*Geological Report on Reconnaissance Survey (G4 Stage) for Graphite in Dindo-Belkurta-Basera Block, District - Balrampur, State – Chhattisgarh*

*Under*

**National Mineral Exploration Trust**

**Ministry of Mines,**

**Room No. 325 & 326, Wing-F,**

**Udyog Bhawan, Rafi Ahmed Kidwai Marg,**

**Rajpath Area, Central Secretariat,**

**New Delhi-110011**

*Prepared by*


**Avijit Roy Geologist (Jr.)**

**&**

**Swarbhanu Dey Geologist (Jr.)**

Maheshwari
Global Technologies. Ecological Mining.

**Maheshwari Mining Private Limited, FR - 07, Shilpangan Building, Sector - III Salt lake, Kolkata - 700106,West Bengal, India**

# INDEX

## Geological Report on Reconnaissance Survey (G4 Stage) for Graphite in Dindo-Belkurta-Basera Block, District - Balrampur, State – Chhattisgarh

# CHAPTER - 1

# सारांश

छत्तीसगढ़ के बलरामपुर जिले के डिंडो-बेलकुर्ता-बसेरा ब्लॉक में **F.No.23/380/2023-NMET/246 के तहत पूर्वानुमान (G-4) सर्वेक्षण किया गया था**। यह क्षेत्र छोटानागपुर गे्रनाइट नीस कॉम्प्लेक्स (सीजीजीसी) के पश्चिमी विस्तार का एक भाग है और टोपोशीट सं **64M/05** के अंतर्गत आता है। वर्तमान जांच में 54.4 वर्ग किमी के क्षेत्र को कवर करते हुए 1: 12,500 बड़े पैमाने पर भूवैज्ञानिक मानचित्रण, स्व-संभावित सर्वेक्षण के 3-लाइन किमी और जी 4 चरण में हाइड्रोस्टैटिक स्काउट ड्रिल सहित विभिन्न कार्य घटक शामिल हैं। ग्रेफाइट खनिजकरण इस क्षेत्र में अभ्रक शीस्ट के भीतर हो रहा है और असंतत बैंड के रूप में मौजूद है, जो स्ट्राइक लंबाई के साथ लगभग 2.7 किमी तक जोड़ता है, और वन क्षेत्र के भीतर एक नाला खंड और कुछ अन्य भागों के साथ देखा जा सकता है।

ग्रेफाइट शीस्ट के निश्चित कार्बन मूल्य को निर्धारित करने के लिए समीपवर्ती विश्लेषण के लिए कुल 155 बेड रॉक नमूने एकत्र किए गए और विश्लेषण किए गए। निश्चित कार्बन मान 0.03% से 8.45% तक होते हैं।

ट्रेंच के कुल 20 नमूने एकत्र किए गए और समीपस्थ विश्लेषण विधि का उपयोग करके निश्चित कार्बन के लिए विश्लेषण किया गया। निश्चित कार्बन मान 0.49% से 0.93% तक होते हैं।

300 मीटर के संचयी ड्रिलिंग मीटर के साथ कुल 5 बोरहोल ड्रिल किए गए थे, और समीपवर्ती विश्लेषण के साथ-साथ प्रमुख ऑक्साइड और ट्रेस तत्व विश्लेषण के लिए 142 कोर नमूने उत्पन्न किए गए थे। निश्चित कार्बन मान 0.11% से 4.23% तक होता है।

प्रमुख ऑक्साइड और ट्रेस तत्वों के परिणाम अनुलग्नक- II और अनुबंध- III में संलग्न हैं।

13324.25 वर्ग मीटर के क्षेत्र को कवर करने वाले इस ब्लॉक से 3.34% निश्चित कार्बन मूल्यों के औसत ग्रेड के साथ कुल 99539.81 टन अनंतिम ग्रेफाइट संसाधन का अनुमान लगाया गया है। इस संसाधन का अनुमान " **पूर्वानुमान श्रेणी (334)" के तहत लगाया गया है**।

# SUMMARY

A Reconnaissance (G-4) survey was carried out in Dindo-Belkurta-Basera block in Balrampur district of Chhattisgarh under **F.No.23/380/2023-NMET/246**. This area is a part of western extension of Chhotanagpur Granite Gneissic Complex (CGGC) and falls under the toposheet No. **64M/05**. The current investigation involves various work components including Large Scale Geological Mapping on 1:12,500 scale covering an area of 54.4 sq. km., 3-line km of Self-Potential survey and hydrostatic scout drill at G4 stage. Graphite mineralization is occurring within mica schist in this area and is present as discontinuous bands, adding up to almost 2.7 km along the strike length, and outcrops can be seen along a nala section and some other parts within the forest area.

A total no of 155 bed rock samples were collected and analysed for proximate analysis to determine the fixed carbon value of the graphite schist. The fixed carbon values range from 0.03% to 8.45%.

A total 20 no of trench samples were collected and analysed for fixed carbon using proximate analysis method. The fixed carbon values range from 0.49% to 0.93%.

A total 5 no of boreholes were drilled with the cumulative drilling meterage of 300m, and 142 core samples were generated for proximate analysis as well as major oxide and trace element analysis. The fixed carbon values range from 0.11% to 4.23%.

The major oxide and trace elements result is attached in Annexure- II & Annexure- III.

A total of 99539.81 tonnes of tentative graphite resource with the average grade of 3.34% fixed carbon values has been estimated from this block covering an area of 13324.25 sq. m. This resource has been estimated under "**Reconnaissance Category (334)**".

# CHAPTER - 2

# INTRODUCTION

***Graphite*** was categorized under critical mineral by Govt. of India in the year of 2023. It is crystalline allotrope of carbon. It occurs naturally and is consumed on a large-scale for use in many industries including refractories (50%), lithium-ion batteries (18%), foundries (10%), lubricants (5%) and among others (17%) (*Distribution of graphite consumption as of 2019, by type and use, Statista*). It also holds importance in reducing import dependency fostering economic opportunities through responsible mining practices, and helping our nation strengthen its strategic position and promote sustainable development. Leveraging advanced exploration techniques and investing in domestic graphite resources, aligns with India's goals of self-reliance and global competitiveness while supporting the nation's transition towards renewable energy solutions. Therefore, prioritizing graphite exploration is a crucial component of our nation's industrial and economic development strategy.

Initially graphite was discovered in 1564 in Borrowdale, England by a local shepherd. After that, a German chemist and mineralogist Abraham Gottlob Werner (1752–1817) named graphite in the year of 1789. Werner named it after its primary use at the time as an ingredient in pencil lead. He named graphite from the Greek word ***"Graphein"*** which means to write. Before the term graphite was coined, it was known by other names including black lead and plumbago. These names came from the misconception with the similar looking lead ore, specifically Galena.

Graphite is an opaque, grey to black in colour and has metallic lustre. It is non-elastic, has greasy feel and soils hands when touch. It is a non-metal which behaves as a good conductor of heat and electricity due to the presence of free carbon atoms. The chemical composition of graphite is pure carbon and denoted by C. It usually occurs in metamorphic rocks such as marble, schist, and gneiss. It can also be found in igneous rocks and meteorites. Graphite is formed when organic material, driving off H and O2 as water, and leaving carbon behind.

India boasts significant graphite ore resources, estimated at around 211.62 million tonnes as of 01/04/2020 according to the Indian Bureau of Mines. This includes both reserves (8.56 million tonnes) and remaining resources (203.06 million tonnes), with varying grades of fixed carbon content. Arunachal Pradesh holds total resources (36%), Tamil Nadu leads in terms of reserves

(36%) followed by Jharkhand (30%) and Odisha (33%) (IBM Yearbook, 60th Edition, 2021). In the published annual report for 2022-23, the Ministry of Mines revealed that a total lease area of 1557.85 hectares was allocated for graphite across 38 leases as of March 31, 2021. Economically significant graphite deposits are found in Chhattisgarh, Jharkhand, Odisha, and Tamil Nadu. Jharkhand led in production, followed by Odisha. Key mining areas include Palamau district in Jharkhand, Nawapara and Balangir districts in Odisha, and Madurai and Sivagangai districts in Tamil Nadu. Jharkhand hosts disseminated flaky graphite deposits, while Odisha yields various graphite grades in and around Balangir. In pursuance of NMET-Mineral Exploration project ***F.No. 23/380/2023-NMET/246*** Reconnaissance Survey (G4 Stage) for graphite, geological work was conducted by Maheshwari Mining Private Limited, Kolkata, West Bengal. The authors along with other workers conducted mapping in parts of the Toposheet No. 64M/05 in and around Dindo-Belkurta-Basera block, Balrampur district, Chhattisgarh within the Chhotanagpur Granite Gneissic Complex (CGGC). Large-Scale Geological Mapping on 1:12,500 scale was conducted to cover an area of 54.4 square kilometre during the field investigation. A total of 155 Bed Rock Samples (BRS), Groove and Channel Samples along with 20 trench samples were collected from different locations within the designated block to analyse chemically. In addition, Self- Potential (SP) survey was conducted to comprehend the continuity of graphite band. A total of 5 boreholes were planned and drilling was done in the study area with a cumulative length of 300 meter and 142 core samples were generated for chemical analyses.

## 2.1 Objective:

The objectives of the present exploration are as follows:

**I.** Mapping the designated area of Dindo-Belkurta-Basera block on 1:12,500 scale and identifying and delineating the graphite bearing zone. It also involved study and mapping of other rock types.

**II.** Geophysical SP survey was done to confirm the continuity of graphite exposure in subsurface which was identified through geological mapping on surface.

**III.** In reconnaissance stage (G4) of exploration, the objective was to confirm the continuity of band and to assess the tentative resource of graphite in the designated block. Furthermore, determination of the grade of graphite analysing the Fixed Carbon (FC) content, was also a component of this work.

**IV.** Finally, it aims to identify the specific ore bearing zone or areas which are potential for further exploration and assessment for graphite deposits at G3 stage of exploration**.**

## 2.2. Basis for taking up the investigation:

Mishra and Kumar (1991-92) mapped an area on the Toposheet no. 64M/05 & 63P/08 on 1:50,000 scale and they reported discontinuous bands of graphite schist from Oranga shear zone to the northeastern part of the area interbanded with marble, calc-silicate and amphibolite lithounits. Thin bands of graphite bearing schist are also exposed to the south of Baharchura within the east-west trending banded garnetiferous quartzite and within gneiss around Dhulangi (shear zone) area. Very thin bands of graphite is also reported in Semarwa within migmatite lithology. Later B. Saha (1995-96) carried out exploration for base metal, manganese and graphite in Oranga metamorphic belt and reported that phyllites to the south of Revatipur and northwest of Revatipur grades into graphite schist. The fixed carbon value showed by the collected samples by Saha from 1.91% to 10.60%.

In the recent past GSI has also reported a number of graphite occurrences within the Chhotanagpur Granite Gneiss Complex (CGGC) in adjoining states of Jharkhand and Bihar.

Keeping in view above reporting the area around Dindo, Belkurta and Basera was proposed by Maheshwari Mining Private Limited for reconnaissance survey (G4) for graphite.

## 2.3. Nature and Quantum of work done during the present investigation:

**Table - 2.1: List of associated personnel**

| Table-2.1: Nature and Quantum of Work (Target assigned and achieved) | | | |
|---|---|---|---|
| **Sl. No.** | **Nature of Work** | **Target assigned** | **Total achievement** |
| 1 | Geological Survey - (DGPS/Total Station Survey) (Sq. Km.) | - | - |
| 2 | Geological Mapping (LSM) (Sq. Km.) | 54.4 | 54.4 |
| 3 | Technological | | |
| | (a) Surface exploration- Pitting/Trenching (cubic m) | 100 | 20 |
| | (b) Subsurface exploration - Drilling (m) | 300 | 300 |
| 4 | Geochemical Survey | | |
| | (a) Bed Rock Samples (Nos.) | 100 | 155 |
| | (b) Stream Sediment Sample (Nos.) | - | - |
| | (c) Core Sample (Nos.) | 150 | 142 |
| | (d) PT Sample (Nos.) | 50 | 20 |
| 5 | Geophysical Survey (Self Potential method) (L. Km)/ (sq. km) | 3 L.Km | 3 L.Km |
| 6 | Petrographic/Minera graphic studies | | |
| | (a) Petrographic (Nos.) | 5 | 5 |
| | (b) EPMA (Nos.) | | |
| | (c) Petrographic Core (Nos.) | 5 | 5 |
| | (d) Ore Microscopy (Nos.) | | |
| 7 | Chemical analysis (Nos.) (As per approved NQT) | | |
| | (a) Proximate analysis for Graphite | 300 | 297 |

| | | | |
|---|---|---|---|
| | (b) Whole rock analysis (XRF method V2O5) | 50 | 50 |
| | (c) Associated 34 elements by ICPMS (Core Samples) | 10 | 10 |
| 8 | Check samples | 30 | 30 |

## 2.4. Mode of operations of different work components and associated agencies:

Large-Scale Geological Mapping on 1:12,500 scale in G4 stage, surface and subsurface sampling, subsurface drilling, Digital Global Positioning Survey (DGPS), geophysical SP survey, and petrographic studies were conducted by Maheshwari Mining Private Limited. Core cutting and sample preparation was done by in-house resources and samples analysed from NMCI Shree Coal Laboratory and Shiva Analytical (India) Pvt. Ltd laboratory.

## 2.5. Acknowledgement

The authors express their sincere gratitude to the National Mineral Exploration Trust (NMET), Ministry of Mines, Government of India for approving the project and funding it. The Directorate of Geology and Mining (DGM, Chhattisgarh) is thankfully acknowledged for monitoring the program.

During the execution of the project constant support from Mr. Sanjeev Ganeriwala, Joint MD of Maheshwari Mining Private Limited and Mr. Ambika Prasad Samantaray, President & CEO, Head of Geology Division , Maheshwari Mining Private Limited, is gratefully acknowledged.

In addition, relentless support from colleagues of Maheshwari Mining Private Limited is-being acknowledged humbly.

Support by the local administration/authorities of Balrampur district, Chhattisgarh, and relentless support of the Department of Forest, Chhattisgarh state are being thankfully acknowledged.

Thanks are due to the local Gram Panchayats for their cooperation for accomplishment of the project.

## 2.6. List of associated personnel:

**Table - 2.2 : List of associated personnel**

| Responsibility | Name |
|---|---|
| Project Coordinator | Shri Ambika Prasad Samantaray |
| Technical Area Expert-Geology | Shri Pradipta Tarafdar |
| Technical Area Expert-Geophysics | Shri Arindam Roy |
| Overall Coordination | Shri Sourabh Sarkar, DGM |
| Headquarter Coordination | Balkrishan Vishawakarma, Senior Geologist<br>Promit Roy, Geologist |
| Geological field report preparation and documentation | Avijit Roy, Junior Geologist |
| | Swarbhanu Dey, Junior Geologist |
| Field Geologist | Avijit Roy, Junior Geologist<br>Swarbhanu Dey, Junior Geologist |
| Petrographic Study | Ms Medha Sarkar, Geologist |
| Draftsman | Ms Gargi Roy Chowdhury |
| ArcGIS | Avijit Roy, Junior Geologist |
| | Swarbhanu Dey, Junior Geologist |
| SURPAC | Ms Moulipriya Bhakta, DM |
| Geophysical Survey (Self Potential) | Dr. Subhendu Mondal, Consultant<br>Modalavalasa Kiran Kumar, Geophysicist<br>Manash Pritam Phukan, Geophysicist(Trainee)<br>Abhishek Deori, Geophysicist(Trainee) |
| Peer Reviewer | B.P. Raturi, GM(Retd.) MECL |
| Drilling | Samik Mukherjee (Drilling in charge) |
| | Meghnath Bauri, Driller |
| | Sk. Hannan, Driller |

***Maheshwari Mining Private Limited NABET accreditation bearing no.-***

***QCI/NABET/AEA/ACO/22/004***

***NPEA order no.- M.VI-16/15/2021-Mines VI9***

# CHAPTER – 3

# PROPERTY DESCRIPTION

## 3.1. Introduction

Large Scale Geological Mapping of 54.40 sq km area, around Dindo-Belkurta-Basera in Ramchandrapur Tehsil in Balrampur district (Formerly Surguja district) falling in the Survey of India Toposheet No. 64M/05 was carried out on 1:12,500 scale. The objective of the field study was reconnaissance survey (G4 stage) for graphite in this area. The area of mapping is bounded by 23.88°N to 23.95°N and 83.33°E to 83.41°E. The cardinal points are:

**Table-3.1: <u>Cardinal points of block boundary</u>**

| P | Latitude | Longitude |
|---|---|---|
| A | 23.94°N | 83.33°E |
| B | 23.95°N | 83.41°E |
| C | 23.88°N | 83.41°E |
| D | 23.88°N | 83.35°E |
| E | 23.92°N | 83.35°E |
| F | 23.92°N | 83.33°E |

## 3.2. Location and accessibility

The area is located to the northeastern part of Balrampur district of Chhattisgarh, bordered by Sonbhadra district of Uttar Pradesh in the north and Palamu district of Jharkhand in the east.

The area forms part of Ramchandrapur Tehsil of Balrampur District and can be approached by well-connected roads from Wadraf Nagar and Ramanujganj. The area is also well-connected by metalled roads with Ambikapur, the district headquarters. Wadraf Nagar is at a distance of 45 km and Ramanujganj is at a distance of 52 km from Dindo-Belkurta area. Ambikapur is located about 130 km from Dindo-Belkurta area. The nearest railway station is Renukut in Uttar Pradesh which is about 86 km away on the Howrah-Delhi railway line and comes under the East-Central Railway

Zone. In addition, another nearby railway station is Ambikapur in Chhattisgarh which is about 92 km away and comes under Southeast-Central Railway Zone.

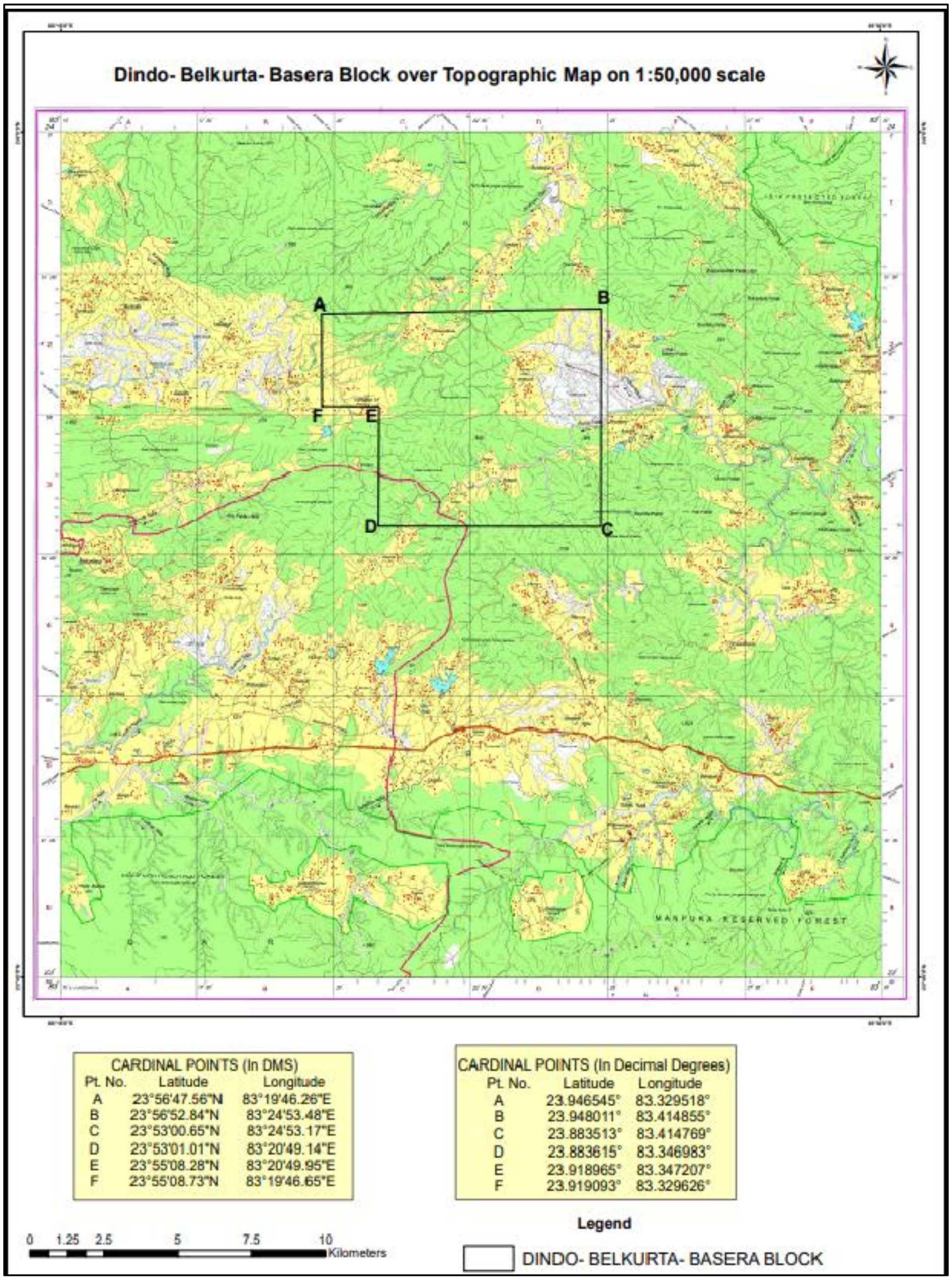



**Fig no-1:** Location of the study area of Dindo-Belkurta- Basera Block on Toposheet No. 64M/05.

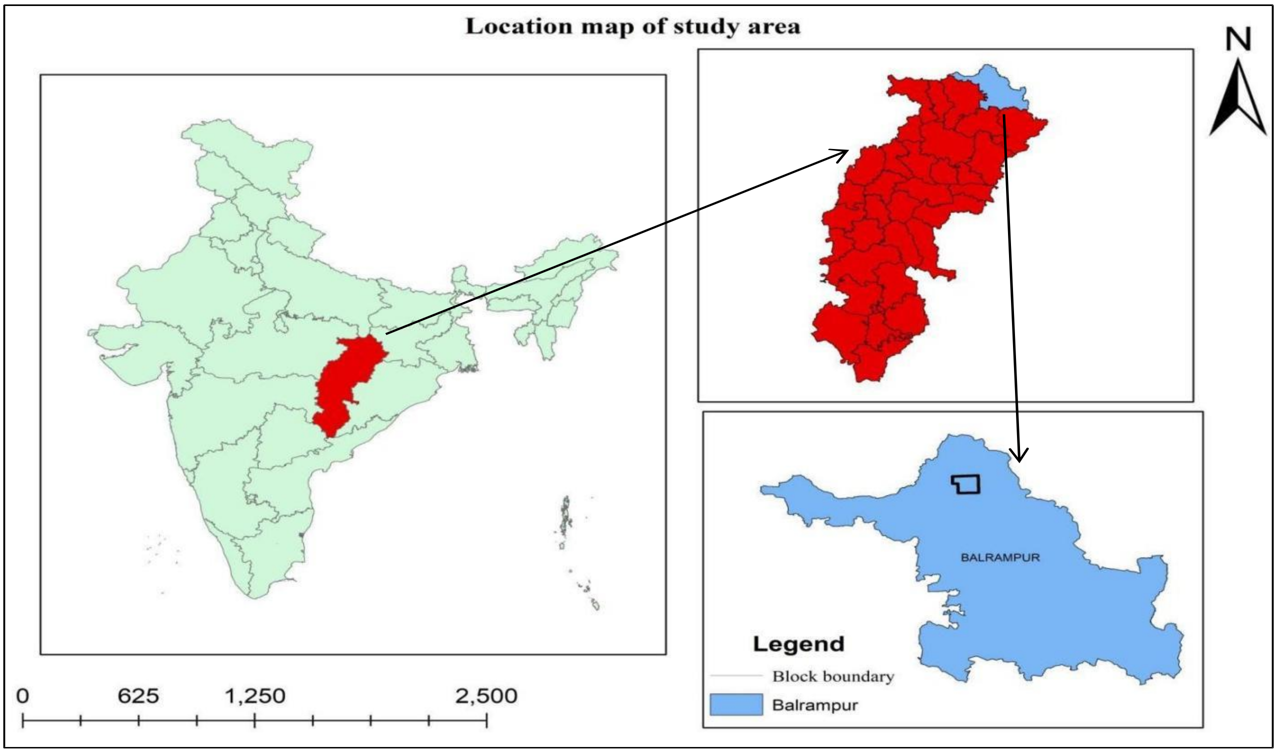



**Fig no-2:** Location of the study area of Dindo- Belkurta-Basera Graphite Block, Chhattisgarh.

## 3.3. Physiography and drainage:

Most of the mapped area of the terrain is hilly and undulating with shallow valley plains around the village areas. In the central part of the area, the hills are trending almost E-W and the maximum elevation is 550 m above the mean sea level located to the south-eastern part around Basera village. The average RL of the flat area is 415 m above the mean sea level. The area has a general easterly slope with various small nalas. Kursa Nadi and Lothia Nala are amongst the main which are flowing towards northeast and southeast direction respectively through the jungle of open scrub.

## 3.4. Climate:

The area suffers extreme climatic condition with hot summer and cold winter. The highest temperature reaches up to 45°C in the month of May and lowest temperature goes to 5° in winter. Southwest monsoon is confined to the months from July to September with an average rainfall of about 150 cm.

