GEOLOGICAL REPORT ON RECONNAISSANCE SURVEY (G-4 STAGE) FOR MANGANESE AND ASSOCIATED MINERALS IN

KATORI-JHIRIYA BLOCK

(Area-140.22 Sq Km)
TEHSIL-WARASEONI & KHAILANJI,
DISTRICT- BALAGHAT, MADHYA PRADESH
(Under NMEDT Programme)
Parts of Toposheet no. 55O/14

Manganese ore body exposed near Shankar Pipariya village in the Katori Jhiriya Block

MECL

MINERAL EXPLORATION AND CONSULTANCY LIMITED
(Formerly known as Mineral Exploration Corporation Limited)
A Government of India Enterprises
CORPORATE OFFICE, NAGPUR

DECEMBER-2025

GEOLOGICAL REPORT ON RECONNAISSANCE SURVEY (G-4 STAGE) FOR MANGANESE AND ASSOCIATED MINERALS IN KATORI- JHIRIYA BLOCK, DISTRICT- BALAGHAT, MADHYAPRADESH

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1.0.0 कार्यकारी सारांश

1.1.0 परिचय

1.1.1 मैंगनीज़ का ऐतिहासिक महत्व लगभग 17,000 वर्ष पूर्व से रहा है। वर्तमान में विश्व में मैंगनीज़ की कुल खपत का लगभग 90% इस्पात उत्पादन में होता है, जबकि शेष बैटरियों और रसायनों में प्रयुक्त होता है। वैश्विक खनिज संसाधन आकलन के अनुसार, मैंगनीज़ अयस्क का कुल विश्व भंडार लगभग 570 मिलियन टन अनुमानित है। इसमें प्रमुख योगदान दक्षिण अफ्रीका (~26%), यूक्रेन (~25%), ऑस्ट्रेलिया (~17%), ब्राज़ील और भारत (~9%), तथा अन्य देशों का है। भूमि-आधारित भंडारों के अतिरिक्त, प्रशांत महासागर तल पर गहरे समुद्री नोड्यूल्स में भी विशाल अप्रयुक्त मैंगनीज़ संसाधन पाए जाते हैं, जिनमें लगभग 2.5 बिलियन टन मैंगनीज़-समृद्ध सामग्री होने का अनुमान है (आईबीएम, 2015)।भारत के पास विश्व के कुल भंडार का लगभग 9% है, जो मुख्यतः मध्यप्रदेश, महाराष्ट्र, ओडिशा और कर्नाटक में स्थित है।

1.1.2 तुलनात्मक रूप से, 1 अप्रैल, 2020 तक भारत में मैंगनीज़ अयस्क के भंडार/संसाधन 503.62 मिलियन टन हैं, जैसा कि एनएमआई डेटाबेस (यूएनएफसी प्रणाली) में दर्ज है। इनमें से 75.04 मिलियन टन भंडार श्रेणी में आते हैं, जबकि 428.58 मिलियन टन शेष संसाधन के अंतर्गत हैं। ग्रेड के अनुसार, भारतीय सूची में बीएफ ग्रेड (29%), फेरोमैंगनीज़ ग्रेड (8%), मध्यम ग्रेड (6%) तथा शेष 57% मिश्रित, निम्न, अन्य, अपवर्गीकृत और बैटरी/रासायनिक ग्रेड सम्मिलित हैं।

1.1.3 खनिज नीलामी की तैयारी हेतु गवेषण-आधारित राष्ट्रीय आवश्यकताओं के प्रत्युत्तर में, मध्यप्रदेश के बालाघाट जिले में स्थित काटोरी झिरिया ब्लॉक को आवीक्षण-स्तर (जी-4) गवेषण के लिए नेशनल मिनरल एंड डेवलपमेंट ट्रस्ट (एनएमईडीटी) के अंतर्गत चुना गया। यह ब्लॉक अत्यधिक संभावनाशील सौसर समूह में आता है, जहाँ प्रमुख मैंगनीज़ खदानें जैसे भरवेली, उकवा और तिरोडी स्थित हैं। प्रारंभिक आवीक्षण जाँच कार्यों में सतही मानचित्रण, पुराने खदान गड्ढों का निरीक्षण, फ्लोट नमूनों का अध्ययन और हैंडहेल्ड एक्सआरएफ परीक्षण शामिल थे, जिनमें 16–27% मैंगनीज़ मान प्राप्त हुए। इन परिणामों ने तकनीकी आधार प्रदान किया, जिसके आधार पर "काटोरी झिरिया में मैंगनीज़ एवं संबद्ध खनिजों का आवीक्षण (जी-4) गवेषण" प्रस्ताव तैयार कर 47वीं टीसीसी बैठक में प्रस्तुत किया गया। टीसीसी ने कुछ संशोधनों के साथ इसे ईसी को अनुशंसित किया। तत्पश्चात, एनएमईटी की 27वीं ईसी बैठक (10 जनवरी,2023) में काटोरी झिरिया ब्लॉक के जी-4 स्तर गवेषण प्रस्ताव को ₹1,67,81,229/-

की अनुमानित लागत पर स्वीकृति दी गई, जिसका उल्लेख कार्यालय ज्ञापन सं. F.No. 23/296/2023-NMET/317, नई दिल्ली, दिनांक 3 फरवरी 2023 में किया गया।

1.1.4 गवेषण कार्य 10 फरवरी, 2023 को शुरू हुआ। जियोलॉजिकल मैपिंग और बेडरॉक और चैनल सैंपल इकट्ठा करने समेत फील्ड वर्क 30 जून, 2023 को पूरा हुआ। बेडरॉक और चैनल सैंपल से आरंभिक एनालिटिकल परिणामों के बाद, एक ग्राउंड जियोफिजिकल सर्वे की योजना बनाई गई और उसे पूरा किया गया; सर्वे में तीन ज़ोन दिखाए गए जिन्हें आगे की ट्रेंचिंग के लिए चुना गया। ट्रेंचिंग के परिणामों के आधार पर, सबसरफेस कंटिन्यूटी को परीक्षण करने के लिए नौ स्काउट बोरहोल का प्रस्ताव रखा गया। ज़रूरी फॉरेस्ट क्लीयरेंस मिलने के बाद, ब्लॉक में कोर ड्रिलिंग 1 जून, 2025 को शुरू हुई; हालाँकि, क्योंकि मैप किए गए मिनरल वाले एरिया का एक हिस्सा मौजूदा त्रिवेदी माइनिंग लीज़ में आता है, इसलिए असल में सिर्फ़ सात बोरहोल ही ड्रिल किए गए। ड्रिलिंग 27 सितंबर, 2025 को पूरी हुई। एनालिटिकल और लैब स्टडीज़ एमईसीएल और दूसरी सरकारी/एनएबीएल (NABL)-एक्रेडिटेड लैब में एक साथ की गईं।

1.2.0 परियोजना स्थल

1.2.1 कटोरी झिरिया ब्लॉक मध्य प्रदेश के बालाघाट जिले के खैरलांजी और वारासिवनी तहसीलों में 140.22 वर्ग किमी. में फैला है । यह भंडारा-बालाघाट स्टेट हाईवे के पश्चिम में है, जहाँ वारासिवनी-मोवाड-रामपायली से बारहमासी सड़कें हैं। सबसे पास का रेलवे स्टेशन बालाघाट (20 km NE) और सबसे पास का एयरपोर्ट नागपुर (100 km SW) है। यह ब्लॉक सर्वे ऑफ़ इंडिया की टोपोशीट नंबर 55O/14 के तहत आता है और आक्षांश 21° 31′ 49.721″N से 21° 45′ 0.000″N और देशांतर 79° 48′ 37.464″E से 80° 0′ 0.000″E के बीच है। ब्लॉक के अंदर के गाँव अच्छे मौसम वाली पक्की सड़कों से जुड़े हुए हैं। अच्छी प्रचालनात्क पहुंचने की सुविधा से मानसून में रुकावट वाले शेड्यूल के समय में भी लगातार फील्ड कार्य हो सका है।

1.3.0 ब्लॉक का भूविज्ञान और संरचना

1.3.1 यह ब्लॉक सेंट्रल सौसर मोबाइल बेल्ट में है और इसमें मनसर फॉर्मेशन की रूपांतरित अवसादी शैलें हैं जो तिरोडी बायोटाइट नाइसिक कॉम्प्लेक्स के ऊपर हैं। मुख्य लिथोलॉजी में लेटराइट, ग्रेनाइट, मस्कोवाइट-बायोटाइट शिस्ट, कैल्क-नाइस, क्वार्टजाइट और मैंगनीज वाले बैंड शामिल हैं। रीजनल नतिलंब का ट्रेंड NE-SW है, जिसमें 40° और 75° के बीच नति है , जो सौसर टेक्टोनिक फ्रेमवर्क के अनुसार है। टाइट आइसोक्लिनल फोल्डिंग के कारण मैंगनीज लेयर्स का दोहराव और स्थानीय मोटाई हुई, जबकि NE-SW-ओरिएंटेड फॉल्ट और शियरिंग के कारण डिसकंटिन्यूअस लेंसॉइडल बॉडीज़ में सेगमेंटेशन हुआ है। मिनरलाइज़्ड यूनिट्स मुख्य रूप से एक रीजनल फोल्ड सिस्टम के हिंज ज़ोन में होती हैं, जो मजबूत स्ट्रक्चरल कंट्रोल और सीमित गहराई की कंटिन्यूटी को समझाती हैं। क्षेत्र में 3–5 मीटर मोटी मृदा और जलोढ़ आवरण के कारण अधिकांश आउटक्रॉप ढके हुए हैं, जिसके चलते ट्रेंचिंग, पिट और ड्रिलिंग जैसे अन्वेषण कार्य भूवैज्ञानिक व्याख्या के लिए अनिवार्य बनते हैं।

तालिका- 1.1
कटोरी झिरिया ब्लॉक का स्ट्रेटीग्राफिक अनुक्रम

जिला-बालाघाट, मध्य प्रदेश

स्ट्रेटीग्राफी	समूह	संरचना	लिथोलॉजी
वर्तमान			जलोढ़क और मृदा
क्वार्टनरी			लेटराइट
अर्वेधित			विशाल पोटाश ग्रेनाइट और क्वार्ट्ज वेंस
(मेसोप्रोटेरोज़ोइक)	सौसर समूह	चोरबाहुली संरचना	चेर्टी फेरुजिनस क्वार्टजाइट और मेटा-आर्कोज, मैग्नेटाइट और/या गार्नेट के स्थानीय विकास के साथ
		मानसर संरचना	बायोटाइट (± फाइब्रोलाइट) - मस्कोवाइट-क्वार्ट्ज शिस्ट जिसमें क्वार्टजाइट की पतली पट्टियां और Mn- अयस्क की मोटी परतें होती हैं
		लोहांगी संरचना	कैल्क सिलिकेट चट्टानें, कैल्क-गनीस
-------------------------- टेक्टोनाइज्ड संपर्क---------------------------			
(आर्कियन)	प्री-सौसर बेसमेंट	तिरोडी बायोटाइट नीस (टीबीजी)	बायोटाइट नाइस, मिग्माटाइट नाइस

1.4.0 खनिजीकरण

1.4.1 ब्लॉक में मैंगनीज मिनरलाइज़ेशन, मस्कोवाइट-बायोटाइट शिस्ट और मैंगनीज वाले क्वार्टजाइट के अंदर मौजूद मेटामॉर्फोज़्ड स्ट्रैटाबाउंड गोंडाइट-टाइप डिपॉज़िट को दिखाता है। ओर बड़े गहरे ग्रे-काले लेंस के रूप में लैमिनेटेड होता है जो फोलिएशन के हिसाब से होता है। तीन सरफेस मिनरलाइज़्ड ज़ोन तय किए गए थे,शंकर पिपरिया , चोरपिंडकेपर और टेकाडी टीजू सभी का प्रवृति NE–SW की ओर है। 225 बेडरॉक, चैनल और ट्रेंच सैंपल के एनालिटिकल नतीजे 0.56% से 50.70% Mn तक आये हैं , जो सतही समृद्धि की पुष्टि करते हैं लेकिन ग्रेड और कंटिन्यूटी में बहुत ज़्यादा बदलाव है। मिनरलॉजी में ब्राउनाइट, पायरोलुसाइट, साइलोमेलेन और हौसमैनाइट के साथ क्वार्ट्ज और सिलिकेट गैंग के रूप में शामिल हैं। स्काउट ड्रिलिंग से केवल दो बोरहोल (MKJ-01 और MKJ-05) में ही अयस्क अवरोधित हुआ, जिनकी

वास्तविक मोटाई 1.29 मीटर से 1.96 मीटर तक पाई गई, जो उपसतही निरंतरता के अत्यंत सीमित होने की पुष्टि करती है।

1.5.0 वर्तमान अन्वेषण कार्य

1.5.1 निर्धारित उद्देश्यों की प्राप्ति हेतु, एमईसीएल ने कटोरी झिरिया ब्लॉक, बालाघाट जिला, मध्य प्रदेशमें एक आवीक्षण सर्वेक्षण (G-4 स्तर) किया । वर्तमान NMET-वित्तपोषित G-4 स्तरीय अन्वेषण के दौरान एक व्यापक कार्यक्रम लागू किया गया, जिसमें भूवैज्ञानिक, भूभौतिकीय, भू-रासायनिक, ट्रेंचिंग तथा स्काउट ड्रिलिंग जैसी सभी अन्वेषण गतिविधियों का समन्वित रूप से निष्पादन शामिल था।

1.5.2 140.22 वर्ग किमी क्षेत्र में 1:12,500 स्केल पर भूवैज्ञानिक मानचित्रण किया गया, जिससे पूरा प्रस्तावित कवरेज हासिल हुआ। भूभौतिकीय सर्वेक्षण (चुंबकीय पद्धति) के अंतर्गत 1,200 लाइन-किमी कार्य सम्पन्न किया गया, जो मूल प्रस्तावित 450 लाइन-किमी की तुलना में काफी अधिक है। यह वृद्धि अधिक सघन लाइन स्पेसिंग और बेहतर संरचनात्मक व्याख्या की आवश्यकता के कारण की गई।

1.5.3 लिथोलॉजिकल कॉन्टैक्ट्स और सरफेस मैंगनीज मिनरलाइज़ेशन को सामने लाने के लिए प्लान के मुताबिक कुल 100 क्यूबिक मीटर की ट्रेंचिंग पूरी की गई। स्काउट ड्रिलिंग में सात बोरहोल शामिल थे, जिनकी कुल लंबाई 358.50 मीटर थी, जबकि प्रस्तावित नौ बोरहोल (500 m) थे। त्रिवेदी माइनिंग लीज़ बाउंड्री और तिजू टेकाडी सेक्टर में खेती की ज़मीन के अंदर पाबंदियों की वजह से दो बोरहोल ड्रिल नहीं किए जा सके।

1.5.4 भू-रासायनिक जांच के अंतर्गत 225 प्राथमिक बेडरॉक, ट्रेंच, तथा चैनल नमूनों, साथ ही 11 आंतरिक जाँच एवं 23 बाह्य जाँच नमूनों का विश्लेषण किया गया, जो प्रस्तावित संख्या के अनुरूप है। ड्रिल कोर से 77 प्राथमिक, 4 आंतरिक जाँच, तथा 8 बाह्य जाँच नमूनों का विश्लेषण किया गया, जबकि 100, 5, और 10 नमूने प्रस्तावित थे। इसके अलावा, ड्रिल कोर से 3 कम्पोजिट सैंपल का छह रेडिकल के लिए एनालिसिस किया गया।

1.5.5 10 संपूर्ण-शैल नमूनों (5 सतही एवं 5 बोरहोल) का प्रमुख ऑक्साइडों और सूक्ष्म तत्वों के लिए विश्लेषण किया गया। निर्धारित कार्यक्रमानुसार 10 पेट्रोग्राफिक तथा 10 मिनरोग्राफिक अध्ययन संपन्न किए गए। क्षेत्रीय आउटक्रॉप, ट्रेंच तथा ड्रिल साइट्स के 20 डिजिटल फोटो रिपोर्ट में सम्मिलित किए गए। NMET दिशानिर्देशों के अनुसार रिपोर्ट का डिजिटल प्रारूप में संपूर्ण तैयार किया जाना भी पूर्ण किया गया।

1.6.0 मैपिंग और सैंपलिंग (सरफेस और सबसरफेस) के रिजल्ट पर विमर्श

1.6.1 1:12,500 स्केल पर जियोलॉजिकल मैपिंग से ब्लॉक का लिथोलॉजिकल डिस्ट्रीब्यूशन और स्ट्रक्चरल फ्रेमवर्क पता चला, जिससे यह कन्फर्म हुआ कि मैंगनीज मिनरलाइजेशन मस्कोवाइट-बायोटाइट शिस्ट और मैंगनीज वाले क्वार्टजाइट के अंदर मानसर फॉर्मेशन तक ही सीमित है।

1.6.2 कुल 85 बेडरॉक, 91 चैनल, और 49 ट्रेंच सैंपल इकट्ठा किए गए और Mn , SiO_2, P_2O_5, Fe_2O_3, MnO_2 और एसिड में न घुलने वाले पदार्थों के लिए उनका एनालिसिस किया गया। एनालिटिकल

परिणामों से मैंगनीज कंसंट्रेशन में बहुत ज़्यादा अंतर दिखता है, जो 0.56% से 50.70% Mn तक है, जो ओर ज़ोन के पैची और लेंसॉइडल नेचर को दिखाता है। ट्रेंच और चैनल सैंपलिंग ने तीन सरफेस मिनरलाइज़्ड ज़ोन तय किए। शंकर पिपरिया , चोरपिंडकेपार और टेकाड़ी टीजू प्रत्येक उत्तर-पूर्व-दक्षिण-पश्चिम की ओर प्रवृत्त है और फोल्डेड स्किस्ट-क्वार्टजाइट अनुक्रमों से जुड़ा हुआ है।

1.6.3 भूभौतिकीय विसंगति क्षेत्र और ट्रेंचिंग के नतीजों के आधार पर, सात स्काउट बोरहोल ड्रिल किए गए। मैंगनीज मिनरलाइज़ेशन सिर्फ़ MKJ-01 (असली मोटाई 1.96m) और MKJ-05 (असली मोटाई 1.29m और 1.89 m) में मिला।

1.6.4 कुल मिलाकर, मानचित्रण, नमूनाकरण और ड्रिलिंग से प्राप्त आंकड़े इंगित करते हैं कि कटोरी झिरिया ब्लॉक में मैंगनीज़ खनिजीकरण उथला, संरचनात्मक रूप से नियंत्रित और असतत है, तथा अयस्क की प्रचुरता मुख्यतः सतह के समीपवर्ती स्तरों तक ही सीमित है।

1.7.0 संसाधन

1.7.1 कटोरी झिरिया (G-4) ब्लॉक के लिए आवीक्षण (334) श्रेणी का कुल मैंगनीज़ संसाधन 49,198.68 टन आंका गया है, जो 10% Mn थ्रेशोल्ड वैल्यू पर आधारित है। औसत ग्रेड Mn = 22.51% प्राप्त हुआ है। ये संसाधन मनसर फॉर्मेशन के भीतर स्थित सतही, स्तरीय तथा लेंसाकार मैंगनीज़ पट्टियों (बैंड I एवं II) से संबंधित हैं, जिनकी संरचनात्मक प्रवृत्ति NE–SW दिशा में है।

1.7.2 खनिजीकरण असतत, उथला और संरचनात्मक रूप से नियंत्रित है, जो कि गोंडाइट-प्रकार के सौसर मैंगनीज़ निक्षेपों की विशिष्ट विशेषता है। ध्यान रहे कि त्रिवेदी लीज़ क्षेत्र (4.9 हे.) से संबंधित सभी आंकड़ों को NMEDT एवं UNFC दिशानिर्देशों के अनुसार संसाधन गणना से बहिष्कृत किया गया है।

1.8.0 संसाधनों का वर्गीकरण

1.8.1 कटोरी झिरिया ब्लॉक के मैंगनीज़ संसाधन का आकलन UNFC-2009 (United Nations Framework Classification) तथा भारतीय खान ब्यूरो (IBM) के दिशा-निर्देशों के अनुरूप किया गया है, तथा इसे G-4 अन्वेषण चरण के रिकॉन्नेसां मिनरल रिसोर्स (334) श्रेणी में वर्गीकृत किया गया है।

1.9.0 निष्कर्ष और सुझाव

1.9.1 **निष्कर्ष:** कटोरी–झिरिया ब्लॉक में मनसर फॉर्मेशन के अंदर लेंसॉइडल, स्ट्रक्चरल रूप से कंट्रोल्ड मैंगनीज मिनरलाइजेशन (गोंडाइट/मैंगनीज सिलिकेट-ऑक्साइड टाइप) है। सतही मानचित्रण, ट्रेंच तथा चैनल नमूनाकरण से कई पृथक सतही खनिजीकृत क्षेत्र पहचाने गए हैं, जहाँ स्थानीय रूप से Mn>10% पाया गया, परंतु समग्र रूप से खनिजीकरण पतला, असतत एवं सीमित गहराई निरंतरता वाला है।

1.9.2 सबसे ज़्यादा सरफेस कंसंट्रेशन ब्लॉक के अंदर त्रिवेदी माइनिंग लीज़ (4.9 ha) में देखा गया, जिससे काम के प्रोग्राम और रिसोर्स के इस्तेमाल में रुकावट आई। स्काउट ड्रिलिंग से सबसरफेस परसिस्टेंस लिमिटेड होने की पुष्टि होती है, सिर्फ़ दो बोरहोल Mn को काटते हैं और असली मोटाई तय स्टॉपिंग चौड़ाई 2m से कम थी।

1.9.3 सतही ट्रेंच/चैनल इंटरसेक्शन के आधार पर अनुमानित संसाधन लगभग 49,200 टन (10% Mn कट-ऑफ पर) है, जिसे UNFC रिकॉन्नेसां (334) श्रेणी में वर्गीकृत किया गया है।

1.9.4 **सुझाव:** G-4 अन्वेषण ने मनसर फॉर्मेशन में मैंगनीज़ खनिजीकरण की उपस्थिति की पुष्टि हुई है, लेकिन इसकी सतही निरंतरता एवं ग्रेड स्थिरता सीमित पाई गई। प्रमुख खनिजीकरण त्रिवेदी लीज़ क्षेत्र में केंद्रित है; इसके बाहर खनिजीकरण मुख्यतः पतला, असतत और केवल रिकॉन्नेसां स्तर का है। ड्रिलिंग ने गहराई तक कोई निरंतरता नहीं दिखाई, जिससे सिद्ध होता है कि ये अयस्क पट्टियाँ सतह-सीमित एवं लेंसाकार हैं। अतः वर्तमान स्थिति में यह ब्लॉक उच्चतर अन्वेषण चरण में उन्नयन योग्य नहीं है, परंतु यह अध्ययन सौसर बेल्ट की क्षेत्रीय मैंगनीज़ संभाव्यता के लिए महत्वपूर्ण भूवैज्ञानिक इनपुट प्रदान करता है।

CHAPTER-1

1.0.0 EXECUTIVE SUMMARY

1.1.0 INTRODUCTION

1.1.1 Manganese has been historically important for 17,000 years BP, and today 90% of global Mn consumption is for steel production, with the remainder used in batteries and chemicals. According to global mineral resource assessments, the total world reserves of manganese ore are estimated at about 570 million tonnes, with major contributions from South Africa (~26%), Ukraine (~25%), Australia (~17%), Brazil & India (~9%), and other countries. In addition to land-based reserves, vast untapped manganese resources also occur as deep-sea nodules on the Pacific Ocean floor, which are estimated to contain about 2.5 billion tonnes of manganese-rich material (IBM, 2015). India holds ~9% of global reserves, mainly in Madhya Pradesh, Maharashtra, Odisha and Karnataka.

1.1.2 In comparison, India's manganese ore reserves/resources as of 1 April 2020 stand at 503.62 million tonnes, as reported in the NMI database (UNFC system). Of these, 75.04 million tonnes fall under Reserves, and 428.58 million tonnes under Remaining Resources. Grade-wise, the Indian inventory comprises BF grade (29%), Ferromanganese grade (8%), Medium grade (6%), and the remaining 57% includes Mixed, Low, Others, Unclassified and Battery/Chemical grades.

1.1.3 In response to national requirements for exploration-driven mineral auction readiness, the Katori Jhiriya Block in Balaghat district, Madhya Pradesh, was selected for Reconnaissance survey (G-4) exploration under the National Mineral Exploration and Development Trust (NMEDT). The block lies within the highly prospective Sausar Group, which hosts major manganese mines such as Bharweli, Ukwa and Tirodi. Initial reconnaissance investigations including surface mapping, examination of old mine pits, float occurrences and handheld XRF testing showed moderately high manganese values ranging from 16–27% Mn. This provided the technical basis for formulation of a proposal, Reconnaissance (G4) exploration of Manganese and associated minerals in katori Jhiriya and submitted the proposal to the 47th TCC meeting, the TCC has recommended the item with some modification to EC. The 27th EC of NMET held on 10th January 2023 approved the G-4 stage exploration proposal for Katori Jhiriya Block at an estimated exploration cost of Rs. 1,67,81,229/-, vide

Office Memorandum F.No. 23/296/2023-NMET/317, New Delhi, dated, 3rd February 2023.

1.1.4 Exploration work commenced on 10 February 2023. Field work, including geological mapping and collection of bedrock and channel samples, was completed on 30 June 2023. Following preliminary analytical results from the bedrock and channel samples, a ground geophysical survey was planned and executed; the survey delineated three anomalous zones which were selected for follow-up trenching. Based on trenching results, nine scout boreholes were proposed to test subsurface continuity. After obtaining necessary forest clearance, core drilling in the block commenced on 1 June 2025; however, because a part of the mapped mineralised area falls within an existing Trivedi mining lease, only seven boreholes were actually drilled. Drilling was completed on 27 September 2025. Analytical and laboratory studies were carried out concurrently at MECL and other Government/NABL-accredited laboratories.

1.2.0 LOCATION

1.2.1 The Katori Jhiriya block covers 140.22 sq km in Khairlanji and Waraseoni Tehsils of Balaghat district, Madhya Pradesh. It is located west of the Bhandara-Balaghat State Highway, with approach via Waraseoni-Mowar-Rampayli along all-weather roads. The nearest railhead is Balaghat (20 km to NE) and nearest airport is Nagpur (100 km to SW). The block is covered under Survey of India Toposheet No. 55O/14 and bounded between latitude 21° 31′ 49.721″ N to 21° 45′ 0.000″ N and longitude 79° 48′ 37.464″ E to 80° 0′ 0.000″ E. Villages within the block are connected through fair-weather metalled roads. Good operational accessibility allowed continuous field progress even during monsoon-interrupted schedule periods.

1.3.0 GEOLOGY AND STRUCTURE OF THE BLOCK

1.3.1 The block is situated within the central Sausar Mobile Belt and consists of metasedimentary rocks of the Mansar Formation overlying the Tirodi Biotite Gneissic Complex. The major lithology include laterite, granite, muscovite–biotite schists, calc-gneiss, quartzite, and manganese-bearing bands. Regional strike trends NE–SW with dips between 40° and 75° direction SE, consistent with the Sausar tectonic framework. Tight isoclinal folding resulted in repetition and local thickening of manganese layers, while NE–SW-oriented faults and shearing have caused segmentation into discontinuous lensoidal bodies. Mineralised units lie predominantly within the hinge zone of a regional fold system, explaining the strong structural control and limited depth continuity. Soil and alluvium cover (3–5 m depth) obscures outcrops, making trench, pit and drill investigations essential for geological interpretation.

Table- 1.1
Stratigraphic Sequence of the Katori Jhiriya Block, District-Balaghat, Madhya Pradesh

STRATIGRAPHY	GROUP	FORMATION	LITHOLOGY
Recent			Alluvium and soil
Quaternary			Laterite
Intrusives			Massive potassic granite and quartz veins
(Mesoproterozoic)	SAUSAR GROUP	Chorbaoli Formation	Cherty ferruginous quartzite and meta-arkose with local development of magnetite and/or garnet
		Mansar Formation	Biotite (± fibrolite) - muscovite-quartz schist with thin bands of quartzite and thick horizons of Mn-ore
		Lohangi Formation	Calc silicate rocks, calc-gneiss
--------------------------Tectonised Contact---------------------------			
(Archaean)	Pre-Sausar Basement	Tirodi Biotite Gneiss (TBG)	Biotite Gneiss, Migmatite Gneiss

1.4.0 MINERALISATION

1.4.1 Manganese mineralisation in the block represents metamorphosed stratabound Gondite-type deposits hosted within muscovite-biotite schists and manganese-bearing quartzite. Ore occurs as laminated to massive dark grey–black lenses conformable with foliation. Three surface mineralised zones were defined, Shankar Pipariya, Chorpindkepar and Tekadi Tiju, all trending NE–SW. Analytical results from 225 bedrocks, channel and trench samples vary from 0.56% to 50.70% Mn, confirming surficial enrichment but strong variability in grade and continuity. Mineralogy includes braunite, pyrolusite, psilomelane and hausmannite with quartz and silicates as gangue. Scout drilling intersected ore only in two boreholes (MKJ-01 and MKJ-05) with true thickness ranging from 1.29 m to 1.96 m, confirming very limited subsurface persistence.

1.5.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

1.5.1 To achieve the objectives, MECL executed a Reconnaissance Survey (G-4 level) in the Katori Jhiriya Block, Balaghat District, Madhya Pradesh. During the present NMET-funded G-4 stage exploration of the Katori Jhiriya Block, a comprehensive programme integrating geological, geophysical, geochemical, trenching and scout drilling investigations was completed.

1.5.2 Geological mapping covering 140.22 sq. km was carried out on a 1: 12,500 scale, achieving the entire proposed coverage. Geophysical surveys using the magnetic method were conducted over 1,200 line-kilometres, significantly exceeding the originally proposed 450 line-km due to the need for tighter line spacing and enhanced structural interpretation.

1.5.3 A total of 100 cubic metres of trenching was completed as planned to expose lithological contacts and surface manganese mineralisation. Scout drilling comprised seven boreholes, totalling 358.50 metres, against the proposed nine boreholes (500 m). Two boreholes could not be drilled due to restrictions within the Trivedi mining lease boundary and agricultural land in the Tiju Tekadi sector.

1.5.4 Geochemical investigations included 225 primary bedrocks, trench, and channel samples, along with 11 internal check and 23 external check samples, fully meeting the planned sample numbers. From drill core, 77 primary samples, 4 internal check samples, and 8 external check samples were analysed against the planned 100, 5, and 10 samples respectively. Additionally, 3 composite samples from drill cores were analysed for six radicals.

1.5.5 Whole-rock analysis was carried out on 10 samples (five surface and five borehole samples), covering major oxides and trace elements. Ten petrographic studies and ten mineragraphic studies were completed as scheduled. A total of 20 digital photographs documenting field exposures, trenches, and drill sites were incorporated into the report. Report preparation in digital format was completed as per NMET guidelines.

1.6.0 DISCUSSION ON RESULT OF MAPPING AND SAMPLING (SURFACE & SUBSURFACE)

1.6.1 Geological mapping at 1:12,500 scale established the lithological distribution and structural framework of the block, confirming that manganese mineralisation is confined to the Mansar Formation within muscovite–biotite schist and manganese-bearing quartzite.

1.6.2 A total of 85 bedrocks, 91 channel, and 49 trench samples were collected and analysed for Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and acid insolubles. The analytical results show wide variation in manganese concentration, ranging from 0.56 % to 50.70 % Mn, reflecting the patchy and lensoidal nature of the ore zones. Trench and channel sampling defined three surfaces mineralised zones Shankar Pipariya, Chorpindkepar, and Tekadi Tiju each trending NE–SW and associated with folded schist–quartzite sequences.

1.6.3 Based on the geophysical anomalies and trenching results, seven scout boreholes were drilled. Manganese mineralisation was intersected only in MKJ-01 (true thickness 1.96m) and MKJ-05 (true thickness 1.29m and 1.89 m).

1.6.4 Overall, the mapping, sampling, and drilling data collectively indicate that manganese mineralisation within the Katori Jhiriya Block is shallow, structurally controlled, and discontinuous, with ore concentrations restricted mainly to the near-surface horizons.

1.7.0 RESOURCES

1.7.1 The total Reconnaissance (334) category manganese resource for the Katori Jhiriya (G-4) Block is estimated at 49,198.68 tonnes at 10% Mn Threshold Value, with an average grade of Mn = 22.51 %. The resources represent surficial, stratabound, lensoidal manganese bands (Band I & II) within the Mansar Formation, following the NE–SW structural trend.

1.7.2 The mineralisation is discontinuous, shallow, and structurally controlled, characteristic of Gondite-type Sausar manganese deposits. All data from the Trivedi lease area (4.9 ha) have been excluded from computation as per NMEDT and UNFC reporting guidelines.

1.8.0 CATEGORISATION OF RESOURCE

1.8.1 The estimation of Manganese resource of Katori Jhiriya Block is in accordance with the United Nations Framework Classification (UNFC-2009) and Indian Bureau of Mines (IBM) guidelines for the Reconnaissance Mineral Resource (334) category under the G-4 stage of exploration.

1.9.0 CONCLUSIONS & RECOMMENDATIONS

1.9.1 **Conclusions:** The Katori–Jhiriya block hosts lensoidal, structurally controlled manganese mineralisation (gondite/manganese silicate–oxide type) within the Mansar Formation. Surface mapping, trenches and channels have identified discrete surficial zones with Mn >10% locally, but overall, the mineralisation is patchy, thin and of limited depth continuity.

1.9.2 The most significant surface concentrations observed lie within the Trivedi mining lease (4.9 ha) inside the block, which constrained the work program and resource use. Scout drilling confirms limited subsurface persistence only two boreholes intersected Mn and true thicknesses were below the adopted stoping width 2m.

1.9.3 Resource estimated from surface trench/channel intersections is modest (≈ 49,200 t at 10% Mn cut-off) and classified as UNFC Reconnaissance (334).

1.9.4 **Recommendations:** The G-4 exploration confirmed the presence of manganese mineralisation in the Mansar Formation, though its surface continuity and grade persistence are limited. Most of the significant manganese occurs within the Trivedi lease boundary, while outside, the mineralisation is thin, patchy, and of reconnaissance significance only. Drilling results show no depth continuity, validating the surface-limited and lensoidal nature of these ore bodies. The block, therefore, does not presently warrant upgradation to a higher exploration stage, but its geological understanding contributes valuable input to the regional manganese prospectivity of the Sausar Belt.

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: 52 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	20 Years
4	Shri Santosh Kumar Satapathy	Sr. Manager (Geology)	M.Sc., Geology	20 Years
5	Shri Indra Kumar Nagpure	Sr. Manager (Geology)	M.Sc., Geology& M.Sc. Tech in Remote Sensing	16 Years
6	Shri Aatish A. Bagde	Manager (Drilling)	B. tech	12 Years
7	Shri Motish Kumar	Manager (Drilling)	B. tech	10 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
10	Mrs. Moumita Ghosh,	Assistant Manager (Geology)	M.Sc., Geology	08 Years

CHAPTER-3

3.0.0 TITLE AND OWNERSHIP

3.1.0 TITLE OF THE REPORT: RECONNAISSANCE SURVEY (G-4 STAGE) FOR MANGANESE AND ASSOCIATED MINERALS IN KATORI- JHIRIYA BLOCK (140.22 SQ.KM) DISTRICT- BALAGHAT, MADHYAPRADESH

Ownership: Government of Madhya Pradesh

Name of Prospector: MINERAL EXPLORATION AND CONSULTANCY LIMITED (Formerly Mineral Exploration Corporation Limited)

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

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 OF PERIOD OF PROSPECTING

3.2.1 MECL prepared a proposal for G-4 stage (Reconnaissance) exploration in the Katori Jhiriya Block, Balaghat District, Madhya Pradesh, for manganese and associated minerals. The proposal was placed before the 47th Technical-cum-Cost Committee (TCC) of NMEDT during its meeting held on 28th–29th November 2022 via video conferencing for technical evaluation. After minor modifications, the TCC recommended the proposal to the Executive Committee (EC) of NMEDT. The 27th Executive Committee (EC), held on 10th January 2023, approved the proposal at an estimated cost of ₹1,67,81,229, vide Office Memorandum F.No. 23/296/2023-NMET/317, dated 3rd February 2023.

