GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G3 STAGE) FOR IRON AND ASSOCIATED MINERALS IN CHITRANGI BLOCK DISTRICT: SINGRAULI, MADHYA PRADESH

Report submitted under the Mineral (Evidence of Mineral Content) Rules-2015 (Amended up to 2021)

TEXT, ANNEXURE

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कार्यकारी सारांश

भारत के पास लौह अयस्क के विशाल भंडार उपलब्ध हैं, किंतु इनका अधिकांश भाग निम्न से मध्यम श्रेणी का है तथा उच्च श्रेणी के भंडार तीव्र गति से समाप्त हो रहे हैं। राष्ट्रीय इस्पात नीति (2030) के अंतर्गत 300 मिलियन टन कच्चा इस्पात उत्पादन का लक्ष्य रखा गया है, जिसके लिए अवसंरचना, निर्माण, ऑटोमोबाइल तथा रक्षा जैसे क्षेत्रों से मांग में उल्लेखनीय वृद्धि होगी। इस परिप्रेक्ष्य में, निम्न-ग्रेड लौह अयस्क का लाभकारीकरण (Beneficiation) कर उपयोग बढ़ाना आवश्यक है, जिसके लिए महाकोशल बेल्ट जैसे क्षेत्रों को संभावित संसाधन विस्तार हेतु प्राथमिकता दी जा रही है।

इसी रणनीति के तहत, मिनरल एक्सप्लोरेशन एंड कंसल्टेंसी लिमिटेड (MECL) ने, खनिज संसाधन एवं खनन संचालनालय (DMG), मध्य प्रदेश की स्वीकृति से, सिंगरौली जिले के चित्रंगी ब्लॉक में 5.015 वर्ग किलोमीटर क्षेत्र में जी-3 प्रारंभिक अन्वेषण कार्यक्रम संचालित किया। यह परियोजना NMET से अगस्त 2024 में 12 माह की अवधि के लिए स्वीकृत हुई और अक्टूबर 2024 में प्रारंभ हुई। भूवैज्ञानिक मानचित्रण, स्थलाकृतिक सर्वेक्षण तथा व्यवस्थित चैनल सैंपलिंग मई 2025 में पूर्ण की गई। समीक्षा उपरांत, निकट भविष्य में आर्थिक रूप से लाभकारी लौह अयस्क संवर्द्धन की सीमित संभावना के कारण कार्य को पूर्व-समापन किया गया, यद्यपि विस्तृत भूवैज्ञानिक, खनिजवैज्ञानिक एवं रासायनिक आंकड़े संकलित हुए।

भूवैज्ञानिक परिप्रेक्ष्य एवं भू-आकृतिक स्वरूप: चित्रंगी ब्लॉक महाकोशल समूह में स्थित है, जो आर्कियन से निम्न प्रोटेरोज़ोइक काल का ज्वालामुखी-अवसादी अनुक्रम है, जिसमें बैंडेड आयरन फॉर्मेशन (BIF) और मैफ़िक अंतःप्रवेश पाए जाते हैं। भू-आकृति में ENE–WSW प्रवृत्ति वाले BHQ/BMQ रिज प्रमुख हैं, जिनके बीच मेटाबेसाल्ट से भरी घाटियाँ हैं। ये रिज लगभग 8.35 किमी लंबाई और औसतन 50 मीटर चौड़ाई के हैं, तथा स्थान-स्थान पर अवरोधित हैं, संभवतः भ्रंश एवं संरचनात्मक टूट-फूट के कारण, जिससे स्थानीय संवर्द्धन के अनुकूल क्षेत्र बने। ऊँचाई घाटियों में 230 मीटर RL से लेकर रिज शिखरों पर 452 मीटर RL तक है, तथा लगभग 95% क्षेत्र कैमूर आरक्षित वन में आता है।

BIF इकाइयों में लयबद्ध मैग्नेटाइट–हीमैटाइट–क्वार्ट्ज–जैस्पर बैंडिंग, निम्न से मध्यम चुंबकीय प्रतिक्रिया तथा सुपरजीन परिवर्तन (मैग्नेटाइट → हीमैटाइट → गीथाइट → लिमोनाइट) पाया जाता है। सहवर्ती शैल-इकाइयों में क्लोरिटीकृत एवं कार्बोनेटीकृत मेटाबेसाल्ट, विशाल डोलराइट, एक्टिनोलाइट–ट्रेमोलाइट-समृद्ध एम्फिबोलाइट, बहुरंगी कंकड़-पत्थर (पॉलीमिक्टिक कॉन्ग्लोमरेट), क्वार्ट्ज़ाइट और क्रॉस कटिंग क्वार्ट्ज शिराएँ शामिल हैं। संरचनात्मक अवरोध सामान्य हैं तथा स्थानीय रूप से हाइड्रोथर्मल शिराकरण विकसित है।

अन्वेषण दृष्टिकोण: स्वीकृत कार्यक्रम में विस्तृत भूवैज्ञानिक एवं स्थलाकृतिक मानचित्रण (5.015 वर्ग किमी में पूर्ण), लौह-धारक BMQ रिज की व्यवस्थित चैनल सैंपलिंग, मेटाबेसाल्ट से PGE सैंपलिंग तथा पेट्रोग्राफिक/खनिजवैज्ञानिक अध्ययन शामिल थे। अयस्क की अत्यधिक कठोर व सघन प्रकृति तथा निम्न लाभकारीकरण संभावना के कारण ड्रिलिंग नहीं की गई।

लौह अयस्क संभावना: कुल 100 चैनल सैंपल BMQ रिज से एकत्र किए गए। परिणामों से दो पृथक संवर्धित क्षेत्र पहचाने गए:

- **क्षेत्र** I: 200 मीटर स्ट्राइक लंबाई, 40 मीटर चौड़ाई, Fe औसतन 36–40%, कुछ बैंड >45% Fe
- **क्षेत्र** II: 350 मीटर स्ट्राइक लंबाई, 45 मीटर चौड़ाई, Fe औसतन 40–48%, अधिकांश IBM मानक से अधिक। संवर्द्धन संरचनात्मक नियंत्रण में है और प्रायः वहीं पाया जाता है जहाँ रिज निरंतरता भूगर्भीय व्यवधानों से टूटी हुई है। कुल मिलाकर, बहुत कठोर और निम्न FeO (औसत 2.6%) वाले अयस्क के कारण मैग्नेटाइट सीमित है और लाभकारीकरण चुनौतीपूर्ण है।

PGE एवं स्वर्ण जाँच: मेटाबेसाल्ट के 18 सैंपलों में पैलेडियम (अधिकतम 612 ppb) और रुथेनियम (अधिकतम 54 ppb) के असामान्य मान मिले, जो महाद्वीपीय क्रस्ट के औसत स्तर से काफी अधिक हैं, साथ ही अनियमित इरिडियम (अधिकतम 9.42 ppb) भी मिला। Pt और Rh दुर्लभ तथा Os अनुपलब्ध रहा। रासायनिक पैटर्न मैग्माई स्रोत और संभावित हाइड्रोथर्मल पुनःगतिकरण की ओर संकेत करता है, तथा उच्च Pd/Pt अनुपात सल्फर-कम मैग्मा का सूचक है। सल्फाइड एवं क्वार्ट्ज शिरायुक्त 10 नमूनों में स्वर्ण का कोई महत्वपूर्ण मान नहीं मिला।

निष्कर्ष: चित्रंगी ब्लॉक में विशिष्ट महाकोशल BIF–मेटाबेसाल्ट संरचना है, जिसमें स्थानीय उच्च-Fe BMQ क्षेत्र और मेटाबेसाल्ट में उल्लेखनीय Pd–Ru असामान्यताएँ पाई गईं। यद्यपि लौह अयस्क क्षेत्र स्थानीय रूप से मानक ग्रेड से अधिक हैं, सीमित स्ट्राइक निरंतरता, कम मैग्नेटाइट और अयस्क की कठोरता निकट भविष्य में आर्थिक व्यवहार्यता को सीमित करती है। PGE असामान्यताएँ संरचनात्मक रूप से अनुकूल मेटाबेसाल्ट में आगे अन्वेषण योग्य हैं, किंतु स्वर्ण संभावना नगण्य है। भंडार का विकासक्रम प्राथमिक BIF निक्षेपण, क्षेत्रीय रूपांतरण, हाइड्रोथर्मल शिराकरण एवं सुपरजीन ऑक्सीकरण को दर्शाता है, जिससे महाकोशल बेल्ट में भावी लक्षित अन्वेषण के लिए महत्वपूर्ण संकेत प्राप्त हो सकते हैं।

अन्वेषण की संभावना और सिफारिशें: चित्रंगी ब्लॉक वर्तमान में कम ग्रेड, असततता और लाभकारीकरण की कठिनाइयों के कारण बड़े पैमाने पर लौह अयस्क खनन के लिए उपयुक्त नहीं है। तथापि, यहाँ मेटाबेसाल्ट में लगातार पीजीई (PGE) असामान्यताएँ पाई गई हैं, विशेषकर पैलेडियम (612 ppb तक) और रूथेनियम (54 ppb

तक), साथ ही इरिडियम का छिटपुट संवर्धन। यह संकेत करता है कि ब्लॉक में उच्च-मूल्य, निम्न-टन भार वाले Pd–Ru खनिजीकरण की चयनात्मक संभावना मौजूद है। एक द्वितीय चरण पीजीई-केंद्रित अन्वेषण कार्यक्रम की सिफारिश की जाती है, जिसमें शामिल हैं:

- असामान्य क्षेत्रों पर ट्रेंचिंग,
- खनिज मेज़बानों की पहचान हेतु विस्तृत पेट्रोग्राफी और माइक्रोप्रोब अध्ययन,
- भू-भौतिकीय सर्वेक्षण (चुंबकीय और विद्युतचुंबकीय) द्वारा छिपे हुए खनिजीकृत क्षेत्रों का पता लगाना, और
- संरचनात्मक रूप से अनुकूल स्थलों पर स्काउट ड्रिलिंग।

यह लक्षित दृष्टिकोण अधस्तलीय संभावनाओं का आकलन करने और महाकोशल बेल्ट में महत्वपूर्ण खनिज संसाधनों की संभावनाओं को परिष्कृत करने में सहायक होगा।

GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G3 STAGE) FOR IRON AND ASSOCIATED MINERALS IN CHITRANGI BLOCK, SINGRAULI, MADHYA PRADESH

EXECUTIVE SUMMARY

India possesses vast iron ore reserves. However, much of it is of low to medium grade and high-grade deposits are rapidly depleting. Under the National Steel Policy (2030), India aims to produce 300 million tonnes of crude steel, driven by infrastructure, construction, automotive, and defence sectors. This creates an urgent need to explore and utilise low-grade iron ores through beneficiation, with regions such as the Mahakoshal Belt gaining prominence for potential resource expansion.

As part of this strategy, the Mineral Exploration & Consultancy Limited (MECL), with approval from the Directorate of Geology & Mining (DMG), Madhya Pradesh, undertook a G-3 preliminary exploration programme in the Chitrangi Block, Singrauli district, over 5.015 sq km. The project received NMET sanction in August 2024 for a 12-month timeline and commenced in October 2024. Geological mapping, topographical survey, and systematic channel sampling were completed by May 2025. Following review, exploration was pre-closed due to limited scope for economically viable iron ore beneficiation in the near future, though detailed geological, mineralogical, and geochemical datasets were generated.

Geological Setting and Terrain: The Chitrangi Block lies within the Mahakoshal Group an Archaean to Lower Proterozoic volcano-sedimentary belt known for Banded Iron Formations (BIF) and mafic intrusives. The terrain is dominated by ENE–WSW trending BHQ/BMQ ridges flanked by metabasic in valleys. These ridges are long and linear up to 8.35 km in length and average 50 m wide, discontinue at places which might have caused by geological disturbances like faults and structural breaks, creating favourable sites for localised enrichment. Elevations range from 230 mRL in valleys to 452 mRL on top of the ridges, with 95% of the block under Kaimur Reserved Forest.

BIF units exhibit rhythmic magnetite–hematite–quartz–jasper banding, low to moderate magnetic response, and supergene overprinting (magnetite → hematite → goethite → limonite). Associated lithologies include chloritised and carbonated metabasalt, massive dolerite,

actinolite–tremolite rich amphibolite, polymictic conglomerate, quartzite, and cross-cutting quartz veins. Structural discontinuities are common, and hydrothermal veining is locally developed.

Structure and Metamorphism: Structural observations within the Chitrangi Block reveal well-preserved primary bedding (S_0) in Banded Iron Formations, overprinted by a penetrative foliation (S_1) axial planar to tight F_1 folds. Boudinage within competent bands reflects layer-parallel extension under a non-coaxial stress field, indicating interaction of compressional folding with subsequent extensional tectonics. These features collectively demonstrate multiphase deformation, where bedding, axial planar cleavage, and extensional structures are spatially and temporally associated.

The lithological assemblages show evidence of regional metamorphism under greenschist to lower amphibolite facies conditions. BIFs exhibit recrystallisation of hematite, magnetite, and chert, with sericite–biotite development, while metabasalts show chloritisation and carbonation of plagioclase–pyroxene. Dolerite and amphibolite intrusives record actinolite–tremolite–epidote assemblages. Superimposed hydrothermal activity and surface-related alteration are evident from silicification, martitisation, and goethite and limonite replacement, along with quartz calcite veining. Together, these features reflect a complex tectonothermal evolution involving regional metamorphism, ductile deformation, retrogression, and late-stage hydrothermal–supergene overprinting.

Exploration Approach: The approved programme comprised detailed geological and topographic mapping (completed over 5.015 sq km), systematic channel sampling of iron-bearing BMQ reefs, PGE sampling from metabasalts, and petrographic/mineragraphic investigations. No drilling was carried recommended due to the very hard and compact nature of the ore and low beneficiation potential at present.

Iron Ore Potential: One hundred (100) channel samples were collected across BMQ ridges. Results identified two enriched zones:

- Area I: 200 m strike length, 40 m width, Fe averaging 36–40%, with isolated bands >45% Fe.
- Area II: 350 m strike length, 45 m width, Fe averaging 40–48%, most above the IBM threshold.

Enrichment is structurally controlled, occurring where ridge continuity is disrupted by geological disturbances. Overall, very hard iron enriched BMQ, low FeO content (avg. 2.6%), Fe content marginally above the threshold value (45% Fe) and difficulty for beneficiation at present.

PGE and Gold Investigations: Eighteen (18) metabasalt samples yielded anomalous Palladium (up to 612 ppb) and Ruthenium (up to 54 ppb) significantly above average crustal levels along with sporadic Iridium (up to 9.42 ppb). Pt and Rh were rare, and Os was below detection. The geochemical pattern points to a magmatic source with possible hydrothermal remobilization, and high Pd/Pt ratios suggest sulfur poor magmas. Gold analyses from ten sulphide-bearing and quartz-veined samples returned no significant values.

Conclusions: The Chitrangi Block hosts classic Mahakoshal BIF-metabasalt assemblages with localised high iron BMQ zones and notable Pd–Ru anomalies in metabasalts. While the iron ore zones exceed threshold grades locally, the combination of limited strike continuity, low magnetite, and ore hardness constrains near-term economic viability. PGE anomalies merit follow up in structurally prepared metabasalts, but gold potential is negligible. The deposit history reflects primary BIF deposition, regional metamorphism, hydrothermal veining, and supergene oxidation, producing a complex paragenetic sequence that may enlighten future targeted exploration in the Mahakoshal Belt.

Exploration Potential and Recommendations: The Chitrangi Block is not presently viable for large-scale iron ore mining due to limited grade, poor continuity, and beneficiation challenges. However, it exhibits consistent PGE anomalies in metabasalts, particularly Palladium (up to 612 ppb) and Ruthenium (up to 54 ppb), with sporadic Iridium enrichment. This indicates selective potential for high-value, low-tonnage Pd–Ru mineralisation. A Phase-II PGE-focused exploration programme is recommended, comprising:

- Trenching across anomalous zones,
- Detailed petrography and microprobe studies to identify mineral hosts,
- Ground geophysics (magnetic and EM surveys) to delineate concealed zones, and
- Scout drilling in structurally favourable sites.
- Such a targeted approach would help assess the subsurface potential and refine prospects for critical mineral resources within the Mahakoshal Belt.