## 3.5. Flora and fauna:

Out of the 54.4 sq. km (5440 ha) area, 38.0 sq. km (3800 ha) area is covered with dense forest of Dindo-Belkurta forest range which is defined as reserved forest. Recorded plants are mainly Sal (Shorea robusta), Segun (Tectona grandis), Saja (Terminalia Alata), Seedha (Aegostromia parviflora), Tendu (Diaspyros melanoxylon), Khair (Acacia catechu), Mohua (Madhuca langifolia) and Bamboo (Bambusa vulgaris).

The wild animals of these forest are including bear, leopard, tiger, monkeys and a variety of birds and snakes apart from insects.

## 3.6. Culture:

The inhabitants of the area mainly belong to tribal group of Surguja District. Agriculture is the main occupation for them. Their livelihood to some extent depends upon the forest products like mahua, tendu leaves, Sal seeds and bamboos etc.

# CHAPTER - 4

# PREVIOUS WORK

## 4.1 Introduction

During the year of 1880, C. L. Greisbach mapped the Precambrian metamorphites and the Gondwana sediments in the northern part of Surguja district. After a long gap, in 1951 to 1952, Murthy studied the Granite Gneiss Complex in the toposheet No. 64M/01 and carried out the detailed petrological work. During the F.S.1991-92, Mishra and Kumar carried out Systematic Geological Mapping (1:50,000) around Dindo Ramchandrapur area in the toposheet No. 63P/08 and 64M/05. During their mapping, the authors had reported the presence of galena, sphalerite, and chalcopyrite at a few places around Oranga-Dhulangi area. During field season 1959-1960, Modak mapped the Precambrian rocks and Gondwana sediments in the Toposheet No. 64M/09. After that, Saha (1995-1996) worked on the preliminary exploration for base metal, manganese, and graphite in Oranga metamorphic belt in the Toposheet No. 63P/08 and 64M/05.

Mishra and Kumar (1991-1992) broadly subdivided the rocks of this area into three groups.

**Group-A:** Older Metasedimentary rocks:

(a) Massive and current bedded quartzite with occasional meta-conglomerate.

(b) Quartz-mica-schist, quartz-biotite-garnet-andalusite schist, and quartz- mica-garnet- staurolite-kyanite-fibrolite-cordierite (?) schist.

(c) Marble and calc-silicate rocks.

**Group-B:** Grey Granite gneiss and migmatites with enclaves of meta-sedimentary, meta- basics.

**Group-C:** Younger Granitoids and alkali granites with veins of pegmatite, syenite and quartz.

As per Mishra and Kumar (1991-1992), the oldest group comprising the metasedimentary sequence and showing general east-west trend occur in the central portion of the area occupies the core of a refolded anticline (?). Granitization of these metasediments resulted into the development of the granite gneiss-migmatite which occupies the major part the area. The granitization was possibly due to the partial melting of metasediments because of intense deformation during metamorphism. Enclaves of metasediments are frequently observed in the southern and northern parts of the area. The culmination of deformation and granitization is marked by diapiric emplacement of granites forming domes and apophyses within the gneiss migmatite complex. The pink granites, well exposed around Dugru and Oranga indicate the late phase of granitic activity. Intrusion of pegmatite, development of shear zones and tourmalinization, shearing and mylonitization of basement and metasediments near the contact zone are later events.

## 4.2 The Litho-Stratigraphic succession of the Dindo-Ramchandrapur area (After Mishra & kumar, 1993)

| | | |
|---|---|---|
| Recent-Subrecent | | Soil, Alluvium |
| | ---------- Unconformity ---------- | |
| | Deccan Trap (?) Igneous activity | Basic dykes |
| | ---------- Intrusive contact ---------- | |
| Permian<br>Upper Carboniferous | Lower | Ferruginous<br>Sandstone |
| | ---------- Unconformity ---------- | |
| Granitoids | Veins of pegmatite, syenite, aplite and quartz.<br>pink alkali granite, leucogranites | |
| P R E C A M B R I A N | ---------- intrusive contact ---------- | |
| | Grey granite gneiss and migmatites with minor enclaves of quartz-mica schist, quartzite, marble, calc-silicate, graphite schist, basic granulite, amphibolite and B.M.Q. and tonalitic gneiss. | |
| | ---------- Gradational contact ---------- | |
| Metasedimentary<br>(Lithotomic units) | Marble and calc-silicate, graphite schist, banded garnetiferous quartzite, mica schist, quartz-biotite- plagioclase-garnet schist, quartz-biotite-garnet<br>andalusite schist quartz-biotite-garnet-staurolite kyanite-fibrolite-cordierite (?) schist, quartz-muscovite-feldspar-sillimanite schist. pebbly quartzite, massive quartzite and micaceous quartzite with meta-conglomerate. | |

# CHAPTER – 5

# GEOLOGY OF THE AREA

## 5.1 Geological Setting:

The study area (Toposheet no. 64M/05) region is mainly comprised of Precambrian meta-sedimentary sequence and granite gneiss which is the western extension of the Chhotanagpur Granite Gneiss Complex (CGGC). A small portion of younger Dugru pink granite is present in this area which is surrounded by the granitic gneiss.

## 5.2 Description and distribution of rock types:

The distribution and description of the observed rock types is given below:

### 5.2.1 Micaceous quartzite and quartzite:

The micaceous quartzite is occurring to the southwestern part of the area. This lithology is extended to the northwest-southeast direction with strike of N30°W and dip easterly, forming the Baghmanwan Pahar and Baharapar Pahar of the area. It is wider to the southeast and thinner to the northwest. It is generally grey in colour, fine grained and the bedding plane shows N30°W strike with dip of 30° easterly. In the field observation quartzite shows fine to medium grained texture with grey to white colour. The elongated quartz grains are formed due to deformation and defined metamorphic bandings.

### 5.2.2 Sillimanite bearing quartz-mica schist:

This occupies the eastern part of the area with northwest-southeast trend with a thick zone. In the north-eastern part, sillimanite bearing quartz-mica schist is well exposed around Kursa Nadi and shows gradational contact with granite gneiss to the north and north-western part. The schist in this part contains abundant veins of quartz and pulverized knots of sillimanite resulting from intensive metamorphism and deformation. The petrographic study of this schist shows the mineral assemblage of k-feldspar-sillimanite-quartz-biotite-muscovite.

Eastern part consists of crenulated k-feldspar-sillimanite-quartz-biotite-muscovite schist, andalusite-garnet-quartz-biotite schist and staurolite-kyanite-fibrolite-cordierite-garnet-quartz-muscovite-biotite (?) schist which are best exposed further east beyond the block boundary of the designated area.

**5.2.3. Quartz-mica schist and garnetiferous quartz-mica schist:**

The central part of the designated area, to the north and south of graphite schist zone is occupied extensively by quartz-mica schist. The schistosity (S1) is trending almost east west with dip varying between 37° and 43° towards south.

Mineralogically the rock is composed of quartz, feldspar, muscovite and biotite. The amount of muscovite is higher in compared to that of biotite in this rock. The lithology is well-exposed in and around Dindo-Belkurta forest area and in Basera village.

To the northern part of the quartz-mica schist bearing area, a narrow band of garnetiferous quartz-muscovite-biotite schist is exposed along Dindo-Belkurta road. This lithounit is composed of quartz, feldspar, muscovite, biotite and garnet. Presence of garnet in this litho-package indicates medium grade of metamorphism of the rock. Crenulation cleavage has been noticed and recorded from this rock. The most abundant and conspicuous linear structure developed in mica schist is pucker/crenulation on schistosity planes. This lineation generally plunges with an amount of 10° to 15° due WNW, NW and occasionally NE near Dindo and Belkurta regions.

**5.2.4. Graphite Schist:**

Mishra & Kumar (1993) reported discontinuous bands of graphite schist occur within the Oranga shear zone in the northern part of the area which is interbedded with marble, calc-silicate and amphibolite. They have recorded graphite schist in dug wells near Oranga village which is 1 km northeast of Revatipur (dimension is 100m × 30m), also in the southeast of Revatipur (dimension is 150m × 50m) up to a depth of 6 m. A thin band of graphite bearing schist exposed to the south of Baharchura village within the east-west trending banded garnetiferous quartzite reported by these workers. Petrographically the rock consists of sillimanite, muscovite and graphite.

### 5.2.5. Low grade phyllite:

Phyllites are found in two parts as impersistent lithounits well exposed mainly around Revatipur village. One is to the south of Revatipur and to the northwest of it (Saha, 2001). This low-grade phyllite is found within the quartz-mica schist lithounit. This rock exhibits crude schistosity trending NW-SE.

### 5.2.6. Calc-silicate:

There are few calc-silicate bands in and around Oranga and Revatipur village. These bands show the effects of shearing in many places and contain the base metal mineralization (mainly galena, sphalerite and minor chalcopyrite) (Saha, 2001). Thin section study revealed that this calc-silicate lithounit is composed of calcite, diopside, tremolite and actinolite (Saha, 2001).

### 5.2.7 Amphibolite:

Amphibolite lithounit occurs within the quartz-mica schist and also associated with the calc-silicate rock of this area as small, isolated bands (Saha, 2001). The rock consists of quartz, hornblende, plagioclase feldspar, chlorite and biotite (Saha, 2001).

### 5.2.8 Granite Gneiss Complex:

Quartz-feldspar-biotite gneiss and migmatite are the predominant rock type exposed to the northern, north-eastern and southern portion of Dindo-Belkurta villages. These gneisses are composed of quartz, k-feldspar, plagioclase and biotite. These are medium to coarse grained and in some place porphyroblasts of k-feldspar noticed. In some places augens of quartz and k-feldspar recorded.

Migmatites are intimately associated with quartz-feldspar-biotite gneiss or granite gneiss in the form of thin bands showing its characteristic structure. The neosomal bands are composed of pink and greyish-white coloured quartzo-feldspathic materials ranging in thickness from 0.5 cm to 5 cm and palaeosomal bands are composed of quartz and biotite and their thicknesses are ranging from 0.3cm to 6 cm. These bands are generally parallel to the gneissic foliation planes. The biotite rich layers within the migmatites indicating the metamorphic segregation.

### 5.2.9 Quartz veins:

Quartz veins are ranging in width from a few centimetres to 0.5 m. These quartz veins intruded granite gneiss and quartz-mica schist and those occur along joints and fractures with predominant NW-SE and NE-SW trends.

### 5.2.10. Younger granitoids:

The younger granitoids mainly occupy the areas around Dugru, Silaju, Surangpan, Balchauraghat and Jhara.

***Granodiorite:***

Small linear bodies of granodiorite showing intrusive character occur within the gneissic complex, which is well-exposed along Kanhar river section, north of Semarwa and near Libarghat, the dimension of which is 5 m wide and 50 m long (Mishra & Kumar, 1993). The rock is massive in nature and grey coloured coarse grained and composed of bluish quartz, plagioclase, k-feldspar and hornblende.

***Granite:***

Dugru granite is restricted to the north-west part of the designated area, i.e., west of Bhagoditola and northeast of Dindo villages. The outcrops show a pink granite with coarse texture. The granite gives a rugged topography with hills and tors. The hill forming stocks occur to the west of Bhagoditola. The stock has irregular and sharp contact with gneissic complex (Mishra & Kumar,1993). As per Mishra & Kumar (1993), the colour of the granite is due to the presence of potash feldspar (Mishra & Kumar,1993).

As per these authors, swerving of gneissosity and/or crude foliation around the Dugru granite with a quaquaversal and relatively low dips favour its diapiric intrusive character. These crude foliations frequently present on the outer part of the granitic pluton, whereas to the core region of the pluton, frequency of these foliation planes are very less. Formation of these crude schistosity and/or gneissosity to the outer part of the granite pluton possibly due to emplacement of the granite and its flow along the margin of the country rocks.

***Pegmatite:***

The pegmatite of the designated area noticeably fall into two groups (Mishra & Kumar,1993). Pegmatites are dominant in the southern part of the area is greyish white in colour, composed of very coarse and essentially muscovite and tourmaline bearing. On the other hand, pegmatites which are pink in colour and contain biotite belongs to the second group. Muscovite and tourmaline are rare or nearly absent in the later type (Mishra & Kumar,1993). During the present work it was noticed that in general pegmatite occurs as linear intrusive parallel to the schistosity or gneissosity within the gneissic complex. Several major and minor muscovite pegmatite occur to the east of Dindo and Vimtapur and west of Belkurta villages. Sharp contacts of pegmatite with quartz-feldspar-muscovite-biotite schists were noticed. Mica books of size ranging from 5 - 9 cm were noticed and recorded in pegmatite within the dense forest area between Dindo and Belkurta. Numerous tourmaline crystals of size ranging from few mm to 12 cm were also noticed in Belkurta and Basera villages. Numerous fractures in these tourmaline crystals are present. Near Basera, a number of tiny crystals of tourmaline occur at a high-angle to the contact of pegmatite and quartz-biotite schist. Mica flakes are arranged in radial manner.

**5.2.11. Basic Dyke:**

A 4 kilometre long and 50-meter-wide basic dyke is found to the west of Revatipur village cutting across the micaceous quartzite and quartz-mica schist with NW-SE trend. It is dark coloured, medium to coarse grained rock.

# CHAPTER - 6

# ACTIVITY DURING THE PERIOD

## 6.1. GEOLOGICAL MAPPING

### 6.1.1 Large-Scale Geological mapping:

Large-Scale Geological Mapping was carried in the Dino-Belkurta-Basera block of 54.4 sq km in 1:12,500 scale. The boundaries of the block are defined by the specific coordinates A (23.94°N, 83.33°E), B (23.95°N, 83.41°E), C (23.88°N, 83.41°E), D (23.88°N, 83.35°E), E (23.92°N,83.35°E), F (23.92°N, 83.33°E) on a 1:50,000 toposheet map (Fig no-1).

The primary objective to carry out the large-scale geological mapping was to identify the different lithologies and identify the orientation of the graphite bearing zone within the designated study area.

During the present investigation, mainly pink granite, granite gneiss, mica-schist, garnetiferous mica-schist, graphite schist, kyanite-sillimanite schist, and pegmatite were observed in this area. A total of 155 bed rock samples were generated in which fixed carbon value ranges from 0.03% to 8.45%.

### 6.1.2 Geological Map on 1:12,500 Scale:

In the present investigation, mapping was carried out over an area of 54.4 square kilometre on 1:12,500 scale in a part of Toposheet No 64M/05. The objective was to delineate the lithological boundaries of the mineralized zone and other lithologies (PLATE-I).

### 6.1.3 Description of the rock types:

#### 6.1.3.1 Kyanite/Sillimanite bearing Quartz-Mica schist:

This occurs in the eastern part of the area as NE-SW trending thick belt. In the north-eastern part, quartz-sillimanite schist is well exposed around Kursa Nadi. The schist in this part contains abundant of stigmatic veins of quartz and pulverized knots of sillimanite resulting from intensive metamorphism and deformation.

#### 6.1.3.2 Mica-schist:

The rock occurs extensively along the central portion of the designated block from west to east with a bifurcation to the east. The schistosity is trending almost E-W with an amount of dip varying from 37° to 43° towards south. Mineralogically the rock is composed of quartz, feldspar, muscovite, and biotite. The amount of muscovite is higher in comparison to that of biotite in this rock. This rock is well exposed in and around Dindo, Belkurta and Basera villages. To the northern part of the quartz-mica schist, a narrow band of garnetiferous quartz-muscovite-biotite schist is exposed on the Dindo-Belkurta road. Crenulation cleavage has been recorded from this lithounit. Most abundant and conspicuous linear structure developed in mica schist is pucker/crenulation on schistosity planes. This lineation generally plunges with an amount of 10° to 15° due WNW, NW and occasionally NE near Dindo and Belkurta.

#### 6.1.3.3 Graphite schist:

Continuous band of graphite schist occur within the central portion of the mapped area with low-grade phyllite and garnetiferous quartz-mica schist on either side of it. Outcrops are studied along the nala sections within the dense forest. The strike length of the graphite bearing schist is almost 2700 m, and the average width of the lithounit is 3-4 m. The rock is composed of muscovite, quartz, feldspar and graphite with a very minor quantum of biotite. It is greyish black to dark grey in colour and shows black streak on paper, soils the hand and give waxy feeling upon touch.

#### 6.1.3.4 Phyllite:

Phyllite is mainly exposed to the south of mica schist near the Basera village in contact with pegmatite intrusion. The rock is composed of quartz, feldspar, sericite, and little amount of biotite. The rock shows typical phyllitic sheen. Crude schistosity recorded in it with E-W strike and 30° to 40° dip towards south.

#### 6.1.3.5 Granite Gneiss:

Granite gneiss is exposed to the northern part of the area around Vimtapur, Bhagoditola and Basera villages. It also covers the southern part of the mapped area.

Granite gneiss is characterised by the presence of alternate dark and light-coloured bandings. The light-coloured bands are composed of quartz and alkali feldspar and the dark coloured bands are composed of biotite and amphibole. Pyroxene is also present along these dark bands. In general, the gneissosity planes dip towards south with an amount of 25° to 40°. A few asymmetric folds defined by stretched quartz veins have also been noted during the present work. Usually, the plunges of the fold axes varying from 45° to 50° due W-WNW.

#### 6.1.3.6 Pink granite:

A small part of Dugru granite covers a small portion of north-western area of mapping, i.e., west of Bhagoditola and north of Dindo. Study shows a medium pink tone and coarse texture and composed of quartz, alkali feldspar as major minerals with biotite as accessory. This rock has irregular and inferred contact with gneissic complex to the north of Vimtapur and west of Bhagoditola. The dip amounts of crude foliation planes around the granite body increases from 20° near the centre to 50° near the margin. These crude foliations are frequent on the outer part of the granite pluton. To the core region of the pluton, these planes are less likely to occur

#### 6.1.3.7 Pegmatite:

Greyish white pegmatites are dominant in southern part of the area are very coarse grained, and composed of feldspar, quartz, muscovite and tourmaline. While pink coloured pegmatites are mainly biotite bearing and cover northern part of the area. Muscovite and tourmaline are rare or absent in the second category. In general, the pegmatite veins occur as intrusive parallel to the schistosity or gneissosity of the gneissic complex.

Several minor and major muscovite pegmatite bodies occur to the east of Dindo and Vimtapur villages, and west of Belkurta village to the Basera village. Xenoliths of schists are commonly present in it. Muscovite books of size 4 - 11 cm have been noticed in the dense forest area in between Dindo and Belkurta. The tourmaline crystals ranging in size from a few mm to 10 cm are recorded in and around Belkurta and Basera villages. Near Basera village, numerous small tourmaline crystals are developed perpendicular to the contact of pegmatite and quartz-biotite schist. Muscovite and biotite flakes are arranged radially.

**Fig no.3** outcrop of pegmatite body near Basera village

## 6.1.4 Petrographic studies:

Petrographic examination of thin sections of 5 bedrock samples of Graphite schist from Dindo-Belkurta Block, Chhattisgarh show that those are composed mainly of muscovite, quartz, and minor proportions of plagioclase, which later hosts the development of graphite. This study was aimed at elucidating the mineralogical and textural variations in the samples.

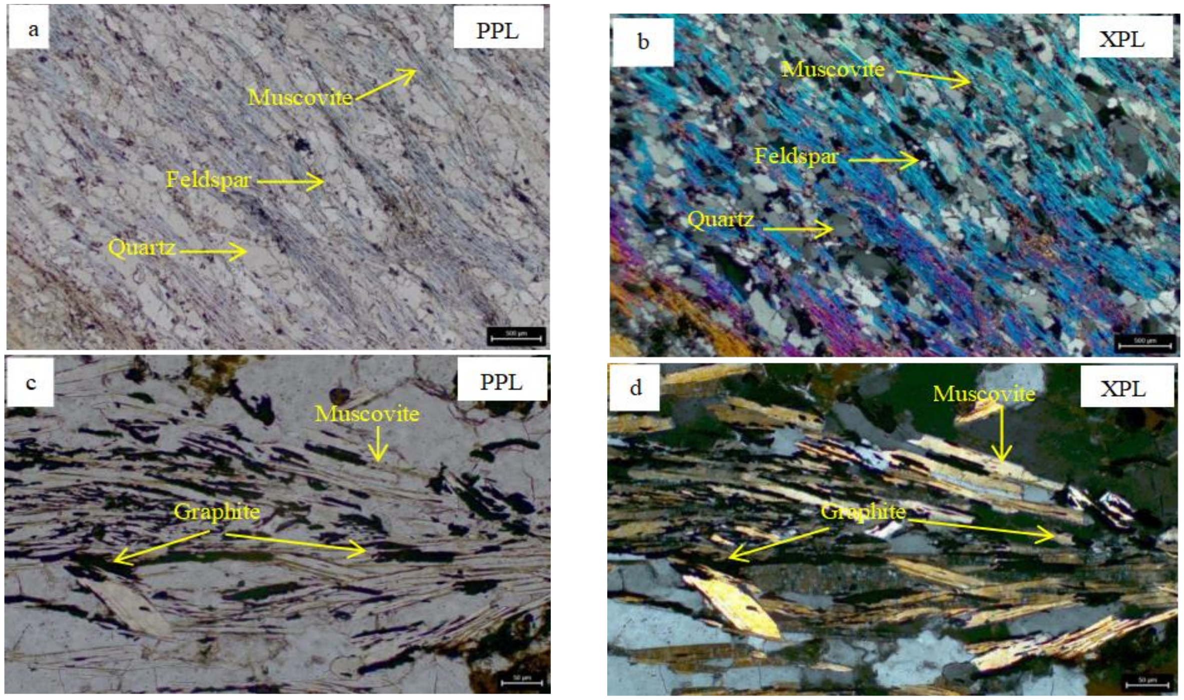
### 6.1.4.1 Petrographic observation:

The following observations are noted in the thin sections under Transmitted and Reflected Light:

**Bedrock Samples:**

❖ **Thin section: DBAS - 203**

In thin section (Fig no 4a and 4b), shows a mineralogical distribution of muscovite, quartz with rare presence of plagioclase grains. All The grains are aligned showing a crude gneissosity defined by alternate quartz-rich and muscovite-rich zones. Quartz is anhedral to subhedral in nature, showing medium grain size, low relief, colourless in PPL, elongated parallel to the dominant schistosity. Graphite is flaky in nature (Fig no. 4c, 4d and 4e), elongated, black in colour in transmitted light and anisotropic and pleochroic, observed under reflected light microscopy. Graphite is present along the grain boundary and as well as within the interstitial spaces of the muscovite rich zones.



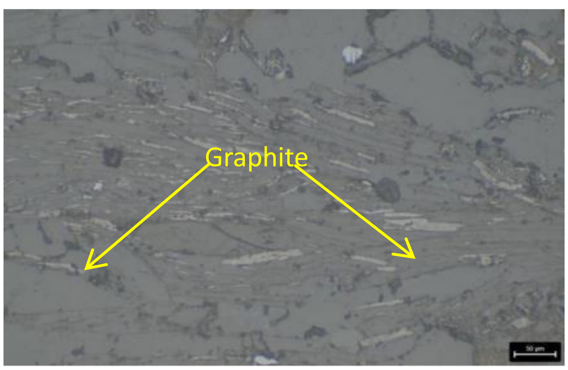




**Fig no-4: Photomicrographs of thin section DBAS-203 shows (a,c) Overall distribution of oriented muscovite and quartz grains PPL under transmitted light, (b, d) in XPL under transmitted light with graphite flakes oriented along the schistosity plane (c). Microphotographs shows the distribution of graphite flakes in PPL under reflected light**.

### ❖ Thin section: DBAS - 210

The photomicrographs (Fig no: 5a and 5b), shows a mineralogical distribution of garnet, muscovite, and quartz. Garnets are euhedral in shape and show high relief and isotopism under transmitted light microscopy. All The grains are aligned along the dominant schistosity plane.

Quartz is anhedral to subhedral in shape. Although we observe grain orientation representing the regional metamorphic regime, but muscovite are minorly developed in the thin section indicating limited hydrothermal activity in this section. Since the graphite development is generally associated with the muscovite in this area, graphite is also not much observed even under reflected light. The development of garnets and schistosity planes indicate middle to upper greenschist facies metamorphism.