3.2.1 Exploratory work in the block commenced on 10.02.2023 with surface geological mapping, geophysical studies, and trenching. Since all nine planned boreholes fall within the Phulchur Reserved Forest, the forest clearance application was duly submitted on 02.02.2024 and drilling activities were taken up only after the forest clearance was accorded on 15.05.2025. Owing to the delay in approval, exploratory drilling could commence with BH No. MKJ-01 on 01.06.2025, and the programme was completed with the closure of BH No. MKJ-07 on 27.09.2025. Allied field activities, including geological logging, core handling, and sampling, were carried out simultaneously. The analytical and laboratory studies were also undertaken in parallel in MECL laboratories and other Government/NABL-accredited laboratories, ensuring timely completion of the exploration programme.

3.2.2 After completion of the exploration work and receipt of all analytical results, the draft Geological Report for the Katori Jhiriya Block was prepared and submitted to the Peer Reviewer, Shri Sarat Kumar Jena, Dy. Director General (Retd.), GSI, on 21.11.2025. The peer reviewer comments were received on 01.12.2025 (Annexure XV) detail and were subsequently examined in. All observations and suggestions provided by the reviewer were incorporated into the revised Geological Report. The updated report was thereafter presented before the 18th TCC-II Meeting held on 04.12.2025. Following deliberations, the Committee recommended submission of the Final Geological Report, incorporating the peer-reviewed changes and committee suggestions, for further consideration and approval.

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

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

3.3.2 **QUALIFICATION :** M. Sc. / M. Sc. Tech. (Geology)

3.3.3 **EXPERIENCE: Experience Since 1972**

Exploration agency: Mineral Exploration Corporation Ltd

(A Govt. of India Enterprise-A Miniratna PSE)

Experience: Since 1972

M.Sc (Geology) / M. Tech (Geology)

CHAPTER-4

4.0.0 DETAILS OF THE AREA

4.1.0 LOCATION OF THE BLOCK

4.1.1 The present exploration block is located at about 30km south-west of Balaghat town in the vicinity of Katori - Jhiriya village, Waraseoni & Khairlanji Tehsil, District Balaghat, in the southern region of Madhya Pradesh. It lies in the parts of Survey of India Toposheet No. 55O/14 and is bounded by latitude 21° 31' 49.721"N to 21° 45' 0.000"N and longitude 79° 48' 37.464"E to 80° 0' 0.000"E (Text Fig. No-1 & Plate No.-I). The coordinates of cardinal points of block boundary of Katori Jhiriya Block are given below.

Table -4.1
Co-ordinates of Block boundary corner points ofKatori JhiriyaBlock, Dist: Balaghat, Madhya Pradesh

Corner Point ID	WGS 84		UTM, Zone 44	
	Latitude	Longitude	Easting (m)	Northing (m)
A	21° 45' 00.000" N	79° 58' 10.934" E	393462.3810	2405510.860
B	21° 43' 42.152" N	80° 00' 00.000" E	396579.9063	2403096.574
C	21° 42' 40.123" N	80° 00' 00.000" E	396567.5860	2401189.277
D	21° 31' 49.721" N	79° 53' 44.766" E	385643.6877	2381263.390
E	21° 34' 40.151" N	79° 48' 37.464" E	376842.5511	2386568.955
F	21° 36' 22.491" N	79° 50' 12.147" E	379589.2441	2389695.266
G	21° 36' 35.097" N	79° 55' 21.904" E	388498.9812	2390018.747
H	21° 42' 01.522" N	79° 55' 25.802" E	388680.6415	2400055.147

4.1.2 The area is connected by fair weather road from the National Highway (NH-543K) (Bhandara-Balaghat Road). The Katori Jhiriya Block can be approached from Balaghat via Waraseoni by an all-weather pucca road. It is about 8 km from Khairlanji tehsil. The intervening villages are connected by fair weather jeepable metalled / unmetalled roads. The nearest railhead is Waraseoni and nearest airport is Nagpur.

4.2.0 DETAILS OF THE AREA WITH LAND USE

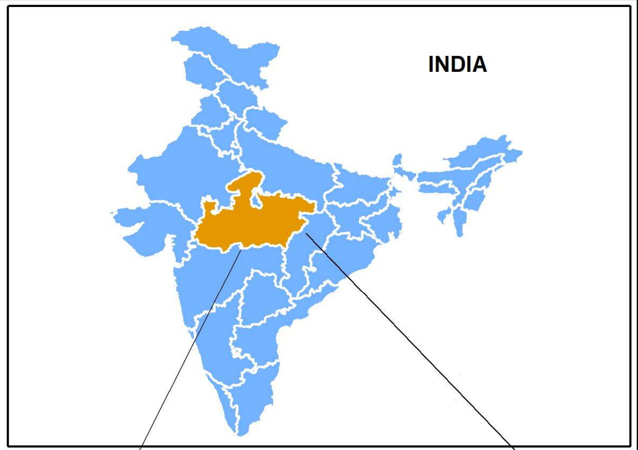
4.2.1 Approximately 40% of the total geographical area of Balaghat district is covered by forest. Within this district, the Katori Jhiriya Block consists of 30% forest area, while the remaining 70% is private land.

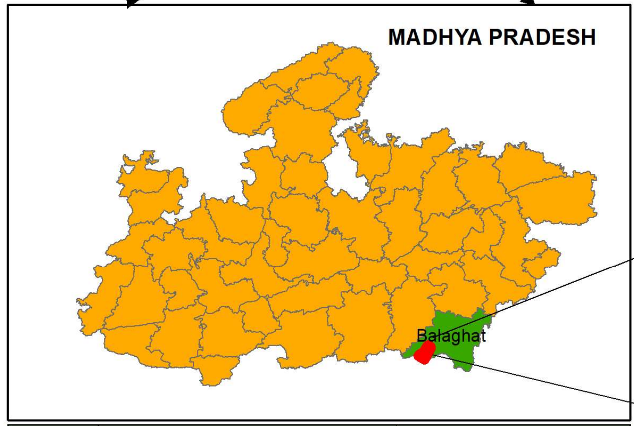
4.3.0 MINERAL(S) UNDER INVESTIGATION:

4.3.1 The block has been explored for manganese ore and associated minerals.

TEXT FIGURE 4.1: LOCATION MAP OF KATORI JHIRIYA BLOCK, DISTRICT – BALAGHAT, MADHYA PRADESH

LOCATION MAP SHOWING KATORI JHIRIA BLOCK (G4 STAGE) FOR MANGANESE AND ASSOCIATED MINERALS IN BALAGHAT DISTRICT, MADHYAPRADESH. (SOI TS NO. 55O14)





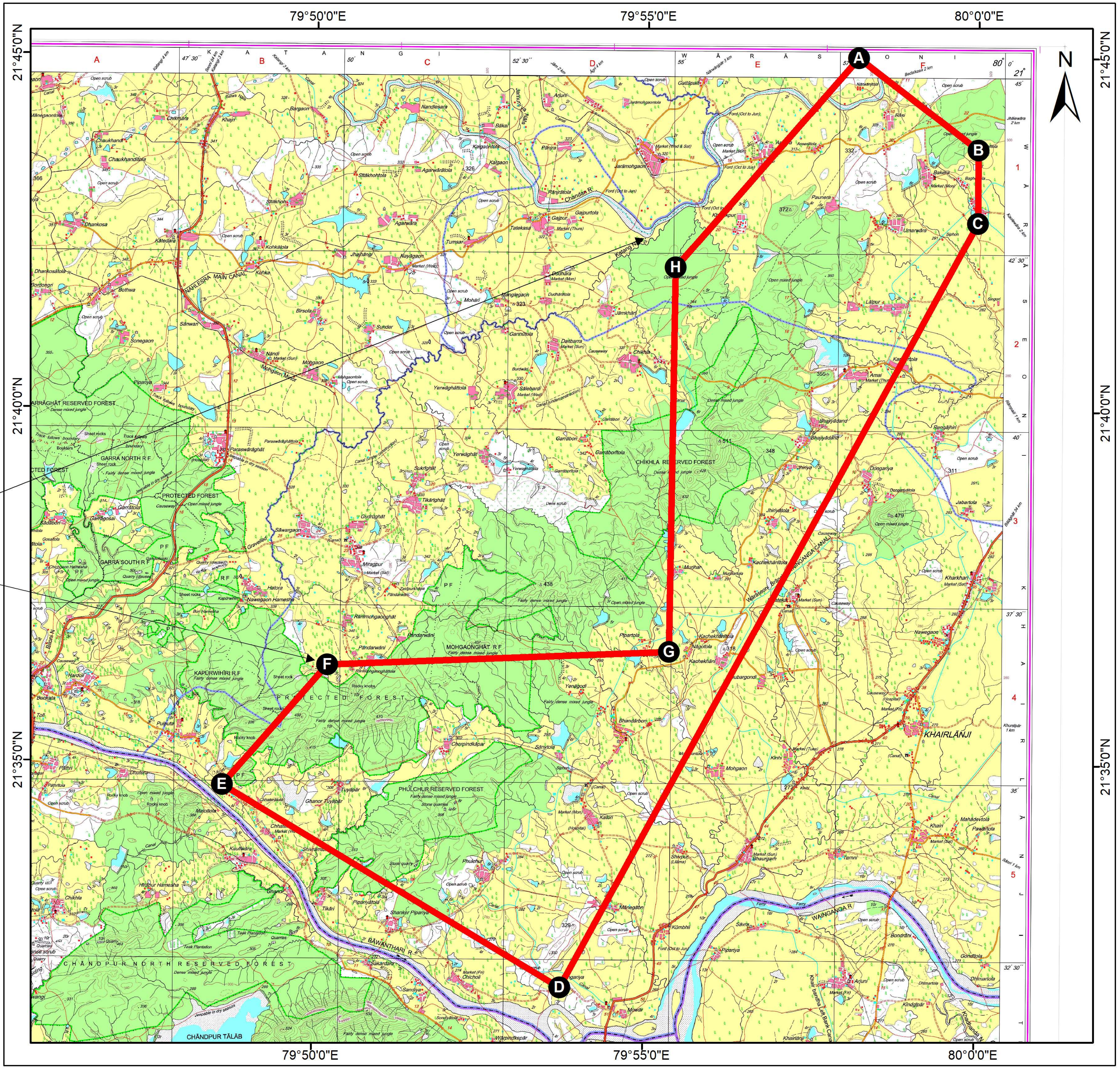
Corner Point ID	WGS 84		UTM, Zone 44	
	Latitude	Longitude	EASTING	NORTHING
A	21° 45' 0.000" N	79° 58' 10.934" E	393462.381	2405510.86
B	21° 43' 42.152" N	80° 0' 0.000" E	396579.9063	2403096.574
C	21° 42' 40.123" N	80° 0' 0.000" E	396567.586	2401189.277
D	21° 31' 49.721" N	79° 53' 44.766" E	385643.6877	2381263.39
E	21° 34' 40.151" N	79° 48' 37.464" E	376842.5511	2386568.955
F	21° 36' 22.491" N	79° 50' 12.147" E	379589.2441	2389695.266
G	21° 36' 35.097" N	79° 55' 21.904" E	388498.9812	2390018.747
H	21° 42' 1.522" N	79° 55' 25.802" E	388680.6415	2400055.147

SCALE: 1: 50,000

0 1 2 4 6 8 km

Legend

- Corner Points
- Katori Jhiriya Block



MINERAL EXPLORATION AND CONSULTANCY LTD.

MECL

KATORI JHIRIA BLOCK (G4 STAGE)	
DISTRICT: BALAGHAT	STATE: MADHYA PRADESH
LOCATION MAP OF THE BLOCK	
R.F. 1:50,000	
PARTS OF TOPOSHEET NO. – 55O/14	
PREPARED BY- EXPLORATION DIVISION, MECL, NAGPUR	
M.E.C.L/EXPLOR./DEC-2025	PLATE-I 1

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 Katori Jhiriya Block lies in the southern part of Balaghat District, Madhya Pradesh, and exhibits a landscape of gently undulating to moderately hilly terrain typical of the Sausar metamorphic belt. The elevation in the block ranges 258- 504 metres above mean sea level (MSL). The maximum elevation (504 m) is observed along the ridges and hillocks in the southern and western parts of the block, while the minimum elevation of about 258 m occurs in the northern low-lying plains, forming smooth pediplains and valley floors. The relief gradually decreases northward, producing a gentle slope towards the plains adjoining the Chandan River basin.

5.1.2 The overall topography of the area is characterised by broad interfluves, linear ridges, and narrow valleys developed due to differential erosion of schist, quartzite, and gneissic rocks of the Sausar Group and the underlying Tirodi Biotite Gneiss. The hilly regions are covered with thin vegetation and lateritic soil, while the lowlands are occupied by agricultural fields and small settlements. The relief pattern reflects the geological control, with ridge lines following the regional NE–SW structural trend of the Sausar belt.

5.1.3 The drainage system of the block is sub-dendritic to sub-parallel, largely influenced by the foliation and structural pettern of the rocks. The northern part of the area is drained by the Chandan River, which flows eastward, whereas the southern part is drained by the Bawanthadi River, which flows southeast and eventually joins the Wainganga River, the major river system of the region. Numerous seasonal nalas and first-order streams originate from the ridges and hill slopes, particularly during the monsoon season, and contribute to these two major drainage systems.

5.1.4 A few small tanks and reservoirs constructed across minor streams serve as sources of surface water for agriculture and domestic use in nearby villages. These include small village ponds near Chorpindkepar, Shankar Piparia, and Jhiriya villages. Groundwater occurs in weathered and fractured zones of gneiss and schist, while surface runoff is high during the monsoon season due to moderate relief and hard rock terrain.

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

5.2.1 The Katori–Jhiriya Exploration Block is located about 30 km south-west of Balaghat town, in the vicinity of Katori–Jhiriya village, covering parts of Waraseoni and Khairlanji Tehsils in the southern region of Balaghat District, Madhya Pradesh. The block is well connected through both road and rail networks, ensuring easy accessibility for exploration activities and transportation of personnel and materials.

5.2.2 The National Highway NH-543K (Bhandara–Balaghat) passes along the eastern margin of the block, providing excellent regional connectivity. The area is conveniently accessible from Balaghat via Waraseoni through an all-weather pucca road, which further branches into a network of fair-weather metalled and un metalled jeepable roads connecting all major villages and the drilling locations within the block. The block lies approximately 8 km from Khairlanji Tehsil headquarters, ensuring ease of access for administrative coordination and logistical support during exploration activities.

5.2.3 In terms of railway connectivity, the block can be reached through the Nagpur–Balaghat railway line (approximately 170 km) and further through the Balaghat–Tirodi branch line (~45 km). The nearest railway station is Waraseoni, while the nearest airport is at Nagpur, about 170 km away.

5.2.4 Electric power is available in most of these villages through 11 kV and 33 kV transmission lines, with local distribution transformers catering to domestic and agricultural needs. Telephone connectivity is established through mobile networks and BSNL landlines in major villages, while broadband and internet facilities are available in nearby towns such as Waraseoni and Khairlanji.

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

5.3.1 As per Census 2011, Balaghat District has a total population of 1,701,698, which constitutes about 2.34 % of the total population of Madhya Pradesh. Of this, 1,438,877 persons (84.6 %) reside in rural areas, while 262,821 persons (15.4 %) live in urban regions. The population growth rate during the decade 2001–2011 was 13.56 %, which is considerably lower than the state average of 20.35 %, indicating a relatively stable population trend in the district.

5.3.2 The total geographical area of Balaghat District is 9,245 km², accounting for approximately 3 % of the total area of Madhya Pradesh. The population density is 184 persons per square kilometre, which is below the state average of 236 persons/km², reflecting the predominance of forested and hilly terrain, as well as scattered rural settlements.

5.3.3 In terms of gender distribution, Balaghat records a sex ratio of 1,021 females per 1,000 males, which is significantly higher than the state average of 931. The child sex ratio (0–6 years) is also favourable at 967, compared to 918 for Madhya Pradesh, suggesting better gender balance and awareness in the district.

5.3.4 The district demonstrates a strong literacy performance. The overall literacy rate stands at 77.09 %, which is well above the state average of 69.32 %. In rural areas, the literacy rate is 75.79 %, while in urban areas it reaches 84.65 %. The male literacy rate is 85.36 %, and the female literacy rate is 69.04 %, both higher than the state averages of 78.73 % and 59.24 % respectively. This indicates a comparatively good educational status, particularly among women, in both rural and urban settings.

5.3.5 Overall, Balaghat District shows a moderate population density, high literacy rate, and favourable sex ratio, which reflect progressive social indicators compared to the state averages. The dominance of rural population and tribal communities (such as Gond, Baiga, and Halba) highlights the socio-cultural diversity of the region. The demographic characteristics suggest that the district, including the Katori–Jhiriya exploration area, possesses a stable and well-distributed population with adequate human resources for supporting mineral exploration and development activities while maintaining ecological and social balance.

5.3.6 The villages within and around the Katori–Jhiriya Block include: Amai, Bhajiyadand, Jhiriya, Tekadighat, Mohgaon Ghat, Chorpindkepar, Tuiyapar, Tekadi Tiju, Shankar Pipariya, Fulchur, Katori, Manegaon, Bhandarbodi, Kachekhani, Saleteka, Ghubadgondi, Pounera, Basi, Bodalkasa, Bakera, Bagholi, Lalpur, and Umarwada.

MECL

Table-5.1

Census Data of Balaghat District, Madhya Pradesh

Description	Census-2011		Overall (District)	Madhya Pradesh (State Average)	Remarks / Proportion
	Rural	Urban			
Population	14,38,877	2,62,821	**17,01,698**	7,26,26,809	Balaghat forms ~ 2.34 % of MP population
Population Growth (2001–2011)	–	–	**13.56%**	20.35%	Lower than state average
Area (sq km)	–	–	**9,245 km²**	308,252 km²	~ 3.0 % of MP area
Density (persons/km²)	–	–	**184**	236	Lower than state average
Sex Ratio (females per 1000 males)	**1,025**	**987**	**1,021**	931	Higher than state average
Child Sex Ratio (0–6 years)	**969**	**955**	**967**	918	Higher than state average
Average Literacy Rate (%)	**75.79%**	**84.65%**	**77.09%**	69.32%	Higher than state average
Male Literacy (%)	**84.20%**	**89.94%**	**85.36%**	78.73%	Higher than state average
Female Literacy (%)	**67.64%**	**79.18%**	**69.04%**	59.24%	Higher than state average

Table-5.2

Census Data of Villages falls under Katori Jhiriya Block, Balaghat District, Madhya Pradesh

Sl No	Village Name	Tehsil	Total Geographical Area (in Hectares)	Total Households	Total Population of Village	Total Male Population of Village	Total Female Population of Village
1	Amai	Khairlanji	1230.7	762	3048	1497	1551
2	Bhajiyadand	Khairlanji	407.71	474	1845	933	912
3	Jhiriya	Khairlanji	618.27	374	1336	665	671
4	Tekadighat	Khairlanji	646.97	409	1594	768	826
5	Mohgaon Ghat	Khairlanji	775.02	337	1220	598	622
6	Chorpindkepar	Khairlanji	606.08	249	960	484	476
7	Tuiyapar	Khairlanji	714.64	425	1620	790	830
8	Tekadi Tiju	Khairlanji	274.39	265	1043	518	525
9	Shankar Pipariya	Khairlanji	568.39	389	1380	673	707
10	Fulchur	Khairlanji	742.31	489	1858	891	967
11	Katori	Khairlanji	931.95	701	2726	1365	1361
12	Manegaon	Khairlanji	374.78	342	1280	627	653
13	Bhandarbodi	Khairlanji	1412.24	838	3520	1690	1830

Sl No	Village Name	Tehsil	Total Geographical Area (in Hectares)	Total Households	Total Population of Village	Total Male Population of Village	Total Female Population of Village
14	Kachekhani	Khairlanji	358.9	385	1531	720	811
15	Saleteka	Khairlanji	466.29	460	1897	955	942
16	Ghubadgondi	Khairlanji	584.75	513	2093	1039	1054
17	Pounera	Waraseoni	351.75	166	605	305	300
18	Basi	Waraseoni	379.51	168	720	341	379
19	Bodalkasa	Waraseoni	514.89	330	1371	688	683
20	Bakera	Waraseoni	564.96	483	1954	953	1001
21	Bagholi	Waraseoni	589.19	284	1173	586	587
22	Lalpur	Waraseoni	875.28	555	2474	1228	1246
23	Umarwada	Waraseoni	455.87	474	1837	933	904

5.4.0 SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

5.4.1 The Katori–Jhiriya exploration block comprises some two dozen villages across Khairlanji and Waraseoni tehsils. According to the 2011 census records, the block contains villages with widely varying sizes and socio-economic characteristics from small hamlets of a few hundred people to larger villages with populations exceeding 2,500. Major villages in the block (by population) include Katori, Bhandarbodi, Fulchur, Saleteka and Tuiyapar, which together account for a sizeable share of the local population and services hub for smaller neighbouring habitations.

5.4.2 **Population structure and social groups:** The block hosts a mixed social composition with both Scheduled Castes (SC) and Scheduled Tribes (ST) present across most villages. Tribal presence is significant in several villages, reflecting the long-standing indigenous population of the Sausar–Tirodi belt; this is consistent with regional patterns in south-eastern Balaghat. SC and ST groups form a noticeable proportion of village populations and are important stakeholders for any field activity or project planning.

5.4.3 **Village population sizes vary:** Many villages fall in the 900–1,900 range, while a few larger villages exceed 2,500 residents. Household counts likewise range from small hamlets (few dozen households) to larger settlements with several hundred households.

5.4.4 **Education, health and amenities:** Primary education facilities (government primary and middle schools) are commonly available either within the village or in the immediate neighbourhood (most villages report availability within 5–10 km).

Secondary and senior-secondary schools are typically located in larger villages or tehsil/town centres (Waraseoni, Khairlanji, and Balaghat). Health infrastructure at the village level is limited: most primary health centres or community health centres are located in nearby towns (Khairlanji / Waraseoni / Balaghat). For specialised medical services and district-level care, residents travel to Waraseoni (≈15–21 km) or Balaghat (≈30–40 km). Basic amenities such as electricity, mobile phone coverage and PCO/PCN services are available in most villages; distribution is better around larger settlements. Sanitation and household piped water coverage shows mixed levels across villages (some villages have functioning tap/handpump/tank facilities, others rely on wells and seasonal sources).

5.4.5 **Transport, market access and services:** Road connectivity varies from all-weather pucca roads connecting major villages to jeepable metalled/unmetalled roads for smaller hamlets. The State Highway (Bhandara–Balaghat) and arterial roads provide the primary external links; Waraseoni and Balaghat towns serve as nearest statutory towns for higher order services. Regular public transport (bus services) and access to banking/ATMs are concentrated in larger villages and tehsil towns. Weekly haats and local mandi facilities are available in market villages and support the agrarian economy.

5.4.6 **Livelihood and land use:** Agriculture is a primary livelihood in the area. The village data show cultivation of sugarcane, paddy (dhan), wheat, chana, and oilseed crops (alsi, etc.) in many villages; area under cultivation varies considerably by village depending on topography and availability of irrigated land. Large tracts of each village's area are also under forest (common in this part of Balaghat) and uncultivable rocky terrain, reflecting the hard-rock geology and lateritic soils of the block.

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

5.5.1 The Katori–Jhiriya block lies within a region of long human habitation and modest cultural heritage. Scattered across the landscape are small village shrines and temples, many centuries old in local memory that serve as focal points for daily worship and annual festivals. These places of worship (Hindu temples and local tribal shrines) are important social centres for the surrounding communities and are commonly located in village nuclei such as Katori, Fulchur and Jhiriya. While there are no major archaeological monuments recorded inside the exploration block itself, the broader Balaghat district contains a number of heritage sites and vernacular structures that reflect the region's agrarian and forest-edge history; these are consulted during fieldwork planning to avoid inadvertent disturbance.

5.5.2 Public utilities and civic infrastructure in and near the block are concentrated in larger villages and tehsil towns. Primary schools, panchayat offices and small markets serve local needs, while district-level services such as the government district hospital, higher secondary schools, police stations, post offices and banking branches, are located at Waraseoni and Balaghat. Drinking-water sources (hand pumps, wells and village tanks), rural health sub-centres and Aanganwadi centres are available in many villages, although more comprehensive medical and administrative services require travel to the tehsil or district headquarters.

5.5.3 **The region is also ecologically significant:** Kanha National Park lies in the broader landscape of central India and is the nearest major protected area of note, underscoring the need for careful environmental planning and liaison with forestry and wildlife authorities when locating field camps, trenches or drill sites. In view of local cultural sensitivities and the presence of tribal communities, all field activities are carried out only after village consultations and with due respect to places of worship, burial grounds and other community landmarks.

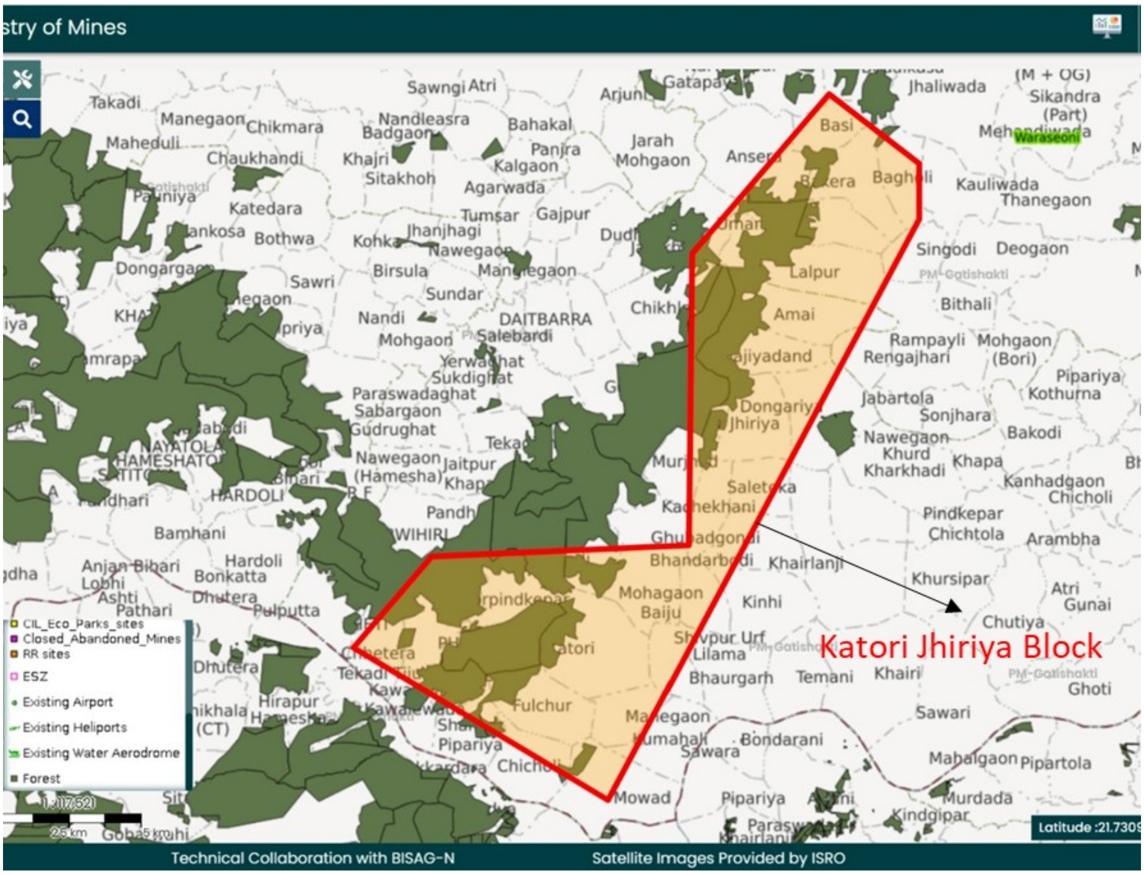
5.6.0 FORESTS, SANCTUARIES, NATIONAL PARK AND WILD LIFE SANCTUARIES ETC:

5.6.1 The Katori–Jhiriya Block, situated in the southern part of Balaghat District, Madhya Pradesh, lies within a region that is part of the central Indian forest belt, a landscape renowned for its rich biodiversity, dense sal and mixed deciduous forests, and close ecological association with the Sausar geological terrain. Nearly 40% of Balaghat District's total geographical area is under forest cover, making it one of the most forested districts in the state. Within the Katori–Jhiriya block, a significant portion of the land is classified as Reserve and Protected Forest, particularly in the Fulchur, Chorpindkepar, Shankar Pipariya, and Jhiriya areas. The block mainly falls within the Fulchur Reserve Forest, Chikhla Reserve Forest and Mohgaon Reserve Forest which are managed by the South Balaghat Forest Division.

5.6.2 The Kanha National Park, one of India's most famous tiger reserves, lies approximately 80–90 km northeast of the block and forms the major conservation hub of the region. The forest ecosystems of Balaghat district act as a transitional zone linking Kanha to other wildlife habitats of eastern Madhya Pradesh and adjoining

Pench National Park of Maharashtra. Although the Katori–Jhiriya block itself does not fall within any designated wildlife sanctuary or national park boundary, its proximity to these protected landscapes underscores the need for environmentally sensitive exploration practices.

5.6.3 No Eco-Sensitive Zone (ESZ) or wildlife corridor has been officially notified within the block area.



Text Figure 5.1: Map showing forest area in Katori Jhiriya Block (Source: Gati Sakti Portal)

5.7.0 FLORA AND FAUNA WITHIN AND NEARBY

5.7.1 The Katori–Jhiriya Block, located in the southern part of Balaghat District, lies within the ecologically rich Satpura–Maikal landscape of central India, a region known for its dense deciduous forests and rich biological diversity. The area falls under the South Balaghat Forest Division, which supports a mixture of tropical dry and moist deciduous vegetation characteristic of the Sausar Belt.

5.7.2 **Flora:** The vegetation within and around the block is dominated by tropical dry deciduous forests, with Teak (Tectona grandis) as the principal species. Other common trees include Sal (Shorea robusta), Saja (Terminalia tomentosa), Dhaora (Anogeissus latifolia), Tendu (Diospyros melanoxylon), Haldu (Adina cordifolia), Mahua (Madhuca indica), Bija (Pterocarpus marsupium), and Bamboo (Dendrocalamus strictus). The forest undergrowth comprises shrubs, grasses, and climbers such as Lantana camara, Cassia tora, and Ageratum conyzoides. These forests provide not only ecological balance but also livelihood support to local and tribal communities through the collection of non-timber forest produce (NTFP) like tendu leaves, bamboo, mahua flowers, and char seeds.

5.7.3 Scattered patches of agricultural land and open scrub are interspersed with forested areas. During the monsoon season, the vegetation becomes lush and dense, creating favourable conditions for wildlife movement. Seasonal streams and nalas further support aquatic vegetation and riparian plant species.

5.7.4 **Fauna:** The fauna of the region is typical of the Central Indian Plateau, with a variety of mammals, birds, reptiles, and amphibians inhabiting the forests around the block. Commonly observed mammals include spotted deer (Axis axis), sambar (Rusa unicolor), wild boar (Sus scrofa), Indian hare (Lepus nigricollis), jackal (Canis aureus), langur (Semnopithecus entellus), and porcupine (Hystrix indica). Occasionally, leopard (Panthera pardus) and sloth bear (Melursus ursinus) are reported in nearby forested hills and riverine tracts.

Photograph No. 5.1: Russell's Viper (Daboia russelii) observed during fieldwork in the Fulchur Reserved Forest area, Katori Jhiriya G-4 Block, Balaghat District.

5.7.5 Birdlife is abundant and diverse, including peafowl (Pavo cristatus), partridges, drongos, parakeets, woodpeckers, hornbills, and various migratory species during the winter season. Reptilian fauna such as monitor lizards, snakes (cobra, rat snake, and python), and geckos are also common.

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

5.8.1 The Katori–Jhiriya Block lies within the upper catchment of the Wainganga River Basin and is drained by a network of seasonal and perennial streams that shape the local geomorphology and provide limited water for domestic, agricultural, and ecological needs. The drainage pattern is predominantly sub-dendritic to sub-parallel, controlled by the structural grain of the Sausar Group rocks. The northern part of the block is drained by the east-flowing Chandan River, while the southern sector drains into the southeast-flowing Bawanthadi River, both ultimately joining the Wainganga. Numerous monsoon-fed nalas and first- to third-order streams arise from the hilly terrain around Fulchur, Jhiriya, Tekadi, and Chorpindkepar. Small tanks and ponds such as Fulchur tank and Jhiriya pond support irrigation and groundwater recharge. Overall runoff is moderate to high due to hilly topography and hard-rock terrain, while groundwater occurs in weathered and fractured zones with moderate yields.

5.9.0 CLIMATIC CONDITIONS

5.9.0 The Katori–Jhiriya Block, located in the southern part of Balaghat District, Madhya Pradesh, experiences a tropical monsoon climate typical of central India, with three well-defined seasons i.e. summer, monsoon, and winter. The climate is influenced by its position on the Satpura–Maikal plateau and proximity to dense forest cover, which moderates' temperature extremes to some extent.

5.9.1 **Temperature:** The summer season, extending from March to June, is generally hot and dry. During this period, the maximum temperature often rises to 42–44°C, while the minimum temperature in early mornings averages around 20–22°C. Hot winds locally known as loo are common during May. The winter season, from November to February, is cool and pleasant, with mean daily temperatures ranging between 10°C and 25°C. The coldest months are December and January, when minimum temperatures may occasionally drop below 8°C.

5.9.2 **Rainfall:** The district receives the bulk of its rainfall from the south-west monsoon, which generally sets in by the third week of June and lasts until late September. The average annual rainfall in and around the Katori–Jhiriya Block ranges between 1,200 and 1,400 millimetres, as recorded at nearby meteorological stations in Balaghat and Waraseoni. Rainfall is often heavy and concentrated in short durations, resulting in high surface runoff and temporary flooding in low-lying areas. Post-monsoon and winter rainfall from retreating monsoon currents is very limited.

5.9.3 **Humidity and Wind:** Relative humidity remains high (70–90%) during the monsoon months and declines sharply to about 30–40% during the summer season. Winds blow predominantly from the south-west and west during the monsoon and from the north-east during the dry months. Occasional thunderstorms occur during pre-monsoon months (April–May).

5.10.0 OTHER PHYSIOGRAPHIC, SOCIAL AND ENVIRONMENTAL FACTOR

5.10.1 The Katori–Jhiriya Block, located in the southern part of Balaghat District, Madhya Pradesh, lies within a region of undulating plateau and forested terrain, forming part of the Sausar–Tirodi metamorphic belt of the Satpura–Maikal physiographic province. The area is characterised by gently to moderately hilly topography, with ridges and mounds trending predominantly northeast–southwest, reflecting the regional structural grain of the Sausar Group of rocks. Elevations range from approximately 258 metres to 504 metres above mean sea level, with isolated hillocks rising above the general ground level. The physiographic features of the block exert a strong control on local drainage, soil formation, vegetation, and land use.

5.10.2 **Physiography and Land Use:** The terrain is a mixture of forest-covered uplands, agricultural plains, and lateritic surfaces. The forested slopes consist mainly of teak, sal, and mixed deciduous species, while the lower plains are used for seasonal agriculture. The principal crops cultivated include paddy, wheat, gram, and oilseeds, largely dependent on monsoon rainfall and small-scale tank irrigation. The soil profile is composed mainly of lateritic, sandy loam, and clayey soils, derived from the weathering of schist, gneiss, and quartzite bedrock. These soils are generally shallow and moderately fertile, supporting single cropping under rain-fed conditions.

5.10.3 **Social Setting:** The block is inhabited by a predominantly rural and tribal population, spread across several small and medium-sized villages such as Katori, Jhiriya, Fulchur, Chorpindkepar, Shankar Pipariya, Tuiyapar, Saleteka, and Manegaon. The Gond and Baiga tribes form a significant portion of the local community, with agriculture and forest produce collection as their main livelihoods. The literacy rate in the region is moderate, and basic infrastructure such as schools, primary health centres, and local markets are available in larger villages, while higher-order facilities are located in Waraseoni and Balaghat towns.

5.10.4 The communities maintain traditional ties with the surrounding forests, collecting non-timber forest produce (NTFP) such as tendu leaves, bamboo, mahua flowers, and char seeds, which serve as an important source of income. Seasonal migration for labour is also observed during non-agricultural months. The local population has a strong cultural identity and religious attachment to their land and sacred groves, making social consultation and participatory engagement essential during exploration activities.