CHAPTER-1

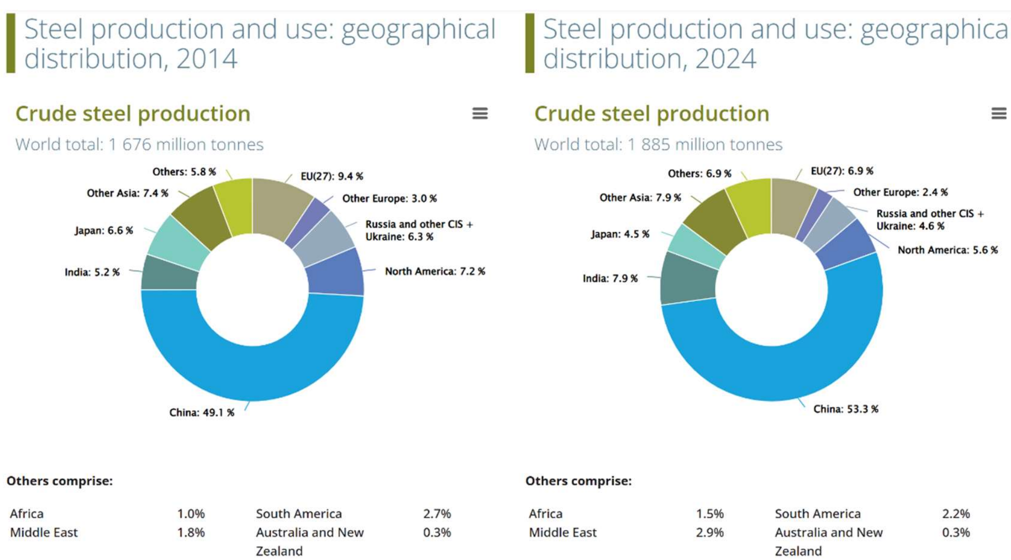
1.0.0 INTRODUCTION

1.1.1 Iron is estimated to make up 32.07% of the Earth's mass and its elemental abundance varies between about 5% of the Earth's crust and as much as 80% of the planet's core (Morgan and Anders, 1980). It is therefore not surprising that there are a number of commonly occurring iron minerals and many iron ore deposits found at the surface of the Earth. Morris (1985) suggested that just one of the iron-enrichment deposit types alone, derived from iron formations, represents the largest and most concentrated accumulation of any single metalliferous element in the Earth's crust. Although iron is the fourth most abundant element by mass in the Earth's crust, only certain oxide minerals—primarily hematite (Fe_2O_3) and magnetite (Fe_3O_4) are sufficiently concentrated to constitute profitable ore bodies. The term "iron ore" is used here as an economic term to refer to iron-bearing deposits and products that have been, are being, or could be expected to be exploited economically for their iron content. Any uneconomic iron accumulations are simply referred to as "iron mineralisation." Iron ore is the primary raw material from which metallic iron is extracted to make steel.

1.1.2 Virtually all extracted iron ore (≈98 %) is directed toward steelmaking, where it serves as the primary source of iron in blast furnaces and direct-reduced iron (DRI) processes. The steel industry is a very important one for the economy as a whole. It is the backbone of any industrial economy. Steel finds widespread applications in many sectors such as construction, power, infrastructure, aerospace, consumer products, industrial machinery and so on. The steel industry has strong forward and backward linkages in terms of material flows and income generation.

1.1.3 Worldwide steel production reached an estimated 1 900 million tonnes in 2024, driving iron ore demand to over 2 500 million tonnes of usable ore. India, as the fourth-largest iron ore producer, achieved record output of 289 million tonnes in FY 2024-25 a 4.3 % increase over the previous year and yet remains short of the 300 million tonnes per annum requirement to sustain its burgeoning steel sector as per steel policy. Domestic demand is projected to escalate in line with a target of 300 million tonnes crude steel capacity by 2030-31, implying sustained pressure on exploration and production.

1.1.4 India's share of global crude steel production in 2024 was 6.6% (149.4 million tonnes) which has been raised from 5.2% to 7.9% in 2014 to 2024 (Figure 1.1). The Indian steel sector has grown dramatically over the few years and is the second-largest producer of steel globally, contributing to about 2% of the country's GDP. Further, The National Steel Policy which was released in 2017 aims to attain a steel production capacity in India of 300 MT by 2030. It has a long-term vision to enhance domestic consumption, produce high-quality steel and make the sector globally competitive. As a result, traditional high-grade iron ore reserves are being significantly depleted and many new iron ore deposits of lower grade are being explored to meet the future demand.



Text Figure 1.1- Iron and crude steel production worldwide (Source: World steel Association)

1.1.5 India's crude iron ore reserves are estimated to be around 5.5 billion tonnes, containing 3.4 billion tonnes of iron, the major economic deposits of iron ore in India are distributed across the following five broad zones:

- Zone A- Chiria, Noamundi, Kiriburu, Meghahatuburu, Thakurani, Bolani, Gua, Malangtoli, Gandhamardan, Daitari.
- Zone B- Bailadila, Dalli, Rajhara, Rowghat, Mahamaya, Aridongri, Surajgarh.
- Zone C- Donimalai, Ramgad, Kumaraswamy, NEB Range, Ettinahatti, Tumti, Belagal, Chitradurga & Tumkur Districts of Karnataka.
- Zone D- Goa, Ratnagiri in Maharastra and North Karnataka

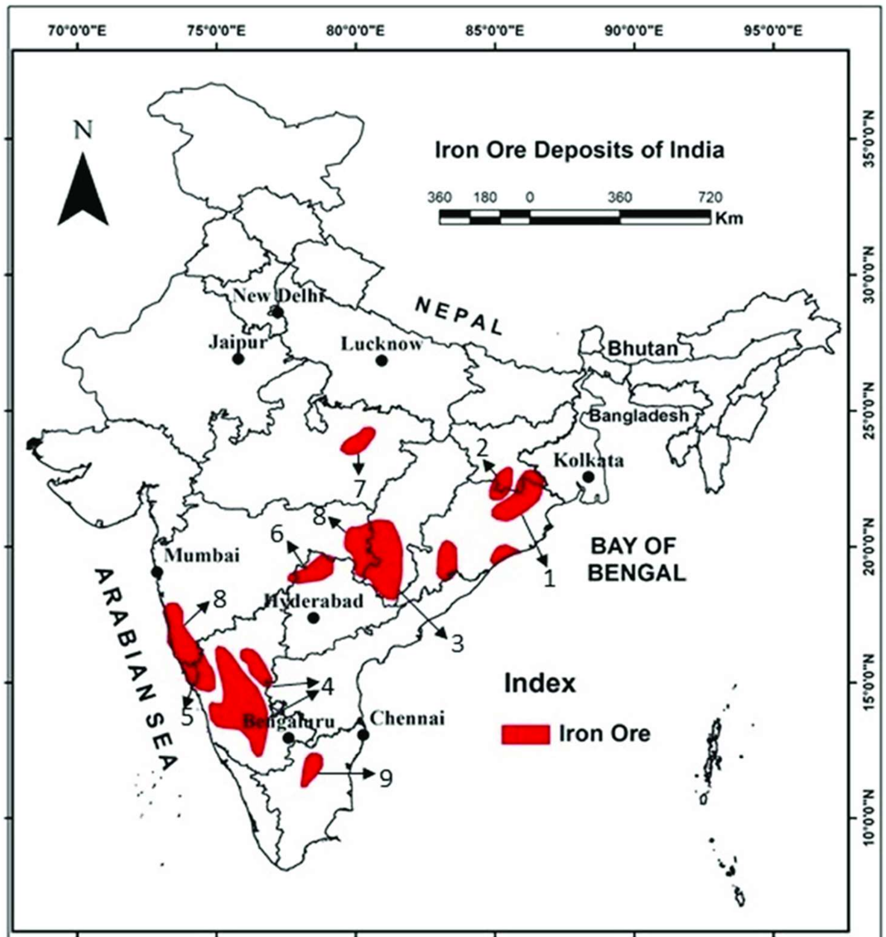
- Zone E- Kudremukh, Bababudan, Kudachadri

1.1.6 The first four zones (A–D) account for hematite/goethite mineralisation and Zone E accounting predominantly for the magnetite mineralisation. The most common names used in India to describe iron ore types are Banded Hematite Quartzite (BHQ), Banded Hematite Jasper (BHJ), and Banded Magnetite Quartzite (BMQ). Major economic deposit of India is presented in the Text Figure 1.2.

1.1.7 Almost all the current iron ore production in India comes from hematite/goethite reserves (BHQ/BHJ). While there are also substantial magnetite resources in India, they are not exploited because they are located in the environmentally and ecologically sensitive areas of the Western Ghats, a UNESCO World Heritage Site in India and one of the eight "hottest hotspots" of biological diversity in the world. India's iron ore reserves and production are predominantly concentrated in a few key states, with Odisha accounting for approximately 51% of the national output, contributing around 150 million tonnes annually. This is followed by Chhattisgarh at 17%, Karnataka at 14%, and Jharkhand at 11%, while the remaining contribution of about 7% comes from other states, including Madhya Pradesh, Goa, Maharashtra, and Rajasthan. Among these, Madhya Pradesh holds a modest share of approximately 3–4% of the country's iron ore production. However, it is geologically significant due to the presence of the Mahakoshal Greenstone Belt, which hosts promising occurrences of hematite and banded iron formations (BIF). These geological features indicate considerable potential for resource augmentation, emphasizing the need for systematic and detailed exploration in the region to support the long-term objectives of India's mineral and steel policies.

1.1.8 Unlike Australia and Brazil, the iron ore mines in India are numerous and relatively small in size. Ownership of the mining companies spans both the public and private sectors, with the state-owned National Mineral Development Corporation (NMDC) being the largest iron ore producer in India. Other major iron ore producers include the state-owned Steel Authority of India (SAIL), and Tata Steel, Jindal Steel, and Essar Steel from the private sector.

1.1.9 India is close to self-sufficient with respect to iron ore, but the current reserves have a limited life of 15–20 years at the present rate of steel production. Hence, despite revision of the threshold value for iron ore reserves to 35–45% Fe depending on the ore type, with their high-grade reserves under threat of depletion it is now obligatory for the mining industry to look at exploitation of the huge resources/reserves of low/lean-grade iron ores including the new areas in India, which in the past have been left undeveloped.



Distribution of Iron-ore deposits of India (after GSI, 2011)

1. Sundergarh, Kendujhar, Mayurbanj and Cuttack districts of Odisha, 2. East and West Singhbhum districts of Jharkhand, 3. Bastar and Durg districts of Chhattisgarh, 4. Bellary, Hospet and Chikmagalur districts of Karnataka, 5. North and South Goa, 6. Adilabad district of Telangana, 7. Jabalpur and Sarguja districts of Madhya Pradesh, 8. Chandrapur and Ratnagiri districts of Maharashtra and 9. Salem and Trichinapally of Tamil Nadu.

Text Figure 1.2- Major economic deposits of iron ore in India

MECL

CHAPTER-2

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

2.1.0 INVESTIGATING AGENCY

2.1.1 The block was explored by Mineral Exploration And Consultancy Limited (formerly Mineral Exploration Corporation Limited)-MECL during field execution from October 2024 to June 2025 and the exploration programme was funded by National Mineral Exploration Trust (NMET). MECL was established as an autonomous Public Sector Company in October 1972, under the administrative control of Ministry of Mines, Government of India for systematic exploration of minerals, to bridge the gap between the initial discovery of a prospect and its eventual exploitation.

2.1.2 Experience**:** MECL has completed over 1717 projects/reports and established 212 billion tonnes of ores / mineral reserves of minerals like Coal, Lignite, Bauxite, Copper, Gold, Lead-Zinc, Iron Ore, Limestone, Manganese, Magnesite, Chromite, Fluorspar, graphite and other critical minerals and several other Industrial Minerals since inception (As on March 2025).

2.1.3 MECL's registered address is:

Mineral Exploration And Consultancy Limited
(Formerly Known as Mineral Exploration Corporation Limited)
(A PSE under Ministry of Mines, Govt. of India)
Dr. Babasaheb Ambedkar Bhawan, Highland drive road, Seminary Hills,
Nagpur- 440006, Maharashtra, India.

2.2.0 QUALIFIED PERSONS

Exploration agency: Mineral Exploration and Consultancy Limited
Experience: 52 Years, Since 1972
Email: cmd@mecl.gov.in; gm-exploration@mecl.gov.in
List of qualified persons involved in the project are tabulated below:

Table 2.1
List of qualified persons involved in exploration in the Chitrangi Block Singrauli District, Madhya Pradesh.

Sl No.	Name
1	Shri Shrikant Sharma HoD (Exploration)
2	Shri S. K. Satapathy, Sr. Manager (Geology)
3	Shri Rajnikant Singh, Manager (Drilling), Project Management.
4	Shri Ravinant, Asst. Manager (Geology)
5	Smt. Rajanya Roy, Asst. Manager (Geology)
6	Shri Rohit Sharma, Manager (Chemical Lab.)
7	Shri Sayantan Pal, Manager (Geology), Petrology Lab.
8	Shri Durgesh Devarshee, Asst. Survey & Map Officer

CHAPTER-3

3.0.0 TITLE AND OWNERSHIP

3.1.0 TITLE OF THE REPORT

"GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3 STAGE) FOR IRON ASSOCIATED MINERALS IN CHITRANGI BLOCK DISTRICT-SINGRAULI, MADHYA PRADESH"

3.1.1 Ownership: Government of Madhya Pradesh

3.1.2 Name of Prospector: MINERAL EXPLORATION AND CONSULTANCY LIMITED
(Formerly Mineral Exploration Corporation Limited)
A Govt. of India Enterprise; A Miniratna-I CPSE
Ministry of Mines, Govt. of India.

3.1.3 Address of Prospector: Mineral Exploration And Consultancy Limited
(Formerly Known as Mineral Exploration Corporation Limited)
(A PSE under Ministry of Mines, Govt. of India)
Dr. Babasaheb Ambedkar Bhawan, Highland drive road, Seminary Hills, Nagpur- 440006, Maharashtra, India.

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

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

3.2.0 DETAILS ABOUT THE PROJECT AND PERIOD OF PROSPECTING

3.2.1 India is endowed with large reserves of iron ore, but much of it is of low to medium grade and high-grade ores depleting. Rising demand and need for utilising low-grade iron ore has become essential. India aims to produce 300 million tonnes of crude steel by 2030 (as per the National Steel Policy). Demand from sectors like infrastructure, construction, automotive, and defence will increase. Low-grade iron ore, after beneficiation, can feed this rising demand. To align with this demand more and more potential areas having low grade iron ore like in Mahakoshal belt to be explored and establish the resources. In light of above, few areas in the Mahakoshal belt have been identified and the present block is one of them. Subsequently, after receipt of consent from DMG, Madhya Pradesh, MECL had prepared an exploration proposal for Preliminary Exploration (G-3) for iron and associated minerals in Chitrangi Block over an extent of 5.015 sq km in Singrauli district of Madhya Pradesh and submitted to NMET. The proposal was discussed in the 66th meeting of the TCC-I, NMET in June 2024 and recommended for EC, NMET approval. The project was approved in the 36th meeting of the EC, NMET held in July 2024 and approval received vide letter No. F.No.23/485/2024-NMET/305, dated 29.08.2024 with a time line of 12 months (up to 28.08.2025).

3.2.2 Execution of the block commenced on 01.10.2024. Geological mapping, topographical survey and collection of channel samples completed in May 2025. Based on analytical result the project was reviewed in 9th TCC II, NMET in May 2025 and committee suggested to pre-close the block due to analyses results are not encouraging for iron ore and its beneficiation in the near future and advised to submit the geological report based on the activities carried in the block.

3.2.3 A draft geological report was prepared and peer reviewed by Shri C R Dash, Director (Retd.) GSI. Final geological report has been prepared after incorporating the comments and suggestions of the peer reviewer. Comments of the peer reviewer is provided in the the Annexure- VII and compliance to the comments in Annexure- VIII.

CHAPTER-4

4.0.0 DETAILS OF THE AREA

4.1.0 LOCATION AND ACCESSIBILITY OF THE BLOCK

4.1.1 Chitrangi block is in Chitrangi taluk, Singrauli district, Madhya Pradesh. It lies between latitudes 24°28'16.62588" N and 24°29'59.32450"N and longitudes 82°29'59.00496" E and 82°34'42.67946"E. The block covers an area of 5.015 sq km and falls within the Survey of India Toposheet No 64L11. The Location map of the block is provided as Plate-I.

4.1.2 Chitrangi is the nearest small town and tehsil headquarter located around 4km south of the block. Singrauli the district headquarter is located about 50 km to the south of the block. Google image showing location of the block with respect to the surrounding area is provided in the Text Figure 4.1. The block is well connected with the surrounding areas with the state and district level roads.

4.1.3 DGPS co-ordinates of the boundary corner points are provided in the following table which were recorded during the topographical survey.