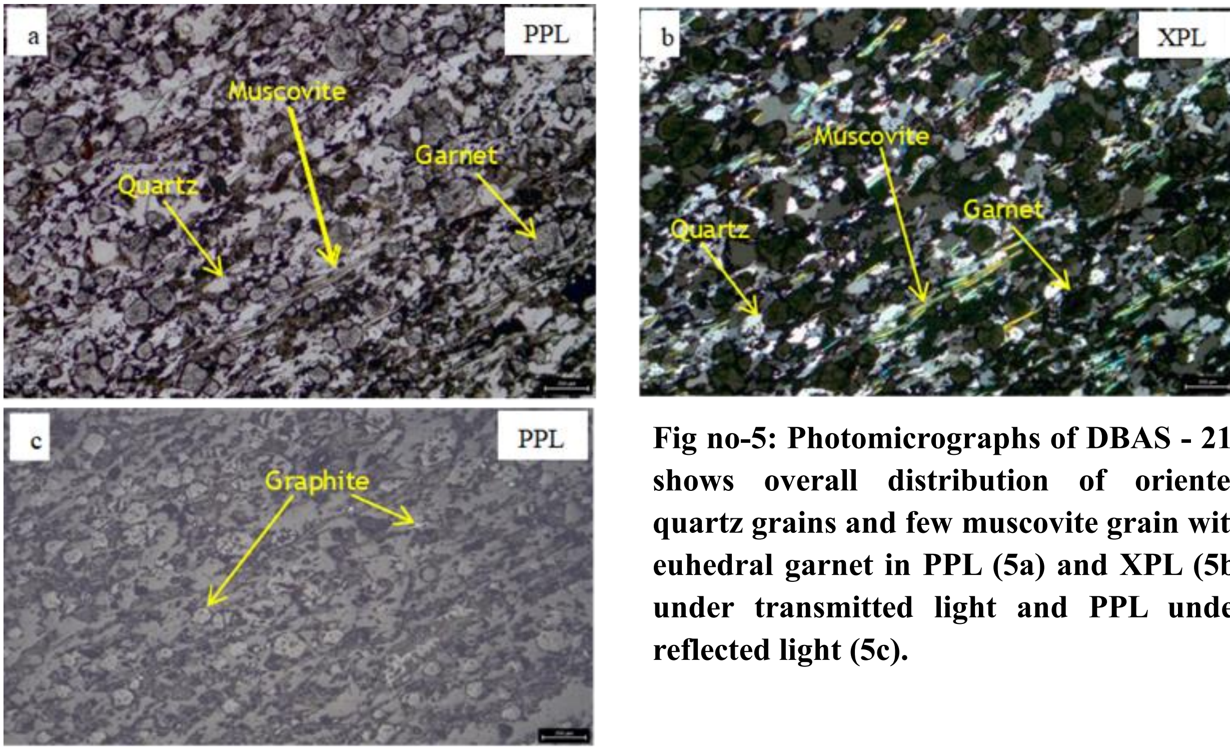



**Fig no-5: Photomicrographs of DBAS - 210 shows overall distribution of oriented quartz grains and few muscovite grain with euhedral garnet in PPL (5a) and XPL (5b) under transmitted light and PPL under reflected light (5c).**

- ❖ **Thin section: DBABS - 134**

Quartz with randomly distributed porphyroblast grains. Quartz is subhedral in shape, showing medium grain size, low relief, colourless in PPL. Graphite is identified under reflected light but hasn't developed enough to form flaky grains (6c) Graphite, black in colour in transmitted light and anisotropic and pleochroic under reflected light are observed as patches of microcrystalline graphite, developed in the interstitial spaces. Some Graphite, as minute flakes, seen in higher magnification, is present along the dominant schistosity plane direction (6a and 6b)). In few portions of the thin section, we observe the presence of porphyroblast. These grains were present before the development of the dominate schistosity. The schistosity planes defined by the muscovite grains are seen to wrap around the boundaries of the porphyroblast. An interesting observation is that the porphyroblast are almost completely pseudo morphed by chlorite(?)/Biotite(?) group of hydrous minerals. The previous schistosity planes that are seen within the pseudomorphs are in inclined (varying up to 90°) relation with the later generation schistosity defined by muscovite. Some porphyroblast shows a faded lamellar twinning which indicate that the original mineral grain can be Plagioclase feldspar.

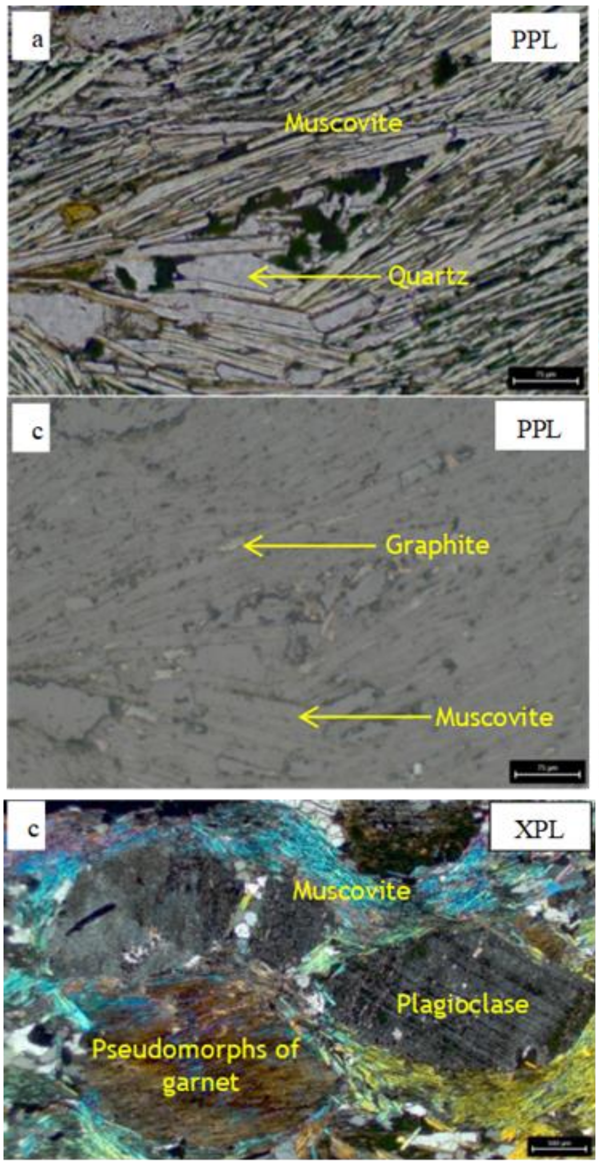



**Fig no-6: Photomicrographs of DBABS-134 shows overall distribution of oriented quartz and muscovite grains (6a and 6b) and several subhedral to euhedral porphyroblast in PPL (6d) and XPL (6e) under transmitted light. Minute flaky grains of graphite are seen under PPL under reflected light(6c)**

- ❖ **Thin section: DBAS-05**

The thin section shows a similar mineralogical distribution as the earlier sample, with quartz, muscovite, and garnet. All The grains are oriented along the overall schistosity direction. Quartz is anhedral to subhedral in nature, showing medium grain size, low relief, colourless in PPL, elongated parallel to the dominant schistosity. Graphite is present along the grain boundary and as well as within the interstitial spaces of the muscovite rich zones as small patches of microcrystalline grains (7c and 7d), black in colour in transmitted light and anisotropic and pleochroic, observed under reflected light microscopy.

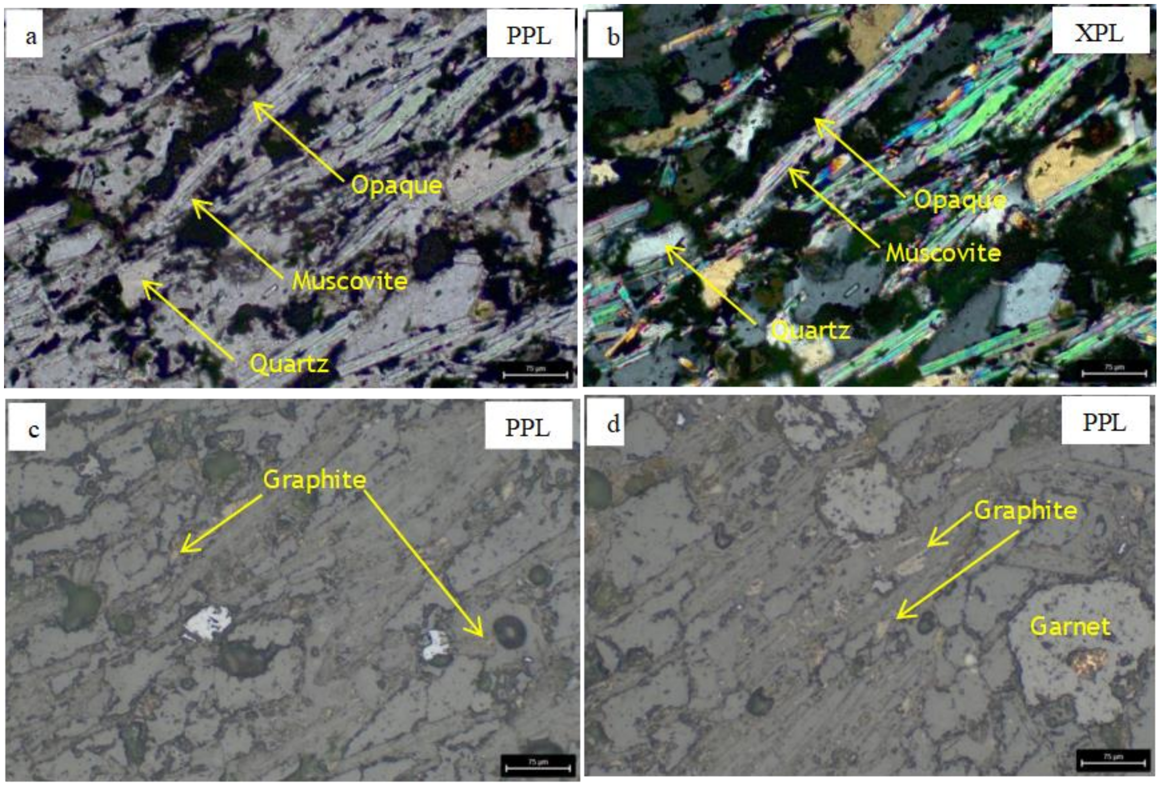
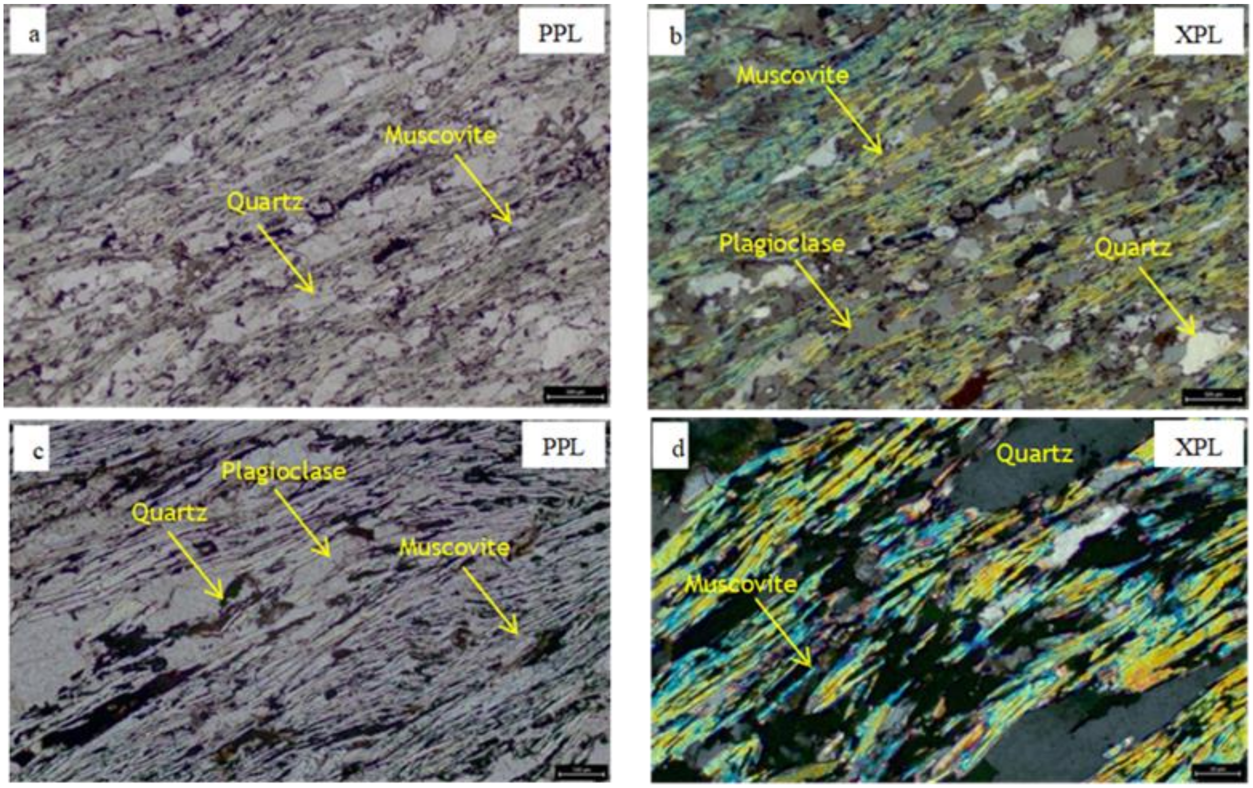



**Fig no-7: Photomicrographs of DBAS-05 shows overall distribution of oriented quartz and muscovite grains with subhedral to euhedral garnet in PPL (7a) and XPL (7b) under transmitted light and PPL under reflected light (7c). Small patches of microcrystalline graphite are identified under reflected light microscope**

❖ **Thin section: G/VIM/GR-5/5**

The thin section shows oriented grains of muscovite and quartz along the overall schistosity direction. Quartz is anhedral to subhedral in nature, showing small to medium grain size, low relief, colourless in PPL, elongated parallel to the dominant schistosity. Small, flaky graphite is extensively developed throughout the slide, mimicking the orientations of the schistosity plane, (8e). These grains are black in colour in transmitted light and anisotropic and pleochroic, observed under reflected light microscopy.



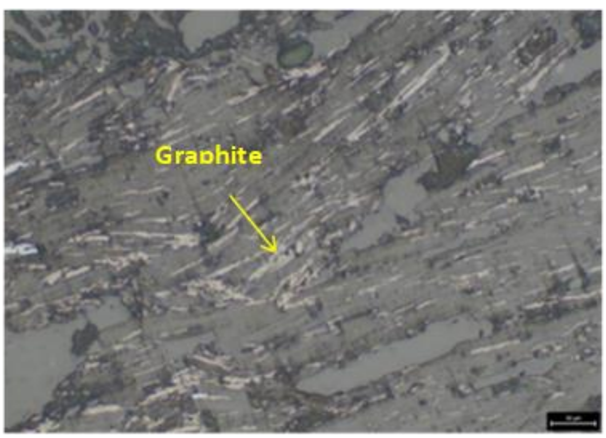
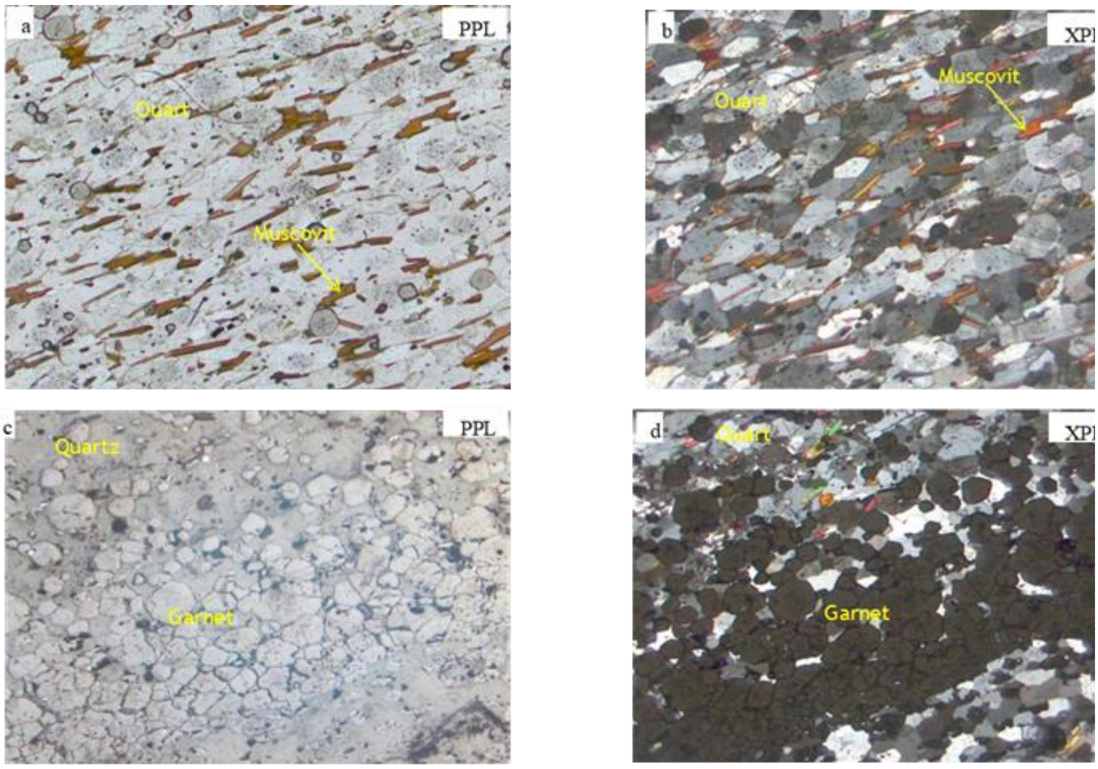




**Fig no-8**: Photomicrographs of G/Vim/G-5/5 shows overall distribution of oriented quartz and muscovite in PPL (8a and 8c) and XPL (8b and 8d) under transmitted light Small patches of microcrystalline graphite is identified under reflected light microscope. Extensive development of small flakes of graphite are seen under PPL of reflected light microscope(8e)

## Core Samples:

❖ **Thin Section: DBCD-03/020A**

The thin section shows the grains of muscovite and quartz along the overall schistosity direction. Quartz is anhedral to subhedral in nature, low relief, colourless in PPL, elongated and parallel to the dominant schistosity. Garnet is present with euhedral to subhedral shape. Small, flaky graphite is extensively developed throughout this section, following the orientations of the schistosity plane (9e). These grains are black in colour in transmitted light and anisotropic and pleochroic under reflected light microscopy.



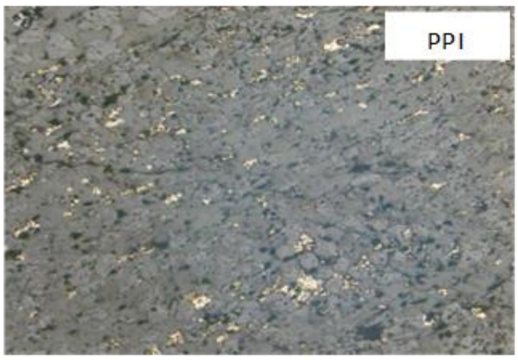




**Fig no-9: Photomicrograph of DBCD-03 overall distribution of oriented quartz an (Fig no- 9a,9b,9c). Garnet is observed under transmitted light. Small pat microcrystalline graphite is identified und light microscope. Extensive developme flakes of graphite are seen under PPL**

**Thin Section: DBCD- 03/18**

the photomicrographs (10a), show a mineralogical distribution of quartz, feldspar and muscovite under XPL. All The grains are aligned along the dominant schistosity plane. Quartz is anhedral to subhedral in shape. Although we observe grain orientation representing the regional metamorphic regime, but muscovites are minor developed in the thin section indicating limited hydrothermal activity in this section.

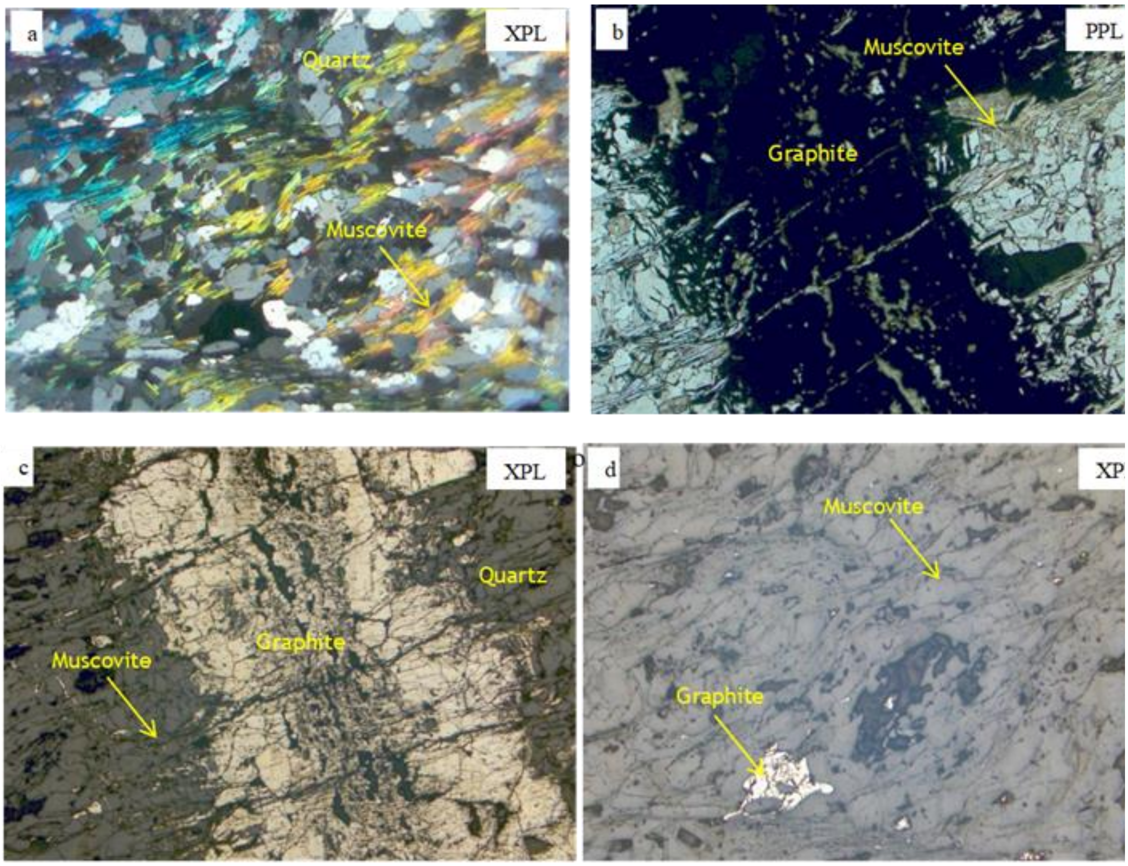



**Fig no-10: Photomicrographs of section number DBCD-03/18 show the ov distribution of quartz and muscovite in transmitted light. Under reflected light grap presence is showing in this section.**

- **Thin Section: DBCD- 03/11**

The photomicrographs (11a), show a mineralogical distribution of quartz, feldspar and muscovite under PPL and the same mineral assemblage under XPL (11b). All The grains are aligned along the dominant schistosity plane. Quartz is anhedral to subhedral in shape while feldspar grains are showing more or less euhedral to subhedral shape. Although the grain orientation representing the regional foliation trend, but muscovite is minor developed in the thin section indicating limited hydrothermal activity. Since the graphite development is generally associated with the muscovite in this area, graphite is observed even under transmitted light (11c and 11d).