5.10.5 **Environmental Considerations:** The block lies in a forest-rich zone that forms an ecological corridor linking the Balaghat forest ranges with the Kanha landscape. The area supports diverse flora and fauna, including several species of ecological significance. Although the Katori–Jhiriya block itself does not fall within a protected wildlife sanctuary or national park, its proximity to the Kanha–Bhandara Forest corridor warrants careful environmental management during exploration operations.

5.10.6 All exploration activities by MECL under the NMEDT programme have been conducted with strict adherence to environmental, forest, and safety regulations. Vegetation clearance was kept to a minimum, and drilling and trenching operations were carried out with prior forest clearance and local administrative consent. After the completion of field activities, all disturbed sites were restored to near-original condition to maintain the ecological integrity of the landscape.

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 Katori–Jhiriya Exploration Block, located in the southern part of Balaghat District, Madhya Pradesh, forms part of the Sausar geological belt, which is well known for hosting significant manganese and associated mineral deposits. The area lies within Waraseoni and Khairlanji tehsils and covers several villages, including Katori, Jhiriya, Fulchur, Chorpindkepar, Shankar Pipariya, Tuiyapar, Saleteka, Bhandarbodi, and Manegaon. The block exhibits a gently undulating to hilly terrain with elevations ranging between 258 m and 504 m above mean sea level, characteristic of the metamorphic terrain of the Sausar Group and the underlying Tirodi Biotite Gneiss.

6.1.2 **Local Infrastructure:** The block is well connected by road and rail networks, ensuring accessibility throughout the year. The Bhandara–Balaghat State Highway passes through the area, linking it to Waraseoni (≈20 km) and Balaghat (≈30 km). A network of metalled and un metalled roads connects individual villages and field locations. The nearest railway station is Waraseoni, situated on the Balaghat–Tirodi branch line, which in turn connects to the Nagpur–Balaghat railway corridor. The nearest airport is at Nagpur, approximately 170 km away. Electricity supply is available in most villages through 11 kV and 33 kV lines, and mobile network coverage is adequate for communication. Primary health centres, schools, post offices, and small markets exist in larger villages, while higher medical, banking, and administrative facilities are located at Waraseoni and Balaghat towns. The district hosts several important mining centres, including the Balaghat, Tirodi, Ukwa, and Sitapatore Manganese Mines operated by MOIL Limited, and the Malanjkhand Copper Project of Hindustan Copper Limited (HCL), located about 90 km northwest of the block. In addition, smaller mines such as Ramrama and Katangjhari extract manganese on a limited scale. These active and historical mines reflect the rich Sausar metallogenic belt, of which the Katori–Jhiriya area forms a part. The presence of roads, power, communication facilities, and nearby mining infrastructure makes the block favourable for continued mineral exploration and development

6.1.3 **Host Population and Socio-Economic Setting:** The block is inhabited predominantly by rural and tribal populations, with Gond and Baiga tribes forming a significant portion of the local community. The main occupation of the population is agriculture, supported by collection of non-timber forest produce (NTFP) such as tendu leaves, bamboo, mahua, and char seeds. The literacy rate is moderate, with educational facilities up to the middle school level in most villages. Livelihoods are seasonal and largely dependent on monsoon rainfall. The region's social fabric is closely tied to its natural surroundings, with local traditions and festivals often linked to forest and agricultural cycles.

6.1.4 **Historical and Cultural Sites:** The region has a long history of habitation and cultural heritage, reflected in its village shrines, temples, and sacred groves. Small but culturally significant places of worship are present in villages like Katori, Fulchur, and Jhiriya, which serve as focal points for social and religious activities. While no major archaeological monuments are reported within the exploration block, several historic temples and old settlements exist in the broader Balaghat region, which are preserved as part of the district's cultural heritage.

6.1.5 **Forests and Protected Areas:** Approximately 40% of Balaghat District is covered by forest, and a portion of the Katori–Jhiriya Block falls within Reserved and Protected Forests, particularly in the Fulchur and Chorpindkepar areas, managed by the South Balaghat Forest Division. The forests are predominantly tropical dry deciduous, with major tree species including Teak (Tectona grandis), Sal (Shorea robusta), Saja (Terminalia tomentosa), Dhaora (Anogeissus latifolia), Tendu (Diospyros melanoxylon), and Bamboo (Dendrocalamus strictus). These forests provide essential ecological services and livelihood support to local communities.

6.1.6 The Kanha National Park and Tiger Reserve, one of India's most prominent protected areas, lies approximately 80–90 km northwest of the block. The forests of southern Balaghat act as a transition zone and wildlife corridor between Kanha and adjoining habitats in Maharashtra, making this area ecologically significant. The fauna includes spotted deer, sambar, wild boar, langur, jackal, peafowl, sloth bear, and occasionally leopard, indicating a healthy wildlife presence in the region.

6.1.7 **Environmental Setting:** The environmental setting of the Katori–Jhiriya Block is defined by its mixed land use, comprising forested uplands, agricultural plains, and small settlements interspersed with water bodies such as seasonal nalas, ponds, and tanks. The block falls within the catchments of the Chandan and Bawanthadi rivers, which drain into the Wainganga River, a major river system of central India. The climate is tropical monsoon, with an annual rainfall of 1,200–1,400 mm, hot summers, and mild winters.

CHAPTER-7

7.0.0 GEOLOGY OF THE AREA

7.1.0 REGIONAL GEOLOGY

7.1.1 Regionally, the rock formations exposed in the area belong predominantly to the Sausar Group of Mesoproterozoic age, which unconformably overlies the Tirodi Biotite Gneiss (Pre-Sausar Basement). The Proterozoic Sausar Belt is located along the southern margin of the Central Indian Tectonic Zone (CITZ). The 300 to 350 km long CITZ trends in E-W to ENE-WSW direction and has a width of about 20 to 40 km. Geologically, the CITZ is made up of four major geologic components, from south to north (i) the southern granulite belt (Ramakona – Katangi granulite belt) (ii) the supra-crustal meta-sedimentary rocks of the Sausar Group (iii) reworked inliers of the Tirodi Gneiss and (iv) the northern granulite belt (Bhandara – Balaghat granulite belt). The central domain between two granulite belts is composed of the Sausar Group, highly deformed gneissic rocks and several intrusive granites.

7.1.2 The rocks of the Sausar Series are intensely folded in isoclinal and recumbent folds along E-W axes which generally plunge eastward or westward at low to moderate angles. The folds are generally overturned northward with their axial planes dipping steeply southward at 60°-80° along the southern part of the belt, and flattening to moderate southward dips of 30º -50° along the central parts where the isoclinal folds are recumbent. In parts of Balaghat District at the north-eastern end of the belt, the recumbent folds are very flat and are overturned to the south with low northward dips of 10°-30°. Along the northern margin of the map area, the recumbent folds are found to be thrust over older rocks in the form of thrust sheets and nappes. The belt is traversed by some major steeply dipping thrust faults trending parallel to the strike, and by minor, transverse faults, the isoclinal folds of the southern belt and the recumbent folds and thrust sheets of the northern belt have an en echelon disposition as the folds themselves show successive northward shifts when followed to the east and north-east. A similar reverse pattern of northward shifts is also apparent in Chindwara District towards the west. The structure of the belt is further complicated due to refolding or cross-folding of the earlier fold axes of the isoclinal and recumbent folds and thrust sheets. The axes of these cross-folds plunge at low to moderate angles to the west and southwest, Granite plutons and ortho-gneisses are generally found emplaced along the axes of these late cross-folds.

7.1.3 The Sausar Group is divided into six Formations which in ascending order are Sitasaongi, Lohangi, Mansar, Chorbaoli, Junewani, and Bichua Formations (Narayanaswami et al., 1963; Bandyopadhyay et. al., 1995). The Sausar Group comprises of quartzite, pelite and carbonate associations, containing stratiform manganese deposits which form the largest manganese reserves in India (e.g. Dasgupta et. al., 1984; Bhowmik et. al., 1997). The rocks are regionally metamorphosed and folded under the upper amphibolite to granulite facies condition, and intercalate tectonized gneissic rocks, which are probably derived from the reworked basements. The basement gneissic rocks, called the Tirodi gneiss, include mostly tonalitic gneiss and to lesser extent pelitic to psammitic gneisses, calc-silicate gneiss and amphibolite.

7.1.4 The area is the South-western continuation of the Balaghat-Ukwa manganese ore belt occurring within the intensely folded and metamorphosed rocks of the Pre-Cambrian Sausar Group. The geological formations of the area consist mainly of 1. Pink and Grey Gneisses and Migmatites with enclaves of high grade metamorphites and gneiss represented by Archaean aged Amgaon Gneissic complex/Tirodi Gneissic Complex and 2. Quartz-Muscovite Schist, Muscovite-Biotite Schist, Quartzo feldspathic Gneiss and Sericite Schist etc. belonging to the Mansar formation of Sausar Group of Meso-Proterozoic age., the tentative stratigraphic succession of the area given by GSI is given in Table 7.1.

Table -7.1
Generalized stratigraphy of Sausar Group (After Khan et al. (2002)

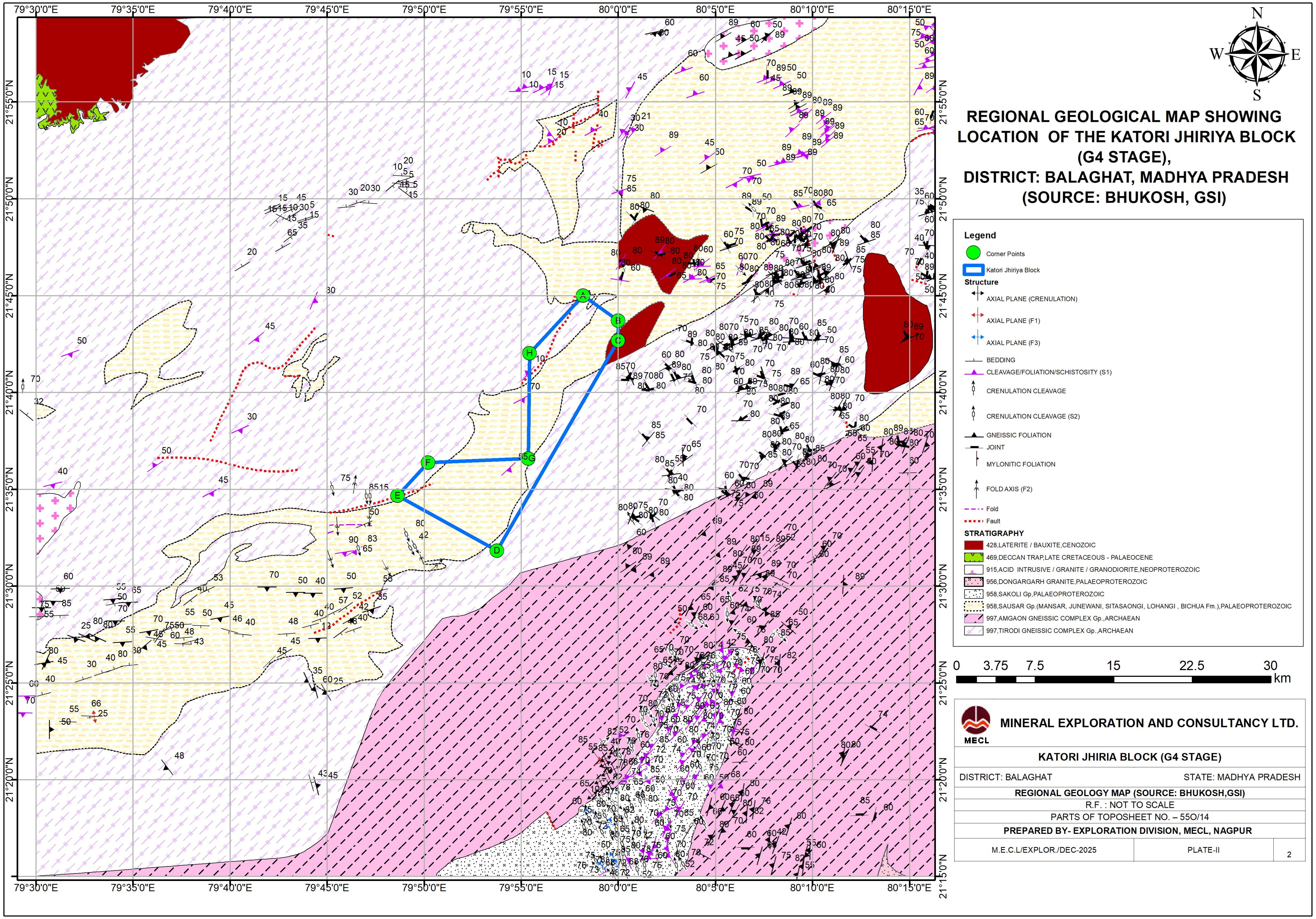
STRATIGRAPHY	GROUP	FORMATION	LITHOLOGY
Recent			Alluvium and soil
Quaternary			Laterite
Intrusives			Massive potassic granite, pegmatite, aplite and quartz veins Foliated potassic granite, occasionally rich in biotite and/or fibrolite
(Mesoproterozoic)	SAUSAR GROUP	Bichhua Formation	Pure and impure dolomitic marble with subordinate red, yellow and grey chert
		Chorbaoli Formation	Coarse grained, garnetiferous quartz mica schist with local development of magnetite and staurolite: Micaceous and/or cherty ferruginous quartzite and meta-arkose with local development of magnetite and/or garnet
		Mansar	Biotite (± fibrolite) - muscovite-quartz

STRATIGRAPHY	GROUP	FORMATION	LITHOLOGY
		Formation	schist with thin bands of quartzite and dolomitic marble and thick horizons of Mn-ore and gondite
		Lohangi Formation	Calc silicate rocks, calc-gneiss with subordinate pink calcitic marble and minor Mn ore horizons.
--------------------------Tectonised Contact---------------------------			
(Archaean)	Pre-Sausar Basement	Tirodi Biotite Gneiss (TBG)	Multicomponent gneiss e.g. biotite gneiss, migmatite gneiss, quartzo feldspathic gneiss, felsic gneiss, tonalite-gneiss, cordierite-gneiss etc with small metabasic and mafic granulite enclaves; often highly deformed and converted to biotite-fibrolite-schist

7.1.5 The stratigraphic succession proposed for the Sausar Mobile Belt is still unresolved to some extent due to the absence of any basement-cover relationship as well as structural and metamorphic complexities. Narayanswami et.al., 1963, considered Tirodi Biotite Gneiss (TBG) as the basement of the Sausar Group. The contact between Tirodi Biotite Gneiss and the Sausar Group is mostly tectonised at most places. Recently polymictic conglomerate has been reported at the contact of Tirodi Biotite Gneiss and the Sausar Group from the locality of Mansar (Mohanty, 1993), thereby conforming that the Tirodi gneiss is the basement of the Sausar Group.Recent workers (Pal and Bhowmik, 1998; Khan et al., 2000 and Chatopadhyay et al., 2001) on the basis of structural evidences have said that the TBG is a combination of different type of gneisses i.e. biotite gneiss, granite gneiss, migmatite gneiss and patches of older supracrustalsforming the crystalline basement.

7.1.6 Sausar Group is composed primarily of metamorphosed sandy, shaly and calcareous sediments. Volcanic rocks are virtually absent. Calcareous formations are best developed to the north and west, and argillaceous units to the south and east. In general, they have been metamorphosed to upper amphibolite facies, but have also undergone anatexis to produce migmatites and gneisses. In general, the metamorphism increases to the north and west. Near the Balaghat Mn mine they are of greenschist facies, while farthest to the north-west rocks with a granulite assemblage are encountered. Deformation is intense and is coeval with the metamorphism, producing shearing, thrusting and nappe development (Mahmood Naqvi and Rogers, 1987; Jain, et al., 1995).

TEXT FIGURE 7.1: REGIONAL GEOLOGICAL MAP OF THE PART OF SAUSAR MOBILE BELT (AFTER GSI) SHOWING LOCATIONS OF KATORI JHIRIYA BLOCK, DISTRICT-BALAGHAT, MADHYA PRADESH



MECL

7.2.0 REGIONAL STRUCTURE

7.2.1 The Sausar rocks are known to have undergone three phases of deformation. Tight, isoclinal to recumbent folding along NE-SW to ENE-WSW axial trend marks the first phase of folding and produces S1 schistosity. The second phase of isoclinal folding is essentially co-axial but non co-planner to F1 folds and produced shallow dipping (30°) S2 axial plane cleavages. NW-SE to WNW-ESE trending open warps with steep plunges (70°) represent last phase of folding.

7.2.2 The structure of the belt may be described under the following four divisions:

- Southern belt of overturned, isoclinal folds.
- Northern belt of recumbent folds and thrust blocks or nappes.
- Central belt of gneissic formations of the nature of crystalline axis with narrow and linear outcrops of infolded schists.
- Regions of refolding or cross-folding and associated granite plutons.

7.2.3 **1) Southern belt of isoclinal folding:** This belt, characterized by steeply dipping, overturned, isoclinal folds extend along the southern portion of the manganese ore belt from Kelod-Salai-Parseoni in north-western Nagpur District, through Mansar-Goguldoho in northern and north-eastern Nagpur District and Dongari Buzurg-Chikhla-Bhajiadand-Waraseoni region innorthern Bhandara and Balaghat Districts to Bharweli-Ukwa region in eastern Balaghat District. The axes of these folds' trend WNW-ESE to eastwest in Nagpur District, and gradually veer to ENE and NE in Bhandara and Balaghat Districts. They plunge at low angles of 20°-30 ° eastward, though westerly plunges are also noticeable at intervals due to the cross folding.

7.2.4 2) **Northern belt of recumbent folds, thrust blocks and nappes.** This belt extends from Sapghota-Ambajhiri in north-western Nagpur through Deolapar region (W. D. West, 1936) in northern Nagpur District to the Sonawani and the Dhansua R.F. in northern and north-eastern Balaghat. District. The belt is characterized by at least four thrust blocks or nappes which have not yet been connected together along their strike. These are (1) Sapghota thrust block, (2) Ambajhiri thrust block, (3) Deolapar nappe and (4) Sonawani thrust block. They consist of younger rocks of the Sausars (Chorbaoli to Bichua stages) which have been thrust over the Tirodi biotite-gneiss, and form steep to moderate dipping overturned, isoclinals folds and fiat-dipping recumbent folds whose axes are conformable to the regional fold axes. In the Sapghota-Ambajhiri and Deolapar thrusts, the thrust plates reveal steep to moderate southerly dips along their southern margins and low to flat dips along their northern margins. The Sonawani thrust block shows low to moderate dips to the north, but the northern limit of the thrust has not yet been mapped. The folds within the thrust blocks or nappes are generally doubly plunging synclinal structure which are themselves folded, recumbent folds; the succession of rocks in the case of Ambajhiri and Deolapar nappes is reversed, but is normal in the case of Sonawani and adjacent thrust blocks.

7.2.5 **3) Central belt of gneissic formations with narrow infolded schist:** This belt consisting of extensive stretches of Tirodi biotite-gneiss arid characterized by numerous narrow, linear, infolded runs of schists occupy the region between the two structural divisions described above and appears to represent the central crystalline axis of the tectonic framework. An extensive area of this belt is exposed in Balaghat District between the Bawanthari River in the south-west, Tangla and Karwahi RF on the west and Kurai and Sonawani RF in the north and extends through the alluvial plains of Katangi, Waraseoni and Balaghat up to the Dhansua RF and other hill tracks in north-eastern Balaghat District. The individual outcrops are mostly less than 200 ft. in width and some are four to five miles in length, and occur within the biotite gneiss with a general ENE-WSW to NE-SW regional trend. They are considered to be remnants of steep to flat dipping infolded, recumbent, refolded folds, consisting chiefly of Mansar muscovite schist and the associated manganese ore horizon and Sitasongi quartz-muscovite-schist. The Tirodi-Sukli-Garra area is underlain by the largest number of these infolded runs of Mansar schists and manganese ore bodies in an apparently inverted sequence. There are three other detached areas that form part of this belt: (1) An east-west area in the Warpani R.F. in north-western Nagpur District, (2) An east-west area extending westward from Mangarli to west of Paunia in Northern Nagpur District, and (3) A small area extending westward from Aoleghat in north-eastern Nagpur District. The area to the east of Mangarli is characterized by numerous infolded Mansar schist outcrops.

7.2.6 **4) Regions of Cross-folding and refolding:** Evidences are found throughout the manganese ore belt for a late-stage deformation which has affected the earlier folds to varying degrees. These later folds which may be described as cross-folds are classified into the following groups:

7.2.7 (1) These cross-folds have their axes at about 45 ° to the axes of earlier folds, and plunge at moderate angles in the opposite direction. They are found in force in the central part of the belt from Ramtek in Nagpur District to Pusada in northern Bhandara and Tirodi area in Balaghat District. The most characteristic one in this region is the Alesur-Susurgeh-Pusada crossfold which plunges at 30°-50° south-west, whereas the earlier isoclinal folds plunge at 25°-30 ° east.

7.2.8 (2) Those which are parallel to the earlier ones, but their axes plunge in the opposite direction generally at 20°-30 ° west or south-west. Examples of this type are found in the Goguldoho--Junewani-Suwardhara-Parseoni region of northern Nagpur District, and along the Chandpur quartzite range ia northern Bhandara District.

7.2.9 (3) Those having their axial planes parallel to the main folds and whose axes plunge at 10°-20 ° west or WSW. These are common in the thrust blocks in the Ambajhiri, Deolapar and Sonawani areas.

7.2.10 4) Those whose axes plunge in the direction opposite to that of earlier folds at intervals along their strike. This type is commonly seen in the southern belt of isoclinal folding, e.g., in the Bharweli-Ukwa syncline in eastern Balaghat District, in the Chilha-Mangarli region in northern Bhandarn District and in the Goguldoho-Junewani-Suwardhara in northern Nagpur District. Cross-folding is seen to be intensely developed in the central belt of gneissic formation extending from Ramtek to Pusada and Tirodi where the first type is common. A number of granite plutons is also seen along this axis indicating the severity of deformation. The intensity of crossfolding fades out on either side of this central axis, where other types of cross-folds are developed.

7.3.0 METAMORPHISM IN THE REGION:

7.3.1 Metamorphism in the Balaghat region is primarily characterized by upper amphibolite to granulite facies conditions that affect the rocks of the Sausar Group and the underlying Tirodi Biotite Gneiss basement.

7.3.2 The metasedimentary rocks of the Sausar Group, such as calc-silicates, marbles, quartz-muscovite schists, and ferruginous quartzites, typically exhibit mineral assemblages including garnet, diopside, epidote, hornblende, microcline, plagioclase, quartz, staurolite, and sillimanite, marking the transition from upper amphibolite to lower granulite facies. In marbles and dolomitic rocks, minerals like tremolite and saccharoidal calcite are prominent, indicating the effect of contact as well as regional metamorphism.

7.4.0 **MINERALISATION IN THE REGION:**

7.4.1 Manganese mineralisation in the region is primarily hosted within the metasedimentary rocks of the Sausar Group, part of the Proterozoic Sausar Mobile Belt. This belt is renowned for its substantial stratiform manganese deposits, some of which represent the largest reserves in India.

7.4.2 The main manganese ores occur as stratiform bands within the Mansar and Lohangi Formations of the Sausar Group. These formations comprise biotite-muscovite-quartz schists, quartzites, and marbles that have undergone regional metamorphism up to upper amphibolite facies. The manganese ores are closely associated with silicate (gondite) and oxide ore assemblages, with the ore bodies occurring as lensoid, tabular, and sometimes irregular bands concordant and occasionally discordant within the host rocks.

7.4.3 The major manganese ore minerals include Manganese oxides (pyrolusite, psilomelane), Manganese silicates (spessartine, rhodonite), Carbonates (rhodochrosite, kutnohorite in altered zones), Iron oxides (hematite, magnetite, often as accessory phases in ore bands). The exposures frequently demonstrate banding and schistosity, and metasedimentary structures are usually preserved, indicating a primary sedimentary origin which has been overprinted by regional metamorphism and deformation. The genesis of manganese deposits is interpreted as sedimentary, with subsequent metamorphism resulting in silicate ore (gondite) formation. Structural features, such as fold hinges and shear zones, localize ore concentrations, with the ore horizons typically paralleling the regional foliation. Late-stage hydrothermal fluids may remobilize Mn locally, resulting in the redeposition of oxides and carbonates.

7.5.0 BLOCK GEOLOGY

7.5.1 The Katori Jhiriya G-4 Block forms an integral part of the Sausar Mobile Belt, located in the southern part of Balaghat District, Madhya Pradesh. The area represents one of the most significant metamorphic segments of the central Indian shield. The block occupies the central portion of the Sausar Series and exhibits a well-preserved stratigraphic succession of Mesoproterozoic age, comprising metamorphosed sedimentary and igneous rocks. The region is known for hosting economically important manganese and associated mineralization within the Mansar Formation of the Sausar Group.

7.5.2 Geologically, the Katori Jhiriya Block predominantly exposes lithounits belonging to the Palaeo to Meso Proterozoic Mansar Formation of the Sausar Group. The principal rock types include muscovite schist, biotite schist, and quartzite with manganese enrichment, intruded by quartz veins and granitic bodies. The pre-Sausar basement is represented by the Tirodi Biotite Gneiss (TBG), which underlies the Sausar metasedimentary sequence and exhibits a tectonic contact relationship with it.

7.5.3 The lithounits exhibit a general strike of NE–SW with moderate to steep dips (45°–75° SE). The structural pattern indicates multiple deformation episodes, resulting in tight to isoclinal folding, crenulation, and shearing. The muscovite schist is the dominant unit, while biotite schist occurs interlayered with it. The manganese-bearing quartzite appears as thin bands conformable with foliation. The gneissic basement shows strong lineation and banding, often sheared along the contact with schistose rocks.

7.5.4 Overall, the lithostratigraphic succession of the Katori Jhiriya G-4 Block displays a complete and conformable sequence from biotite gneiss of Tirodi Biotite Gneiss through the muscovite-biotite schist, quartzite, and manganese-bearing, iron ore and calc-gneissof Sausar group intruded by granitic and quartz vein, and finally covered by lateritic and alluvial deposits.

7.5.5 Metamorphism in the Katori Jhiriya Block is of medium to high grade, corresponding to the amphibolite facies, as confirmed by petrographic analysis of drill core samples. The mineral assemblages include quartz, muscovite, biotite, feldspar, garnet, and sillimanite, with accessory hematite and manganite. The textures range from lepidoblastic in schists to granoblastic and gneissic in gneisses, indicating dynamic metamorphism.

7.5.6 Manganese occurs in oxide and silicate phases, commonly as disseminations and streaks of pyrolusite, psilomelane, braunite, and hausmannite, along foliation planes and quartz lenses. The Mn mineralization is syn-sedimentary in origin, later remomilised and deposited during metamorphism and deformation.

7.5.7 The local stratigraphic sequence of litho units exposed in the Katori Jhiriya block area is given in Table 7.2. The detail description of the different litho units occurring in the block is given in the following paragraphs. The Geological map of the block is presented as Plate No.-IIIA and Text Figure-7.2.

Table 7.2

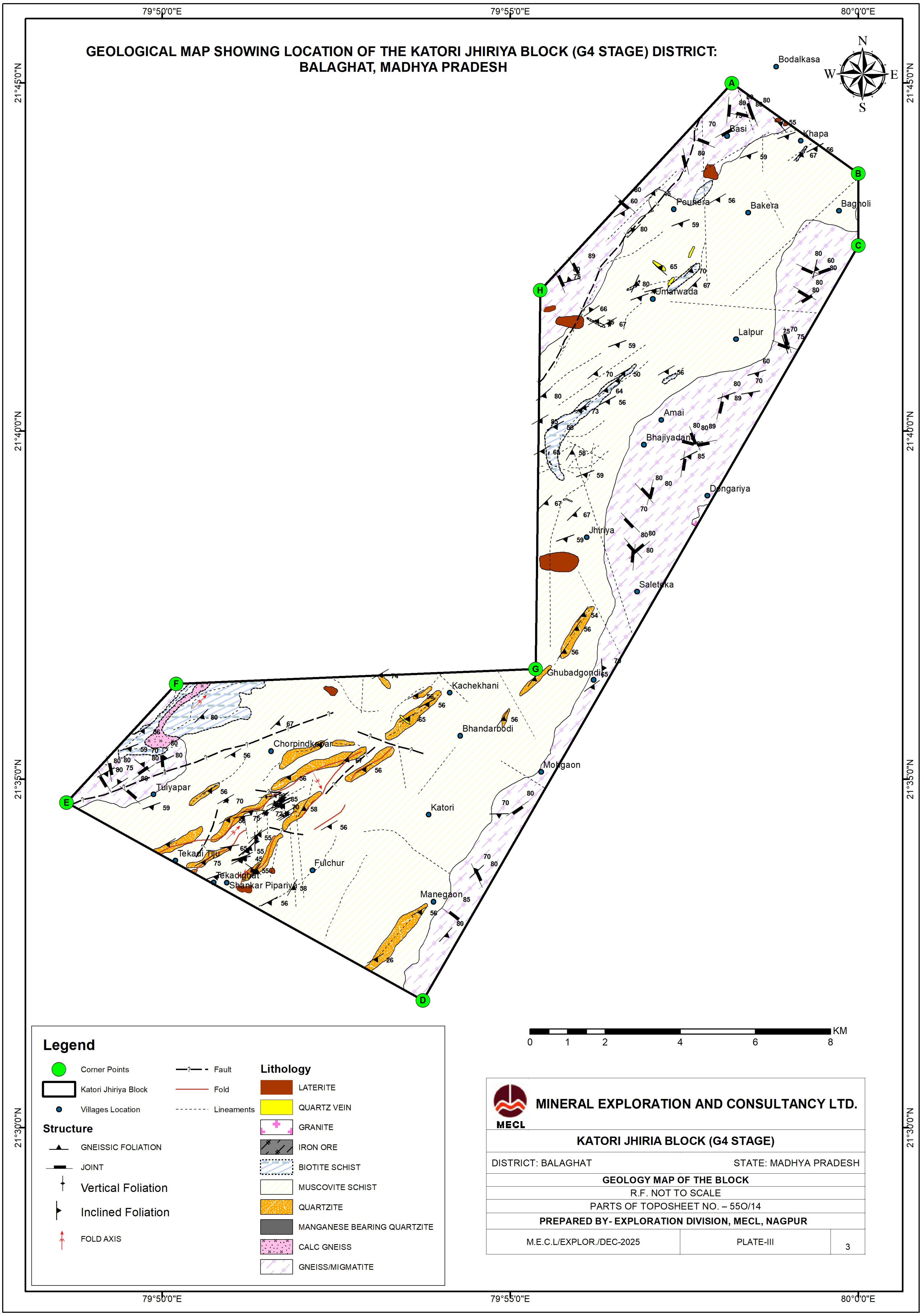
Stratigraphic Sequence of Katori Jhiriya Block, District: Balaghat, Madhya Pradesh (After, GSI)

STRATIGRAPHY	GROUP	FORMATION	LITHOLOGY
Recent			Alluvium and soil
Quaternary			Laterite
Intrusives			Massive potassic granite and quartz veins
(Mesoproterozoic)	SAUSAR GROUP	Chorbaoli Formation	Cherty ferruginous quartzite and meta-arkose with local development of magnetite and/or garnet
		Mansar Formation	Biotite (± fibrolite) - muscovite-quartz schist with thin bands of quartzite and thick horizons of Mn-ore
		Lohangi Formation	Calc silicate rocks, calc-gneiss
--------------------------**Tectonised Contact**--------------------------			
(Archaean)	Pre-Sausar Basement	Tirodi Biotite Gneiss (TBG)	biotite gneiss, migmatite gneiss

7.6.0 DESCRIPTION OF ROCK TYPES PRESENT IN BLOCK.

7.6.1 The Katori Jhiriya G-4 Block, located within the Sausar metamorphic belt, exposes a sequence of metasedimentary rocks belonging to the Mansar Formation of the Sausar Group, resting over the Tirodi Biotite Gneiss (TBG) basement. The lithounits encountered both in surface mapping and subsurface drilling include soil/laterite, muscovite schist, biotite schist, manganese-bearing quartzite, quartzite, and granite gneiss. These are described below in order of their stratigraphic position.

TEXT FIGURE 7.2: GEOLOGICAL MAP OF KATORI JHIRIYA BLOCK, DISTRICT – BALAGHAT, MADHYA PRADESH



7.7.0 GRANITE GNEISS / MIGMATITE (TIRODI BIOTITE GNEISS – BASEMENT UNIT):

7.7.1 The Tirodi Biotite Gneiss (TBG) represents the oldest lithological unit forming the basement complex of the Katori Jhiriya G-4 Block. It is a high-grade metamorphic rock of Archaean to Paleoproterozoic age, belonging to the Tirodi Gneissic Complex, which underlies the metasedimentary succession of the Sausar Group. The gneiss occurs prominently in the eastern and southeastern parts of the block, where it forms low-lying outcrops and rugged hillocks.

7.7.2 **Field Occurrence and Distribution:** In the field, the Tirodi Biotite Gneiss is exposed mainly around Dongariya, Jhiriya, and southeastern portions of the block, where it shows well-developed gneissic banding and tight folding, as seen in the reference photograph. It forms the basement rock over which the metasedimentary sequence of the Sausar Group (Mansar and Lohangi formations) is deposited with a tectonized contact. The gneiss is generally grey to dark grey, medium- to coarse-grained, and shows alternating felsic (quartz–feldspar) and mafic (biotite–hornblende) bands.

7.7.3 The unit frequently displays migmatitic textures, particularly in zones where partial melting occurred, producing leucocratic quartzo-feldspathic veins and patches that intrude the gneissic foliation. These migmatitic veins exhibit irregular folding, warping, and boudinage structures, demonstrating the intense ductile deformation experienced by the basement during regional metamorphism. In drilling, the TBG / migmatite was intersected asthin layer in MKJ-07 (46.00–48.00 m), underlying the muscovite and biotite schists of the Mansar Formation. The cores show gneissic banding, leucocratic granitic veins, and feldspar-rich segregations, confirming the intrusive and migmatitic character of this basement unit.

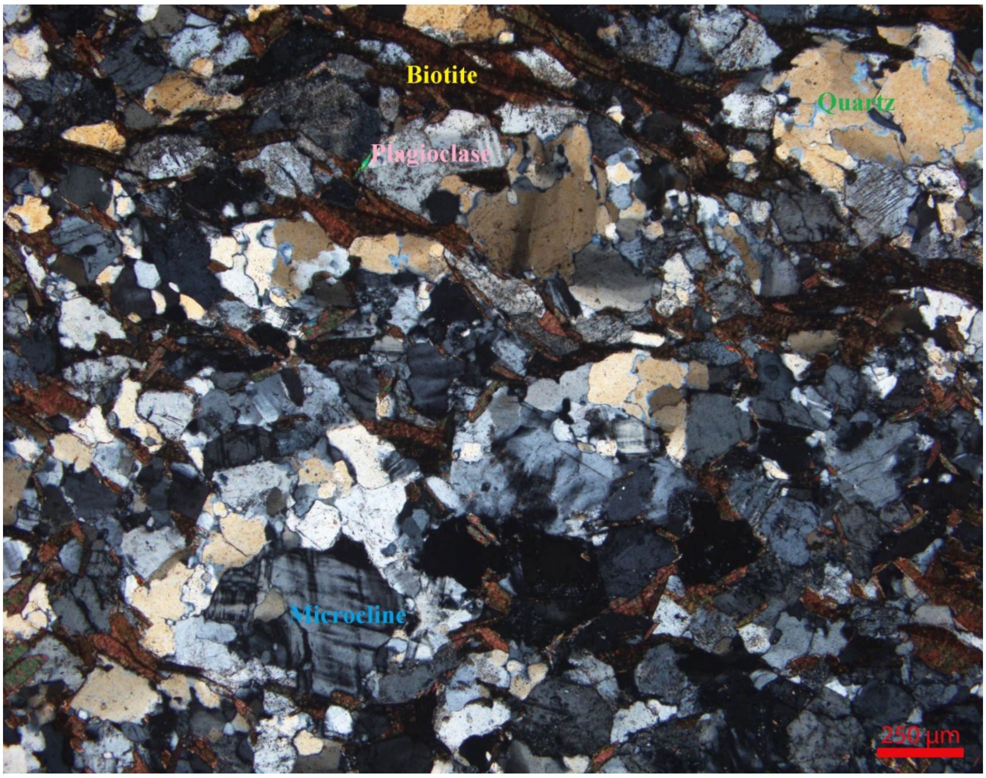
7.7.4 **Lithology and Mineral Composition:** Petrographic studies (sample MP-KJ/P/21 and) reveal that the rock is composed primarily of:

- Quartz (30–35%) – clear, anhedral to subhedral, showing undulose extinction.
- Plagioclase and K-feldspar (25–30%) – partly altered, showing perthitic intergrowth.
- Biotite (20–25%) – brown to dark brown, flaky, showing pleochroism and aligned along foliation.
- Hornblende (5–10%) – in the migmatitic zones, indicating amphibolite facies metamorphism.