Table 4.1
DGPS Co-ordinates of the boundary corner points of Chitrangi Block, Singrauli District, Madhya Pradesh

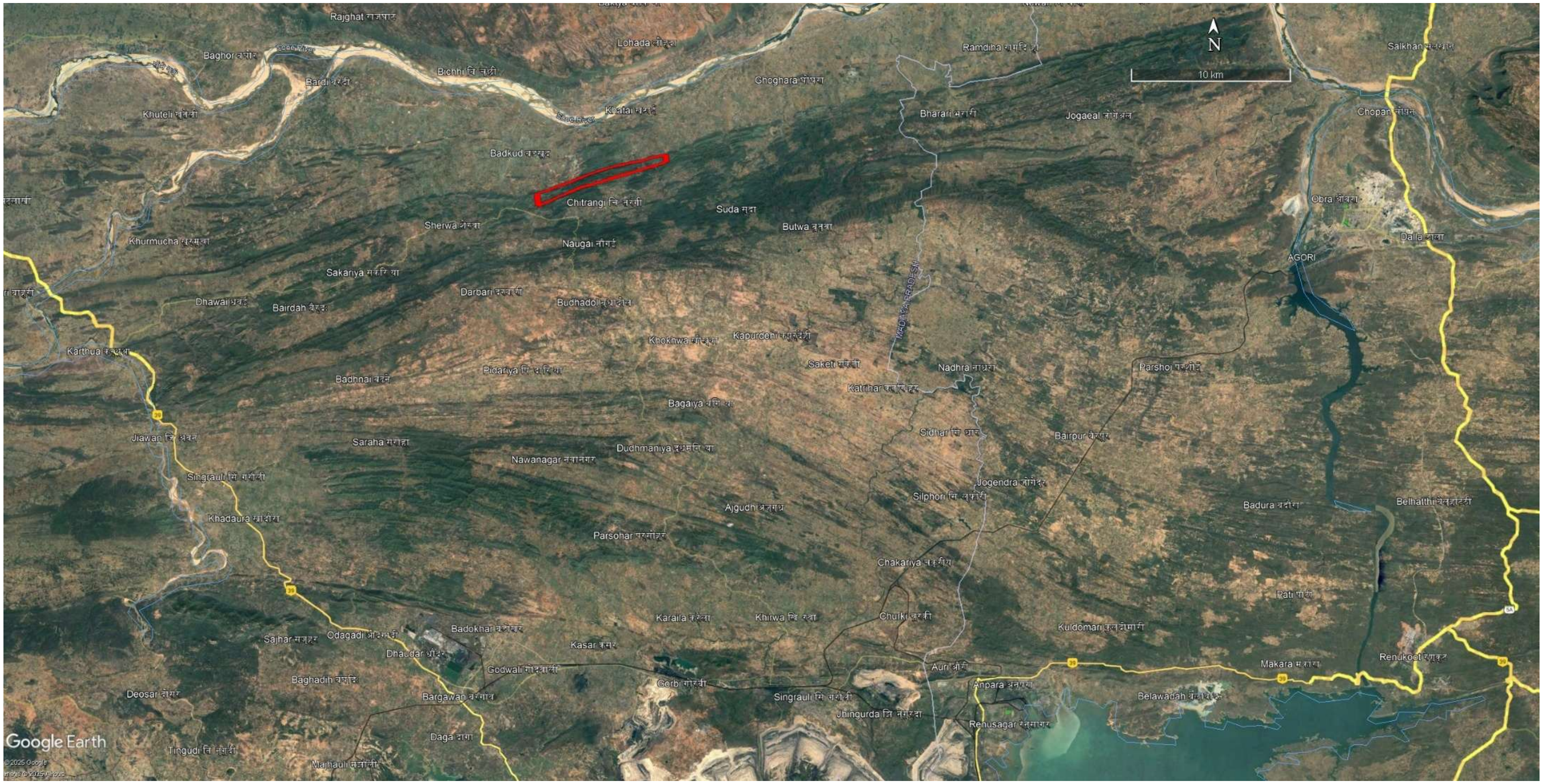
Sl No.	DMS Co-ordinates (WGS 84)		UTM Co-ordinates WGS 84		Descript-ion of Corner Points
	Latitude (N)	Longitude (E)	Northing (m)	Easting (m)	
1	24°28'40.22300"	82°29'59.00496"	651981.452	2707955.975	"A"
2	24°29'28.61490"	82°32'23.26285"	656026.355	2709489.316	"B"
3	24°29'59.32450"	82°34'41.66034"	659911.672	2710478.010	"C"
4	24°29'44.44497"	82°34'42.67946"	659945.597	2710020.588	"D"
5	24°28'52.09827"	82°31'34.54450"	654667.269	2708350.737	"E"
6	24°28'16.62588"	82°29'59.48251"	652002.778	2707230.213	"F"

4.2.0 DETAILS OF THE AREA WITH LAND USE

4.2.1 Most part of the block falls in forest land except areas lying in the foothills.

4.3.0 MINERAL (S) UNDER INVESTIGATION OR GRANTED UNDER LICENSE OR LEASE APPLIED FOR

4.3.1 Iron Ore, PGE and associated minerals.



Text Figure 4.1- Google image showing location of Chitrangi block

Chitrangi Block

CHAPTER-5

5.0.0 PHYSIOGRAPHY AND ENVIRONMENT

5.1.0 PHYSIOGRAPHY

5.1.1 The block and the surrounding area are characterised by long linear hills and intermittent valleys. Mostly, the top of the hill ranges is occupied by BHQ/BHJ and intermittent valleys are occupied by meta-basic/phyllite rocks including the flanks of the hills.

5.1.2 A long linear ridge having ENE-WSW trend occupies the central portion of the block. Whereas northern and southern part of the block is occupied by steep flanks of the hill and low-lying areas.

5.1.3 Most of the area in the block lie in forest land. However, some part of the foothills is under cultivation.

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

5.2.1 Highest elevation recorded in the block is 452mRL in the central part on top of the hill whereas lowest elevation recorded is 230mRL in the eastern part of the block.

5.2.2 The block and surrounding area have the both trellis pattern due to the long, linear ridges and valleys and dendritic on homogeneous rock or gently sloping terrain. With in the block the drainage pattern is trellis due to the linear ridge in the central part of the block.

5.2.3 No perennial water courses flow within the block. No prominent water reservoirs are located within the block. However, in the western part of the block a seasonal nala flows south to north across the trend of the ridges due to discontinuity.

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

5.3.1 No railway tracks, electric transmission lines, telephone lines pass through the block area. However, in the eastern part of the block where ridges are discontinued, all weathered roads connecting villages in the north and south of the ridges.

5.4.0 SOCIO DEMOGRAPHIC PROFILE OF THE AREA AND NEARBY

5.4.1 The block area falls in the Chitrangi which administrative tehsils of Singrauli district in the state of Madhya Pradesh, India. Hence, socio demographic details of Chitrangi tehsil have been provided for better assessment of the block and the surrounding area.

5.4.2 As per the Census of India 2011, Chitrangi tehsil presents a distinct socio-economic and demographic profile marked by a predominantly rural population, significant tribal presence, and modest development indicators.

5.4.3 Chitrangi Tehsil, located in Singrauli district of Madhya Pradesh, had a population of 195,580 as per the 2011 Census, with a sex ratio of 961 females per 1000 males and a child sex ratio of 956. A significant portion of the population belongs to Scheduled Tribes (49.2%), mainly the Gond and Kol communities, while Scheduled Castes account for 5.7%. The tehsil has a young population, with over 17% in the 0–6 age group, indicating a high dependency ratio and a need for child-focused services.

5.4.4 Literacy levels in Chitrangi are relatively low at 54.97%, with a marked gender disparity, male literacy at 64.72% and female literacy at just 44.81%. Nearly half of the population is engaged in some form of work, predominantly in agriculture. A substantial 49.74% of workers are agricultural labourers, and 28.36% are cultivators, reflecting the area's economic dependence on traditional farming and limited occupational diversity.

5.4.5 Infrastructure in the region remains underdeveloped. Most villages have access to primary education but lack higher educational institutions and adequate healthcare facilities. Water supply is primarily through hand pumps and wells, while electricity and sanitation services are inconsistently available. Firewood remains the main source of cooking fuel. While Hindi is the official language, regional languages like Bagheli and Gondi are also widely spoken. The socio-economic indicators highlight the urgent need for targeted interventions in education, health, infrastructure, and skill development to support the predominantly tribal and rural population.

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

5.5.1 No historical sites, archaeological monuments, places of worship and public utilities are located within the block. However, the hilly and rocky outcrops of Chitrangi exhibit Mesolithic painted rock shelters, notably at Ranimachi, Dholagiri, and Goura Pahad, carved into Vindhya/Kaimur-type sandstone exposures.

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

5.6.1 No sanctuaries, national park and wild life sanctuaries are located with in the block. However, 95% of the block area falls in forest land falls in Kaimur Reserved Forests.

5.7.0 FLORA AND FAUNA WITHIN AND NEARBY

5.7.1 Based on the provided District Census Handbook 2011, the flora and fauna of Jabalpur district can be characterized as follows:

5.7.2 **Flora:** Chitrangi Tehsil, located in the northeastern part of Singrauli district in Madhya Pradesh, lies within a transitional zone between the Vindhyan plateau and forested hill ranges. The region is characterized by a mix of tropical dry deciduous forests and patches of moist deciduous vegetation, owing to moderate rainfall and undulating terrain. The natural vegetation is dominated by Sal (Shorea robusta), which forms the primary forest cover in many areas. Other prominent tree species include Teak (Tectona grandis), Mahua (Madhuca indica), Tendu (Diospyros melanoxylon), Palash (Butea monosperma), Aonla (Phyllanthus emblica), and various species of Acacia and Terminalia. The understorey vegetation consists of shrubs, grasses, bamboo clumps, and medicinal plants, some of which are locally harvested by tribal communities.

5.7.3 **Fauna:** The fauna of the region reflects the typical biodiversity of central Indian forests. Mammals such as Indian leopard (Panthera pardus), sloth bear (Melursus ursinus), wild boar (Sus scrofa), Indian fox (Vulpes bengalensis), jackal (Canis aureus), and chital

(Axis axis) are commonly found in forested tracts. Occasional sightings of hyenas and Indian pangolins have also been reported. The forests also provide habitat to a wide range of avifauna, including peafowl, parakeets, drongos, barbets, eagles, and owls, making the region ornithologically significant. Reptilian species such as Indian cobra, rat snake, monitor lizard, and various skinks are present in the area.

5.7.4 Many of these forests form part of community-managed or reserved forest lands and are ecologically important for maintaining biodiversity and supporting local livelihoods, particularly for the tribal population that relies on forest produce such as mahua flowers, tendu leaves, and medicinal herbs.

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

5.8.1 No water bodies such as river, nala, stream or reservoir are located within the block.

5.9.0 CLIMATIC CONDITIONS

5.9.1 The physiographic setting contributes to a tropical monsoon climate, with average annual rainfall of approximately 1,014 mm, and temperature extremes ranging from ~7 °C in winter to ~42 °C in summer. The region lies in a rain shadow or transitional zone influencing soil moisture and vegetation cover.

CHAPTER 06

6.0.0 INFRASTRUCTURE AND CONSUMER INDUSTRIES

6.1.0 INFRASTRUCTURE

6.1.1 Chitrangi Tehsil, situated in the northeastern part of Singrauli district, Madhya Pradesh, functions both as an administrative block and a Gram Panchayat. It now benefits from enhanced connectivity through National Highway 135C, which links it to major urban centers such as Prayagraj and Waidhan. This improved road network has been supported by infrastructure investments from Northern Coalfields Limited (NCL), such as rural roads in Semuar Panchayat that serve thousands of villagers. Rail connectivity is available via the nearby Singrauli Railway Station, located around 50 km away, and is connected to major routes after its electrification in 2017.

6.1.2 Although a proposed Reliance Power project in Chitrangi was shelved, the surrounding region remains a hub of energy production, hosting several major thermal power plants like NTPC's Vindhyachal and the Sasan UMPP. NCL continues to improve industrial logistics through First-Mile Connectivity (FMC) corridors that enhance coal evacuation. These developments have implications for regional employment and access, even as some interior areas remain rural and agricultural.

6.1.3 Significant progress has been made in the areas of water supply, sanitation, and education through CSR initiatives. NCL has established 75 "Phulwari" early childhood care centers, installed RO drinking water systems in schools, equipped classrooms with smart technology, and introduced solid waste management services in semi-urban settlements. These efforts directly support thousands of children and residents, improving both health and educational outcomes in the tehsil.

6.1.4 Social infrastructure continues to evolve, with a Lok Seva Kendra operational in the Chitrangi tehsil campus to facilitate access to government services. While Chitrangi lacks its own higher education institutions, nearby Waidhan offers secondary schools, polytechnic colleges, and banks. Primary health services are available locally through health centers and sub-centers, whereas advanced medical care is accessed in Waidhan or NTPC's hospital in Vindhyanagar. Overall, Chitrangi's infrastructure is gradually improving, though focused investment is still needed in healthcare, internet connectivity, and higher education to meet growing developmental needs.

CHAPTER 07

7.0.0 GEOLOGY OF THE AREA

7.1.0 REGIONAL GEOLOGY

7.1.1 The geological background described here for the sake of clarity in local geology, is taken from earlier workers and also from traverses made in the areas.

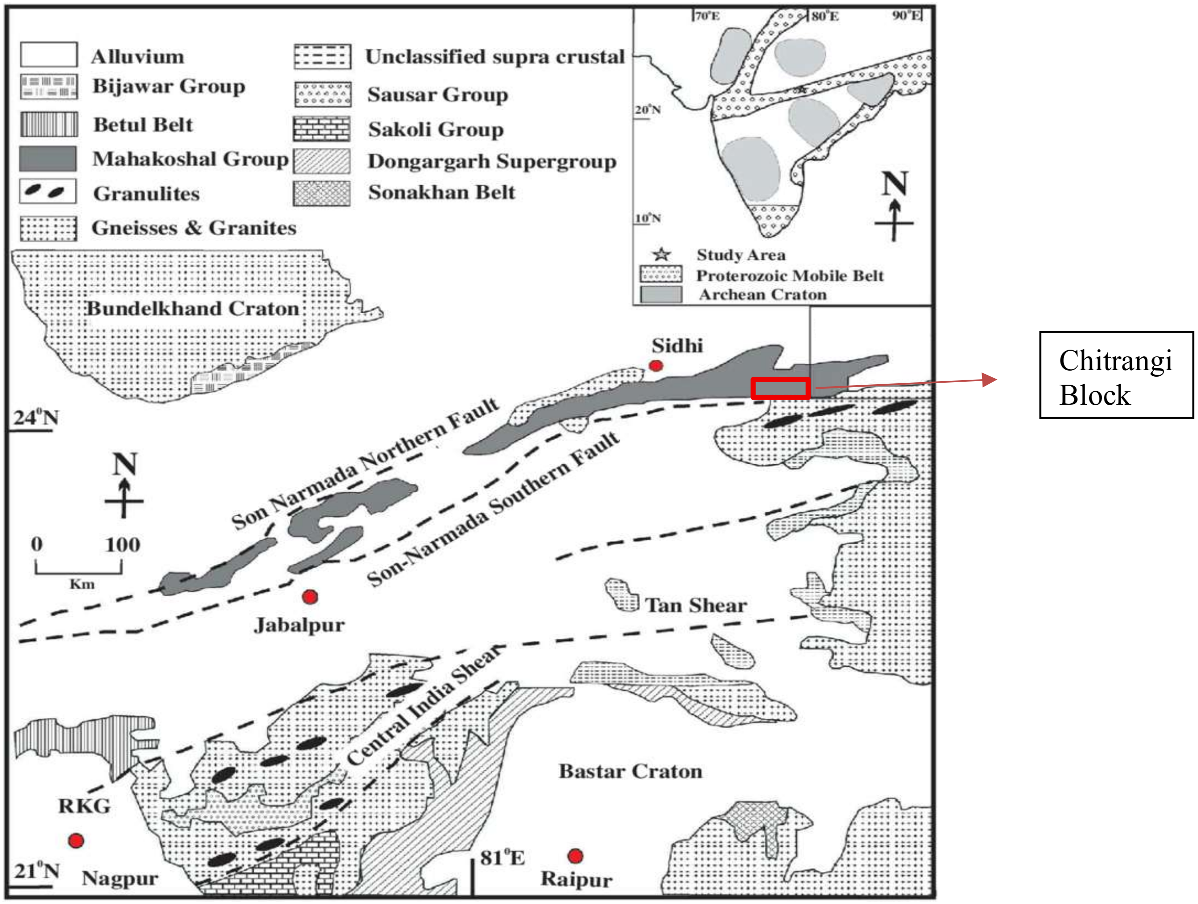
7.1.2 The Proposed block falls in the Mahakoshal Group of rocks which is famous for various mineral assemblages. Mahakoshal Group of rocks are represented by the volcano-sedimentary sequence occurring as ENE-WSW trending linear belt extending from Narsinghpur district in M.P. to Palamau district in Jharkhand. The sediments include quartzite, conglomerate, phyllite, chert, stromatolitic dolomite, limestone and Banded Iron Formation inter-layered with metabasics of basaltic composition. The narrow belt of high-grade gneisses which occur to the north and south of this belt in the area have been considered to be the basement for Mahakoshal Group of rocks. The Mahakoshal Supracrustal is intruded by serpentinised ultramafic bodies of dunite-peridotite and pyroxenite composition. Syn to post kinematic granitoids have intruded this sequence which are 1800 Ma and 2400 Ma old (Rb-Sr age dating, Bandyopadhyay et al, 1990). The Supracrustal rocks have been subjected to three phases of deformations, the first two phases are more pronounced (Roy & Bandyopadhyay, 1990). Green schist facies of metamorphism are seen in the entire belt, however, locally higher-grade minerals also occur. Location of the Chitrangi block on regional map of the area is presented in the following Text Figure 7.1.

