	80°43′45.6″E
Jhari	24°19'24.1"N	80°49'51.8"E
Majhgawan	24°54'50.79"N	80°47'57.60"E
Kanpur	24°53'53.99"N	80°46'13.20"E

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MECL

ABBREVIATIONS

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	NMEDT	National Mineral Exploration and Development Trust
9	BH	Borehole
10	TCC	Technical cum Cost Committee
11	EC	Executive Committee
12	DMG, MP	Directorate of Geology & Mining, Madhya Pradesh
13	NABL	National Accreditation Board for Testing and Calibration
14	JNARDDC	Jawaharlal Nehru Aluminium Research Development and Design
15	F.S.P.	Field Season Programme
16	MEMC	Minerals (Evidence of Mineral Contents)
17	MMDR	Mines & Minerals (Development and Regulation)
18	NH	National Highway
19	WGS-84	World Geodetic System-84
20	UTM	Universal Transverse Mercator
21	RL	Reduced Level
22	cu m	Cubic Meter
23	ICP-MS	Inductively Coupled Plasma Mass Spectrometry
24	DGPS	Differential Global Positioning System
25	DMS	Degree Minute Second
26	M / m	Meter
27	Sq. km	Square Kilometer
28	M. Sc.	Master of Science
29	M. Sc. Tech	Master of Science Technology
30	mRL	Reduced Level in metre
31	R.F.	Reserve Forest
32	QA/QC	Quality Assessment/ Quality Checks
33	WD-XRF	Wavelength Dispersive X-ray Fluorescence
34	CRM	Certified Reference Material
35	SARM	South African Reference Material
36	SOI	Survey of India
37	GOI	Government of India
38	GNSS	Global Navigation Satellite System
39	CORS	Continuously Operating Reference Station