

GEOLOGICAL REPORT

ON PRELIMINARY EXPLORATION

(G-3 STAGE) FOR

REE & ASSOCIATED MINERALS



IN

UMPRIKHOLA BLOCK

DISTRICT – KAMRUP (METRO),

STATE – ASSAM

(Under NMEDT Programme)

TEXT, ANNEXURE AND PLATES



Area

4.80 sq. km



Toposheet

78N/16 (SOI)



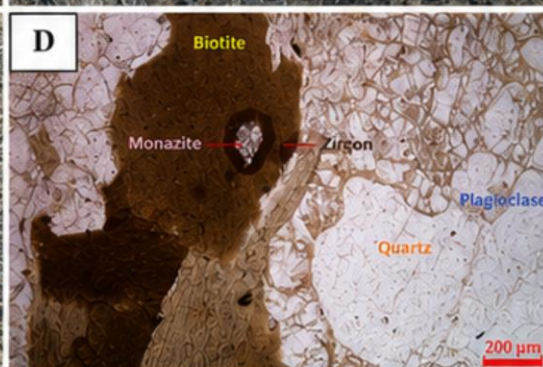
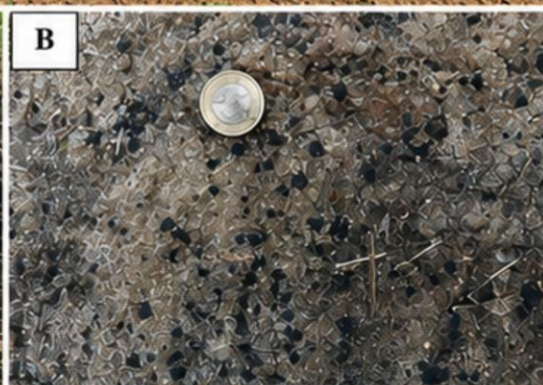
Location

26° 01' 49.58902" N to

26° 03' 05.91748" N

91° 52' 24.37977" E to

91° 54' 12.56495" E



A: Stockwork intrusion of pegmatitic vein into the Diorite **B:** Coarse grain pegmatite within the Outcrop

C: Sulphide mineralised vein in the Diorite **D:** Photomicrograph showing monazite and zircon inclusions within biotite as seen under plane polarized light.



MINERAL EXPLORATION & CONSULTANCY LIMITED

(formerly known as Mineral Exploration Corporation Limited)

(A Government of India Enterprise)

Ministry of Mines, Govt. of India



JULY 2026

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TEXT

उमप्रिखोला ब्लॉक, जिला कामरूप (मेट्रो), असम में दुर्लभ मृदा तत्व (REE) एवं संबंधित खनिजों हेतु
प्रारम्भिक गवेषण (G-3 चरण) पर भूवैज्ञानिक रिपोर्ट

अध्याय 1

1.0.0 कार्यकारी सारांश

उमप्रिखोला ब्लॉक, जिला कामरूप (मेट्रो), असम में दुर्लभ मृदा तत्वों (REE) एवं संबंधित खनिजों के लिए प्रारम्भिक गवेषण (G-3 चरण) कार्य मिनरल एक्सप्लोरेशन एंड कंसल्टेंसी लिमिटेड (MECL) द्वारा राष्ट्रीय खनिज अन्वेषण न्यास (NMET) कार्यक्रम के अंतर्गत संपादित किया गया। इस गवेषण कार्यक्रम की अनुशंसा NMEDT की TCC-II की तृतीय बैठक में की गई तथा NMEDT की 39वीं EC बैठक में इसे अनुमोदित किया गया। अध्ययन क्षेत्र लगभग 4.80 वर्ग कि.मी. क्षेत्रफल में विस्तृत है तथा भारतीय सर्वेक्षण के टोपोशीट संख्या 78N/16 का भाग है। भौगोलिक रूप से यह ब्लॉक 26°01'49.598" N से 26°03'05.954" N अक्षांश तथा 91°52'24.380" E से 91°54'12.534" E देशांतर के मध्य स्थित है। क्षेत्र गुवाहाटी-शिलांग मार्ग (NH-40) से सुगमता से जुड़ा हुआ है तथा पक्की सड़क, कच्ची सड़क एवं पैदल मार्गों द्वारा सुलभ है।

उमप्रिखोला ब्लॉक शिलांग पठार के उत्तरी किनारे पर स्थित है तथा असम-मेघालय नीसिक कॉम्प्लेक्स (AMGC) का भाग है। क्षेत्र में मुख्यतः ग्रेनाइट ग्राइस, बायोटाइट ग्राइस, एम्फीबोलाइट, डायोराइट/मेटा-ग्रेनोडायोराइट, पिक ग्रेनाइट, पेग्माटाइटिक वेंसों, क्वार्ट्जो-फेल्डस्पैथिक वेंसों तथा क्वार्ट्ज वेंसों पाई जाती हैं। ग्रेनाइट ग्राइस प्रमुख शैल इकाई है, जिसमें डायोराइटिक एवं फेल्सिक अंतःप्रवेश पाए जाते हैं। पेग्माटाइटिक तथा क्वार्ट्जो-फेल्डस्पैथिक वेंसों भ्रंशों, संधियों एवं फोलिएशन तल के साथ व्यापक रूप से विकसित हैं, जो संरचनात्मक नियंत्रण एवं अंतिम चरण की मैग्माई-हाइड्रोथर्मल गतिविधि

को दर्शाती हैं। क्षेत्रीय संरचनात्मक प्रवृत्ति मुख्यतः NE-SW दिशा में है, जो फोलिएशन, भ्रंश एवं रेखीय संरचनाओं के रूप में परिलक्षित होती है।

गवेषण कार्यक्रम के अंतर्गत 1:4000 स्केल पर विस्तृत भूवैज्ञानिक मानचित्रण, स्थलाकृतिक सर्वेक्षण, बेडरॉक/चैनल नमूना संग्रहण, पेट्रोग्राफिक अध्ययन, मिनेराग्राफिक परीक्षण एवं भू-रासायनिक विश्लेषण किए गए। कुल 50 नमूनों का 34 तत्वीय REE एवं संबद्ध तत्वों के लिए विश्लेषण किया गया। इनमें से 5 चयनित नमूनों का प्लेटिनम समूह तत्वों (PGE) हेतु फायर असे विधि से परीक्षण किया गया तथा उन्हीं नमूनों में Ni एवं Cr का AAS तकनीक द्वारा विश्लेषण किया गया।

पेट्रोग्राफिक अध्ययन से ज्ञात होता है कि ग्रेनाइटोइड एवं डायोराइटिक शैलों में विभिन्न स्तरों का विकृति एवं कायांतरण हुआ है। क्षेत्र में मैप की गई डायोराइटिक शैलों को कुछ स्थानों पर पुनःस्फटीकरण, विकृति तथा ग्रैनोडायोराइटिक खनिज संघटन के कारण पेट्रोग्राफिक रूप से मेटा-ग्रैनोडायोराइट के रूप में पहचान की गई। प्रमुख खनिजों में क्वार्ट्ज, प्लेजियोक्लेस फेल्डस्पार, K-फेल्डस्पार, बायोटाइट एवं हॉर्नब्लेंड सम्मिलित हैं, जबकि मोनाजाइट, जिरकोन, एपेटाइट, स्फीन, मैग्नेटाइट एवं अपारदर्शी खनिज सहायक खनिजों के रूप में उपस्थित हैं। पेग्माटाइटिक एवं क्वार्ट्जो-फेल्डस्पैथिक वेंसों मोटे दानेदार फेल्सिक खनिज संघटन प्रदर्शित करती हैं तथा अंतिम चरण की अंतःवेधन गतिविधि को सूचित करती हैं।

मिनेराग्राफिक अध्ययनों में पाइराइट, चाल्कोपाइराइट, पाइरहोटाइट, मैग्नेटाइट, इल्मेनाइट तथा द्वितीयक डाइजेनेट-चाल्कोसाइट संघटन की उपस्थिति ज्ञात हुई। सल्फाइड खनिजीकरण मुख्यतः डायोराइट/मेटा-ग्रैनोडायोराइट, पेग्माटाइटिक वेंसों एवं क्वार्ट्जो-फेल्डस्पैथिक वेंसों से संबद्ध प्रसारित रूप, फ्रैक्चर भराव, पतली शिरिकाओं एवं

पैच के रूप में पाया जाता है। मैग्नेटाइट एवं इल्मेनाइट अपारदर्शी खनिजों के रूप में प्रसारित अवस्था में उपस्थित हैं तथा कुछ स्थानों पर मार्टिटाइजेशन के कारण हेमेटाइट में परिवर्तित हो गए हैं। सल्फाइड खनिजीकरण संरचनात्मक रूप से नियंत्रित प्रतीत होता है तथा अंतिम चरण की हाइड्रोथर्मल गतिविधियों से संबंधित है।

भू-रासायनिक अध्ययन से ज्ञात हुआ कि पेग्माटाइटिक एवं कार्बो-फेल्डस्पैथिक वेंसों के साथ-साथ ग्रेनाइट ग्राइस एवं मेटा-ग्रेनोडायोराइट में REE का स्थानीय समृद्धिकरण पाया जाता है। कोड्राइट-नॉर्मलाइज़्ड REE प्रतिरूप Light Rare Earth Elements (LREE) की Heavy Rare Earth Elements (HREE) की अपेक्षा अधिक समृद्धि प्रदर्शित करते हैं, जो विकसित फेल्सिक मैग्माई प्रवृत्ति एवं अंतिम चरणीय विभेदन के दौरान असंगत तत्वों के संकेन्द्रण को सूचित करता है। कुछ पेग्माटाइटिक वेंस नमूनों में $\Sigma\text{REE}+\text{Y}$ का मान 1000 ppm से अधिक दर्ज किया गया। REE खनिजीकरण मुख्यतः मोनाजाइट, जिरकॉन, एलनाइट एवं स्फीन जैसे सहायक खनिजों द्वारा नियंत्रित है।

विश्लेषित नमूनों में डायोराइटिक/मेटा-ग्रेनोडायोराइटिक शैलों में Ni एवं Cr जैसे परिवर्तित धातुओं का मध्यम स्तर का समृद्धिकरण भी पाया गया, जो सीमित माफिक प्रवृत्ति को इंगित करता है। तथापि, कोई महत्वपूर्ण अल्ट्रामाफिक संबद्धता अथवा आर्थिक दृष्टि से महत्वपूर्ण Ni-Cr खनिजीकरण स्थापित नहीं हुआ। PGE विश्लेषण में Pt, Pd, Rh, Ru एवं Ir की निम्न सांद्रताएँ प्राप्त हुईं, जबकि अधिकांश नमूनों में Os जाँच सीमा से नीचे पाया गया, जिससे क्षेत्र में महत्वपूर्ण PGE खनिजीकरण का अभाव स्पष्ट होता है।

समग्रतः अध्ययन से स्पष्ट होता है कि उमप्रिखोला ब्लॉक में स्थानीय एवं संरचनात्मक रूप से नियंत्रित REE खनिजीकरण उपस्थित है, जो मुख्यतः विकसित फेल्सिक अंतर्वेधन

गतिविधियां, पेग्माटाइटिक अंतःस्थापन एवं हाइड्रोथर्मल परिवर्तन से संबद्ध है। यद्यपि कुछ स्थानों पर REE के असामान्य मान प्राप्त हुए हैं, तथापि खनिजीकरण असतत, अनियमित एवं पार्श्व तथा गहराई में निरंतरता से रहित है। वर्तमान अध्ययन में ऐसा कोई आर्थिक रूप से व्यवहार्य खनिजीकरण स्थापित नहीं हुआ है, जिसके आधार पर आगे विस्तृत गवेषण अथवा ड्रिलिंग की अनुशंसा की जा सके। तथापि, विकसित फेल्सिक अंतर्वेधन गतिविधियां, पेग्माटाइटिक गतिविधियों तथा संरचनात्मक रूप से नियंत्रित वेंस अंतःस्थापन वाले अनुकूल भूवैज्ञानिक परिवेश को दृष्टिगत रखते हुए, समीपवर्ती समान भूवैज्ञानिक संरचना वाले क्षेत्रों, विशेषकर पेग्माटाइटिक एवं क्वार्ट्जो-फेल्डस्पैथिक वेंस प्रणालियों का REE खनिजीकरण हेतु मूल्यांकन किया जा सकता है।

**GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3 STAGE)
FOR REE & ASSOCIATED MINERALS IN UMPRIKHOLA BLOCK
DISTRICT- KAMRUP (METRO), ASSAM**

CHAPTER - I

1.0.0 EXECUTIVE SUMMARY

Preliminary Exploration (G-3 Stage) for Rare Earth Elements (REE) and associated minerals was carried out in the Umprikhola Block, Kamrup (Metro) District, Assam by Mineral Exploration and Consultancy Limited (MECL) under the National Mineral Exploration Trust (NMET) programme. The exploration programme was recommended in the 3rd meeting of TCC-II, NMEDT and approved in the 39th EC meeting of NMEDT. The block covers an area of about 4.80 sq. km and forms part of Survey of India Toposheet No. 78N/16. Geographically, the block lies between latitude 26°01'49.598" N to 26°03'05.954" N and longitude 91°52'24.380" E to 91°54'12.534" E. The area is well connected through the Guwahati–Shillong Road (NH-40) and is accessible by metalled roads, kutchra roads and foot tracks.

The Umprikhola Block is situated along the northern fringe of the Shillong Plateau and forms part of the Assam–Meghalaya Gneissic Complex (AMGC). The area is represented mainly by granite gneiss, biotite gneiss, amphibolite, diorite/meta-granodiorite, pink granite, pegmatitic veins, quartzo-feldspathic veins and quartz veins. Granite gneiss constitutes the dominant lithology and is intruded by dioritic and felsic intrusive phases. Pegmatitic and quartzo-feldspathic veins occur extensively along fractures, joints and foliation planes, indicating strong structural and late-stage magmatic-hydrothermal control. The regional structural trend is predominantly NE–SW and is represented by foliations, fractures and lineaments.

The exploration programme comprised detailed geological mapping on 1:4000 scale, topographic survey, collection of bedrock/channel samples, petrographic studies, mineragraphic investigations and geochemical analysis. A total of 50 samples were subjected to 34-element analysis for REE and associated elements. Out of these, 5 selected samples were analysed for Platinum Group

Elements (PGE) through fire assay method, and the same samples were further analysed for Ni and Cr through AAS technique.

Petrographic studies indicate that the granitoid and dioritic rocks have undergone varying degrees of deformation and metamorphism. Dioritic rocks mapped in the field were petrographically identified as meta-granodiorite in some sections due to recrystallisation, deformation and granodioritic mineral assemblages. The major mineral constituents observed include quartz, plagioclase feldspar, K-feldspar, biotite and hornblende, while accessory minerals include monazite, zircon, apatite, sphene, magnetite and opaque phases. Pegmatitic and quartzo-feldspathic veins show coarse-grained felsic mineral assemblages and represent late-stage intrusive activity.

Mineragraphic studies reveal the presence of pyrite, chalcopyrite, pyrrhotite, magnetite, ilmenite and secondary digenite–chalcocite assemblages. Sulphide mineralisation occurs mainly as disseminations, fracture fillings, thin veinlets and patches associated with diorite/meta-granodiorite, pegmatitic veins and quartzo-feldspathic veins. Magnetite and ilmenite occur as disseminated opaque phases and are locally altered to hematite through martitisation. The sulphide mineralisation appears structurally controlled and related to late-stage hydrothermal activity.

Geochemical investigations indicate localized enrichment of Rare Earth Elements within pegmatitic and quartzo-feldspathic veins as well as granite gneiss and meta-granodiorite. Chondrite-normalised REE patterns show pronounced enrichment of Light Rare Earth Elements (LREE) over Heavy Rare Earth Elements (HREE), indicating evolved felsic magmatic affinity and concentration of incompatible elements during late-stage differentiation. Sporadic anomalous $\Sigma\text{REE}+\text{Y}$ values exceeding 1000 ppm have been recorded in a few pegmatitic vein samples. REE mineralisation is mainly controlled by accessory phases such as monazite, zircon, allanite and sphene.

The analysed samples also indicate moderate enrichment of transition metals such as Ni and Cr within dioritic/meta-granodioritic rocks, reflecting limited mafic affinity. However, no significant ultramafic association or economically viable Ni–Cr mineralisation has been established. PGE analysis returned low

concentrations of Pt, Pd, Rh, Ru and Ir, while Os remained below detection limit in most samples, indicating absence of significant PGE mineralisation within the block.

Overall, the investigation indicates that the Umprikhola Block hosts localized and structurally controlled REE mineralisation associated mainly with evolved felsic intrusive activity, pegmatitic emplacement and hydrothermal alteration. Although sporadic anomalous REE concentrations have been recorded, the mineralisation is discontinuous, erratic and lacks significant lateral and vertical continuity. The present investigation does not establish economically viable mineralisation warranting further detailed exploration or drilling within the block. However, considering the favourable geological environment comprising evolved felsic intrusive, pegmatitic activity and structurally controlled vein emplacement, adjoining areas exhibiting similar geological setup, particularly pegmatitic and quartzo-feldspathic vein systems, may be evaluated for REE mineralisation.

CHAPTER - II

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

(To be provided separately for all the qualified persons signing off the report)

Table No 2.1
Details of Qualified Person(S) / Exploration Agency

(a) Name:	MINERAL EXPLORATION AND CONSULTANCY LIMITED (Formerly Mineral Exploration Corporation Limited) (A Govt. of India Enterprise; A Miniratna-I PSE) (Ministry of Mines, Govt. of India)
(b) Address:	Dr. Babasaheb Ambedkar Bhawan, High Land Drive Road, Seminary Hills, Nagpur-440006.
(c) Contact Mobile No:	0712-2510289; 0712-2511829
(d) E-Mail id:	cmd@mecl.gov.in gm-exploration@mecl.gov.in
(e) Qualification:	Professionals with M.Sc. / M.Tech (Geology) Qualification
(f) Experience:	Professionals with experience > 30 Years
(g) Affiliation to any organization/company, if yes, specify the name of the organization or company.	A Govt. of India Enterprise; A Miniratna-I PSE Ministry of Mines, Govt. of India

2.1.0 Details of qualification and experience of persons associated with various aspects of exploration assessment of resources and reserves.

2.1.1 The Details of personnel associated with the Exploration in Umprikhola Block is given in following Table No 2.2

Table No 2.2
Details of Personnel Associated with The Exploration Umprikhola Block,
Dist: Kamrup (Metro), Assam

1	Overall Planning, Co-ordination & Overall supervision	:	Shri Shrikant Sharma, DGM/HoD (Exploration)
2	Project management & Field Operation	:	Shri Uddipta Narayan Patar, E.T. (Geology)/OIC
		:	Miss Talisenla Longkumer, E.T. (Geology)
		:	Mr. Dipanjan Halder, STA(Survey)
3	Chemical Laboratory, MECL	:	Shri Rohit Kumar Sharma, Head (Laboratory)/ Manager (Chemistry)
		:	Dr. (Mrs.) Deepti R. Rahangdale, Manager (Chemistry)
4	Petrological Laboratory, MECL	:	Shri Sayantan Pal, Manager (Geology)
5	Data Processing & Documentation	:	Shri Uddipta Narayan Patar, E.T. (Geology)
		:	Miss Talisenla Longkumer, E.T. (Geology)
		:	Mrs. Moumita Ghosh, Assistant Manager (Geology)
		:	Shri Sayandeep Chakraborty, Assistant Manager (Geology)
		:	Shri Ashok Kumar, Sr Assistant (I.T)
6	Reprography & Printing	:	Shri P.S Negi, OIC, Survey
			Shri Durgesh Devarshee ASMO

CHAPTER - III

3.0.0. TITLE AND OWNERSHIP

3.1.0 GEOLOGICAL REPORT ON PRELIMINARY EXPLORATION (G-3 STAGE) FOR REE & ASSOCIATED MINERALS IN UMPRIKHOLA BLOCK DISTRICT- KAMRUP (METRO), ASSAM

Ownership: Government of Assam

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

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

(Ministry of Mines, Govt. of India)

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

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

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

3.2.0 Details of period of Prospecting

3.2.1 Preliminary exploration (G3) for REE and associated minerals in Umprikhola Block, Kamrup (Metro) District, Assam was recommended in 3rd meeting of Technical cum Cost Committee-II (TCC-II) of NMEDT was approved in 39th meeting of EC, NMEDT (24th January, 2025) and the same was intimated to MECL vide MoM letter No. F/No./23/560/2025-NMET/888 dated 24th February, 2025 (Annexure VIII).

3.2.2 Pursuant to the approval, after mitigation the local issues and monsoon period, MECL commenced the field work on 15th November 2026 and completed the first phase of exploration by April, 2026. The first phase comprised detail geological mapping with topographic survey, and collection of surface samples, including bedrock channel samples and petrographic samples. The results of the first phase were reviewed in the 25th Meeting of TCC-II held on 17th March 2026, wherein the committee opined that no further work is required in this block as the values of REE are not significant and the

committee advised not to take up further exploration including drilling and advised MECL to prepare and submit the Geological Report to NMEDT by 23rd July, 2026 (Annexure IX).

CHAPTER - IV

4.0.0 DETAILS OF THE AREA UNDER STUDY

4.1.0 Location of the Block

4.1.1 The Umprikhola Block is situated in the Kamrup (Metro) District of Assam and falls under the administrative jurisdiction of Kamrup (Metro) Tehsil. The block covers parts of the villages namely Umprikhola, Tanduk, and Rohana, and forms a part of the Survey of India (SOI) Toposheet No. 78 N/16. The location map of the block is furnished as Text Fig No-4.1 as well as Plate No-I.

4.1.2 Geographically, the block is demarcated by six cardinal boundary points (A to F), whose coordinates have been established in both the Geographic Coordinate System (Datum WGS-84) and Universal Transverse Mercator (UTM) Zone 46N projection. The block extends between latitudes 26°01'49.598" N and 26°03'05.954" N, and longitudes 91°52'24.380" E and 91°54'12.534" E. The coordinates of the cardinal points of the block boundary are given below in Table No. 4.1 as well as Annexure IA.

Table No-4.1

**Coordinates of cardinal points of Umprikhola Block, District: Kamrup
(Metro), Assam**

Sl. No.	Point	GCS WGS 1984 (DMS)		UTM Zone: 46N (m)		Area (sq km)
		Latitude	Longitude	Easting	Northing	
1	A	26° 02' 03.85505" N	91° 52' 44.98229" E	387857.387	2879975.369	4.80
2	B	26° 02' 11.23145" N	91° 52' 35.81562" E	387604.557	2880204.501	
3	C	26° 02' 51.38535" N	91° 52' 24.37977" E	387297.373	2881442.615	
4	D	26° 03' 05.91748" N	91° 54' 03.68894" E	390061.079	2881866.168	
5	E	26° 02' 13.95751" N	91° 54' 12.56495" E	390294.312	2880265.501	
6	F	26° 01' 49.58902" N	91° 52' 49.23785" E	387971.904	2879535.446	

4.2.0 Accessibility to the Block

4.2.1 The Umprikhola Block is well connected by road, rail, and air transport facilities, which provides easy accessibility for geological investigation and exploration activities. The nearest railhead is the Guwahati Railway Station, located approximately 25 km towards the northwest of the block.

4.2.2 The area is primarily accessible through the Guwahati–Shillong Road (NH-40), which passes along the western side of the block. Several metalled as well as kutcha roads branch out from the G.S. Road and provide access to different parts of the study area. In addition, a network of foot tracks traverses the block, facilitating movement within the hilly and forested terrain during field investigations.