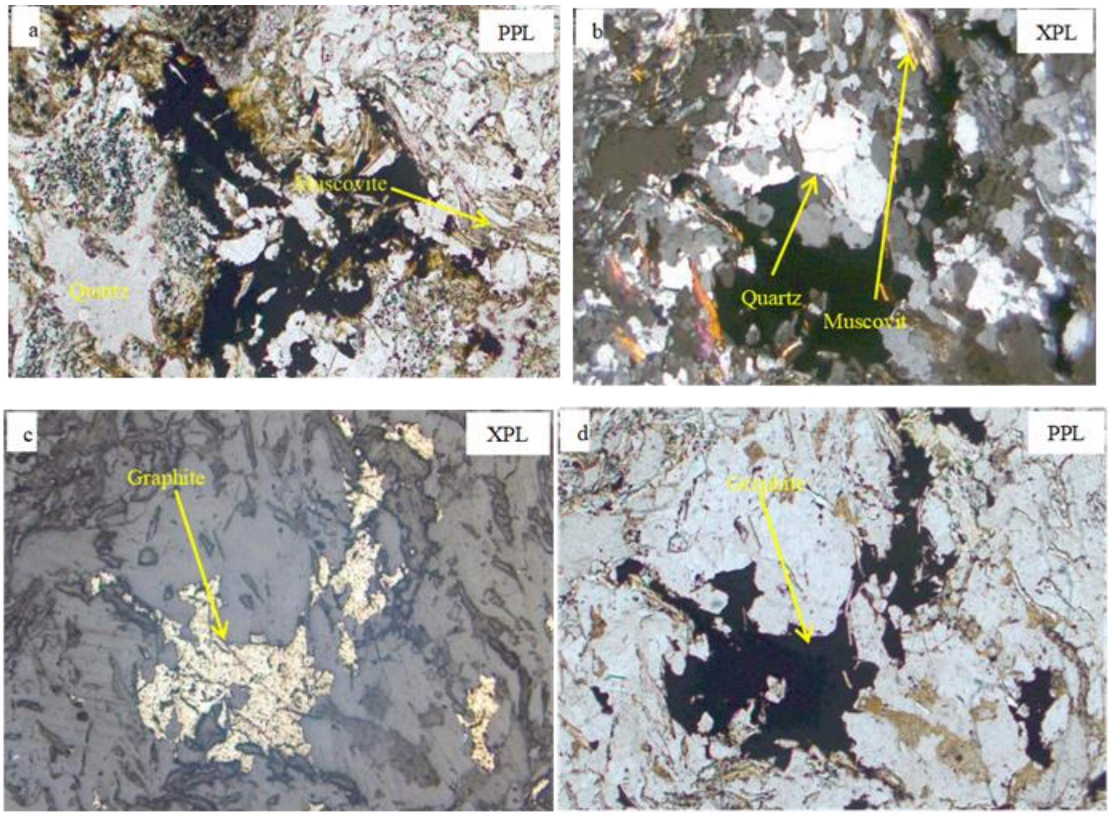
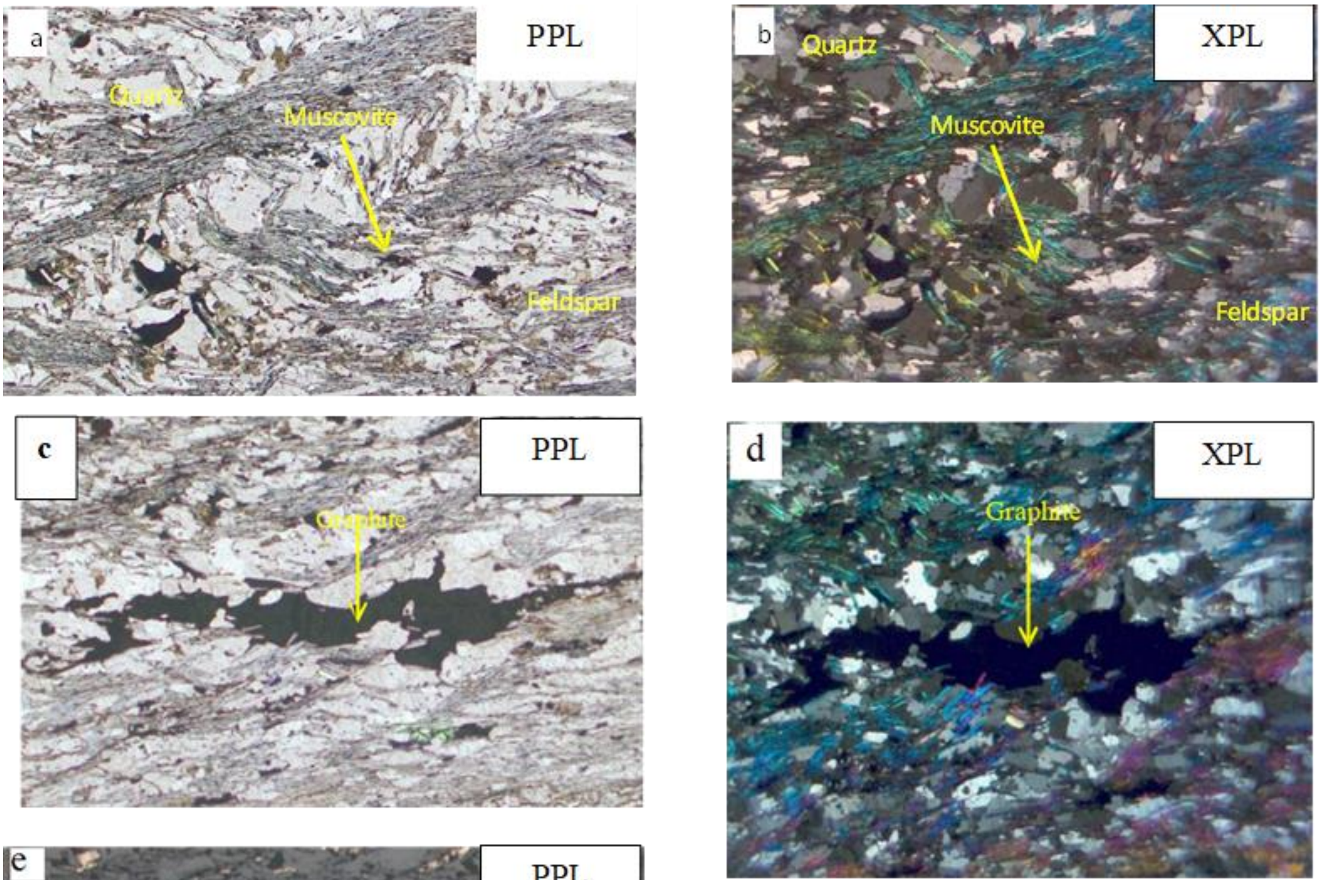



**Fig no-11: Photomicrographs of DBCD-03/11 show overall distribution of oriented quartz and muscovite in PPL (11a and 11c) and XPL (11b and 11d) under transmitted light small patches of microcrystalline graphite is identified under reflected light microscope.**

❖ **Thin Section: DBCD- 03/12**

The photomicrographs (12a), show a mineralogical distribution of quartz, feldspar and muscovite under PPL and the same mineral assemblage under XPL (12b). All The grains are aligned along the dominant schistosity plane and micro folding (puckers) defined by muscovite is well preserved in this section.

Quartz is anhedral to subhedral in shape while feldspar grains are showing more or less euhedral to subhedral shape. Although it can be observed the grain orientation representing the regional foliation trend, but muscovites are minor developed in the thin section indicating limited hydrothermal activity in this section. Muscovite is refolded due to second stage of deformation which forms crenulation cleavage, and the graphite is brecciated due to this deformation. Graphite is also defining the crenulation cleavage with muscovite and can be seen even under transmitted light (12d and 12.e).



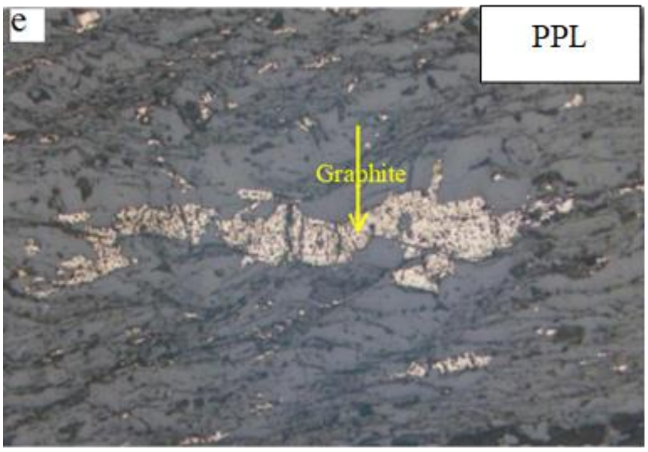




**Fig no-12: Photomicrographs of DBCD-03/12 show overall distribution of oriented quartz and muscovite in PPL (12a and 12c) and XPL (12b, 12d and 12e). Under transmitted light Small patches of microcrystalline graphite is identified under reflected light microscope. Extensive development of small flakes of graphite are seen under PPL of reflected light microscope (12e). Microfolds defined by muscovite and quartz is well preserved in this section.**

### ❖ Thin Section: DBCD- 03/03

The photomicrographs (14a), show a mineralogical distribution of quartz, feldspar and muscovite under PPL and the same mineral assemblage under XPL (14b). All The grains are aligned along the dominant schistosity plane and micro folding defined by muscovite is well preserved in this section.

Quartz is anhedral to subhedral in shape while feldspar grains are showing more or less euhedral to subhedral shape. Although the grain orientation representing the regional foliation trend muscovites are minor developed in the thin section indicating limited hydrothermal activity in this section. Since the graphite development is generally associated with the muscovites in this area. Graphite is present along fold hinge and limbs of these microfolds and can be seen even under transmitted light (14d and 14e).

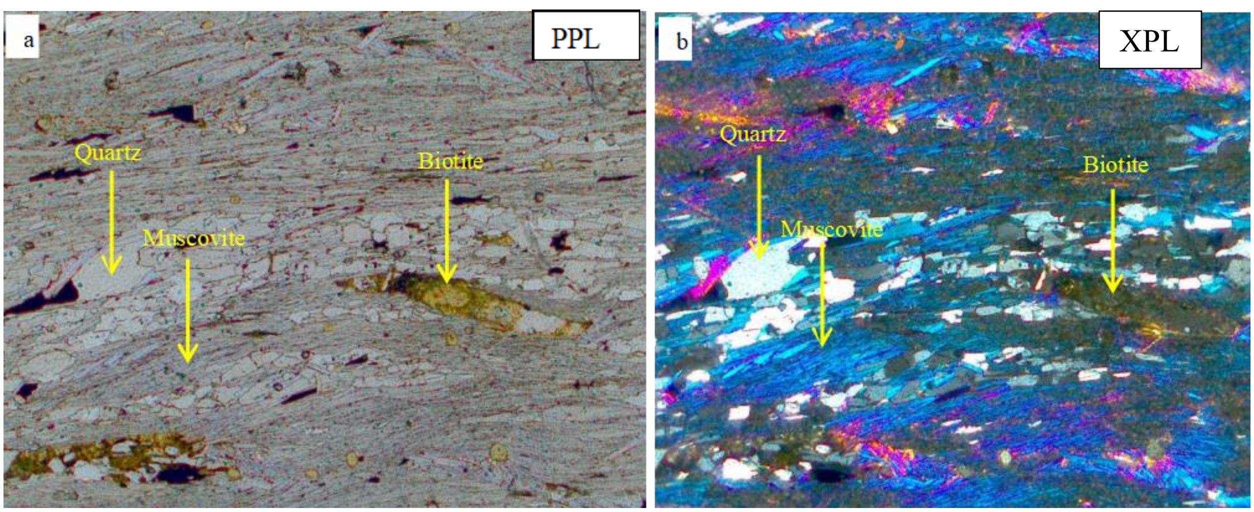



**Fig no 13**: **Photomicrographs of DBCD-03/03 shows overall distribution of oriented quartz, feldspar, muscovite and biotite in PPL (13a) and XPL (13b).**

### 6.1.5 Metamorphism:

The study area falls on the western part of the Chhotanagpur Granite Gneiss Complex and the age of the area is precambrian. The entire area has undergone intensive regional metamorphism and is composed of kyanite/sillimanite bearing quartz-mica schist, graphite schist, garnetiferous mica schist, granite gneiss and phyllite. The petrographic study of the lithologies has revealed the following mineralogical assemblages:

**Sillimanite bearing quartz-mica schist**: Kyanite/Sillimanite + Quartz + Feldspar + Biotite + Muscovite + Opaque mineral

**Mica schist:** Biotite + Muscovite + Feldspar + Quartz

**Garnetiferous mica schist:** Garnet + Biotite + Muscovite + Feldspar + Quartz

**Graphite schist:** Graphite + Biotite + Muscovite + Feldspar + Quartz

**Granite gneiss:** Plagioclase feldspar + Alkali feldspar + Quartz + Biotite + Muscovite

**Phyllite:** Sericite + Plagioclase feldspar + Alkali feldspar + Quartz

## 6.1.6 Regional Structures

## 6.1.6.1 Planar structures:

I. **Foliation (S1)/Schistosity:**

These are ubiquitous in the area and are best developed in schist. They are defined by parallel arrangement of flakes of micaceous minerals and acicular sillimanite. In general, the overall trend of the schistosity planes are E-W and dips southerly of the study area. Amount of dip varies from 30° near Vimtapur to 46° in the central part of the block.

II. **Foliation (S1)/Gneissosity:**

These are restricted to the northern and southern portion of the mapped area in the gneissic rocks. This structure is defined by alternate light and dark coloured bands. the light-coloured bands are composed of quartz and feldspar and dark coloured bands are defined by the presence of biotite and amphiboles. Additionally, a few pyroxenes are also **present along these dark** bands. Overall trend of gneissosity is E-W and dipping 30° to 43° southerly.

III. **Crenulation cleavage:**

They are restricted to mica and kyanite/sillimanite schist and graphite schist and are best developed around Vimtapur and Belkurta region. The development of cleavage is attributed to micro folding of mica layers and kyanite/sillimanite bands (Thin section no. DBCD-03/12). They are mostly sub-horizontal to low/gently dipping from 5° to 15° due west to north-westerly.

**IV. Joints:**

In the study area two major sets of joint planes are present trending NW-SE and NE-SW. These joint planes are mainly observed in granite gneiss. In a few places quartz veins are present along the joint planes.

**V. Lineation:**

These are most abundant within granite gneiss in and around Bhagoditola and Basera region. These structures are defined by quartzo-feldspathic minerals garnet and stretched quartz veins. The pitch of the lineation around Bhagoditola 20° due 284°. The amount of pitch of mineral lineation near Basera region is 18° due 290°.

**VI. Folds:**

In Basera region various small-scale folds were observed. Along the nala section within the forest near Basera region, mushroom shaped/arrowhead superposed fold have been observed. Trend of the axial plane of S1 are 124°-304°and 034°-214° and dipping towards NNE and WNW. The trend of the S2 is 012°-192°. Folded quartz veins are present along fracture planes within granite gneiss.

**VII. Other structures:**

This includes boudinage of quartz veins and pinch and swell structure and have been observed near Bhagoditola, Basera and within the dense forest between Dindo and Belkurta regions. This structure is defined by quartzo- feldspathic material within gneiss.

### 6.1.7 Mineralogy of the ore zone and ore texture :

Above mentioned detailed petrographic studies and field observation indicate that the mineralized zone is composed with flaky graphite associated with quartz-mica schist and graphite bearing schist. Graphite is mainly present along the grain boundaries and foliations. Graphite, black in colour in transmitted light and anisotropic and pleochroic under reflected light (Thin Section No. DBABS-05, G/Vim/GR-5/5, DBCD-03/201, DBCD-03/18, DBCD-03/12, DBCD-03/11). Associated minerals like quartz is subhedral to anhedral in shape, having low relief and colourless under plane polarized light. The muscovites are elongated and euhedral to subhedral in shape, and their orientation defines the regional foliation.

Graphite in some places under thin section is present in garnet bearing mica-schist showing cross-cutting relationship with the regional foliation trend. The presence of porphyroblasts of garnet indicates medium grade of metamorphism. In some thin sections, foliations are seen to be truncated against the grains of garnet, which indicate that garnet was formed after the regional deformation event.

### 6.1.8 Groove-Channel and Trenching:

A total of 12 groove lines are developed with 50-meter gaps along the strike in between every two groove lines namely G-1 and G-2, G-2, G-3, G-4, G-5, G-6, G-8, G-9, G-11, G-12, G-13, G-14 and 2 trenches across the identified mineralised zone within the mapped area. Groove lines G-7 and G-10 could not be developed for topographic constraints and abandoned. These north-south oriented grooves were planned across the strike direction of the ore body. Groove lines were named from west to east in three segments as G1 to G9 were planned on the western part of the mineralised zone and G11 and G12 were planned in the central part and G13 and G14 similarly placed in the eastern part of the mineralised zone. The maximum length of excavation was along the groove line G12 which is 27m and the minimum length of excavation is 10 m. Width of grooves was fixed between 25 cm-30cm and the depth varies from 10 cm to 50 cm. Due to topographic constraints and inconvenience, groove lines were not possible to plan throughout the mineralised zone.

Groove samples were collected from northern extremity to southern extremity. Sampled zone vary from 8 m to maximum of 24 m after exposing of graphite body. Samples from wall rock, mica schist were also collected for 1 m length from each end of the groove line.

Based on the FC value >2%, obtained from proximate analyses of the collected graphite samples, a width of 1 m to 11 m of graphite band was marked.

Two trenches were developed with the consideration of geophysical SP anomaly map. The dimensions of trenches are 10 m×1 m× 1 m. Total 20 number of soil samples were collected from 1 m interval from each trench. Since the topsoil layer was very thick, attempt to expose the bedrock failed from these two trenches. Groove line locations are shown in PLATE-V