7.1.3 Nair et.al. (1995) has carried out work in MB and proposed three-fold stratigraphic classification to the belt. The three formations in the order of younging are Chitrangi formation, Agori Formation and Parsoi Formation. The Chitrangi Formation is mainly 10 dominated by the mafic and ultramafics with sedimentary sequences of BIF interbanded with Metabasalt. Main lithology exposed in the lower part of MB is metabasalt in deformed form, grading in to schist rock and pillow basalt that at places is weathered and deformed also. Younger to Chitrangi formation is Agori Formation that is exposed in the eastern as well as western part of MB. Agori Formation is flanked with chemogenic sediments such as carbonates, cherts and BIF interbanded with phyllite and schist. The phyllite also metamorphosed and graded from greenschist facies to lower amphibolites facies. Clastic dominated with thick sequence of argillites and greywacke with intercalation of quartzite bands is the typical cahracterstics of Parsoi Formation of MB. Along with that the formation also includes BIF interbanded with phyllites and garnet bearing Banded Magnetite Grunerite Quartzite (BMGQ) and forms the upper part of the MB. With time there has been a lot of modification regarding the stratigraphy of MB has been done by many workers. Recently Roy and Devrajan (2000) and Devrajan (2006) have brought out some changes to the stratigraphic nomenclature of different Formation of MB. They coined the younger Formation of Mahakoshal as Dudhamiya Formation in areas of Chitrangi-Deosar and Gurhar pahar and Agori Formation as Sleemnabad Formation. Dudhmaniya Formation is the upper part of the Parsoi Formation and consists of BIF argillite sequences. The lower Chitrangi becomes part of Agori Formation. Eastern part of MB comprises all the Formations of it and they are well exposed and established by many workers. Lastly at the closing of the basin the MB have been intruded by ultramafic –mafic, alkaline rocks and granitoids during the time gap of 2.045 Ga to 1.75 Ga (Sarkar, et al., 1995; Roy and Deverajan, 2000). These granotids play an important role in the crustal evolution and formation of Mahakoshal belt. The most recent work related to the geology of MB has been carried out by Devrajan in 2006. stratigraphic Succession of the Mahakoshal Group is provided in the following table.

Table 7.1

The stratigraphic Succession of the Mahakoshal Group as proposed by Nair et al., (1995) in and around chitrangi area

Formation	Litho-units
Intrusive	Gold bearing quartz–carbonate veins, quartz reefs, dolerite. Granitegranodiorite- intrusive plutonite belt along the southern margin. Jhigradandi granite and equivalents and syenite-barite in Sidhi
Parsoi Formation	Tuffaceous and carbonaceous phyllites, feldspathic quartzite, conglomerate, tuffaceous phyllite with metabasalt intercalations.
Agori Formation	Banded hematite/magnetite quartzite and jasperoid with associated tuffs and ash beds. Impure marble, dolomite and interbedded calc-chlorite schist with occasional metabasalt lenses and conglomerate.
Chitrangi Formation	Basic and ultrabasic plugs and dykes including peridotites and serpentinite, agglomerates, metabasalt and peridotitic pillow lava



Text Figure- 7.1 Map showing Proterozoic Mobile belt, Mahakoshal Group and the Chitrangi block (Modified After Bora, S and Kumar, S., 2015)

7.2.0 REGIONAL STRUCTURE

7.2.1 **Diastropic Structures:** The overall structural framework of the Mahakoshal belt is represented by a series of upright to slightly overturned folds on southerly dipping axial planes and the folds developed during the initial stage of deformation were refolded into nearly vertical to reclined folds during the course of the progressive deformation, especially in the vicinity of the shear zones. According to Roy and Bandyopadhyay (1990), the Supracrustal rocks of the Mahakoshal belt have been involved in folding of at least three generations (D1, D2 & D3) and the present day ENE-WSW disposition of the belt is due to the development of D1 and D2 structures. The shear zone rocks include as part of the Mahakoshal Supracrustal and the granitoids occurring further on the southern margin. The mylonitic foliation within the shear zone is parallel to the schistosity of the dominant folds (D1) and sheath like folds are found in the mylonites. The North to NNW sub horizontal shortening across a large terrain of the deformed rocks and a shearing movement superimposed over the regional strain along the steep southerly dipping slip/shear planes represented by slip faults (Abhinaba Roy and M. K. Devarajan).

7.2.2 The regional strike of the Mahakoshal Group of rocks is ENE-WSW to East-West with dips ranging from 55° to 80°. Presence of isoclinal folds, asymmetrical folds and cross folds, reflect the deformational events. The earliest recognized folding which has generated tight, isoclinal, reclined folds with sub vertical axial planes is represented by a closure at Pan Umariya village located at south west of the Imaliya village. The pervasive foliation in the volcano sedimentary sequence, which strikes in ENE-WSW direction and was generated during this deformation, is seen in this part of the Mahakoshal belt. The plunge of the folds is towards SSE. The second event of the deformation has developed folds with sub vertical axial planes with axis plunging very gently either ENE or WSW. Both of these events have developed folds which are co-axial but one has a gentle plunge whereas the other has steep plunge of axis. Topography in this part is also representing ENE-WSW trending alternate hills and valleys. The third event, which has NNW-SSE axial trend with open warps where cross faults are present, has caused discontinuity or gap in these ridges. This particular activity is most important in the Mahakoshal belt for localization of mineralisation. The above-mentioned diastrophic structures like foliation, mesoscopic and minor folds, are reflecting the deformational history of the supracrustals in the present area. In the central part of Mahakoshal belt fold closures of the major folds as such are not well preserved, however, some of the F2 fold closures seen in the central part are at Pan Umariya, Sihora and Tindni which also represent the large scale folds of the Mahakoshal belt. The map scale folds and minor folds have varying plunges which are either plane cylindrical or non-planar and non-cylindrical, tight to isoclinal, upright to reclined folds. These may overall represent sheath geometry. These are seen in the Sarda area (23°28’31”:80°08’41”, 64A/3) in the central part of the Mahakoshal belt (Singhai and Keshava Prasad, 1997-98). Plunge in the minor fold of Tindni closure, which is plane, cylindrical, upright to reclined fold, varies from 15° to 80° both towards ENE and WSW as observed in this part of the Mahakoshal belt. Such variations have been attributed to inhomogeneous nature of the strata in the area (Roy and Bandyopadhyay, 1990).

7.2.3 **Non-Diastrophic Structures:** The non-diastrophic structures and planar features like bedding is represented by compositional layering within the BIF, colour banding in the chert and jasper bands and alternate silica rich and mica rich layers within the metapelites of the Mahakoshal belt. The colour banding in the dolomite and chert, which is a dominant unit in this part, is exhibited by light to dark greyish tone and pink to pinkish & purple impurities in chert bands. Intercalations of phyllite within the dolomite and calcareous intercalations in argillaceous rocks are reflecting the depositional characters. Thin sedimentary units, which are of arenaceous nature, are also found in the calcareous and argillaceous rocks. The variation in grain size, fineness and coarseness are characteristic of these units. Presence of intra-formational conglomerate and its gradation towards coarseness or fineness is indicative of its depositional nature. In this part, the regional stratification is ENE-WSW to WNW-ESE with sub vertical dips varying from 70° to 80° due south. Meta basaltic flows, which occur in Shahdar and Madhana area upto east of Pan Umaria show flow structures like vesicles filled with secondary materials or minerals. Flows may contain Pahaehoe like features and these may have development of pillow structure as has been suspected form the north eastern part of Dungaria in Sleemanabad area.

7.3.0 MINERALISATION

7.3.1 Iron and Manganese mineralisation associated with the Early Proterozoic Mahakoshal Group of rocks has been present in the area marked by the presence of BIF and Mn bearing Phyllites etc. Previous agencies have also observed the presence of Iron and Manganese. Banded Hematite Jasper (BHJ) in the area occurs mainly as a rhythmic layering of hematite and jasper. Hematite is dark reddish-black and Jasper is dark pinkish. Banded Hematite Quartzite (BHQ) are also present in the area with an alternate layering of hematite and quartz bands. Hematite layer is having a dark reddish black colour and quartz is white.

7.3.2 Several small occurrences of manganese are reported throughout the Mahakoshal especially in and around Sihora. Primary mineralised bodies are manganiferous argillites associated with phyllite and BHC and manganiferous cherts. Secondary mineralisation is associated with quartz veins which have intruded the BHC. Main manganese minerals are psilomelane and pyrolusite.

7.3.3 The supracrustal of Mahakoshal Group in the southern part of the mapped area come into contact with the intrusive Madan Mahal granite. Near the contact quartz reefs are emplaced at places. Visible sulphide mineralisation is also seen occupied these reefs at places. GSI reported presence of Au in these reefs.

7.4.0 GEOLOGY OF THE BLOCK

7.4.1 The block and the surrounding area are characterised by long linear hills and intermittent valleys. Banded Iron Formation (BIF) occurs as a series of parallel ridges separated by intermittent valleys. Based on the geological traverses carried out within the block and the outcrop map prepared, two parallel, long, linear Banded Hematite Quartzite (BHQ) / Banded Magnetite Quartzite (BMQ) ridges have been identified, exhibiting discontinuities at several locations. The cumulative length of the BHQ/BMQ ridges is approximately 8,350 metres, with an average width of around 50m. The discontinuities observed in the eastern and western segments of the block and are interpreted to be the result of faulting and other tectonic disturbances. Such structural disruptions have created favourable zones for localized mineral enrichment, making these areas significant from an exploration perspective. The ridges in the area exhibit a predominant ENE–WSW trend, while the intervening valleys are mainly occupied by metabasic rocks. The observed repetition of BIF ridges in subparallel alignment can be explained by the structural history of the greenstone belt. Regional deformation has imposed tight to isoclinal folding on the stratigraphic sequence, resulting in repeated exposures of the same BIF horizon. These repetitions occur where fold limbs are brought up to the surface, giving the appearance of multiple, parallel BIF ridges across strike.

7.4.2 This geomorphological pattern is primarily controlled by the contrasting resistance of different lithologies to weathering and erosion. BIF consists predominantly of magnetite, hematite, jasper, and chert, which are highly resistant to both chemical and physical weathering. Consequently, these layers tend to stand out as topographic highs in the landscape. In contrast, the associated country rocks, such as metabasic, are comparatively softer and more susceptible to erosion, thereby forming valleys between the BIF ridges.

7.4.4 Integrating earlier exploration studies from the surrounding areas with the present investigations in the block, the following local stratigraphic framework has been deduced.

Quaternary - Soil / Alluvium

Cenozoic- Laterite (ferruginous duricrust capping ridges and BIF exposures)

Younger intrusives- Quartz ± calcite veins with magnetite–ilmenite ± minor sulphides

Banded Iron Formation (BIF)- BMQ / BHQ / BHJ / BHC

Conglomerate

Metabasalt

Dolerite

Amphibolite

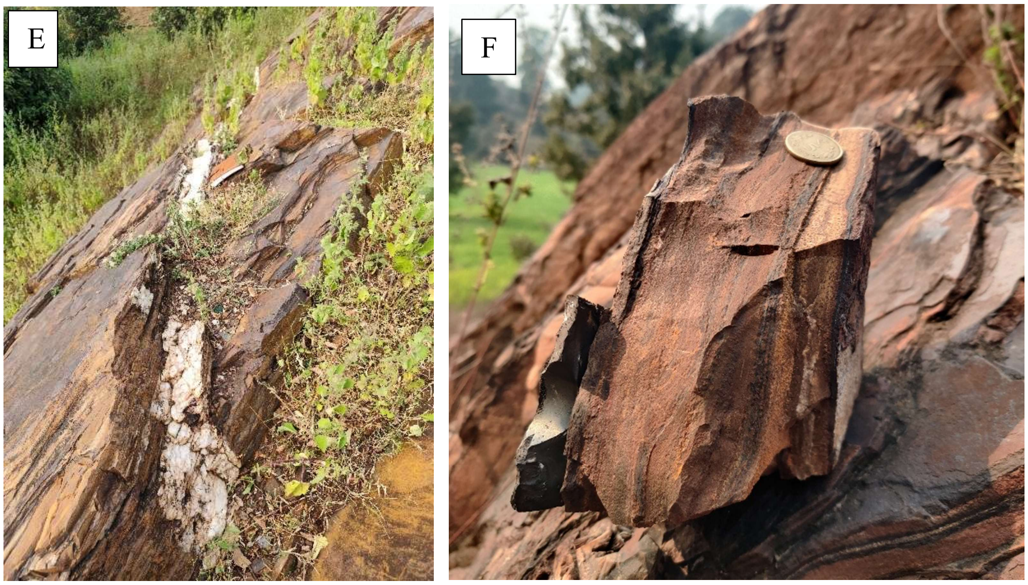
Basement not exposed

7.4.3 Geologically, the area exposes rocks belonging to Mahakoshal Supracrustal belt of Archean to Lower Proterozoic age. The area comprises the rocks of Agori and Chitrangi formation (Nair et al. 1995). Details of litho units exposed in the block are emphasised in the following paragraphs.

7.5.0 LITHO UNITS

7.5.1 **Soil**: Soil represents the quaternary deposits in the area. Mostly, on top of the hill near the BHQ the soil is reddish-brown to yellowish-red whereas dark grey to black over metabasalt in low lying areas. In low lying areas soil is clayey to loamy.

7.5.2 **Banded iron formation (BIF)** which is a distinct formation common to all the younger schist belt. BIF included banded hematite quartzite (BHQ), banded hematite chert (BHC), banded hematite jasper (BHJ) and banded magnetite quartzite (BMQ). The most striking feature is their striped and banded character with layers of quartzite/chert/Jasper alternating with pure hematite. Clastic grains are absent. They are very hard, compact, and brittle in nature. Central part of the block is occupied by two long linear nearly parallel BIF reefs having length of around 8300m showing nearly ENE-WSW trend dipping 45-60º towards SE. At few places BIF bands show subvertical to vertical dip. In the block BMQ, BHQ and BHJ have been mapped. All are showing low to moderate magnetic property when tested with hand magnet. The discontinuities observed for the BIF reefs in the eastern and western segments of the block and are interpreted to be the result of faulting and other tectonic disturbances. Such structural disruptions have created favorable zones for localised iron enrichment. At places the BIFs have been intruded by quartz veins across the bedding at low angle. The minor faults post-date quartz vein emplacement, as evidenced by the clear lateral offsets of the veins (Field Photo 7.1(C)). Boudinage structures along with joints/fractures within the BHJ bands have been recorded at few places (Field Photo 7.1(B)). The presence of boudinage suggests that after lithification, the rock experienced ductile to brittle-ductile deformation under extensional stress. The silica-rich jasper bands acted as competent layers, breaking into boudin segments, while hematite bands accommodated stretching. Subsequent brittle deformation (joints/fractures) cross-cuts the boudins and bedding indicating later cooling and strain localization. Overall, the assemblage implies polyphase tectonics. Field photographs of the BIF exposed in the block are provided in the following photographs.



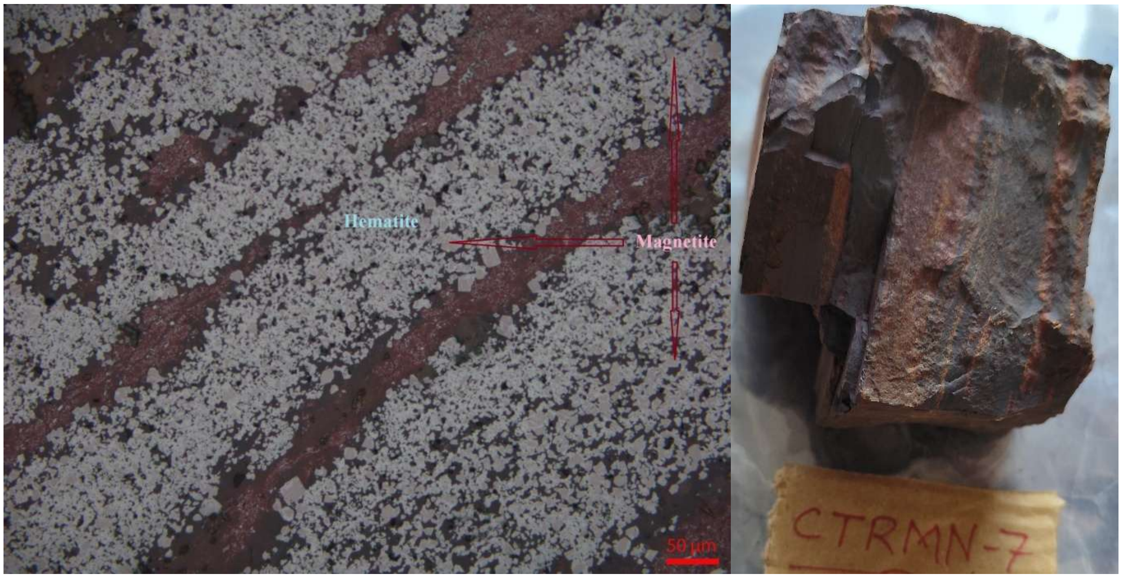
Field Photo 7.1: (A) Outcrop of BMQ in the central part of the BMQ reef. (B) Outcrop of BHJ showing boudinage structures in jasper bands (C) BHQ exposure in the western part of the block showing nearly vertical dip (D) Out crop of BMQ along nala section in the western part of the block. (E) & (F) Outcrop of inclined BMQ beds intruded by a quartz vein and hand specimen showing magnetic property when tested with a magnet near the 09km milestone to Pundi.