4.2.3 The nearest airport is Lokpriya Gopinath Bordoloi International Airport, situated about 50 km west of the block, providing air connectivity to major cities of India. Overall, the block is reasonably accessible throughout the year for geological mapping and mineral exploration operations.

4.3.0 Land Use Pattern

4.3.1 The Umprikhola Block covers a total aerial extent of approximately 4.80 sq. km (480 ha) and exhibits a mixed land-use pattern comprising forest land, private land, agricultural areas, and water bodies. The dominant land-use category is Reserved Forest, occupying approximately 347.8 ha, which constitutes about 72.5% of the total block area. This indicates that the block is predominantly under forest cover and suggests limited anthropogenic disturbance over a major portion of the area.

4.3.2 The remaining 132.2 ha (27.5%) consists of privately owned land, representing areas utilized for settlement, cultivation, and other local land-use activities. Within the private land category, approximately 32 ha is under agricultural use, accounting for around 24.2% of private land and 6.7% of the total block area. Agricultural activities in the block are mainly dependent on surface water availability, particularly from the stream network flowing through the agricultural fields, indicating a predominantly stream-fed or rain-supported cultivation system.

4.3.3 In addition, approximately 5 ha of the total area is occupied by a lake/water body, which contributes to local hydrological conditions and may support agricultural requirements and ecological balance within the block.

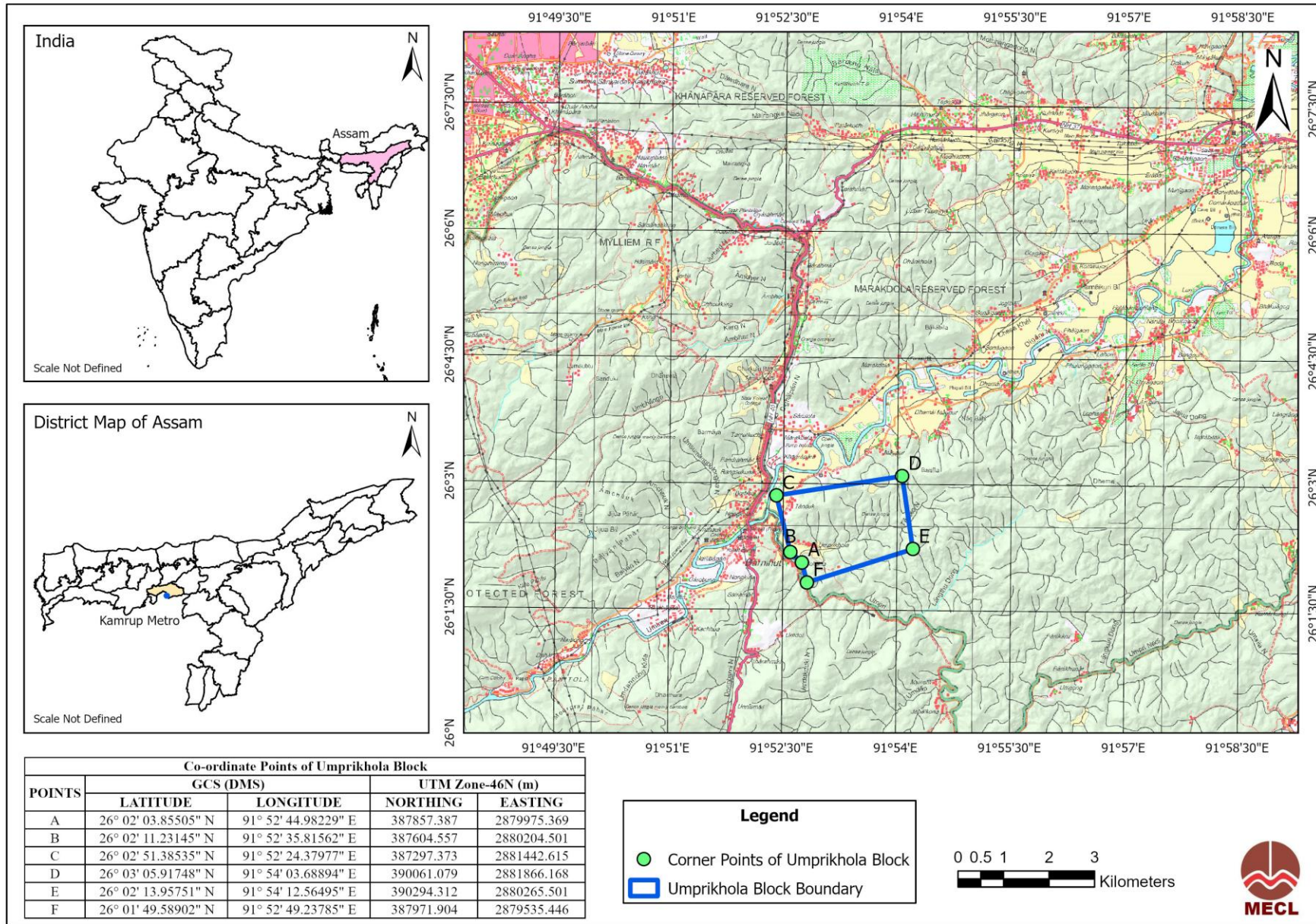
4.3.4 Overall, the land-use pattern of Umprikhola Block reflects a forest-dominated landscape with localized agricultural activity concentrated within privately owned areas and supported by natural surface water resources. This

distribution indicates relatively low land-use intensity and highlights the importance of forest and water resources in controlling the environmental and socio-economic characteristics of the block.

4.4.0 Mineral(s) under investigation or granted under license or lease

- 4.4.1 The Umprikhola Block was explored for the occurrences of Rare Earth Elements and associated minerals.

Text Fig. 4.1:
Location map of
Umprikhola Block,
District Kamrup
(Metro), Assam



CHAPTER - V

5.0.0 PHYSIOGRAPHY AND ENVIRONMENT

5.1.0 Topography

5.1.1 The topography of the Umprikhola Block is characterized by a moderately undulating to hilly terrain with significant elevation variation across the area. The elevation ranges from approximately 80 m above mean sea level (MSL) at the lowest point to about 320 m above MSL at the highest point, giving a total local relief difference of nearly 240 m. This variation in elevation indicates the presence of moderately rugged terrain with distinct upland and lowland geomorphic units.

5.1.2 The higher elevation zones are represented by hilltops and elevated ridges, whereas the lower elevation areas correspond to valleys, stream channels, and gently sloping terrain. The gradual to moderate slope development facilitates surface runoff from elevated regions towards the lower reaches, contributing to the formation and maintenance of local drainage systems.

5.1.3 The topographic configuration of the block exerts an important control on drainage pattern, weathering processes, soil development, vegetation distribution, and land use activities. Agricultural activities are mainly concentrated in relatively low-lying and gently sloping areas where water availability is supported by stream flow, while the elevated areas remain predominantly under forest cover.

5.1.4 Overall, the Umprikhola Block exhibits a moderate relief landscape with dissected hill slopes and intervening valleys, reflecting active geomorphic processes and topographic control over hydrological and land-use characteristics of the area.

5.2.0 Connectivity

5.2.1 The Umprikhola Block is well connected through road, rail, and air transportation facilities, which provide accessibility for exploration activities and movement of personnel and materials. The block is accessible through the Guwahati–Shillong Road (National Highway–40), which passes along the

western side of the block and serves as the principal transportation corridor connecting the area with nearby urban centres.

5.2.2 Within the study area, accessibility is supported by a network of metalled roads and kutcha (unpaved) roads, most of which originate from the Guwahati–Shillong Road and extend into different parts of the block. In addition, foot tracks and local trails are developed within the interior areas, facilitating access to forested and elevated terrains where vehicular movement is limited.

5.2.3 The nearest railway connectivity is provided by Guwahati Railway Station (GHY), located approximately 25 km northwest of the block, offering linkage to major regional and national railway networks. The nearest airport facility is available at Lokpriya Gopinath Bordoloi International Airport, Guwahati, which provides air connectivity to the study area and supports logistical requirements.

5.2.4 Overall, the Umprikhola Block possesses moderate to good connectivity, with primary access controlled by the national highway network and secondary access supported by local roads and foot tracks, enabling efficient movement for geological exploration and field operations.

5.3.0 Population

5.3.1 The Umprikhola Block extends across the administrative boundaries of three villages, namely Umprikhola, Tanduk, and Rohana. However, approximately 90% of the total block area falls within Umprikhola village, making it the principal settlement influencing the socio-economic characteristics of the study area.

5.3.2 According to the Census of India, 2011, Umprikhola village comprises a total of 50 households with a population of 320 persons. The population includes 170 males and 150 females, indicating a relatively balanced gender distribution within the village. The settlement pattern is entirely rural in nature, with no urban habitation present within the block area.

5.3.3 The population density within the block is generally low, reflecting the predominance of forest-covered land, undulating topography, and limited

cultivable area. Overall, the Umprikhola Block exhibits a sparsely populated rural settlement pattern, where habitation is largely confined to Umprikhola village and influenced by the physical characteristics and land-use distribution of the area.

5.4.0 Socio Demographic profile

- 5.4.1 The socio-demographic characteristics of the Umprikhola Block indicate a predominantly rural population with livelihoods closely linked to local natural resources and agricultural activities. The demographic structure shows that approximately 10% of the total population belongs to the 0–6 years age group, indicating the presence of a young dependent population and reflecting ongoing population continuity within the village community.
- 5.4.2 The educational status of the area suggests a moderate level of literacy and human resource development. More than 50% of the population has completed formal schooling, demonstrating relatively good educational access within the rural setting. Among the educated population, approximately 30% have attained graduate-level education, indicating gradual improvement in higher educational attainment and the availability of skilled human resources.
- 5.4.3 The economic structure of the block is primarily agrarian and labour-oriented. The major sources of household income are derived from agriculture and daily wage labour, which form the backbone of the local economy. In addition, a smaller proportion of the population is engaged in government services and private-sector employment, providing supplementary and relatively stable income sources to some households.
- 5.4.4 From a socio-cultural perspective, the block exhibits linguistic diversity. Karbi is the predominant spoken language, reflecting the local ethnic composition of the area, while Garo is spoken by a smaller section of the population. Assamese and Hindi are also used for communication, contributing to social interaction and regional connectivity.
- 5.4.5 Overall, the socio-demographic profile of Umprikhola Block represents a rural community with moderate educational development, agriculture-based

livelihoods, and multicultural linguistic characteristics, reflecting the socio-economic conditions typical of forest-dominated and semi-rural landscapes.

5.5.0 Historical / Archaeological Site

5.5.1 Based on field observations and available records, no historical or archaeological sites have been identified within the Umprikhola Block. The study area does not contain any known monuments, heritage structures, archaeological remains, or culturally significant historical features of protected or documented importance.

5.5.2 The absence of such sites indicates that the block is predominantly characterized by natural landscapes, forest cover, agricultural land, and rural habitation, with no recognized historical or archaeological constraints affecting land use or exploration activities within the area.

5.6.0 Forests, sanctuaries, national park and wild life sanctuaries

5.6.1 The Umprikhola Block is predominantly covered by forest land and does not contain any national park, wildlife sanctuary, or other protected wildlife conservation areas within the study boundary. Out of the total geographical area of 480 ha, approximately 347.8 ha is occupied by the West Aparikula Reserve Forest, accounting for nearly 72.5% of the total block area.

5.6.2 The extensive forest cover indicates that the block is largely influenced by reserved forest ecosystems and associated natural vegetation. The presence of reserve forest contributes significantly to ecological stability, biodiversity conservation, watershed protection, and regulation of local environmental conditions. The forested area also acts as an important natural landscape element controlling soil conservation and surface runoff processes within the block.

5.6.3 Apart from the Reserve Forest area, no notified national parks, wildlife sanctuaries, eco-sensitive zones, or protected conservation areas have been identified within the block limits. Therefore, the environmental setting of the Umprikhola Block is primarily characterized by the dominance of reserved forest land with limited human intervention outside localized agricultural and habitation zones.

5.7.0 Flora and Fauna within and nearby

5.7.1 The Umprikhola Block is characterized by predominantly forested terrain owing to the extensive coverage of the West Aparikula Reserve Forest, which supports a diverse assemblage of flora and fauna typical of the region. The area exhibits natural forest vegetation along with localized plantation and agroforestry practices associated with rural habitation.

5.7.2 The flora of the block is dominated by dense mixed forest and extensive bamboo cover, which constitute the major vegetation types within the reserve forest area. In addition to bamboo, common tree species observed in and around the block include Teak (*Tectona grandis*), Sida, and Simul (*Bombax ceiba*), along with other associated secondary forest species. These species contribute to the structural diversity of vegetation and play an important role in maintaining ecological stability, soil conservation, and watershed functions. Betel nut (*Areca nut*) plantations are also present near settlement and agricultural areas, representing an important component of local agroforestry practices.

5.7.3 The fauna observed within and nearby the block includes commonly occurring wild mammals such as wild cat, deer, and wild pig, which inhabit the forested areas and utilize the reserve forest as shelter and movement corridors. Their occurrence reflects the presence of relatively intact habitat conditions and moderate biodiversity within the forest ecosystem.

5.7.4 Overall, the Umprikhola Block supports a forest-dominated ecosystem characterized by bamboo-rich vegetation, mixed tree species including teak and simul, and associated wildlife populations, indicating the ecological significance of the reserve forest landscape and its role in sustaining local biodiversity.

5.8.0 Drainage Pattern

5.8.1 The drainage pattern of the Umprikhola Block is controlled primarily by the topography and geomorphological characteristics of the area. The block is characterized by moderately to highly undulating terrain comprising ridges,

hills, and intervening valleys, which influence the development and orientation of surface drainage channels.

5.8.2 The area is drained by a network of seasonal and perennial streams, with most of the local drainage exhibiting a southerly flow direction following the regional slope gradient. These streams originate from elevated hill slopes and flow through the valley portions, forming an integrated drainage system within the block.

5.8.3 The Digaru River is the principal river controlling the regional drainage of the area. It receives runoff from several smaller tributaries and stream channels developed within the surrounding catchment. The Umpri and Umtrew rivers form an important confluence near Byrnihat, contributing to the overall drainage network of the region. Further downstream, the Digaru River flows in a north-easterly direction and ultimately joins the Kalang River near Gobardhan Grant, which subsequently drains into the Brahmaputra River system.

5.8.4 The drainage configuration reflects the influence of terrain relief, slope orientation, and structural controls, resulting in efficient surface runoff and stream development. The stream network also plays a significant role in supporting local agricultural activities, sediment transport, and maintaining the hydrological balance of the Umprikhola Block.

5.9.0 Climatic Condition

5.9.1 The Umprikhola Block experiences a warm and humid tropical to sub-tropical climatic regime, influenced by seasonal monsoon conditions and local topographic variations. The overall climate of the area is moderate, with distinct rainy, winter, and summer seasons.

5.9.2 The area receives average annual rainfall ranging between approximately 1000 mm and 2000 mm per year (the earlier value of 100–200 mm appears unrealistically low for this region and has been corrected to 1000–2000 mm based on the stated source and regional climatic conditions). Rainfall is predominantly controlled by the southwest monsoon, with the rainy season generally commencing in mid-May and continuing up to September. The monsoonal precipitation contributes significantly to groundwater recharge,

stream flow, agricultural activities, and maintenance of forest ecosystems within the block.

5.9.3 Temperature conditions are generally warm to moderate throughout the year. During the winter season (December–January), the climate becomes comparatively cooler, with temperatures generally ranging between 9°C and 11°C (corrected from 90°C–110°C, which is physically unrealistic and appears to be a typographical error). The summer months experience relatively higher temperatures accompanied by increased humidity.

5.9.4 Overall, the climatic conditions of the Umprikhola Block are favourable for the development of dense vegetation, agricultural activities, and stream-fed hydrological systems, while seasonal rainfall and moderate temperature variations play an important role in controlling geomorphic and ecological processes within the area (Source: Department of Agriculture, Government of Meghalaya and Assam).

5.10.0 Any other factor having potential to affect the viability of the project and assessment of resources and reserves.

5.10.1 The feasibility or pre-feasibility studies were not undertaken during the G-3 stage of exploration, since the preliminary exploration did not establish mineralization to warrant further techno-economic evaluation or resource/reserve estimation.

CHAPTER - VI

6.0.0 INFRASTRUCTURE

6.1.0 Local infrastructure Connectivity and facilities

- 6.1.1 The Umprikhola Block possesses basic rural infrastructure that supports the day-to-day socio-economic requirements of the local population. The available infrastructure facilities indicate the presence of essential educational, healthcare, recreational, and community services within and around the habitation areas.
- 6.1.2 Educational infrastructure is represented by the Aparikula Lower Primary School, which provides access to primary-level education for the local population and contributes to literacy development within the area. Basic healthcare services are supported through the presence of a Public Health Centre (PHC), which serves as the primary healthcare facility for routine medical care and community health requirements.
- 6.1.3 The block also contains social and recreational infrastructure including a playground and club house, which support community interaction, sports, and local cultural activities. Community-based facilities such as a community hall serve as important centres for social gatherings, meetings, and public events. In addition, the presence of a church reflects the socio-cultural and religious infrastructure available to the local population.
- 6.1.4 Overall, the infrastructure within the Umprikhola Block is rural in character and provides basic educational, healthcare, recreational, and social amenities, supporting the livelihood and community development of the local inhabitants while maintaining connectivity with surrounding areas.

CHAPTER - VII

7.0.0. GEOLOGY

7.1.0. Regional Geology

- 7.1.1 The study area (Toposheet No. 78N/16) is situated along the northern fringe of the Shillong Plateau and lies west of the Um-Ngot Lineament, bounded to the north by the Brahmaputra Fault System. The area forms part of the tectonically active Shillong–Meghalaya Plateau, which represents an uplifted Precambrian crustal block separated from the Indian Peninsular Shield by the Garo–Rajmahal Gap (Evans, 1964).
- 7.1.2 Regionally, the Shillong Plateau comprises a complex assemblage of Archean to Recent lithological units. The oldest basement rocks belong to the Archean–Paleoproterozoic Assam–Meghalaya Gneissic Complex (AMGC), consisting predominantly of biotite gneiss, quartzo-feldspathic gneiss, migmatites, amphibolite, schists and granitoids, which have undergone amphibolite to granulite facies metamorphism. These basement rocks are unconformably overlain by metasedimentary successions of the Shillong Group of Mesoproterozoic–Neoproterozoic age, represented mainly by quartzite, phyllite and associated supracrustal rocks.
- 7.1.3 The Shillong Plateau records extensive episodes of granitoid magmatism associated with Grenvillian and Pan-African tectonothermal events. Numerous syn- to post-tectonic granitoid plutons intruded both the AMGC and Shillong Group rocks during Neoproterozoic to Early Palaeozoic times (approximately 881–479 Ma). Major plutonic bodies include the Nongpoh, Myllem, South Khasi and Rongjeng granitoids. The granitic intrusions occur mainly as discordant plutons and batholiths whose emplacement was controlled by pre-existing fractures and lineaments.
- 7.1.4 In the present study region around Byrnihat–Nongpoh sector, exposures include granite gneiss, amphibolite, diorite and cordierite-bearing metapelite of the AMGC (Text figure 7.1 as well as Plate No II). The porphyritic granite of the Nongpoh Pluton occupies the southern part of the study area and intrudes both basement gneisses and Shillong Group metasediments. Contact zones commonly exhibit migmatisation, indicating high-temperature

interaction between granitic melts and country rocks. Numerous quartz, pegmatite and aplite veins traverse all lithologies and are interpreted as late-stage magmatic-hydrothermal products of granite emplacement. Quartz veins commonly host disseminated to vein-controlled base metal sulphide mineralisation and therefore possess economic significance.

- 7.1.5 Structurally, the Shillong Plateau is one of the most tectonically active intraplate regions of northeastern India and behaves as an uplifted horst or pop-up structure within the Himalayan foreland. The plateau is bounded by major crustal-scale fault systems including the Brahmaputra Fault System in the north, Dauki Fault in the south, Kopili Fault in the east and Dhubri Fault in the west. Present-day tectonic deformation results from continued convergence between the Indian and Eurasian plates and interactions with the Indo-Burman ranges (Text Figure No. 7.2). Approximately 1.5–3.5 mm/year of north–south convergence is accommodated within the plateau region.
- 7.1.6 The dominant regional structural grain across the Shillong Plateau trends NE–SW and is expressed by foliation, lithological contacts, fractures and fault systems. This structural trend is locally modified around major granitoid intrusions where deformation patterns become more complex. The Um-Ngot Lineament cuts across the regional NE–SW fabric and is considered a major crustal discontinuity developed during Late Jurassic–Early Cretaceous tectonic evolution.
- 7.1.7 The eastern margin of the plateau is marked by the NE–SW trending Kopili Fault, which separates the Shillong Plateau from the Mikir Hills and Kopili Valley. The Kopili Fault is a major seismically active dextral strike-slip to oblique-slip fault with reported slip rates of approximately 2–3 mm/year and plays a significant role in controlling regional seismicity. The Mikir Hills represent the northeastern continuation of the Shillong Plateau and are separated from Meghalaya by the alluvial tract of the Kopili River.
- 7.1.8 The cumulative effect of repeated uplift, fault reactivation, granite emplacement and prolonged erosion has produced the present structural architecture of the Shillong Plateau, characterised by fault-bounded basement highs, lineament-controlled plutonic intrusions and extensive brittle deformation expressed through joints, fractures and quartz–pegmatite veining.

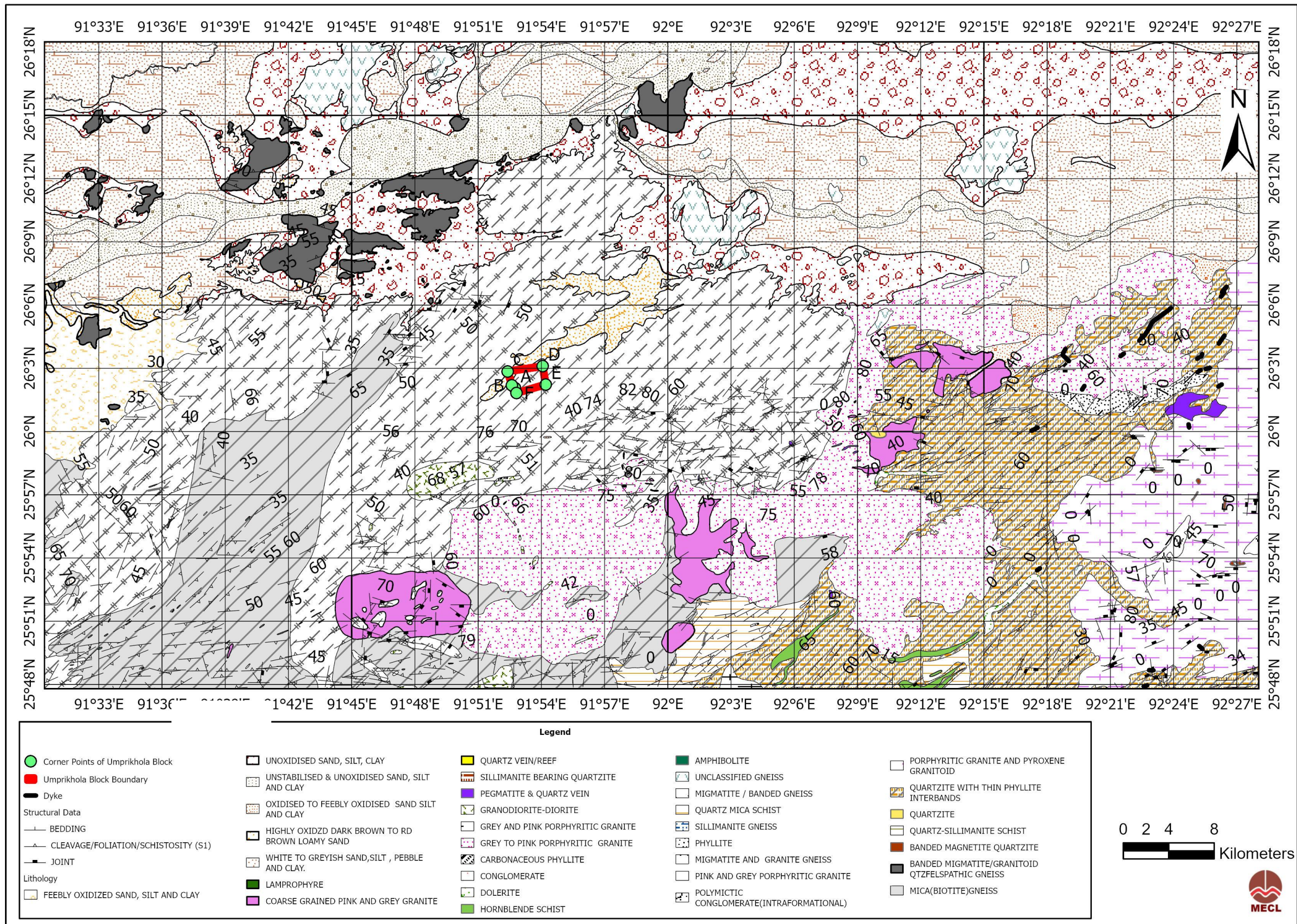
7.1.9 The regional Stratigraphic Succession around the area as established by GSI is furnished below

Table No 7.1
Regional Stratigraphy of Meghalaya (GSI, Misc. Pub. No.30 Part IV Vol 2(ii)
Meghalaya, 2009).