7.7.5 Accessory minerals include muscovite, epidote, zircon, and opaques. The gneiss shows alternating mafic and felsic layers, and in places, granitic melt veins cut across the foliation, indicating anatexis during metamorphism.

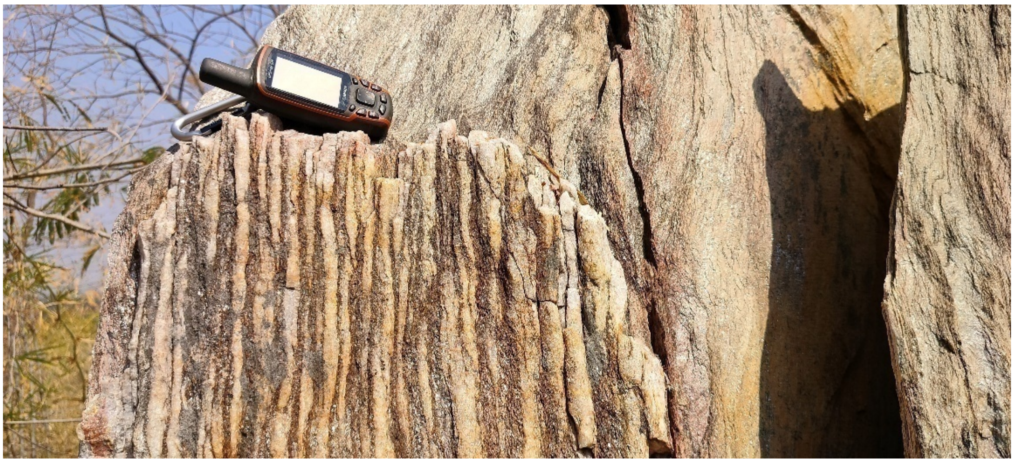
7.7.6 MKJP-06: Borehole MKJ-07 (47.70–47.80 m depth): The thin section shows a medium- to fine-grained metamorphic rock with a lepidoblastic to granoblastic texture. Microcline and plagioclase occur as medium- to fine-grained subhedral to anhedral crystals, commonly exhibiting crude alignment. Microcline is also present as moderately coarse blasto-porphyritic grains, some showing rotational strain features. Quartz occurs as fine- to medium-grained anhedral crystals and as clustered pockets occupying interstitial spaces.

7.7.7 Biotite is present as fine- to medium-grained flakes and flaky aggregates, displaying preferred parallel alignment. Muscovite occurs as fine flakes, commonly associated with biotite. Sericitization of plagioclase is evident, with sericite forming along cleavage and grain boundaries. Calcite vein/filling material is observed locally, intruding grain boundaries and microfractures. Zircon appears as very fine inclusions within biotite, surrounded by distinct pleochroic halos, indicating metamorphic overprint.



Pmg – 4: Photomicrograph showing association and parallel alignment of microcline, quartz, plagioclase and biotite in granite gneiss as seen under crossed nicols.

Specimen No.: MKJP-06 **Magnification : 40X**



Photograph No. 7.1: Field exposure of Tirodi Biotite Gneiss showing folded gneissic banding with alternating quartz-feldspar and biotite layers showing nearly vertical dip.

Photograph No. 7.2: Steeply standing gneissic ridges in the western part of the Katori Jhiriya Block showing NE–SW foliation trend and tight folding pattern.

7.8.0 CALC-GNEISS (LOHANGI FORMATION, SAUSAR GROUP):

7.8.1 The Calc-gneiss represents one of the significant lithounits of the Lohangi Formation within the Sausar Group, occupying the southwestern and western part of the Katori Jhiriya G-4 Block, particularly around Chorpindkepar villages. It marks the transition from argillaceous (Mansar Formation) to calcareous lithologies within the Sausar metasedimentary sequence.

7.8.2 The rock is well foliated, fine- to medium-grained, and banded, composed mainly of calc-silicate minerals, quartz, feldspar, and subordinate mica, often grading into biotite or muscovite schist.

MECL

7.8.3 Field Occurrence and Distribution: In the southwestern part of the Katori Jhiriya Block, especially west and northwest of Chorpindkepar village, the calc-gneiss forms low ridges and small knolls showing a distinct greyish-white to light greenish colouration.

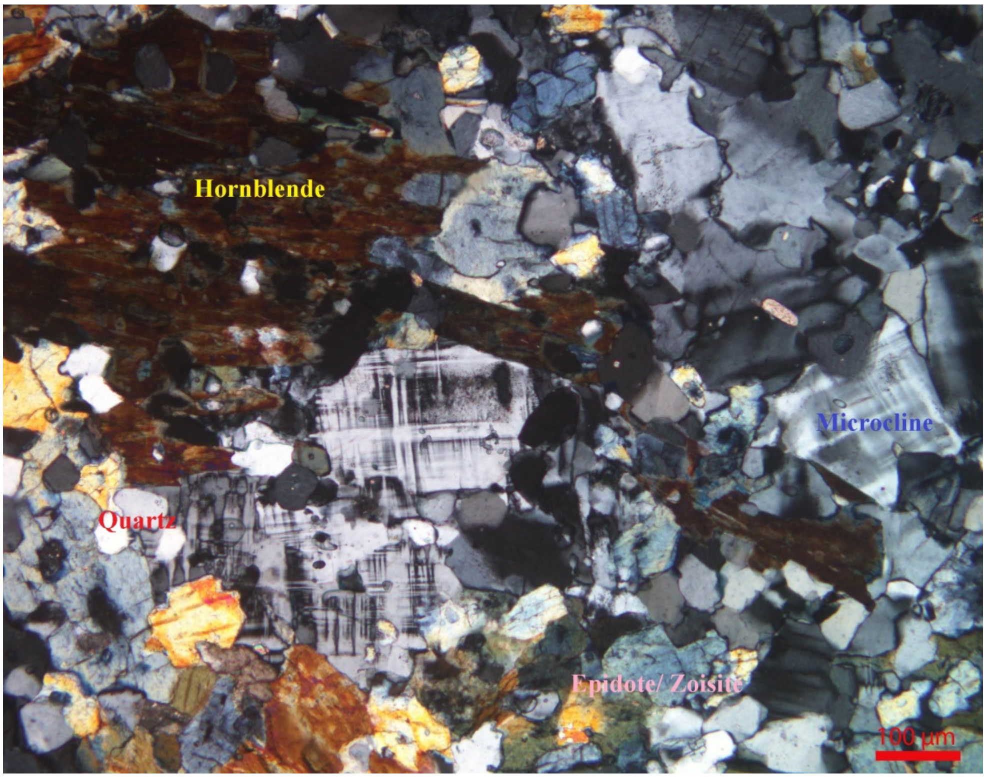
7.8.4 It is spatially associated with biotite schist and quartzite bands of the Mansar Formation and occurs conformably below them, suggesting stratigraphic continuity within the Sausar succession. The foliation is NE–SW to ENE–WSW, dipping 45°–70° SE, consistent with the regional Sausar structural trend.

7.8.5 The gneiss displays alternating quartz-feldspathic and calc-silicate bands, giving it a gneissic to banded appearance. The weathered surface is light brown to pale grey, while the fresh rock is greyish-white with greenish streaks due to the presence of amphibole minerals.

7.8.6 Although no distinct calc-gneiss layer was recorded in drilling, thin calc-silicate interbands were observed within the biotite schist zones in the southwestern boreholes (MKJ-05 and MKJ-06). These subsurface occurrences suggest that the calc-gneiss unit is relatively thin and laterally discontinuous, restricted to the southern and southwestern extremities of the block.

7.8.7 **Petrographic and Mineralogical Characteristics**: (Petrographic sample: MP-KJ/P/23, NW of Chorpindkepar village) Petrographic examination of the representative sample (MP-KJ/P/23) reveals that the rock is a fine- to medium-grained calc-silicate gneiss, composed mainly of:

- Plagioclase (30–35%) – subhedral, polysynthetically twinned, showing partial saussuritization.
- Quartz (25–30%) – anhedral, strained, interlocking grains.
- Hornblende (20–25%) – dark green to brown, pleochroic, forming elongate prismatic crystals aligned along foliation.
- Biotite (5–10%) – reddish brown, flaky, locally altered to chlorite.
- Calcite (5–8%) – fine to medium grained, occurring as discrete granules and interstitial patches.
- Accessory minerals: opaques (magnetite, ilmenite), zircon, epidote, and sphene (titanite).



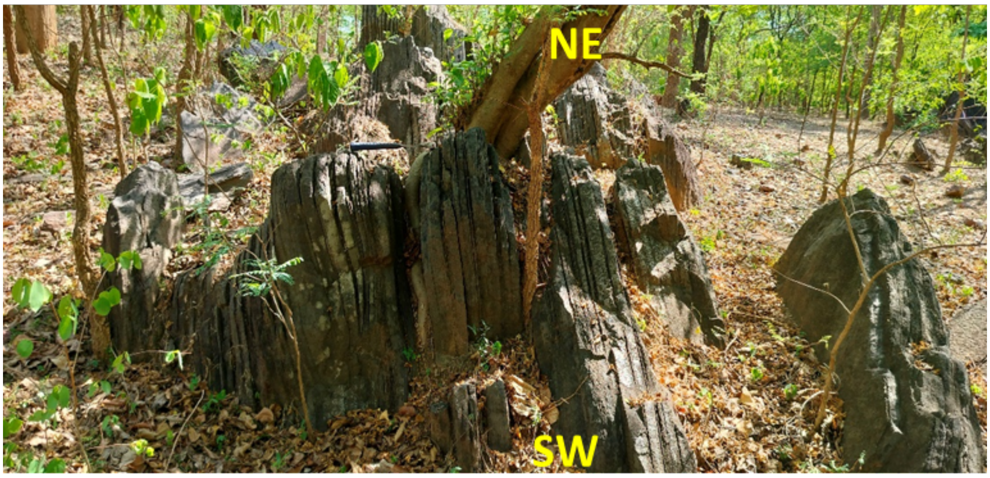
Pmg – 2: Photomicrograph showing association of microcline, quartz, hornblende and epidote/ zoisite in hornblende rich granite gneiss as seen under crossed nicols.

Specimen No. :MP-KJ/P/23 **Magnification : 100X**

7.8.8 The texture is granoblastic to nematoblastic, indicating recrystallization under amphibolite facies conditions. The intergrowth of hornblende with calcite and quartz, together with subordinate biotite and plagioclase, suggests a metamorphosed calcareous sedimentary protolith rather than an igneous parent rock. Field and petrographic evidence indicate that this rock represents calcareous metasediments, which underwent regional metamorphism and deformation during the Sausar Orogeny. The alternating quartz-feldspar–calcite–hornblende layers reflect original chemical sedimentary banding, now transposed into gneissic foliation.

7.8.9 The presence of hornblende results from metamorphic reaction between calcite and silicate minerals, marking contact metamorphism or localized thermal overprint at the transition between the Mansar and Lohangi Formations. The chemical composition and mineralogy suggest derivation from impure carbonate sediments (marl or dolomitic limestone), metamorphosed under amphibolite-facies conditions (550–650°C, medium pressure). Minor silicification and ferruginous staining along foliation planes are common, caused by late-stage fluid movement and partial oxidation Though the calc-gneiss itself is not mineralized, its stratigraphic position is critical in understanding the structural setting and metamorphic gradient of the block. It provides a lithological marker horizon indicating the base of the Mn-bearing sequence.

7.8.10 The presence of hornblende and epidote suggests localized hydrothermal or metasomatic activity, which may have contributed to minor Fe–Mn remobilization within the adjacent schist and quartzite bands. Thus, the calc-gneiss in the southwestern Katori Jhiriya Block marks the lower limit of manganese-bearing stratigraphy, underlying the ore-hosting muscovite and biotite schists, and recording the transition from pelitic to calcareous depositional conditions within the Sausar basin.



Photograph No.7.3: Photograph Calc-Gneiss exposure west of Chorpindkepar village showing NE–SW trending foliation and folding

7.9.0 QUARTZITE (MANSAR FORMATION, SAUSAR GROUP):

7.9.1 Quartzite forms an important but non-mineralised lithounit within the Mansar Formation of the Sausar Group, representing metamorphosed arenaceous sediments of the original manganese-bearing basin. It is distinct from the gondite/manganese horizons, although it locally occurs in close association with them. The major exposures of quartzite are observed near Fulchur, Manegaon, and Saleteka villages, extending westward towards Chorpindkepar and Paunera, forming narrow ridges and low hills trending NE–SW.

7.9.2 **Field Occurrence and Distribution:** In the field, quartzite appears as light grey to milky white, hard, compact, and fine- to medium-grained rock. It displays well-developed foliation and banding, corresponding to the regional NE–SW structural grain of the block. Bedding and foliation are often parallel, with the unit dipping between 45° and 60° towards the SE, as observed near Saleteka (Photo 7.4: field exposure). In certain localities, thin muscovite-rich laminae are interbedded within the quartzite, suggesting gradational contact with overlying schists.

7.9.3 The quartzite horizons are laterally persistent and occur stratigraphically above the calc-gneiss and below the muscovite–biotite schist, forming a conformable part of the Mansar metasedimentary sequence. They represent metamorphosed arenaceous facies deposited contemporaneously with the chemical sediments that later gave rise to the gonditic manganese bands.

7.9.4 **Petrographic and Mineralogical Characteristics:** Petrographic examination (sample MP-KJ/P/4, south of Manegaon village; borehole MKJ-05, 42.30–42.40 m) reveals that the rock is composed predominantly of:

- Quartz (≈90%),
- Muscovite and biotite (≈5–8%), and
- Minor feldspar and hematite as accessory constituents.

7.9.5 The rock exhibits a granoblastic to lepidoblastic texture, with sutured quartz grains and parallel flakes of muscovite defining a weak foliation. Iron oxide staining and minor ferruginisation are common along fractures and foliation planes.

Photograph No. 7.4: Photograph Quartzite exposed near Saleteka village showing NE–SW strike and 54° SE dip

7.9.6 Quartzite exposure near Saleteka village displaying a well-defined NE–SW strike (045°/225°) and a moderate dip of 54° towards the SE. The quartzite bed shows prominent foliation/bedding planes dipping SE, accompanied by two distinct joint sets: (i) a sub-vertical joint set striking approximately NW–SE (320°/140°), and (ii) a cross-joint set striking roughly ENE–WSW (070°/250°) with moderate dips. The exposure illustrates typical brittle deformation features of the Mansar Formation quartzite within the Sausar Group.

7.10.0 GARNET RICH QUARTZITE / MANGANESE BEARING QUARTZITE (MANSAR FORMATION, SAUSAR GROUP):

7.10.1 Manganese mineralisation in the Katori Jhiriya G-4 Block occurs as lensoidal to banded bodies within the Mansar Formation of the Sausar Group. The ore bands are conformable with the regional foliation and enclosed within muscovite–biotite schist and Mn-bearing quartzite. Field mapping, geophysical survey and trenching have delineated three principal mineralised zones, (i) Shankar Pipariya Zone, (ii) Chorpindkepar–Jhiriya Zone, and (iii) Tekadi Tiju Zone. These zones collectively define a NE–SW-trending manganese belt exhibiting variable dips from 43°–50° due NE (Shankar Pipariya), 65° NW to 90° vertical and 45°–85° SE (Chorpindkepar), and 52° SE (Tekadi Tiju).

7.10.2 The manganese occurs as banded, streaky, and lensoid bodies, usually 1–3 m thick, with limited lateral continuity due to folding and shearing. The ore exposures are often associated with oxidised and ferruginised zones within the schistose host, and small old working pits mark earlier local exploitation.

7.10.3 **Lithological Association and Field Relationship:** The mineralisation is confined to the Mansar Formation, resting over the Lohangi Formation (calc-gneiss) and underlain by the Tirodi Biotite Gneiss (TBG) basement. The Mn-bearing zones are concordant with the regional schistosity and typically occur as thin intercalations of manganiferous quartzite and schist.

7.10.4 At surface, manganese ore exhibits dark brown to black, compact, occasionally associated with manganiferous laterite in weathered zones. In the subsurface, drilling has confirmed mineralised body intersections only in MKJ-01 (25–27 m) and MKJ-05 (42.24–44.33 m and 46.30–49.00 m), indicating narrow and discontinuous bands of manganese enrichment within muscovite–biotite schist and Mn-bearing quartzite.

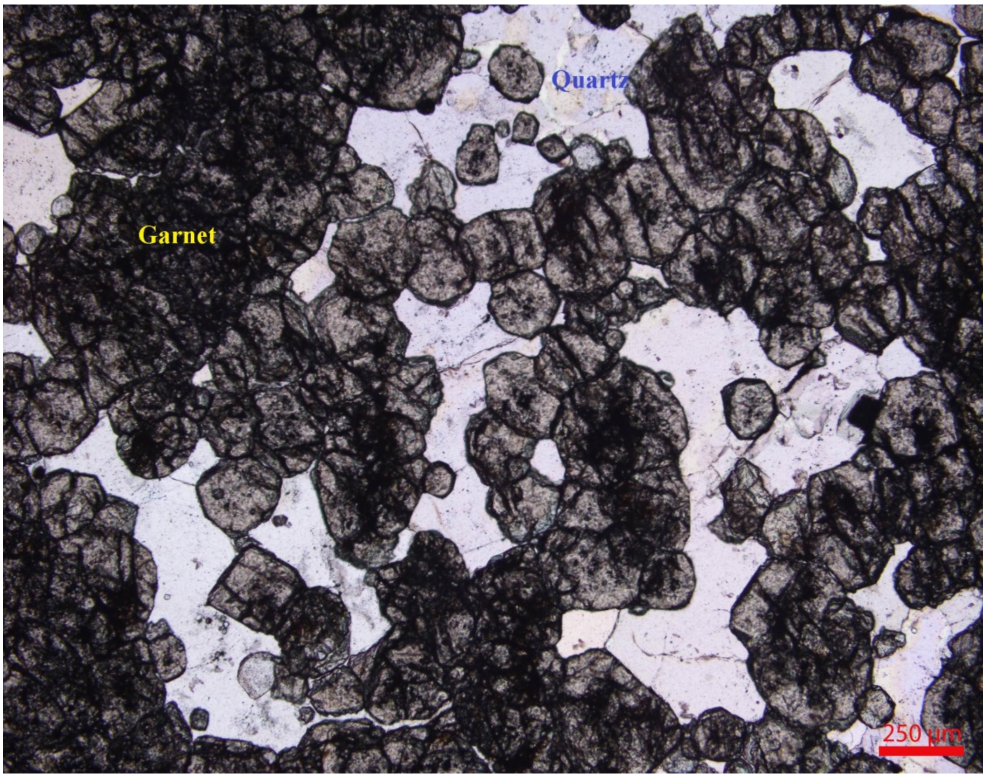
Photograph No. 7.5: showing Manganese Bearing Quartzite intersected in MKJ-05 borehole

7.10.5 **Petrographic and Mineralogical Features of Mn Ore:** Microscopic and mineragraphic studies on representative core and hand specimens reveal that the ore consists primarily of:

- Braunite, Hausmannite, and Pyrolusite as dominant manganese minerals;
- Accessory psilomelane, hematite, and spessartite garnet within a quartz–muscovite matrix.

7.10.6 The manganese minerals occur as granoblastic aggregates, disseminations, and streaky bands, often replacing silicate minerals along foliation planes. The ore exhibits a metamorphic texture indicating recrystallisation under regional metamorphism of the Sausar Mobile Belt. The mineral assemblage (Braunite–Spessartite–Quartz–Muscovite) confirms the gondite-type paragenesis typical of the Mansar Formation. (*Reference: Krishnan, M.S. (1982): Geology of India and Burma, CBS Publications, New Delhi — discussion of gondite-type Mn deposits of the Sausar Belt*)

7.10.7 The MKJP-04 petrographic thin section was prepared from a borehole sample collected between 42.30 m and 42.40 m depth in Borehole MKJ-05. The rock displays a granoblastic to lepidoblastic texture. Garnet occurs as patchy segregations composed of fine- to medium-grained, subrounded crystals. Quartz is present as fine- to medium-grained anhedral crystals occupying interstitial spaces between garnet clusters. Opaque minerals occur as fine intrusive fillings and irregular patches. Biotite appears as fine to very fine flakes and patchy aggregates, locally replacing garnet, indicating retrogressive alteration during the later metamorphic stages



Pmg – 3: Photomicrograph showing association of garnet and quartz in garnet rich quartzite as seen under plane polarized light.

Specimen No. : MKJP-04 **Magnification : 40X**

7.11.0 MUSCOVITE SCHIST (MANSAR FORMATION, SAUSAR GROUP):

7.11.1 The Muscovite Schist represents the dominant lithounit of the Mansar Formation within the Sausar Group and forms the principal rock type in the Katori Jhiriya G-4 Block, occupying nearly 60% of the total mapped area. It is well exposed along the hill slopes and ridges extending from Shankar Pipariya in the south to Khapa village in the north, forming a continuous belt of micaceous metasediments that host the manganese-bearing horizons of economic significance.

7.11.2 The rock exhibits a well-developed schistosity and foliation, defined by the parallel alignment of muscovite and biotite flakes, often alternating with thin quartzose laminae. The colour varies from light grey to greenish-grey or brownish-grey, and in weathered zones, it becomes yellowish-brown to reddish-grey, disintegrating into a micaceous soil. The schist is fine- to medium-grained, moderately hard when fresh, but becomes friable and fragile, where weathered or sheared.

7.11.3 Muscovite schist is widely distributed throughout the block, forming the country rock around Shankar Pipariya, Chorpindkepar, and Tekadi Tiju villages. It occurs as a dominant host rock to the Mn-bearing quartzite and Mn-ore bands, displaying a NE–

SW regional strike with variable dips ranging from 43° to 85°, depending on local structural conditions.

7.11.4 Subsurface data from exploratory boreholes (MKJ-01 to MKJ-07) confirm the predominance of muscovite schist at depth. The unit typically overlies calc-gneiss and quartzite and is occasionally underlain by biotite schist or granite gneiss. In several cores, the schist contains thin interbands of quartzite and Mn-bearing zones, establishing its role as the immediate host of the manganese mineralization within the Mansar Formation.

7.11.5 Drilling data confirm the widespread presence of muscovite schist across the block, underlying a thin soil or weathered cover (3–7 m). It has been intersected in nearly all boreholes, with thicknesses ranging from 10 to 35 m. Notable intersections include: MKJ-01: 7.00–25.00 m and 27.00–43.61 m, MKJ-02: 7.00–14.89 m and 19.84–40.70 m, MKJ-03: 7.00–31.20 m, MKJ-04: 8.00–40.00 m, MKJ-05: 7.00–19.00 m and 46.30–49.00 m (Mn-bearing zone), MKJ-06: 7.00–13.56 m and 22.00–40.00 m, MKJ-07: 7.00–31.00 m and 38.53–43.00 m.

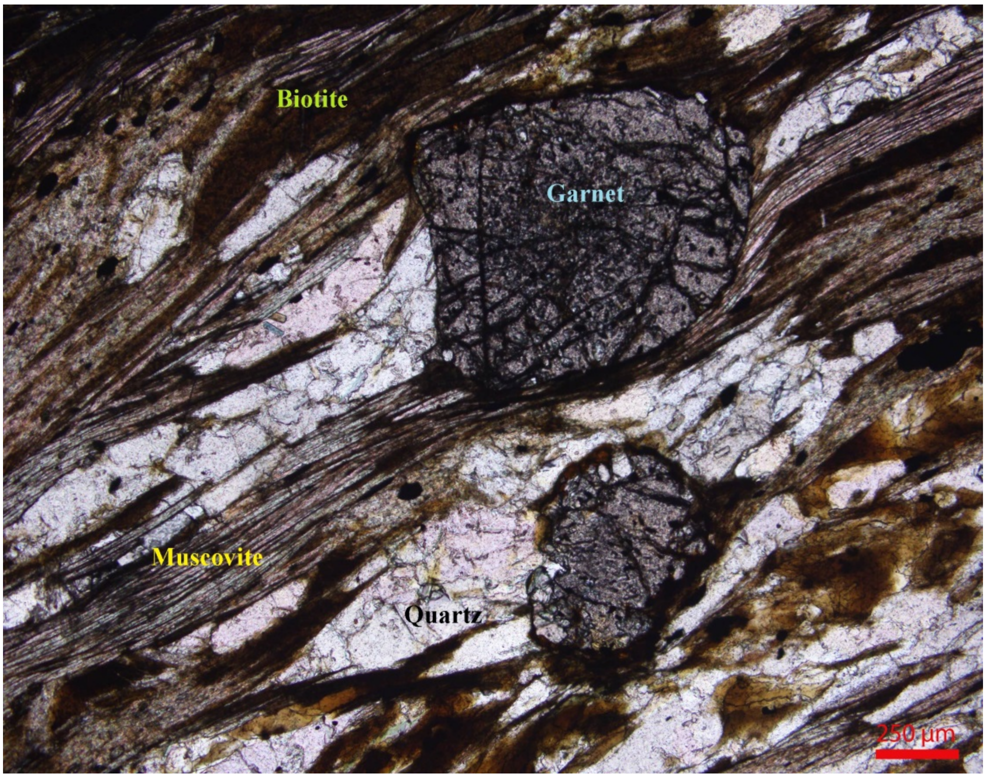
Photograph No. 7.6: Showing Muscovite Schist intersected in MKJ-06 borehole

7.11.6 In cores, the rock shows foliated to laminated texture, with alternating thin laminae of mica-rich and quartz-feldspathic bands. It is soft to moderately hard, often breaking along foliation planes. The presence of thin quartz and calcite veinlets is common, occasionally associated with ferruginous staining.

7.11.7 The Mn-bearing zones encountered in MKJ-01 (25–27 m), MKJ-05 (42.24–49.00 m), and MKJ-07 (7.00–31.00 m) occur within or adjacent to muscovite schist bands, confirming its role as the principal host rock for manganese mineralization.

7.11.8 **Petrographic and Mineralogical Characteristics of Rock Type:** Petrographic examination (refer Katori Jhiriya Petrography Report) reveals that the Muscovite Schist is composed mainly of:

- ❖ Muscovite (45–55%) – colourless to pale silvery, flaky, forming dominant foliation.
- ❖ Quartz (25–35%) – anhedral, strained grains showing undulose extinction.
- ❖ Plagioclase (10–15%) – subhedral, partly sericitized and occasionally replaced by fine muscovite.
- ❖ Biotite (5–10%) – brown, locally altered to chlorite.
- ❖ Accessory minerals: zircon, tourmaline, magnetite, ilmenite, and iron oxides.



Pmg – 1: Photomicrograph showingassociation and parallel alignment of quartz, muscovite, garnet and biotite in garnetiferous quartz-muscovite-biotite schist as seen under plane polarized light.

Specimen No. :MP-KJ/P/2 **Magnification : 40X**

7.11.9 The texture is typically lepidoblastic to granolepidoblastic, with a strong preferred orientation of mica flakes defining the schistosity. In Mn-bearing zones, thin bands and disseminations of psilomelane, braunite, and pyrolusite have been noted in hand specimens and surface samples.

7.11.10 Weathered varieties show clayey decomposition, and muscovite alteration results in the rock becoming friable and fragile, explaining the low RQD values observed in cores. The Muscovite Schist displays a structural pattern that mirrors the geometry of the manganese-bearing zones, indicating that both have undergone the same tectono-metamorphic evolution. The rock shows strong foliation trending NE–SW, with variable dips ranging from 43° to 85° in different parts of the block. The structural framework corresponds to three distinct but genetically linked mineralized zones:

7.11.11 **Shankar Pipariya Zone**: The schist exhibits dip of 43°–50° towards NE, parallel to the Mn-bearing quartzite intersected in MKJ-01 to MKJ-03. The foliation planes are closely spaced and exhibit crenulation and minor shearing, suggesting deformation along the limb of a regional fold.

7.11.12 **Chorpindkepar Zone:** Here, the schist displays complex structural variation, with dips of 65° towards NW, 45°–85° towards SE, and locally vertical foliation near the manganese-rich lenses intersected in MKJ-04 to MKJ-07. These variations represent tight isoclinal folding and axial plane shearing, typical of the Sausar Fold Belt. The near-vertical fabric indicates proximity to a major fold hinge zone that has influenced the local distribution of manganese mineralization.

7.11.13 **Tekadi Tiju Zone:** The schist maintains a NE–SW strike and dips 52° towards SE, consistent with the trend of the Mn-bearing quartzite exposed in the area. Although drilling could not be undertaken due to land restrictions, surface mapping confirms its continuity with the regional folded sequence.

7.11.14 Collectively, these three zones define a folded and structurally disturbed manganese horizon, and the muscovite schist, being the enclosing lithounit, records the same polyphase deformation. The foliation and schistosity correspond to axial-plane structures developed during successive episodes of folding.

Photograph No. 7.7: Muscovite Schist exposed along the road cutting near Tekadi Tiju showing well-developed foliation

7.12.0 **BIOTITE SCHIST (MANSAR FORMATION, SAUSAR GROUP):**

7.12.1 The Biotite Schist constitutes one of the most extensive and characteristic lithounits of the Mansar Formation within the Sausar Group and is prominently developed across the Katori Jhiriya G-4 Block. It represents the metamorphosed equivalent of argillaceous to psammitic sediments, formed under medium-grade (amphibolite facies) metamorphic conditions. This unit forms a significant part of the metasedimentary sequence enclosing the manganese-bearing horizons of the Mansar Formation.

7.12.2 **Field Occurrence and Distribution:** The Biotite Schist is well exposed in several parts of the Katori Jhiriya Block, forming low ridges and hillocks aligned along the regional NE–SW to ENE–WSW structural trend. It is prominently developed in the southwestern and western parts of the block, particularly around Chorpindkepar, Amai, Bhajiyadand, Paunera, and Umarwada villages.

7.12.3 The unit extends eastward into the central sector near Chorpindkepar, where it is spatially associated with muscovite schist, calc-gneiss, and manganese-bearing quartzite. The foliation trend parallels the regional structural grain of the Sausar belt (NE–SW to ENE–WSW) with moderate to steep dips (45°–75°) towards the southeast. The weathered surface is brownish to greyish, while fresh rock is dark grey to black with a silky sheen, reflecting the high biotite content.

7.12.4 **Subsurface Occurrence:** Subsurface exploration through core drilling confirms the persistence of this unit across the block. The biotite schist has been intersected in multiple boreholes, including: MKJ-01 (43.61–52.00 m), MKJ-02 (40.70–76.00 m), MKJ-03 (31.20–40.00 m), MKJ-05 (19.00–42.24 m), MKJ-06 (13.56–22.00 m; 40.00–50.00 m), MKJ-07 (31.00–38.53 m; 43.00–46.00 m).

Photograph No. 7.8: Photograph: showing biotite Schist intersected in MKJ-02 borehole

7.12.5 The core shows foliated, medium- to coarse-grained biotite schist, with alternating biotite-rich and quartz-feldspathic laminae. In several boreholes, particularly MKJ-

05, the schist encloses thin manganese-bearing quartzite and schist bands, indicating proximity to the Mn horizon of the Mansar Formation. The rock is moderately hard, but in weathered zones it becomes friable due to alteration of biotite to chlorite.

7.12.6 **Petrographic and Mineralogical Characteristics:** Petrographic study shows that the rock consists primarily of:

- Biotite (30–45%) – dark brown to black, flaky, strongly pleochroic, forming the main foliation.
- Quartz (25–35%) – interlocking anhedral grains, often strained.
- Plagioclase feldspar (10–15%) – subhedral, partly sericitized.
- Muscovite (5–10%) – intergrown with biotite along foliation planes.
- Accessory minerals: magnetite, ilmenite, zircon, and tourmaline.

7.12.7 The texture is lepidoblastic to granolepidoblastic, typical of regionally metamorphosed schists. Chloritization of biotite and ferruginous staining are common in weathered samples, particularly near shear zones and Mn-bearing horizons.

7.12.8 Structurally, the biotite schist shows a well-developed schistosity parallel to bedding ($S_1//S_0$), reflecting isoclinal folding and tectonic flattening during the Sausar orogeny. The foliation and fold axes are oriented ENE–WSW, dipping moderately to steeply southeast (45°–75°). The rock represents metamorphosed argillaceous and psammitic sediments of the Mansar Formation, deposited in a shallow marine to marginal basin environment. During regional metamorphism under amphibolite facies, biotite and muscovite developed prominently, imparting the rock's characteristic schistosity. Localized Mn and Fe enrichment within the schist suggest chemical remobilization and metasomatic exchange along fractures and shears during metamorphism.

Photograph No. 7.9: Photograph Biotite schist exposure west of Pidkepar village showing well-developed NE–SW trending foliation.

7.13.0 IRON ORE (CHORBAOLI FORMATION, SAUSAR GROUP):

7.13.1 Iron ore within the Katori Jhiriya Block occurs only as minor, discontinuous lithological and geochemical features, associated with the Chorbaoli Formation of the Sausar Group. These represent supergene to metamorphosed chemical-sedimentary iron enrichment, genetically linked to the iron–manganese metallogenic system of the Sausar Basin. Although these occurrences are not of commercial or resource significance, they are important indicators of weathering, remobilisation, and secondary enrichment processes in the block.

7.13.2 **Field Occurrence and Bedrock Samples:** The principal iron-enriched zone lies 1.5 km north of Jhiriya village, where ferruginous material occurs as scattered, small, lateritic caps and discontinuous bands within the schistose terrain. A total of seven bedrock/float samples from Paunera and Jhiriya sectors show elevated Fe_2O_3 (55–76%) and Fe (38–53%), confirming localised iron enrichment but no regular ore body.

7.13.3 **Paunera Area Occurrence:** In the Paunera sector, the iron-oxide body is extremely small and localized, occurring near a village lake and completely surrounded by agriculture fields. The exposure measures roughly 15–17 m in length and 5–6 m in width. Because of land use restrictions and the very limited extent of iron enrichment, trenching or pitting could not be conducted.

7.13.4 **Jhiriya Area Occurrence:** In Jhiriya village, only surface float of botryoidal iron ore, mainly goethite, limonite, and hematite, was observed. No in-situ iron ore body could be identified. The float occurs near the Sharda Mata Temple, where excavation is restricted due to cultural and community sensitivities. Consequently, no trenching or subsurface investigation could be undertaken. The ferruginous material appears to be residual and transported, derived from weathering and downslope movement from ferruginous schist exposures north of the village.

7.13.5 All iron ore bodies in the block are confined to lateritized terrain, particularly in the north-central (Jhiriya) and southwestern (Paunera) sectors. The laterite acts both as a protective cap and a zone of secondary enrichment. Iron oxides have been mobilized from underlying ferruginous schists and quartzites through tropical weathering and leaching, resulting in secondary precipitation of hematite and goethite within the laterite profile.

7.13.6 The botryoidal and pisolitic textures, porous structure, and occurrence as isolated cappings strongly suggest that the iron ore is laterito-ferruginous in origin, representing supergene enrichment zones developed over the weathered top of the Bichhua Formation.

Photograph No. 7.10: Photograph showing hand specimen sample of botryoidal goethite collected near Bhajiyadand village

7.14.0 GRANITE (INTRUSIVE):

7.14.1 A granitic intrusive body is exposed near Dongariya village in the eastern part of the Katori Jhiriya Block. It forms a small hillock standing out from the surrounding schistose terrain and represents a younger intrusive phase emplaced into the metasedimentary rocks of the Sausar Group.