Under microscope Banded Iron Formation (BIF) samples display a dominant mineralogical assemblage of chert, hematite, calcite, carbonaceous matter, sericite, and minor biotite. Chert occurs as thin to moderately thick sub-parallel bands composed of very fine microcrystalline quartz, often interlayered with hematite-rich bands made up of fine subhedral granular aggregates. Calcite is disseminated as very fine grains throughout the matrix, while carbonaceous matter occurs as fine lamellar segregations within cherty layers. Hematite bands are commonly associated with reddish ferruginous patches and stains, suggesting secondary iron enrichment or oxidation. Sericite and biotite occur as very fine flaky segregations, locally concentrated in patchy pockets, sometimes in association with carbonaceous matter. Quartz-rich bands exhibit tight quartzitic contacts, and localized brittle deformation textures are noted, indicating post-depositional structural overprinting. Photomicrographs of the samples is presented in the following image Pmg 7.1

Pmg – 7.1: Photomicrograph showing sub-parallel bands of quartz and opaques (hematite) in banded mineralized (hematite) quartzite as seen under crossed nicols. Specimen No.: CTRPT-02 (silicified BIF in central part of the block), Magnification: 40X

Mineragraphic studies of few BHQ/BMQ/silicified BIF samples were carried out. These samples were collected from the BIF ridges covering total length of the ridges in the block. Study indicates that a dominant assemblage of magnetite, hematite, goethite, limonite, and accessory sulphides with variable proportions of ilmenite and graphitoid. Magnetite typically occurs as fine to medium subhedral grains, blades, and relicts within goethite, segregated into thick to thin sub-parallel bands, and is variably replaced by hematite through martitisation. Hematite appears as fine bladed segregations, prismatic to anhedral grains, and moderately thick bands of segregated patches and fine aggregates. Goethite is widespread as patches, fillings, and pseudomorphs after hematite, sometimes displaying colloform textures, and is in turn replaced by limonite in the form of reddish amorphous aggregates, patches, stains, and cavity fillings. Sulphides occur in traces — pyrite and pyrrhotite are common as very fine specks, with occasional chalcopyrite in accessory amounts. Ilmenite is present as fine skeletal grains disseminated in the groundmass or associated with quartz–calcite veins, while graphitoid occurs as fine flakes or aggregates showing crude parallel alignment.

Magnetic properties vary from strong to feeble depending on the relative abundance and preservation of magnetite. Specimens with high magnetite content, lesser oxidation, and intact subhedral grains display strong magnetism, while those with extensive replacement by hematite, goethite, and limonite show weaker magnetic response. The mineral textures



Pmg – 7.2: Photomicrograph showing very fine relicts of magnetite within hematite as seen under reflected light. Specimen No. : CTRMN-07, Magnification : 200X

and replacement patterns indicate a primary BIF origin with rhythmic banding of magnetite and hematite, later subjected to progressive supergene and/or hydrothermal alteration. The sequence of alteration follows magnetite → hematite (martitisation) → goethite → limonite, with sulphides largely relict. The presence of calcite–quartz veins with associated magnetite–ilmenite suggests later hydrothermal fluid activity, while colloform goethite and limonitisation point to near-surface oxidation processes.

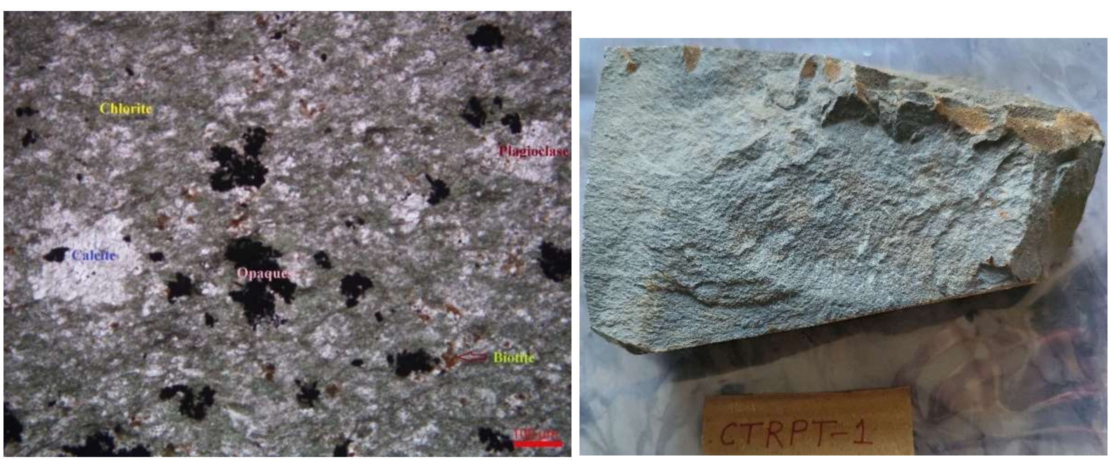
Mineragraphic studies (Annexure VI) of the samples clearly suggest metamorphosed and variably silicified Banded Iron Formations (BHQ/BMQ), where primary magnetite–hematite banding has been overprinted by multiphase alteration. The preservation of magnetite in strongly magnetic samples suggests minimal oxidation, whereas hematite-, goethite-, and limonite-rich samples record intense supergene weathering under oxidising conditions. Sulphide phases, though minor, indicate that the system was once sulphide-bearing, possibly due to syn- or post-depositional hydrothermal fluids. The association of ilmenite and graphitoid, along with calcite–quartz vein magnetite, supports an input of metamorphic–hydrothermal processes superimposed on the original chemical sedimentary fabric. Overall, the paragenetic sequence and mineral associations are consistent with a BIF protolith modified by regional metamorphism, hydrothermal veining, and subsequent supergene oxidation. Photomicrographs of sample along with the hand specimen are provided in the following images.

Pmg – 7.3: Photomicrograph showing very fine disseminated skeletal grains of ilmenite and fine to medium subhedral grains of magnetite as seen under reflected light. Specimen No.: CTRMN-08 (extreme western part of the BIF reef), Magnification: 100X

7.5.3 Metabasalt: After BIF, the main lithological unit exposed in the area is metabasalt. They occur as fine grained, light green to dark grey in colour, massive to foliated in nature. At places they are intruded by thin quartz veins. Mostly they are occupied the low lying areas and low elevation mounds.

Field Photo 7.2: (A) Metabasalt exposed on the low elevation mounds in the SW part of the block (B) Metabasalt exposed along the nala section in the western part of the block.

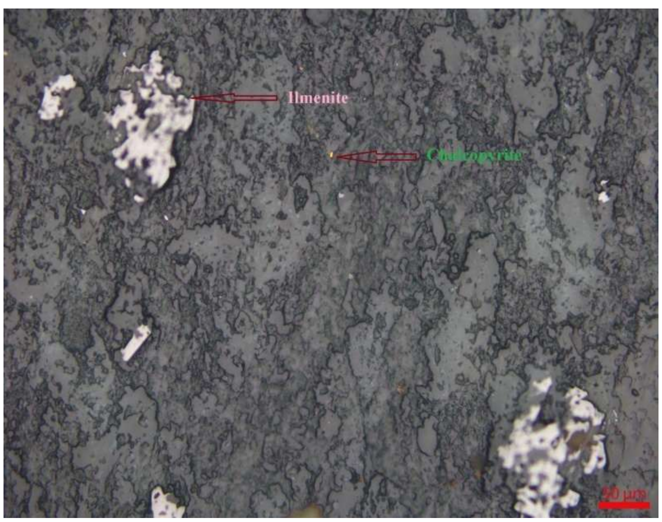
Under microscope metabasalt is predominantly composed of very fine microcrystalline chloritic aggregates displaying a vermicular texture, within which very fine relicts of pyroxene are locally preserved. Calcite occurs as fine to medium anhedral patches in dissemination, as well as in thin to moderately thick vein fillings, often associated with quartz and plagioclase grains. Plagioclase is present as very fine to fine subhedral prismatic laths or anhedral grains, with occasional relicts set in a calcitic matrix. Opaque minerals occur as fine subhedral to anhedral disseminated grains and patches, while biotite appears as very fine disseminated flakes or patches. Chlorite forms fine to medium anhedral patches of microcrystalline aggregates, sometimes enclosing pyroxene relicts. Accessory reddish ferruginous patches and stains are also noted. The mineral assemblage and textural relationships suggest that the rock has undergone significant hydrothermal and/or low-grade metamorphic alteration. Primary plagioclase and pyroxene have been largely replaced by chlorite and calcite, indicating retrogressive metamorphism under greenschist facies conditions. The presence of calcite and quartz veins points to later brittle deformation accompanied by fluid influx. The overall texture and mineralogy are consistent with a mafic protolith that has been chloritised and carbonated during deformation and fluid activity. Photomicrograph along with hand specimen of the samples is provided in the following images.



Pmg – 7.4: Photomicrograph showing association of chlorite, opaques, calcite and plagioclase and biotite as minor constituent minerals in altered basalt as seen under plane polarized light. Specimen No.: CTRPT-01, Magnification: 100X

To access any mineralisation in the metabasalts few samples were subjected to mineragraphic studies. Results indicate ilmenite occurring as medium-to-fine skeletal grains and disseminated patches is consistent with a primary magmatic crystalline oxide phase formed in a mafic protolith typical of metabasaltic rocks. The development of hematite after ilmenite indicates later oxidation/alteration of that primary Ti–Fe oxide; this replacement likely occurred during an oxidative event driven either by metamorphic fluids with elevated oxygen fugacity or by late hydrothermal/near-surface weathering. Because hematite is an oxidation product of Fe-Ti oxides, its presence implies a net increase in oxygen activity or fluid circulation after crystallisation.

The very fine specks of pyrite and chalcopyrite in accessory/trace amounts point to a late, low-volume sulphide introduction most probably from hydrothermal fluids that percolated through the metabasalt after or during the alteration event. These sulphides are too sparse to imply primary magmatic sulphide accumulation but are important as indicators of fluid activity and minor metal mobility (Cu, Fe, S). Most likely overall paragenesis is primary magmatic ilmenite → subsolidus/metamorphic or hydrothermal oxidation (ilmenite → hematite) → late introduction/precipitation of minor pyrite ± chalcopyrite.



Pmg – 7.5: Photomicrograph showing fine skeletal grains in dissemination and chalcopyrite specks in traces as seen under reflected light. Specimen No.: CTRMN-03, Magnification: 50X

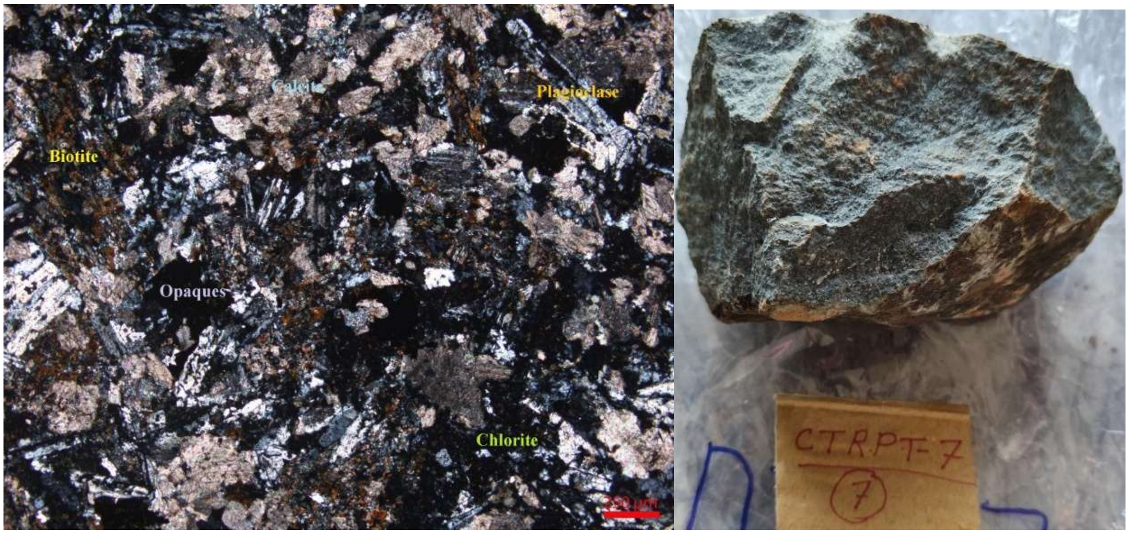
7.5.4 Conglomerate: In the central part of the block and south of the BIF ridges thin bands of conglomerate has been mapped. The outcrop exhibits a polymictic conglomerate composed of rounded to sub-rounded pebbles and cobbles within a finer-grained sandyargillaceous matrix. The clasts vary significantly in composition, colour, and size, indicating derivation from multiple lithologies. The assemblage mostly includes Quartz-rich pebbles mostly quartzite, derived from metamorphic sources. The matrix appears moderately abundant, suggesting that parts of the unit are matrix-supported, while other portions may be clast-supported. Sorting is poor to moderate, with no uniform clast size, pointing to fluctuating transport energy. Clast rounding indicates significant mechanical abrasion during transport. Although bedding is subdued in the exposed surface, the overall structure suggests a massive to weakly stratified fabric. Field photograph of the conglomerate is provided in the following Field photograph.

Field Photo 7.3: Conglomerate exposed in the central part of the block south of the BIF ridges.

7.5.5 Dolerite: The outcrop shows a massive, dark grey to black, fine- to medium-grained crystalline texture. Individual crystals are not resolvable in hand specimen. White calcite–quartz veinlets are observed filling some fractures, suggesting brittle deformation followed by hydrothermal fluid infiltration. Slight brownish discoloration along joints; otherwise, the rock is resistant and massive. Massive blocky exposure, lack of bedding, and crystalline texture suggest a shallow intrusive body likely a dyke. Dark grey to bluish-grey fresh surfaces and weathered surfaces are brownish. Abundant rounded to sub-rounded vesicles (2–6 mm) distributed throughout the rock indicates high volatile content during magma solidification. Some vesicles appear partially infilled with secondary minerals mostly quartz. At places outer layers peel off in thin flakes, suggestive of spheroidal weathering. Dissemination of sulphides have been observed as pyrite. Joints have been developed cutting across the trend of the dolerite bodies. Trend of the dolerite is aligned with the trend of the BIF in the block i.e ENE- WSW. Field photographs of the dolerite bodies are provided in the below Field Photos:

Field Photo 7.4: (A) & (B) Massive dolerite exposed in the north central part of the block. (C) Dolerite with vesicles. (D) Dissemination of pyrite in the dolerite

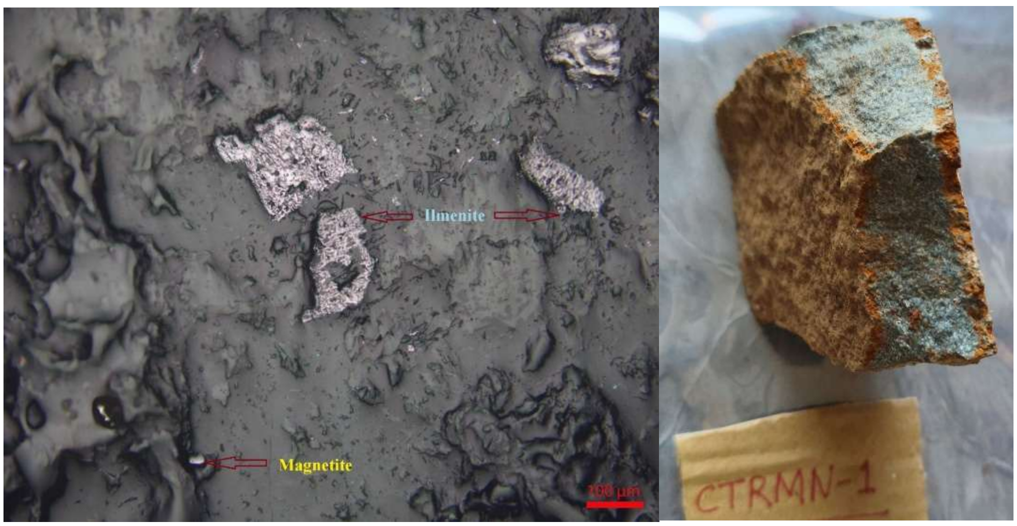
Petrographic studies of the dolerite sample revealed that Plagioclase occurs as medium subhedral prismatic laths showing relicts of sub-ophitic and intergranular textures, indicating original igneous cooling relations. Chlorite occurs as medium to moderately coarse anhedral patches, formed from retrograde alteration of mafic phases. Calcite as disseminated and patchy, interpreted as secondary infill from hydrothermal fluids. Biotite as fine to very fine flaky dissemination, often associated with chlorite patches, indicative of low-grade metamorphism. Photomicrograph of the sample along with hand specimen are provided in the following figures.