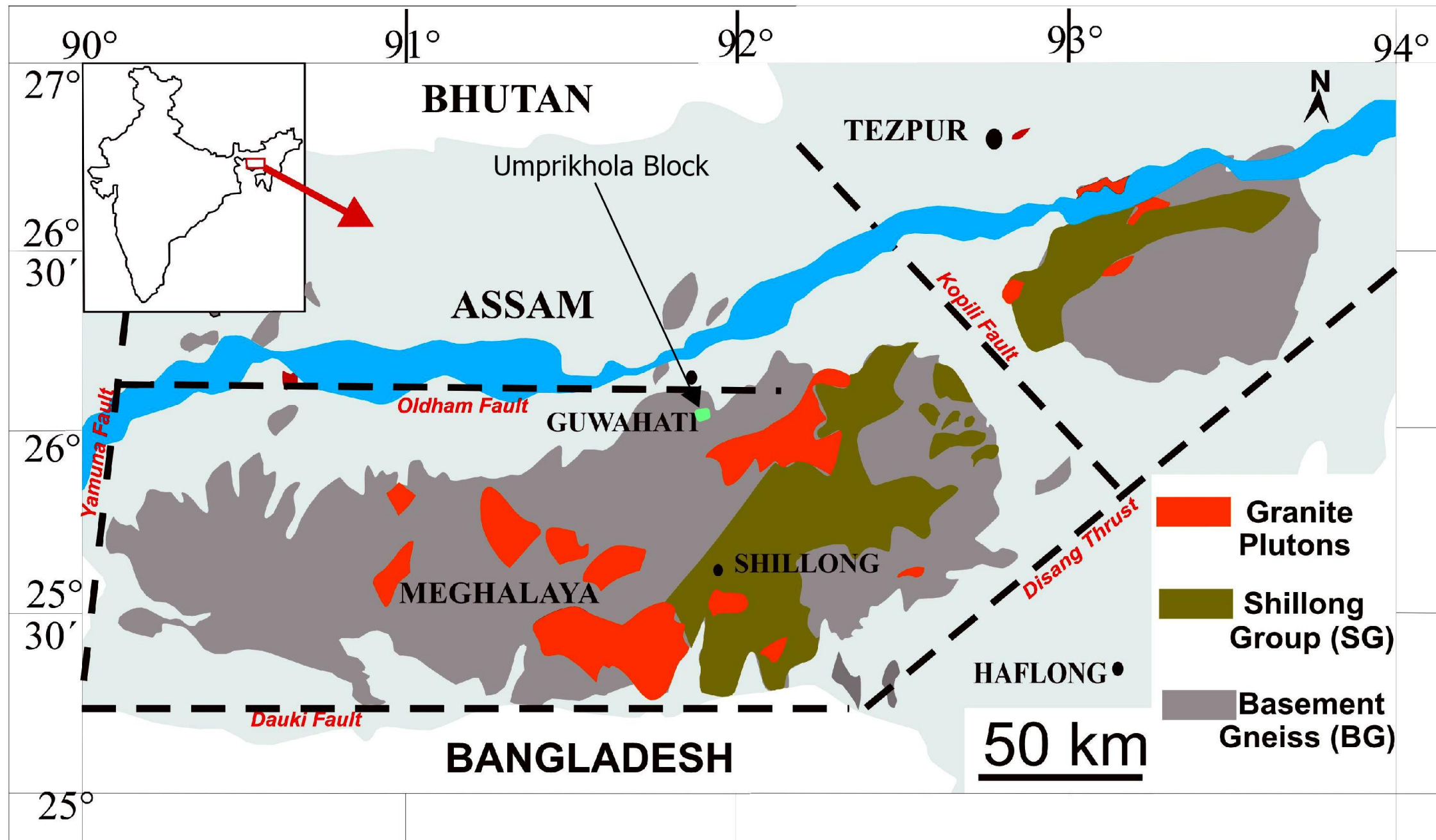
Age	Group Name	Formation	Lithology
HOLOCENE	Newer Alluvium	Unclassified	Sand, silt and clay
PLEISTOCENE	Older Alluvium	Unclassified	Sand, clay, pebble, gravel and boulder deposit
-----Unconformity-----			
MIO-PLIOCENE		Dupitila Formation	Mottled clay, feldspathic sandstone and conglomerate
-----Unconformity-----			
OLIGOMIOCENE	Garo Group	Chengapara Formation (700m)	Coarse sandstone, siltstone, clay and marl
		Baghmara Formation (530m)	Coarse feldspathic sandstone pebble, conglomerate, clay, silty clay with fossiliferous limestone horizon at the top
		Simsang Formation (1150m)	Siltstone and fine sandstone and alternations of siltstone-mudstone
EOCENEOLIGOCENE	Barail Group	-----	Coarse sandstone, shale, carbonaceous shale with streaks and minor lenses of coal
PALAEOCENEE OCENE	Jaintia Group	Kopili Formation (50m)	Shale, Sandstone, marl
		Shella Formation (600m)	Upper Sylhet Limestone (Prang Limestone)
			Upper Sylhet Sandstone (Narpuh Sandstone)
			Middle Sylhet Limestone (Umlatdoh Limestone)
			Middle Sylhet Sandstone (Lakadong sandstone)
			Lower Sylhet Limestone (Lakadong Limestone)
			Lower Sylhet Sandstone (Therria Sandstone)
		Langpar Formation (100m)	Calcareous shale, sandstone and limestone
UPPER CRETACEOUS	Khasi Group	Mahadek Formation(150m) Conglomerate (25m) Jadukata Formation(140m)	Arkosic sandstone (often Glauconitic and Uraniferous) Conglomerate Conglomerate/sandstone
-----Unconformity-----			
CRETACEOUS	Alkaline-Ultramafic-Carbonatite Complex of Sung	-----	Pyroxenite-Serpentinite with abundant development of melilite pyroxene rock, ijolite, syenite and carbonatite
-----Unconformity-----			

Age	Group Name	Formation	Lithology
CRETACEOUS	Sylhet Trap (600m)	-----	Basalt, alkali basalt, rhyolite and acid tuff
-----Unconformity-----			
CARBONIFEROUS TO PERMIAN	Lower Gondwana	Karharbari Formation	Very coarse to coarse grained sandstone with conglomerate lense, siltstone, shale, carbonaceous shale and coal
		Talchir Formation	Basal tillite with sandstone bands, siltstone and shale
-----Unconformity-----			
NEO PROTEROZOIC TO EARLY PALAEOZOIC		Granite plutons: Kyrdem Granite Pluton Nongpoh Granite Mylliem Granite South Khasi Granite	Porphyritic coarse granite, pegmatite, aplite/quartz vein traversed by epidiorite, dolerite and basal dykes
-----Intrusive contact-----			
PROTEROZOIC	Khasi basic-Ultrabasic intrusive (Khasi greenstone)	-----	Epidiorite, dolerite, amphibolite and pyroxenite dykes and sills.
PALAEO-MESOPROTEROZOIC	Shillong Group	-----	Quartzite, phyllite, quartz sericite schist, Conglomerate.
-----Unconformity-----			
ARCHAEAN (?) - PROTEROZOIC	Meghalaya Gneissic Complex		Biotite gneiss, biotite hornblende gneiss, granite gneiss, mica schist, sillimanite quartz schist, biotite-granulite-amphibolite, pyroxene granulite, gabbro and diorite.

Text Fig 7.1: Regional
Geology Map of the
study region.
Source of Data: NGDR
Portal)



Text Figure No. 7.2:
Tectonic map of
Shillong plateau.
(Representative Open
source map)



Legend

Umprikhola Block Boundary

0 12.5 25 50 75 100
Kilometers

7.2.0 GEOLOGY OF THE BLOCK

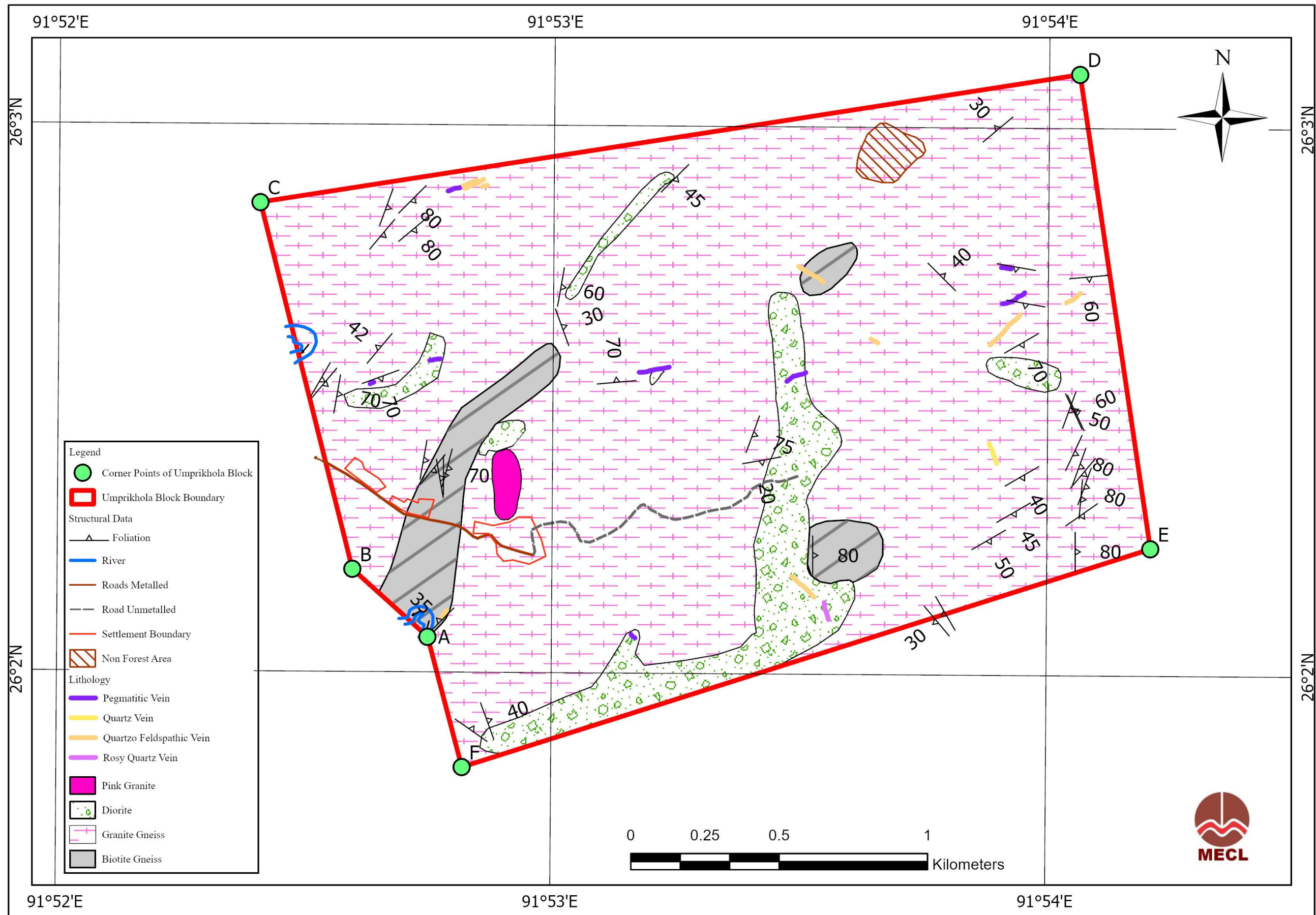
7.2.1 The Umprikhola Block mainly composed of Granite Gneiss, Biotite Gneiss, Diorite, Pink Granite with Pegmatitic vein, Quartzo feldspathic vein, Quartz vein which are intruded into the Granite Gneiss and Diorite. Though the amount of outcrop the lithology are less but based on total number and area of outcrop the granite is the dominant lithology. The topographic and detailed geological map of the block and the locations of bedrock samples are furnished in Text Figures No. 7.3 and Text figure No. 7.4, as well as in Plates III and IV, respectively. The generalized stratigraphy of the block area is given in Table No 7.2

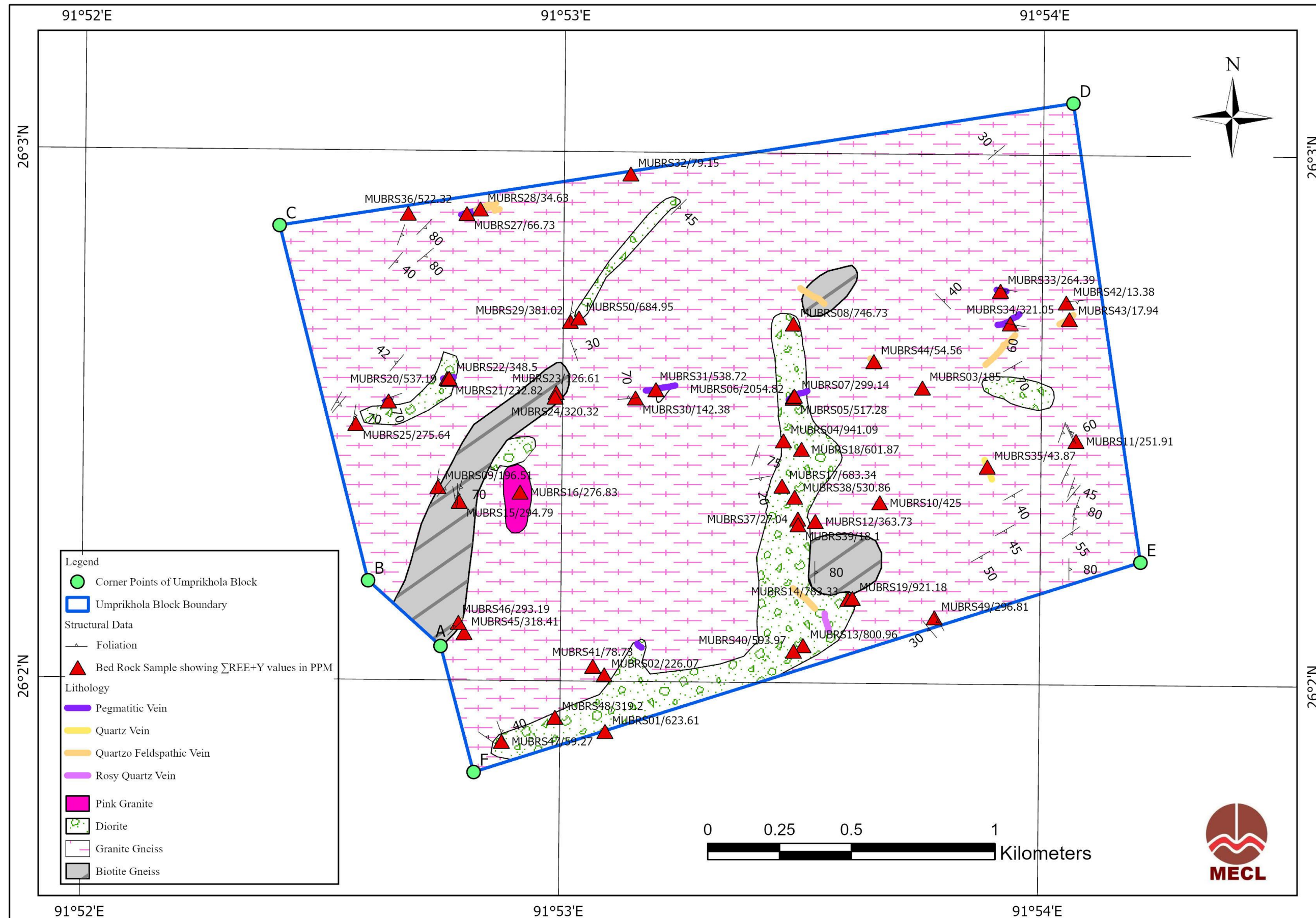
Table- 7.2

The generalized stratigraphic succession in the block.

AGE	Group	LITHO UNITS
Recent	Quaternary Deposits	Weathered soil and Fluvial deposits
Neo-Proterozoic to Early Palaeozoic	Intrusive Body	Veins (Pegmatitic Vein, Quartzo Feldspathic vein and Quartz Vein)
		Pink Granite
Archaean to Proterozoic	Assam Meghalaya Gneissic Complex	Diorite
		Granite Gneiss
		Biotite Gneiss

Text Fig. 7.3. Detail Geological map of Umprikhola Block, District Kamrup (Metro), Assam.



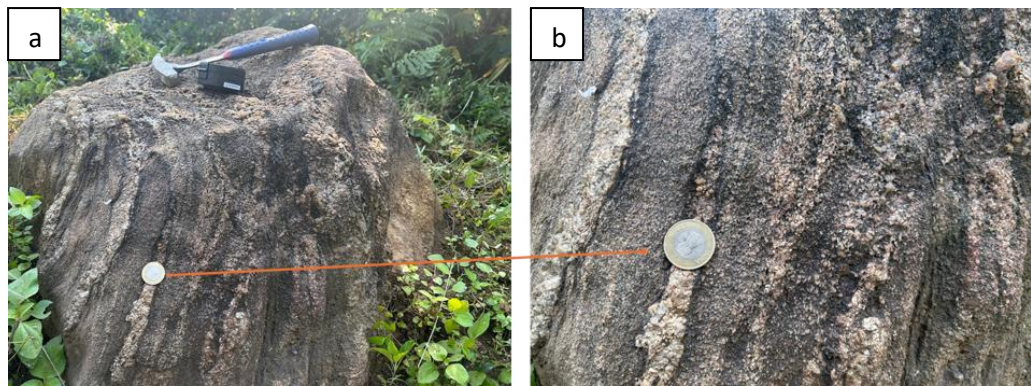


Text Fig No. 7.4:
Location of the 50
Bed rock samples
along with $\Sigma\text{REE}+\text{Y}$
value in ppm

7.2.2 Description of lithology

7.2.2.1 Granite Gneiss:

Granite gneiss is one of the dominant lithological units exposed in the Umprikhola Block. Megascopically, the rock is medium- to coarse-grained, foliated and distinctly banded in nature (Field Photograph No 7.1). It is predominantly composed of quartz, feldspar and mica, exhibiting well-developed gneissic foliation marked by alternating felsic and mafic bands. The felsic bands are mainly composed of quartz and feldspar, whereas the mafic bands are enriched in biotite and other mica minerals.



Field Photograph No 7.1: a) Granite Gneiss with Quartzo-feldspathic vein along the foliation. b) 0.5-1.5 cm of Quartzo feldspathic vein intruded along the foliation of Granite Gneiss.

Thin quartzo-feldspathic veins, varying from 0.5 cm to 3 cm in thickness, are observed intruding both parallel and transverse to the foliation planes. Although the rock exhibits distinct compositional banding, quartz and feldspar grains are also present within mica-rich bands, making the darker bands comparatively lighter and brighter than those typically observed in biotite gneiss.

The foliation is well developed due to the preferred alignment of mica minerals, while quartz and feldspar occur as granular to elongated aggregates within felsic layers. Traces of magnetite occur along biotite-rich foliation bands. In certain parts of the block, particularly towards the northeastern side, medium-grained ilmenite grains are observed aligned parallel to the foliation planes, indicating their close association with the metamorphic fabric of the rock (Field Photograph No 7.2).



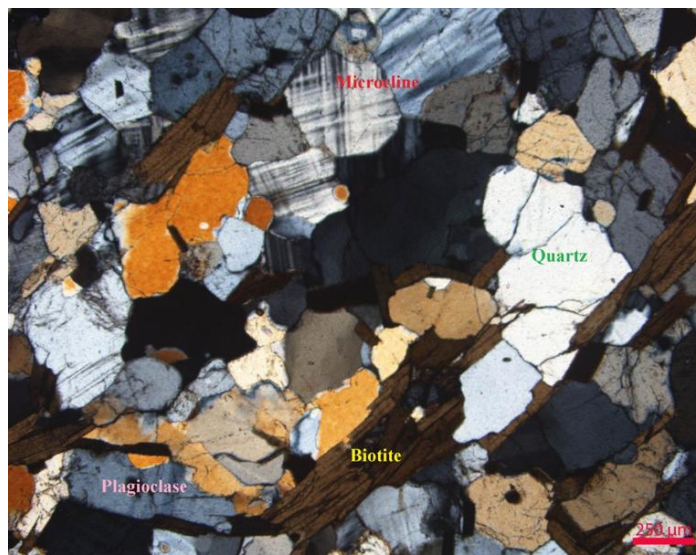
Field Photograph No. 7.2: Dark color Ilmenite present within the Granite Gneiss towards the North Eastern side of the block. Some Ilmenite grains are demarcated by the red circle.

Under the microscope, the granite gneiss shows medium- to coarse-grained granoblastic to gneissose texture with crude to well-developed mineral alignment (Pmg 1, Pmg2 and Pmg3 as well as annexure V and IX). The rock is composed predominantly of microcline/orthoclase, plagioclase, quartz and biotite, with subordinate hornblende and muscovite. Feldspars occur as medium- to moderately coarse subhedral prismatic grains showing crude alignment, whereas quartz occurs as anhedral grains and patches, locally exhibiting elongation parallel to foliation.