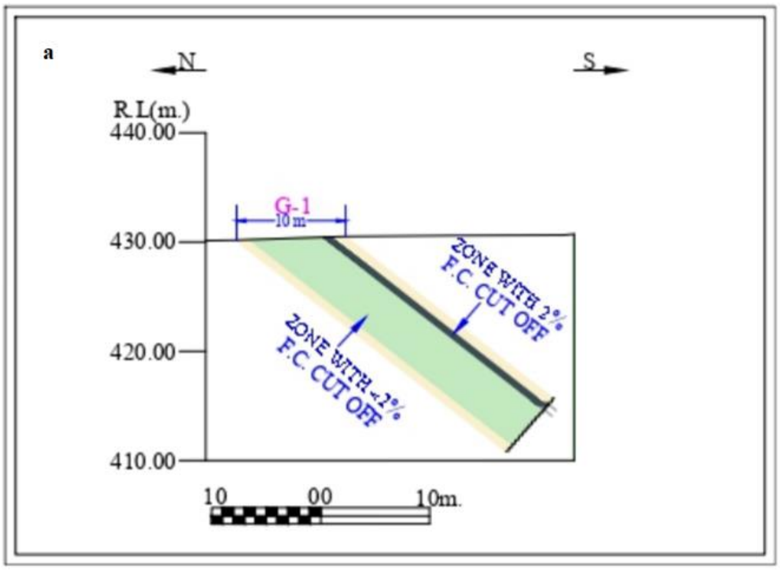



**Fig no-14 a:** Profile section of showing lithological variations along groove lines G-1

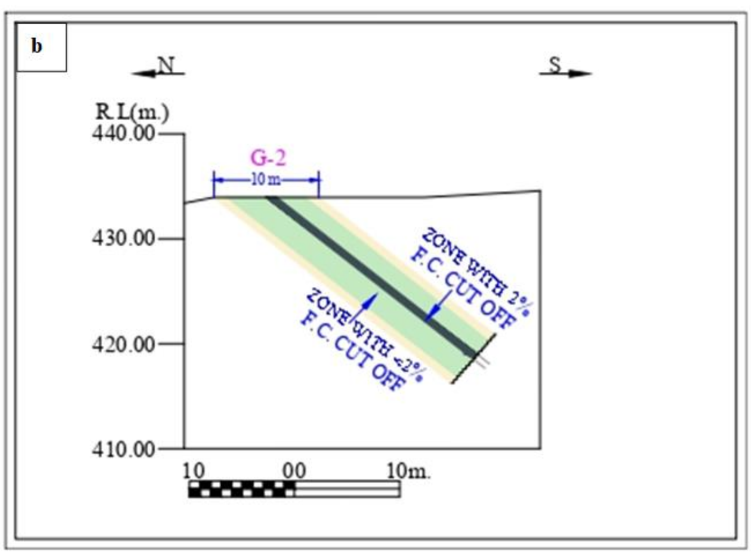



**Fig no-14 b:** Profile section of showing lithological variations along groove lines G-2

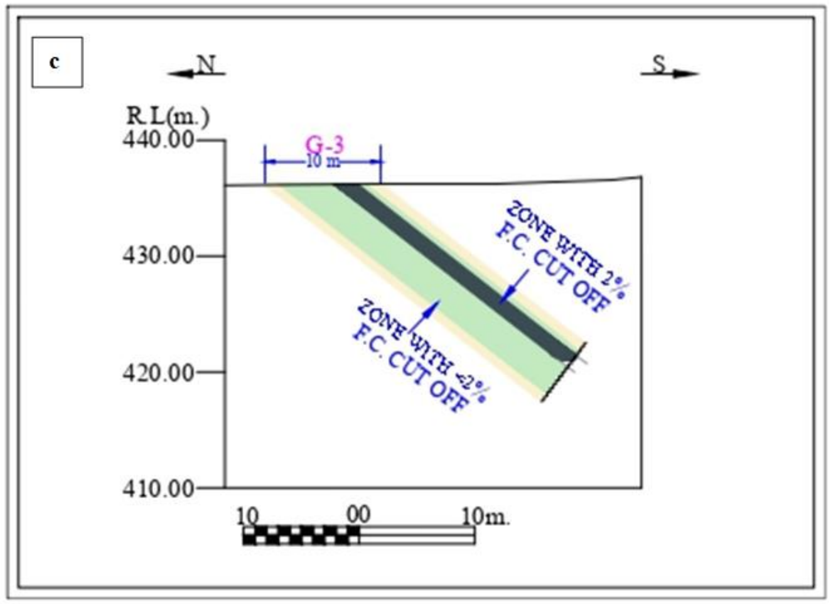



**Fig no-14 c:** : Profile section of showing lithological variations along groove lines G-3

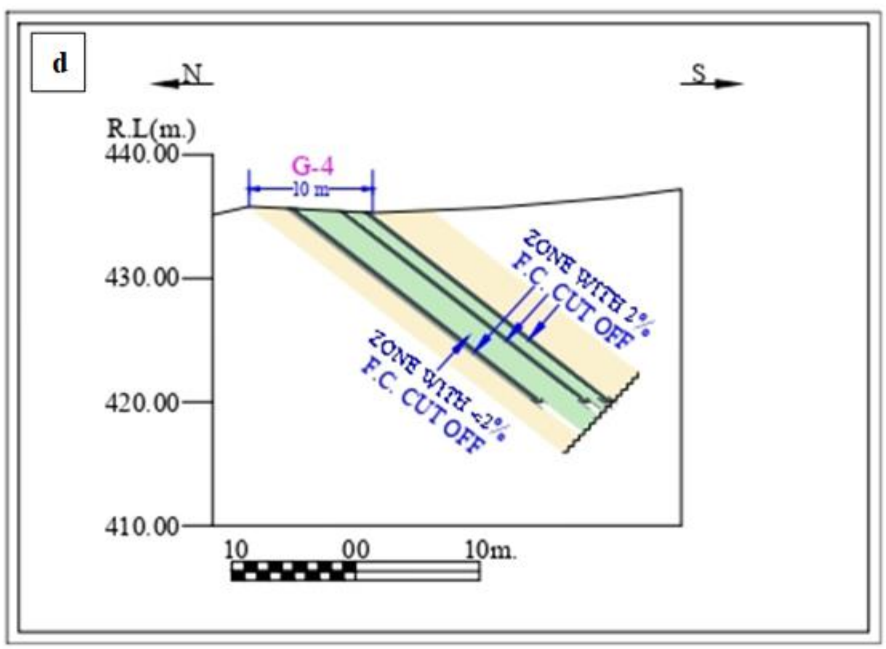



**Fig no-14 d**: Profile section of showing lithological variations along groove lines G-4

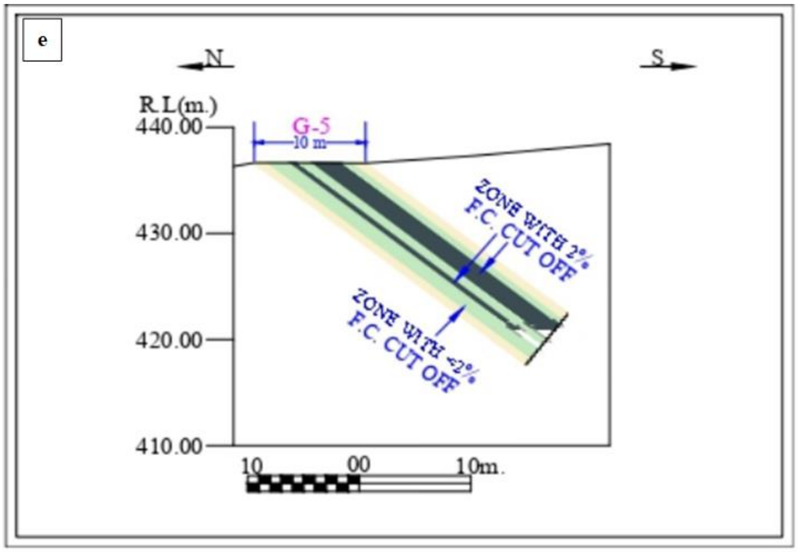



**Fig no-14 e***:* Profile section of showing lithological variations along groove lines G-5

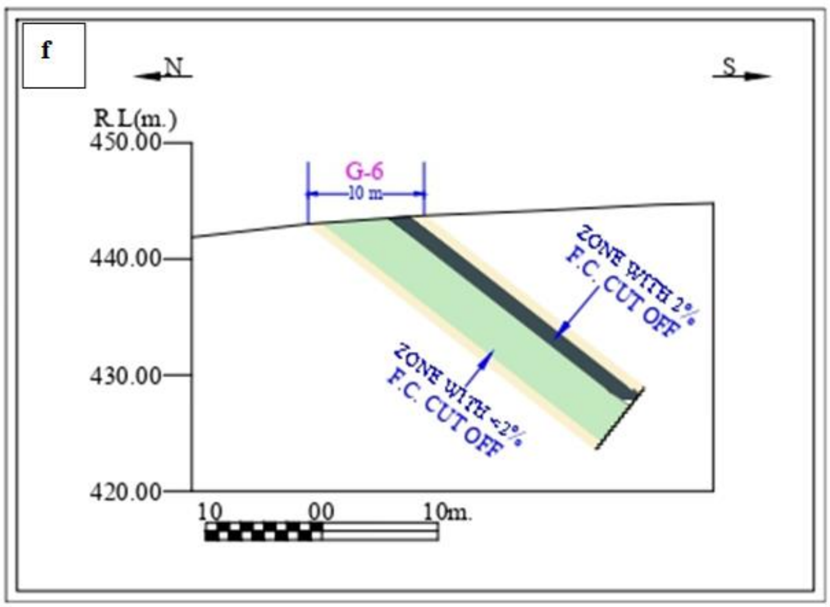



**Fig no-14 f***:* Profile section of showing lithological variations along groove lines G-6

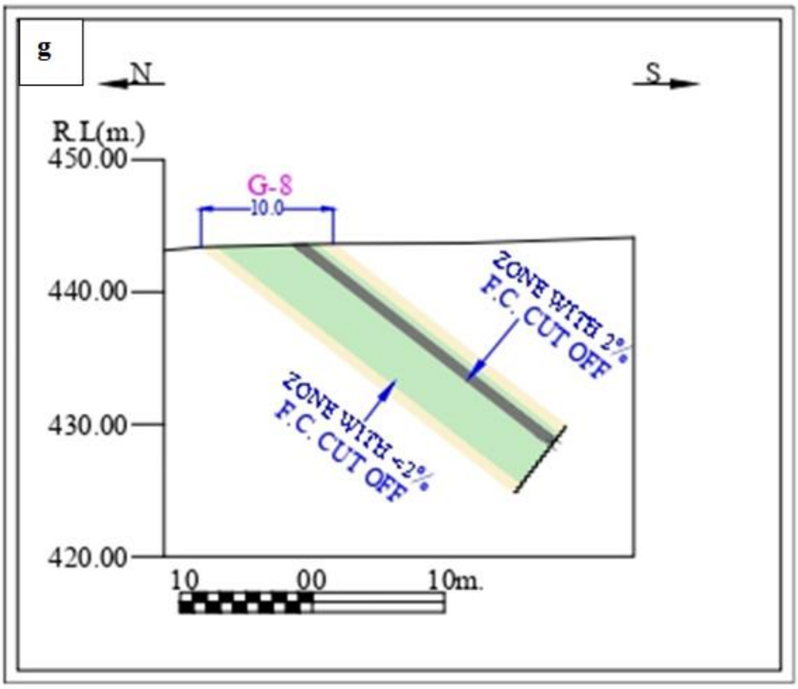



**Fig no-14 g: Profile section of showing lithological variations along groove lines G-8**

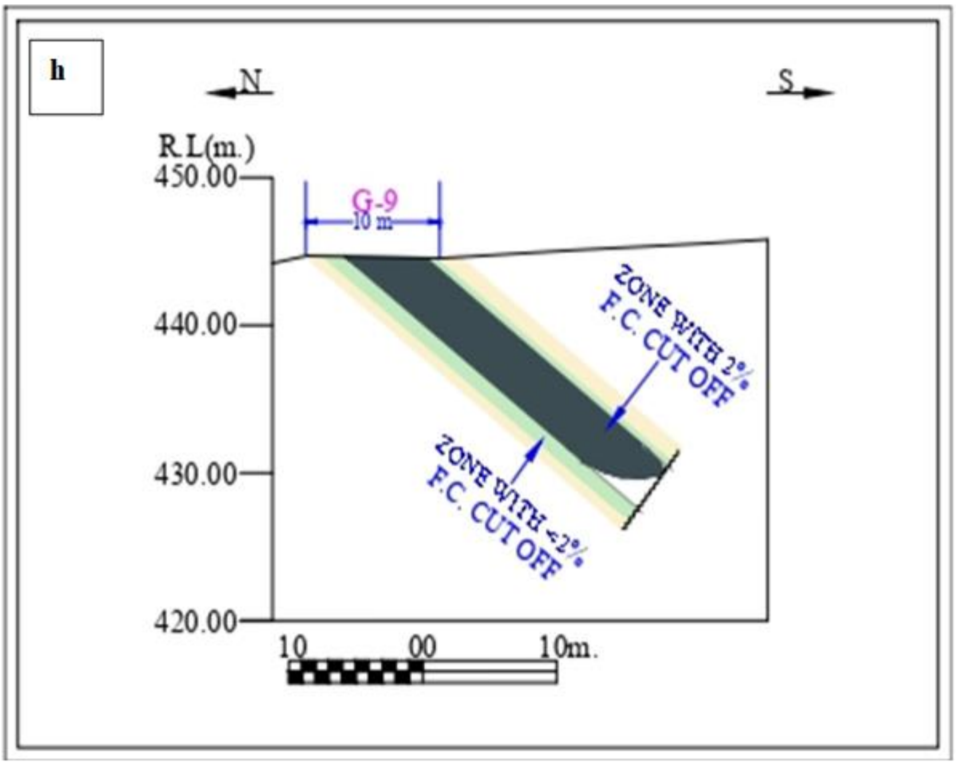



**Fig no-14 h***:* Profile section of showing lithological variations along groove lines G-9

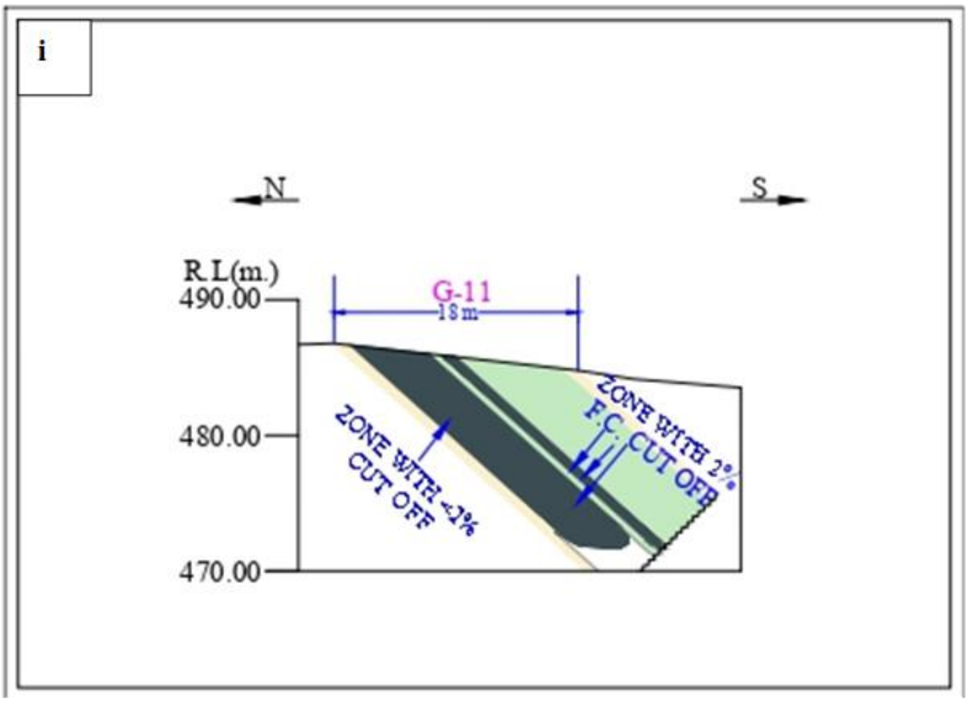



**Fig no-14 i**: Profile section of showing lithological variations along groove lines G-11

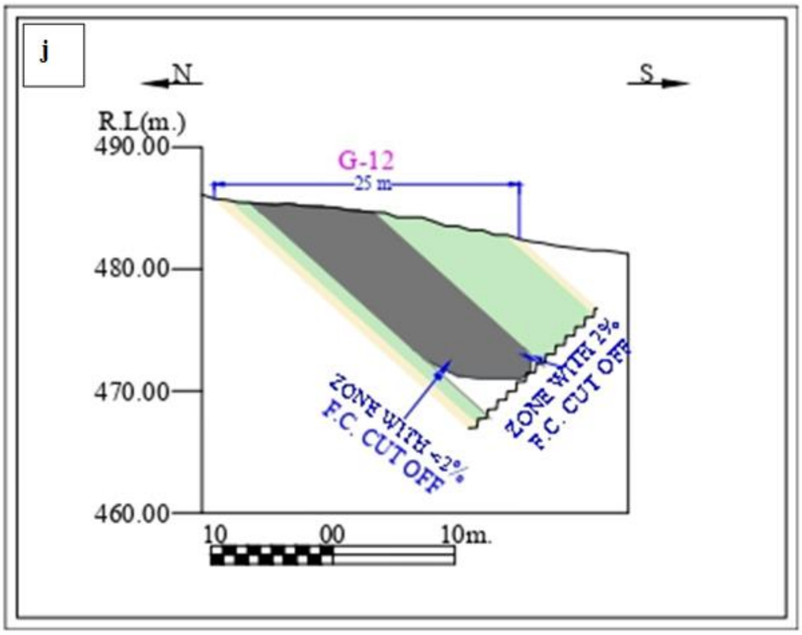



**Fig no-14 j**: Profile section of showing lithological variations along groove lines G-12

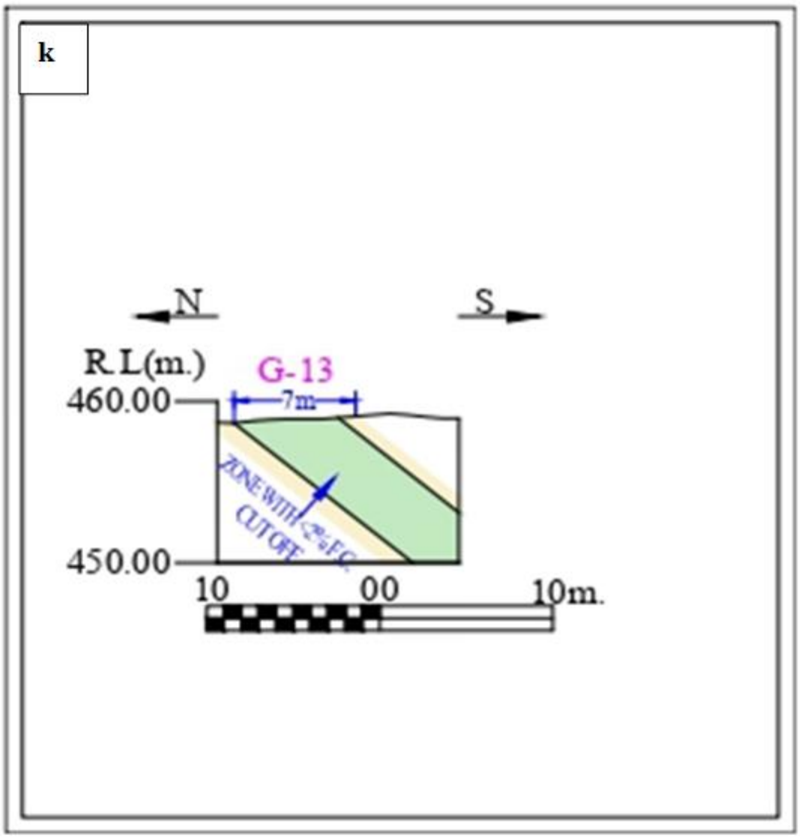



**Fig no-14 k**: Profile section of showing lithological variations along groove lines G-13

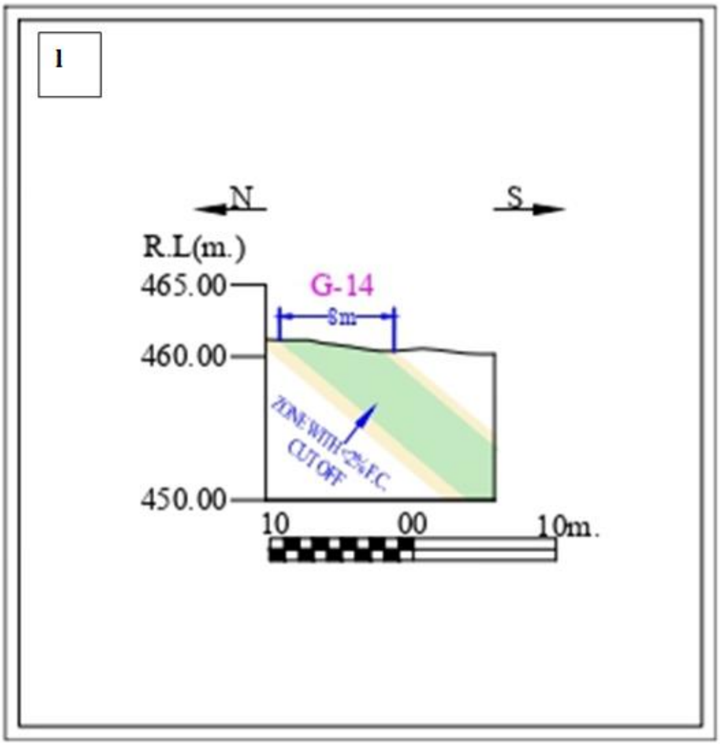



**Fig no-14 l**: Profile section of showing lithological variations along groove lines G-14

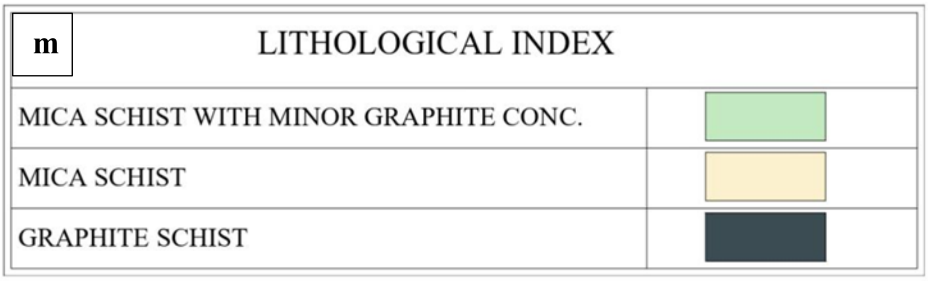



**Fig no-14 m:** Diagram shows the lithological index of the profile sections'

### 6.1.9 Sampling

During the field work, a total number of 155 surface samples were collected for the geochemical analyses. Out of these 155 BRS samples, 131 samples were systematically collected from groove lines, 24 grab samples were generated from other part of the designated area including the mineralised zone. Out of 131 groove samples, 110 numbers are graphite bearing and rest of the samples were collected from wall rock. Locations of the surface samples are shown on the geological map (Plate No. ). For analyses of fixed carbon % samples were submitted to NMCI Shree Coal Laboratory and for whole rock and minor elements analyses were done by Shiva Analytical (India) Pvt. Ltd. 30 number of check samples were arbitrarily selected from BRS samples, trench and drilled core samples and those were submitted to Shiva Analytical (India) Pvt. Ltd. by changing the sample Id.

### 6.1.10 Discussion on the chemical analyses result

During the current investigation a total number of 155 bedrock samples were generated from grooves and 24 grab samples from the graphite bearing zones and associated rock types. Out of 155 samples 44 samples show the fixed carbon values ranging from 2.00 % to 8.45 and rest of the samples show the values ranging from 0.03% to 1.99 %. The analytical data is provided in the Annexure-III, and the analytical results of the major oxides and minor elements are provided in the Annexure- V & VI.

## 6.2 GEOPHYSICAL EXPLORATION

Self-potential (SP) surveys are integral to graphite exploration, as they detect distinctive electrical characteristics of graphite-bearing lithounits, notably negative SP anomalies. These surveys offer a preliminary assessment over large areas, aiding target selection for further exploration. Complementing other geophysical techniques, such as electromagnetic surveys and resistivity surveys, SP data integration enhances accuracy in delineating graphite deposits. Moreover, SP anomalies reflect subsurface geological structures associated with graphite mineralization, aiding in understanding geological controls and identifying favourable exploration targets.

### 6.2.1 SP data acquisition

In this project, the Fixed Base approach was employed for the acquisition of Self-Potential (SP) data. A total of 3.7-line km in 13 profiles were surveyed, each spanning a length of 285 meters at the end of March 2024 (Fig. no. 16). The spacing between profiles was irregular, tailored to meet the specific objectives of the study while adhering to a total approved profile length of 3 kilometres . Data points were recorded at regular intervals of 15 meters. The selection of field parameters for SP data acquisition was informed by geological insights into graphite occurrences. Profile orientation was standardized along a North-South direction, perpendicular to the strike of the geological lithounits under investigation. Some profiles are taken across the known graphite bearing areas whereas some are across no exposed zone.


**Fig no-15: Location and orientation of the SP profiles (P1-P13)**

To carry out SP IGIS DC resistivity meter model DDR-3 utilizing two copper sulphate porous pots as electrodes to record the SP voltage of the earth was used. One handheld Garmin GPS was used to note down latitude longitude and elevation information. One universal base station and 13 different local base stations were established for each profile. **Fig no.16** shows some moments of field data acquisition. Repeat readings were taken to collect good quality data enhancing the reliability and confidence.

### 6.2.2 SP data processing

The prepossessing encompassed drift correction, reference electrode calibration, and the determination of absolute SP values relative to a universal reference point at each location. The absolute SP anomaly was depicted in two formats: spatially, utilizing grid anomaly strips generated through Geosoft v.8.4 software, which presented anomalies based on their spatial locations and corresponding values; and through profile plots, illustrating the fluctuation of SP values in relation to distance. Areas characterized by negative SP values in both spatial representations and profile locations are indicative of potential promising zones for graphite occurrence (PLATE-II).


**Fig no-16 : (a) SP data recording in DDR3 instrument, (b), (c) Base electrode and rover electrode establishment, (d) team of the geologist and geophysicist involved for this survey.**

### 6.2.3 Result and Discussion

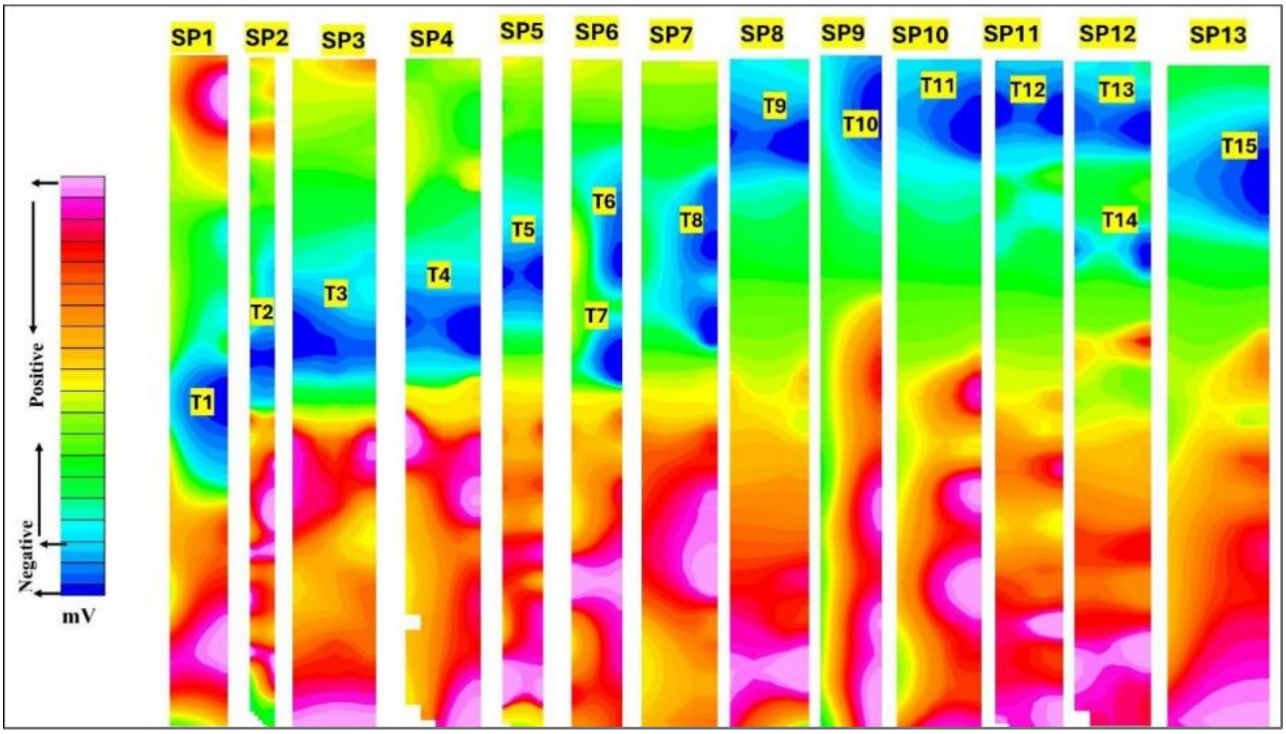
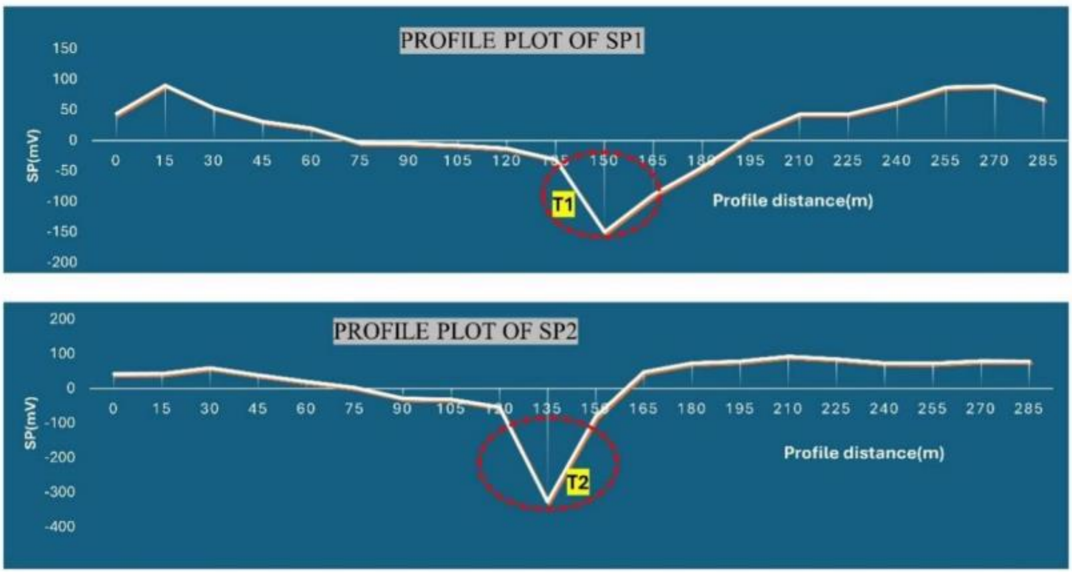
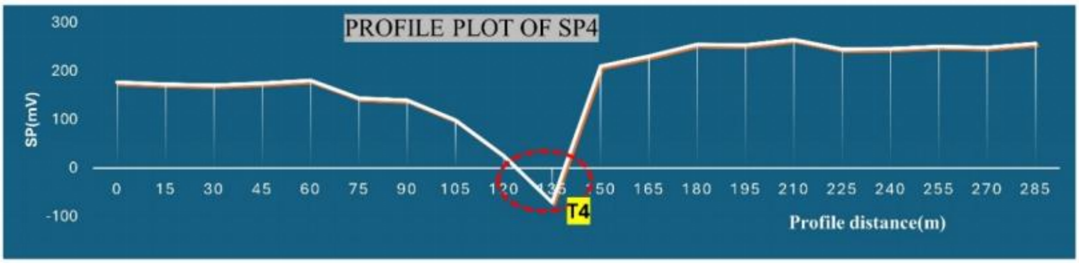


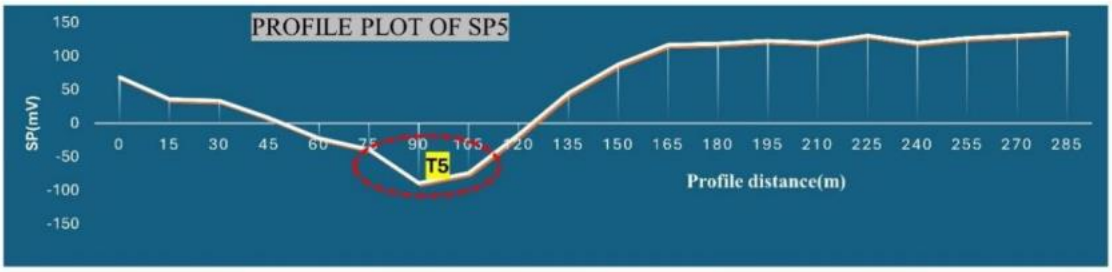

**Fig no-17 : The strip anomaly grid map of all the SP profiles (SP1-SP13). T1 - T15 are the potential zones for graphite occurrences.**

A total of 13 strip anomaly grid maps were constructed utilizing the absolute SP values from all the SP profiles (**Fig no-17**). Negative SP values are associated with the blue region of each map corresponding to graphite occurrences. T1-T15 zones are identified for concealed graphite occurrences. These zones have SP values in the range of -304 mV to -61 mV