Pmg 7.6: Photomicrograph showing association of plagioclase, chlorite, calcite and biotite in altered (chloritised & carbonatised) dolerite as seen under crossed nicols. Specimen No.: CTRPT-07, Magnification: 40X

Mineragraphy studies of the dolerite sample shows that the ore assemblage comprises ilmenite and magnetite occurring as medium- to fine-grained skeletal crystals and as disseminated very fine grains. Pyrite is present as medium to moderately coarse subhedral to anhedral grains, along with fine disseminated specks. Goethite occurs as patches and peripheral fillings, replacing pyrite and displaying colloform textures. Limonite appears as reddish patches and stains along pore spaces and cavities. Chalcopyrite and pyrrhotite are present as very fine grains and as inclusions within pyrite. Digenite is observed as thin coronas around chalcopyrite in certain areas.

The textural relationships suggest a primary sulphide assemblage dominated by pyrite, chalcopyrite, pyrrhotite, and Fe–Ti oxides (ilmenite, magnetite), likely formed under magmatic or hydrothermal conditions. The presence of chalcopyrite and pyrrhotite as inclusions within pyrite indicates early crystallization of pyrite, followed by later introduction or exsolution of these sulphides. The thin digenite coronas around chalcopyrite point to secondary supergene or low-temperature alteration under oxidizing conditions. Extensive goethite and limonite replacement of pyrite reflect intense supergene weathering, with colloform textures indicating progressive Fe-hydroxide precipitation during oxidation. This assemblage suggests a multi-stage paragenesis Primary mineral deposition (Fe–Ti oxides, sulphides)-Inclusion formation during crystallization-Supergene oxidation producing Fe-hydroxides and secondary Cu-sulphides. However, further studies to be carried out to conclusively establish the nature, extent, and economic potential of the mineralisation.



Pmg 7.7: Photomicrograph showing fine skeletal grains of ilmenite and associated very fine specks of magnetite as seen under reflected light. Specimen No.: CTRMN-01, Magnification: 100X

7.5.6 Amphibolite: The rock shows a coarse-grained, equigranular texture with interlocking mineral grains and likely composed of quartz, feldspar, and biotite/amphibole. Subhedral grains indicate slow cooling at depth (plutonic origin). Exposure of sub-rounded to rounded shaped big boulders indicating spheroidal weathering. The absence of obvious foliations or layering supports a massive intrusive body rather than a metamorphic banded gneiss.

Petrographic studies of the amphibolite indicate actinolite–tremolite occurs dominantly as fibrous / acicular and columnar aggregates and locally as coarse prismatic pseudomorphs. Plagioclase is present as medium to fine, subhedral prismatic laths. Chlorite occurs in anhedral patches. Epidote is present as fine subhedral–anhedral grains and as granular aggregates within pockets. Calcite occurs as anhedral patches and late fine fillings. Opaque phases are present as fine to very fine disseminated accessory grains. The mineralogy is consistent with low to medium metamorphic grade broadly from the upper greenschist to lower amphibolite facies for mafic protoliths.

Field Photo 7.5: Amphibolite exposed in the south-central part of the block near southern boundary.

7.5.7 Quartzite: In the central part of the block a quartzite band is exposed which in between the BIF in north and metabasalt in south. Quartzites are hard, resistant surfaces exhibiting conchoidal fracture while breaking, light-gray to creamy-white and lack of foliation or schistosity.

Field photo 7.6: Quartzite exposed in the central part of the block.

7.5.8 **Quartz Vein:** Numerous quartz veins having thickness of 1-10cm have been intruded across the bedding of BIF at low angle, metabasalt and dolerite characterized by the infilling of fractures and joints. The quartz veins are post-tectonic, emplaced after formation and lithification of the BIF, metabasalt and dolerite. Their cross-cutting relationship with bedding and host lithologies indicates a younger hydrothermal event.

7.6.0 STRUCTURE

7.6.1 On the basis of detailed field observations, an attempt has been made to identify and interpret the structural features present in the block. In the given outcrop, the primary bedding (S_0) is clearly observed as alternating red and dark bands, which represent the original sedimentary layering. These layers are later affected by deformation, producing a penetrative foliation (S_1) that cuts across the bedding at a high angle. The foliation is axial planar to the first phase of folding (F_1), and the axial trace of F_1 can be seen trending nearly vertical in the exposure. The presence of boudinaged bands within the competent layers indicates that the deformation involved layer-parallel extension under a non-coaxial stress–strain field, where σ_1 acted perpendicular to the layering and σ_3 parallel to the long axes of the boudins.

7.6.2 Thus, the structural relationships in the outcrop demonstrate overprinting of S_1 foliation onto S_0 bedding, development of F_1 folds with axial planar cleavage, and subsequent boudinage due to extension. These features together indicate multiphase deformation, recording both compressional folding and extensional tectonics within the same lithological sequence. Interpretaiton of structural features is demonstrated in the Field Photo 7.8

7.7.0 METAMORPHISM

7.7.1 The lithological assemblage and mineralogical features observed in the block indicate that the area has undergone regional metamorphism of low to medium grade, broadly within the greenschist to lower amphibolite facies. The Banded Iron Formation (BIF) units exhibit recrystallization of hematite, magnetite, and chert bands, with development of sericite, biotite, and secondary carbonates, pointing to metamorphic overprinting on the original chemical sedimentary fabric. The presence of boudinage structures and axial planar foliation further suggests ductile to brittle–ductile deformation under metamorphic conditions. Metabasalts are characterized by the replacement of primary plagioclase and pyroxene by chlorite and calcite, typical of greenschist facies retrogression. Dolerite and amphibolite intrusives also show chloritisation, carbonation, and development of actinolite–tremolite–epidote assemblages, implying metamorphic re-equilibration under greenschist to lower amphibolite facies conditions.

7.7.2 Superimposed hydrothermal activity and late-stage oxidation are evident in the widespread silicification, martitisation of magnetite, and transformation to goethite and limonite, accompanied by quartz calcite vein emplacement. These features point to a multiphase metamorphic and tectonic history involving regional metamorphism, ductile deformation, and later hydrothermal–supergene processes. Collectively, the mineralogical assemblages and deformation structures record progressive metamorphism, followed by retrogression and surface-related alteration, consistent with the tectonothermal evolution of the Mahakoshal supracrustal belt.

Field photo 7.7: Photograph showing structural features in BHJ.

CHAPTER-8

8.0.0 PREVIOUS WORK

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

8.1.1 The volcano sedimentary sequences of Mahakoshal Group are the prime important part of investigation through decades by many researchers and scientist. Breakthrough work was carried out by Narain and Thambi (1978), who propounded the name of Mahakoshal over the historic name of the geographic name of Bijawars of Son valley. Among all the three parts, western, central and eastern, the later one has been extensively studied by the earlier workers. Predominance of clastic sediments over non-clastic in eastern part and non-clastic over clastic sediments in western part is the general character of Mahakoshal Group. Mallet (1869) followed by Oldham et.al. (1901) has contributed to the scientific information about MG by conducting geological traverses in the area. Nair et.al. 1995 detailed the stratigraphy, structure and geochemistry of Mahakoshal Greenstone belt.

8.1.2 Gold exploration in the area was carried out by Khan et al., 1994 in Gurhar Pahar (part of toposheet no. 63L/11), Son valley gold belt, Singrauli district, Madhya Pradesh and explained that gold mineralisation is mainly associated with bluish to grey quartz veins, quartzcarbonate sulphide veins and tuffaceous variegated and carbonaceous phyllite. Gold occurs in fine particles (30-50 micron in size) in native form. In Gurhar Pahar area gold mineralisation reported to have extended over a strike length of 3.4 km with a width varying 10-110 m with barren partings. Pockmarked with ancient workings were also reported.

8.1.3 Jha and Agasty (2008), Jha et al, 2001, 2002, Bage et.al. 2016, 2017 and Gupta and Maurya, 2019 had carried out investigation for gold prospect in different parts of eastern Mahakoshal belt among which chakariya gold prospect was carried out up to G-2 stage of investigation. Exploration for gold in Randhor area, Sidhi district, Madhya Pradesh (E-1stage) brought to light a 2.5 km long and 05 m to 10 m wide gold bearing zones with barren partings. The mineralised zone occurs within the Mahakoshal Group of rocks.

8.1.4 During the FS 2018-20 Singh et.al. from GSI, NR has carried out Regional Mineral Targeting (RMT) project in parts of toposheet no. 63L/07,10,11,12,14 and 15 and 63P/03,04 and 07 and prepared various prospective maps for localisation of gold mineralisation and other sulphides. They have collected 30 nos. BRS samples from the area and reported Au values ranging from 0.05 ppm to 0.12 ppm and one BRS shows value of 1.37 ppm.

8.1.5 Khadse and Roy (1997) carried out investigation of PGE & Gold associated with Copper and Nickel mineralization in ultra-mafic suite near Thapna, Sidhi district, Madhya Pradesh. Chemical analysis of bedrock samples revealed anomalous content of gold. Samples of ultramafic rocks around Thapna have analysed 0.15% Cu, 0.20% Ni and 0.30 to 0.70 ppm Au. Ultramafic body have recorded upto 200 ppb Pt, 8 ppb Pd and 12 ppb Ir. Ultramafic rock samples from Karhiya have analysed 58 ppb Pt, 118 ppb Pd and 1.5 ppb Ir. Further investigation in terms of gold, PGE, Nickel and associated minerals were recommended.

8.1.6 Bage and Kewat (2016) undertook Geochemical Mapping of the Toposheet Nos 63L/11 and 64I/5(Part) in Sidhi District, Madhya Pradesh and Mirzapur District of Uttar Pradesh and had reported good values of Iron and gold in the area in soil samples.

8.1.7 Paul and Sikdar (2016) undertook geochemical mapping of the toposheet nos 63L03, 06 & 07 covering parts of Mirzapur district of Uttar Pradesh and Rewa & Sidhi districts of Madhya Pradesh. The concentration of Cr, Ni, Zr and Hg is considerably higher than the average crustal abundance of these elements. The values of Co, Cu, V, Zn, La, Ce, Nd shows slightly higher values as compared to the average crustal abundance of these elements but does not show any anomaly as none of these elements cross the threshold value. Higher concentration of Au was found in northern part of toposheet nos. 63L03 & 07 at the contact of Mahakoshal and Semri Group of rocks and recommended to be taken up for further investigation. Presence of ultramafic and feldspathoid rocks in northern part of toposheeet no. 63L07 was recommended for further attention. Therefore, the area was recommended for further systematic geological prospecting of minerals of interest.

8.1.8 Maurya, Kewat and Gupta (2022) carried out Reconnaissance survey for Gold and basemetals in Mishirgawan area where they observed sulphide and iron mineralization. Sulphides in the area are observed mainly in the form of veins or in the disseminated forms. Iron mineralisation was observed in the form of Banded Magnetite Quartzite (BMQ) running all along the mapped area and striking the regional strike of Mahakoshal

Belt. Sulphides of copper and iron in the form chalcopyrite, malachite and pyrite in vein of quartz carbonate and in disseminated form were observed within the carbonated metabasalt. They have reported the occurrence of gold mineralization in the area in different form within different lithounits which indicates the association of mineralization with the carbonates and/or quartz carbonate veins and quartz veins within the area. BIFs in the form of BMQ has yielded Fe2O3 varying from 24% to 59% can be explored for iron since the band is running along the strike throughout the mapped area and has considerable width varying from 10-20 m. It was mentioned that one sample of quartz vein (near Khatai turn) intruded within BMQ has yielded 7700 ppb of gold and other sample has yielded 470ppb of Au and thus recommended to be investigated further.

8.1.9 Apart from GSI, the GeoMysore (2006) Karnataka was engaged in exploration study for gold, PGE and Nickel in Sidhi district, Madhya Pradesh under Reconnaissance Permit. During the course of investigation Geomysore reported Stream samples with analytical values of more than 30 ppb of Pt+Pd and 5 rock chip samples with analytical value of more than 50 ppb of Pt.+Pb. In addition to that in the studied area Au more than >100ppb were reported in 2 samples and more than >30ppb in 4 samples of stream sediments were reported.

8.1.10 The presence of similar geological set up and mineralization reported in the block and surrounding area further investigation was taken up for Iron and PGE mineralization in the Chitrangi block.

CHAPTER-9

9.0.0 GEOPHYSICAL SURVEY

9.1.0 No geophysical survey was carried out in the Chitrangi Iron and Manganese G3 block during the current exploration.

CHAPTER-10

10.0.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 INTRODUCTION

10.1.1 On the basis of geological set up and mineralization reported in the block and surrounding area further investigation was taken up for Iron, PGE and gold mineralization in the Chitrangi block. Objectives and strategies adopted during the exploration are explained in the following paragraphs.

10.2.0 OBJECTIVES OF INVESTIGATION

10.2.1 The main objective of exploration by MECL was to establish the iron ore enrichment in the BIF and estimate resources. In addition, occurences of PGE mineralization in the metabasic rocks present in the block. The following objectives were set for this purpose:

1. To survey the area and to prepare the topographical map
2. To prepare geological map of the area to delineate the BHQ/BHJ along with the iron enriched part and structural features.
3. To assess the strike and depth continuity of iron ore in the area.
4. Estimation of iron ore resources as per UNFC classification.
5. To assess the occurrences of PGE and gold in the block.

10.3.0 DETAILS OF EXPLORATION ACTIVITIES TAKEN UP

10.3.1 To meet the above objectives, activities mentioned in the following table were planned. The table also shows a comparison between approved and achieved quantum in the block.

Table 10.1

Quantum of work achieved in Chitrangi Block, Singrauli District, Madhya Pradesh

Sl. No.	Item of Work	Unit	Approved	Achieved
1	Geological Mapping (1:4000)	sq. km	5.00	5.015*
2	Topographical Survey (1:4000)	sq. km	5.00	5.015*
3	Core Drilling	m.	600	0

Sl. No.	Item of Work	Unit	Approved	Achieved
4	**Sample Preparation & Chemical Analysis**			
	i) Primary samples for Iron Ore	Nos.	400 Suface-100 Borehole-300	100 (Surface)
	ii) Primary Sample for PGE (ICP-MS, Ni-S fire assay)	Nos.	25	18
	iii) Primary Sample for gold by fire assay)	Nos.	25	12
5	Petrographic Studies	Nos	10	8
6	Mineragraphic Studies	Nos	10	8
7	Digital Photographs	Nos	10	8
8	Bulk Density	Nos	5	0
9	Report Preparation (Digital format)	Nos.		

*The difference between the approved and achieved area is marginal, which is expected after the DGPS survey of the block boundary points, as the initial proposal was based on GPS coordinates.

10.4.0 SURVEY

10.4.1 The entire survey work had been carried out with the help of Differential Global Positioning System (DGPS). The topographical survey i.e., leveling/contouring had been carried out on 2m contour interval in the entire lease area. The coordinates and reduced level of base station have been recorded along with the surface features in the area i.e. roads, water bodies, canal and other features. The Topographical map of the block has been provided as Plate III.

10.4.2 Survey work has been carried by using Differential Global Positioning System (DGPS) of Tremble make having an accuracy of 0.10 m with WGS 1984 datum. In absence of survey of India reference point in the vicinity of area, base station C1 is fixed (N 24°28'04.17031" and E82°31'48.23577")

10.5.0 GEOLOGICAL MAPPING

10.5.1 The geological mapping was carried out with the help of total station and compass over the entire lease area on 1:4000 scale.

10.5.2 During the mapping nature and behavior of BHQ/BHJ had been delineated along with other formations. Surface geological features were also incorporated in the topographical and geological map. Structural features viz. attitude, different formations, joints, foliation etc. and were also recorded. Detailed geological map of the lease area is provided in Plate-IV.

10.6.0 CHANNEL SAMPLE

10.6.1 A total of 100 samples was collected from the exposed BMQ reef covering the total length of the reef. These samples were collected by means of channels (22 Nos.) cut across the BHQ reef exposed on the surface. Length of the samples with in the channel have been kept 1m and length of channels as per the width of the BMQ at that place. Samples collected were subjected to analysis of Total Fe%, FeO%, SiO_2%, Al_2O_3%, P% and S% by XRF and wet classical method at MECL, chemical Laboratory, Nagpur. Analytical results along with the other details are provided in the Annexure II and locations of channels are plotted on the geological map of the blocks (Plate IV).

10.6.2 Analytical results from channel sampling indicate that in six channels, the average Fe content exceeds 35%, while in one channel the average Fe value is greater than the threshold of 45% Fe prescribed by the Indian Bureau of Mines (IBM) on 25 April 2018. This confirms the presence of localized iron enrichment within the Banded Magnetite Quartzite (BMQ) reef. Although the average Fe content in the channels is either below or marginally above the threshold, individual bands or zones within these channels record Fe values higher than the prescribed limit, further supporting the occurrence of localized enrichment.