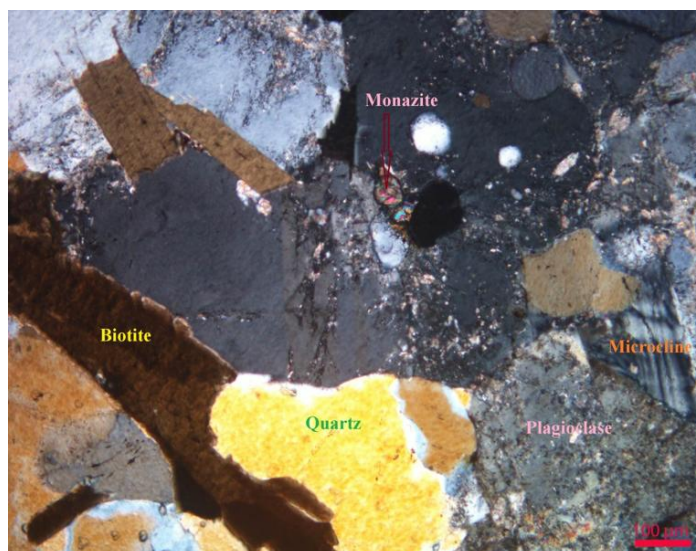
Biotite occurs as fine- to medium-grained disseminated flakes showing preferred parallel orientation, imparting the characteristic gneissosity to the rock. Hornblende, where present, occurs as fine- to medium-grained subhedral prismatic grains, occasionally altered to biotite and chlorite. Secondary minerals such as sericite, chlorite, epidote and calcite are observed developing along alteration zones within feldspars and ferromagnesian minerals.

Accessory minerals identified in thin section include apatite, sphene, zircon, monazite and opaques (Pmg 3 and Annexure V). Zircon commonly occurs as very fine inclusions within biotite and is associated with prominent pleochroic haloes. Monazite is observed as very fine subrounded grains in accessory proportions, indicating the REE-bearing nature of the granite gneiss. Opaque minerals occur as fine anhedral to subhedral grains disseminated within the rock fabric.

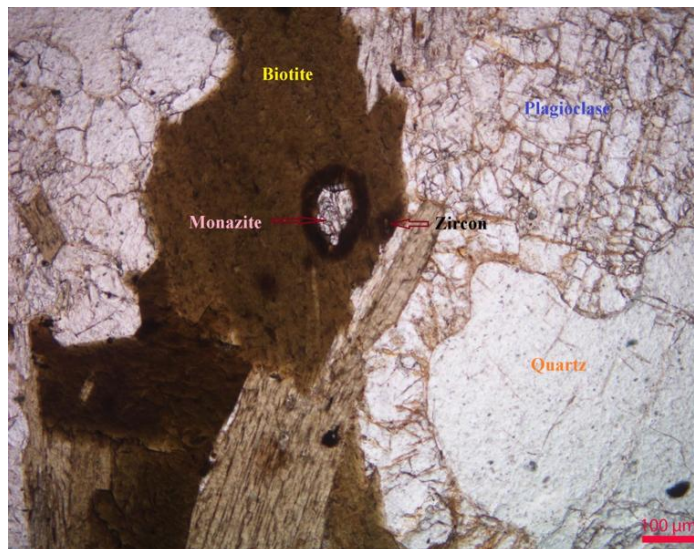
Petrographically, the rock is classified as granite gneiss, with local variations showing crude gneissosity and weak recrystallisation effects.



Pmg – 1:
Photomicrograph showing association and parallel alignment of microcline, quartz, plagioclase and biotite in granite gneiss as seen under crossed nicols.



Pmg – 2:
Photomicrograph showing presence of monazite in granite gneiss as seen under crossed nicols.



Pmg – 3:
Photomicrograph showing monazite and zircon inclusions within biotite as seen under plane polarized light.

A total of seven granite gneiss samples collected from different parts of the Umprikhola Block were analysed for 34 elements through ICP-MS analysis. The analytical results indicate the presence of Rare Earth Elements (REE), High Field Strength Elements (HFSE) and other incompatible trace elements within the granite gneiss. The summarized analytical values are given in table no 7.3 as well as annexure II.

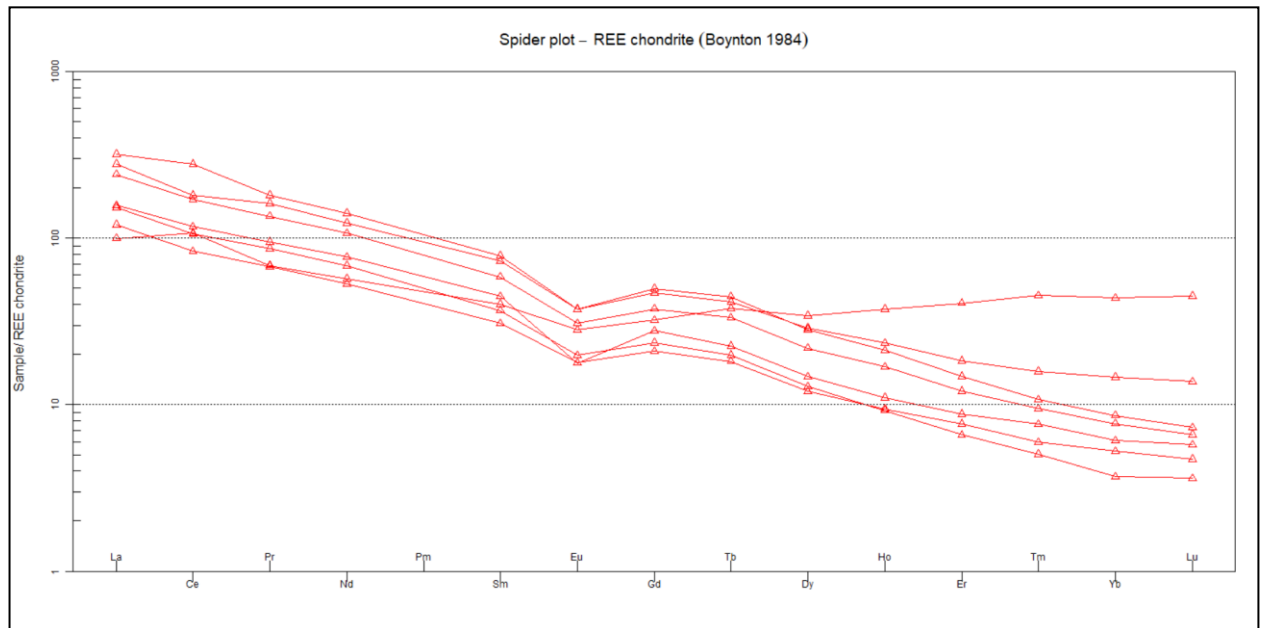
Table no 7.3. Summarized table of ICP-MS analysis of Granite Gneiss (N=7) for 34 elements.

Elements	Min(ppm)	Max(ppm)	Mean(ppm)
Sc	9.41	29.76	15.71
V	19.42	151.03	70.87
Cr	61.82	283.04	140.29
Co	7.33	82.00	24.80
Ni	21.12	72.72	30.80
Cu	16.57	102.14	44.62
Zn	54.77	210.14	95.06
Ga	10.77	30.39	17.80
Rb	86.79	197.18	135.34
Sr	124.69	320.38	213.86
Y	18.33	82.21	37.84
Zr	82.23	334.46	204.13
Nb	1.98	10.83	4.90
Sn	0.12	0.26	0.16
La	30.92	99.05	60.68
Ce	67.43	225.74	120.70
Pr	8.26	22.12	13.88
Nd	31.98	84.74	53.77

Elements	Min(ppm)	Max(ppm)	Mean(ppm)
Sm	5.99	15.26	10.08
Eu	1.31	2.76	1.99
Gd	5.43	12.87	8.83
Tb	0.86	2.11	1.48
Dy	3.87	11.04	7.03
Ho	0.66	2.70	1.32
Er	1.38	8.55	3.27
Tm	0.16	1.47	0.46
Yb	0.77	9.16	2.68
Lu	0.12	1.45	0.40
Hf	2.77	9.85	5.98
Ta	0.35	1.95	0.73
W	8.09	338.70	66.07
Pb	16.77	39.24	28.26
Th	12.65	34.38	23.70
U	1.87	4.76	3.02
TREE+Y	185.00	522.32	324.41
TREE+Sc+Y	195.00	541.43	340.11

The granite gneiss shows total REE (Σ REE+Y) values ranging from 185.00 ppm to 522.32 ppm, with an average value of approximately 324.41 ppm. The analysed samples exhibit relative enrichment of Light Rare Earth Elements (LREE) such as La, Ce and Nd. Lanthanum values range from 30.92 ppm to 99.05 ppm, cerium from 67.43 ppm to 225.74 ppm and neodymium from 31.98 ppm to 84.74 ppm. The distribution pattern indicates predominance of LREE over HREE within the granitoid system.

Among the Heavy Rare Earth Elements (HREE), yttrium ranges from 18.33 ppm to 82.21 ppm, dysprosium from 3.87 ppm to 11.04 ppm and ytterbium from 0.77 ppm to 9.16 ppm. The presence of both LREE and HREE suggests the occurrence of REE-bearing accessory minerals within the granite gneiss.



Text Fig 7.5: The chondrite-normalised REE spider diagram of granite gneiss (N=7).

The chondrite-normalised REE spider diagram of granite gneiss (Text Figure No. 7.5) from the Umprikhola Block exhibits a well-developed fractionated REE pattern characterized by pronounced enrichment of Light Rare Earth Elements (LREE) relative to Heavy Rare Earth Elements (HREE). The normalised profiles show high La, Ce and Nd concentrations followed by a gradual decrease towards the middle and heavy REE segments.

The LREE-enriched nature of the pattern suggests derivation from an evolved felsic granitoid protolith and reflects preferential concentration of incompatible elements during magmatic differentiation. Most samples display a smooth declining trend from La to Sm, indicating coherent magmatic fractionation behaviour

A distinct negative europium (Eu) anomaly is observed in almost all samples. The depletion of Eu relative to neighbouring Sm and Gd indicates feldspar fractionation during crystallisation, as Eu is preferentially incorporated into plagioclase feldspar under magmatic conditions.

The HREE segment shows comparatively lower concentrations with moderate inter-sample variation (Text Figure No. 7.4). Some samples exhibit gradual depletion from Gd to Lu, whereas a few samples show relatively flatter HREE

patterns. This variation may be related to differential distribution of accessory minerals such as zircon, monazite and sphene within the granite gneiss.

Overall, the chondrite-normalised REE patterns indicate fractionated felsic magmatic affinity of the granite gneiss and suggest that REE distribution is primarily controlled by accessory mineral phases and magmatic differentiation processes.

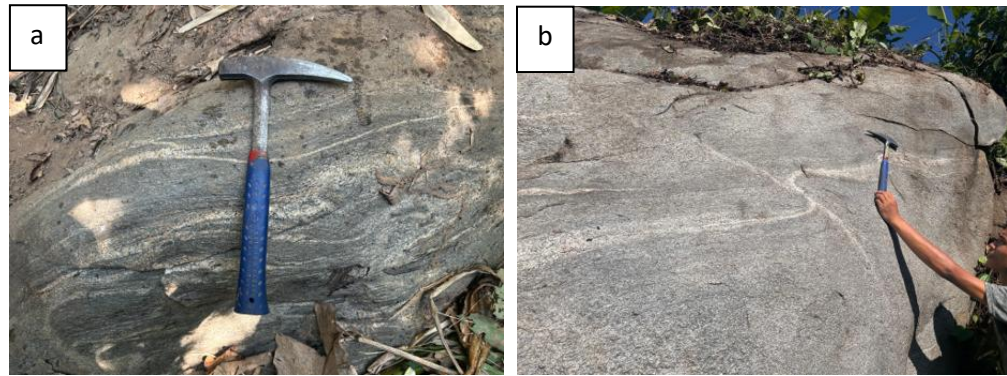
The rock also contains High Field Strength Elements (HFSE) such as zirconium (82.23–334.46 ppm), niobium (1.98–10.83 ppm), thorium (12.65–34.38 ppm), uranium (1.87–4.76 ppm), hafnium and tantalum. Elevated zirconium and thorium contents indicate the presence of accessory minerals such as zircon, monazite and sphene, which is corroborated by petrographic studies.

Trace element concentrations reveal moderate enrichment of Rb (86.79–197.18 ppm) and comparatively lower Sr values (124.69–320.38 ppm), suggesting feldspar fractionation within the granitoid protolith. Tungsten values vary from 8.09 ppm to 338.70 ppm, indicating possible hydrothermal influence in certain parts of the block.

Transition metal concentrations such as Cr (61.82–283.04 ppm), Ni (21.12–72.72 ppm), Cu (16.57–102.14 ppm) and Zn (54.77–210.14 ppm) indicate minor mafic contribution and sulphide association within the gneissic terrain.

Overall, the geochemical characteristics indicate that the granite gneiss represents an evolved granitoid protolith containing REE-bearing accessory mineral phases along with associated incompatible trace elements.

7.2.2.2 Biotite Gneiss: The Biotite Gneiss exposed in the block is characterized by well-developed gneissic foliation, defined by alternating melanocratic biotite-rich bands and leucocratic feldspathic bands (Field Photograph No 7.3). The rock is fine- to medium-grained in nature and exhibits distinct compositional banding. The biotite-rich bands are comparatively thicker and more prominent than the quartzo-feldspathic veins and leucocratic layers.



Field Photograph No 7.3: a) Quartzo feldspathic vein present along the foliation. b) Concordant and discordant quartzo feldspathic vein within the Biotite Gneiss.

Quartzo-feldspathic veins, varying from approximately 0.5 cm to 3 cm in thickness, are observed intruding both along and across the foliation planes. In several locations, these veins, along with the foliation planes, exhibit folding, indicating the effect of multiple phases of deformation. The folded nature of the foliation and veins suggests ductile deformation under regional metamorphic conditions.

The mineral assemblage mainly comprises quartz, feldspar, and biotite, with accessory occurrences of magnetite observed as disseminated traces within the biotite-rich bands. The presence of magnetite is particularly associated with the mafic layers, imparting a dark grey to black appearance to the biotite bands.

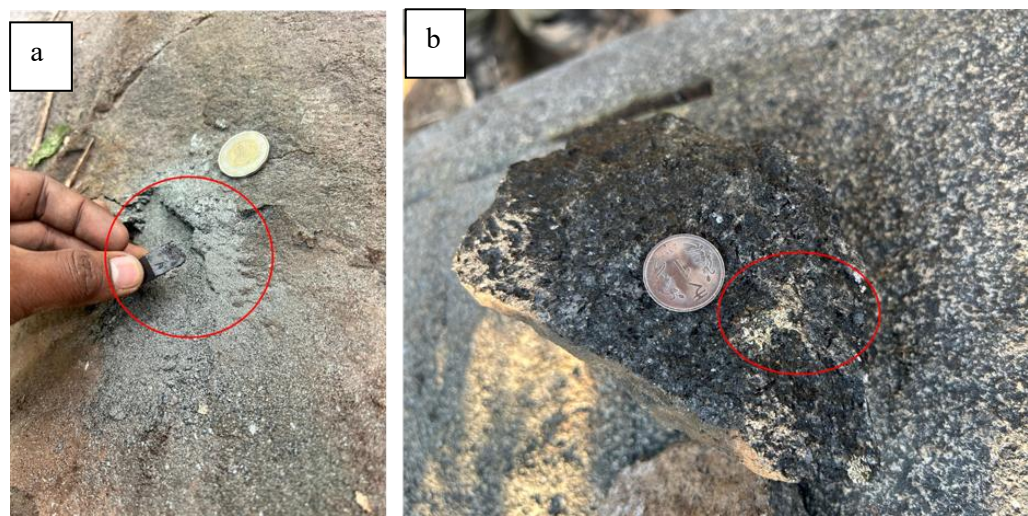
7.2.2.3 Diorite:

Diorite constitutes the second most dominant lithology within the Umprikhola Block and occurs extensively in the form of massive to bouldery outcrops. Based on grain-size variations, the rock is classified into fine-grained, medium-grained and coarse-grained varieties. Megascopically, the rock is grey to dark grey in colour and generally exhibits massive character, although weak foliation is developed locally in certain exposures.

Mineralogically, the rock is composed predominantly of hornblende, biotite, feldspar and quartz, with hornblende and biotite forming the principal mafic constituents. Feldspar occurs mainly as plagioclase, whereas quartz is present

in minor to moderate proportions. Thin quartz veins ranging from approximately 0.5 cm to 2 cm in thickness commonly traverse the rock along fractures and joints.

Sulphide mineralisation is commonly associated with the dioritic rocks and occurs mainly in the form of disseminated pyrite (Field Photograph No 7.4). Sulphide mineralisation is more prominently developed within the medium- and coarse-grained varieties, where pyrite occurs as disseminations, patches and fracture fillings. In contrast, the fine-grained variety contains comparatively lesser sulphide mineralisation but shows disseminated magnetite grains within the rock matrix.



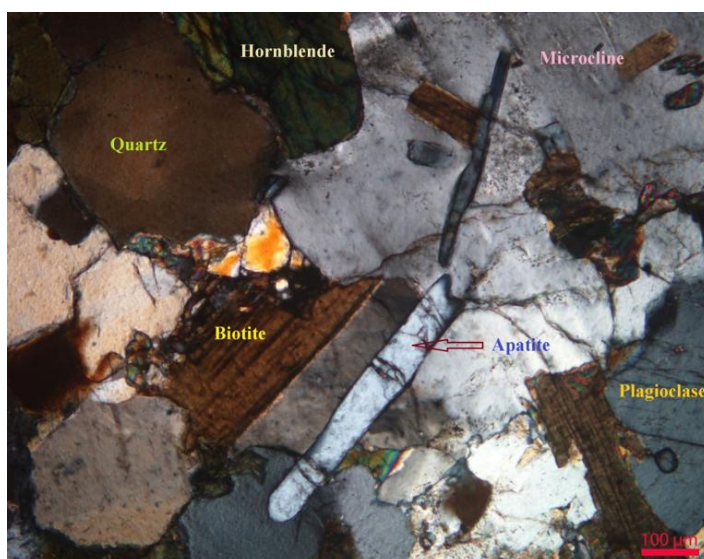
Field Photograph No 7.4: a) Magnetite present within the fine grain diorite. b) Pyrite present within the coarse grain diorite.

The coarse-grained variety is characterised by relatively larger crystals of hornblende and feldspar, whereas the fine-grained variety exhibits compact texture with finer mineral intergrowths. The medium-grained variety represents the most widespread lithological type in the block and commonly occurs associated with quartz veining and sulphide enrichment.

Under the microscope, the rock shows medium- to coarse-grained hypidiomorphic granular texture composed predominantly of plagioclase, quartz and biotite with subordinate microcline, hornblende and actinolite–tremolite (Pmg 4, annexure V and annexure VII). Plagioclase and microcline occur as medium- to moderately coarse subhedral prismatic grains, whereas

quartz occurs as fine- to medium-grained anhedral grains. Biotite occurs as disseminated flakes and patches, while hornblende and actinolite–tremolite occur as subhedral prismatic grains.

Secondary minerals such as epidote and calcite are observed as alteration products and fracture fillings. Accessory minerals include apatite, sphene, opaques, monazite and diopside. Monazite occurs as very fine accessory grains indicating the presence of REE-bearing phases within the rock. Opaque minerals occur as disseminated specks and along cleavage traces of biotite.



Pmg – 4:
Photomicrograph showing association of plagioclase, quartz, biotite, microcline and hornblende and presence of apatite in accessories in meta-granodiorite as seen under crossed nicols.

Although mapped as diorite during field investigations based on megascopic characteristics, petrographic studies indicate granodioritic mineralogical composition with effects of metamorphic recrystallisation. Accordingly, the rock is petrographically classified as meta-granodiorite.

A total of thirteen diorite samples from the Umprikhola Block were analysed for 34 elements through ICP-MS analysis to evaluate the distribution of REE and associated trace elements within the lithounit (Table 7.4 and annexure II). In addition, five selected samples, namely MUBRS-04, MUBRS-08, MUBRS-18, MUBRS-19 and MUBRS-50, were analysed for Platinum Group Elements (PGE) through fire assay method, while Ni and Cr were analysed through AAS. The summarized analytical values are given in table no 7.4 and annexure II.

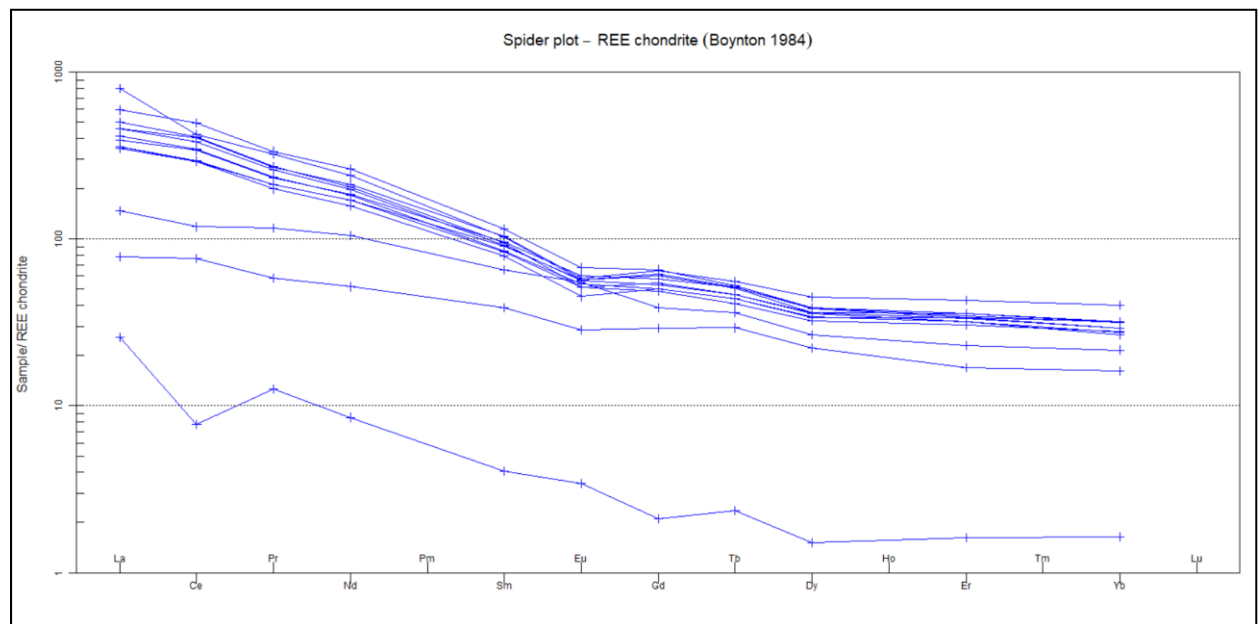
Table no 7.4 Summarized table of ICP-MS analysis of Diorite (N=13) for 34 elements

Elements	Min(ppm)	Max(ppm)	Mean (ppm)
Sc	1.51	47.32	33.14
V	7.74	225.94	165.21
Cr	177.58	727.22	355.77
Co	3.82	72.36	47.64
Ni	18.43	293.66	150.56
Cu	15.45	269.97	65.51
Zn	22.27	159.42	84.02
Ga	12.44	21.97	17.59
Rb	81.24	367.43	162.29
Sr	0.00	908.58	501.40
Y	3.28	89.80	65.37
Zr	101.38	338.82	198.94
Nb	3.06	8.08	4.97
Sn	0.10	0.27	0.16
La	7.99	248.28	117.75
Ce	6.25	399.51	241.13
Pr	1.54	40.92	25.67
Nd	5.12	157.78	99.38
Sm	0.79	22.31	15.75
Eu	0.25	4.97	3.65
Gd	0.54	16.98	12.66
Tb	0.11	2.64	2.01
Dy	0.49	14.46	10.39
Ho	1.42	3.10	2.41
Er	0.34	9.03	6.23
Tm	0.56	1.37	1.02
Yb	0.34	8.39	5.58
Lu	0.49	1.16	0.84
Hf	3.27	9.00	5.94
Ta	0.37	1.25	0.73
W	4.47	152.47	55.65
Pb	9.69	61.95	35.54
Th	1.72	40.94	23.06
U	0.30	3.83	2.73
TREE+Y	27.04	941.09	609.52
TREE+ Sc+Y	28.55	976.58	642.66

The analytical results indicate variable concentrations of Rare Earth Elements (REE), High Field Strength Elements (HFSE) and transition metals within the dioritic rocks. Total REE (Σ REE+Y) values range from 27.04 ppm to 941.09

ppm, indicating moderate variation in REE distribution within the lithounit. None of the analysed samples record anomalous $\Sigma\text{REE}+\text{Y}$ values exceeding 1000 ppm.