7.14.2 In hand specimen, the granite is massive, compact, and very hard, displaying a medium- to coarse-grained crystalline texture. The rock exhibits a dark grey appearance in the field, primarily due to the dominance of plagioclase feldspar and mafic minerals, as seen in the specimen collected from the block. Quartz and lighter feldspar grains occur as dispersed speckles, giving the rock a mottled look.

7.14.3 Because detailed petrographic studies have not been carried out, the mineralogical description is based solely on field characteristics. The rock is non-foliated and lacks the banding typically seen in muscovite–biotite schists and Tirodi Biotite Gneiss, indicating its igneous intrusive nature.

7.14.4 The intrusive body appears to cut across the regional foliation of surrounding schists, consistent with a younger phase of emplacement. No visible mineralisation or alteration zones were observed along the contact in the accessible exposures in the area.

Photograph No. 7.11: Photograph showing Hand specimen sample of granite collected from Dongariya village

7.15.0 QUARTZ VEIN (LATE HYDROTHERMAL):

7.15.1 Quartz veins are one of the most widespread late-stage features observed within the Katori Jhiriya Block, occurring both as surface exposures and subsurface intersections in several boreholes. These veins represent the younger hydrothermal phase of the Sausar tectono-metamorphic cycle and are mainly concentrated along fracture zones, foliation planes, and shear-controlled joints within the muscovite–biotite schists and Tirodi Biotite Gneiss.

7.15.2 **Field Occurrence:** On the surface, quartz veins are prominently exposed near Jhiriya, Shankar Pipariya, and Chorpindkepar areas, as well as along minor ridges and slopes where the schist and gneiss units are fractured. The veins occur as discordant to slightly concordant bodies, trending NE–SW to ENE–WSW and dipping moderately to steeply (50°–80°) towards the southeast, parallel to or crosscutting the regional foliation. These structures are consistent with the Sausar Belt's deformational grain.

7.15.3 The veins are typically milky white in colour, hard, compact, and crystalline, with massive to saccharoidal texture. The thickness of individual veins varies from a few centimetres to nearly 1.5 metres, locally bifurcating and forming network-type vein systems. In several exposures (as shown in photographs above), quartz exhibits distinct jointing and cross-fracturing, suggesting post-emplacement brittle deformation. The sharp contacts with host schist indicate that these are post-metamorphic hydrothermal intrusions, emplaced along reactivated shear fractures during late tectonic events.

7.15.4 **Subsurface Occurrence**: In drilling, quartz veins were intersected in MKJ-02 (14.89–19.84 m) and minor stringers in other boreholes such as MKJ-05 and MKJ-06. The quartz is very hard and compact, and broken core recovery was noted in several runs due to its brittle nature. The intersections confirm the continuity of surface structures into the subsurface.

7.15.5 In core samples, the veins are milky white, massive, and crystalline, occasionally containing muscovite flakes and fine-grained hematite along fracture planes. The contact zones between quartz and host schist show minor silicification and ferruginous staining, but no direct manganese enrichment was observed within or adjacent to these veins.

Photograph No. 7.12: Photograph showing exposure of milky quartz vein exposure near Chorpindkepar area.

7.16.0 LATERITE (QUATERNARY):

7.16.1 Laterite within the Katori Jhiriya G-4 Block occurs as a thin, discontinuous capping over the elevated plateaus, ridges, and interfluves, prominently distributed over the southern, central, and north-western parts of the block, notably near the villages of Jhiriya, Paunera, Umarwada, and Shankar Pipariya. It represents a residual ferruginous crust developed through intense tropical weathering of the schistose and gneissic rocks belonging to the Sausar Group and the Tirodi Biotite Gneiss.

7.16.2 Laterite is predominantly ferruginous, with only minor to very weak manganiferous enrichment. The lateritic horizon is typically 0.5 m to 3.0 m thick, reddish-brown to dark brown in colour, and composed mainly of hydrated iron and aluminum oxides with subordinate silica and minor manganese oxides. It displays pisolitic, nodular, and vesicular textures, indicating repeated cycles of leaching, oxidation, and reprecipitation under subaerial conditions.

7.16.3 In contrast, borehole lithologs from the present exploration have not recorded any lateritic horizon, confirming its surface-restricted and patchy nature. The subsurface is dominated instead by soil, weathered schist, and fresh schist/gneiss. This absence in drilling data supports the interpretation that laterite represents a localized surficial weathering product rather than a stratigraphic lithounit of significant areal continuity.

7.16.4 Field observations indicate that laterite occurs mainly as thin capping and patchy surface horizons developed over schist, quartzite, and gneiss. The material is generally reddish-brown to dark brown, porous, and earthy, composed mainly of: goethite and limonite (dominant iron oxy-hydroxides), Minor hematite, Clay minerals and quartz, very low Mn content, occurring only as trace oxide coatings in a few locations (Jhiriya and Paunera sectors).

7.16.5 During fieldwork and interaction with villagers, no evidence of extraction or utilization of laterite for building slabs, bricks, or foundation stones was observed within or around the block area. The laterite is soft, porous, and weakly indurated, making it unsuitable for dimension stone or structural use. It is occasionally used informally for leveling small village pathways or filling low-lying areas, but there is no organized or commercial utilization of laterite in the region.

Photograph No. 7.13: Photograph showing leterite exposure near Shankar Pipriya area

7.17.0 SOIL (RECENT):

7.17.1 More than 60% of the Katori Jhiriya Block is covered by soil and weathered material. The soil occurs as a loose to moderately compact cover over the parent rocks, with thickness varying from 0.0 m to 04 m, depending upon topography and bedrock exposure. It is mainly residual in origin, derived from in-situ weathering of muscovite–biotite schist, quartzite, and gneissic rocks of the Sausar Group and Tirodi Biotite Gneiss.

7.17.2 The soil is generally fine- to medium-grained, earthy to reddish-brown, and locally clayey, containing coarse-grained manganese-bearing garnet fragments, manganiferous kankar/nodules, and plant roots. In areas close to manganese outcrops, particularly around Chorpindkepar and Shankar Pipariya, the soil shows a dark grey to blackish coloration due to the presence of dispersed manganese oxide particles and fine Mn-stained clay.

7.17.3 In the central and northern portions of the block, the soil exhibits a micaceous and silty character, reflecting the disintegration of underlying schistose rocks. The weathered schist zone immediately below the soil is highly fragile and foliated, rich in muscovite flakes and ferruginous coatings, indicating progressive chemical weathering under humid tropical conditions.

7.17.4 In the valley and nala zones, the soil merges with recent alluvium, consisting of fine sand, silt, and clay transported by local drainage such as Jhiriya Nala and its tributaries. The presence of lateritic nodules and iron-stained horizons at certain elevated sites reflects secondary enrichment due to prolonged leaching and oxidation.

Photograph No.7.14: Panoramic view from hilltop near Jhiriya village showing extensive soil-covered terrain of the Katori–Jhiriya Block,

7.18.0 **STRUCTURE OF THE BLOCK:**

7.18.1 The Katori Jhiriya G-4 Block forms a part of the Sausar Mobile Belt in the southern part of Balaghat District, Madhya Pradesh. The area exhibits the typical regional structural fabric of the Sausar Group, which has undergone polyphase deformation and regional metamorphism. The general strike of foliation and bedding is NE–SW, conformable with the regional trend of the Sausar Belt (Figure 7.4 Rose Diagrame), while the dip varies between 40° and 75°, mostly towards the southeast, though local variations are common due to folding and shearing.

7.18.2 **Data Source and Mapping Constraints:** A major portion of the block is covered by soil, with thickness ranging from 3 to 4 m, as confirmed from borehole lithologs. Because of this limited surface exposure, direct structural measurements (foliation, dip, strike, joint orientation) could only be recorded from isolated outcrops and trench exposures where lithology is visible.

7.18.3 To overcome this limitation, Landsat satellite imagery was interpreted to delineate structural trends and lineaments, and the NGDR (National Geoscience Data Repository) structural data compiled by GSI were used as supplementary reference for regional validation.

7.18.4 NGDR structural datasets indicate the presence of two faults within the block area: i) One in the southern part near Tuiyapar, trending NE–SW, with an estimated length of about 1 km. and ii) Another in the northwestern part, extending from west of Basi village to west of Jhiriya village, also trending NE–SW, and about 1 km long.

7.18.5 Based on satellite image interpretation and field mapping, the mineralised area in the Katori Jhiriya Block appear to lie within the hinge zone of a regional isoclinal fold, with both limbs dipping southeasterly and the axial plane striking ENE. Secondary quartz veins are commonly developed along limb-parallel and stretching fractures, oriented approximately perpendicular to the fold axis. These features, along with minor faulting and shear disturbances, have further disrupted the continuity of the manganese bands and contributed to their lensoidal and discontinuous character within the block.

7.18.6 **Structural Configuration:** Geological mapping, trenching, and drilling data collectively indicate that lithological units comprising muscovite schist, biotite schist, quartzite, and manganese-bearing horizons are conformable and follow the NE–SW regional trend.

7.18.7 Three structural domains have been recognised: i) Shankar Pipariya Area: Foliation dips 43°–50° NE, with gentle to moderate inclination, ii) Chorpindkepar Area: Foliation is steeply inclined (65° NW to 90° vertical) and locally 45°–85° SE, reflecting folding and warping. and iii) Tekadi Tiju Area: Foliation dips 52° SE, conformable with the regional schistosity. These variations suggest tight isoclinal folding and minor warping, resulting in repetition and local thickening of manganese-bearing zones.

7.18.8 The rose diagram of structural data from the Katori Jhiriya Block shows a dominant NE–SW to ENE–WSW structural grain, reflecting the regional trend of the Sausar Belt. Most foliation, joint, and fracture orientations cluster along this axis, indicating strong tectonic control and alignment with the Mansar Formation. A secondary NW–SE set represents cross-fractures that locally disrupt the manganese horizons.

7.18.9 **Folds, Faults, and Deformation Features:** Field observations and subsurface data confirm the presence of isoclinal to tight folds affecting the Mansar Formation rocks. The fold axes trend NE–SW, parallel to the regional structural grain of the Sausar Belt, with axial planes dipping 25°–70° SE.

7.18.10 Such folding has produced repetition of lithounits and localized thickening of manganese-bearing horizons, particularly near Chorpindkepar, where dips reach near vertical (up to 90°).

7.18.11 Minor faults and shears have been inferred from satellite lineaments and NGDR data, particularly in the southern (Tuiyapar) and northwestern (Jhiriya–Basi) sectors, but no major displacement has been observed in the field.

7.18.12 **Joints, Lineaments, and Remote Sensing Interpretation:** Four principal sets of joints and fractures have been recorded or interpreted from satellite data, trending: (i) NE–SW (parallel to foliation and regional trend), (ii) NW–SE (cross-fracture set), (iii) E–W, and (iv) N–S.

7.18.13 The NE–SW system dominates and is associated with regional schistosity, while the NW–SE set forms cross fractures, locally guiding minor drainages and controlling the exposure pattern of quartz veins and Mn-bearing horizons.

7.18.14 The lineament analysis from Landsat imagery and GSI NGDR data significantly aided in defining these structural elements in areas where field exposure was poor due to thick soil cover.

7.18.15 **Structural Control on Mineralisation:** The manganese-bearing horizons follow the regional foliation and show a strong structural control.

7.18.16 The folded and reoriented schist–quartzite sequence governs the disposition of ore lenses, with foliation planes and shear zones serving as loci for later remobilisation and local enrichment of manganese minerals.

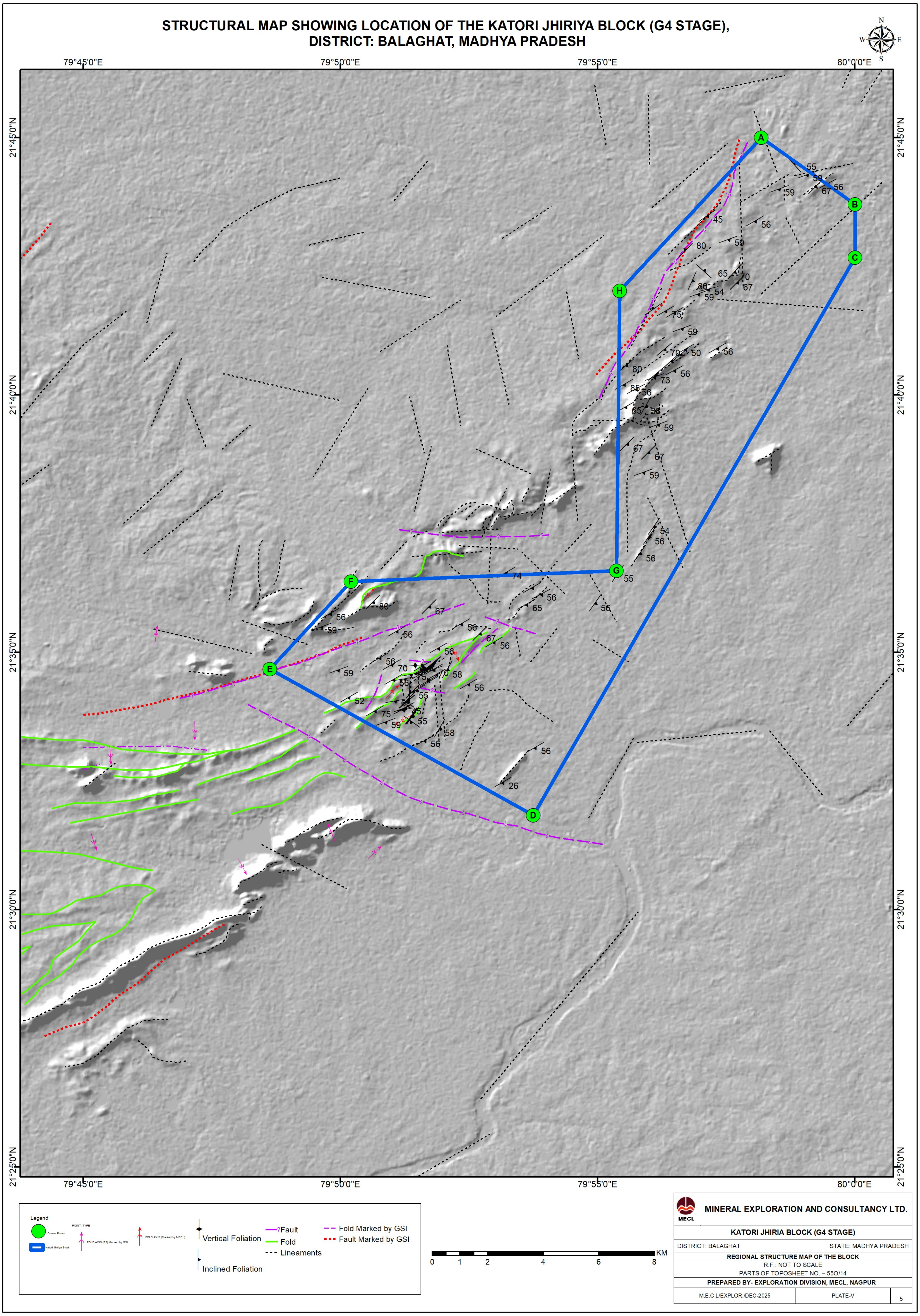
7.18.17 Tight folding and minor shearing have imparted a lensoid, discontinuous character to the manganese bands.

7.18.18 Thus, the mineralisation occurs as stratabound, conformable bands, structurally controlled by the fold geometry and schistosity a hallmark of Sausar-type metamorphosed sedimentary manganese deposits

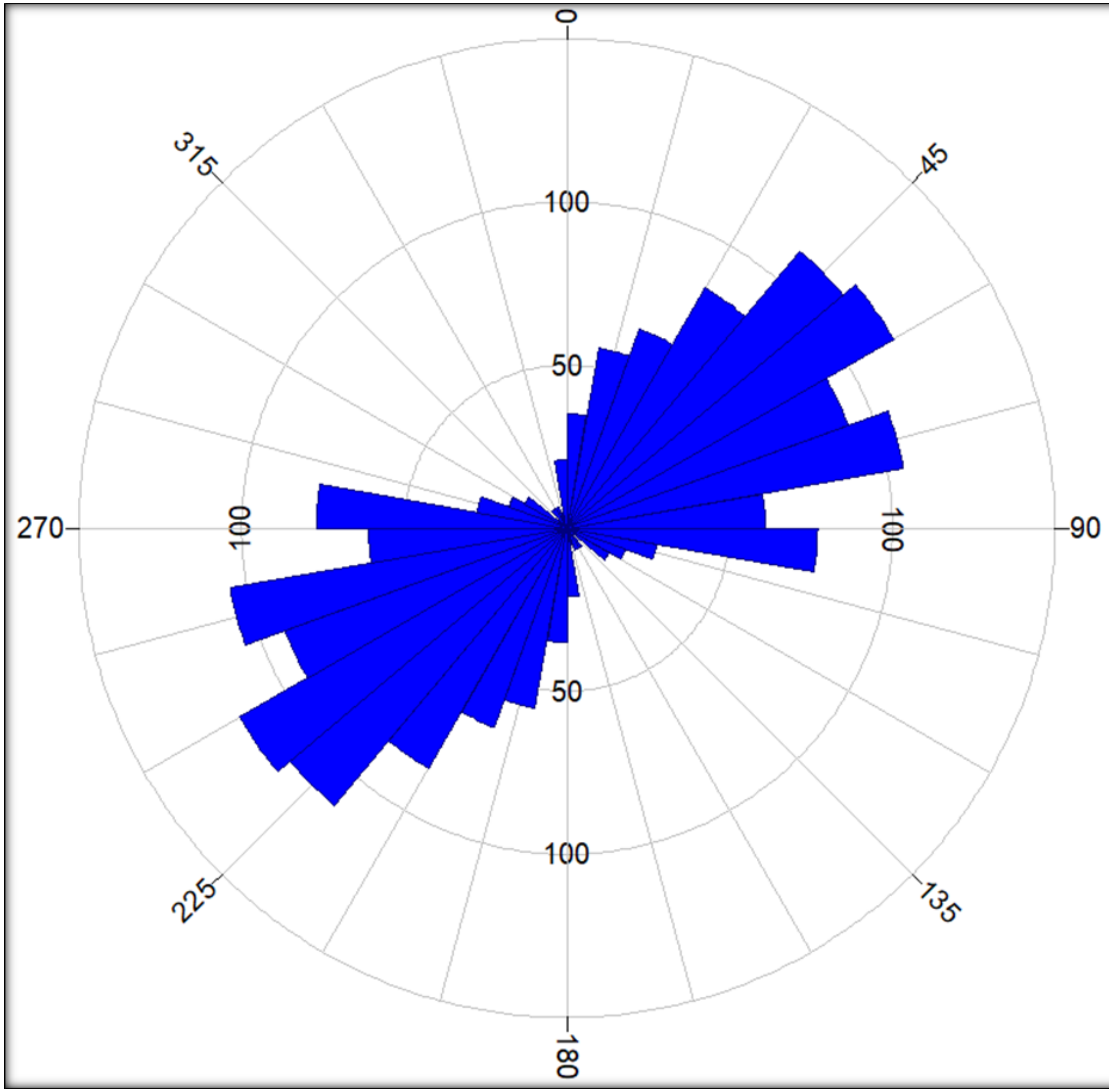
Photograph No. 7.15: Photograph showing Foliation trend in quartzite located in Maanegaon Village

Photograph No. 7.16: Photograph showing tight folding in migmatite/gneiss

TEXT FIGURE 7.3: STRUCTURE MAP OF KATORI JHIRIYA BLOCK, DISTRICT – BALAGHAT, MADHYA PRADESH



TEXT FIGURE 7.4: ROSE DIAGRAM ILLUSTRATING THE DOMINANT NE–SW STRUCTURAL TREND IN THE KATORI JHIRIYA BLOCK



Rose Diagram

Statistical Summary	
Calculation Method:	Length
Class Interval:	10.0 Degrees
Min.Length Filtering:	Deactivated
Max.Length Filtering:	Deactivated
Azimuth Filtering:	Deactivated
Data Type:	Bidirectional
Population:	908
Total Length of All Lineations:	1,034,924.18
Maximum Bin Population:	116.0
Mean Bin Population:	50.44
Standard Deviation of Bin Population:	39.18
Maximum Bin Population (%):	6.39
Mean Bin Population (%):	2.78
Standard Deviation of Bin Population (%):	2.16
Maximum Bin Length:	70,877.91
Mean Bin Length:	28,747.89
Standard Deviation of Bin Lengths:	19,689.54
Maximum Bin Length (%):	6.85
Mean Bin Length (%):	2.78
Standard Deviation of Bin Lengths (%):	1.9
Vector Mean:	57.1 Degrees
	237.06 Degrees
Confidence Interval:	5.8 Degrees
	(95 Percent)
R-mag:	0.43

7.19.0 MINERALISATION:

7.19.1 Manganese mineralisation in the Katori–Jhiriya G-4 Block occurs within the Mansar Formation of the Sausar Group (Palaeo-Proterozoic). The ore is syn-sedimentary type, originally formed by basin-floor chemical precipitation and later recrystallised under regional amphibolite-facies metamorphism. Mineralisation occurs as thin, lensoidal, discontinuous bands conformable with foliation in muscovite–biotite schist and Mn-bearing quartzite. Structural control is strong, with good strike continuity but poor down-dip persistence.

7.19.2 Surface Expression and Structural Setting: Surface mapping, trenching, and channel sampling delineated three NE–SW–trending mineralised sectors:

1. Shankar Pipariya Sector
2. Chorpindkepar–Jhiriya Sector
3. Tekadi Tiju Sector

7.19.3 The manganese occurs as dark grey to black, hard, massive to laminated bands, enclosed within micaceous schist and quartzite sequences. Dips vary due to folding and structural disturbance. The mineralisation exposured at Shankar Pipariya dip 43°–50° towards the NE; in Chorpindkepar–Jhiriya, dips are 65° towards the NW and locally vertical (up to 90°) due to folding; and in Tekadi Tiju, the horizon dips 52° towards the SE. These variations confirm a folded and structurally disturbed manganese horizon of NE–SW orientation. These variations reflect a folded stratabound manganese horizon, typical of Sausar manganese deposits.

Photograph No. 7.17: PhotographManganese ore exposure near Chorpindkepar village, showing steep dipping trending NE–SW with quartz vein cutting across.

7.19.4 **Description of Old Workings**: (a) Chorpindkepar Pit: A large abandoned excavation, believed to have been worked during the British period. The pit measures approximately at Chorpindkepar (~100 m × 50 m × 25 m deep), now water-filled). The pit exposes alternating bands of muscovite schist and manganese-bearing quartzite, visible along the pit walls. Manganese appears as repeated thin lenses following the schistosity: muscovite schist → manganese band → muscovite schist → manganese band, indicating a folded, stratabound geometry. Most of the economic manganese from this site appears to have been extracted in the past.

Photograph No. 7.18: Photograph showing old pit excavated during the British period near Chorpindkepar village.

7.19.5 (b) Shankar Pipariya Pit: A smaller abandoned working about 15–20 m deep, where earlier extraction has removed most of the manganese ore. Borehole MKJ-01, drilled across dip of the quartzite–Mn band near this pit, intersected a 2 m manganese-bearing zone, corresponding to a true thickness of 1.96 m after dip correction. However, the next boreholes along strike (MKJ-02 & 03) was barren, confirming limited subsurface continuity.

Photograph No. 7.19: Mn-bearing laminae near Shankar Pipariya pit

7.19.6 (c) At Tekadi Tiju, a very thin surface manganese layer is exposed, but drilling could not be conducted because the zone lies within active agricultural land.

Photograph No. 7.20: Photograph showing Manganese bearing quartzite laminae near TejuTekadi Village

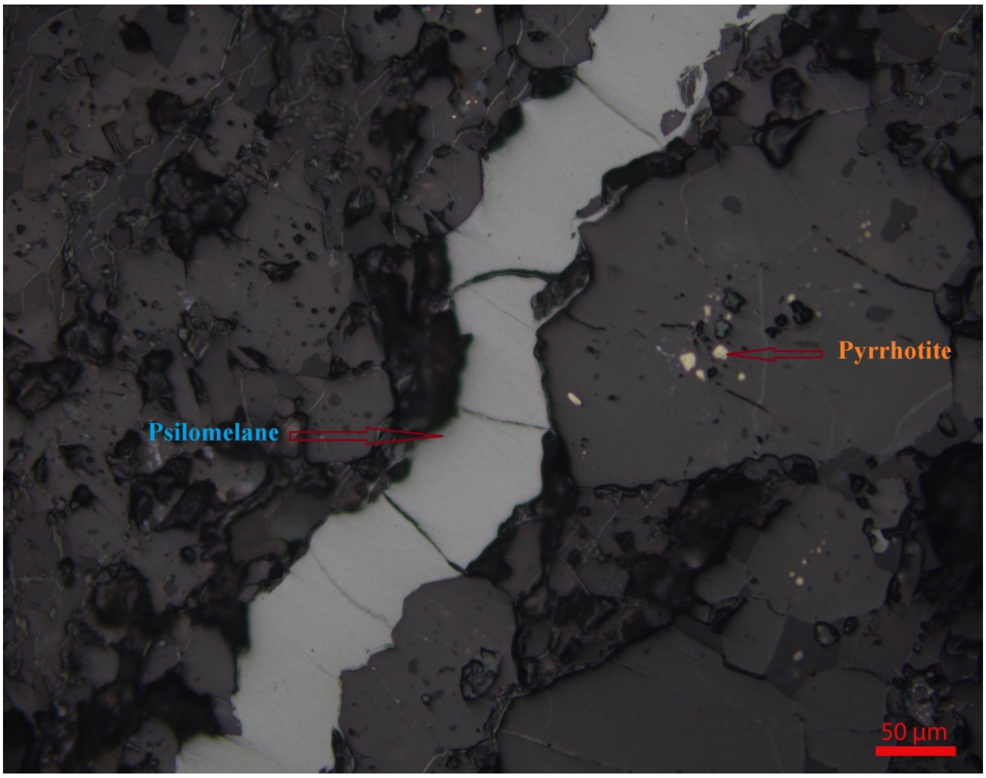
7.19.7 **Trench and Channel Sampling Results**: A total of six trenches (TR-01 to TR-06) and eight channels (CH-01 to CH-08) were excavated to verify surface continuity and grade distribution. Overall, 30% of all samples exceed 10% Mn, and 15% of the samples exceed 25% Mn, indicating localized surface enrichment.

Table No.7.19

Summary of the trench and Chennel samples results in Three Mineralised sectors of Katori Jhiriya Block

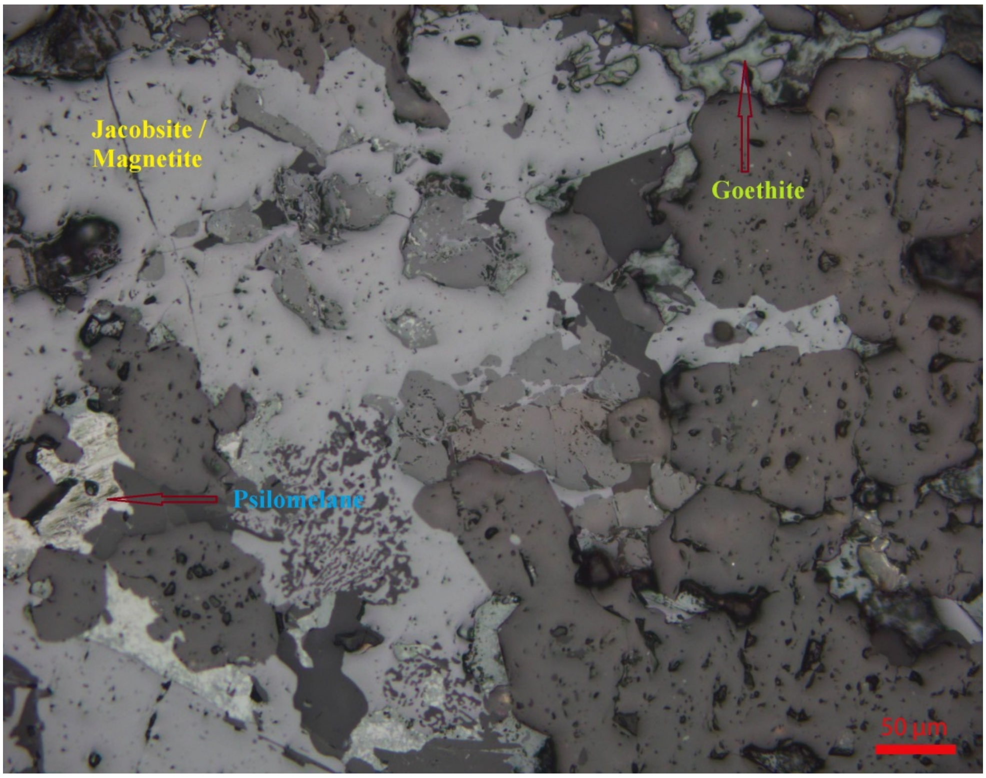
Area / Trenches & Channels	Mn Range (%)	Remarks
TR-01 & TR-02 (Chorpindkepar Sector)	**0.36–34.52**	Several samples in the 15–30% Mn range (comes under Trivedi Mining Lease)
TR-03 to TR-05 (Shankar Pipariya Sector)	**0.26–35.92**	Three samples >25% Mn
TR-06 (Tekadi Tiju Sector)	**0.15–21.09**	Very thin manganiferous lens
Channels CH-01 to CH-05 (Chorpindkepar Sector)	**4.40–47.30%** (avg. ~22%)	Strongest and most consistent surface enrichment (comes under Trivedi Mining Lease)
Channels CH-06 & CH-07 (Shankar Pipariya Sector)	**0.56–43.40%** (avg. ~18%)	Patchy but significant enrichment
Channel CH-08 (Tekadi Tiju Sector)	**0.56–21.09%** (thin surface lens)	Weak, discontinuous mineralisation

7.19.8 **Ore Petrography, Mineralogy, and Genesis**: Microscopic and mineragraphic examination of ten polished sections from the Shankar Pipariya, Chorpindkepar, and Tekadi Tiju zones reveals that the manganese ore is dominated by braunite, hausmannite, psilomelane, and pyrolusite, with minor hematite, goethite, and spessartite garnet. Braunite (35-40%) occurs as medium- to coarse-grained subhedral to anhedral, granoblastic aggregates within a quartz–muscovite matrix, locally intergrown with hausmannite (20-25%), which appears as fine to medium granular masses. Psilomelane (10-15%) is developed as botryoidal to colloform patches and disseminations along foliation planes, while pyrolusite (5-10%) forms soft, earthy veinlets and microfracture fillings, indicating supergene oxidation of primary manganese oxides. Spessartite garnet (<5%) appears as subhedral to anhedral grains associated with quartz and muscovite, representing the metamorphic silicate facies (gonditic). Gangue minerals include quartz, muscovite, feldspar, and chlorite with minor calcite and iron-oxide staining. These mineralogical and textural features collectively confirm a metamorphosed chemical sedimentary origin modified by regional deformation and low-temperature oxidation.



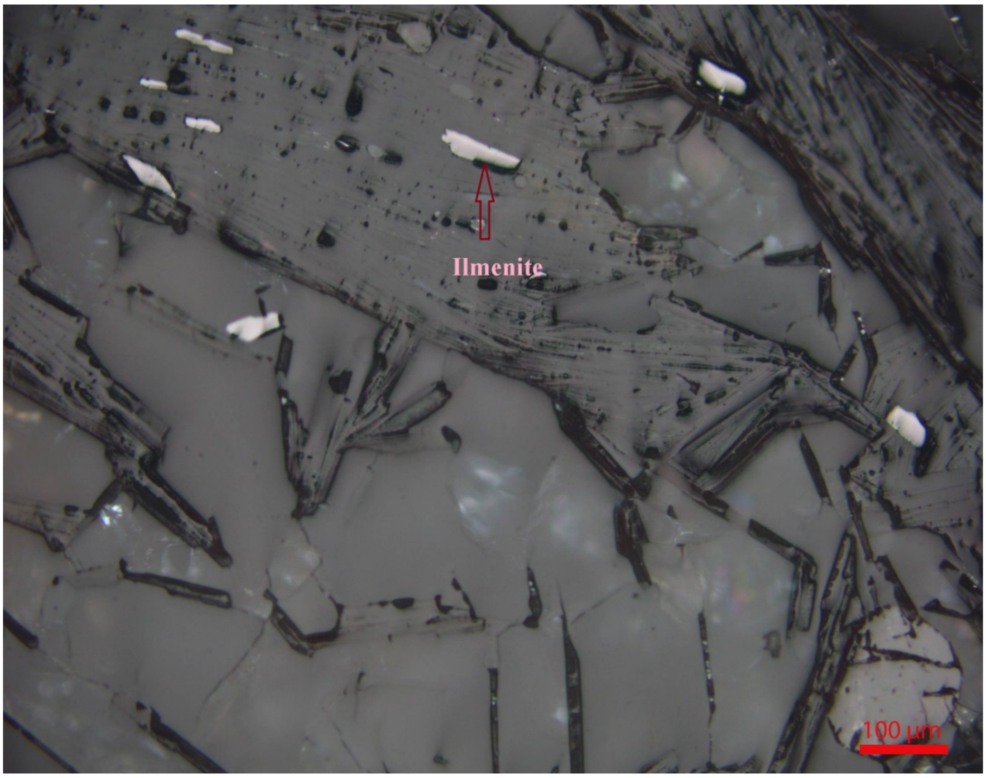
Pmg – 5: Photomicrograph showing psilomelane filling and pyrrhotite specks as seen under reflected light.

Specimen No.:MP-KJ/M/2 **Magnification: 200X**



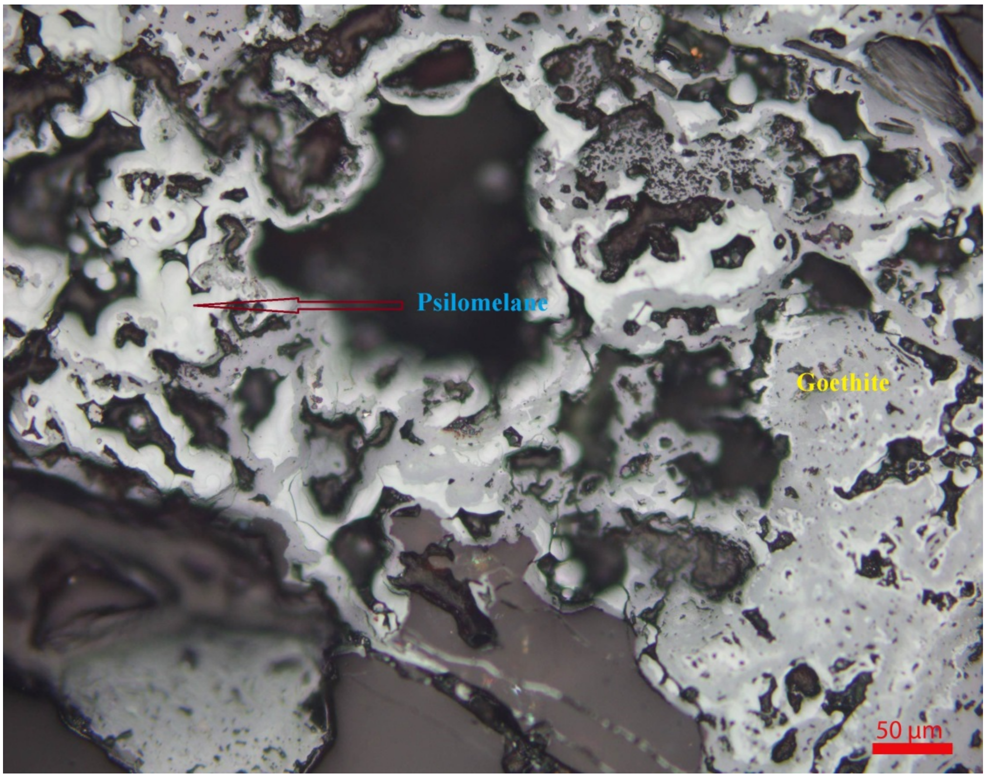
Pmg – 6: Photomicrograph showing jacobsite/ magnetite patches being cut across by psilomelane and goethite fillings as seen under reflected light.

Specimen No. :MKJM-01 **Magnification : 200X**



Pmg – 7: Photomicrograph showing very fine bladed ilmenite grains aligned along the foliation as seen under reflected light.