10.6.3 The BMQ in the study area is characterized by low magnetite content, as reflected in FeO percentages ranging from 0.36% to 7.85%, with an average of 2.60% across 100 samples. Based on the analytical data and the observed physical characteristics of the exposed BMQ, two enriched zones have been delineated. The first is located in the central-eastern part of the block, adjacent to the eastern block boundary, and encompasses Channels 1 and 7. The second zone lies in the eastern part of the block, on both sides of the road connecting Chitrangi in the south to Deora in the north, near the 9 km milestone to Pondi. These mineralized zones are marked on the geological map as Area 1 and Area 2. The detailed channel sample results for these zones, which contain significant Fe enrichment, are presented in Table 10.2.

Table 10.2

Details of the chemical analysis of channel samples have considerable Fe values

Sl. No	Sample No.	T Fe (%)	FeO (%)	SiO2 (%)	Al_2O_3 (%)	P (%)	S (%)	Location/ Potentical zone
1	CTRCH-1/01	45.50	3.74	28.66	0.84	0.36	<0.01	Area I
2	CTRCH-1/02	38.59	2.66	39.3	0.64	0.28	0.01	
3	CTRCH-1/03	31.63	6.55	51.44	0.48	0.15	<0.01	
4	CTRCH-1/04	30.05	2.23	55.07	0.03	0.59	<0.01	
5	CTRCH-7/01	35.97	5.54	44.35	0.46	0.4	<0.01	
6	CTRCH-7/02	48.73	2.74	24.57	0.56	0.35	<0.01	
7	CTRCH-7/03	51.41	5.90	21.69	0.65	0.31	<0.01	
8	CTRCH-7/04	26.31	1.66	60.22	0.33	0.19	<0.01	
9	CTRCH-7/05	42.87	3.46	33.33	0.52	0.39	0.01	
10	CTRCH-7/06	47.42	7.85	27.38	0.53	0.26	0.01	
11	CTRCH-7/07	33.05	3.10	51.09	0.22	0.16	0.01	
12	CTRCH-8/01	41.76	3.60	35.47	0.50	0.37	0.01	Area II
13	CTRCH-8/02	40.69	2.66	37.15	0.48	0.42	0.01	
14	CTRCH-8/03	32.52	5.11	50.01	0.38	0.16	0.01	
15	CTRCH-8/04	46.57	2.52	29.11	0.51	0.29	<0.01	
16	CTRCH-8/05	44.23	2.02	28.9	1.08	0.26	0.01	
17	CTRCH-8/06	30.82	6.12	53.79	0.28	0.17	0.01	
18	CTRCH-8/07	44.06	3.17	32.6	0.53	0.28	0.01	
19	CTRCH-8/08	36.18	1.87	44.84	0.24	0.44	0.01	
20	CTRCH-8/09	48.15	2.38	25.43	0.72	0.37	<0.01	
21	CTRCH-18/01	53.89	0.86	18.74	0.52	0.28	<0.01	
22	CTRCH-18/02	50.34	1.30	23.15	0.59	0.3	<0.01	
23	CTRCH-18/03	48.95	2.16	25.34	0.52	0.28	<0.01	
24	CTRCH-18/04	49.80	1.22	23.5	0.66	0.26	<0.01	
25	CTRCH-18/05	45.12	2.59	30.65	0.59	0.26	0.01	
26	CTRCH-18/06	52.72	1.87	19.63	0.66	0.31	<0.01	
27	CTRCH-18/07	45.68	3.89	30.04	0.57	0.26	0.01	
28	CTRCH-18/08	46.52	3.10	29.33	0.45	0.31	0.01	
29	CTRCH-18/09	49.29	1.80	24.88	0.47	0.23	0.01	
30	CTRCH-18/10	39.55	2.81	38.65	0.56	0.28	0.02	
31	CTRCH-18/11	48.45	3.10	25.11	0.74	0.26	<0.01	

10.7.0 BED ROCK SAMPLES FOR PGE

10.7.1 On the basis of the mineralization reported in the block and surrounding area which is similar geological set up, a total of 18 samples were collected to access the platinum group of metal (PGE) mineralization from metabasalts, dolerite exposed all over the block. These 18 samples were subjected to analysis of PGE minerals Ruthenium (Ru), Rhodium (Rh), Palladium (Pd), Osmium (Os), Iridium (Ir) and Platinum (Pt) by ICP-MS, Ni-Sulphide fire assay at MECL, chemical laboratory, Nagpur. Analytical details of the samples analysed for PGE are provided as Annexure III

10.7.2 The platinum group element (PGE) concentrations in the analysed samples exhibit notable variability. Ruthenium (Ru) ranges from 14.43 to 54.29 ppb and is consistently detected in all samples. Rhodium (Rh) is generally below detection limits, with measurable values up to 5.03 ppb in only three samples. Palladium (Pd) is present in all samples, displaying a broad range between 22.42 and 612.26 ppb. Platinum (Pt) is largely absent, being detected in only two samples with concentrations up to 12.27 ppb. Iridium (Ir) shows sporadic presence, occurring in eight samples with values up to 9.42 ppb. Osmium (Os) remains below detection limits in all cases. This distribution pattern indicates selective enrichment and variable mobilization of PGEs within the study area.

10.8.0 BEDROCK SAMPLES FOR GOLD

10.8.1 A total 10 samples were collected from the different lithounits characterized by intrusion of quartz veins with in the metabasalt, brecciated quartzite/BMQ and visible sulphide mineralization in chloritized & carbonatized dolerite. These samples were analysed by fire assay method at MECL, chemical laboratory, Nagpur. Analytical results indicate absence of Au values in all samples. Analytical details of the samples analysed for gold are provided as Annexure IV.

10.9.0 DRILLING

10.9.1 No drilling activities has been carried out in the block and pre-closed the exploration activities due to very hard nature of iron ore and not feasible for beneficiation in near future.

10.10.0 PETROGRAPHIC STUDIES

10.10.1 A total of 8 nos of samples of various litho-units exposed on the surface were subjected to petrographic studies at Petrology Laboratory, MECL Nagpur. Thin sections were prepared and petrographic studies of the same were carried out using Leitz and Ortholux II microscopes to know the mineral composition, texture, characteristics of individual minerals and the rock type. Litho-units identified by petrographic studies are metabasalt, dolerite, amphibolite, phyllite/slate and banded mineralized (hematite/magnetite) quartzite. Descreption of different rock types have been explained and interpretated in Chapter 10 under Litho Units. Details of the petrographic study of samples are provided in Annexure V and in the following Table 10.2.

Table 10.3

Details of Petrographic Samples in Chitrangi Block, Singrauli District, Madhya Pradesh

Sl. No.	Sample No.	Latitude	Longitude	Remarks
1	CTRPT-01	24° 29' 4.91" N	82° 31' 57.56" E	Altered basalt.
2	CTRPT-02	24° 29' 12.74" N	82° 32' 23.23" E	Banded Hematite Quartzite.
3	CTRPT-03	24° 29' 50.26" N	82° 34' 6.78" E	Shale/ Slate
4	CTRPT-04	24° 29' 14.72" N	82° 32' 51.96" E	Amphibolite.
5	CTRPT-05	24° 29' 27.89" N	82° 33' 26.79" E	Banded Hematite Chert.
6	CTRPT-06	24° 29' 4.59" N	82° 31' 50.88" E	Banded (hematite) cherty quartzite.
7	CTRPT-07	24° 29' 35.37" N	82° 32' 57.75" E	Altered (chloritised & carbonatised) dolerite.
8	CTRPT-08	24° 28' 25.91" N	82° 30' 9.65" E	Altered (carbonatised & chloritised) basalt.

10.11.0 MINERAGRAPHIC STUDIES

10.11.1 A total of 08 surface samples was subjected to mineragraphic studies at Petrology Laboratory, MECL Nagpur. Polished sections of mineralized samples were prepared and mineragraphic studies were carried out using Leitz and Ortholux II microscopes to know the mineral composition, percentage of minerals present in polished section, characteristics of individual minerals and their paragenesis. The results of mineragraphic studies are given as Annexure- VI and summary has been provided in the following Table 10.4.

Table 10.4

Details of Mineragraphic studies in Chitrangi Block, Singrauli District, Madhya Pradesh

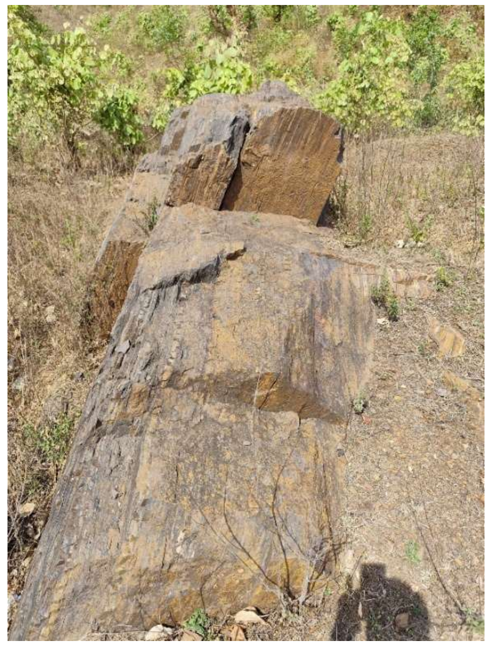
Sl. No.	Sample No.	Latitude	Longitude	Remarks
1	CTRMN-01	24° 29' 35.59" N	82° 32' 58.57" E	Dolerite
2	CTRMN-02	24° 29' 46.1" N	82° 33' 54.58" E	BHJ
3	CTRMN-03	24° 29' 4.74" N	82° 31' 58.45" E	Metabasalt
4	CTRMN-04	24° 29' 18.37" N	82° 32' 16.77" E	Brecciated BHQ
5	CTRMN-05	24° 29' 31.53" N	82° 33' 36.53" E	BHQ
6	CTRMN-06	24° 29' 4.59" N	82° 31' 50.88" E	Brecciated BHQ
7	CTRMN-07	24° 29' 52.05" N	82° 34' 40.59" E	BMJ
8	CTRMN-08	24° 28' 36.72" N	82° 30' 4.99" E	BHQ

10.12.0 IRON MINERALIZATION

10.12.1 BHQ/BMQ was the proto-ore for the iron ores. The enrichment of iron is primarily through the process of leaching of silica from the BHQ/BMQ. Subsequently there was enrichment of Fe through super enrichment by the circulating of Fe containing solutions. The cavities got sealed to different degrees in different ores. Depending upon the degree of enrichment, different types of ores have resulted. The very hard ore, hard laminated ore and soft laminated ores belong to this category. In majority the iron ore contains hematite.

10.12.2 In Chitrangi block very hard iron enriched zones have been developed in two potential areas (Area I and Area II) as mentioned in the above paragraphs. Details of the areas are as follows.

10.12.3 In Area I, in the central-eastern part of the block very hard enriched iron in BMQ are exposed over a strike length of 200m and average width 40m. Here the strike of the bands is nearly subvertical and trending in ENE-WSW direction and dipping towards SE. It exhibits a grey to dark grey colour, very hard, and shows low to moderate magnetic response when tested with a hand magnet, suggesting the presence of magnetite partially altered to hematite. Two channels, Channel 1 and Channel 7, have been excavated within the Banded Magnetite Quartzite (BMQ) band, approximately 100 m apart. Channel 1, with a length of 3 m, records an average Fe content of 36.44%, though a 1 m section within it contains enriched bands with Fe value 45.50%. In contrast, Channel 7, with a length of 7 m, yields a higher average Fe content of 40.72%. However, with in the channel 3m section shows marginally above the 45% threshold value. Field photographs of the exposed enriched iron are provided in the field photograph 10.1.



Field Photo 10.1: Exposure of hard enriched iron ore near the eastern block boundary in the central-eastern part of the block.

10.12.4 In Area II, the Banded Magnetite Quartzite (BMQ) is characterized by thick, prominent bands of iron oxides (magnetite and hematite) alternating with comparatively thinner silica (quartz) bands exposed along the road cuttings and having a strike length of 350m and average width 45m. It trends nearly ENE–WSW and dips 45–50° towards the southeast. It exhibits a grey to dark grey colour, very hard, and shows low to moderate magnetic response when tested with a hand magnet, suggesting the presence of magnetite partially altered to hematite. The dominance of iron-rich bands over silica layers indicates localized enrichment, while the structural orientation is consistent with regional deformation patterns commonly observed in Banded Iron Formation belts. In Area II, two channels, Channel 8 and Channel 18, have been excavated within the Banded Magnetite Quartzite (BMQ) band, approximately 110 m apart. Channel 8, with a length of 9 m, records an average Fe content of 40.55%, though a 4 m section within it contains enriched bands with Fe values marginally above or below the 45% threshold. In contrast, Channel 18, with a length of 11 m, yields a higher average Fe content of 48.21%, and except for one sample, all results exceed the threshold value, indicating significant localized enrichment of iron in this section of the BMQ. Field photographs of the exposed enriched iron are provided in the field photograph 10.2.

Field Photograph 10.2: Exposure of hard enriched iron ore along the road cuttings near the 09km milestone to Pundi.

10.12.5 In both potential areas, notable enrichment has been observed in zones where the continuity of the Banded Magnetite Quartzite (BMQ) ridges is disrupted. Such breaks are likely attributable to faulting and other tectonic displacements, which may have facilitated localized structural preparation and enhanced mineral concentration. These structural discontinuities often act as channels for hydrothermal activity or as sites of mechanical disruption, thereby creating favourable conditions for mineral enrichment. The dimensions and spatial extents of both potential areas are presented in Table 10.5 for reference.

Table 10.5

Details of dimension of potential iron ore zones in the Chitrangi Block.

Sl No.	Location	Strike Length (m)	Width (m)	Nature of ore
1	Area I	200	40	Very hard laminated low magnetite ore
2	Area II	350	45	

10.12.6 The iron ore enrichment in the Chitrangi Block is primarily controlled by the lithology, structure, and supergene processes acting in combination. The Banded Hematite/ Magnetite Quartzite (BHQ/BMQ) served as the proto-ore, where original banding of iron oxides and silica provided the framework for enrichment through selective leaching of silica and subsequent supergene addition of iron. Structural elements such as ENE–WSW trending tight to isoclinal folds and tectonic breaks disrupted ridge continuity, creating zones of structural preparation that acted as conduits for Fe-bearing solutions and localized enrichment. Supergene and metasomatic processes further concentrated iron, with circulating fluids replacing magnetite by hematite, leaching silica, and variably sealing cavities, leading to different ore types ranging from very hard to laminated varieties. Together, these lithological, structural, and chemical controls explain the distribution, grade variability, and localization of high-grade iron ore within the block.

10.12.7 At this stage, only preliminary mapping and limited channel sampling have been carried out, and therefore it is not possible to reliably estimate the iron ore resources of the block. While localised zones of enrichment have been identified, the current data are insufficient to establish the continuity, volume, and grade distribution of the ore bodies. A systematic programme of detailed sampling, trenching, and subsurface exploration (including drilling) will be essential before resource estimation which can be undertaken in the future exploration.

10.13.0 PGE MINERALISATION

10.13.1 On the basis of bedrock samples collected from the exposed metabasalts and dolerite all over the block to acess the PGE mineralization. It is observed that all samples have given anamolus values in terms of Ru and Pd which is distributed all over the metabasalts without any clear trend. Details of the outcomes of the chemical results are mentioned in the following paragraphs.

10.13.2 The PGE data indicate unusually high Palladium (Pd, up to 612 ppb) and Ruthenium (Ru, up to 54 ppb) in metabasalt, which are noticeably above average continental crustal abundances (Pd ~0.52 ppb; Ru ~0.40 ppb; Wedepohl, 1995; Rudnick & Gao, 2014). These enrichments suggest fractional crystallization of mafic–ultramafic magma and potential low-sulfide Pd-rich mineralization. The consistently high Pd/Pt ratios (>50 in some cases) point toward sulfur-poor magmas, late-stage Pd enrichment, or possible hydrothermal remobilization.

10.13.3 Iridium (Ir) occurs sporadically (up to 9.42 ppb), significantly exceeding typical crustal levels (~0.022 ppb; Wedepohl, 1995), hinting at a mantle-derived signature, while Rhodium (Rh) is rare and Osmium (Os) is entirely below detection, possibly due to the absence of Os-rich phases or surface weathering. Overall, the geochemical pattern supports a magmatic source with sulphide fractionation, highlighting zones with Pd and Ru enrichment as potential exploration targets.

10.13.4 At this preliminary stage, where only a limited number of bedrock samples have been collected and analysed, it is premature to make a definitive interpretation of the controls of PGE mineralisation. Although the geochemical data indicate anomalous enrichment of Pd and Ru and suggest possible magmatic and sulphur-poor processes, the current dataset is insufficient to establish the precise lithological, structural, or hydrothermal controls. A more comprehensive sampling programme, supported by detailed petrography, geochemical profiling, and structural studies, will be required to reliably constrain the processes and settings governing PGE enrichment in the block.