The diorite/meta-granodiorite samples show relative enrichment of Light Rare Earth Elements (LREE) over Heavy Rare Earth Elements (HREE). Lanthanum values range from 7.99 ppm to 248.28 ppm, cerium from 6.25 ppm to 399.51 ppm and neodymium from 5.12 ppm to 157.78 ppm. Among the HREE, yttrium values range from 3.28 ppm to 89.80 ppm, dysprosium from 0.49 ppm to 14.46 ppm and ytterbium from 0.34 ppm to 8.39 ppm.



Text Fig No. 7.6: The chondrite-normalised REE spider diagram of granite gneiss (N=13).

The chondrite-normalised REE spider diagram of the diorite/meta-granodiorite samples exhibits a distinctly fractionated REE pattern characterised by enrichment of Light Rare Earth Elements (LREE) relative to Heavy Rare Earth Elements (HREE) (Text Figure No 7.6). Most samples display elevated La, Ce and Nd concentrations followed by gradual depletion towards the HREE segment, indicating evolved magmatic differentiation trends.

A moderate negative europium (Eu) anomaly is observed in several samples, suggesting plagioclase fractionation during crystallisation. The depletion of Eu relative to adjacent Sm and Gd reflects preferential incorporation of Eu into feldspar phases during magmatic evolution.

The HREE segment is comparatively flatter with moderate depletion towards Yb and Lu. Inter-sample variation within the HREE region is likely related to differential distribution of accessory minerals such as monazite, apatite and sphene. One sample exhibits overall depleted REE concentrations compared to the remaining population, indicating local geochemical heterogeneity within the dioritic body.

High Field Strength Elements (HFSE) such as zirconium, niobium, thorium and uranium are present in moderate concentrations. Zirconium ranges from 101.38 ppm to 338.82 ppm, niobium from 3.06 ppm to 8.08 ppm, thorium from 1.72 ppm to 40.94 ppm and uranium from 0.30 ppm to 3.83 ppm. The presence of these elements indicates contribution from accessory mineral phases such as monazite, sphene, apatite and zircon, which is corroborated by petrographic studies.

Trace element concentrations reveal moderate enrichment of Rb (81.24–367.43 ppm) with variable Sr concentrations. Tungsten values range from 4.47 ppm to 152.47 ppm, suggesting local hydrothermal influence within quartz-veined zones.

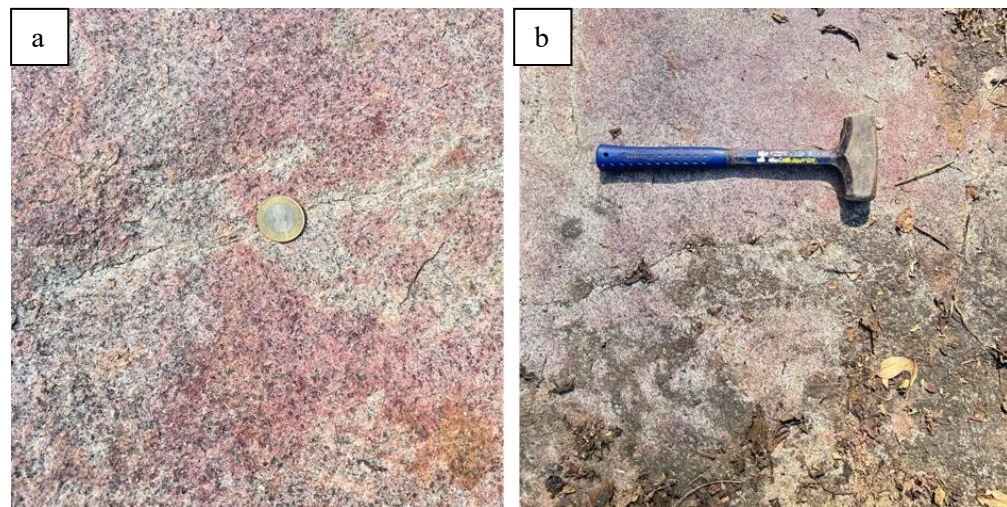
Transition metal concentrations such as Cr (177.58–727.22 ppm), Ni (18.43–293.66 ppm), Cu (15.45–269.97 ppm) and Zn (22.27–159.42 ppm) indicate moderate mafic affinity and sulphide association within the dioritic rocks. Elevated Cu values correspond well with the occurrence of disseminated pyrite and quartz-sulphide veining observed in the field.

The PGE analytical results indicate comparatively low concentrations of platinum group elements within the analysed samples. Platinum (Pt) values range from 9.24 ppb to 36.33 ppb, palladium (Pd) from 150.69 ppb to 340.28 ppb, rhodium (Rh) from below detection limit to 5.06 ppb, ruthenium (Ru) from 51.32 ppb to 59.49 ppb, iridium (Ir) from below detection limit to 8.34 ppb and osmium (Os) is below detection limit (Annexure III). These low concentrations suggest absence of significant PGE mineralisation within the dioritic bodies.

Overall, the geochemical characteristics and chondrite-normalised REE patterns indicate fractionated intermediate intrusive affinity with transitional characteristics between diorite and granodiorite. The REE distribution appears

to be primarily controlled by magmatic differentiation and accessory mineral phases.

7.2.2.4 Pink Granite: Pink Granite occurs as intrusive bodies within the Granite Gneiss and is predominantly exposed towards the western part of the Umprikhola Block. The rock is medium- to coarse-grained, massive, hard and leucocratic in nature with characteristic pink colour imparted by abundant K-feldspar (Field Photograph No 7.5). It occurs both as in situ outcrops and as large bouldery exposures exhibiting moderate to coarse jointing patterns.



Field Photograph No 7.5: a) Medium-grained pink granite with thin quartz veins and traces of magnetite grains, b) Outcrop of Pink Granite.

Megascopically, the rock is composed predominantly of K-feldspar, plagioclase feldspar and quartz, while biotite and hornblende occur in minor proportions as mafic constituents. Quartz generally occurs as medium-grained anhedral crystals, whereas feldspars are subhedral to euhedral in habit. Thin quartz and quartzo-feldspathic veins are observed traversing the granite along joints and fractures at several places.

The contacts of the Pink Granite with surrounding Granite Gneiss are sharp and intrusive in nature, indicating emplacement of younger felsic intrusive phases within the gneissic terrain. Minor disseminated sulphide specks are occasionally observed within fractured portions of the rock. Weathered surfaces commonly exhibit light pink to reddish colouration, whereas fresh surfaces appear pinkish grey.

Geochemically, the Pink Granite shows enrichment of felsic incompatible elements and REE-bearing accessory phases. ICP-MS analysis of the representative sample indicates total REE (Σ REE+Y) value of 276.83 ppm. The rock shows relative enrichment of Light Rare Earth Elements (LREE), with La, Ce and Nd values of 56.73 ppm, 103.30 ppm and 45.44 ppm respectively. Among the Heavy Rare Earth Elements (HREE), Y, Dy and Yb record values of 28.11 ppm, 5.53 ppm and 2.25 ppm respectively (Annexure II).

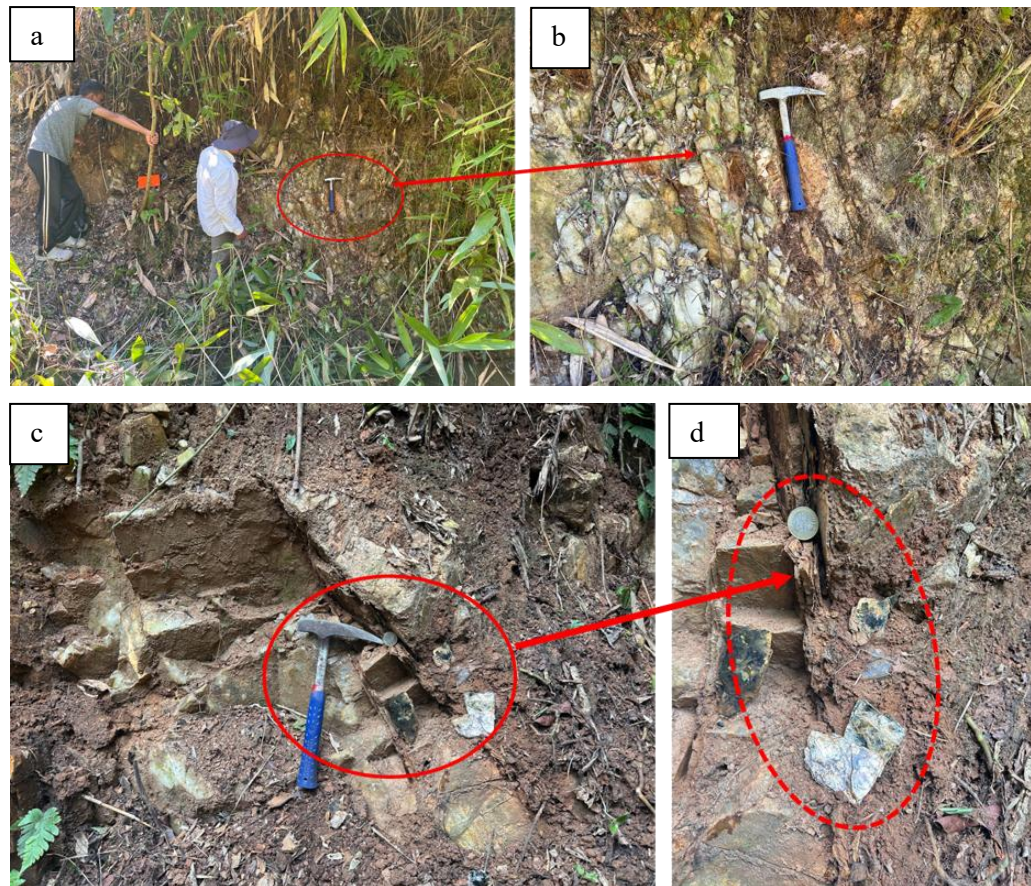
High Field Strength Elements (HFSE) such as Zr, Th and U show concentrations of 309.05 ppm, 36.98 ppm and 2.77 ppm respectively, indicating the presence of accessory minerals such as zircon and monazite within the granitoid body. Rb content is relatively high (166.60 ppm), whereas Sr records 218.31 ppm, suggesting evolved felsic magmatic affinity.

Transition metal concentrations such as Cr (125.18 ppm), Ni (13.54 ppm), Cu (20.74 ppm) and Zn (38.35 ppm) are comparatively low, indicating limited mafic contribution within the rock. Tungsten records 13.05 ppm, possibly reflecting minor hydrothermal influence associated with late-stage quartz veining.

7.2.2.5 Pegmatite, quartz veins and quartzo-feldspathic veins: There are mainly four types of veins, which intruded the major litho units of the study area. Those veins were categorized on the basis of their mineral content.

a. Quartz vein: Based on appearance two types of Quartz vein are observed they are-

i) Milky Quartz Vein: Milky quartz veins are prominently exposed within the Umprikhola Block as fracture- and joint-controlled veins cutting across the host rocks, mainly diorite/meta-granodiorite and granite gneiss. The larger quartz veins are commonly developed near the contact zones between diorite and granite gneiss, indicating strong structural control over vein emplacement. The thickness of the quartz veins varies from approximately 10 cm to 5 m, while the exposed strike length ranges from 1 m to 10 m. The largest milky quartz vein is exposed near the waterfall area of Aporikula Village (Field Photograph No 7.6) and trends in the 120°–300° direction.



Field Photograph No 7.6: a and b) Milky Quartz vein exposed at the contact between Granite Gneiss and Diorite near water fall of Aporikula villages. c and d) Biotite flakes present along the fracture within the Quartz.

Megascopically, the quartz veins are massive, hard, compact and milky white in colour. The quartz is predominantly coarse grained and locally exhibits saccharoidal texture. Minor feldspar and opaque minerals occur as accessory constituents within the vein material. Thin biotite bands ranging from 0.5 cm to 2.5 cm in thickness are also observed within the quartz veins, particularly along fracture planes and joint surfaces.

Three prominent sets of fractures/joints are developed within the quartz veins, comprising two vertical joint sets and one horizontal joint set. The vertical joint sets trend along 20° – 200° and 110° – 290° respectively. These fractures are moderately to widely spaced and are locally filled with secondary iron oxide staining.

In several places, the quartz veins exhibit brecciated and fractured nature, suggesting multiple phases of hydrothermal activity and repeated reactivation

along structurally weak zones. Weathered surfaces commonly appear dull white to yellowish due to iron staining, whereas fresh surfaces are milky white with vitreous lustre.

Geochemically, the milky quartz veins show comparatively low to moderate concentrations of REE and associated trace elements. Total REE ($\Sigma\text{REE}+\text{Y}$) values range from 41.83 ppm to 486.27 ppm (Annexure II). The samples show relative enrichment of Light Rare Earth Elements (LREE) over Heavy Rare Earth Elements (HREE), with La values ranging from 4.82 ppm to 116.34 ppm, Ce from 8.94 ppm to 201.28 ppm and Nd from 3.75 ppm to 79.46 ppm. Among the HREE, Y values range from 2.91 ppm to 68.73 ppm, Dy from 0.42 ppm to 9.48 ppm and Yb from 0.21 ppm to 5.14 ppm.

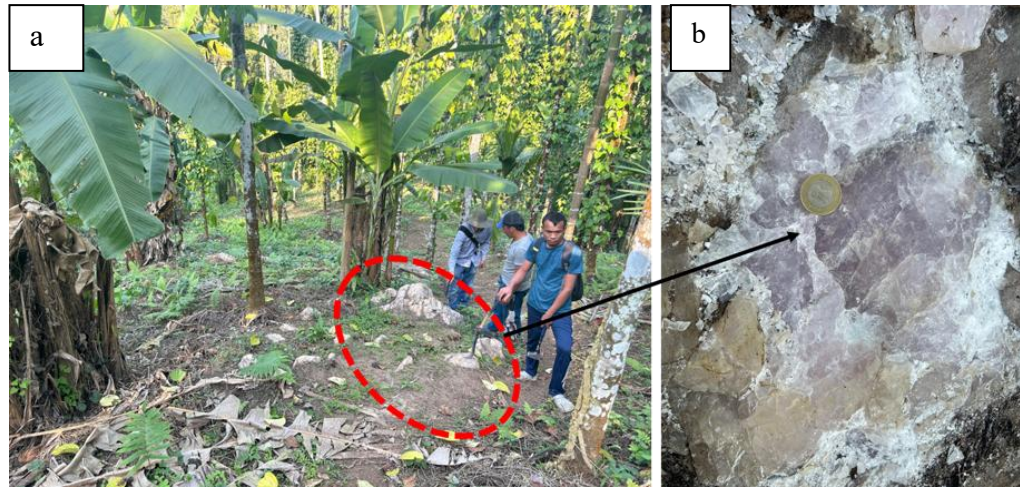
High Field Strength Elements (HFSE) such as Zr, Nb, Th and U occur in comparatively lower concentrations, with zirconium ranging from 18.42 ppm to 162.37 ppm, niobium from 0.84 ppm to 6.92 ppm, thorium from 0.76 ppm to 22.54 ppm and uranium from 0.18 ppm to 2.46 ppm. Tungsten values range from 2.11 ppm to 74.38 ppm, indicating hydrothermal influence within certain quartz vein zones.

Transition metal concentrations such as Cr, Ni, Cu and Zn are generally low, although localized enrichment is observed near sulphide-bearing fracture zones. Minor disseminated sulphides and iron oxide staining correspond well with elevated Cu and associated trace element values in certain samples.

ii) Rosy Quartz vein: Rosy quartz veins are exposed mainly in the southern part of the block and occur predominantly within the diorite lithology (Field Photograph No 7.7). The veins are light pink in colour, medium to coarse grained, and exhibit massive to compact nature. The thickness of the veins ranges from 1.3 m to 3 m, while the exposed strike length varies from 4 m to 7 m. The veins trend predominantly in the 0° – 180° direction with steep to near-vertical dip.

Two prominent joint sets are observed within the rosy quartz veins. One joint set is parallel to the vein trend (0° – 180°), whereas the second joint set trends 60° – 240° . The joints are moderately to widely spaced and, in some places, are filled with secondary silica and iron oxide staining. Minor fractures and

shearing are also observed along the vein margins, indicating post-emplacement tectonic activity.



Field Photograph No 7.7: a) Rosy Quartz Vein with trend 0° - 180° , b) Close up view of rosy quartz.

The contact between the rosy quartz vein and the host diorite is not distinct. The veins may appear to be structurally controlled and emplaced along prominent fracture zones within the diorite.

b) Quartzo-feldspathic vein: Quartzo-feldspathic veins are widely exposed throughout the block and are predominantly emplaced within the granite gneiss and biotite gneiss lithologies, while a few occurrences are also observed in proximity to diorite bodies. These veins are coarse-grained, leucocratic, and composed mainly of quartz and feldspar with minor amounts of biotite and opaque minerals. The veins vary considerably in dimension, ranging from thin stringers of 0.5 cm thickness to massive veins exceeding 5–6 m in width. Their strike continuity ranges from a few metres to more than 150 m along exposure.

Quartz occurs as coarse, anhedral to subhedral translucent grains showing vitreous lustre, whereas feldspar occurs as pinkish white to grey coarse crystals, locally altered to kaolin. In weathered exposures, feldspar-rich portions show moderate kaolinisation and iron staining.

The quartzo-feldspathic veins occur both concordant and discordant to the foliation planes of the host rocks, indicating multiphase intrusive activity and strong structural control during emplacement. Concordant veins are generally thin (0.5–30 cm thick) and parallel to the gneissic foliation of granite gneiss

and biotite gneiss, while discordant veins range from 1 m to 6 m in thickness and cut across the foliation at moderate to high angles. The general trend of the veins varies from NE–SW to NW–SE, with dominant orientations recorded at 120° – 300° , 130° – 310° , and 040° – 220° . The dip of the veins ranges from 55° to 85° towards SW and NW directions.

The largest quartzo-feldspathic vein is exposed in the central part of the block near the contact zone of granite gneiss and bouldery diorite (Field Photograph No 7.8). This vein attains a thickness of approximately 4–6 m with an exposed strike length of nearly 120 m and trends along 120° – 300° . The contact with the surrounding granite gneiss and diorite is sharp, irregular, and intrusive in nature. Chilled margins are absent; however, local silicification and alteration are observed near the contact zones.



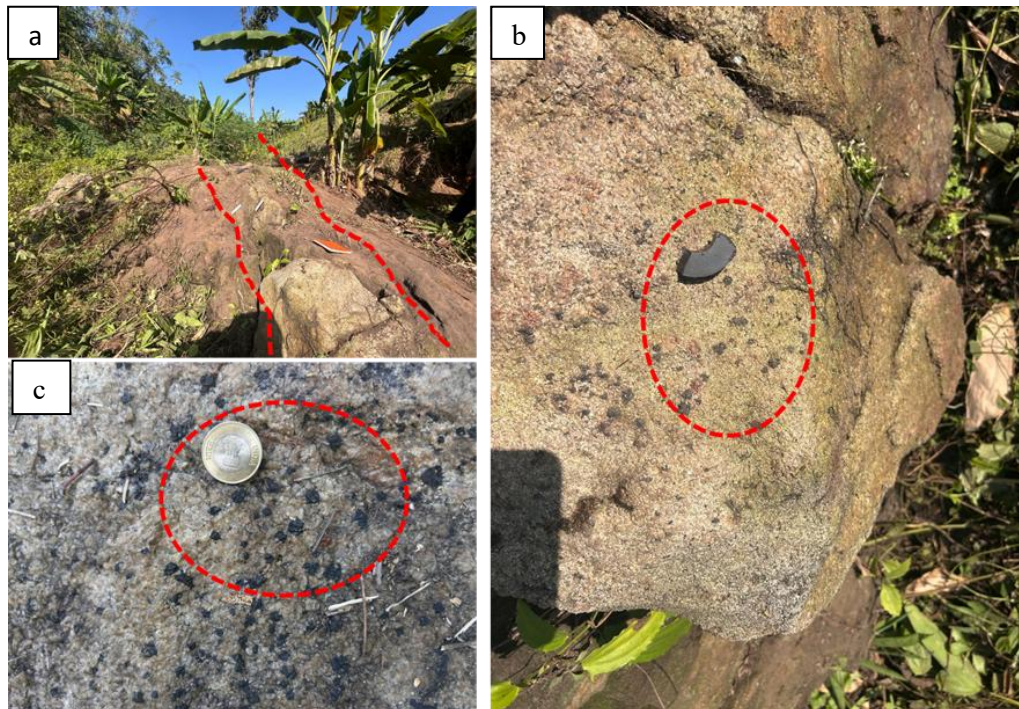
Field Photograph No 7.8: a) Quartzo feldspathic vein at contact between Granite Gneiss and Diorite. b) 4-6 m width Quartzo feldspathic vein with trends 120° – 300° .

Three prominent joint sets are developed within the veins. Two vertical to sub-vertical joint sets trend along 130° – 310° and 120° – 300° , respectively, while the third set is horizontal to sub-horizontal in nature. Joint spacing varies from 10 cm to 1.5 m. In several locations, the fractures are filled with secondary silica and iron oxide coatings, indicating later hydrothermal activity. Minor brecciation, shearing, and brittle deformation are also observed along some fracture zones, suggesting post-emplacement tectonic disturbances.

The quartzo-feldspathic veins are generally compact, hard, and resistant to weathering, forming ridge-like outcrops in several parts of the block. Quartz-rich portions display vitreous lustre and conchoidal fracture, whereas feldspar-rich domains exhibit moderate alteration under prolonged weathering

conditions. In a few exposures, weak sericitisation are observed adjacent to fracture zones.

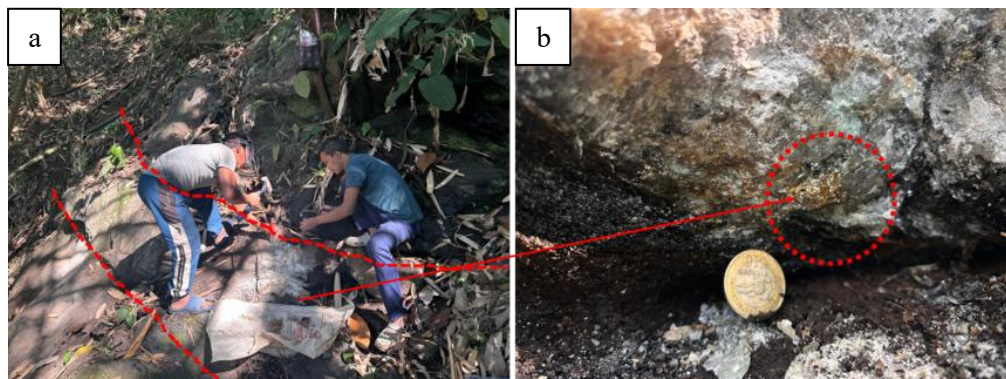
Magnetite crystals occur sporadically within the quartzo-feldspathic veins as disseminated grains and small clusters, particularly within quartz-rich portions (Field Photograph No 7.9). The magnetite grains are medium- to coarse-grained and exhibit subhedral to anhedral forms. Sulphide mineralisation comprising pyrite and chalcopyrite is observed mainly along the contact zones between quartzo-feldspathic veins and diorite/granite gneiss (Field Photograph No. 7.10). The sulphides occur as disseminations, fracture fillings, and thin veinlets associated with silicification and iron oxide staining. Pyrite occurs as fine- to medium-grained euhedral cubic crystals, while chalcopyrite occurs as yellowish metallic disseminations intimately associated with pyrite.