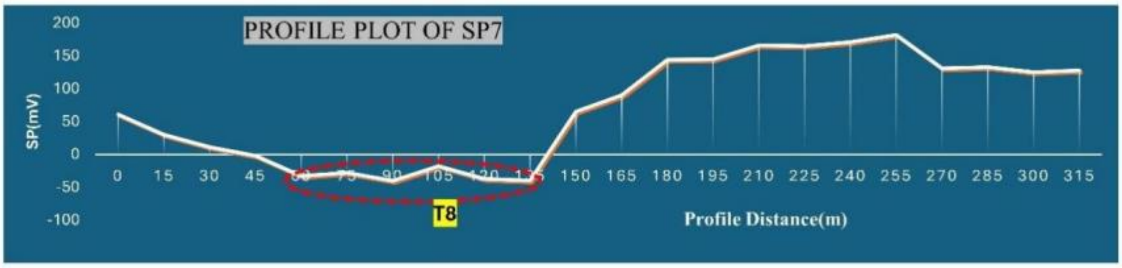


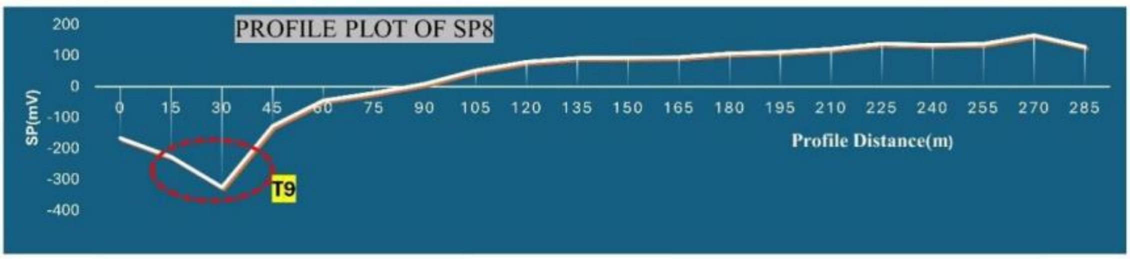

PROFILE PLOT OF SP3
SP(mV)
Profile distance(m)
T3


PROFILE PLOT OF SP4
SP(mV)
Profile distance(m)
T4


PROFILE PLOT OF SP5
SP(mV)
Profile distance(m)
T5


PROFILE PLOT OF SP6
SP(mV)
Profile distance(m)
T6
T7


PROFILE PLOT OF SP7
SP(mV)
Profile Distance(m)
T8


PROFILE PLOT OF SP8
SP(mV)
Profile Distance(m)
T9

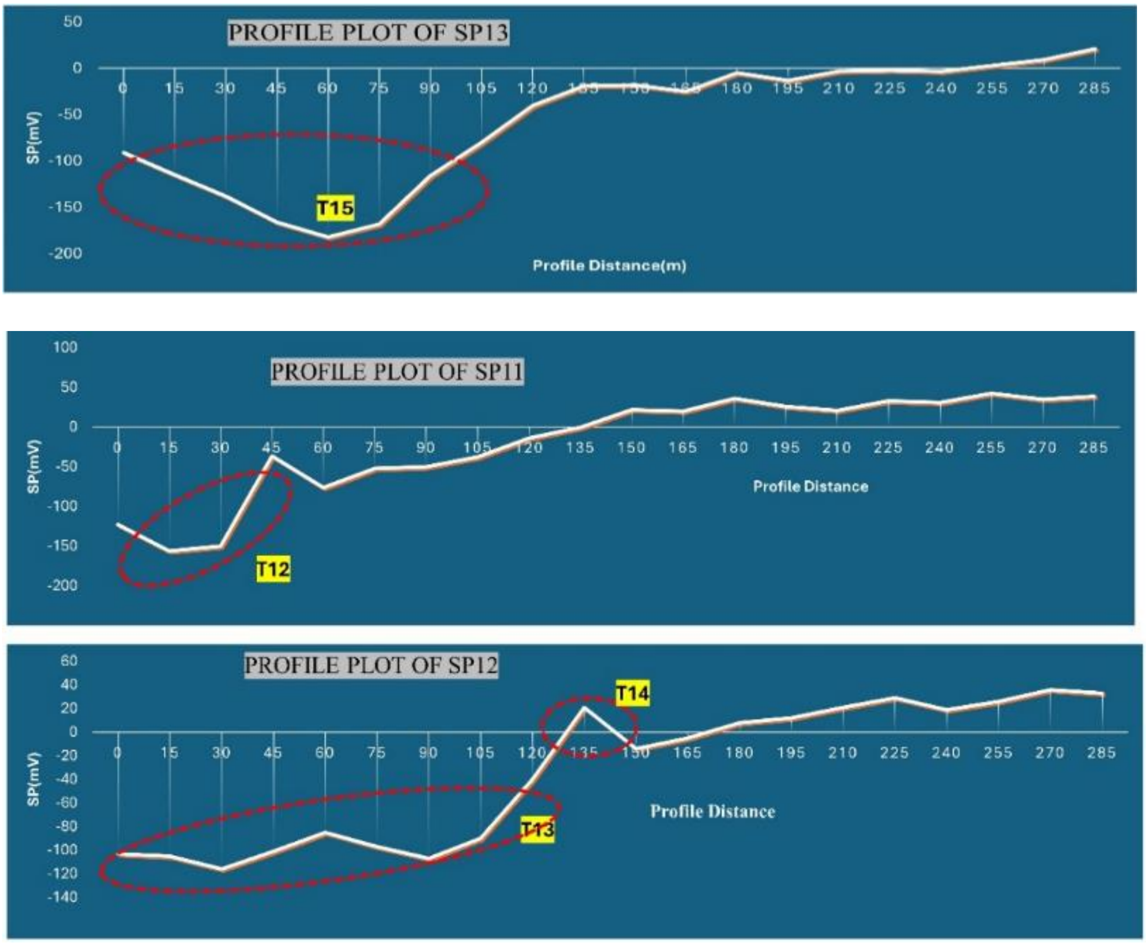



**Fig no-18: Profile plots of all the SP profiles and restricted potential zones**

All the SP values for each SP profile were plotted with the profile distance. Profile areas with negative SP value for each profile were marked with red dotted polygons (T1-T15). The spatial boundaries of these zones were demarcated using ArcGIS 10.5 software and were superimposed on the geological map for validation and correlation. Notably, the regions with the highest graphite potential consistently appeared in the northern sections of each profile. This observation prompts further investigation into the continuity of graphite bodies by increasing the number of SP profiles at standardized intervals.

The findings of this study highlight that every profile reveals at least one prospective area for graphite occurrences, as depicted in **Fig no-18**. Notably, Profiles 12 and 6 exhibit two potential zones, namely (T6, T7) and (T13, T14), indicating heightened prospects for graphite. Furthermore, upon analysing these anomalies in conjunction with the geological map, it becomes evident that Profiles 1, 2, 3, and 5 exhibit a strong correlation with the mapped outcrop zones. This correlation suggests that the outcrops within these anomalous zones possess subsurface continuity, bolstering the for graphite. The zones T12, and T15 associated with Profile 11, and 13 have shown a potential zone shifted northward from the mapped outcrop area. This indicates that along this profile, concealed locations of graphite bodies may lie in the northern part of these profile.

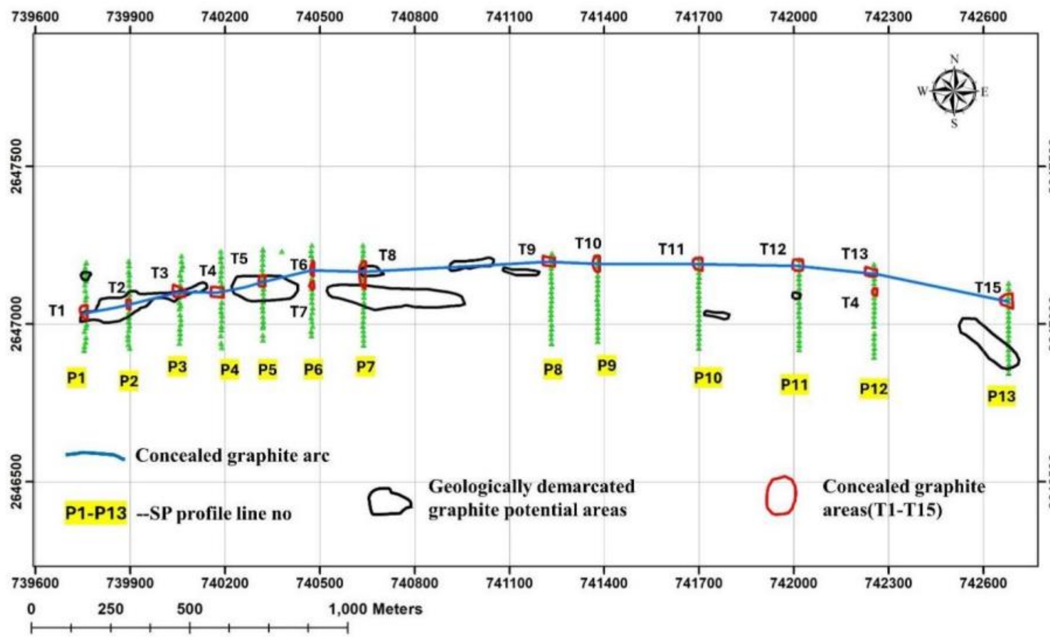



**Fig no-19: a. The potential zones for graphite occurrences are overlain on the geological map b. composite map showing the distribution of SP profiles (P1-P13), graphite outcrop and concealed graphite zones (T1-T15).**

Certain profiles (SP4, SP6, SP8, SP9, SP10, SP12) were conducted in areas where no graphite outcrop exist or reported. The purpose was to assess the subsurface continuity of graphite occurrences in these regions. The positive outcomes from these profiles have validated the existence of subsurface continuity among the graphite bodies. A potential line has been drawn, connecting all the confirmed concealed bodies. This line exhibits an elongated orientation in an East-West direction.

**Recommendation**

Some recommendations can be given to enhance the future quality of the work in graphite exploration.

a. The above interpretation is based on the SP method which may not be sufficient in detail exploration so for another geophysical survey like electrical resistivity tomography, the electromagnetic method can be applied along with SP to enhance the accuracy of the study.

b. Drilling or trenching operations conducted within the aforementioned anomalous zones would be beneficial for confirming the presence of graphite occurrences.

**Table 6.2.1 – Details of Co-ordinates of promising S.P. Anomaly zones in Dindo-Belkurta-Basera Block.**

| Id | UTM_X | UTM_Y |
|---|---|---|
| T1 | 739758.1 | 2647040 |
| T2 | 739894.7 | 2647060 |
| T3 | 740056 | 2647100 |
| T4 | 740187.8 | 2647101 |
| T5 | 740320.4 | 2647136 |
| T6 | 740477 | 2647175 |
| T7 | 740475.8 | 2647125 |
| T8 | 740638 | 2647159 |
| T9 | 741236 | 2647194 |
| T10 | 741380 | 2647185 |
| T11 | 741699.5 | 2647189 |
| T12 | 742018 | 2647189 |
| T13 | 742247.8 | 2647161 |
| T14 | 742254 | 2647101 |
| T15 | 742680 | 2647071 |

## 6.3 GEOCHEMICAL EXPLORATION

### 6.3.1 Selection of surface geochemical exploration type

In Dindo-Belkurta-Basera area, the geochemical exploration has been carried out by random bedrock sampling and followed by groove & trench sampling.

### 6.3.2 Methodology of surface geochemical exploration

Initially the graphite bearing schists were sampled at random from the outcrops, wherever it is available in the mapped area. With the finding of graphite bearing zone along the area between Vimtapur & Belkurta villages for a strike length of 2.7 km, a sampling method was adopted to carry out systematic sampling across the zone gradually to trace the mineralized zone on surface. Wherever it was felt that the graphite zone is covered under a very thin veneer of soil there groove lines were planned across the strike of the zone. A number of groove lines were planned across the zone in a regular interval.

Rock chip samples were collected from each groove from one extremity to other with a definite interval of 1 m. Enough care was taken that samples of different host lithology may not mix with each other. Sampling carried out across the graphite zone and one or two samples from the wall rocks, i.e., non-mineralized zone.

Two trenches were planned in the area where the thickness of the soil cover was almost one meter. Further deeper trenches were avoided keeping in view some local issues. None of the trenches was successful to underlying bedrock.

#### 6.3.2.1 Bedrock sampling

During the field work, a total number of 155 bed rock samples (BRS) were collected for the geochemical analysis. Out of these 155 BRS samples, 131 sample have been collected through systematic groove sampling process and rest of the 24 samples were collected from the other parts of the mapped area including the mineralized zone. Among all BRS samples, 110 samples are of graphite bearing rocks and 21 are of wall rocks and other 24 are of associated rocks. Locations of the surface samples samples are shown on the geological map (PLATE-III).

#### 6.3.2.2 Chemical analyses of surface geochemical data and interpretation

Total 155 bedrock samples were undergone for proximate analyses to determine the fixed carbon value. The FC value ranging from 0.03% to 8.45%. The chemical results are presented in Annexure-III

# CHAPTER 7

# INTERPRETATION OF GEOLOGICAL, GEOCHEMICAL AND GEOPHYSICAL EXPLORATION DATA

## 7.1 Introduction

Large Scale Mapping, geochemical and geophysical investigations were carried out during the G4 stage of exploration in Dindo-Belkurta area. Geochemical data of bedrock samples were correlated with the ground geology to comprehend the surficial influence and control of graphite mineralization. In addition, a geophysical Self-Potential (SP) survey was also conducted to elucidate the concealed bodies of graphite below the surface. Planning of boreholes were done on the basis of these two studies.

The lithological map shows the analytical results of the fixed carbon values (%) of the bedrock samples and SP anomaly stripes (PLATE-IV). The value of fixed carbon in bedrock samples is primarily and indicator of the grade of graphite mineralization.

## 7.2 Discussion

Geophysical study highlighted at least one promising region for graphite mineralization along each SP profile line. Profiles 1–5 show a good association with the recorded outcrop zones on the geological map, implying that the outcrops within these anomalous zones have subsurface continuity. The prospective zones associated with profiles 11 to 13 shifted northward from the mapped outcrop of feebly mineralised graphite zone, and this hinted the presence of source graphite zone. Attempt was done to correlate all the concealed graphite bodies with the surface outcrops. Based on a fixed carbon value larger than 2.00%, a 1-4 m thick graphite band is found on the western side across groove lines 1–6, 1-2m wide graphite band intersected in groove lines 8 and 9, and a thick 11-13 m graphite band in groove lines 11 and 12. Graphite bands practically coincide with geophysical anomalies from the western to the middle region. Difficulties was focused to establish correlation of geophysical anomaly to the east of groove line 12 vis-a-vis the feebly graphite bearing zone.

# CHAPTER 8

# MINERAL PROSPECT

## 8.1 Surface indication of mineralization

Graphite mineralization is predominantly exposed within the dense forest of Dindo-Belkurta forest range along the nala section and limited exposures have been observed at some man-made excavation sites at Belkurta village. The graphite exhibits a colour ranging from light to dark grey as per its concentration along with other minerals and it is microcrystalline in nature. Graphite is occurring here as an essential constituent of micaceous graphite schist, graphite schist and graphite bearing mica schist. Presence of graphite noticed more or less as continuous body in mica schist host rock. The topsoil on graphite zone are grey to light grey in colour in few places. Besides, graphite bearing mica schist are well exposed in a few man-made excavations and agricultural lands in Belkurta village of the mapped area.

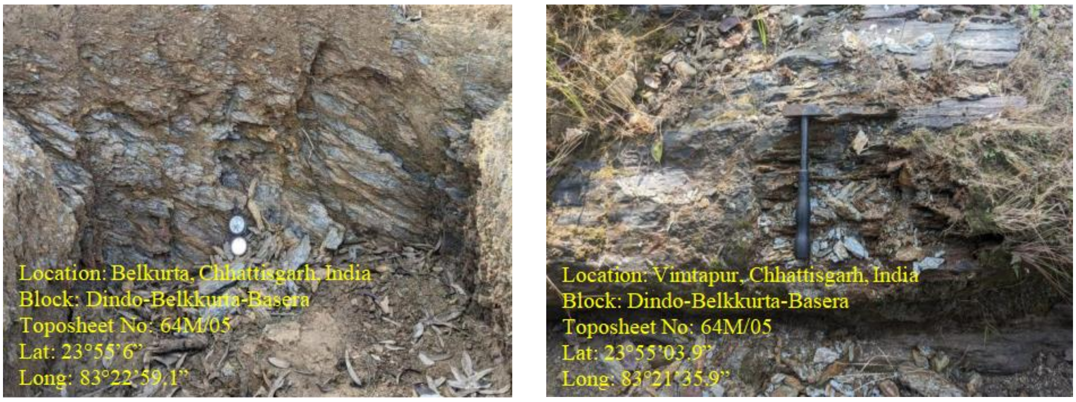



**Fig no-20: Field photographs of graphite bearing mica schist in Vimtapur and Belkurta region, Balrampur district, Chhattisgarh.**

## 8.2 Mode of Occurrence

In the mapped area, the graphite mineralisation shows a concordant nature with the host rock and form parallel to the regional schistosity. The band of graphite varies in width from 1 m to the maximum of 15 m and the strike length of the zone is tentatively 2.7 km. In some places the mineralisation shows small lensoidal bodies along the regional trend.

The host rock of graphite quartz-mica schist and graphite schist is highly deformed and intruded by pegmatites and/or quartz veins. In some places, pegmatite intersects mica schists at low to moderate angle while it exhibits a concordant relation with the host rock in places adjacent to graphite mineralization.

**Fig no-21: Field photograph showing the concordant relationship between pegmatite and mica schist in the dense forest of Dindo-Belkurta forest range, Balrampur district, Chhattisgarh.**

## 8.3. Nature of Mineralization:

In Dindo-Belkurta area the nature of graphite is flaky to amorphous. The ore body mainly consists of small flakes of graphite with steel grey in colour and intimately associated with muscovite flakes. In hand specimen it appears as black to steel grey in colour and usually soils hand and shows greasy lustre. The amorphous variety has comparatively dull or earthy lustre whereas the flaky graphite gives shiny lustre with flakes of muscovite, biotite and graphite. At places within Dindo-Belkurta forest range, graphite bearing mica schist is associated with manganese bearing rocks. Pegmatite emplaced parallel to the body.

## 8.4. Details of Mineralized zone:

The graphite mineralization in the area is an essential component of the graphite schist, graphite bearing mica schist which extend from Vimtapur in the west to Belkurta in the east of the designated block as more or less continuous band. Bands appear intermittently and the total strike length of the mineralized zone is almost 2.7 km in length with the trend of almost east west and the maximum outcrop width of 5 m.

## 8.5. Genesis of Mineralization:

Several hypotheses have been put forth to explain the source of graphite and control on mineralization. Some of these explain the origin and mineralization in a better way. For instance,

(1) In syngenetic origin where later re-mobilization along favourable deformation event takes place and (2) epigenetic origin which is related to deformation events and folding activities which may enhance the mobilization and localization process along less stress area such as hinge of a fold or along a shear zones. Graphite considered to be a progressive and temperature dependant transition from amorphous kerogen to crystalline graphite (Landis, 1971; Grew, 1974; Buseck and Bo-Jun 1985). Graphitization involves the progressive solid-state transformation of carbonaceous materials with increasing crystallinity and increase in metamorphic grade (Sharma et al., 2022). Graphitization of naturally occurring organic carbon may occur at temperatures as low as 300° C to 500° C or as high as 800° C to 1200° C, when an igneous intrusion gets in contact with a carbonaceous body (Rustu S. Kalyoncu, 2000). Since the graphitization process is irreversible is an important indicator of grade of metamorphism. formation in regionally metamorphosed terrain is traditionally.

Carbonaceous matter is ubiquitous in sedimentary and metamorphic rocks; hence the carbonaceous matter changes its crystal structure and its composition systematically with increase in grade of metamorphism irrespective of its origin. At a low grade of metamorphism up to green schist facies, the composition of the precursor material will control the process of graphitization (Diesel et. al. 1978, Busec and Huang 1985, Okuyama Kusunose and Itaya, 1986), whereas, in the high-grade metamorphism, all the carbonaceous matter is converted to graphite (Okuyama, Kusunose and Itaya, 1986). In low grade rocks many authors (Diesel et.al. 1975; Itaya 1981) have noted mixture of carbonaceous matter and graphite (detrital graphite) can be identified by X-ray diffraction (Diesel et. al., 1978) and Wang, 1989). Graphitization process is accelerated in the presence of calcite in pelitic rocks in comparison to arenaceous rocks. Itaya (1981), Wang 1(989) reported further, that to a great extent, graphitization in a regional terrain of metamorphism compared to a contact metamorphic terrain is attained in the temperature range of 410° C to 440°C with little pressure dependence. Thus, the degree and process of graphitization of carbonaceous matter is considered to be controlled mainly by the metamorphic temperature, the duration of metamorphism and metamorphic fluid with some influence from the lithology and original texture of the organic matter. Graphite mineralization in the present study area may occur as a result of epigenetic process which is evident from both field observations, structural relationship with the host rock and microscopic study. Graphite might have deposited as a result of mobility of carbonaceous materials along weak foliation planes of the host rock. This is also evident from thin section study of graphite schist and graphite bearing mica schist rocks (e.g., G/Vim/GR-5/5, DBAS - 134, DBAS - 203).

# CHAPTER - 9

# EXPLORATION BY SCOUT DRILLING

## 9.1. Introduction

Geological mapping, geophysical survey and geochemical sampling were conducted in Dindo-Belkurta-Basera graphite block through large scale geological mapping at 1:12,500 scale, covering an area of 54.4 sq. km. During large-scale geological mapping, discontinuous patches of graphite bodies found to occur along the strike length for a zone of 2.7 km long. Following this the geophysical SP survey confirmed the geological observations regarding the continuity of the ore body below the surface. Geochemical analyses of the bed rock samples and the geophysical SP survey result to plan five boreholes on 25$^{th}$ September 2024. The drilling was completed on 12$^{th}$ October 2024.

Total five number of boreholes were drilled by Maheshwari Mining Private Limited to study the depth continuity and the thickness of the graphite zones in subsurface. A total cumulative meterage of 300 m were drilled in five boreholes.

## 9.2. Stages of Exploration: G4 stage of exploration

Guidelines of MEMC Rule, 2015 has been complied with to accomplish the investigation.

## 9.3. Methods of Drilling

In Dindo-Belkurta-Basera block Hydrostatic Diamond drilling rigs with the wireline method were deployed. In this method diamond tip drill-bit were used to penetrate the lithounits and the core samples were retrieved using a wireline system that allows for quick and efficient extraction of the drill cores without removing the entire drill string from the hole. Boreholes were drilled at an angle of 45° by HQ size drill bit with triple tube techniques for better core recovery. The outer diameter of the HQ rod is 96 mm, and the inner diameter is 63.5 mm. The short runs were drilled to maintain and achieve optimum core recovery.

## 9.4. Borehole planning

Boreholes were strategically planned at five locations to intersect the graphite bearing zone where it has surface manifestations. A total 5 number of inclined boreholes were planned against the dip direction of the interpreted ore body, with an attempt to intersect the ore body at a vertical depth of 30m. Angle of boreholes were maintained 45°.

## 9.5. Borehole summary

**Table-9.1: Borehole summary, Dindo-Belkurta-Basera Block, District – Balrampur, Chhattisgarh**

| Sl no | BH ID | Easting | North i ng | Azimuth | Borehole Inclia tion | Drilling depth (m) | RL of Collar | Date of Commencement | Date of Completion |
|---|---|---|---|---|---|---|---|---|---|
| 1 | DBCD- 01 | 740210.054 | 2647031.666 | N350° | 45° | 60 | 457.181 | 04/10/2024 | 08/10/2024 |
| 2 | DBBH- 02 | 740602.77 | 2647047.84 | N360° | 45° | 60 | 439.836 | 08/10//2024 | 12/10/2024 |
| 3 | DBCD- 03 | 740945.314 | 2647092.387 | N350° | 45° | 60 | 460.242 | 04/10/2024 | 08/10/2024 |
| 4 | DBCD- 04 | 742125.898 | 2646944.836 | N360° | 45° | 60 | 471.406 | 25/09/2024 | 30/09/2024 |
| 5 | DBCD- 05 | 742673.045 | 2647019.416 | N360° | 45° | 60 | 465.173 | 08/10/2024 | 12/10/2024 |

## 9.6. Level of intersection of ore bearing zone

In Dindo-Belkurta-Basera block a total 5 number of boreholes were drilled. The intersection levels of graphite bearing zone for each borehole are described below:

***(i)*** **DBCD - 01:**

Along the borehole from the depth of 37.50 m to 50.00 m, light, grey-coloured mica schist is observed, where graphite is present in variable concentrations as several thin bands. This zone starts at 430.5 m vertical depth and continues upto 421.6m and the fixed carbon values range from 0.21 % to 2.38 %.

***(ii)*** **DBCD - 02:**

Along the borehole from the depth of 10.00m to 32.00 m light greyish mica schist is encountered which contains graphite with variable concentrations as a thin band. This zone corresponds from 432.8m vertical depth to 417.2mvertical depth. Again, along the borehole from the depth of 38.84 m to 39.32 m, 40.31 m to 41.96 m, 42.33 m to 42.79 m, 46.80 m to 47.25 m, 47.45 m to 48.24 m, 52.56 m to 52.87 m, 53.70m to 54.02 m and 54.75 m to 55.00 m thin bands of graphite are encountered in a discreet manner with minor concentration within the mica schist. These zones starts at 412.6 m vertical depth and continues upto 400.9 m vertical depth. The fixed carbon values range from 0.19 % to 2.16 %.

***(iii)*** **DBCD - 03:**

Along the borehole from the depth of 36.00 m to 42.00m graphite is present within the mica schist rock as various thin bands. The vertical depth of intersection of this zone is 434.8 m and it continues upto 430.5m vertical depth This zone shows a fixed carbon value from 0.43 % to 1.90 %. Again, along the borehole from the depth of 42.00m to 54.00 m dark, grey-coloured graphite schist rock is observed. This 12 m thick zone intersected at the depth of 430.5 m and continues upto 422.1m and showing the fixed carbon value varies from 2.16 % to 4.23% .