Specimen No. :MKJM-03 **Magnification : 100X**



Pmg – 8: Photomicrograph showing psilomelane-goethite intermixed patches and fillings with colloform texture as seen under reflected light.
Specimen No. :MKJM-04 **Magnification : 200X**

7.19.9 The manganese mineralisation is interpreted to be syn-sedimentary in origin, representing basin-floor chemical precipitation of manganese oxides and carbonates during deposition of the Mansar Formation. later regional metamorphism under amphibolite-facies conditions transformed these sediments into spessartite–quartz–muscovite schists subsequently remobilization by meteoric water and supergene enrichment plays a major role in depositing Mn ore bodies along suitable structural traps. Occurrence of discontinuous lensoidal Mn ore bodies along foliation showing pinching and swelling structure are formed due to interference of various fold systems in the block. Folding and shearing within the Sausar Belt have led to repetition, thickening, and lensoidal concentration of the ore horizons. The mineralisation follows the foliation planes and exhibits pinch-and-swell geometry typical of structurally modified Sausar-type manganese deposits.

CHAPTER-8

8.0.0 PREVIOUS WORK:

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

8.1.1 Prior to 1883, manganese ore was reported in Nagpur district by Col. Bloomfield (Bull.Geol.Surv.Ind.Ser.A.No.22, pt. 1,1960, pp 5). Jenkins, however, was first to discover manganese ore in Nagpur district in 1833 (Jenkins, Sci.Vol.1, pp.226-227). P.N. Dutta of GSI. in the course of systematic geological mapping discovered major manganese deposits of the adjacent Bhandara district.

8.1.2 A detailed description of the known manganese deposits of this area is given by L.L. Fermor (1909) in his exhaustive memoir on ″ The Manganese Ore Deposits of India″ (Mem.G.S.I.Vol. 37,1909). R.C. Burton in 1912 examined some of the manganese deposits in the northern portion. W.D. West (1940) made a rapid survey of the important mines for appraisal of the manganese ore reserves available in the mines.

8.1.3 N.A. Vemban and coworkers carried out detailed large-scale mapping and investigation of manganese ore deposits of Tirodi area of Waraseoni Tahsil of Balaghat district, during 1951-54 under the supervision of John A. Strackzek.

8.1.4 The southwestern part of the Balaghat district noticed intensive mining activity in the beginning of the present century. Mining was first initiated by a British firm, - Central India Mining Company, which held the lease for most of the area. Exploitation was done mainly by open cast method, and was restricted between Miragpur and Gosai pahadi hillock. The Miragpur area lies to the west of the present exploration block.

8.1.5 Mahurkar (1973-75) has done Assessment for low phosphorus manganese ore in the area west of Miragpur, Balaghat district, Madhya Pradesh, including regional mapping of 8 sq.km. on 1: 15,840 scale and large-scale mapping of 0.20 sq.km. on 1:1000 scale in Hatoda mines area was carried out, besides collection of samples and examination of old workings. The manganese ore horizon occurs at or near the contact between Tirodi biotite gneisses and Mansar muscovite schists. The 1 to 1.5m. thick ore horizon is mainly gonditic, occurring as impersistent bands and lenses, with ore as thin bands, veins stringers and pockets, conformable with the enclosing rocks.

The samples collected analysed 18.57% to 46.43% Mn and 0.06% to 0.66% phosphorus.

8.1.6 Further manganese-focused investigations were conducted by GSI officers including Chakravarty (1973), Narasimha Rao (1973), Basu (1981), Rao (1981), Muley, Bhonskar & Rao (1977), Sarkar et al. (1986), Yedekar (1990), Bandopadhyay et al. (1995), Banerjee et al. (1997), Jaiswal & Mohanty (1990), and Reddy & Thorat (1997). Academic institutions also contributed significantly (Supriyo Roy, 1958–1966; Mohanty, 1993).

8.1.7 The most recent major synthesis was produced under GSI's Project "Archaean–Sausar Belt", undertaken by A.S. Khan, A.K. Huin, and A. Chattopadhyay over three field seasons. Their work provided a comprehensive account of Sausar belt geology, metamorphism, structural evolution, and tectonostratigraphy, reaffirming that the manganese deposits represent primary sedimentary horizons metamorphosed during regional deformation.

CHAPTER-9

9.0.0 AREAL OR GROUND GEOPHYSICAL OR GEO-CHEMICAL DATA:

9.1.0 GEOPHYSICAL SURVEY:

9.1.1 As per approval of 27th EC held on 10th January 2023, surface geophysical (Magnetic) survey was undertaken in 6.73 sq km area of Katori Jhiriya block. The Geophysical Survey has been commenced on 01.09.2023 and completed on 30.09.2023. The detail Geophysical Report on Magnetic (1200 stations each) for Manganese mineralisation in Katori Jhiriya block is given in Annexure-V.

9.2.0 OBJECTIVE AND SCOPE OF WORK:

9.2.1 The main objective of the geophysical survey was to delineate manganese ore zones and other associated minerals in Katori Jhiriyablock.

9.2.2 The scope of work consisted of Acquisition, Processing and Interpretation of ground Magnetic survey data. The Geophysical Survey has to be carried out with 300m as profile interval and 20m as station interval in a grid pattern (20 x 300 mts) covering an area of 6.73 sqkm. The main objective of the Geophysical survey was to delineate Manganese ore zones and other associated minerals if any.

9.3.0 EXPLORATION PARAMETERS:

9.3.1 **Project Area Location:** The survey area, Katori Jariya block is located 45 Km away from Bhalaghat, Madhya Pradesh. The location of the block is shown in Figure-9.1.

9.3.2 The corner points of the block demarcated for Geophysical Survey are as follows:

Table 9.1:

Block boundary Coordinates of target area where geophysical studies carried out in katori Jhiriya Block

Corner Points	Easting (m)	Northing (m)
A	378556.35	2385571.97
B	382480.57	2387401.45
C	383272.83	2386547.62
D	380823.76	2384205.66

9.3.3 **Instrument Details:** Theequipment's details of geophysical survey were used in Katori Jhiriya Block are given below**.**

Table 9.2: Details of Equipment deployed

Type	Proton Precision magnetometer (PPM)
Make	Scintrex (ENVI Pro MAG)
Sensitivity	0.1 nT
Accuracy	+/- 1nT
Range	23000 to 100,000 nT

9.4.0 FIELD DATA ACQUISITION:

9.4.1 The Block boundary demarcations and survey stations were fixed in the grid pattern with spacing of 20m as station interval and 300m as profile interval with bearing N140°E using DGPS and Total Station. Pegs with marked station number were placed at every point. The Reduced level (RL) of every station was determined with Total Stations with an accuracy of ±2cm.

9.4.2 The Magnetic data was recorded at every station with respect to a fixed base station on routine basis with Proton Pression Magnetometer respectively. The coordinates of the base for Magnetic is given in Table 9.3. A total of 1200 stations were recorded for Magnetic covering 6.73 sq. km area. The digital elevation map (RL) of study area is shown in Figure 9.2 in which the Centre portion and Eastern portion is elevated where as South and Western part is low lying area.

Table 9.3: Location of Base station

Base Station	**Easting (m)**	**Northing (m)**
Gravity & Magnetic	726384.513	2302846.16

9.5.0 DATA REDUCTION AND PROCESSING:

9.5.1 **Magnetic Data Reduction and Processing:** Recorded magnetic data was corrected for diurnal variation of the geomagnetic field with respect to the base where data was recorded at the start and end of everyday field work. The Magnetic Anomaly (MA) was calculated with respect to base. The data was processed using Geosoft Oasis Montaj software and the below listed figures were generated (Annexure-V).

MECL

9.6.0 INTEGRATION OF GEOLOGICAL AND GEOPHYSICAL EXPLORATION DATA AND INTERPRETATION:

9.6.1 **Magnetic Survey:** The total variation in TMI of 413.20 nT with the highest value of 45713.20 nT and 45300.07 nT as lowest is observed whereas total variation in MA of 413.19 nT with 213.19 nT as highest and -200.00nT as lowest was observed.

9.6.2 The total magnetic intensity (TMI) as well as magnetic anomaly (MA) has indicated characteristics magnetic response over different litho units with significant NE-SW. From the magnetic anomaly map, the area appears to be geologically controlled in NE-SW direction.

9.6.3 The detected anomalies on the residual magnetic map of MA with 50m, 100m, 150m, 200m and 300m upward continuation reflects the geological features / structures. The horizontal derivatives, the first vertical derivative maps of TMI have been generated for enhancing local anomalies. Derivative tends to sharpen the edges of anomalies and to enhance shallow features. Thus, the smaller anomalies are more readily apparent in areas of strong regional disturbances. The vertical derivative map is much more responsive to local influences than to broad or regional effects and therefore tends to give sharper picture than the map of the total magnetic field intensity. The first vertical derivative of MA has clearly demarcated the anomalous zone in NE-SW direction.

9.6.4 An attempt also has been made to determine the depth of anomalous zones / body in the area by Source parameter imaging. In addition to the depth estimation of the bodies by Source parameter imaging it also locate the edges of the bodies. The source parameter imaging works well on 3D bodies and the map of the tilt angle was obtained from potential data, the minimum of which is placed on the boundaries of the causative bodies. From Source parameter imaging the depth of mineralized zones at proposed boreholes are found ranging from 20 mts to 80 mts. The average depth of mineralized zone from Radially averaged power spectrum of MA was found upto a maximum depth of 80 mts.

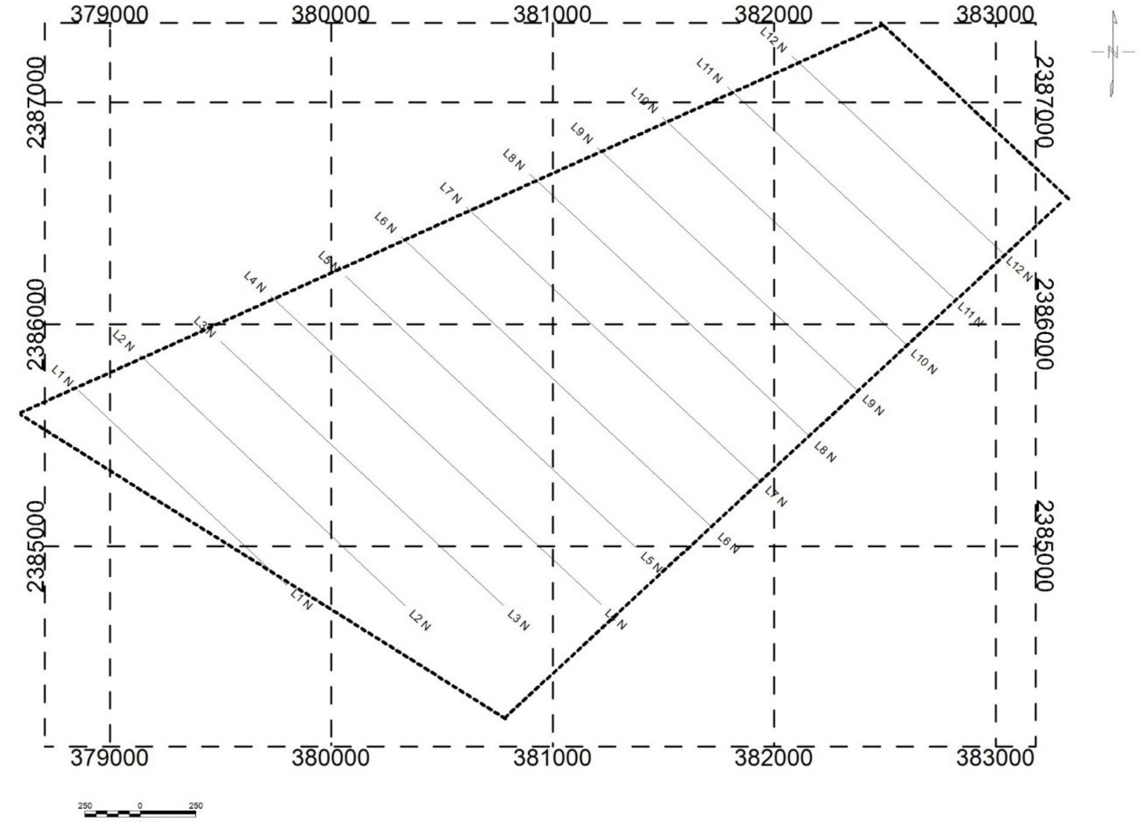
9.7.0 CONCLUSION AND RECOMMENDATIONS:

9.7.1 The Ground Magentic survey conducted has demonstrated the capability to detect mineralized zones area. Spatial filtering like first vertical derivative, Horizontal derivatives and analytical signal analysis etc were applied to enhance the outcomes. For obtaining source depth information, source parameter imaging, radially averaged power spectrum etc., were applied and depth of the anomalous zones found ranging from 20mt to 80 mts.

9.7.2 The large magnitude short spatial anomalies in the residual Magnetic map are primarily due to relatively shallow high magnetic intensity / Susceptibility geological features / Mineralized zones. From the study carried out, it appears that mineralisation in the form of irregularly shaped lensoidal bodies has taken place in the central portion in the North side where as towards the south it was distributed in East and West of the study area. On the basis of study made three zones (Zone-1, Zone-2 and Zone-3) were marked / identified as interesting / probable mineralisation and further investigations has to be done like trenching /pitting in the probable mineralized zones and shown in figure 9.4 on the Magnetic Anomaly Map and the mineralized zones found.

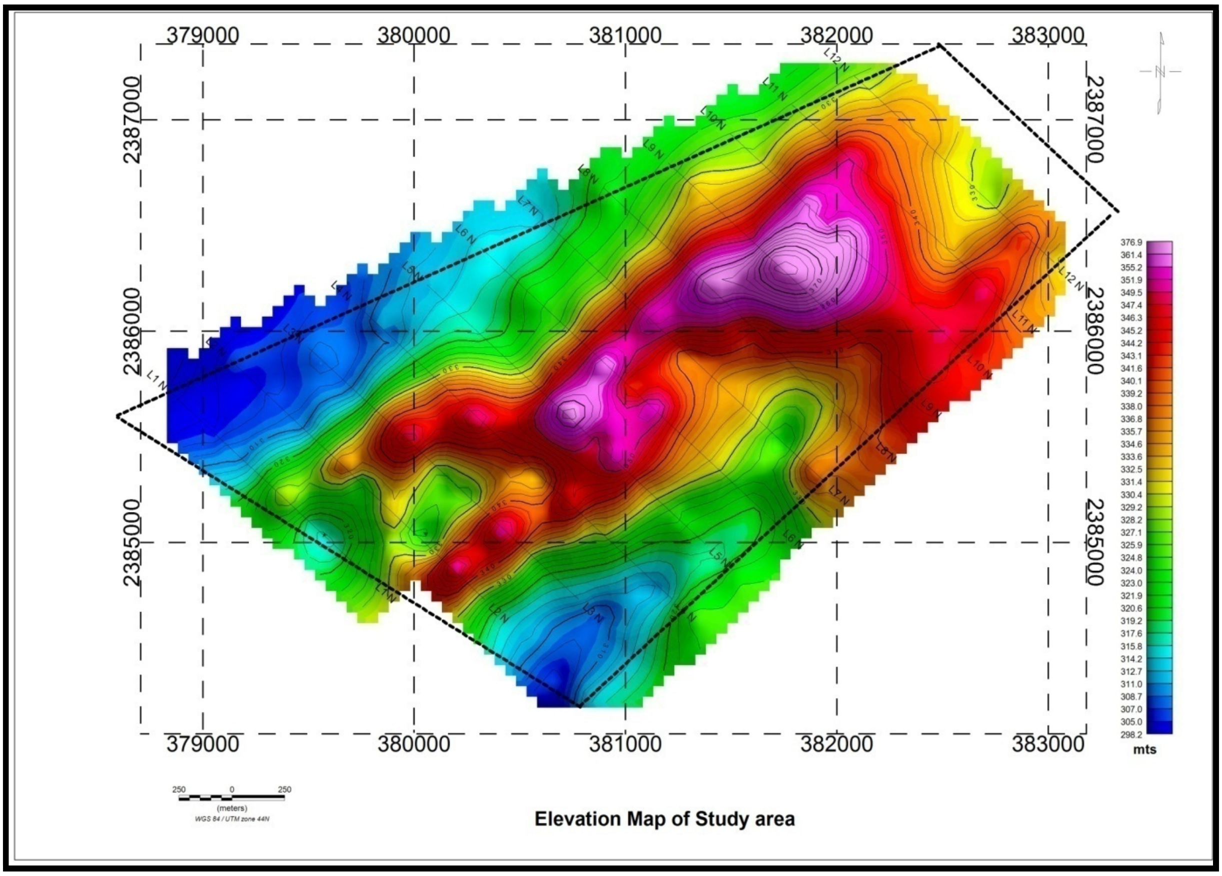
Text Figure-9.1: Layout Map of Magnetic Survey

Text

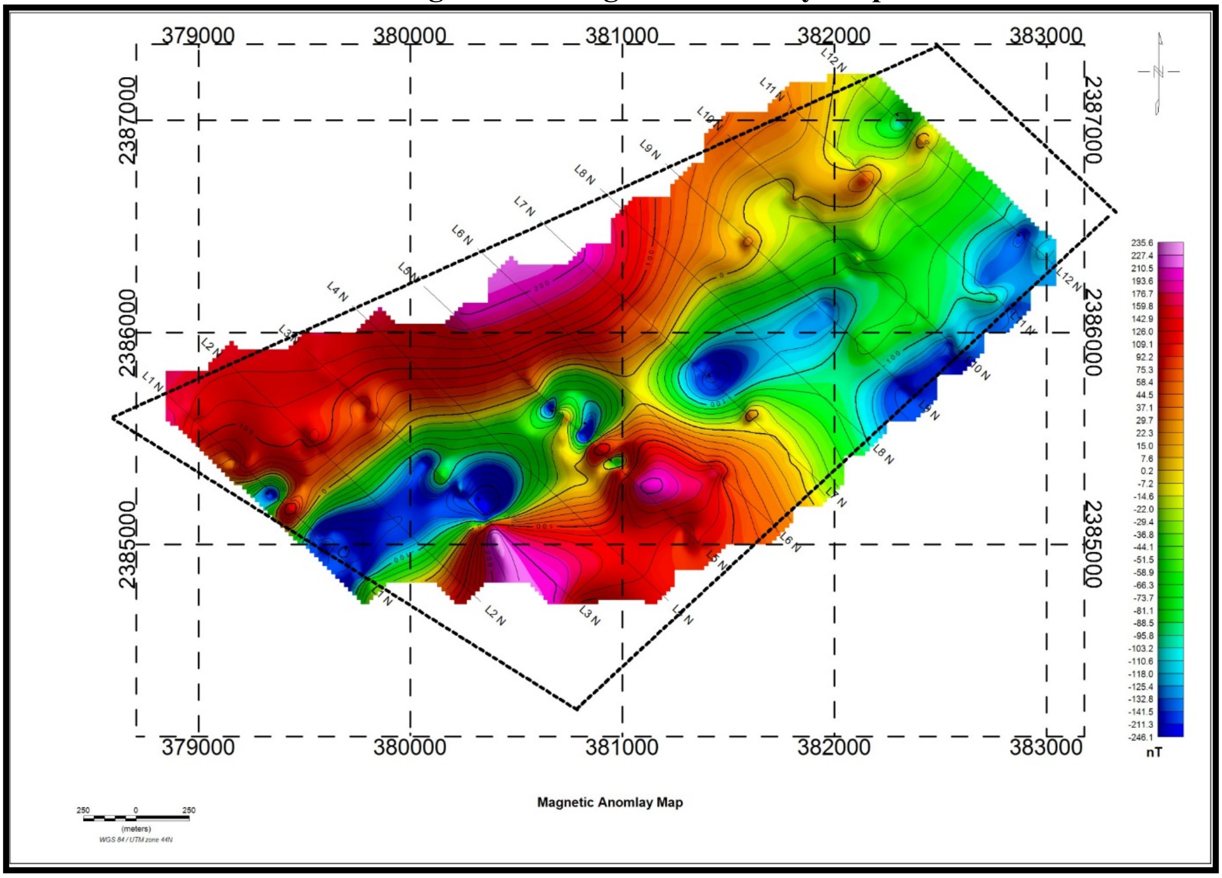


Layout Map of the Area

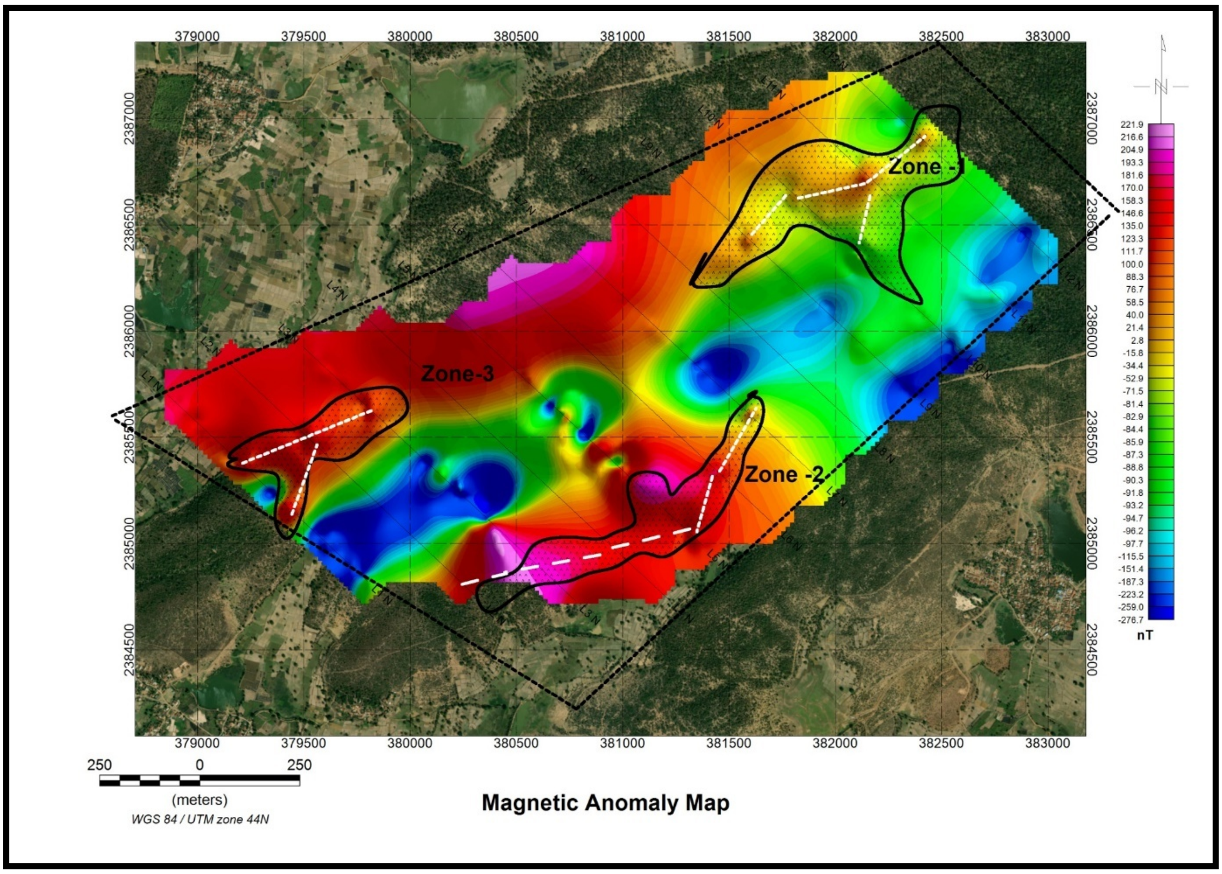
Text Figure 9.2: Elevation (RL) Map of the Block



Text Figure 9.3: Magnetic Anomaly Map



Text Figure 9.4: Magnetic Anomaly Map with zones on Google Earth



CHAPTER-10

10.0.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION:

10.1.0 INTRODUCTION

10.1.1 The Katori Jhiriya Block, situated in Balaghat District, Madhya Pradesh, was selected for mineral exploration under the ongoing National Mineral Exploration and Development Trust (NMEDT) programme. This block forms part of the Sausar Group of rocks, a well-known geological sequence that hosts several major manganese deposits such as Bharweli, Tirodi, Ukwa, and Sukli–Sitapathore. The area was chosen for investigation because it shows strong geological similarities with these established deposits. The block contains muscovite schist, quartzite, calc-gneiss, and dolomitic marble of the Sausar Group, which are recognized host rocks for manganese mineralisation. In addition, the area exhibits clear signs of surface manganese enrichment and lies within a structurally favourable zone that trends northeast–southwest (NE–SW) consistent with the regional ore-bearing trend of the Sausar Belt. Given these factors, the block was proposed by the Mineral Exploration and Consultancy Limited (MECL) for Reconnaissance (G-4) stage exploration to assess its potential for manganese and associated minerals.

10.1.2 Subsequently, MECL prepared a proposal for G-4 stage exploration in the Katori Jhiriya Block and put up the Technical cum Cost Committee (TCC) of NMEDT in its 47th meeting, held on 28th – 29th November 2022 via video conferencing for its technical evaluation. The proposal with some minor modifications was recommended to the Executive Committee (EC) of NMEDT for its approval. The 27th Executive Committee (EC) held on 10th January 2023 approved the G-4 stage exploration proposal for Katori Jhiriya Block at an estimated exploration cost of Rs. 1,67,81,229/-, vide Office Memorandum F.No. 23/296/2023-NMET/317, New Delhi, dated, 3rd February 2023 (Annexure No-XIV).

10.1.3 The Katori Jhiriya (G-4 stage) block over an area of 140.2 sq. km. lies in the Waraseoni and Khairlanji tehsil of Balaghat district in Madhya Pradesh. The exploration block is covered in Survey of India Toposheet no. 55O/14. The current investigation was aimed to find out the potentiality for manganese and associated minerals in the block.

10.2.0 OBJECTIVES OF INVESTIGATION

10.2.1 On approval of EC, NMEDT, the exploration programme in Katori Jhiriya block has been formulated to fulfil the following objectives:

1) **Geological Mapping:** Geological mapping will be done in the entire 140.22 sq km area on 1: 12,500 scale. Rock types, their contact, structural features will be mapped. Surface manifestations of the ore bodies available along with their surface disposition will be marked on map.
2) **Geochemical Sampling:** Surface sampling (Bed Rock/Channel Sample): During the course of Geochemical Sampling the bed rock / channel samples shall be collected from the outcrops along with soil and stream sediment samples.
3) **Geophysical Survey:** Integrated Geophysical Surveys Magnetic have been planned to carry out in the potential area marked by geological mapping. A total of 450 Line km of Magnetic Surveys will be covered in the block.
4) **Exploratory Mining (Trenching/Pitting):** Shallow trenching/pitting (Excavation) shall be carried out in the potential zones identified based on the results of geological mapping and geochemical sampling.
5) **Core Drilling:** To find out the potentiality of mineralized zones in strike & dip direction, 9 Nos of scout boreholes involving 500m of drilling will be carried out for first level of intersection of mineralized zones.
6) To estimate reconnaissance resources (334) along with accessory elements as per UNFC norms and Minerals (Evidence of Mineral Content) Rules-2015 at G-4 level.

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

10.3.0 BASIS FOR TAKING UP INVESTIGATION

10.3.1 The Katori Jhiriya Block forms part of the manganese-bearing belt of the Sausar Group, located in Waraseoni and Khairlanji Tehsil of Balaghat District, Madhya Pradesh, and lies east of the well-known Miragpur and Chorpindkepar mining areas. The block was proposed for reconnaissance-level exploration (G-4 stage) under the aegis of the National Mineral Exploration and Development Trust (NMEDT) with the objective of delineating potential manganese and associated mineralisation zones within the Mansar Formation of the Sausar Group.

10.3.2 The Reconnaissance Survey (G-4) proposal for manganese and associated minerals in the Katori Jhiriya Block was examined by the 47th Technical-cum-Cost Committee (TCC) of NMEDT. After technical discussions and subsequent modifications, the proposal was approved by the 27th Executive Committee (EC) of NMEDT in its meeting held on 10th January, 2023, for implementation by Mineral Exploration and Consultancy Limited (MECL).

10.3.3 The approved project envisaged geological, geochemical, and geophysical exploration over a total area of 140.22 sq. km, aimed at establishing manganese-bearing zones and understanding their lithological and structural controls. The work was sanctioned under the scheme titled "Reconnaissance Survey (G-4) for Manganese and Associated Minerals in Katori Jhiriya Block, Balaghat District, Madhya Pradesh" at an estimated cost of ₹1.67 crore.

10.4.0 PRESENT EXPLORATION WORK

10.4.1 To achieve the objectives outlined in para 10.4.0, MECL executed a Reconnaissance Survey (G-4 level) in the Katori Jhiriya Block, Balaghat District, Madhya Pradesh. The work included the following major components: i) Geological mapping on a 1:12,500 scale, ii) Surface geophysical (magnetic) survey over an area of 6.73 sq. km to identify subsurface anomalous zones, iii) Trenching and pitting (total excavation volume: 100 m^3) in selected anomalous areas at Tekadi Tiju , Shankar Pipariya and Chorpindkepar zones, vi) Bedrock, trench, channel and core sampling (total 225 surface and 100 core samples) for chemical analysis of Mn, Fe_2O_3, SiO_2, P_2O_5, MnO_2, and Acid Insoluble, v) Exploratory drilling of 7 boreholes (total 358.5 m) based on surface and geophysical results, and vi) Laboratory studies, including petrography, mineragraphy, and whole rock analysis determinations on representative samples.

10.4.2 The exploration activities commenced on 10th February 2023 and were completed by March 2025. All field operations, including geological mapping, trenching, sampling, and drilling, were carried out under strict geological supervision. Laboratory analyses were conducted at MECL's Chemical Laboratory, Nagpur, and selected samples were sent for external verification to NABL-accredited laboratories.

10.4.3 The details of the approved versus achieved quantum of work (geological mapping, geophysical survey, trenching, sampling, and drilling) are summarised in Table 10.1, while the analytical results, petrographic data, and geophysical interpretations are presented in the subsequent sub-sections of this report.

Table – 10.1

Approved Quantum of Work Vs Achievement in Katori Jhiriya Block

Sl. No.	Item of Work	Unit	Proposed Quantum of work	Quantum of Work Done
1	Geological Mapping (on 1:12,500 Scale)	Sq. Km.	140.22	140.22
2	Geophysical Work			
	i) Magnetic Survey	Line Km	450	1200
3	Trenching	Cu. m	100	100
4	Core Drilling 500m (9 Scout Boreholes)	m.	500 (9 BH)	358.5 (7 BH)
5	Sample Preparation & Chemical Analysis			
A.	Primary samples for Manganese (Bedrock/Channel /Trench Samples)			
	i) Primary samples for 6 radicals i.e. Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles	Nos.	225	225
	ii) Internal Check samples (5% of Primary samples) for 6 radicals	Nos.	11	11
	iii) External Check sample (10% of Primary samples) for 6 radicals	Nos.	23	23
B.	Primary samples for Manganese (Core)			
	i) Primary samples for 6 radicals i.e. Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles	Nos.	100	77
	ii) Internal Check samples (5% of Primary samples) for 6 radicals	Nos.	5	4
	iii) External Check sample (10% of Primary samples) for 6 radicals	Nos.	10	8
C.	Composite Samples for Manganese (Core) for 6 radicals i.e. Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles	Nos.	10	10
6	Whole Rock Analysis for SiO2, Al2O3, Fe2O3, TiO2, MnO, CaO, Na2O, K2O+H2O, MgO, P2O5, CO2, & S.	Nos	10	10
7	Petrographic Studies	Nos	10	10
8	Digital Photographs	Nos	20	20
9	Mineragraphic Studies	Nos	10	10
10	Report Preparation (Digital format)	Nos.	1	1

10.4.4 The proposed borehole locations initially fell within the Fulchur Reserve Forest, for which the necessary forest clearance was duly obtained prior to commencement of drilling operations. During the approval and layout verification stage, five boreholes planned near Chorpindkepar were found to overlap with the Trivedi Mining Lease area and were therefore either omitted or suitably relocated to avoid encroachment. Consequently, against the approved proposal of nine (9) boreholes totaling 500.00

metres, only seven (7) boreholes were ultimately executed, achieving a total drilled meterage of 358.50 metres.

10.5.0 DETAILS OF EXPLORATION ACTIVITIES TAKEN UP

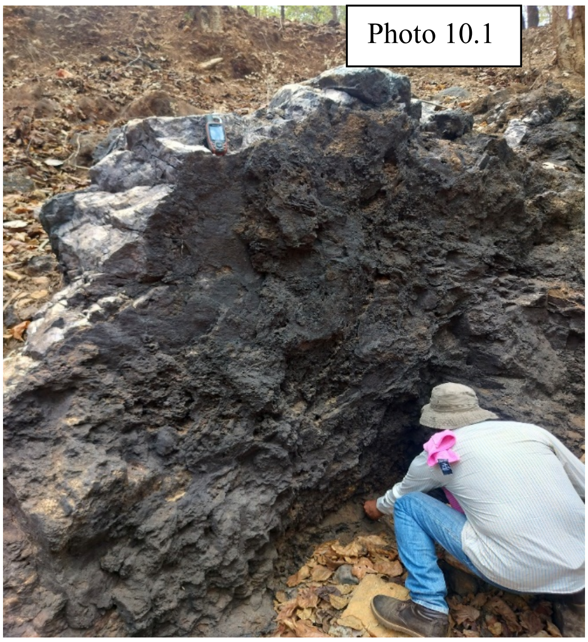
The exploration work in the Katori Jhiriya Block, District Balaghat, Madhya Pradesh, was undertaken by Mineral Exploration and Consultancy Limited (MECL) under the funding of the National Mineral Exploration and Development Trust (NMEDT). The approved scope of work included large-scale geological mapping, surface geophysical studies, trenching, and scout drilling to delineate manganese and associated mineralisation within the Sausar Group of rocks.

10.6.0 GEOLOGICAL MAPPING:

10.6.1 Detailed geological mapping was carried out on a 1:12,500 scale over the prospective part of the Katori Jhiriya Block, covering approximately 140.22 sq. km area. The work involved delineation of lithological units, identification of structural elements, and documentation of surface manganese mineralisation. The mapping was conducted using handheld GPS for spatial control, and Brunton compass for recording the attitude of foliations, joints, and shear planes. The litho-contact boundaries were marked in the field and later refined through integration of geophysical and drilling data. The general strike of the lithological units is NE–SW, with variable dips ranging from 30° to 85° towards both southeast and northwest, indicating a polydeformed structural setup within the Mansar Formation of the Sausar Group. The geological mapping operations commenced on 10.02.2023 and were successfully completed on 30.06.2023.

10.6.2 The Katori Jhiriya Block exhibits a moderately undulating topography, with elevations ranging between 290 m and 340 m above MSL, and is dissected by several small seasonal streams flowing southeastward. The mapped lithological units include soil, laterite, quartzite, muscovite schist, biotite schist, calc-gneiss, gneiss/mimgatite and manganese-bearing bands, along with minor quartz veins and granitic intrusives. The foliation and structural trends were systematically recorded to understand their relation with manganese mineralisation. Surface manganese exposures, old workings, and float ore occurrences were mapped near Shankar Pipariya, Chorpindkepar, and Tekadi Tiju areas.

10.6.3 The geological map was prepared by integrating surface data with subsurface information obtained from trenching, sampling, and exploratory boreholes (MKJ-01 to MKJ-07). The final interpreted geological map delineates the distribution of lithounits, structural features, and manganese mineralised zones, providing a reliable framework for understanding the local stratigraphic succession and ore control. The interpreted geological map of the Katori Jhiriya Block, has been compiled at a 1: 12,500 scale and is presented as Plate III.



Photograph No. 10.1 & 10.2: Photographs showing geologist collecting data from the exposed Manganese bearing quartzite in Chorpindkepar area

10.7.0 <u>GEOCHEMICAL BEDROCK / CHANNEL SAMPLING:</u>

10.7.1 During exploration for manganese and associated minerals in the Katori Jhiriya Block, manganese mineralisation was observed at the surface in the form of float ore, old workings, and manganiferous exposures, particularly in the Shankar Pipariya, Chorpindkepar, and Tekadi Tiju areas. These mineralised zones occur within muscovite schist and quartzite of the Mansar Formation. Since a major part of the area is covered with soil and lateritic overburden, trenching was undertaken to expose the subsurface continuation of manganese-bearing horizons and remove the weathered surface layers.