Field Photograph No 7.9: a) Magnetite bearing Quartzo-feldspathic vein within the Granite Gneiss b) Magnet bar attracting Magnetite grains, c) Coarse grain magnetite within the Quartzo feldspathic vein.

Field observations suggest that the quartzo-feldspathic veins represent late-stage felsic intrusive phases emplaced along pre-existing fractures, foliation planes, and shear zones within the host rocks. Subsequent tectonic reactivation and hydrothermal activity have resulted in fracturing, silicification, oxidation,

and local sulphide mineralisation along the contact zones (Field Photograph No 7.10).



Field Photograph No 7.10: a and b) Sulfide mineralization at contact between Quartzo feldspathic vein and Fine grain Magnetic Diorite

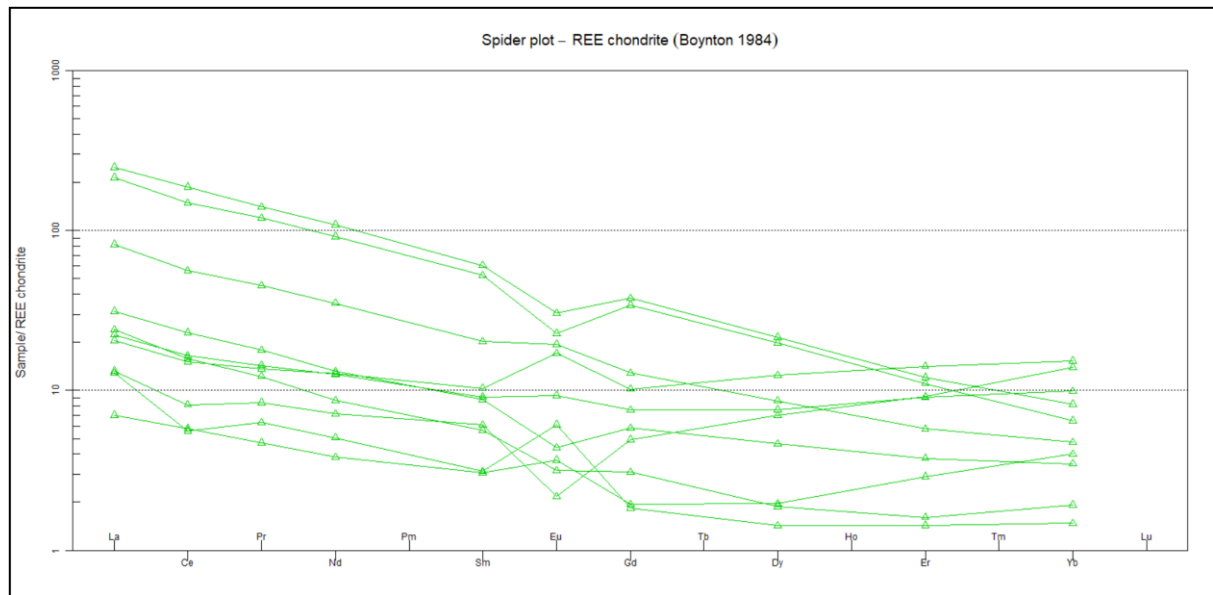
A total of ten quartzo-feldspathic vein samples from the Umprikhola Block were analysed for 34 elements through ICP-MS analysis to evaluate the distribution of REE and associated trace elements within the felsic intrusive phases.

The analytical results indicate variable concentrations of Rare Earth Elements (REE), High Field Strength Elements (HFSE) and transition metals within the quartzo-feldspathic veins. Total REE ($\Sigma\text{REE}+\text{Y}$) values range from 17.94 ppm to 381.02 ppm, indicating low to moderate REE concentration within the lithounit (Table 7.5).

The quartzo-feldspathic veins exhibit relative enrichment of Light Rare Earth Elements (LREE) over Heavy Rare Earth Elements (HREE). Lanthanum values range from 2.17 ppm to 77.06 ppm, cerium from 4.50 ppm to 151.57 ppm and neodymium from 2.29 ppm to 65.36 ppm. Among the HREE, yttrium values range from 3.21 ppm to 32.51 ppm, dysprosium from 0.46 ppm to 6.94 ppm and ytterbium from 0.31 ppm to 3.20 ppm (Table 7.5 and annexure II).

Table 7.5: Summarized table of ICP-MS analysis of Quartzo Feldspathic vein (N=10) for 34 elements

Elements	Min (ppm)	Max (ppm)	Mean (ppm)
Sc	0.48	27.27	7.54
V	3.86	108.89	37.85
Cr	85.35	272.96	154.66
Co	2.87	195.72	66.87
Ni	16.13	64.74	27.64
Cu	13.33	173.46	44.40
Zn	20.80	199.48	73.96
Ga	2.62	23.70	9.59
Rb	26.69	242.29	116.99
Sr	28.70	245.37	124.41
Y	3.21	32.51	16.28
Zr	14.74	547.32	125.57
Nb	1.16	7.51	3.02
Sn	0.15	0.17	0.16
La	2.17	77.06	20.97
Ce	4.50	151.57	38.98
Pr	0.57	17.18	4.68
Nd	2.29	65.36	17.92
Sm	0.60	11.81	3.50
Eu	0.16	2.24	0.87
Gd	0.48	9.76	3.11
Tb	0.14	1.52	0.67
Dy	0.46	6.94	2.80
Ho	0.13	1.13	0.61
Er	0.30	2.98	1.49
Tm	0.11	0.47	0.28
Yb	0.31	3.20	1.45
Lu	0.11	0.55	0.26
Hf	0.62	14.41	3.67
Ta	0.12	1.31	0.48
W	6.74	689.69	245.14
Pb	10.15	55.54	27.44
Th	1.00	26.60	7.82
U	0.68	5.89	2.42
TREE+Y	17.94	381.02	113.55
TREE+ Sc+Y	18.42	408.28	121.09



Text Fig 7.7: The chondrite-normalised REE spider diagram of Quartzo Feldspathic Vein (N=10).

The chondrite-normalised REE spider diagram of the quartzo-feldspathic veins exhibits variable but generally fractionated REE patterns characterised by relative enrichment of Light Rare Earth Elements (LREE) over Heavy Rare Earth Elements (HREE). Most samples display elevated La, Ce and Nd concentrations followed by gradual depletion towards the HREE segment.

A weak to moderate negative europium (Eu) anomaly is observed in several samples, indicating feldspar fractionation and late-stage hydrothermal alteration processes (Text Figure 7.7). However, a few samples exhibit a positive Eu anomaly, which may be attributed to accumulation or preservation of plagioclase feldspar within the vein material, as europium can substitute for calcium in feldspar during crystallisation. Positive Eu anomalies may also reflect hydrothermal fluid interaction under reducing conditions, where Eu^{2+} becomes relatively mobile and enriched compared to other REE. Inter-sample variation in the REE pattern suggests heterogeneous distribution of accessory mineral phases and varying degrees of hydrothermal remobilisation within the vein system.

Some samples exhibit comparatively flatter HREE patterns, whereas a few samples display relative enrichment or positive trends towards the HREE

segment, particularly for Yb and Lu. Such positive HREE trends may be attributed to the concentration of HREE-bearing accessory minerals such as zircon, xenotime and apatite, as well as selective hydrothermal remobilisation and fluid-rock interaction during late-stage alteration processes.

High Field Strength Elements (HFSE) such as zirconium, niobium, thorium and uranium show moderate variation. Zirconium values range from 14.74 ppm to 547.32 ppm, niobium from 1.16 ppm to 7.51 ppm, thorium from 1.00 ppm to 26.60 ppm and uranium from 0.68 ppm to 5.89 ppm.

Trace element concentrations reveal variable enrichment of Rb and Sr, with Rb ranging from 26.69 ppm to 242.29 ppm and Sr from 28.70 ppm to 245.37 ppm, suggesting feldspar-rich felsic affinity and local hydrothermal alteration. Tungsten values vary significantly from 6.74 ppm to 689.69 ppm, indicating strong hydrothermal influence in certain quartz-rich zones.

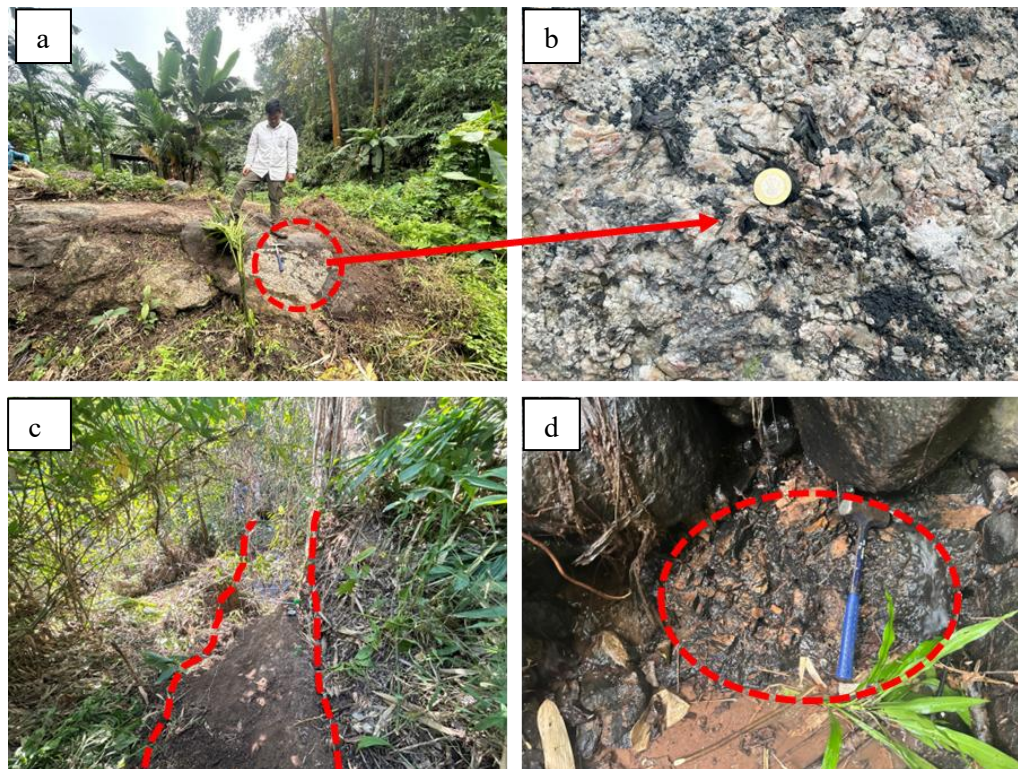
Transition metal concentrations such as Cr (85.35–272.96 ppm), Ni (16.13–64.74 ppm), Cu (13.33–173.46 ppm) and Zn (20.80–199.48 ppm) indicate minor mafic contribution and local sulphide association within the vein system. Elevated Cu and Zn concentrations correspond well with the observed pyrite and chalcopyrite mineralisation along fractures and contact zones.

Overall, the geochemical characteristics and chondrite-normalised REE patterns indicate that the quartzo-feldspathic veins represent late-stage felsic intrusive to hydrothermal phases emplaced along structurally controlled zones within the host rocks. The veins also acted as channels for hydrothermal fluid migration, silicification and local sulphide mineralisation.

c) Pegmatite vein: Pegmatitic veins constitute important late-stage felsic intrusive bodies within the Umprikhola Block and occur mainly in association with diorite/meta-granodiorite and granite gneiss lithologies. These veins are coarse- to very coarse-grained, leucocratic, massive and resistant in nature, and are composed predominantly of quartz, feldspar and biotite with minor opaque minerals.

The pegmatitic bodies occur as irregular veins, lensoidal intrusions and stockwork systems controlled by fractures, joints, shear zones and foliation planes within the host rocks (Field Photograph No 7.11). Most of the pegmatitic veins are emplaced within the diorite/meta-granodiorite where they

commonly form stockwork systems comprising numerous interconnected veinlets and coarse felsic injections. Thin pegmatitic veins are also observed intruding parallel to the foliation planes of granite gneiss, indicating strong structural control during emplacement. Both concordant and discordant relationships with the host rocks are observed.



Field Photograph No 7.11: a) Stockwork intrusion of Pegmatitic vein into the Diorite, b) Pegmatite vein intrusion with Quartz, K feldspar, Plagioclase feldspar and Biotite in the host Diorite, c) ~10 meter long and 03-1.5 meter width Pegmatitic vein trending 80°-200° intruded in the Diorite and d) Large and well-developed crystals of quartz, feldspar, and biotite occur within the pegmatitic vein intruding into the diorite.

Based on grain-size variations, the pegmatitic veins are classified into fine-, medium- and coarse-grained varieties. Fine-grained pegmatitic veins are generally thin and closely associated with foliation planes, whereas medium- and coarse-grained pegmatites form thicker intrusive bodies. The coarse-grained pegmatites are characterised by the presence of large feldspar and quartz crystals, suggesting slow crystallisation from volatile-rich residual felsic magma during the terminal stages of magmatic differentiation.

Quartz occurs as coarse anhedral to subhedral milky white crystals showing vitreous lustre and conchoidal fracture. Feldspar occurs as coarse pinkish white to grey crystals and locally exhibits alteration and kaolinisation under weathering conditions. Biotite occurs as coarse flaky aggregates distributed within the felsic matrix and along marginal portions of the veins. Minor opaque minerals are also observed in association with quartz-rich portions of the pegmatitic bodies.

The pegmatitic veins are compact, hard and resistant to weathering, forming prominent ridge-like and bouldery outcrops in several locations. Sharp intrusive contacts with surrounding diorite/meta-granodiorite and granite gneiss indicate emplacement along pre-existing fractures and zones of weakness during late-stage magmatic activity. Local fracturing, brittle deformation and minor shearing observed within several pegmatitic bodies indicate post-emplacement tectonic reactivation.

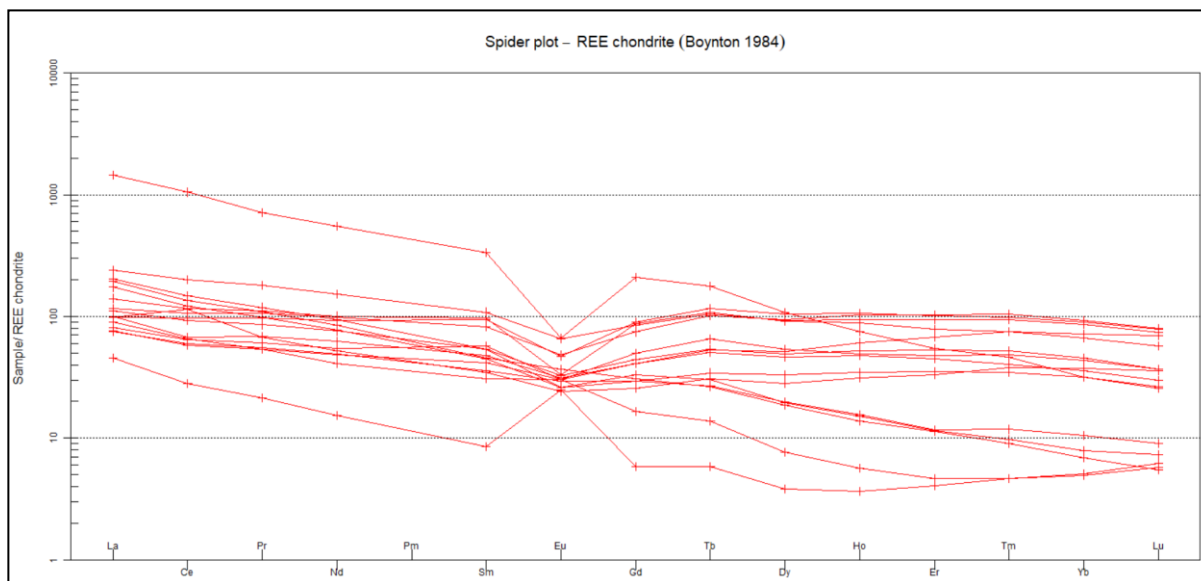
Geochemically, the pegmatitic veins show variable but comparatively elevated concentrations of Rare Earth Elements (REE), High Field Strength Elements (HFSE) and incompatible trace elements. Total REE ($\Sigma\text{REE}+\text{Y}$) values range from 72.48 ppm to 2197.63 ppm (Table 7.6 and annexure II). Among the analysed samples, certain pegmatitic veins record $\Sigma\text{REE}+\text{Y}$ values exceeding 1000 ppm, indicating anomalous REE concentration within localized zones.

The pegmatitic veins exhibit strong enrichment of Light Rare Earth Elements (LREE) over Heavy Rare Earth Elements (HREE). Lanthanum values range from 12.45 ppm to 512.78 ppm, cerium from 28.62 ppm to 1038.44 ppm and neodymium from 10.36 ppm to 402.57 ppm. Among the HREE, yttrium values range from 6.28 ppm to 186.34 ppm, dysprosium from 0.92 ppm to 24.73 ppm and ytterbium from 0.54 ppm to 12.47 ppm (Table 7.6 and annexure II).

Table 7.6: Summarized table of ICP-MS analysis of Pegmatitic vein (N=16) for 34 elements

Elements	Min (ppm)	Max (ppm)	Mean (ppm)
Sc	2.13	26.46	13.27
V	11.50	144.54	61.50

Cr	63.81	133.46	96.48
Co	3.99	78.98	38.76
Ni	15.78	47.57	28.75
Cu	15.36	70.25	28.54
Zn	29.25	316.66	105.18
Ga	13.29	35.81	20.02
Rb	142.53	335.31	228.02
Sr	106.69	685.20	439.77
Y	9.14	225.71	105.82
Zr	39.10	230.83	118.97
Nb	1.45	12.53	5.47
Sn	0.11	0.21	0.15
La	14.16	446.63	63.61
Ce	22.64	847.32	127.24
Pr	2.59	86.74	15.21
Nd	9.24	331.11	61.86
Sm	1.66	65.17	14.25
Eu	1.77	4.85	2.67
Gd	1.51	53.92	14.42
Tb	0.28	8.37	2.95
Dy	1.22	34.45	16.54
Ho	0.26	7.62	3.57
Er	0.85	21.61	9.92
Tm	0.15	3.37	1.51
Yb	1.03	19.45	8.74
Lu	0.18	2.56	1.17
Hf	1.43	8.50	3.90
Ta	0.32	2.56	1.08
W	5.76	379.79	127.22
Pb	22.64	178.08	64.09
Th	1.55	274.18	26.58
U	0.72	15.89	3.91
TREE+Y	66.73	2054.82	449.49
TREE+ Sc+Y	68.87	2081.28	462.76



Text Fig 7.8: The chondrite-normalised REE spider diagram of Pegmatitic Vein (N=16).

The chondrite-normalised REE spider diagram of the pegmatitic veins exhibits strongly fractionated REE patterns characterised by pronounced enrichment of LREE relative to HREE (Text Figure 7.8). Most samples display steeply declining trends from La to Sm followed by comparatively flatter HREE segments.

A prominent negative europium (Eu) anomaly is observed in most samples, indicating strong feldspar fractionation during crystallisation of residual felsic magma. However, a few samples exhibit subdued or weak positive Eu anomalies, possibly related to local feldspar accumulation and hydrothermal redistribution processes.

The HREE segment shows moderate inter-sample variation. Certain samples display comparatively flatter HREE patterns, whereas a few exhibit relative enrichment towards Yb and Lu. Such variation is likely controlled by heterogeneous distribution of HREE-bearing accessory minerals such as zircon, xenotime, allanite and apatite together with localized hydrothermal remobilisation.

High Field Strength Elements (HFSE) such as zirconium, niobium, thorium and uranium show moderate to high concentrations within the pegmatitic veins. Zirconium values range from 58.43 ppm to 892.65 ppm, niobium from

2.12 ppm to 38.74 ppm, thorium from 3.86 ppm to 146.82 ppm and uranium from 0.74 ppm to 12.46 ppm. Elevated concentrations of Zr and Th indicate the presence of accessory minerals such as zircon, monazite and allanite within the pegmatitic bodies.

Trace element concentrations indicate enrichment of felsic incompatible elements, with Rb ranging from 84.62 ppm to 486.53 ppm and comparatively lower Sr concentrations ranging from 24.48 ppm to 196.84 ppm, reflecting evolved felsic magmatic affinity and feldspar fractionation. Tungsten values range from 8.37 ppm to 774.28 ppm, indicating significant hydrothermal influence associated with late-stage fluid activity.

Transition metal concentrations such as Cr (28.41–218.63 ppm), Ni (5.62–74.38 ppm), Cu (12.45–294.66 ppm) and Zn (18.72–238.54 ppm) indicate local sulphide association and hydrothermal remobilisation along fractured zones and contacts.

Overall, the geochemical characteristics and chondrite-normalised REE patterns suggest that the pegmatitic veins represent highly evolved late-stage felsic intrusive phases enriched in incompatible elements and REE-bearing accessory minerals. Structural control, hydrothermal activity and magmatic differentiation collectively played significant roles in the localisation and enrichment of REE within the pegmatitic bodies.

7.2.2.6 Soil/Alluvium: Soil and alluvium constitute the unconsolidated surficial cover over a substantial part of the Umprikhola Block and represent the youngest geological deposits in the area. These deposits are predominantly composed of residual soils formed by the in-situ weathering of the underlying gneissic rocks, along with transported Quaternary alluvium accumulated along drainage channels and low-lying areas. Based on colour and texture, the soils of the Umprikhola Block can be broadly classified into two categories, namely dark brown soil and reddish-brown soil. The dark brown soil is chiefly associated with the diorite bodies and is medium grained in nature, containing abundant biotite and quartz grains. In contrast, the reddish-brown soil is mainly developed over granite gneiss and varies from fine- to medium-grained. It is composed predominantly of feldspar and quartz, with minor amounts of biotite. Quaternary alluvium is mainly confined to the

southwestern part of the block, where it has been deposited by the west-flowing streams draining the area. These alluvial deposits generally consist of unconsolidated sand, silt, clay, and locally gravel, reflecting recent fluvial sedimentation processes.