***(iv)*** **DBCD - 04:**

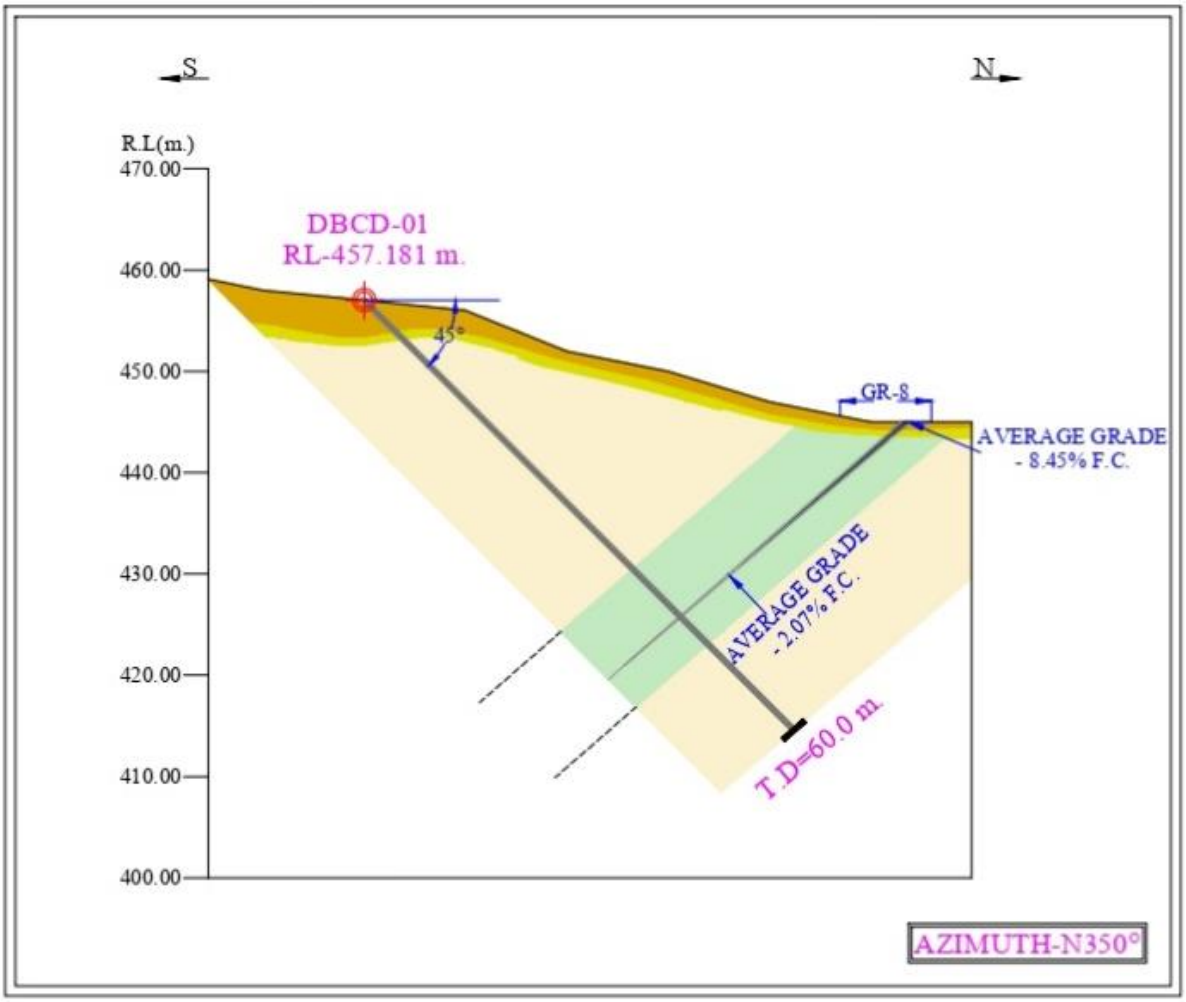
Along the borehole from the depth of 31.90 m to 34.90 m graphite is observed within the mica schist rock with very less concentration. This zone starts from 448.4 m vertical depth and continues upto 446.3m and shows the fixed carbon value from 0.53 % to 0.90 %. After that a 3.1 m thick graphite schist zone is observed where the fixed carbon value ranges from 0.83 % to 1.00 %. Again, along the borehole from the depth of 38.40m to 47.40 m graphite is present discreetly within the mica schist. This zone starts from 412.6 m vertical depth and continues upto 400.9 m vertical depth and shows the percentage of fixed carbon value from 0.35% to 1.53%.

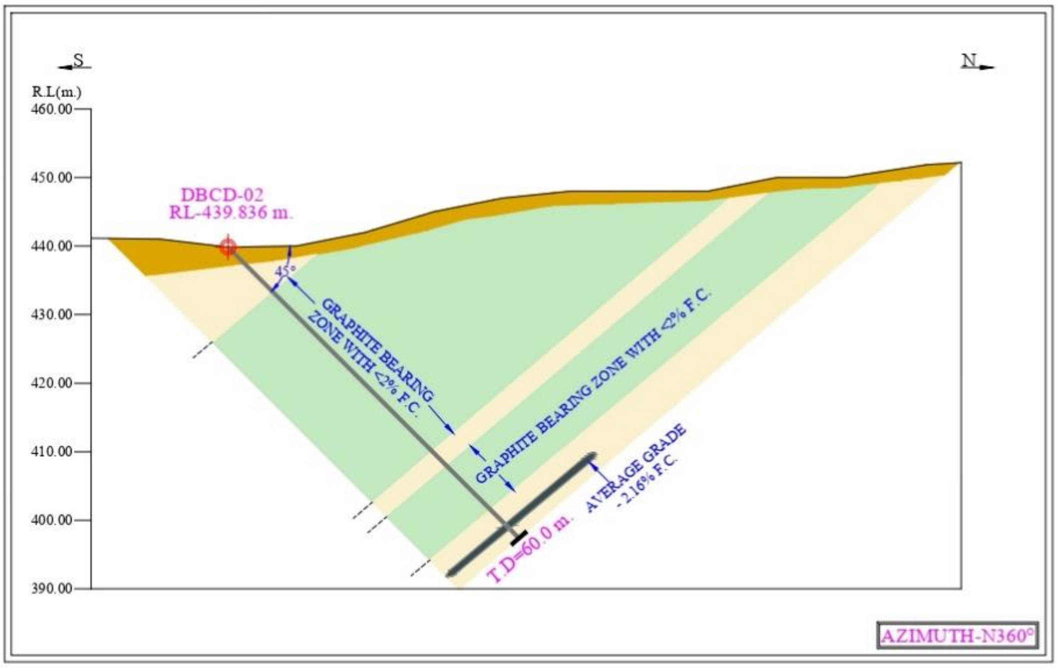
***(v)*** **DBCD - 05:**

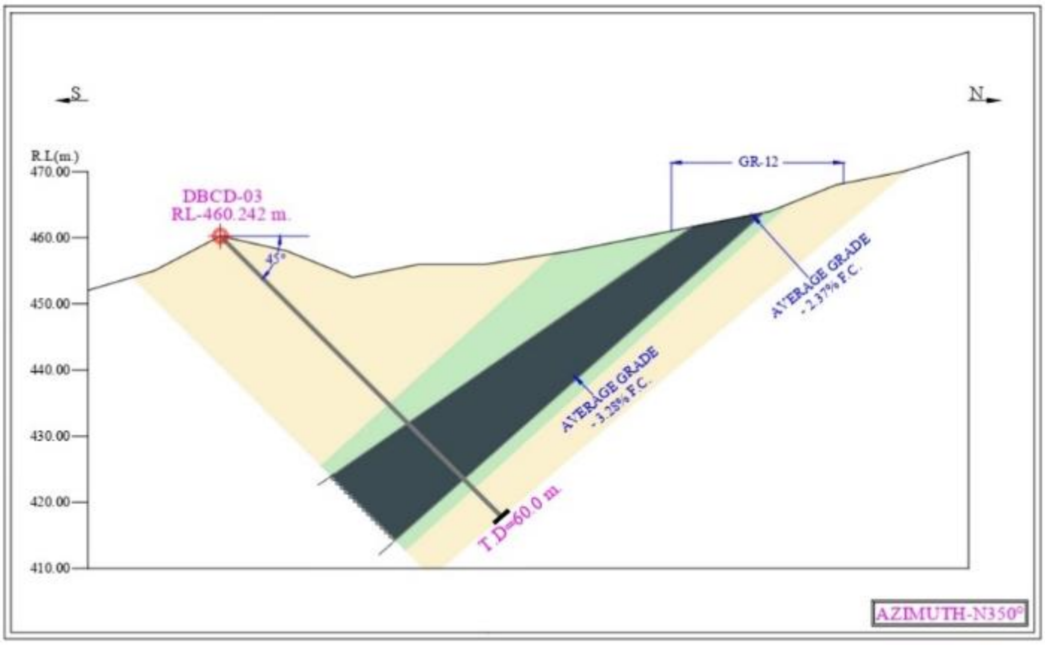
From the depth of 27.50 m to 32.00 m, graphite schist rocks are recorded along the borehole axis. The initial intersected vertical depth is 446.3m and it is continuing upto 443.4m vertical depth. This zone shows the fixed carbon values from 0.39% to 0.92%.

## 9.7. Borehole logging:

The cores obtained from drilling were kept in core boxes for logging and sampling. The core samples were marked with arrows indicating the top and bottom level and steel separator were used after the completion of each run, with the depth of the borehole written on each separator. Borehole data including physical properties, mode of occurrence and percentage of recovery in details for each run were systematically recorded during core logging. The coordinates of each borehole was determined with the help of DGPS survey method. The lithological descriptions of the cores of 5 boreholes drilled by Maheshwari Mining Private limited, are given in the Annexure- II.




S
N
R.L(m.)
460.00
450.00
440.00
430.00
420.00
410.00
400.00
390.00
DBCD-02
RL-439.836 m.
45°
GRAPHITE BEARING ZONE WITH <2% F.C.
GRAPHITE BEARING ZONE WITH <2% F.C.
AVERAGE GRADE - 2.16% F.C.
T.D=60.0 m.
AZIMUTH-N360°


S
N
R.L(m.)
470.00
460.00
450.00
440.00
430.00
420.00
410.00
DBCD-03
RL-460.242 m.
45°
GR-12
AVERAGE GRADE - 2.37% F.C.
AVERAGE GRADE - 3.25% F.C.
T.D=60.0 m.
AZIMUTH-N350°

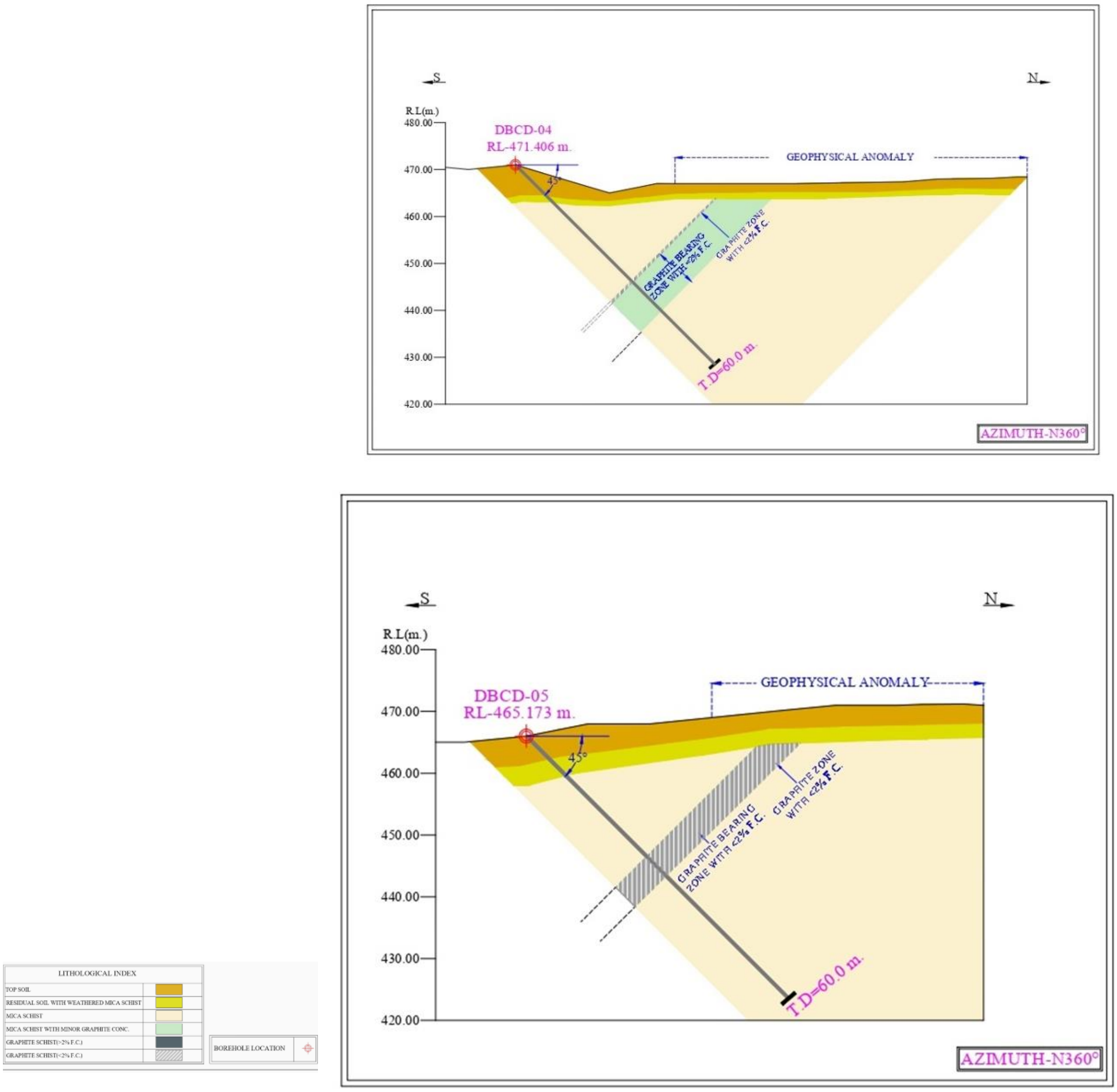



**Fig no-22: Profile sections showing the lithological variations along the boreholes**

**a) DBCD-01; b) DBCD-02; c) DBCD-03; d) DBCD-04; e) DBCD-05**

## 9.8 Core recovery

In Dindo-Belkurta-Basera block the average core recovery varies across 5 number of boreholes depending on the properties of the rock types, RPM of the drilling bits & usage of water. The average recovery is 96.95%. In the first borehole that is DBCD-01, the maximum recovery percentage is 100 and the minimum percentage is 90, maintaining an average recovery percentage value at 96.94. While in the borehole DBCD-02 the maximum recovery percentage is 100 and the minimum percentage is 96, keeping an average recovery percentage value at 98.58. In the borehole DBBH-03, the maximum recovery percentage is 100 and the minimum percentage is 88, maintaining an average recovery percentage value at 96.74. In DBCD-04, maximum value of core recovery percentage is 100 and minimum percentage is 80 and the overall percentage of core recovery is 93.66. Finally for the borehole DBCD-05, maximum value of recovery percentage is 100 and minimum percentage is 96 and the average percentage of core recovery is 98.82.

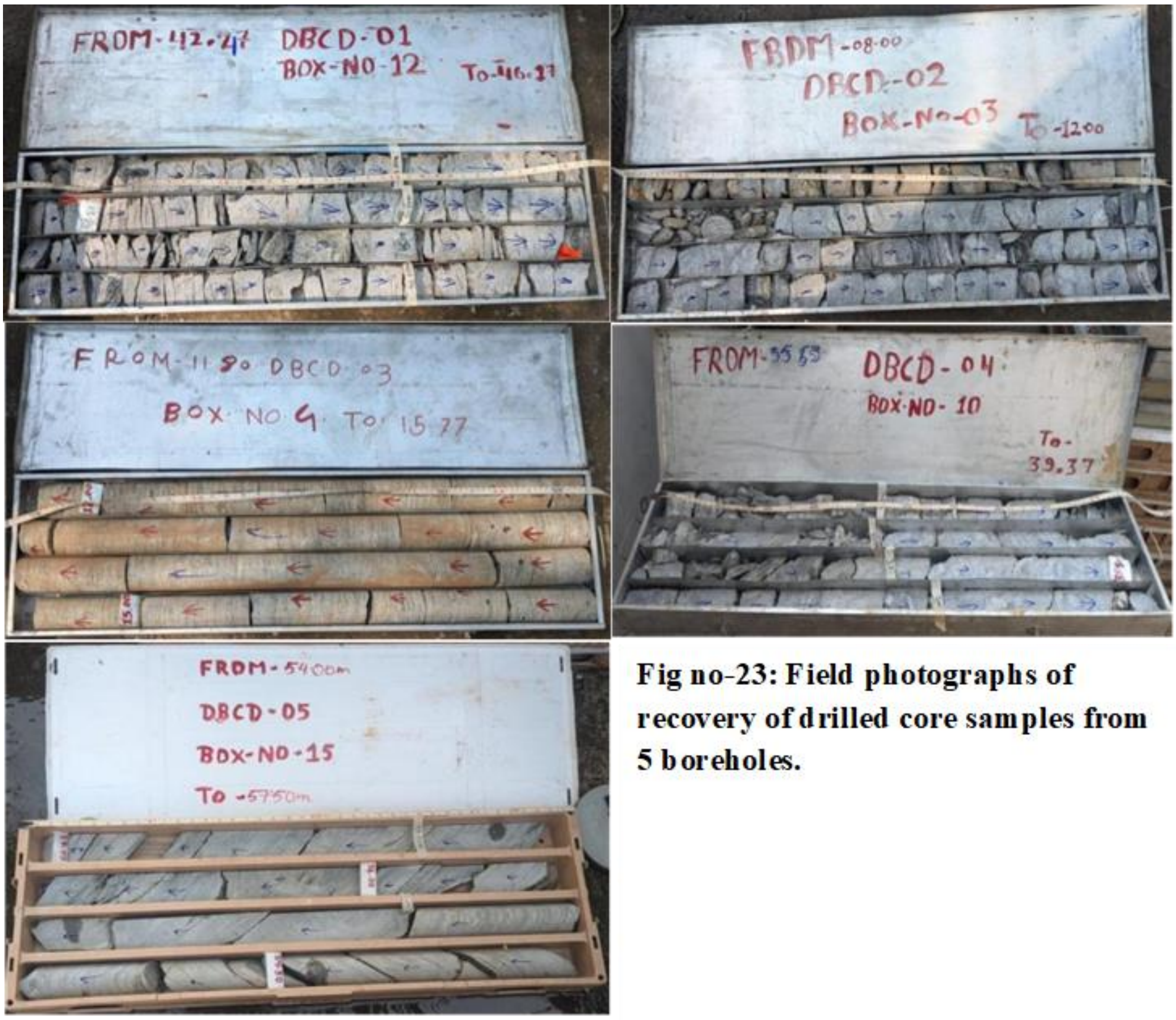



**Fig no-23: Field photographs of recovery of drilled core samples from 5 boreholes.**

## 9.9 Mineralogy of the ore zone

Detailed petrographic studies and field observation indicates that the mineralized zones are composed of flaky graphite associated with quartz-mica schist and graphite bearing schist. Graphite is mainly present along the grain boundaries and foliations. Graphite, black in colour in transmitted light and anisotropic and pleochroic under reflected light (Thin Section No. DBABS-05, G/Vim/GR-5/5, DBCD-03/201, DBCD-03/18, DBCD-03/12, DBCD-03/11). Associated minerals like quartz is subhedral to anhedral in shape, having low relief and colourless under plane polarized light. The muscovites are elongated and euhedral to subhedral in shape, and their orientation defines the regional foliation.

Graphite in some places under thin section is present in garnet bearing mica-schist showing cross- cutting relationship with the regional foliation trend. The presence of porphyroblasts of garnet indicates medium grade of metamorphism. In some thin sections, foliations are seen to be truncated against the grains of garnet, which indicate that garnet was formed after the regional deformation event.

## 9.10 Borehole pillaring

On the successful completion of drilling of all 5 boreholes, pillars were constructed at each drilling point for future reference and identification.


**Fig no. 24 : 5 pillars embedded at 5 borehole drilling point**

## 9.11 Methodology of ore zone sampling and sample preparation

During the exploration of the Dindo-Belkurta-Basera Graphite block, 5 number of boreholes were drilled as a follow up of planning through five profiles. Inclined boreholes drilled to intersect the graphite bearing zone. The boreholes drilled have intersected soil, sludge, different rock types and graphite mineralised zone. All through the mineralised zone, suspected mineralised zones along with wall rocks were carried out from longitudinally half split cores. Minimum standard sample length was maintained at 50 cm, although variations occur due to the differences in lithology and concentration of ore mineralization. In areas where the thickness of the ore zone was less than 50 cm, the entire thickness was taken into consideration for sampling as single sample. However, the ore zones having thickness more than 1 m, sampling was conducted with the maximum thickness of 1 m, but in few instances the maximum thickness reached to 1.40 m to limit the number of samples as specified in NQT guidelines.

After the marking of meterage on ore bearing zone and two samples from each hanging wall & foot wall rocks the core samples were split longitudinally into two halves, one half was taken for geochemical analysis and the other put forward for the preservation in the respective core boxes for future reference. Each marked sample was then powdered through 120 mess size sieve using mortar and pestle at camp. Furthermore, these powdered samples were dispatched to NMCI Shree Coal Laboratory for analysis of fixed carbon content. The samples underwent proximate analysis in NMCI Shree Coal Laboratory using IS: 11321-1982 test method. The major oxide and some minor elements were analysed using XRF and REEs with some trace elements analysed by ICP-MS by Shiva Analyticals (India) Pvt. Ltd.

## 9.12 Chemical analysis and laboratory procedure

Total of 142 samples were selected for proximate analyses study to determine the fixed carbon value. Process for determining fixed carbon content adheres to IBM standard IS: 11321-1982. Proximate analysis involves removing moisture and measure volatile matter and ash concentration. After determining these two parameters, the summation is then subtracted from100. This is how fixed carbon value can be obtained.

**9.12.1. Determination of moisture:** About 5 gm of sample is weighted in a tared porcelain dish and covered with a watch-glass. Then this dish is placed in an air-oven maintained at a temperature 150°± 1° and remove the watch-glass from it. Then the sample is heated for 2 hours in the oven and dish is covered with the watch-glass before it is taken out from the oven. Next the dish keep cooling down in desiccator and weighed. The following formula is used for calculating the moisture content.

$\text{Moisture (\%)} = \frac{A}{B} \times 100$ A= Loss in weight in gram after heating B= Weight in gram is taken.

**9.12.2 Determination of volatile matter:** Nearly 1 gm of moisture free sample is introduced in weighted volatile matter crucible with tightly fitted lid. Then this crucible is heated in muffle furnace maintained at a temperature of 925°± 25° C for 7 minutes. The bottom of the crucible shall not rest on the floor of the muffle furnace. Upon removal of the crucible from the furnace, cooling it in a desiccator and weigh can lead to the determination of volatile matter content. The following formula can use for the calculation of the volatile matter.

$$\text{Volatile Matter (\%)} = \frac{A}{B} \times 100$$

(A= Loss in weight in gram of the moisture free sample after heating. B= Weight in gram is taken.)

**9.12.3. Determination of Ash:** Nearly 1 gm of moisture free sample is taken in a silica crucible, keep the crucible in a muffle furnace and heating upto 500°± 10° C for 1 hour and 75°± 10° C for 2 hours. Slow stream of air is maintained through the muffle furnace is allowed. The temperature is further increased to 925°± 25° C is keeping for 1 hour. After this cooling it in a desiccator and weigh the sample. This procedure repeats till the residue the crucible is get constant in weight. The following formula can be used for the calculation of the ash content.

$$\text{Ash Content (\%)} = \frac{A}{B} \times 100$$

(A= Weight of ash in gram B= Weight of the sample taken in gram)

After determination of these parameter, fixed carbon can be calculated from the following formula:

$$\text{Fixed Carbon (FC)} = 100 - \text{VM (\%)} + \text{Ash (\%)}$$

FC= Fixed Carbon. VM = Volatile Matter. Ash = Ash content.

**9.13 Major oxide and trace elemental analyses:**

A total 60 samples were selected from different bedrock samples and core samples and sent to Shiva Analytical (India) Pvt. Ltd. for major oxide and trace elemental studies through X-Ray Fluorescence (XRF) and Inductively coupled Mass Spectrometer (ICP-MS).

The analytical results are attached in Annexure- IV, Annexure- V & Annexure- VI.

### 9.14 Check sample analyses:

As a part of G4 stage of exploration, approximately 10% of duplicate samples from bedrock samples and core samples obtained from 5 boreholes were sent to NABL accredited laboratory of TATA for checking the variation in results of proximate analyses of the samples analysed from NMCI Shree Coal Laboratory. The analytical results are attached in Annexure- VII.

### 9.15 Details of intersected ore zone of drilled boreholes and their correlation:

The details of the intersected ore zones at ≥ 2% cut-off of graphite of the boreholes are presented in the tabular format in Annexure-II. The mineralized zone ≥ 2% cut-off were plotted in various profile sections to understand the behaviour of the ore body. In the western portion, the graphite band is found to intersect in borehole DBCD-01 at a depth of 49.00m and continues upto 50m along the borehole and the graphite is correlated with the 1m band of graphite schist encountered in groove line G8. For borehole DBCD-02, 1m thick graphite zone is intersected at a depth of 58.00m and continues upto 59.00m along the borehole. Corresponding to these boreholes there is no surface exposure of graphite. In borehole DBCD-03, a zone of 11m graphite intersected at a depth of 41.00m and continues upto 52.00m and it is correlated with 11m wide band of graphite exposed on surface along groove line G-12. For boreholes DBCD-04 and DBCD-05 mica schist with very less concentration of graphite intersected the boreholes at the depth of 34.90 m and27.50m respectively along the borehole.

# CHAPTER – 10

# RESOURCE ESTIMATION

MMPL carried out G4 stage of exploration to understand and study the presence of graphite and its depth continuity and potentiality in Dindo-Belkurta-Basera Graphite Block, Balrampur district of Chhattisgarh. Along the strike direction of the graphite band, a total of 5 number of inclined boreholes were drilled with irregular spacing within the mapped area of 54.4 square kilometre. Total drilled meterage was 300 meters with 60 m drilled meterage for each borehole. The primary objective was to study the depth continuity and evaluate the grade of the graphite mineralization of the area and estimate the Reconnaissance Resource (334).

Resource estimation was attempted for graphite on the basis of fixed carbon value of the ore bearing zone along groove lines and intersected in the drilled boreholes. The analytical results of the surface samples ranging from 0.03% to 8.45% and the core samples representing the graphite bearing mica schist, graphite schist and micaceous graphite schist exhibit the value of fixed carbon content ranging from 0.11% to 4.23%. However, the resource estimation was attempted considering a cut-off of fixed carbon value 2.00% ( Threshold value).