10.7.2 A total of 85 bedrock (chip) samples were collected from various litho-units of the Katori Jhiriya Block, primarily from Pindkepar, Shankar Pipariya, Jhiriya, and Tekadi Tiju areas. The analysis was conducted for six radicals, Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2, and Acid Insoluble, to assess manganese mineralisation and associated geochemical variations.

10.7.3 To obtain true grade distribution along exposed Mn bands, channel samples were collected from 8 channels (CH-1 to CH-8) opened on surface in Chorpindkepar, Tekadi Tiju and Shankar Pipriya areas exactly where mapping, and old pits indicated mineralisation. A total of 91 channel samples were systematically collected from mineralised zones, footwall, and hanging wall lithounits exposed in the surface. The sampling intervals generally ranged from 0.75 m to 1.0 m, depending on changes in lithology and intensity of mineralisation. The samples were collected using a chisel-and-hammer channeling technique, ensuring uniform representation across wall.

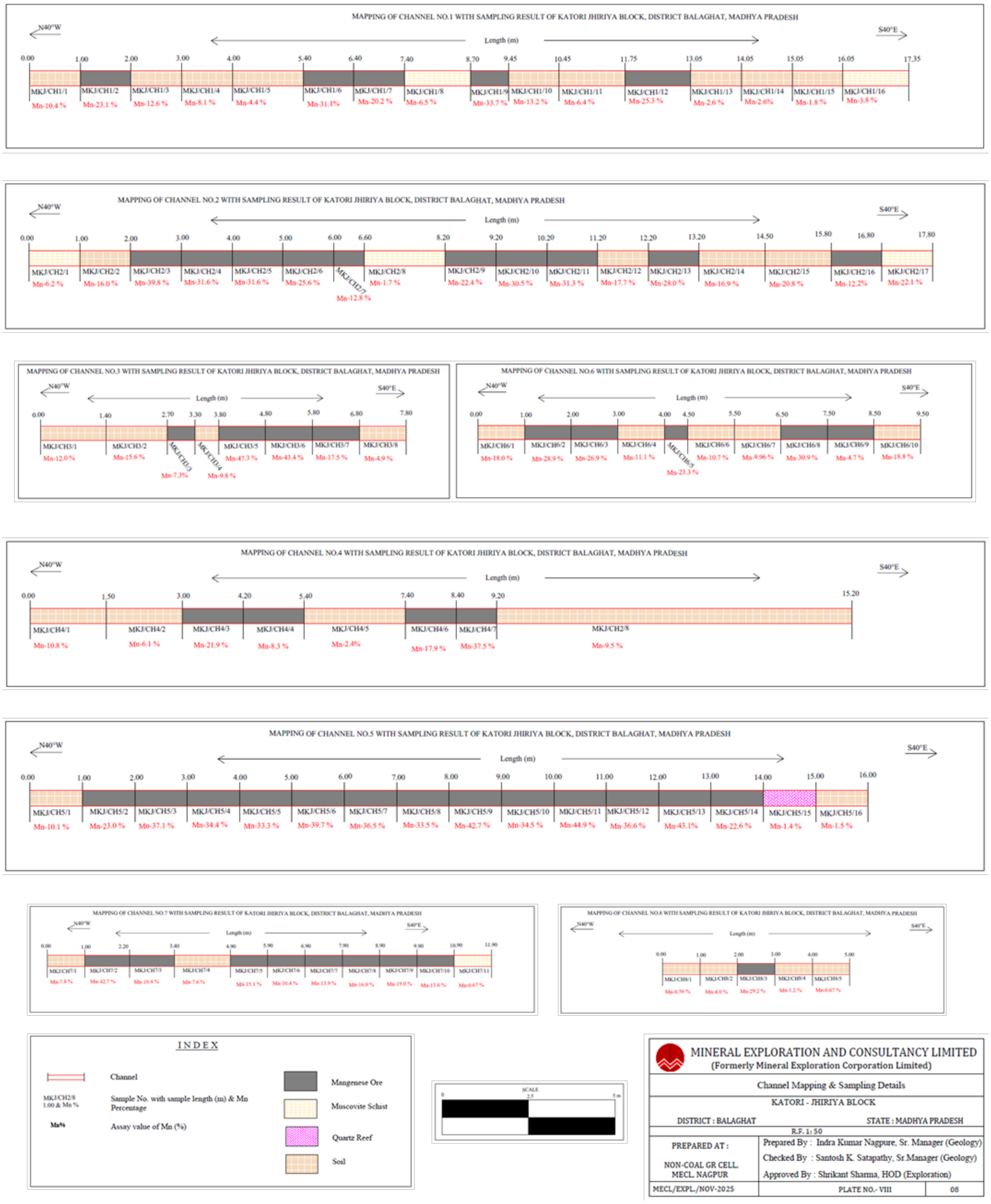
10.7.4 Trenching work was undertaken in the Katori Jhiriya Block to establish the surface continuity of manganese-bearing horizons identified during geological mapping and geophysical interpretation. A surface geophysical (magnetic) survey was carried out over an area of 6.73 sq. km, which delineated three magnetic anomaly zones corresponding to ferruginous and manganese-rich formations. Based on the integrated interpretation of geophysical anomalies, field observations, old workings, and anomalous geochemical results from bedrock sampling, three promising areas, Shankar Pipariya, Chorpindkepar and Tekadi Tiju were selected for detailed trenching operations. A total of six trenches were excavated across the anomalous areas to verify the subsurface extension and lateral continuity of the mineralised zones. The trenches were oriented perpendicular to the geological strike (NE–SW) of the formations to obtain true cross-sections of the mineralised horizons. The average depth of trenches ranged from 1.5 to 2.0 metres, depending upon overburden thickness and weathering conditions. In total, about 100 cubic metres of trenching was completed under close geological supervision. Each trench was cleaned, geologically mapped, and logged for lithological variations, mineralisation patterns, and structural features such as foliation, joints, and shears. The trench locations and orientations were fixed using GPS and plotted on the geological map (1:12,500 scale). Detailed geological logging was carried out along both trench walls, recording lithology, structure, and mineralisation features. The trench locations are shown in Plate IV (Geological Map with Boreholes location) of this report.

10.7.5 The collected samples were dried, ground, and homogenised through repeated coning and quartering to achieve uniform representative subsamples of (-120 mesh) fineness. Approximately 500 grams of each sample was prepared for analysis; one portion was sent to the MECL Chemical Laboratory, Nagpur, for determination of major oxides, while the duplicate portion was preserved as a check sample for quality assurance and future reference.

10.7.6 All 225 bedrocks, channel and trench samples were analysed using the WD-XRF method and classical wet chemical methods for Mn, Fe_2O_3, SiO_2, P_2O_5, MnO_2, and Acid Insolubles. The analytical results revealed highly variable manganese content, ranging from 0.12% to 50.70% Mn, with elevated Mn values concentrated in the Shankar Pipariya, Chorpindkepar and Tekadi Tiju zones, confirming the presence of discontinuous and lensoidal manganese enrichment within the Mansar Formation.

10.7.7 Detailed information regarding the location of each sample and their respective analytical results can be found in Annexure-IV for reference.


Photograph No. 10.3: Photograph showing collection of channel sample in Chorpindkepar area.



Text Figure 10.1: Result of all 8 channel samples collected from the Katori Jhiriya Block

Table-10.2

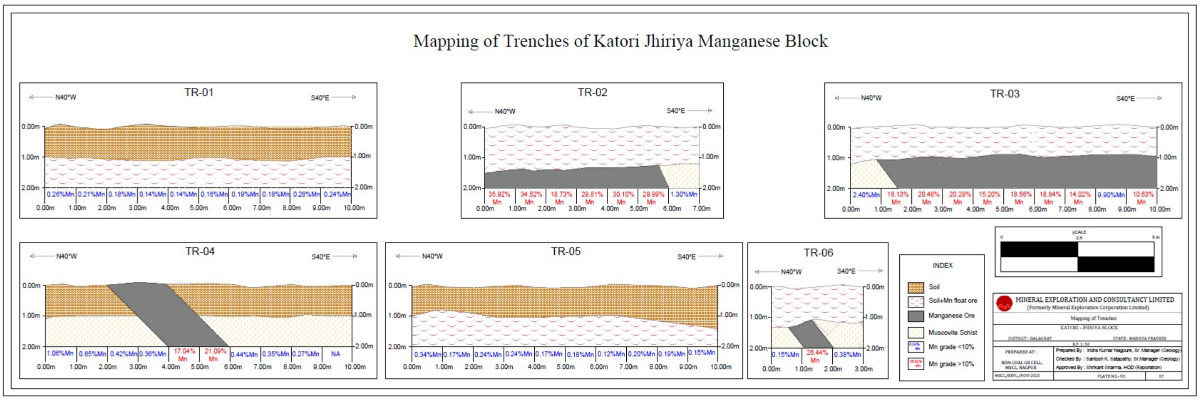
Details of Channel excavated by MECL in Katori Jhiriya Block, District: Balaghat, Madhya Pradesh

Sl. No.	Channel No.	Location (UTM)		Azimuth of Trench towards	Remarks
		Easting (m)	Northing (m)		
1	Channel 1	382171.062	2386574.009	N40°E	Near Chorpindkepar village
2	Channel 2	382290.216	2386232.118	N40°E	Near Chorpindkepar village
3	Channel3	382314.151	2386212.991	N40°E	Near Chorpindkepar village
4	Channel 4	382162.537	2386442.255	N40°E	Near Chorpindkepar village
5	Channel 5	382221.345	2386404.193	N40°E	Near Chorpindkepar village
6	Channel 6	381319.626	2385226.153	N40°E	Near Shankar Pipriya village
7	Channel 7	381319.626	2385226.153	N40°E	Near Shankar Pipriya village
8	Channel 8	379388.382	2385431.056	N40°E	Near Tekadi Tiju village

Table-10.3
Details of Trench excavated by MECL in Katori Jhiriya Block, District: Balaghat, Madhya Pradesh

Sl. No.	Trench No.	Location (UTM)		Azimuth of Trench towards	Dimension (L X W X H)	Remarks
		Easting (m)	Northing (m)			
1	Trench 1	382117.73	2386555.68	N40°E	10m X 1m X 2m	Near Chorpindkepar village
2	Trench 2	382172.66	2386397.88	N40°E	7m X 1m X 2m	Near Chorpindkepar village
3	Trench 3	381549.25	2385588.21	N40°E	10m X 1m X 2m	Near Shankar Pipriya village
4	Trench 4	381305.09	2385211.67	N40°E	10m X 1m X 2m	Near Shankar Pipriya village
5	Trench 5	381059.59	2384961.48	N40°E	10m X 1m X 2m	Near Shankar Pipriya village
6	Trench 6	379412.75	2385453.67	N40°E	3m X 1m X 2m	Near Tekadi Tiju village

Photograph No.10.4: Photograph showing manual trench excavated in mineralisation area



Text Figure 10.2: Result of all 6 trench samples collected from the Katori Jhiriya Block

10.8.0 GEOPHYSICAL SURVEY:

10.8.1 A ground magnetic survey covering 6.73 sq. km was conducted over the Katori Jhiriya Block with the objectives of: (i) refining the structural and lithological configuration of the Sausar Group schist–quartzite sequence concealed beneath soil and lateritic cover, and (ii) identifying low-amplitude, linear to lensoidal magnetic breaks or corridors potentially associated with manganese-bearing horizons, which are generally weakly magnetic compared to adjacent biotite-rich and ferruginous bands.

10.8.2 The survey results delineated several weak to moderate magnetic lineaments trending NE–SW to NW–SE, broadly conformable with the regional foliation. Distinct magnetic lows were recorded coinciding with old workings and manganese exposures in the Chorpindkepar and Shankar Pipariya sectors, while additional masked magnetic lows were observed beneath soil-covered areas where no outcrop was visible, suggesting possible lithological or structural variation.

10.9.0 EXPLORATORY DRILLING:

10.9.1 To assess the subsurface continuity and depth persistence of manganese mineralisation delineated through geological mapping, trenching, and geophysical surveys, a scout core drilling programme was undertaken in the Katori Jhiriya Block, District Balaghat, Madhya Pradesh. The exploration was carried out under the G-4 level to evaluate the geological potential of manganese and associated minerals.

10.9.2 A total of 7 boreholes (MKJ-01 to MKJ-07) were drilled along NW–SE trending section lines across the interpreted ore body to intersect the mineralised horizons at depth. The drilling operations commenced on 1stJune 2025 and were completed on 27thSeptember 2025, achieving a cumulative meterage of 358.5 metres. The borehole collar coordinatesand elevations, were determined using DGPS (WGS–84 datum) and are presented in Table–10.4.

10.9.3 The proposed boreholes were located within the Fulchur Reserve Forest, for which forest clearance was obtained from the concerned Forest Department. During the clearance process, it was observed that the Chorpindkepar village area, where five boreholes had been planned, overlapped partially with the Trivedi Mining Lease. The Forest Department, therefore, advised omitting the borehole sites falling within the lease area and relocating them accordingly. Following the necessary revisions, exploratory drilling commenced with Borehole No. MKJ-01 on 01.06.2025 and was completed with Borehole No. MKJ-07 on 27.09.2025. All associated fieldwork, including geological logging, sampling, and on-site observations, was carried out simultaneously. The analytical and laboratory studies of the collected samples were undertaken concurrently at MECL laboratories and other Government/NABL-accredited laboratories to ensure quality and reliability of the data.

10.9.4 All boreholes were drilled using wireline coring technique with NX core size, and recovery averaged about 86.55%. The geological sections and borehole locations are plotted on Plate–IV.

10.9.5 Details of boreholes drilled in Katori Jhiriya block with total depth are summarised in below given table 10.4 and submitted as Annexure No. IIA respectively.

Table-10.4
Details of Section-Wise Boreholes drilled by MECL inKatori Jhiriya (G-4) Block

Sl. No.	Bore-hole No.	Easting (m)	Northing (m)	Reduced Level (m)	Bear-ing (°)	An gle (°)	Date of Commence-ment	Date of Closure	Total Depth (m)
1	MKJ-01	381187.70	2384944.70	293.64	320°N	55°	01.06.2025	09.06.2025	52.00
2	MKJ-02	381361.23	2385193.32	298.93	320°N	55°	15.06.2025	03.07.2025	76.00
3	MKJ-03	381551.29	2385546.78	302.80	320°N	55°	10.07.2025	20.07.2025	40.00
4	MKJ-04	382283.74	2386256.71	317.77	140°N	52°	25.07.2025	05.08.2025	40.00
5	MKJ-05	382184.97	2386655.08	316.15	140°N	52°	09.08.2025	21.08.2025	50.50
6	MKJ-06	382084.19	2386582.11	320.88	140°N	52°	26.08.2025	07.09.2025	50.00
7	MKJ-07	382085.00	2386766.00	317.00	140°N	52°	13.09.2025	27.09.2025	50.00
Total:									**358.50**

10.10.0 DATA SPACING

10.10.1 In Katori Jhiriya block the scout boreholes were drilled to establish the Manganese ore resource at G-4 stage. The envisaged input after the reconnaissance survey for Manganese ore by MECL along geological axis as per the specifications given in the Minerals (evidence of Mineral content) Rule-2015, the code (334) can be assigned to the block (as per UNFC system).

10.10.2 **PETROGRAPHIC STUDIES:** A total of 10 bedrock and borehole core samples representing different litho-units of the Katori Jhiriya G-4 Block were subjected to petrographic examination at the Petrological Laboratory of MECL, Nagpur. The samples include muscovite schist, biotite schist, quartzite, calc-gneiss, and granite gneiss. The studies were carried out to identify the mineral composition, textural relationships, and metamorphic features of these rock types. The petrographic results reveal that the rocks belong predominantly to the Sausar Group (Mansar and Lohangi Formations) and exhibit mineral assemblages typical of medium-grade regional metamorphism (amphibolite facies).

10.10.3 The muscovite and biotite schists show pronounced foliation defined by mica alignment, while quartzite samples are granoblastic and contain recrystallized quartz mosaics. Calc-gneiss shows alternating bands of calc-silicate and quartz-feldspar layers, whereas the granite gneiss (Tirodi Biotite Gneiss) exhibits a gneissose texture with feldspar, quartz, and biotite as the main constituents.

10.10.4 Detailed sample-wise descriptions and microphotographic observations are presented in Annexure–VII (Petrographic Study Report).

10.11.0 MINERAGRAPHIC STUDIES

10.11.1 A total of 10 polished sections prepared from manganese-bearing bedrock and borehole samples were subjected to mineragraphic studies at the MECL Ore Dressing Laboratory, Nagpur. The objective was to identify the ore mineral assemblage, paragenetic relationships, and mode of occurrence of manganese minerals in the block.

10.11.2 The mineragraphic examination indicates that the manganese mineralisation in the Katori Jhiriya Block is of the gondite-type, associated with metamorphosed manganiferous sediments of the Mansar Formation, Sausar Group.

10.11.3 The principal ore minerals identified are braunite, hausmannite, and psilomelane, with minor pyrolusite and cryptomelane. The gangue minerals include quartz, spessartine garnet, and muscovite, suggesting metamorphic recrystallisation of an original sedimentary manganese horizon.

10.11.4 The ore occurs as fine to medium-grained, disseminated to massive aggregates, often aligned with the schistosity of the host rock. The textures observed granoblastic, intergrowth, and replacement features, indicate reconstitution during regional metamorphism.

10.11.5 Detailed sample-wise observations and photomicrographs are enclosed in Annexure-VIII (Mineragraphic Study Report).

10.12.0 WHOLE ROCK ANALYSIS:

The whole-rock geochemical data of ten representative samples (five surface and five borehole) from the Katori Jhiriya Block show clear lithological and mineralogical distinctions consistent with the Sausar Group terrain. Samples with high SiO_2 (70–94%) and low Fe_2O_3 + MnO correspond to quartz-rich schists and quartzites, reflecting silicification and intense metamorphic recrystallization. Moderately siliceous samples (50–60% SiO_2) with elevated Al_2O_3 (10–24%) represent muscovite-biotite schists of the Mansar Formation.

10.12.1 Two samples (MKJ-01/03 and MKJ-05/13) exhibit very high MnO (15.6% and 18.8%) along with appreciable Fe_2O_3, confirming the presence of manganiferous bands and gonditic horizons. These Mn-rich samples also show elevated Cu, Zn, Co and V, reflecting their association with Mn–Fe oxide phases and secondary hydrothermal/metamorphic remobilization. In contrast, quartz-dominated samples (e.g., MKJ-P-14 and MKJ-P-19) show extremely low base metals and negligible MnO (<0.02%), indicating barren lithologies.

10.12.2 Trace elements such as Cr and Sr are relatively higher in schistose samples, likely derived from biotite, feldspar and accessory garnet. Overall, the whole-rock chemistry confirms a mixed assemblage of quartzite, schist, and thin manganiferous bands, with manganese enrichment restricted to very localized lenses, consistent with trench, channel, and borehole observations. Result of Whole Rock Studies is attached in Annexure-XI.

10.13.0 COMPOSITE SAMPLES ANALYSIS: Three composite drill-core samples (MKJ-C01 to MKJ-C03), prepared from selected manganese-bearing intervals intersected in scout boreholes, were subjected to X-ray diffraction (XRD) studies at MECL's Physical Laboratory. Chemical analysis for Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Acid Insolubles was performed using wavelength-dispersive X-ray fluorescence (WD-XRF). The analytical results are furnished in Annexure-X.

10.13.1 The composite samples exhibit low to moderate Mn content, consistent with the thin and discontinuous mineralised bands intersected in drilling. The values of MnO_2 are comparatively low to moderate, indicating limited development of secondary supergene enrichment at depth. The samples show high SiO_2 and high Insoluble fractions, reflecting the dominance of quartz–mica schist and quartzite as the primary host lithologies, with manganese occurring only as disseminations and thin laminae.

10.13.2 Moderate Fe_2O_3 values suggest the presence of ferruginous phases (goethite, hematite) associated with manganese oxides, typical of metamorphosed Sausar manganese horizons. P_2O_5 values are very low, indicating minimal apatite or phosphate mineral presence, this aligns with the field observation that the manganese bands in Katori Jhiriya are weakly phosphatic and chemically mature.

10.14.0 DISCUSSION ON RESULTS OF MAPPING, SAMPLING (BEDROCK, CHANNEL AND TRENCH), AND DRILLING

10.14.1 Geological mapping on a 1:12,500 scale was carried out over an area of 140.22 sq. km in the Katori Jhiriya G-4 Block to delineate lithological units, structural elements, and surface manganese indications. The mapping identified rock types belonging to the Sausar Group (Mansar and Lohangi Formations) comprising muscovite schist, biotite schist, quartzite, calc-gneiss, and granite gneiss (Tirodi Biotite Gneiss). The general strike of foliation trends NE–SW with dips ranging from 40° to 80° towards SE and NW, indicating multiple folding and shearing phases. Surface manganese occurrences were recorded near Shankar Pipariya, Chorpindkepar–Jhiriya, and Tekadi Tiju, which guided the trenching and drilling programmes.

10.14.2 A total of 225 surface samples were collected comprising 85 bedrock samples, 91 channel samples, and 49 trench samples to evaluate surface manganese mineralisation. The bedrock samples from manganese-bearing quartzite and schist around Shankar Pipriya, Tekadi Tiju, and Chorpindkepar show Mn values ranging from 0.12% to 50.70%, with Fe_2O_3 varying from 6% to 20.25%. The channel samples collected along manganese exposures and old workings yielded Mn values between 0.18% and 47.32%, reflecting localised enrichment along foliation planes. The trench samples, collected from six trenches excavated across the mineralised zones, show Mn values ranging from 0.1% to 35.9%, confirming the presence of narrow, lensoidal manganese bands within muscovite schist and quartzite of the Mansar Formation. Analytical results collectively indicate highly variable and discontinuous manganese enrichment, controlled primarily by lithology and local structure rather than by stratigraphic continuity.

10.14.3 After obtaining necessary forest clearance, core drilling in the block commenced on 1 June 2025; however, because a part of the mapped mineralised area falls within an existing Trivedi mining lease, only seven boreholes were actually drilled. Drilling was completed on 27 September 2025. A total of seven boreholes amounting to 358.5 m of core drilling were completed in the Shankar Pipariya and Chorpindkepar sectors. Subsurface intersections confirm limited manganese mineralisation, restricted to narrow bands (1.5–2.7 m thick) within muscovite schist–quartzite assemblages. Only two boreholes (MKJ-01 and MKJ-05) intersected manganese zones with Mn grades between 10–12%, while other boreholes were barren. The results demonstrate that manganese mineralisation in the block is discontinuous, structurally controlled, and of limited vertical and lateral persistence, typical of gondite-type metamorphosed manganese deposits within the Mansar Formation of the Sausar Group.

10.14.4 In summary, the integration of geological, geochemical, geophysical, and drilling data demonstrates that manganese mineralisation in the Katori Jhiriya Block is discontinuous, structurally disrupted, and confined to narrow lenses within muscovite schist and quartzite. The average Mn grade in the subsurface varies between 10% and 12%, and the mineralised thickness rarely exceeds 2m. The overall geological and analytical evidences indicate a low-volume, metamorphosed syn-sedimentary manganese deposit of gondite affinity, typical of the Mansar Formation of the Sausar Group.

CHAPTER-11

11.0.0 LOCATION OF DATA POINTS:

11.1.0 ACCURACY AND QUALITY OF SURVEY USED TO LOCATE DRILL HOLES:

11.1.1 The survey of all boreholes drilled within the Katori Jhiriya Block was conducted using a Trimble GNSS DA-2 Catalyst Differential GPS (DGPS) system to ensure high positional accuracy. The Survey of India (SOI) CORS base station was utilised for establishing accurate ground positions and determining the Reduced Levels (RLs) of all boreholes. For this purpose, the KATA base station from the SOI CORS Network (Region-1) was used as the reference point during data processing. The coordinates of the base station are given below in Table-11.1.

Photograph No. 11.1: Photograph showing high-precision DGPS measurement at the collar of Borehole MKJ-01and MKJ-04 in the Katori Jhiriya Block

Table-11.1

Coordinates of the SOI CORS Base Point for DGPS Survey of Katori Jhirya block, Balaghat Madhya Pradesh

Base Station	Latitude	Longitude	Easting (m)	Northing (m)	RL (m)
KATA	N21°45'55.14113"	E79°47'51.37400"	375677.826	2407334.972	347.178

11.2.0 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

11.3.0 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.

11.4.0 QUALITY AND ADEQUACY OF TOPOGRAPHIC CONTROL

11.4.1 All the seven boreholes drilled within the Katori Jhiriya Block were accurately fixed using Differential Global Positioning System (DGPS). The surface coordinates and reduced levels (RLs) of the borehole collars were also determined through DGPS to ensure high positional accuracy.

11.4.2 As per the approved quantum of work, a detailed topographic survey was not included in the current exploration programme; therefore, no dedicated topographic survey was carried out in the field. The topographic map of the area was prepared using the available Survey of India toposheet data, and the surface features, contour patterns, and infrastructure details were plotted and interpreted based on the information derived from these maps.

11.4.3 The overall topographic control is considered adequate for G-4 stage reconnaissance exploration, ensuring sufficient accuracy for geological mapping, borehole positioning, and correlation of surface features.

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 coresampling programme, representative borehole samples were systematically collected from manganese-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.

The sampling and analyses have been carried out for entire mineralized zones/length intersected in the boreholes drilled. The primary samples have been marked in the mineralized zones intersected in the borehole based on type & concentration of mineralization/lithology and in general the sample length has been kept as 0.5 and 1.0 m which varied in some instances because of variation in lithology and type & concentration of mineralisation. The mineralized core has been splitted into two equal halves in such a way that the concentrations of ore minerals are uniform in both the equal halves. One half of the core sample has been crushed to (–) 120 mesh size. By progressive coning and quartering and repeatedly mixing the sample has been reduced to 600 gm. A representative sample of 100 gm has been collected and analyzed for 6 radicals' i.e. Mn, SiO_2, P_2O_5 Fe_2O_3, MnO_2 and Acid insolubles at Chemical Laboratory of MECL, Nagpur.

12.1.2 During sample preparation, strict adherence to standard operating procedures (SOPs) was maintained to ensure data reliability and analytical accuracy. manganese -bearing rock samples were initially reduced in size using a sample crusher, followed by fine grinding in a pulveriser and further homogenisation with a mortar and pestle until a uniform powder of -120 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. This cleaning protocol was applied consistently, thereby ensuring the integrity of the geochemical data generated from the prepared samples.

12.1.3 Following the initial crushing and homogenisation, 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.

Photograph No. 12.1: Photograph showing sample sample crusher used in sample processing

Photograph No. 12.2: Photograph showing pulveriser used in sample processing

Photograph No. 12.3: Photograph showing coning-qurtering equipment used in sample processing

12.2.0 **PRIMARY AND CHECK SAMPLE STUDIES:**

12.2.1 During the current exploration programme, a total of 302 primary samples were prepared and analysed, comprising: 225 bedrock/trench samples, and 77 primary drill core samples. In addition, 15 internal check samples and 31 external check samples were analysed to ensure analytical accuracy and reproducibility. All samples were analysed for six radicals (Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2, and Acid Insolubles). The primary samples have been analysed at Chemical Laboratory of MECL, Nagpur. The, external check samples have been analysed at Jawaharlal Nehru Aluminium Research Development and Design Centre, (JNARDDC) Nagpur (A NABL accridited Laboratory). The details of analysis done for primary samples, and external check samples are given in Annexure-XII and Annexure-XIII respectively.

12.2.2 The overall sampling, preparation, and analytical processes were carried out in accordance with MECL's standard operating procedures to maintain sample integrity and representativity, ensuring that the analytical results are reliable and consistent with the field geology.

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 7 no of scout boreholes with 358.50 and 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-10.1.

13.1.2 Core drilling was carried out by one conventional wire line drill rig viz. RD-60 (MEC-352). 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 82.18% (MKJ-07) and maximum 90.15% (MKJ-02) with an average core recovery is about 86.46%

13.1.3 The short runs were drilled as per necessity so that optimum core recovery is maintained. The core recovery in the mineralized zones is more than 80% which is quite satisfactory except in a few cases. 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. After closure, all the boreholes have been properly plugged and sealed with cement pillars.

13.1.4 A borehole deviation survey was not carried out during the present investigation, as it was not included in the approved quantum of work. All the boreholes were drilled at an inclination of 52°–55°, and their depths were relatively shallow; therefore, any deviation from the planned collar orientation was considered negligible. The drilling alignment and orientation achieved were deemed adequate for Reconnaissance (G-4) stage exploration.

13.2.0 EXPLORATORY DRILLING

13.2.1 Owning to the complex nature of the deposit, scout drilling was planned angular by placing 07 nos. of scout boreholes across the strike of ore body of NW-SE trending section lines in area to check the extent and depth of mineralization.

13.2.2 Details of boreholes drilled by MECL in Katori Jhiriya block are given in table no 10.1 in chapter 10.

13.3.0 DEVIATION SURVEY IN DRILLING

13.3.1 All the exploratory boreholes drilled in the block are inclined with depth ranging from 37.00m to 76.00m. There is no issue of deviation for these incline 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 soil, Muscovite Schist Weather Zone, Muscovite Schist, Mn bearing Quartzite, Biotite Schist, quartz vein and Gneiss/mimgatite.

13.4.2 The detailed run wise litholog and summarized litholog for 07 boreholes drilled by MECL in Katori Jhiriya block are given in Annexure- III A.

13.4.3 Core recovery in Manganese bearing Quartzite zones is 90% which is satisfactory. Samples were marked based on manganese bearing zone based on visual basis, in general, the sample length has been kept at 0.5 to 1.00 m interval which varied in some instances because of variation in lithology and type and concentration of mineralisation. The details of analysis of primary core samples are given in Annexure-IV C.

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. The core recovery in the mineralized zones is about 90% which is satisfactory. Whenever core recovery is less, the grade of the recovered portion has been extrapolated over the non-recovered section. The quality of drilling was ensuredduring 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) X 100

13.6.3 During 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 low Rock Quality Designation (RQD) values observed in several boreholes of the Katori–Jhiriya Block can be primarily attributed to the lithological and structural characteristics of the host rocks.

13.6.5 The boreholes predominantly intersect muscovite–biotite schist of the Mansar Formation (Sausar Group), which is a foliated, fine- to medium-grained metamorphic rock. This lithology inherently possesses well-developed schistosity and planar foliation surfaces, along which the rock tends to split easily during drilling. As a result, the recovered core often breaks into short, thin pieces, reducing the measurable length of sound core fragments (>10 cm) and hence lowering the calculated RQD values.

13.6.6 Additionally, the rock mass is highly fractured and jointed, particularly along foliation planes, minor shear zones, and weathered contacts. Secondary factors such as groundwater ingress, weathering, and alteration of mica-rich zones further weaken the core, contributing to poor recovery and low RQD.

13.6.7 Thus, the low RQD does not necessarily indicate poor rock competence at depth but rather reflects the foliated, micaceous, and brittle nature of the schistose rocks encountered. In contrast, quartzite or compact gneiss zones within the same formation usually show higher RQD and better core recovery.

13.7.0 BOREHOLE CORE SAMPLING

13.7.1 A total 77 no of primary samples are generated from borehole core obtained after drilling by MECL. Samples were marked considering variation of manganese bearing zone as well as lithology. In general, the sample length has been kept at 0.5 to 1.00 m interval which varied in some instances because of variation in lithology and type and concentration of mineralisation.

13.7.2 Sample as demarcated during core logging by geologist, based on visual basis. Once the samples are marked, sample has been prepared by splitting of core into two equal halves by using core splitter identical half is crushed to 100 mesh 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 -120 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 (-120 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 mineralised zones or lengths intersected in the drilled boreholes. Sampling was conducted systematically to ensure complete and representative coverage of manganese bearing horizons. Each sample was precisely marked on the core, with depth intervals clearly indicated before extraction. Special emphasis was given to manganese bearing units, covering both high-grade and marginal zones to evaluate vertical and lateral grade variations. This ensured that all significant lithological variations within the mineralised sequence were represented in the analytical dataset.

14.1.2 The mineralised 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 (-) 120 mesh, and a ~500 g representative sample was obtained by the coning and quartering method using a crusher and pulveriser (Photos 12.1 and 12.2). From this, two 100 g samples were prepared, one sent to MECL Chemical Laboratory, Nagpur, for primary chemical analysis (Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles) 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 77 primary borehole (BH) core samples and 12internal and external check samples were prepared for chemical analysis. The primary BH core samples were analysed for Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles at the Chemical Laboratory of MECL, Nagpur, following standard analytical procedures.

Photograph No. 14.1: Photograph showingcore splitter used to split borehole cores

14.1.4 To ensure analytical accuracy and reproducibility, a set of 31 external check samples was sent to 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.

14.1.5 The detailed analytical results of the primary samples and the Internal & external check samples are presented in Annexure-XII and Annexure-XIII, respectively.

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 Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles by X-ray fluorescence (XRF) analysis, the core samples were first reduced to a particle size of (–)120 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 Reconnaissance Survey (G-4 Stage) for Manganese and associated minerals in Katori- Jhiriya Block (140.22 Sq. Km) District- Balaghat, Madhya Pradesh, included comprehensive laboratory analyses covering bed rock, channel, trench and borehole samples. These samples were analysed for Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles 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 MANGANESE 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 samples. In the present study, WD-XRF was used to analyse four key oxides, SiO_2, P_2O_5, Fe_2O_3, MnO_2, 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.

Photograph No. 15.1: Photograph showing WD-XRF instrument (Rigaku, Japan) at Chemical Lab, MECL, Nagpur

15.2.2 **PROCEDURE OF ANALYSIS BY WD XRF**

15.2.3 Powdered samples were pelletised using a hydraulic press prior to analysis. The WD-XRF instrument (RIGAKU ZSX Primus IV) was calibrated using matrix-matched Certified Reference Materials (CRMs) to ensure accuracy and precision. After calibration, samples were analysed for Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles 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.

15.2.4 **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 Aluminium Research Development and Design Centre (JNARDDC), Nagpur a NABL-accredited laboratory. During the present exploration, a total 31 external check samples from borehole (BH) cores, were analysed for Mn, SiO_2, P_2O_5, Fe_2O_3, MnO_2 and Insolubles.

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-organised process. All samples were prepared at the centralised mechanised 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 15 nos. of internal and 31 no. of external check for bedroch, channel, trench and BH samples analyses has been carried out at chemical laboratory of MECL and JNARDDC, Nagpur. Details of internal and external check samples result are furnished as Annexure-XII & XIII.

15.5.3 The scatter diagrams for Primary Vs Internal Check and Primary Vs External Check Mn% analyses reveal strong linear correlations, indicating consistency between laboratories. Internal check results show near-perfect agreement with primary assays, reflecting high precision and minimal analytical bias. External check data, while also strongly correlated, exhibits a systematic tendency to under-report Mn%, suggesting a negative assay bias. The overall QA/QC results, supported by high correlation coefficients and acceptable error margins, validate the analytical reliability of the Mn% dataset for resource evaluation.

15.5.4 Furthermore, the detailed statistical parameters for Mn values in surface and subsurface samples pertaining to primary and internal & external check samples are comprehensively summarised in Table-15.1 and 15.2.