7.3.0 Structure of the block

7.3.1 The Umprikhola Block exhibits well-developed structural features expressed in the form of foliation, and joints.

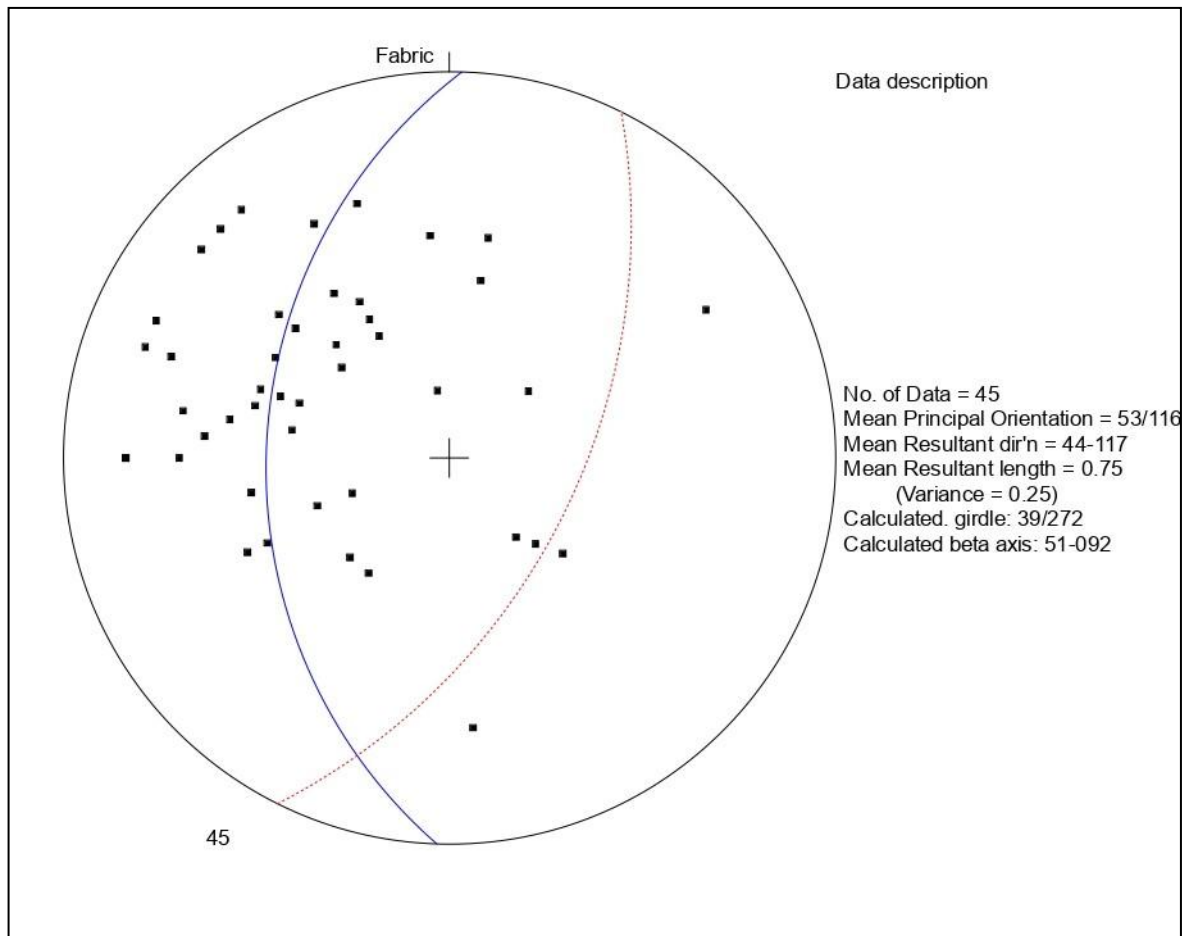
A. Foliation: The foliation measurements collected from the granite gneiss and biotite gneiss of the Umprikhola Block indicate a well-developed metamorphic fabric throughout the block.

The foliation within both the granite gneiss and biotite gneiss generally trends NE–SW to E–W, with moderate to steep dips ranging from 20° to 80° with dominant dip directions between 65° and 150°. In several locations, the foliation also dips towards northwest and southwest directions, suggesting local structural disturbances and folding.

The variation in foliation orientation across the block suggests that the area has undergone polyphase deformation, resulting in local folding, warping, and reorientation of the foliation planes. Steeply dipping foliations observed at several locations may represent zones of intense tectonic deformation and shearing. Overall, the foliation pattern reflects a strongly deformed metamorphic terrain developed under regional tectono-metamorphic conditions.

The stereonet analysis of foliation data from the Umprikhola Block indicates that the area is structurally dominated by a well-developed metamorphic foliation within the granite gneiss and biotite gneiss. A total of 45 foliation measurements were plotted, which show a moderate to strong concentration of poles, indicating a consistent regional fabric orientation throughout the block (Text Figure 7.9). The mean foliation dipping 44° towards 117°, suggesting

that the dominant foliation trends NE–SW and dips moderately towards the southeast.



Text Fig No. 7.9: Stereographic plot of all foliation planes orientation of Umprikhola Block.

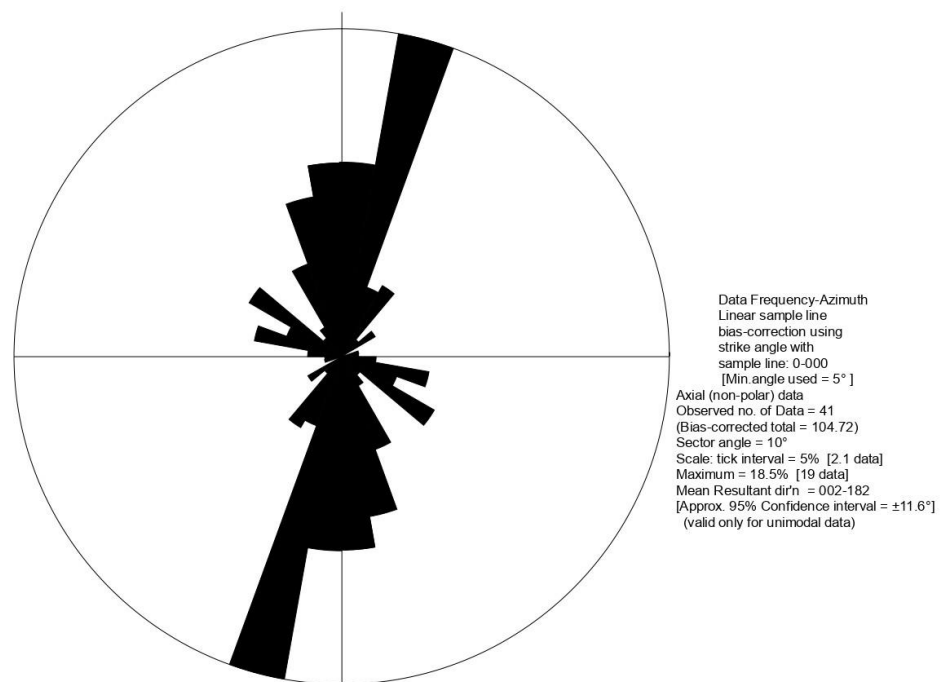
B. Joints:

The joint data of the Umprikhola Block shows a well-developed and structurally significant fracture system within the crystalline rocks. A total of 41 joint measurements were plotted on the stereographic projection. The stereonet indicates that most of the joints are steeply dipping to vertical in nature, with several measurements showing dips between 70° and 90° . Such high-angle joints suggest that the rock mass experienced strong brittle deformation after the crystallization and regional metamorphic events.

The stereographic plot shows a Mean Principal Orientation of $89^\circ/152^\circ$, indicating that the dominant joint set trends approximately NNE-SSW with near-vertical dip (Text Figure 7.10).

Such joint systems play an important role in controlling weathering, groundwater movement, and mineralization within the Umprikhola Block. In granitic and gneissic terrains, these fractures commonly act as pathways for hydrothermal fluids and are therefore structurally significant for sulphide and rare earth element mineralization. The presence of intersecting steep joint sets may also enhance permeability and localization of quartzo-feldspathic and pegmatitic veins observed within the block.

Overall, the stereographic analysis indicates a structurally fractured terrain characterized by dominant steeply dipping joint sets with moderate orientation clustering, reflecting polyphase brittle deformation and tectonic reactivation within the Umprikhola Block.

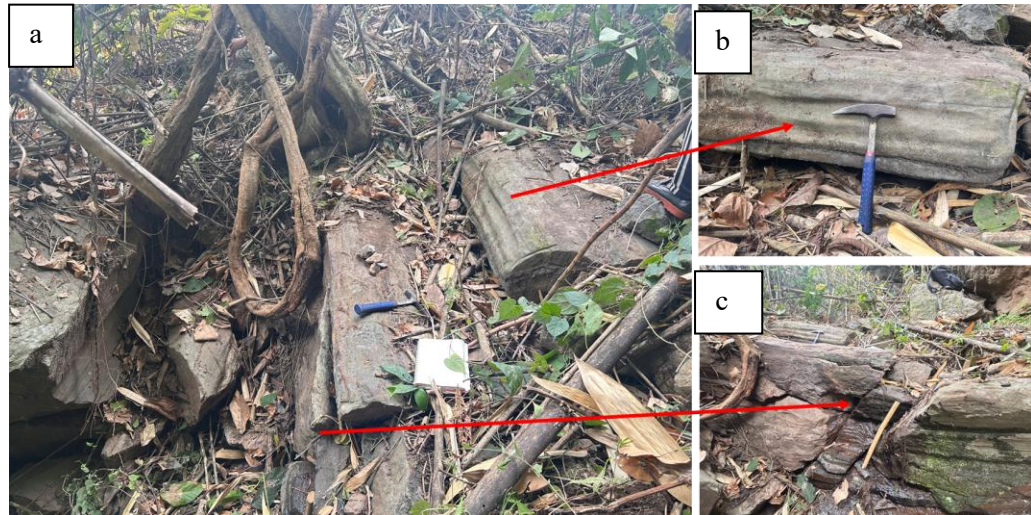


Text Fig 7.10: Stereographic plot of all Joints planes orientation of Umprikhola Block.

C. Faults

Only small-scale strike-slip faults are observed towards the northern part of the Umprikhola Block within the Granite Gneiss. These faults trend approximately 85°–265° and are characterized by well-developed slickensides preserved on the fault surfaces, indicating lateral displacement along the fault plane. The presence of slickenlines suggests brittle shear movement associated with

tectonic stress during the post-crystallization deformation phase. The strike-slip faults are localized and discontinuous in nature, reflecting minor brittle tectonic reactivation within the granitic terrain, as shown in the Field Photograph No. 7.12.



Field Photograph No 7.12: a) local scale Strike slip fault with strike trend 85°-265°. b) slickenlines on fault surface c) Joints present transverse to the fault surface which orientation is 55° → 275°.

7.4.0 Mineralisation

7.4.1 The Umprikhola Block exhibits multiple styles of mineralisation associated with granitoid intrusive activity, pegmatitic emplacement, hydrothermal alteration and structurally controlled sulphide deposition. The mineralisation within the block is represented mainly by REE-bearing accessory mineral phases, sulphide mineralisation, magnetite-ilmenite association and minor enrichment of transition metals such as Ni and Cr. Petrographic, mineragraphic and geochemical investigations indicate that the mineralisation is controlled by lithology, structural features and late-stage magmatic-hydrothermal processes.

7.4.2 REE Mineralisation

REE mineralisation within the Umprikhola Block is mainly associated with granite gneiss, pegmatitic veins, quartzo-feldspathic veins and diorite/meta-granodiorite. Petrographic studies reveal the presence of REE-bearing accessory minerals such as monazite, zircon, sphene and apatite within the

felsic lithologies. Monazite occurs as very fine subrounded grains and inclusions within biotite in granite gneiss and meta-granodiorite, whereas zircon occurs as fine inclusions associated with pleochroic haloes around biotite grains.

Granite gneiss and pegmatitic veins constitute the principal REE-bearing lithologies within the block, while diorite/meta-granodiorite also hosts significant REE-bearing accessory minerals such as monazite, zircon and sphene, indicating contribution from intermediate to felsic magmatic phases to the overall REE enrichment. Pegmatitic veins locally record anomalous $\Sigma\text{REE}+\text{Y}$ concentrations exceeding 1000 ppm, indicating enrichment of REE-bearing accessory phases during late-stage magmatic differentiation. Chondrite-normalised REE patterns of the granitoids, pegmatites and quartzo-feldspathic veins show pronounced enrichment of Light Rare Earth Elements (LREE) over Heavy Rare Earth Elements (HREE), indicating evolved felsic magmatic affinity and concentration of incompatible elements.

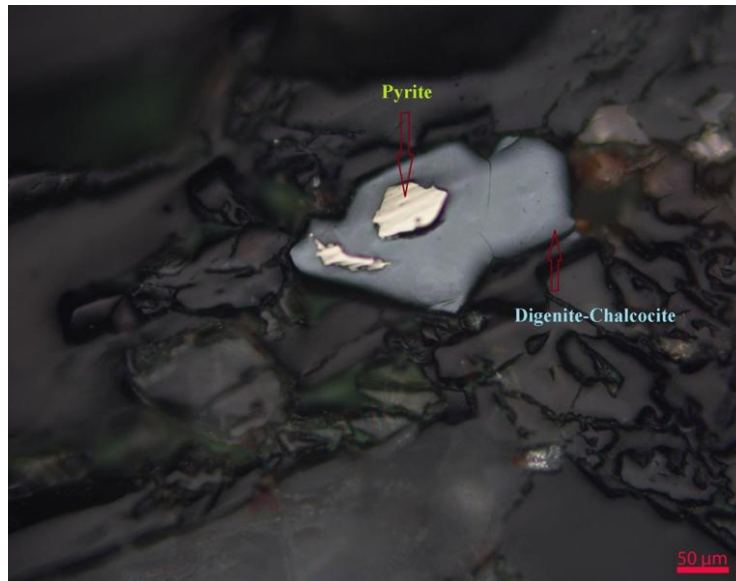
The REE mineralisation appears to be controlled primarily by accessory mineral phases such as monazite, zircon, allanite and sphene. Structural features such as fractures, joints, foliation planes and shear zones acted as favourable pathways for emplacement of pegmatitic and quartzo-feldspathic veins and for subsequent hydrothermal remobilisation of REE-bearing fluids.

7.4.3 **Sulphide Mineralisation**

Sulphide mineralisation within the Umprikhola Block is mainly associated with diorite/meta-granodiorite, quartzo-feldspathic veins, pegmatitic veins and structurally controlled fracture zones. Field observations indicate the occurrence of pyrite and chalcopyrite as disseminations, fracture fillings, thin veinlets and patches, particularly near lithological contacts and silicified zones.

Mineragraphic studies indicate that pyrite, chalcopyrite, pyrrhotite and digenite–chalcocite constitute the major sulphide phases identified within the block (Pmg 5, Pmg 6 as well as annexure VI and IX). Pyrite occurs as fine- to medium-grained subhedral to anhedral grains, disseminations and fracture

fillings, whereas chalcopyrite occurs mainly as very fine specks and fracture-controlled grains associated with pyrite.



Pmg 5:
Photomicrograph showing pyrite relicts within digenite-chalcocite patch as seen under reflected light.



Pmg 6:
Photomicrograph showing very fine grain of chalcopyrite along fracture as seen under reflected light.

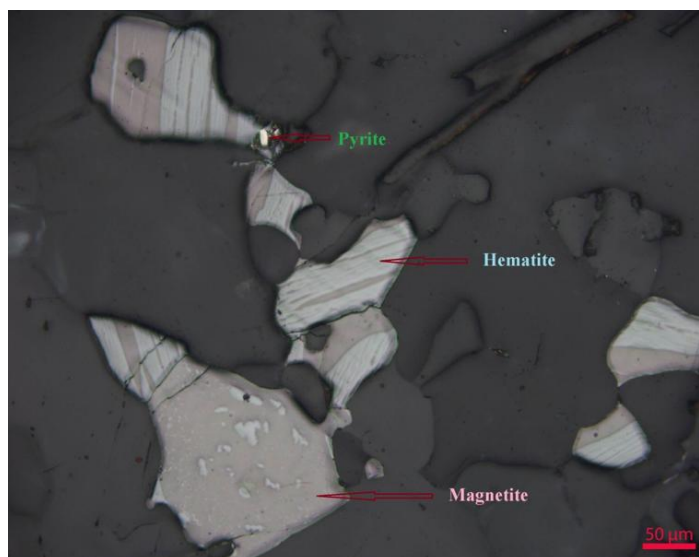
secondary supergene alteration and remobilisation processes. Pyrrhotite occurs as very fine disseminated specks and segregations in pockets associated with sphene and magnetite-bearing assemblages. Photomicrographic studies under reflected light reveal pyrite relicts enclosed within digenite–chalcocite patches and chalcopyrite occurring along fracture planes, suggesting structurally controlled hydrothermal sulphide mineralisation. The sulphide mineralisation

is interpreted to be related to late-stage hydrothermal activity associated with felsic intrusive emplacement and tectonic reactivation along fracture zones.

7.4.4 Magnetite–Ilmenite

Magnetite and ilmenite occur widely as disseminated opaque phases within amphibolite, granite gneiss, diorite/meta-granodiorite and quartzo-feldspathic veins. Magnetite commonly occurs as fine- to medium-grained subhedral to anhedral grains, patches and disseminations, whereas ilmenite occurs mainly as fine bladed grains and lamellar exsolutions within magnetite.

Mineragraphic studies indicate extensive martitisation of magnetite, resulting in partial transformation to hematite along fractures and grain boundaries (Pmg 7, annexure VI and IX). Hematite also occurs as fracture fillings and oxidation products associated with hydrothermal alteration zones. The occurrence of magnetite–ilmenite assemblages along foliations, fractures and quartz-rich zones indicates their association with both magmatic crystallisation and subsequent hydrothermal alteration processes.



Pmg 7:
Photomicrograph showing martitisation of magnetite and associated pyrite speck as seen under reflected light.

7.4.5 Ni–Cr Mineralisation

Geochemical investigations indicate moderate enrichment of transition metals such as Ni and Cr, particularly within diorite/meta-granodiorite and associated mafic lithologies (Annexure IV). Chromium values recorded in the analysed samples range from moderate to high concentrations, whereas Ni values

indicate limited mafic affinity without development of ultramafic characteristics.

The enrichment of Ni and Cr is interpreted to be associated with mafic mineral phases such as hornblende, biotite and magnetite–ilmenite assemblages within the dioritic rocks. However, field, petrographic and geochemical investigations do not indicate the presence of economically significant Ni–Cr mineralisation within the block.

7.4.6 **PGE Mineralisation**

Five selected samples from the Umprikhola Block were analysed for Platinum Group Elements (PGE) through fire assay method. Analytical results indicate low concentrations of platinum group elements such as Pt, Pd, Rh, Ru and Ir, whereas Os is below detection limit in most samples (Annexure III).

The recorded PGE values indicate absence of significant PGE mineralisation within the study area. The low PGE concentration, together with absence of ultramafic intrusive bodies and limited sulphide accumulation, suggests that the geological environment of the block is not favourable for substantial PGE enrichment.

7.4.7 Overall, the mineralisation within the Umprikhola Block is predominantly characterised by REE-bearing accessory mineral phases associated with evolved felsic intrusive activity, accompanied by structurally controlled hydrothermal sulphide mineralisation and subordinate magnetite–ilmenite enrichment. Although sporadic anomalous concentrations of REE have been recorded in pegmatitic and quartzo-feldspathic veins, the mineralisation appears discontinuous and erratic in nature, without evidence of persistent ore-grade zones or significant lateral continuity. In view of the scattered occurrence of REE anomalies and the absence of substantial subsurface indications, further exploratory drilling within the block is presently not considered suitable.

CHAPTER - VIII

8.0.0. PREVIOUS EXPLORATION

8.1.0. General

8.1.1 The Umprikhola Block and adjoining areas form part of the Assam–Meghalaya Gneissic Complex (AMGC), which has been investigated by various agencies through geological mapping, geochemical surveys, geophysical investigations and reconnaissance exploration for REE and associated mineralisation. The salient details of earlier work carried out in and around the present block are summarised below.

8.1.2 The earliest geological investigations in the area were carried out by Gogoi (1964–65), who mapped the region around Umpyrtha and differentiated various lithological units within the gneissic terrain. The area was identified as part of the Assam–Meghalaya Gneissic Complex (AMGC), predominantly composed of granite gneiss with associated amphibolite, biotite granulite, biotite schist, and isolated occurrences of granitoids and diorite. Mazumdar et al. (1968) subsequently established the intrusive relationship of the porphyritic Nongpoh Pluton with the surrounding gneissic rocks.

8.1.3 Regional Geological Mapping and Mineralisation Studies:

Bandyopadhyay et al., 1983, mapped 300 sq km area in the Survey of India Toposheet Nos. 78O/9, 78O/13 and 78 N/16 on the scale of 1: 63,360 and encountered lithounits like Archaean metamorphics and porphyritic granite known as Nongpoh Pluton. According to the author, the Archaean Gneissic Complex is an admixture of a number of rock types most of which appear to grade into one another. Dominant rock types are leucogranite gneiss and biotite granite gneiss of the Archaean Gneissic Complex associated with nonporphyritic granites, diorites, mica schist, biotite granulite and amphibolite occurring as lenses. Bandyopadhyay et al. divided the granite into two contrasted types: (1) nonporphyritic granite, which is intimately associated with the gneisses and (2) porphyritic granite known as Nongpoh Pluton, which is found to be intrusive into the Gneissic complex. The leucogranite gneiss and biotite granite gneiss almost have identical mineralogical composition except for the abundance of biotite flakes in latter. The amphibolite occurring mostly as small disconnected lensoid bodies within the gneisses show sharp contact with them. It was reported that the

Gneissic Complex represents an older suite of psammitic to psammopelitic sedimentary assemblage which were intruded by basic bodies and later metamorphosed to upper amphibolite facies conditions to form present gneissic complex. All these rock types are traversed by numerous veins and veinlets of quartz, pegmatite and aplite. Minor dissemination of sulphide mineralisation in the greisen zone (magnetite, tourmaline, dark mica) adjoining the granitic Pluton near Nongpoh had been located. From the economical point of view, 0.4% to 0.62% Cu values were reported within quartz vein in PWD quarry section.

8.1.4 **Systematic thematic mapping**

Systematic geological mapping of an area of 520 sq.km. was carried out in parts of Ri-Bhoi and West Khasi Hills districts falling under toposheets 83B/4, 83C/1, 78N/16, 78O/10, 78O/13 and 78O/14 by Bhattacharya et al., 2000 during F.S: 1995-96. Two isolated patches were mapped separately, one around Umden-Umlaper (parts of toposheets 83 B/4. 83 O 1. 78 N/16. 78 O/13 and 78 O/14; henceforth referred to as Sector I) and another around Kyrdemkulai -Bhalta (parts of toposheets 78O/10, 78O/13 and 78O/14, henceforth referred to as Sector II). The area comprises mainly of Precambrian Gneissic Rocks, Shillong Group of rocks and granitoids which are intrusive into the former. According to them, Gneisses are granitic to granodioritic in composition and over this gneissic basement rock, Shillong Group of metasedimentaries occupy as cover sequence, which is represented by quartz-mica-schist and quartzite. Granitoids are intrusive of which porphyritic granite is older than non-porphyritic, medium/fine grained granite.

Four phases of deformations are discernible in the area of which first one gives intrafolial folds and second one is steeply plunging. S₂ is the major structural plane; orientation of which is rotated by third deformation in nearly E-W direction. Third folds are regional antiforms and synforms. The last deformation shows nearly upright folds in N-S axis, coupled with ductile shear zones. Gneisses attained upto amphibolite facies of metamorphism where as Shillong Group shows that of greenschist facies. Metamorphism in gneisses might have preceded that of Shillong Group. From the economical point of view, Granitoids are used as road metals as well as dimensional stones. Sulphide mineralisation with pyrite, chalcopyrite was reported within non-

porphyritic granite (south of Umdokha) and also in diorite (near 17 km, on bank of Umtrew). Sulphides occur as specks and are locally disseminated.

8.1.5 **Regional Geochemical Exploration**

Angami et al., 2012 had carried out Regional Geochemical Mapping on Toposheet no. 78N/16, in Kamrup, Darrang and Nagaon district, Assam and Ri-Bhoi district, Meghalaya on 1:50000 scale. Though there are no such significant values of base metal, Sn (upto 20 ppm.), W (upto 5.6 ppm.), REE, the author concluded high anomalous zones of Cu, Zn and Cr around Digaru area in alluvium, and Pb anomaly around Digaru river flood plain between Sonapur and Belguri TG and along the Bardong Nala basin. Even the author has recommended investigation for Ni depending on 42-78 ppm. value around Kumarkuchi Tea Garden, NW of Norbong, West of Dahel colony. 40-85 ppm, Pb values was recorded in the south of Sonapur and around Markong area. High values of REE (total REE: 102.8 -1311.4 ppm.) was reported around Jabaikona.