10.14.0 GOLD MINERALISATION

10.14.1 A total 10 samples were collected from the different lithounits characterized by intrusion of quartz veins with in the metabasalt, brecciated quartzite/BMQ and visible sulphide mineralization in chloritised & carbonatised dolerite. No trace of gold mineralisation has been observed physically in the outcrops and as per chemical analysis of samples.

CHAPTER-11

11.0.0 LOCATION OF DATA POINTS

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

11.1.1 The entire survey work has been carried out with the help of DGPS (Make-Trimble GNSS System, Model-R8s). With the help of DGPS, co-ordinates of surface features i.e., roads, village boundaries, water bodies, base station and co-ordinates of block boundary cardinal points with R.L. has been determined and accordingly the topographical map is presented (Plate-III). Contour interval in topographical map is taken as 2 m. The topographic survey was done in PPK (Post Precision Kinematics) mode. Positional (horizontal) accuracy of the survey is 10mm while the elevation accuracy is 20mm in PPK mode.

11.1.2 **TECHNICAL SPECIFICATION OF DGPS**

MAKE	TRIMBLE DGPS
MODEL	R8-S
YEAR	2017

a) **MEASUREMENT ACCURACY**:

Static Mode
Horizontal – 10 mm +0.1 ppm or better.
Vertical – 20 mm +0.4 ppm or better.

b) **BASE LINE ACCURACY**:

i. Accuracy Horizontal shall not be more than 4 mm for 10 km baseline with occupation line of 10 minutes or less.
ii. Accuracy vertical shall not be more than 7.5 mm for 10 km baseline for with occupation of 10 minutes or less.

c) **FAST STATIC:**

i. Horizontal – 3mm +0.5 ppm
ii. Vertical – 5 mm +0.5 ppm

d) **GNSS RECEIVER:**

- Trimble R8s Multiple frequency GNSS Receiver has internal on-board memory via SD card or internal memory.
- Trimble R8s has 440 channels (GPS + GLONASS +GAGAN) and should be capable of tracking.
- GPS: LIC/A, L2C, LIC, L2E, L5

- GLONASS: LIC/A, L2C/A, LIP, L2P, & L3
- Beidou: B 1 complete with (phase 2) & B2
- SBAS: LIC/A, L5
- Galileo: E1, E5A, E5B
- Systems: EGNOS, QZSS, SBAS, WAAS, GAGAN, (MUST take correction from GAGAN) etc.
- R8s is water proof, shock proof, dust proof, humidity proof, and condensation proof.
- IP 67 with temporary submission in water up to 1 m.
-

e) **SOFTWARE & COMMUNICATION**: Fully functional and Trimble business centre office post processing software.

f) **CONTROLLER:**

- Trimble TSC 3 windows-based controller for base and 02 nos. Rovers should be provided.
- Alpha numeric hard QWERTY keyboard for Base and 02 no's Rover should be provided.
- Internal Memory – 256 MB RAM & 8 GB Non-Volatile memories should be provided.
- Integrated camera for Geo Tagging Must with inbuilt GPS, Compass and Accelerometer should be provided.

11.1.3 **CO-ORDINATE SYSTEM MANAGER:** Should have datum and projection support & should support Grid coordinates.

- COGO: support COGO functionality & able to Key in lines, Sub-divide lines and creating parallel lines for staking out purpose.
- TRANSFER DATA BETWEEN FIELD AND OFFICE: Should be capable of e-mail data collected in the field, should be able import and export DXF files in the field for effective GIS support.
- BACKGROUND MAP: Able to accept background maps in CAD format.
- OPERATING SYSTEMS: Windows 6.5 should be provided.
- EXPORT: Able to exporting the data in RINEX format as well in CAD format.
- REPORTING: Software should be capable of generating reports directly from the surveyed data.
- POST PROCESSING SOFTWARE ADVANCE CAPABILITY: Trimble Business Centre Post Processing software capable of processing Base line with IGS station and processing drawing including engineering application such as

contouring, Cross section & L section etc. All software shall be same OEM make.

11.2.0 QUALITY AND ADEQUACY OF TOPOGRAPHIC CONTROL

11.2.1 Block boundary co-ordinates, the surface features, contour points were surveyed by DGPS). The topographic survey was done in PPK (Post Precision Kinematics) mode. Positional (horizontal) accuracy of the survey is 10mm while the elevation accuracy is 20mm in PPK mode. The detailed topographical map of the blocks has been prepared on 1:4,000 scale and provided as Plate III.

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 During geological mapping, a total of 100 samples were collected from 22 channels excavated across exposed Banded Magnetite Quartzite (BMQ) horizons. The length of the channels varied depending on the width of the exposures. To ensure the integrity and representativeness of the samples, the initial step involved removing all weathered with sampling confined strictly to fresh sections of the channels. Systematic sampling was carried out along the channels, exercising due care to avoid contamination or inadvertent mixing with other lithologies. Each sample, weighing approximately 2 to 3 kg, was carefully selected and packed in high-quality cotton bags for transport.

12.1.2 In the laboratory, each 2–3 kg sample collected from the field was first subjected to primary crushing. The crushed material was mixed thoroughly and reduced to a representative 500 g portion by the coning and quartering method. This representative fraction was then pulverized and passed completely through a (-)120 mesh sieve. From this, a 100 g sub-sample was packed in polythene sample pouches and submitted to the MECL Laboratory, Nagpur, for the required chemical analyses. The remaining 400 g portion was securely stored for future reference and verification.

12.1.3 A similar approach was adopted for bedrock samples collected for the investigation of Platinum Group Elements (PGE) and gold mineralization. In this case as well, strict quality control measures were maintained during both field sampling and laboratory processing to ensure the reliability and reproducibility of analytical results. PGE and gold samples were crushed to -200 mesh and -120 mesh respectively. This consistent methodology across all sample types ensures that the analytical data accurately reflects the in-situ mineralization characteristics.

CHAPTER-13

13.0.0 SUB SAMPLING TECHNIQUES AND SAMPLE PREPARATION

13.1.0 SAMPLE PROCESSING FOR CHEMICAL ANALYSIS

13.1.1 During the sample preparation, adherence to standard operating procedures is paramount. Samples are powdered to required mesh size using sample crusher, pulveriser, mortar and pestle. Rigorous cleaning procedures for all the instruments used in sample processing including sample tray, brush, and all tools, are implemented after each sample is processed thus maintaining and ensure a contamination-free environment.

13.1.2 Standard sampling procedure adopted and the samples were prepared at the centralized sampling unit.

13.1.3 Following the initial crushing, representative samples of around 100 grams are drawn through successive reduction using coning and quartering method. The remaining powdered samples are carefully stored for future reference, with preventive measures in place to avoid sample mixing. This technique involves transfer the bulk sample onto a flat surface, forming a cone, and systematically dividing it into four quadrants. Two opposite quadrants are selected for further processing, and the method is repeated, reducing the sample size while preserving representatives. Thorough cleaning of all tools used in the sampling, drawing, and packaging processes further ensures the homogenity of the collected samples.

CHAPTER-14

14.0.0 QUALITY OF ASSAY DATA AND LABORATORY TESTS

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

14.1.1 The chemical analysis of the iron ore samples for Total Fe%, SiO_2%, Al_2O_3%, P% and S% was conducted in the well-equipped Chemical Laboratory of MECL, Nagpur using a Rigaku *Primus-IV* Wavelength Dispersive X-ray Fluorescence spectrometer (WD-XRF), manufactured in Japan. WD-XRF is a robust and highly precise analytical technique widely used in geochemistry for the determination of major, minor, and trace elements in solid geological materials (Potts & Webb, 1992; Jenkins, 1999). It is capable of analyzing samples in both pressed pellet and fusion bead form, with detection limits ranging from percentage to parts-per-million levels. The instrument provides excellent accuracy and precision for major oxides, making it appropriate for high-quality geochemical analysis. In this study, samples were ground to a particle size of –120 mesh, prepared as pressed pellets using a hydraulic press (15–35 tonnes pressure), and analyzed for SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, TiO_2, and P_2O_5. Loss on Ignition (LOI) was determined separately by heating a known weight of sample in a platinum crucible at 1000 °C in a muffle furnace and recording the weight loss (Govindaraju, 1994).

14.2.0 STANDARD OPERATING PROCEDURE (SoP) FOR THE ANALYSIS BY MECL LAB, NAGPUR

14.2.1 Strict laboratory protocols were followed to ensure data quality and prevent contamination. Personal protective equipment (PPE) was used throughout the process, all sample containers were clearly labelled, and tongs were employed for handling hot crucibles and containers. Waste chemicals were disposed of in accordance with laboratory safety guidelines. Typical quality control (QC) measures included analysis of certified reference materials (CRMs) and measurement standards, use of blind samples, incorporation of QC samples and control charts, and duplicate analysis with internal check standards (IUPAC, 2000). The instrument was calibrated using matrix-matching CRMs before analyzing the unknown samples, thereby minimizing matrix effects.

14.2.2 The WD-XRF analysis is based on the principle that when X-rays irradiate a sample, atoms within emit secondary (fluorescent) X-rays at wavelengths characteristic of the elements present (Jenkins, Gould & Gedcke, 1981). In the *Primus-IV*, the sample is rotated to satisfy Bragg's Law for each wavelength, enabling accurate diffraction and measurement of elemental peaks. The detector records the position and intensity of each peak, from which elemental concentrations are calculated. This combination of rigorous sample preparation, strict SOP adherence, and comprehensive QC procedures ensures that the analytical results are both accurate and reproducible. A photograph of the WD-XRF instrument installed in the Chemical Laboratory of MECL is presented in Photo 14.1.

Photo 14.1: Photograph showing WD-XRF instrument (Rigaku, Japan) at Chemical Lab, MECL, Nagpur

14.2.3 Analysis of FeO in samples were carried out by adopting wet classical methods. Wet-chemical determination of FeO (ferrous iron) was carried out by acidic digestion of the powdered sample to bring all iron into solution under controlled, reducing conditions, followed by quantification of Fe^{2+} by a standardized redox titration. An accurately measured aliquot of the digest is titrated with a pre-standardized oxidizing solution (e.g., potassium dichromate) to the appropriate end-point (visual or potentiometric), and the amount of Fe^{2+} is used to calculate FeO% on a sample weight basis. Results are reported on a dry weight basis and, where required, total iron (by XRF or separate wet methods) and Fe^{2+} are used together to derive Fe^{3+}/Fe^{2+} proportions. All glassware and reagents are analytical grade and sample digestion is performed in acid-cleaned vessels to avoid contamination.

14.2.4 The determination of platinum group elements (PGE) was carried out by fire assay pre-concentration followed by ICP-MS analysis. In this method, the sample pulp was mixed with nickel powder, sulfur, sodium carbonate, and borax in a ceramic crucible and fused at over 1100 °C for two hours. Upon cooling, a Ni-S bead containing the PGEs formed at the bottom of the crucible, which was separated from the slag and dissolved in hydrochloric acid (~110 °C) under reducing conditions. The PGE-rich residue was filtered through a membrane, dissolved in aqua regia, and analysed using an Agilent 7800 ICP-MS at MECL's chemical laboratory, Nagpur. Fire assay fusion was performed using a Krishna Enterprises setup.

14.2.5 Strict safety procedures were followed during analysis, including the use of department-approved safety goggles and protective aprons, and handling hazardous chemicals within fume hoods. Clean, dry tools were used to prevent contamination, and excess reagents were properly disposed of. Quality control measures included the routine analysis of certified reference materials (CRMs), blind and blank samples, spiked samples, duplicates, internal check standards, and the use of control charts to monitor analytical performance. These procedures ensured the accuracy, precision, and reproducibility of PGE determinations.

14.2.6 Gold determination was carried out by fire assay pre-concentration followed by Atomic Absorption Spectrometry (AAS) using an Analytik Jena ZEEnit 700P instrument. Fire assay fusion was performed using a Krishna Enterprises setup, with samples prepared in batches of 50 fusion pots after visual inspection. Each 50 g sample was weighed into a crucible containing a flux mixture of lead monoxide, sodium carbonate, borax, silica, and silver nitrate, and fused in a preheated furnace at 1050 °C for 45 minutes. The molten charge was poured into a cast-iron mold, the resulting lead button separated from the slag, and cupelled for one hour to obtain a precious metal prill. The prill was cooled, digested in aqua regia, and the solution analyzed by AAS for gold content.

14.2.7 All analyses were conducted under strict laboratory safety protocols, including the use of department-approved safety goggles, aprons, and fume hoods for hazardous chemicals. Clean, dry tools were used to avoid contamination, and excess reagents were properly disposed of. Quality control measures included analysis of certified reference materials (BND 3401.01), blind and blank samples, spiked samples, duplicates, internal check standards, and the use of control charts to ensure accuracy, precision, and reproducibility of the gold assay results.

14.3.0 ACCURACY OF SAMPLING PROCEDURE: The grade estimates of the block are based on the results of samples. Each sample undergoes the process of sample preparation and analysis. Since, sampling and analysis are two complimentary links of quality estimation chain, the possible source of errors, if any, could be from the bias during sample preparation and inaccuracies in assaying or both. The sample preparation was carried out by observing prevailing standard procedure. Thus, the reliability of the sampling process is very high and has not been compromised at any stage.

14.4.0 SECURITY AND CHAIN OF CONTROL OF SAMPLES

14.4.1 The security and chain of control of samples from the field unit to sampling unit and finally to the chemical laboratory undergoes through a meticulous and well-organized process. The samples were prepared at centralised mechanised sampling unit under the supervision of qualified sampling technician. The samples were meticulously labeled and tagged before being sent to the chemical laboratory under the direct supervision of the technician. During transportation, the samples were securely sealed in bags, and the integrity of the seals was verified at the sampling unit before the bags were opened. Adhering to standard procedures, the sampling unit implemented robust precautionary measures to prevent any potential contamination, ensuring the reliability of the sample analysis. Additionally, the remaining samples were appropriately preserved and tagged for future reference, highlighting a commitment to maintaining a secure and traceable chain of control under the company's custody. At the sampling unit, standard procedure is followed and all the precautionary measures are taken to avoid contamination. The sampling unit is separate from the chemical laboratory, so there is no chance of contamination

CHAPTER-15

15.0.0 SUMMARY AND RECOMMENDATIONS

15.1.0 The Chitrangi Block is not presently viable for iron ore mining but holds selective exploration potential for PGEs. A shift in exploration focus from bulk iron ore to high-value, low-tonnage Pd–Ru targets is recommended, supported by structural mapping, geophysics, and scout drilling.

15.2.0 The block shows consistent Pd (up to 612 ppb) and Ru (up to 54 ppb) anomalies in metabasalt, with sporadic Ir enrichment. Phase-II PGE focused exploration program, including the following may be carried out to identify mineral hosts, and subsurface mineralization.

- Trenching across anomalous zones.
- Detailed petrography and electron microprobe analysis to identify PGE mineral hosts.
- Ground geophysics (magnetic and electromagnetic surveys) to locate concealed mineralized zones.
- Scout drilling in structurally favourable sites.

CHAPTER-16

16.0.0 PLATES AND MAPS

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

16.1.2 Regional geological map showing block location is given as Plate-II in 1:1,00,000 Scale.

16.1.3 Topographical Map in 1:4000 is given as Plate- III

16.1.4 Geological Map on 1:4000 is given as Plate-IV.

CHAPTER-17

17.0.0 ANNEXURE / ENCLOSURES TO THE REPORT

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

CHAPTER-18

CERTIFICATE FROM THE QUALIFIED PERSON WITH NAME, DATE AND SIGNATURE

This is to certify that geological report has been prepared on preliminary exploration (G-3) for iron and associated minerals in Chitrangi block (5.015 sq km), Singrauli District, Madhya Pradesh by Mineral Exploration and Consultancy Limited (MECL) on behalf of National Mineral Exploration Trust. 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: **Head Of Department (Exploration)**

DATE: 28.08.2025

LIST OF PERSONNEL ASSOCIATED WITH CHITRANGI BLOCK, SINGRAULI DISTRICT, MADHYA PRADESH

Overall guidance	Shri Shrikant Sharma, HoD (Exploration)
Overall Planning, Co-ordination & Supervision	Shri S. K. Satapathy, Sr. Manager (Geology)
Project Management	Shri Rajnikant Singh, Manager (Drilling), Project Management.
Physical Execution of work	
a) Geology	Shri Ravikant, Asst. Manager (Geology)
	Shri S. K. Satapathy, Sr. Manager (Geology)
b) Survey	Shri Durgesh Devarshee, Assistant Survey & Map Officer
	Dev Singh, Sr. Tech (S &D)
Chemical Laboratory	Shri Rohit Sharma, Manager (Chemical Lab)
Petrology Laboratory	Shri Sayantan Pal, Manager (Geology)
Documentation	Shri S. K. Satapathy, Sr. Manager (Geology)
Non-Coal Geological Report Cell	Ms. Rajanya Roy, Sr. Geologist
	Shri Uday Patil, Sr. Computer Operator
Reprography and Printing	Shri Durgesh Devarshee, Assistant Survey & Map Officer

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