Text Figure 15.1

Scatter Plot of Primary Vs Check (Internal) sample analysis of surface and subsurface samples of Mn%

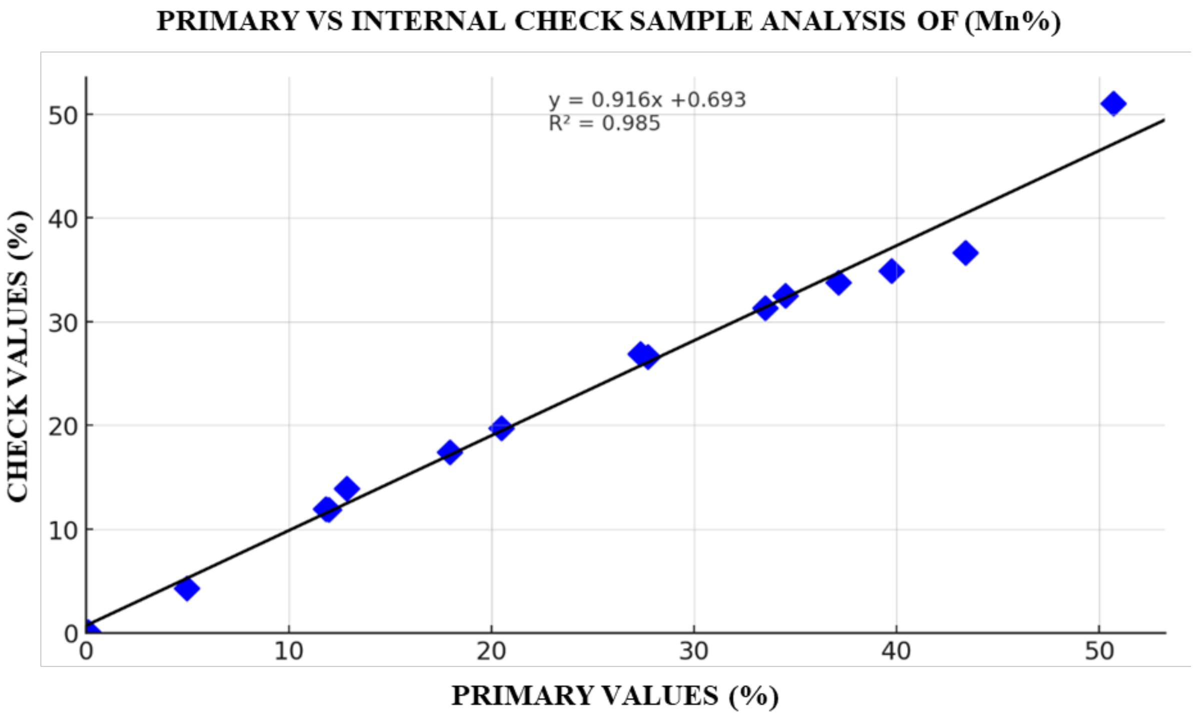


Table-15.1

Statistical comparison of Primary and Internal Check sample analysis for Mn

Comparison Index	Primary (Mn%)	Internal Check (Mn%)
No. of sample pairs	15.00	15.00
Arithmetic mean	24.95	23.54
Standard Deviation	14.93	13.78
Standard error of mean	3.85	3.56
Variance	222.90	189.78
Mean of deviation	1.41	
Standard Deviation (Error)	2.12	
Correlation Co-efficient	0.99	
Mean absolute error	1.62	
Mean relative random error (%)	6.48	
Paired T-value	2.58	
F-test value	1.17	

Text Figure 15.2

Scatter Plot of Primary Vs Check (External)

sample analysis of surface and subsurface samples of Mn%

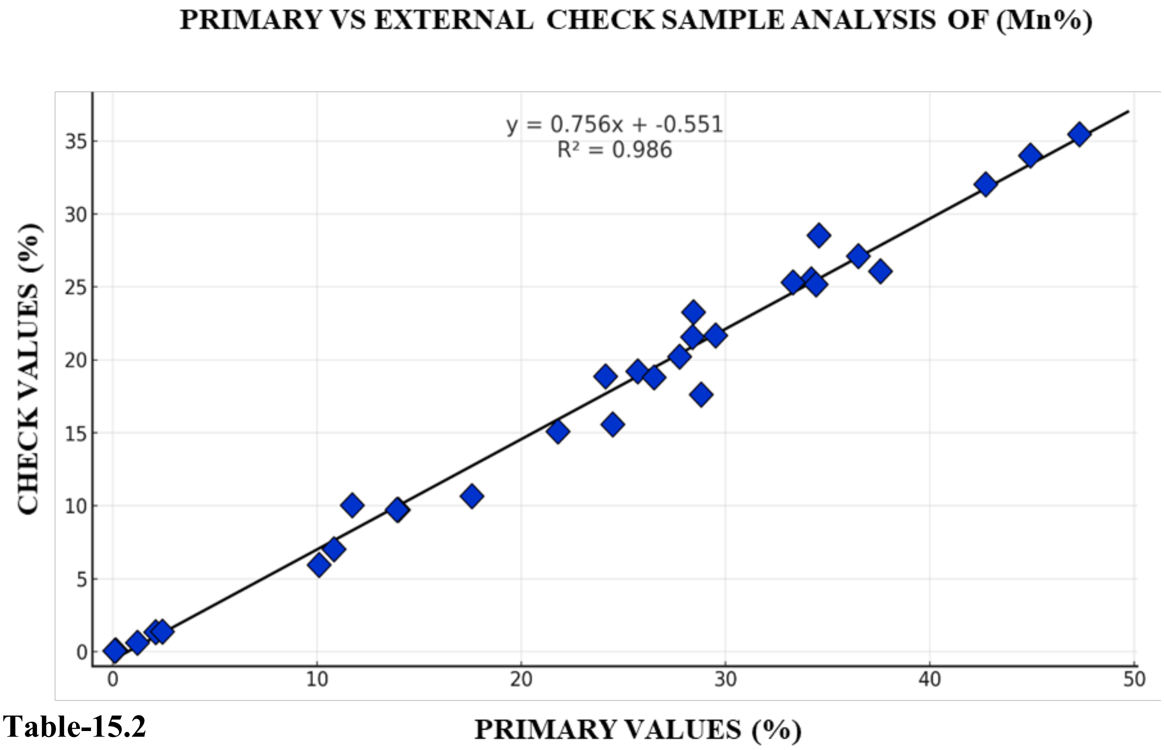


Table-15.2

Statistical comparison of Primary and External Check sample analysis for Mn

Comparison Index	Primary (Mn%)	External Check Mn%)
No. of sample pairs	31	31
Arithmetic mean	22.416	16.397
Standard Deviation	14.216	10.894
Standard error of mean	2.553	1.956
Variance	202.093	118.674
Mean of deviation	6.019	
Standard Deviation (Error)	3.702	
Correlation Co-efficient	0.9928	
Mean absolute error	6.019	
Mean relative random error (%)	26.853	
Paired T-value	9.053	
F-test value	1.703	

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 Being the present exploration programme is of Reconnaissance Survey (G-4), the bulk density has not been carried out in the block. However, based on lithology and similarity to adjacent blocks ((Nagardhan block part of Mansar formation located at about 7 km south of Ramtek town in the Nagpur district of Maharashtra), the host rocks have a specific gravity in the range of ~2.8-3.20 g/cm^3, was used for tonnage computation.

CHAPTER-18

18.0.0 BENEFICIATION STUDIES

18.1.0 Since the present exploration programme is of Reconnaissance Survey (G-4), the beneficiation studies have not been carried out in the block.

CHAPTER-19

19.0.0 RESOURCE ESTIMATION TECHNIQUE

19.1.0 THE RECONNAISSANCE SURVEY (G-4 STAGE): The Reconnaissance Survey (G-4 Stage) for Manganese and Associated Minerals in the Katori Jhiriya Block, District Balaghat, Madhya Pradesh, was executed by MECL under the sponsorship of the National Mineral Exploration and Development Trust (NMEDT). The programme comprised geological mapping on 1:12,500 scale, bedrock/channel/trench sampling, and scout drilling to establish the occurrence, disposition, and grade of manganese mineralisation. Exploration work included: i) 91 channel samples, 85 bedrock samples, and 49 trench samples, ii) 100 cu.m of trenching, and iii) Seven boreholes totaling 358.5 m drilled. Laboratory analyses for Mn, Fe_2O_3, SiO_2, P_2O_5, MnO_2, and acid insolubles were carried out at MECL's Chemical Laboratory (Annexures IV). The objective was to delineate manganese-bearing zones, evaluate their geometry, and estimate the Reconnaissance Mineral Resource (334) category under the G-4 stage of exploration resource at a 10% Mn Threshold Value.

19.2.0 NATURE OF MINERALISATION: Within the block, manganese mineralisation occurs as two discontinuous, lensoidal bands (Band I and Band II) hosted by muscovite–biotite schist and manganese-bearing quartzite of the Mansar Formation (Sausar Group). The bands are stratabound and conformable with regional foliation, trending NE–SW with dips of 43°–90°.

Mineralogically, the ore comprises braunite, psilomelane, pyrolusite, and hausmannite, showing granoblastic to granulitic textures. The ore is steel-grey to dull grey, occasionally powdery, and exhibits gonditic association with spessartite–quartz–muscovite paragenesis, characteristic of a metamorphosed syn-sedimentary (Gondite-type) deposit.

19.3.0 GRADE CLASSIFICATION: Grades were classified following the IBM Expert Group (September 2000) recommendations on optimum industrial use of manganese ores:

Sl No.	Grade of Ore	Chemical Composition	Specifications
1	Battery/Chemical	MnO_2 by mass (dry basis)	72%(Min)
		Cu, Pb, Cr and Ni	Trace
2	Ferromanganese Grade	Mn	38%(Min)
		Mn: Fe Ratio	2.5:1 (Min)
		P	7:1(Max)
3	BlastFurnace Grade	Mn	25to(-)35%
		P	0.2% (Max)
		Al2O3	7.5% (Max)
		SiO2	13% (Max)
4	Medium Grade	Mn	35 to 37%
5	Low Grade	Mn	18-25%

19.4.0 THICKNESS ESTIMATION: The exposed surface width measured from trenches and channel samples represents the apparent width of the dipping manganese body. Since the ore zone occurs as a dipping tabular body, the true thickness corresponds to the perpendicular distance across the ore body. The true thickness is computed only after applying the dip correction using the known dip angle of Mn body.

To obtain the true thickness, a dip correction is applied using the measured dip angle (θ) of the manganese-bearing horizon. When the measured width (W) is a horizontal projection, the true thickness (T) is calculated using the standard geometricrelationship:

$$T = W \times \sin \theta$$

This corrected thickness value represents the actual ore thickness across the dip of the band and is used for resource estimation.

19.5.0 BASIS AND ASSUMPTIONS FOR RESOURCE ESTIMATION: Resource estimation was conducted using the cross-section method at a 10% Mn Threshold Value.A minimum stopping width of 2.0 m was adopted for defining the resource envelope.All mineralised intervals having true thickness less than 2 m were excluded.Accordingly, the borehole data were not used for volumetric calculation because: In MKJ-01, the 2.00 m intersection corresponds to a true thickness of 1.96 m.In MKJ-05, two intersections of 2.09 m and 2.70 m correspond to true thicknesses of 1.29 m and 1.89 m, respectively.As all these intersections fall below the minimum stopping width, borehole intersections were omitted from the estimation.Hence, only surface trench and channel data with true thickness ≥ 2 m were used.A down-dip extension (width) of 5 m was assumed, and the strike influence was taken as the measured strike length of each exposed mineralised body in the sections.A specific gravity of 2.80 taken from the adjacent area, was used for tonnage computation.

19.6.0 EXCLUSION OF LEASE AREA: During exploration, it was observed that part of the Chorpindkepar area falls within the existing Trivedi Mining Lease (covering 4.9 hectares), located within the Katori Jhiriya block boundary.

In this sector, channels CH-1, CH-4, CH-5 and trenches TR-1 and TR-2 were excavated and sampled, confirming significant manganese mineralisation. However, since this lease area is not available for NMEDT-based resource declaration, it has been excluded from the present resource estimation**.** Accordingly, only those trenches and channels outside the lease area, where mineralisation continuity and grade were established, were considered for resource calculation.

19.7.0 TRENCH AND CHANNEL ZONES (10% Mn THRESHOLD VALUE): Visually identified mineralised zones were verified through chemical analysis. Ore zones were defined where Mn ≥ 10 %, and barren sections below this threshold were excluded. Representative trench data used for estimation are summarised below (Derived from Annexure VI):

Table 19.1

Details of Trench/Channel wise Manganese Zones at 10% Mn Threshold Valuein Katori Jhiriya (G4) Block for Manganese and associated minerals, Dist.-Balaghat, Madhya Pradesh

Trench No.	Band No.	Width (m)	Mn%	SiO_2%	P_2O_5%	Fe_2O_3%	MnO_2%	Acid Insoluble%
Channel-2	Band-I	15.22	21.96	37.91	0.85	13.33	10.13	63.59
Channel-3	Band-I	2.71	36.07	27.84	0.85	14.31	19.67	49.21
Channel-6	Band-I	7.78	18.09	41.75	0.69	13.12	7.17	70.06
Channel-7	Band-I	7.12	17.35	46.00	0.52	13.39	6.72	73.02
Trench-3	Band-I	7.37	19.06	45.85	2.09	11.02	2.63	83.68

19.8.0 ESTIMATION METHOD AND RESULTS: Resource estimation was carried out by the Sectional Area (True thickness (m) × Down dip extension 5m) × Strike Influence Length × Specific Gravity method. The results are summarised below:

Table 19.2

Section wise Manganese Ore Resource Estimated in Channel/Trench at 10% Mn Threshold Value in Katori Jhiriya (G4) Block for Manganese and associated minerals, Dist.-Balaghat, Madhya Pradesh

Section No	Band Number	Category	Trench/Channel No.	Thickness (m)	True thickness (m) (E x sin θ)	Width (Down dip extension)	Area (sq m) (F x G)	Strike Influence (m)	Specific Gravity	Resource (Tons) (H x I x J)	Mn %	SiO_2 %	P_2O_5 %	Fe_2O_3 %	MnO_2 %	Acid Insoluble %
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
G-4 category resource (334)																
Manganese Resource (10% Mn Threshold Value)																
S1	Band I	Surficial	CH-7	9.90	7.12	5.00	35.60	183.52	2.80	18293.27	17.35	46.00	0.52	13.39	6.72	73.02
Sub Total (Tons)										**18293.27**						
S2	Band I	Surficial	CH-6	9.50	7.78	5.00	38.90	126.73	2.80	13803.43	18.09	41.75	0.69	13.12	7.17	70.06
Sub Total (Tons)										**13803.43**						
S3	Band I	Surficial	TR-3	9.00	7.37	5.00	36.85	48.16	2.80	4969.15	19.06	45.85	2.09	11.02	2.63	83.68
Sub Total (Tons)										**4969.15**						
S4	Band I	Surficial	CH-2	16.80	15.22	5.00	76.10	54.07	2.80	11521.24	21.96	37.91	0.85	13.33	10.13	63.59
	Band II	Surficial	CH-3	3.00	2.71	5.00	13.55	16.12	2.80	611.59	36.07	27.84	0.85	14.31	19.67	49.21
Sub Total (Tons)										**12132.83**						
Total Resource(Tons) (at 10% Mn Threshold Value)										**49198.68**	**18.72**	**38.42**	**0.22**	**13.70**	**10.79**	**65.65**

19.9.0 INTERPRETATION OF GEOCHEMICAL RESULTS: The geochemical signature of the Katori Jhiriya manganese zone indicates a low- to moderate-grade Mn enrichment, characterized by an average Mn grade of 18–22%. The inverse relationship between Mn% and SiO_2% reflects the typical siliciclastic dilution seen in Sausar manganese deposits, where higher Mn concentrations correspond to reduced silica due to preferential enrichment of manganese oxides within schist–quartzite bands. Fe_2O_3 values remain moderate, suggesting limited iron–manganese segregation during metamorphism. MnO_2 values (6–11%) indicate partial oxidation of primary manganese silicates/oxides under supergene conditions. Acid-insoluble content (50–70%) confirms significant gangue dominance, consistent with thin, lensoidal Mn bands. The observed P_2O_5 values up to ~2.09% indicate minor phosphatic enrichment, likely derived from apatite/fluorapatite associated with metamorphosed pelitic–ferruginous beds. Although elevated, the phosphorus level reflects natural geochemical background of Sausar Mn ores and does not imply marine phosphorite–type deposition. Overall, the geochemistry suggests structurally controlled, discontinuous Mn enrichment with significant gangue material and limited economic potential.

19.10.0 INTERPRETATION AND CLASSIFICATION: The Reconnaissance (334) category manganese resource for the Katori Jhiriya Block is estimated at 49,198.68 tonnes (10% Mn Threshold Value), with an average grade of Mn = 18.72%, SiO_2 = 38.42%, Fe_2O_3 = 13.70%, MnO_2 = 10.79%, and acid insoluble = 65.65%.These resources correspond to surficial, stratabound, lensoidal manganese bodies of Band I and Band II within the Mansar Formation, following the NE–SW regional structural trend.The mineralisation is structurally controlled, discontinuous, and of limited depth persistence, typical of Gondite-type Sausar manganese deposits.

CHAPTER-20

20.0.0 REPORTING OF RESOURCES

20.1.0 RESOURCE ESTIMATION BY GEOLOGICAL SECTIONCROSS-SECTION

The resource estimation for manganese and associated minerals in the Katori Jhiriya (G-4) Block, District Balaghat, Madhya Pradesh, has been carried out by the Cross-Section Method, based on surface trench and channel sampling results. This estimation is in accordance with the United Nations Framework Classification (UNFC-2009) and Indian Bureau of Mines (IBM) guidelines for the Reconnaissance Mineral Resource (334) category under the G-4 stage of exploration.

20.1.1 **Identification of Ore Bodies**

Manganese mineralisation occurs as two lensoidal bands, designated Band I and Band II, hosted within muscovite-biotite schist and manganese-bearing quartzite of the Mansar Formation (Sausar Group).Field mapping, trenching, and channel sampling delineated surficial manganese bands trending NE–SW with dips between 43° and 90°, showing limited depth persistence.Mineralisation is stratabound and structurally controlled, typical of Gondite-type deposits of the Sausar belt.Exploration findings confirm that these ore bodies are predominantly near-surface, lacking continuity at depth; hence, resource estimation is confined to surficial manganese mineralisation only.

20.1.2 **Section Preparation and Data integration**

Geological cross-sections were constructed integrating data from detailed mapping, trench/channel sampling, and chemical assay results. Trench and channel locations were projected onto the nearest corresponding geological section lines. The ore-zone area for each section was computed from the interpreted cross-sectionalgeometry. The geological resources were then estimated by the Cross-Sectional Area × Strike Influence × Specific Gravity method.

20.1.3 **10% Mn Threshold Value of Manganese Mineralization**

A manganese content of 10% Mn has been adopted as threshold value, in accordance with IBM guidelines, to define ore-grade mineralization.

20.1.4 **Resource Estimation Parameters**

The geological resources for Band I and Band II were computed considering only those trench/channel sections with Mn ≥ 10 % and true thickness ≥ 2.0 m (minimum stoping width). Borehole intersections were excluded since their true thicknesses were below the minimum stoping width:

- MKJ-01: True thickness 1.96 m.
- MKJ-05: True thickness 1.29 m and 1.89 m.

The strike influence for each section was taken as the actual strike length of the exposed mineralised body between adjacent trenches or up to 50 m on either side of an isolated exposure. A specific gravity of 2.80 derived from nearby explored area (Nagardhan block part of Mansar formation located at about 7 km south of Ramtek town in the Nagpur district of Maharashtra), was used for tonnage computation.

20.1.5 Exclusion of Lease Area

During field investigation, it was established that the Chorpindkepar sector (covering ~4.9 ha) falls within the existing Trivedi Mining Lease area.This sector includes channels CH-1, CH-4, CH-5 and trenches TR-1 and TR-2, where significant manganese mineralisation was confirmed.However, in compliance with NMEDT guidelines, this lease area was omitted from the present resource calculation.Accordingly, only those trenches and channels located outside the lease boundary were considered for resource estimation.

20.1.6 Grade and Depth Considerations

The average grade of each section was derived from the corresponding trench/channel assays. The mineralised bands are surficial with no significant vertical continuity; therefore, the true thickness intersected in surface exposures was taken as the effective mining thickness for tonnage estimation. A down-dip extension (width) of 5 m was uniformly assumed for resource computation.

20.1.7 Specific Gravity Assumption

A specific gravity value of 2.80 has been adopted for resource estimation in the Katori Jhiriya Block. This value is based on specific gravity studies conducted in the Nagardhan Block, located approximately 7 km south of Ramtek town in Nagpur district, Maharashtra. The Nagardhan area forms part of the same geological setting, belonging to the Mansar Formation of the Sausar Fold Belt, which hosts manganese mineralisation similar to the Katori Jhiriya Block within the Maharashtra–Madhya Pradesh manganese belt.

In the Nagardhan Block, two representative manganese-bearing samples were analysed, yielding specific gravity values ranging from 2.80 to 3.30. Considering the metamorphosed and heterogeneous nature of Sausar manganese ore, the minimum conservative value of 2.80 was selected for tonnage computation in the Katori Jhiriya Block. Using this lower bound ensures a geologically sound and non-inflated estimate of manganese resources at the reconnaissance (G-4) stage.

20.1.8 **Mining Considerations**

Given the shallow nature of the deposit, potential extraction is envisaged by small-scale open-cast mining. A minimum workable ore thickness of 2.0 m has been adopted, and non-ore partings < 1.0 m within the ore zone were included in the mineralised width.

20.2.0 INTERPRETATION

The total Reconnaissance (334) category manganese resource for the Katori Jhiriya (G-4) Block is estimated at 49 198.68 tonnes at 10% Mn Threshold Value, with an average grade of Mn 22.51 % and P_2O_5 1.00 %.The resources represent surficial, stratabound, lensoidal manganese bands (Band I & II) within the Mansar Formation, following the NE–SW structural trend.The mineralisation is discontinuous, shallow, and structurally controlled, characteristic of Gondite-type Sausar manganese deposits.All data from the Trivedi lease area (4.9 ha) have been excluded from computation as per NMEDT and UNFC reporting guidelines.

20.3.0 CATEGORISATION OF RESOURCE

20.3.1 The estimation of Manganese resource of Katori Jhiriya Block is in accordance with the United Nations Framework Classification (UNFC-2009) and Indian Bureau of Mines (IBM) guidelines for the Reconnaissance Mineral Resource (334) category under the G-4 stage of exploration.

CHAPTER-21

21.0.0 SUMMARY AND RECOMMENDATIONS

21.1.0 SUMMARY

21.1.1 The Katori Jhiriya (G-4) Manganese and Associated Minerals Block is situated in Balaghat District, Madhya Pradesh, forming part of the Sausar Mobile Belt, a well-known manganese-bearing province of Central India. The block lies east of Miragpur, covering the villages of Katori, Fulchur, Chorpindkepar, Jhiriya, Shankar Pipariya, and Tekadi Tiju. It falls under Survey of India Toposheet No. 55O/14 and is accessible by metalled roads from Waraseoni (08 km) and Balaghat (35 km).

21.1.2 The block exhibits gentle to undulating topography with elevations ranging between 305 m and 360 m RL. A thick soil and laterite cover (3–5 m) masks much of the underlying lithology, confirmed through borehole and trenching data. Outcrops are sparse and mainly confined to nalla cuttings, old mine pits, and trench excavations.

21.1.3 Geologically, the block forms part of the Sausar Group (Palaeo-Proterozoic) overlying the Tirodi Biotite Gneiss (TBG) basement. The main lithounits are: Muscovite–biotite schist (Mansar Formation), Quartzite and manganiferous quartzite (Mansar Formation), Calc-gneiss (Lohangi Formation), Granite gneiss/migmatite (Basement TBG), Manganese mineralisation occurs within the Mansar Formation, hosted in muscovite schist and manganese-bearing quartzite, representing a metamorphosed syn-sedimentary Gondite-type deposit

21.1.4 The regional strike of lithounits is NE–SW, with foliation dipping 40°–75° towards SE, occasionally varying due to tight folding. Interpretation of Landsat imagery and NGDR structural data reveals two NE–SW trending faults: One near Tuiyapar in the southern part (~1 km long). Another between Basi and Jhiriya villages in the northwest (~1 km long).

21.1.5 **Exploration History and Trivedi Lease Context**: The Reconnaissance (G-4) proposal for manganese and associated minerals in the Katori Jhiriya Block was approved by the 47th TCC and subsequently by the 27th Executive Committee (EC) of NMEDT in its meeting held on 10th January 2023. Initially, during proposal formulation, surface manganese samples from the area Chorpindkepar were considered indicative of mineralisation, and the block boundary was demarcated based on available state government consent.At that stage, it was not known that a portion of the area overlapped with the existing Trivedi Mining Lease (4.9 ha). During forest clearance processing, MECL verified cadastral and lease boundary data and discovered that a significant portion of the manganese-bearing zone including the old workings near Chorpindkepar fell inside the Trivedi mining lease boundary. This lease area hosts the maximum manganese mineralisation, which had been historically worked during the British period. Consequently, all boreholes, trenches, and channels falling within the lease boundary (specifically CH-1, CH-4, CH-5, TR-1, TR-2) were omitted from resource estimation to comply with NMEDTguidelines. Drilling was then planned outside the lease boundary to test the possible lateral extensions of mineralisation.

21.1.6 **Exploration Work Executed:** MECL executed the following work under NMEDT funding: Geological mapping: 140.22 sq km on 1:12500 scale, ground magnetic survey: 6.73 sq km, trenching: 100 cu m (6 trenches), Channel sampling: 91 samples, Bedrock sampling: 85 samples, Trench sampling: 49, Drilling: 7 boreholes (MKJ-01 to MKJ-07) totalling 358.50 m, Petrographic, mineragraphic, and whole rock analysis studies: 10 samples total.

21.1.7 **Surface Findings and Sample Results:** Surface geological mapping and sampling delineated three manganese-bearing sectors:

- Shankar Pipariya Zone (southwest of Trivedi lease): narrow Mn bands within muscovite schist and quartzite, dips 43°–50° NE.
- Chorpindkepar Zone (within Trivedi lease): main manganese body exposed in an abandoned pit (~100 m × 50 m × 25–30 m deep), alternating bands of muscovite schist and Mn-quartzite.
- Tekadi Tiju Zone: thin manganiferous quartzite exposure; drilling not feasible due to agricultural cover in surrounding area.

Analytical results show:

- Bedrock samples (85 nos.) – Mn ranging from 0.12% to 50.70%, confirming patchy surface enrichment.
- Channel samples (91 nos.) – Mn varying 0.18% to 47.32%, with ~35% of samples above 10% Mn.
- Trench samples (49 nos.) – Mn ranging 0.54% to 35.9%, delineating surficial mineralised bands of 2.7–15.2 m thickness.

The highest values were observed in samples within the Trivedi lease area, while outside the lease, manganese bands are thinner and discontinuous.

21.1.8 **Subsurface Findings:** Of seven boreholes, only MKJ-01 and MKJ-05 intersected manganese-bearing quartzite bands, but both intersections were below the minimum stoping width (2.0 m) and therefore not considered for resource estimation. The remaining boreholes (MKJ-02 to MKJ-07) intersected barren schist and quartzite. This confirmed that subsurface continuity is extremely limited and that mineralisation is restricted mainly to the Trivedi lease area.

21.1.9 **Manganese Mineralisation:** Manganese occurs as lensoidal, stratabound bands and pockets within the Mansar Formation. The ore minerals identified are psilomelane, pyrolusite, braunite, and subordinate hematite and spessartite garnet, enclosed within a quartz–muscovite–feldspar matrix. The mineralisation is metamorphosed syn-sedimentary (Gondite-type) and structurally controlled.

Three main mineralised sectors were delineated:

- Shankar Pipariya Zone: Dips 43°–50° NE; mineralisation intersected in MKJ-01 (2.0 m, true thickness 1.96 m @ 12.29 % Mn).
- Chorpindkepar Zone: Major historical pit (100 m × 50 m × 25–30 m) with alternating bands of muscovite schist and manganese-bearing quartzite.
- Tekadi Tiju Zone: Thin manganiferous exposure with 52° SE dip; no drilling possible due to agricultural cover.

21.1.10 **Resource Estimation:** Resource estimation was carried out by the Cross-Section Method using surface trench and channel data only. A cut-off of 10 % Mn, stoping width of 2 m, specific gravity of 2.80, and down-dip extension of 5 m were adopted. Since all borehole intersections were thinner than 2 m, only surface data were used for estimation. The Trivedi lease area (4.9 ha) was excluded from resource calculation. Reconnaissance (334) Category Resource:

Parameter	Value	Remark
Total Resource (≥10% Mn)	49,198.68 tonnes	The resource estimated based the result of trench & channel data
Average Mn Grade	22.51%	
Category (UNFC)	Reconnaissance Resource (334)	

21.1.11 **Exploration Outcome:** The G-4 exploration confirmed the presence of manganese mineralisation in the Mansar Formation, though its surface continuity and grade persistence are limited. Most of the significant manganese occurs within the Trivedi lease boundary, while outside, the mineralisation is thin, patchy, and of reconnaissance significance only. Drilling results show no depth continuity, validating the surface-limited and lensoidal nature of these ore bodies.

21.2.0 RECOMMENDATIONS:

21.2.1 **Geological Assessment**: The exploration has confirmed the occurrence of small, lensoidal manganese pockets within the Mansar Formation, but their areal extent and continuity are very limited. The manganese mineralisation is mainly confined to the Trivedi mining lease area, which has already been worked in the past.

21.2.2 **Further Exploration:** Given the thin and discontinuous nature of mineralisation outside the lease boundary, further detailed exploration may not be immediately warranted. However, if future geological or mining developments occur in adjacent sectors of the Sausar belt, the Katori Jhiriya area can be revisited for correlation and structural re-evaluation.

21.2.3 **Land and Lease Clarification:** Prior to any further stage of exploration, it is strongly recommended to redefine the block boundary, excluding the 4.9 ha Trivedi lease area, to avoid overlapping jurisdictions.

21.2.4 **Overall Conclusion:** The Katori Jhiriya (G-4) Block hosts shallow, discontinuous, Gondite-type manganese bands with limited resource potential. The estimated Reconnaissance Resource (334) of 49,198.68 tonnes (average 22.51% Mn) confirms that the mineralisation is localized, structurally controlled, and largely confined to previously mined areas. The block, therefore, does not presently warrant upgradation to a higher exploration stage, but its geological understanding contributes valuable input to the regional manganese prospectivity of the Sausar Belt.

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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 on 1:1,00,000 scale.

22.4.0 Geological Map of Katori Jhiriya block, Dist.-Satna, Madhya Pradesh on 1: 12,500 scale is given as Plate-III

22.5.0 BlockGeological Map on 1: 2,500 with BH Locations is given as Plate-IV.

22.6.0 Structure Map of Katori Jhiriya block, Dist.-Balaghat, Madhya Pradesh on 1: 50,000 scale is given as Plate-V

22.7.0 Geological cross section along section lines S1-S1' S2-S2', S3-S3', S4-S4', and S5-S5' on 1:1000 scale is given as as Plate-VI.

22.8.0 Trenches Profile Along Trenches - Trench 1 to Trench 6 of Katori Jhiriya (G4) Block for Managnese and associated minerals District - Balaghat, Madhya Pradesh is given as Plate-VII. (Scale 1:100)

22.9.0 Channel Profile Along Channel - Channel 1 to Channel 8, of Katori Jhiriya (G4) Block for Managnese and associated minerals District - Balaghat, Madhya Pradesh is given as Plate-VIII. (Scale 1:100)

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

LOCALITY INDEX

SL. No.	Locality	UTM, North 44		Latitude	Longitude
		Easting (m)	Northing (m)		
1	Amai	391660.85	2396598.24	21° 40' 9.767" N	79° 57' 10.320" E
2	Bhajiyadand	391221.16	2395947.63	21° 39' 48.512" N	79° 56' 55.176" E
3	Jhiriya	389787.01	2393499.52	21° 38' 28.581" N	79° 56' 5.867" E
4	Tekadighat	380475.64	2384421.36	21° 33' 31.201" N	79° 50' 44.330" E
5	Mohgaon	388615.35	2387289.66	21° 35' 6.373" N	79° 55' 26.607" E
6	Chorpindkepar	381926.00	2387894.75	21° 35' 24.502" N	79° 51' 33.865" E
7	Tuiyapar	379007.03	2386764.02	21° 34' 47.027" N	79° 49' 52.666" E
8	Tekadi Tiju	379535.45	2385004.71	21° 33' 49.944" N	79° 50' 11.495" E
9	Shankar Pipariya	380804.92	2384411.57	21° 33' 30.962" N	79° 50' 55.779" E
10	Fulchur	382925.09	2384728.57	21° 33' 41.775" N	79° 52' 9.403" E
11	Katori	385818.11	2386180.04	21° 34' 29.651" N	79° 53' 49.620" E
12	Manegaon	385923.04	2383875.46	21° 33' 14.730" N	79° 53' 53.834" E
13	Bhandarbodi	386617.73	2388262.62	21° 35' 37.560" N	79° 54' 16.911" E
14	Kachekhani	386361.65	2389406.73	21° 36' 14.708" N	79° 54' 7.726" E
15	Saleteka	391023.09	2392050.43	21° 37' 41.730" N	79° 56' 49.205" E
16	Ghubadgondi	389927.14	2389724.30	21° 36' 25.841" N	79° 56' 11.640" E
17	Pounera	392005.37	2402177.55	21° 43' 11.283" N	79° 57' 20.998" E
18	Basi	393337.25	2404110.67	21° 44' 14.438" N	79° 58' 6.903" E
19	Bodalkasa	394564.32	2405940.88	21° 45' 14.222" N	79° 58' 49.194" E
20	Bakera	393845.70	2402073.52	21° 43' 8.300" N	79° 58' 25.071" E
21	Bagholi	396092.67	2402110.76	21° 43' 9.990" N	79° 59' 43.264" E
22	Lalpur	393521.83	2398724.66	21° 41' 19.324" N	79° 58' 14.574" E
23	Umarwada	391464.23	2399810.18	21° 41' 54.177" N	79° 57' 2.723" E
24	Dongariya	392784.45	2394583.12	21° 39' 4.480" N	79° 57' 49.879" E
25	Khapa	395159.65	2403969.31	21° 44' 10.233" N	79° 59' 10.368" E

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

This is to certify that geological report has been prepared on Reconnaissance Survey (G-4) for Manganese and associated minerals in Kotori Jhiriya Block, Balaghat district, Madhya Pradesh by Mineral Exploration and Consultancy Limited (MECL) on behalf of National Mineral Exploration and Development Trust (NMEDT). The report has been prepared in accordance with the Minerals (Evidence of Mineral Contents) Rule 2015 specified under Mineral Auction Rule, 2015 and amended up to 2021.

NAME: **SHRIKANT SHARMA**

DESIGNATION: **HoD (EXPLORATION)**

DATE: DECEMBER 2025

LIST OF PERSONNEL ASSOCIATED WITH RECONNAISSANCE SURVEY (G-4) FOR MANGANESE AND ASSOCIATED MINERALS IN KATORI- JHIRIYA BLOCK (140.22 SQ.KM) DISTRICT- BALAGHAT, MADHYAPRADESH

1	Overall guidance	Shri P. Ravindran, Ex.GM (Exploration)
		Shri Shrikant Sharma, HoD (Exploration)
2	Overall Planning, Co-ordination & Supervision	Shri S.N. Khadse, GM (Exploration)
		Shri Santosh Kumar Satapathy, 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 Aatish A. Bagde, Manager (Drilling)
	Physical Execution of work	
5	a) Geology	Shri Indra Kumar Nagpure, Sr. Manager (Geology)
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6	Sample Processing	Shri Ankush Wagh, Sr. Sampling Assistant
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9	Documentation	Shri Santosh Kumar Satapathy, Sr. Manager (Geology)
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		Shri Narra Chandrasekhara Reddy, Console Operator
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		Shri Ashok Kumar, Sr. Computer Operator
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ABBREVIATIONS USED

SL. No.	Abbreviation	Full form
1	m	Meter
2	Cu m	Cubic Meter
4	RL	Reduced Level
5	mRL	Reduced Level in metre
6	IBM	Indian Bureau of Mines
7	GSI	Geological Survey of India
8	NMEDT	National Mineral Exploration and Development Trust
9	TCC	Technical cum Cost Committee
10	EC	Executive Committee
11	MMDR	Mines & Minerals (Development and Regulation)
12	MEMC	Minerals (Evidence of Mineral Contents)
13	MECL	Mineral Exploration Corporation Limited
14	NABL	National Accreditation Board for Testing and Calibration Laboratories
15	JNARDDC	Jawaharlal Nehru Aluminium Research Development and Design Centre
16	QA/QC	Quality Assessment/ Quality Checks
17	WGS-84	World Geodetic System-84
18	DMS	Degree Minute Second
19	UTM	Universal Transverse Mercator
20	F.S.P.	Field Season Programme
21	DGPS	Differential Global Positioning System
22	ETS	Electronic Total Station
23	PPM	Proton Precession Magnetometer
24	MA	Magnetic Anomaly
25	TMI	Total Magnetic Intensity
26	XRF	X-ray Fluorescence
27	ICP-MS	Inductively Coupled Plasma Mass Spectrometry
28	SoI	Survey of India