In Dindo-Belkurta block graphite bearing zone has been delineated and resource estimation has been done by cross-section method based on the cut-off of FC value 2%.

## 10.1. Detail description of ore zone

Based on the surface evidence and characteristics observed of depth from borehole core samples, the following inferences can be drawn on graphite mineralization of this area.

- Graphite of this area is flaky and mainly found in quartz-mica schist and graphite schist, with quartz, muscovite, biotite, and garnet as the major gangue minerals.
- Graphite mineralization follow mainly the regional schistosity of the area and present along the grain boundary as well as the interstitial spaces of muscovite minerals.
- Within the mica schist few millimetres to centimetres thick streaks of graphite are also present which follow the foliation at DBCD- 04 & DBCD- 05.
- Though graphite mineralization maintained a parallel relation with the regional schistosity, it occasionally show a cross-cutting relationship with schistosity planes at a low to moderate angle and sometimes occur along small fractures or weak planes in microscopic scale (e.g., thin section-DBCD-03/18).

## 10.1. Consideration of cut-off grade

As the nature of graphite in the area is mostly flaky type, the present general cut-off of Indian Bureau of Mines for flaky variety was taken into consideration. The present cut off or threshold value for graphite reported by Indian Bureau of Mines is 2 % (IBM 60$^{th}$ edition of the Indian Mineral Yearbook 2022). The analytical results of surface samples and subsurface samples clearly indicate that the fixed carbon values of Dindo-Belkurta area vary from <1% to as much as 8.45%. Therefore, in compliance with IBM guideline, it has been decided to estimate graphite resources in the area at 2.00% FC.

## 10.2. Correlation of ore bearing zones

Graphite bearing zone was intersected in each borehole from DBCD - 01 to DBCD - 05. Both in the boreholes of DBCD - 01 and DBCD - 02 several thin bands of graphite are intersected within mica schist. While in DBCD - 03 and DBCD - 04, thick band of graphite schist was encountered from a depth of 45.00 m to 54 m and 34.90 m to 38.49m, respectively. Additionally, in these two boreholes, i.e., DBCD - 03 and DBCD - 04 various thin bands of graphite is also present within micaceous graphite schist lithounit but those are not taken into consideration as values of these zone with < 2% FC. In the drilled hole of DBBH - 05, graphite schist was encountered from the depth of 27.50 m to 32.00 graphite bands cut across groove lines on surface are correlated with the intercept in borehole at depth with the help of cross sections. Correlation of boreholes for graphite lithounit and other lithounits is shown in **Fig no-23**

## 10.3. Bulk density determination

A total 4 number of core samples were subjected for the determination of bulk density at Shiva Analyticals (India) Private Limited, Hoskote, Karnataka. The average bulk density of these samples is calculated as 2.55 which is considered for ore resource estimation. Bulk density determined for each sample is given below.

| **Table-10.1: Bulk density result** | | | |
|---|---|---|---|
| **Sl. No.** | **Sample ID** | **Bulk density** | **Unit** |
| 1. | **DBCD - 03/012** | 2.60 | g/cc |

| | | | |
|---|---|---|---|
| 2. | **DBCD - 03/014** | 2.57 | g/cc |
| 3. | **DBCD - 04/007** | 2.51 | g/cc |
| 4. | **DBCD - 04/008** | 2.54 | g/cc |

## 10.5. Assumptions and Methodology for resource estimation

The following principle was adopted during the estimation of resource of graphite under G4 stage:

- Nature of graphite in this area is mostly flaky type, the cut-off for flaky variety was taken into consideration, 2 % FC.
- The average bulk density of 2.55 for 4 graphite schist samples were taken into consideration during the resource estimation.
- True thickness of the ore body was calculated by multiplying the apparent thickness along the borehole axis with Sine of angle produced by core axis and ore body.
- For surface sampling, true thickness was calculated by multiplying the apparent thickness of the mineralized zone along groove lines with Sine of dip angle of ore body.
- Strike influence was taken for a groove line upto 50% distance between two adjoining groove lines. In case of groove line placed on the either extremity, the influence was considered upto 25% distance of the length between two groove lines. Therefore, the strike influence for G1, G6, G8, G9 ,G11 and G12 is 37.5 m and the strike influence for G2,G3,G4, and G5 is 50m.
- The dip influence was taken along the dip length of the ore body upto 50% from groove line to the intersection point of the borehole with the graphite zone on the dip surface. For a borehole 50% of the distance along dip length is considered towards groove line and an additional distance of 25% from borehole intersection on ore body downward.
- For borehole DBCD-01, -03, strike influence was taken similar to their corresponding groove lines G8 and G12, respectively. For borehole DBCD-02 it was taken 50% of distance between G8 & G9 on both side which is around 50m
- For groove line G1 to groove line G6 and G9 and G11, the dip influence was taken upto 15m vertical depth from the surface, since corresponding to this zone no borehole could be planned, whereas the band could be traced consistently on surface along its strike in this segment.

**Table No: 10.2 Resource estimation by cross sectional method**

| BH ID/ GROOVE ID | STRIKE INFLUENCE (m) | DIP LENGTH(m) | AREA OF INFLUENCE/SURFACE AREA (sq.m) | THICKNESS (m) | VOLUME (m^3) | BULK DENSITY (g/cc) | RESOURCE IN TONNES | RESOURCE IN MILLION TONNES | WEIGHTED ASSAY FC % | AVERAGE GRADE (FC%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **G-1** | 37.5 | 25.1 | 941.25 | 0.62 | 583.575 | 2.55 | 1488.12 | 0.001 | 3.35 | **3.34%** |
| **G-2** | 50.0 | 24.5 | 1225 | 0.62 | 759.500 | 2.55 | 1936.73 | 0.002 | 2.01 | |
| **G-3** | 50.0 | 24.7 | 1235 | 1.23 | 1519.050 | 2.55 | 3873.58 | 0.004 | 5.395 | |
| **G-4** | 50.0 | 25.2 | 1260 | 1.85 | 2331.000 | 2.55 | 5944.05 | 0.006 | 2.84 | |
| **G-5** | 50.0 | 25.55 | 1277.5 | 2.46 | 3142.650 | 2.55 | 8013.76 | 0.008 | 2.35 | |
| **G-6** | 37.5 | 24.5 | 918.75 | 1.23 | 1130.063 | 2.55 | 2881.66 | 0.003 | 4.43 | |
| **G-8** | 37.5 | 19.335 | 725.0625 | 0.62 | 449.539 | 2.55 | 1146.32 | 0.001 | 8.45 | |
| **G-9** | 37.5 | 24.6 | 922.5 | 1.23 | 1134.675 | 2.55 | 2893.42 | 0.003 | 2.24 | |
| **G-11** | 37.5 | 22.8 | 855 | 5.35 | 4574.250 | 2.55 | 11664.34 | 0.012 | 2.45 | |
| **G-12** | 37.5 | 30.235 | 1133.8125 | 7.36 | 8344.860 | 2.55 | 21279.39 | 0.021 | 2.37 | |
| **DBBH-1** | 37.5 | 29.02 | 1088.25 | 0.62 | 674.715 | 2.55 | 1720.52 | 0.002 | 2.07 | |
| **DBBH-2** | 50.0 | 21.95 | 1097.5 | 0.67 | 735.325 | 2.55 | 1875.08 | 0.002 | 2.16 | |
| **DBBH-3** | 37.5 | 45.35 | 1700.625 | 8.03 | 13656.019 | 2.55 | 34822.85 | 0.035 | 3.28 | |
| | | | | | | | **99539.81** | **0.100** | | |

## 10.6 Resource estimation by SURPAC 3D modelling

Assessment of resource for graphite has been estimated based on analytical results of surface sample and core samples with fixed carbon ≥2% through Cross-sectional area method using SURPAC 3D Modelling Software. The consideration for resource estimation has been carefully structured, with the following key factors:

1. **Influence along the strike**:

The influence along the strike direction has been considered to be 50% of the distance between two successive groove lines. In this case, the distance between two groove lines is 50 m. Therefore, the calculated strike influence is 50% of 50 m, which results in an influence of 25 m.

For groove lines located at the extreme ends of the graphite zone, the influence is reduced to 25% of the distance between two groove lines. Therefore, to the east and west of extreme groove lines is considered as 12.50 m.

2. **Influence along the dip direction**:

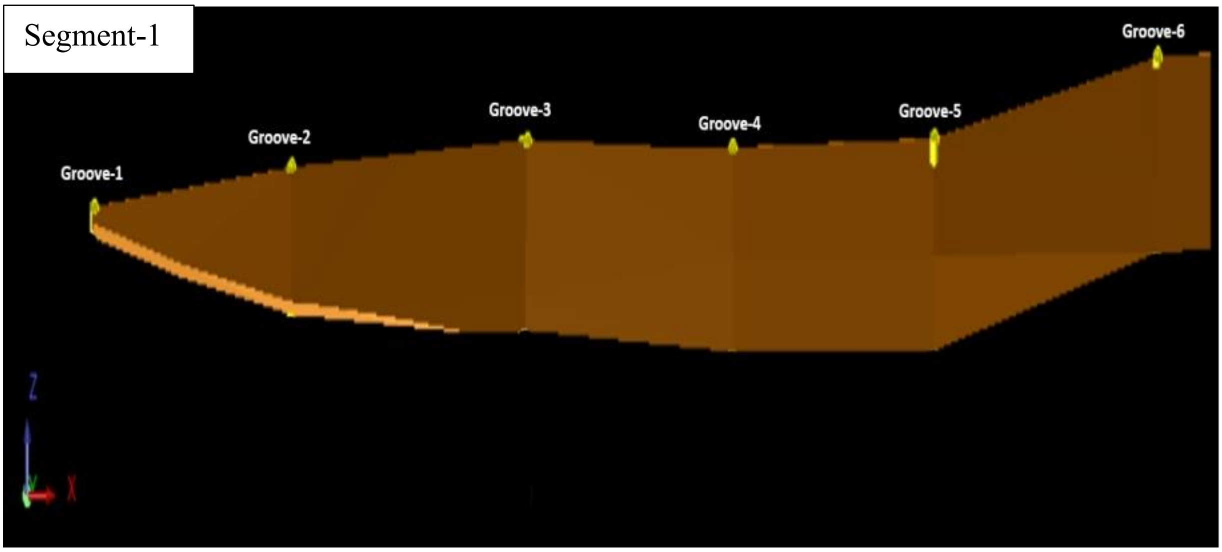
The dip length has been taken as 50% of the distance between groove line and borehole intersected point on ore body. The dip length for a borehole has been considered as 50% distance between groove line and intersected point of borehole on dip surface and 25% distance of the above to the deeper part of the ore body on dip surface.

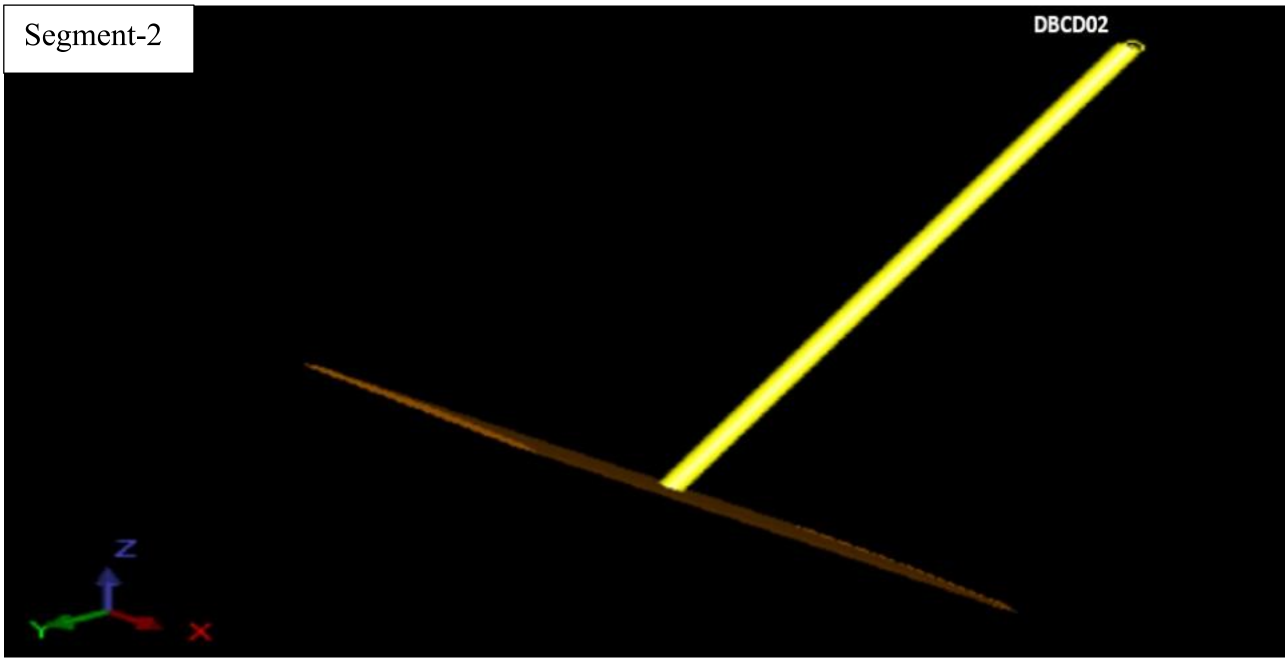
For the groove line G1-G6, G9 and G11, the dip length has been calculated by dividing 50% of vertical depth of intersection which is 15m and the Sine of dip amount of the ore body.

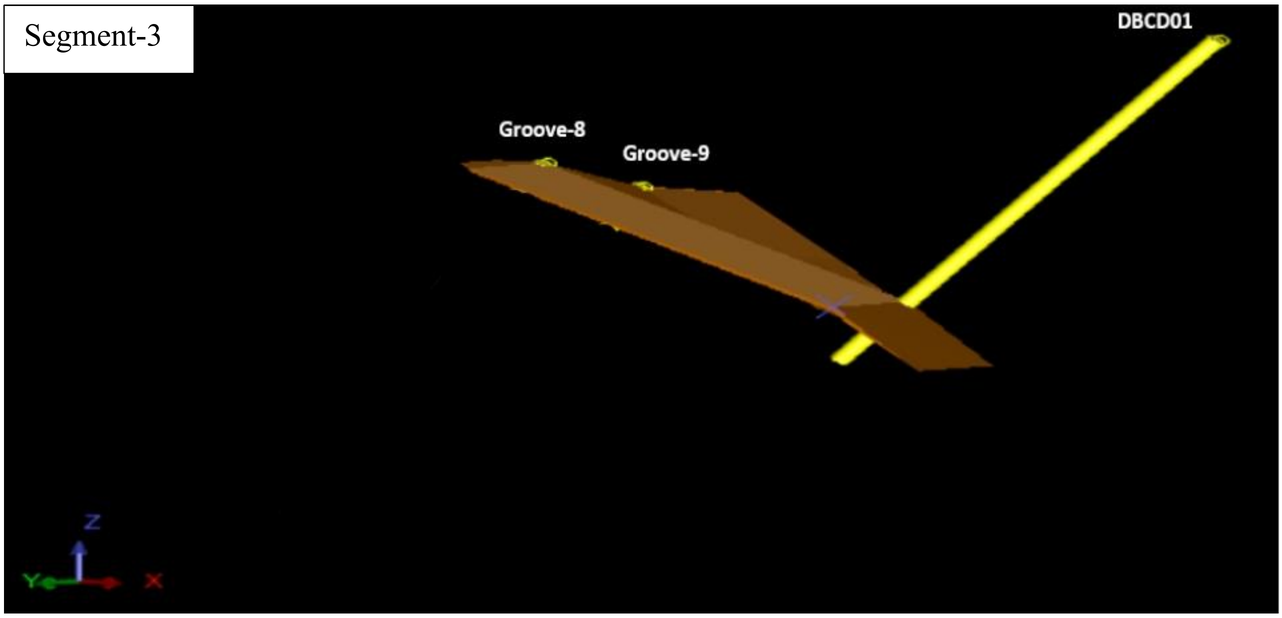
3 **Influence for Inclined Boreholes:**

The same consideration has been applied for boreholes DBCD-01, DBCD-02 and DBCD-03. Since the FC value is below the set cut-off (2% FC) for the samples of DBCD-04 and DBCD-05, these two boreholes have not been taken into account for resource estimation.The resource estimation has been carefully compiled and presented in the table below: (Table No:10.2)

| Table No:10.3: Resource estimation segment wise via SURPAC 3D modelling | | | | |
|---|---|---|---|---|
| **Category** | **Volume (in Cubic meter)** | **Bulk Density (average)** | **Tonnes** | **Resource in MT** |
| Segment I (Groove 1-6) | 12749 | 2.55 | 32509.95 | 0.03250995 |
| Segment II (Groove 8, 9, DBCD01) | 2051 | 2.55 | 5230.05 | 0.00523005 |
| Segment III (DBCD02) | 780 | 2.55 | 1989.00 | 0.00198900 |
| Segment IV (Groove 8, 9, DBCD03) | 25180 | 2.55 | 64209.00 | 0.06420900 |
| **Total Resource of Graphite orebody (FC≥2%) in MT** | **40760** | | **103938.00** | **0.103938≈0.10** |




Segment-2
DBCD02
Z
Y
X


Segment-3
DBCD01
Groove-8
Groove-9
Z
Y
X

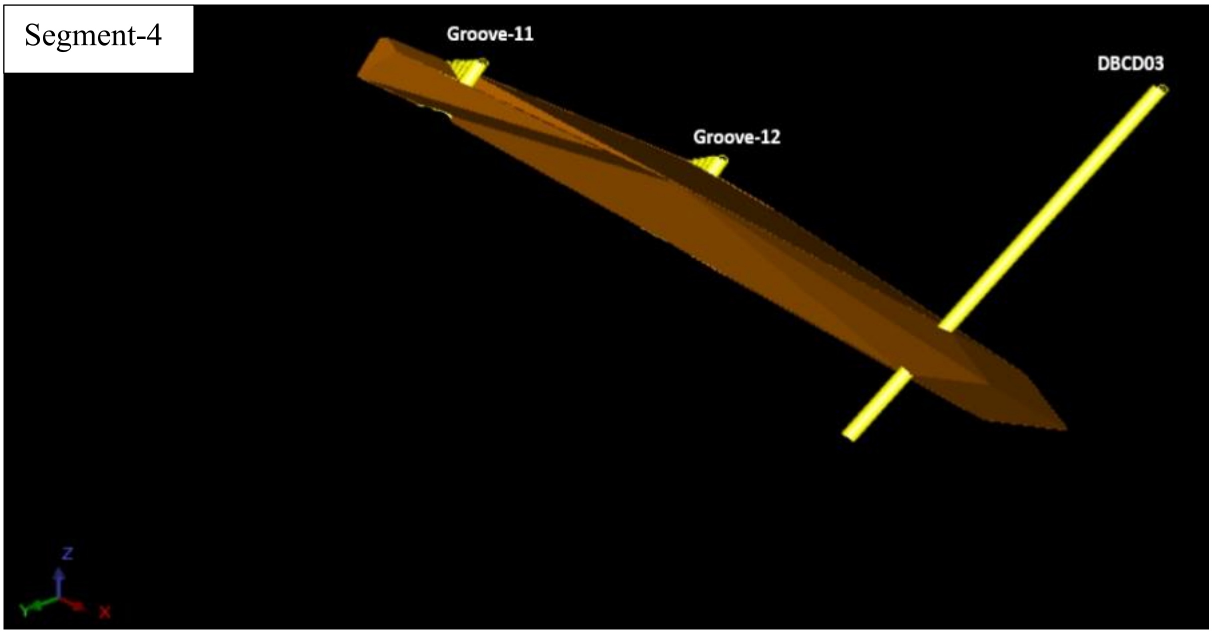



**Fig no-24: The figures provided above offer a detailed pictorial representation of the solid model for the Graphite bearing Ore body by SURPAC 3D Modelling software.**

### 10.7 Category of resource

The tentative resource of graphite belong to **"Reconnaissance Category (334)"** as per the MEMC rule,2015.

### 10.8 Summary of resources

#### 10.8.1 By cross-sectional method:

An attempt of establishing the tentative resource of graphite using cross-sectional method at 2% FC threshold value is 99539.81tonnes with an average grade of 3.34% FC value within 13324.25 sq. m area within the identified and marked ore bearing zone. This tentative resource belong to **"Reconnaissance Category (334)"**.

#### 10.8.2 By SURPAC Modelling:

With the help of SURPAC 3-D modelling software, a tentative estimated resource of 103938.00 tonnes with an average grade of 3.34% FC value was established.

# CHAPTER -11

# CONCLUSION AND RECOMMENDATION

## 11.1. Conclusion

Graphite is present in the mapped area of Dindo-Belkurta-Basera block within mica schist rock and the mineralized zone follows the regional schistosity. The strike of the ore zone is almost east-west southerly dip. In the central part of the mapped area graphite is present along a zone with a strike length of almost 2700 m . Three prominent bands of graphite interpreted for a strike length of 249.97m, 45.37m and 70.00m. The maximum outcrop width of mineralized zone is 13m and minimum width is 1m. These three mineralized zones are located on the western to central part of the mapped area. In the eastern part of the block outside the mapped area graphite bearing schist is present along the strike length of the mineralized body.

The graphite is mainly flaky in nature and present as graphite schist and graphite bearing mica schist. The fixed carbon value of graphite is ranging from 2.00% to 8.45% on surface & core samples within the graphite schist and the FC value ranging from 0.03% to 1.99% in graphite bearing mica schist.

An attempt of establishing the tentative resource of graphite using cross-sectional method at 2% FC cut off value is estimated 99539.81 tonnes with an average grade of 3.34% FC. This tentative resource belong to "Reconnaissance Category (334)".

A total 0.103 million tonnes with an average grade of 3.34% FC value was established using cross-sectional method on SURPAC 3-D model.

## 11.2. Recommendation

Based on field observation, Geophysical SP anomaly map and borehole data, it can be inferred that the graphite is present near surface and may be at a considerable depth in some places. Some deeper boreholes and more line kilometre of geophysical survey can lead to a more detailed and precise understanding of the mineralized zone in this area and adjacent to it. Area is recommended for exploration by upgrading the stage G3 along with characterization of graphite through beneficiation studies.

# CHAPTER -12

# BIBLIOGRAPHY


- Bonijoly, M., Oberlin, M., Oberlin, A., & Laboratoire Marcel Mathieu. (1982). A possible mechanism for natural graphite formation. International Journal of Coal Geology (Vol. 1, pp. 283–312). Elsevier Scientific Publishing Company.
- Buseck PR, Huang B-J (1985): Conversion of carbonaceous material to graphite during metamorphism. Geochim Cosmochim Acta 49: 2003-2016.
- Diessel, C.F.K and Offler, R. (1975): Change in physical properties of coalified and graphitised Phyo clasts with grade of metamorphism. Neues Jahrb Mineral. Mh.,1,11-27.
- Diessel CFK, Brothers RN, Black PM (1978): Coalification and graphitization in high-pressure schists in New Caledonia. Contrib Mineral Petrol 68:63-78.
- Grew, E.S., 1974. Carbonaceous material in some metamorphic rocks of New England and other areas. Journal of Geology, 82, 50-73.
- GOVERNMENT OF INDIA, MINISTRY OF MINES, INDIAN BUREAU OF MINES. (2023,November). Indian Minerals Yearbook 2022 (Part- III : Mineral Reviews).
- Itaya, T. (1981) : Carbonaceous material in pelitic schists of the Sanbagawa metamorphic belt in Central Shikoku, Japan. Lithos, 14, 215-24.
- Landis, C.A., 1971. Graphitization of dispersed carbonaceous material in metamorphic rocks. Contrib. Mineral. Petrol., 30: 34--45.
- Lenka, B., Shukla, S., GEOLOGICAL SURVEY OF INDIA, CENTRAL REGION, A Report on General Exploration of Graphite in Tikari-Gauthana-Chiklar and Surrounding Areas, Betul District, M.P (G-2 stage). Limited Circulation Report.
- Mishra, B. K., Kumar, M., (1993). Geology of Dindo-Ramchandrapur area, Wadrafnagar and Ramanujganj tahsils, Surguja district, Madhya Pradesh.

- Pitroda, S. G., Nehru, J., Mazdoor Kisan Shakti Sangathan, Bhartṛhari, Bureau of Indian Standards, Samant, L. D., Indian Standards Institution. (1985, May). Graphite for graphite crucibles. (S. K. Gupta, Ed.).
- Saha, B. (2001). Preliminary exploration for base metal, manganese and graphite in Oranga metamorphic belt, Surguja district.
- Wang G-F (1989) Carbonaceous material in the Ryoke metamorphic rocks, Kinki district, Japan. Lithos 22:305-316.

# CHAPTER -13

# LOCALITY INDEX

| LOCALITY INDEX | | | |
|---|---|---|---|
| SL. No. | Locality | Latitude | Longitude |
| 1 | Dindo | 23°55'31.9" N | 83°19'15.9" E |
| 2 | Belkurta | 23°55'36.3" N | 83°23'30.2" E |
| 3 | Basera | 23°53'49.3" N | 83°20'33.4" E |
| 4 | Vimtapur | 23°55'15.9" N | 83°23'13.5" E |
| 5 | Bhagoditola | 23°56'30.3" N | 83°22'01.7" E |
| 6 | Ganjar | 23°56'11.9" N | 83°25'31.3" E |
| 7 | Dindo Police Station | 23°55'51.0" N | 83°19'48.0" E |