8.1.6 **REE Mineralisation Studies in Nongpoh Granitoid**

Khonglah et al., 2017 carried out field work on genesis of ion-adsorption type REE Mineralisation in parts of Nongpoh Granitoid, Ri-Bhoi district, Meghalaya, on 1:25000 scale to study REE enrichment in the in-situ soil horizon formed above Nongpoh granitoids and also above adjoining gneissic rocks. Porphyritic granitoid forms the dominant lithology of the Nongpoh pluton with subordinate diorite-granodiorite-monzonite-vaugnerite. Potential REE bearing phases like allanite and sphene were locally identified in the field along certain domains of porphyritic granitoid around Nongpoh and Umta, within pegmatite in south of Nongpoh. Chemical analyses of bed rock samples are having total REE in range of 158.39ppm in diorite of Umran to 1498.87ppm in porphyritic monzogranite compare to the range of 15.38ppm in soil sample developed on gneisses around Myrdon to a maximum range of 1521.18ppm in soil of porphyritic granite. Similar values of bedrocks and soil therefore reflects the area around Nongpoh region, suggest no noteworthy enrichment. The authors had summarized that, the soil samples developed over porphyritic granitoids are having higher total REE of 183.64 to 1521.18 ppm, relative to the surrounding soil formed over gneisses in range from 15.38 to

553.22ppm, which are again reflection of similar REE values in their respective bedrock.

8.1.6 **REE Prospecting in Adjacent Areas**

Majhi et al., 2016 carried out mapping in and around Kumarkuchi and Chagaligaon, Kamrup (Metro) district, Assam for W, Sn and REE. Total REE: 2096.32ppm was found within biotite gneiss at Kumarkuchi (26°07'41.5"; 91°55' 13.9"). Total REE value was higher in case of porphyritic granite (max.1672.45 ppm) compared to other non porphyritic variants (max.1530.6 ppm). It was recommended not to go for further investigation for REE in porphyritic granite but the biotite gneiss of Chagaligaon has a good possibility for REE mineralisation (carbonate phase).

8.1.7 **Geophysical Exploration**

The area (78N/16) was covered by NGPM during FS: 2015-16 by Chakraborty et al. They reported a significant high intensity magnetic (TF) anomaly associated with high Bouguer gravity anomaly of the order -54 mGal around 1.5 Km northwest of Byrnihat, Ri-Bhoi district of Meghalaya. Bipolar magnetic nature also was noticed in this zone. This high gravity anomaly may possibly be due to the combined effect of high-density rock and heavy mineral concentration in pegmatite/quartz veins. Magnetite in association with other magnetic rich body is possibly responsible for higher magnetic anomaly within quartz vein. The source anomalies were well reflected in residual gravity map, upward magnetic continuation map and analytical signal map of magnetic. A major N-S trending magnetic discontinuity passing through Byrnihat was noticed in the southern part of TS No. 78N/16. Authors recommended for further investigation of the area with integrated approach of geological, geochemical and geophysical methods.

8.1.8 **G–4 Stage Exploration for REE and Associated Mineralisation**

Based on previous recommendations, reconnaissance level (G–4 stage) exploration was undertaken during FS 2019–20 for REE and associated mineralisation in and around Byrnihat area, Ri-Bhoi district, Meghalaya and Kamrup (Metro) district, Assam (part of toposheet no. 78N/16). The exploration programme included large-scale geological mapping (1:12,500 scale) over 50 km², collection of 100 bedrock samples, 25 petrochemical

samples, 40 stream sediment samples, 50 m³ pitting and trenching, and 398 m drilling in 15 boreholes (Text Figure 8.1).

The area forms in part of Assam Meghalaya Gneissic Complex (AMGC). Different rock units of the studied area are cordierite metapelite, granite gneiss, foliated granitoid and diorite, which were intruded by pegmatite and quartzo-feldspathic veins of different dimensions. Cordierite metapelite is purplish grey colored, medium to coarse grained and composed of quartz, feldspar, biotite, muscovite, cordierite and garnet. Granite gneiss is grey colored, fine to medium grained and composed of quartz, feldspar, biotite, hornblende etc. Foliated granitoid is grey colored, medium to coarse grained and composed of quartz (35-40%), alkali feldspar (25-30%), plagioclase (20-25 %) and mafic minerals (15- 20%) like biotite and hornblende etc. It is peraluminous in nature. Diorite is medium to coarse-grained; dark colored and composed of plagioclase feldspar, biotite, hornblende and clinopyroxene, which are randomly oriented. The general trend of the regional fabric varies from N50°E to S70°E dipping 50-70° towards North or South. Different sulfide minerals like pyrite, chalcopyrite, bornite etc. were identified in quartz-magnetite veins (2cm to 0.5m wide and 1m to 20m long), intruded within cordierite metapelite.

Gravity, magnetic, IP & SP survey were carried out in three different blocks (Block A, Block B and Block C) within the studied area. The lithological boundaries of some major lithounits are well reflected in the form of low and high magnetic variations arising due to magnetization contrasts. Magnetic survey brought out the lithological contact between the Granite gneiss/ Cordierite metapelite with quartz vein and pegmatite veins in Block-A, which is well collaborated with the steep gravity gradient having a broad circular low anomaly zone varying in the order of -48.2 to -46.2 mGal trending in East-West direction. In the Block-B, several isolated alternative low and high intensity magnetic anomalies were delineated with anomaly variations between “-600nT and 350nT” trending in the NW-SE and NE-SW direction between the traverses L5 and L9 between the stations N500 and N700, N1000 and N1300 in the eastern part of studied area. This magnetic anomaly is well corroborated with high residual gravity anomaly. In Block-C, the high

magnetic anomaly varies between “200nT and 600nT” trending in NE-SW direction in the eastern part and NW-SE direction in the central part of the area. It is well corroborated with the high gravity zone varying from -45.1 mGal and -42.4 mGal between the traverses L9 and L14 over the granite gneiss and cordierite metapelite.

IP/ Resistivity survey was conducted by deploying current electrode spacing of 1000m and potential electrode spacing of 20m for gradient array and dipole-dipole ($n=1,2,3,4,5$ and $a=20m$) array. IP/ Resistivity survey delineated high chargeability and high resistivity zone over the traverses L6, L7 and L12 in the blocks A, B and C respectively. The high chargeability zone is well corroborated with highs of magnetic and gravity and may be structurally favorable zone for possible occurrence of mineralization at depth below the quartz/pegmatite vein.

The Bed Rock Sample (BRS) includes fresh rock sample, weathered rock sample as well as soil sample to target the REE and base metal. BRS samples were collected from those parts of the rock, where the fluid activity and sulphide mineralization were prominent. From the analytical result of BRS, it is found that the calculated total REE (La-Lu +Y+Sc) value varies from 40 to 19563 ppm. 1.95 % total REE value was recorded in pegmatite (not mappable) intruded within cordierite metapelite in Umdot area.

The PCS samples were collected from the fresh exposures of major lithounits (cordierite metapelite, granite gneiss, foliated granitoid, diorite etc.) of the area to know the geochemical characteristics of the rock. From the analytical result of PCS, it is found that the calculated total REE value varies from 68 to 2166 ppm. The high value of total REE was noticed in foliated granitoid. The presence of REE phases like monazite, allanite etc. within foliated granitoid could be contributing factor for the REE enrichment compared to other lithologies.

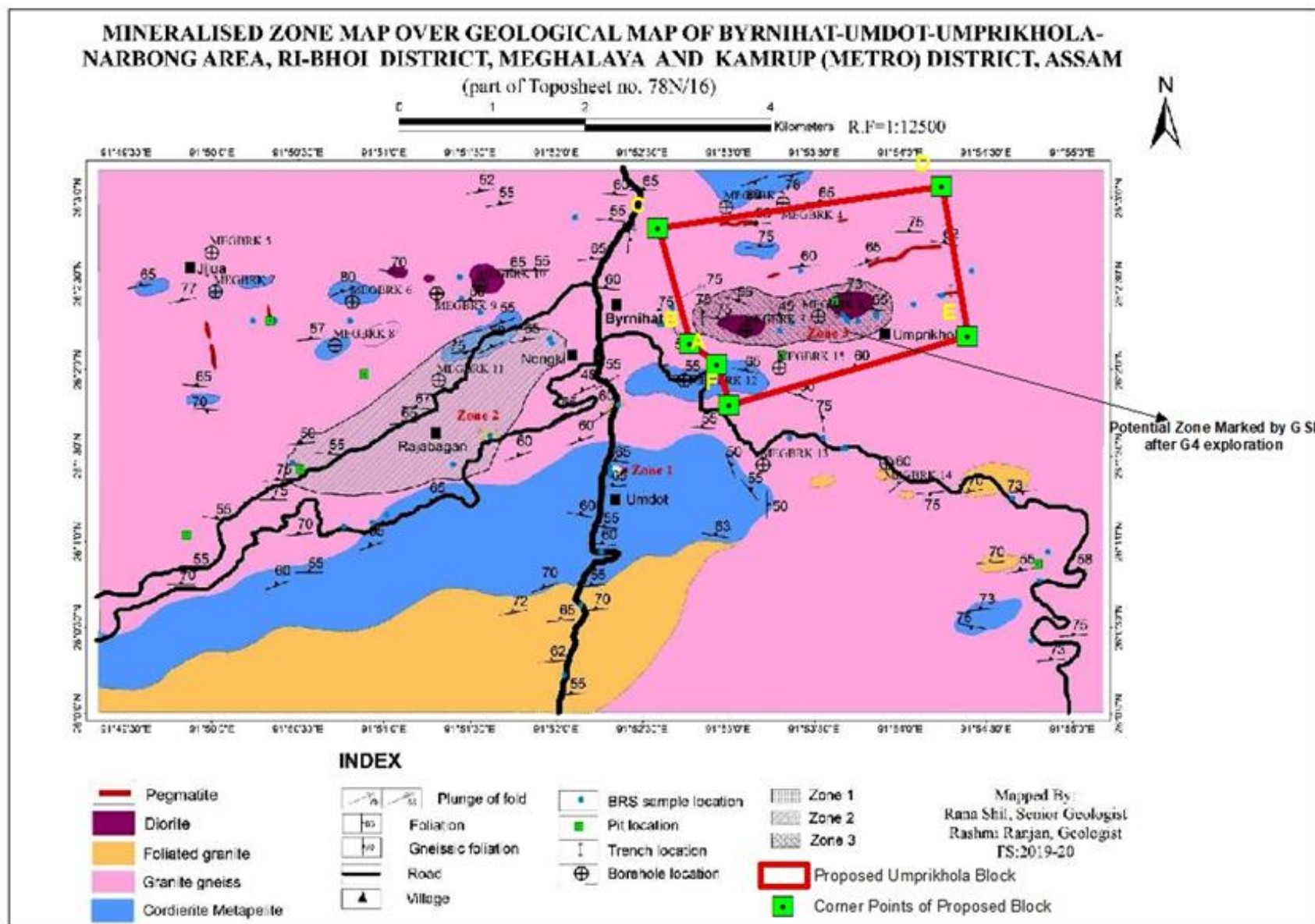
Stream sediment samples (SSS) were collected from 2nd order and 3rd order streams of the study area. From the analytical result of SSS, it is found that the calculated total REE value varies from 130 to 1777 ppm. After panning and bromoform separation of few collected stream sediment samples, the nonmagnetic fractions of the heavy minerals were studied under binocular

microscope and different heavy minerals like zircon, monazite, allanite, sphene, apatite, garnet etc. were identified. REE phases like monazite and allanite may attribute to the higher value of total REE in case of stream sediment. Pitting and trenching were carried out at different locations of the studied area, to expose the subsurface lithology. Pit-Trench Sample (PTS) consists of both soil and weathered rock sample. From the analytical result of PTS, it is found that the calculated total REE value varies from 303 to 1537 ppm. Core logging was carried out based on different soil horizons (A, B & C) and core samples were collected from each horizon. From the analytical result of Core Sample (CS), it is found that, the calculated total REE value varies from 162 to 1200 ppm.

The G4 stage exploration reveals that the REE content is very less in cordierite metapelite whereas it is medium in granite gneiss and medium to high in foliated granitoid. So, it is recommended not to target cordierite metapelite for REE exploration. The foliated granitoid unit could be targeted for REE. 0.24% Ba; 0.14% Cr; 0.1% Sr and 1134 ppm. Σ REE were found within diorite of Umprikhola (mineralized zone- 3). The diorite bodies could be mapped properly and explored for Ni, Cr and PGE. An area in and around Nongki, Kachhua and Rajabagan (mineralized zone-2) was identified as potential area for REE (based on Σ REE values like 2166 ppm in foliated granitoid and 1064 ppm. in granite gneiss near Nongki area; 1548 ppm in stream sediment sample of Rajabagan area and 1777 ppm in stream sediment sample of Kachhua area). More sampling is recommended for foliated granitoid, granite gneiss and its weathered part in and around Nongki. Two sporadic values of Zn (508 & 445 ppm) were recorded from sulfide bearing cordierite metapelite of Tandur. More sampling could be carried out in sulfide rich zone of cordierite metapelite. 1.95 % total REE was recorded in pegmatite (not mappable) intruded within cordierite metapelite in Umdot area (mineralized zone-1). This type of veins might be potential for REE and RM. More emphasis should be given to demarcate younger pegmatite veins, intruded within cordierite metapelite for REE exploration in future.

Within the present Umprikhola Block (Mineralised Zone-3), the G-4 exploration include 18 bedrock samples, 2 pits, 3 trenches and 3 boreholes over an area of 4.80 km². Analytical results indicated Σ REE values ranging from 24.49 ppm to 710.30 ppm, with six samples recording values exceeding 500 ppm. Pit and trench samples yielded values up to 1537.70 ppm, whereas borehole MEGBRK-03 intersected diorite containing 1134.17 ppm Σ REE. Additionally, enrichment of Ba (0.24%), Cr (0.14%) and Sr (0.10%) was recorded within dioritic bodies. These findings established the block as a prospective target for detailed G-3 stage exploration for REE and associated mineralisation.

Text Fig 8.1:
Mineralised zone map
over Geological Map of
Byrnihat-Umdot-
Umprikhola-Narbong
area, Ri-Bhoi district ,
Meghalaya and Kamrup
metro, Assam modified
after Geological Survey
of India.



CHAPTER - IX

9.0.0. AERIAL OR GROUND GEOPHYSICAL OR GEOCHEMICAL SURVEY

9.1.0. Aerial Or Ground Geophysical Survey

9.1.1 Areal or ground geophysical survey was not been carried out during the present exploration.

9.2.0 Geochemical Survey

9.2.1 The ground geochemical survey in terms of Soil Sampling and Stream sediment sampling was not carried out in the G-3 stage exploration work in Umprikhola Block.

CHAPTER - X

10.0.0 EXPLORATION UNDERTAKEN DURING CURRENT INVESTIGATION

10.1.0 Background

10.1.1 Umprikhola Block was proposed for G-3 level of exploration of REE and associated mineralisation. The Exploration has been carried out as per Minerals (Evidence of Mineral Contents) Amendment Rules, 2021 to achieve the following objective

- i. To carry out detail geological mapping on 1:4000 scale.
- ii. To collect surface bed rock samples for analyses of REE and other associated minerals.
- iii. To drill Systematic vertical boreholes in 200 m X 200 m grid within the already identified mineralized zones.
- iv. In case, analytical results of BRS samples outside the potential zones are found positive for pegmatites, inclined boreholes shall be drilled for 1st level of intersection.
- v. Study for diorite hosted Ni, Cr and PGE mineralization.
- vi. To estimate reconnaissance resources of REE bearing minerals as per UNFC norms and Minerals (Evidence of Mineral Contents) Amendment Rules, 2021 at G-3 level mineral exploration.

10.2.0 Exploration Methodology

The components of G-3 level of exploration for REE and associated minerals in Umprikhola Block to full fill the above-mentioned objective in accordance with MEMC rule 2015(amended till 2021) as approved by NMEDT is furnished in the table no 10.1 and the field component wise description has been given in subsequent paragraphs.

Table No 10.1

Summarized Table showing Component wise Proposed quantum, Revised Quantum Vs. Quantum Achieved in Umprikhola Block, District Kamrup (Metro), Assam

Sl. No.	Item of Work	Unit	Target	Achievement
1	Geological Mapping (on 1:4000 Scale)	sq.km	4.8	4.8
2	Geochemical Sampling			
	Surface Samples (BRS Chip Sampling)	Nos	50	50
3	Surveying			
	a) Topographic Survey by Total Station	Sq. Km	4.8	4.8
	b) Determination of Coordinate of Corner points of Block boundary (6 Nos)	Nos	6	6
4	Laboratory Studies			
	a) REE associated Trace Elements (34 Element) by ICP-MS Surface samples-50 BRS	Nos	50	50
	b) External Check Samples	Nos	5	5
	c) Ni and Cr by AAS method	Nos	5	5
	d) PGE by ICP-MS Ni-S fire assay technique		5	5
5	Physical Study			
	a) Petrological Study	Nos	10	10
	b) Mineragraphic Study	Nos	10	10
6	Report Preparation (5 Hard copies with a soft copy)	Nos.	1	1

10.2.1 Geological Mapping

10.2.1.1 Detail Geological mapping (DM) completed in the total area of 4.80 sq. km on 1:4000 scale in the part of Survey of India Toposheet No 78N/16. The surveyed topographic map was used as base map for geological mapping.

10.2.1.2 For recording precise sample location and to carry out a geological survey, DGPS (Make-Trimble GNSS System, Model- Catalyst DA2) was used with help of surveyor. Variation of lithologies along with the structural elements were systematically recorded and prepared the final geological map as presented in Plate No-III as well as Text Fig No 3.

10.2.1.3 During geological mapping, it was observed that the Umprikhola Block comprises lithologies dominated by Granite, granite gneiss, diorite/granodiorite and pegmatite veins. In addition, extensive soil and

alluvial cover derived from weathering of the bedrock mantles the low-lying and valley portions of the block. The description of lithology has been described in detail in Chapter No VII.

10.2.2 Topographic Survey

10.2.2.1 The entire survey work has been carried out with the help of DGPS (Make-Trimble GNSS System, Model- Catalyst DA2). With the help of DGPS, co-ordinates of surface features i.e., roads, village boundaries, water bodies, etc. along with co-ordinates of 06 nos. of block boundary points with elevation. has been determined (Annexure IA and IB) and accordingly the topographical map is presented (Plate-II). Contour interval in topographical map is taken as 2 m. All survey work was done via Survey of India CORS network. Positional (horizontal) accuracy of the survey and while the elevation accuracy is as per the SOI. CORS System.

10.2.3 Surface Sampling

10.2.3.1 In accordance with the approved NQT, the present G-3 stage exploration has been carried out with the surface sampling only which includes collection of 50 nos of surface BRS samples collected by channelling for analysis of 34 Trace elements through ICP-MS.

10.2.3.2 The sampling technique has been described in detail in the Chapter-XII.

10.2.4 Chemical Analysis

10.2.4.1 All the 50 Nos of primary samples were analysed for 34 elements, i.e., Sc, V, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Zr, Y, Nb, Sn, Hf, Ta, W, Pb, Th, U and REEs (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) by ICP-MS instrument. The results have already been described under Chapter-VII along with the lithology wise geochemistry of different lithology. However, the analysis of trace elements have been furnished in Annexure No II.

10.2.4.3 Moreover, the external check samples of 5 Nos have been analysed for same 34 elements from JNARDDC Laboratory, Nagpur.

10.2.4.4 5 Nos of primary samples from Diorite/granodiorite unit have also analysed for PGE by Ni-S fire assay technique and the same samples were also analysed for Ni and Cr by sequential AAS method as per the approved quantum of work. The results have already been described under Chapter-VII

along with the geochemistry of Diorite/granodiorite. However, the analysis of trace elements have been furnished in Annexure No III and IV.

10.2.5 Physical Analysis

10.2.5.1 A total of 10 samples were examined under the microscope for detailed petrographic studies. The results of the petrographic investigation have been incorporated in the description of various lithologies under Chapter VII and are also presented as Annexure V.

10.2.5.2 10 Nos of samples has been subjected for Mineragraphy study and furnished as Annexure No VI.

10.2.6 Preparation of Geological Report:

10.2.6.1 Geological Report has been prepared in Corporate Office, MECL, Nagpur by integration of geological and geochemical data. ArcGIS and Autocad 2026 software has been used for preparation of various maps and GCD kit module of R programming language has been used for generating geochemical plots. The report has been written using Microsoft word and excel 2021 version.

10.3.0 Data spacing for reporting of exploration results

10.3.1 The geological data generated through detail mapping and surface sampling were adequate for preparation of the Detail Geological Map of the block at 1:4000 scale. The investigations revealed that REE occurrence is very sporadic in nature at only few places. As a result, drilling was not undertaken. Hence, the data generated during the course of investigation are considered sufficient for concluding the exploration work and preparation of the Geological Report of the Umprikhola Block.

CHAPTER - XI

11.0.0 Location of Data Point

11.1.0 Accuracy and Quality of Survey

11.1.1 The entire survey work has been carried out with the help of DGPS (Make- Trimble GNSS System, Model- Catalyst DA2) (Table No. 11.1 and 11.2). With the help of DGPS, co-ordinates of surface features i.e., roads, village boundaries, water bodies, etc. along with co-ordinates of 06 nos. of block boundary points with elevation has been determined (Annexure IA and IB) and accordingly the topographical map is presented (Plate-II). Contour interval in topographical map is taken as 2 m. All survey work was done via Survey of India CORS network. Positional (horizontal) accuracy of the survey and while the elevation accuracy is as per the SOI. CORS System.

Table No. 11.1

TECHNICAL SPECIFICATION OF DGPS	
MAKE	TRIMBLE
DGPS MODEL	Catalyst DA2
YEAR	2025

Table No. 11.2

**Co-ordinates of the base station for DGPS survey of Umprikhola block ,
Assam**

Sl. NO.	BASE NAME	WGS-84		RL(m)
		LATITUDE	LONGITUDE	
1	BASE-SOI (GUW3)	N26°07'46.30742"	E91°44'46.34009"	110.999 m

11.2.0 Quality and adequacy of topographic control

11.2.1 The topographic survey including surface features, contour points were surveyed by Trimble Catalyst DA2. Positional (horizontal) accuracy of the survey is 10mm while the elevation accuracy is 20 mm. The detailed topographical map of the Block has been prepared on 1:4,000 scale

CHAPTER - XII

12.0.0 SAMPLING TECHNIQUE

12.1.0 Sampling

12.1.1 Sampling is a systematic process for collection of material from any media which can provide the best representation. In the present study in the Umprikhola Block, sampling includes bed rock sampling only.

12.1.2 A total of 50 bedrock samples were collected during the course of investigation. The bedrock samples were collected through systematic channel sampling across different lithologies exposed at the surface.

12.2.0 Nature, quality and appropriateness of sample preparation technique

12.2.1 The detail description of sampling methods for Bed rock samples has been discussed in subsequent paragraphs.

12.2.2 Sampling techniques:

Bedrock Sampling: A total of 50 Nos. of bed rock samples were collected systematically from different litho units exposed in the study area, mainly from the Granite, granite gneiss, pegmatite, quartzo feldspathic veins and diorite. Each sample were collected by cutting channels on exposed rock units in 1 – 2 m length by sledge hammer (5kg) and chisel. The sample locations are plotted on geological map (Text figure No 7.3 as well as Plate No-IV). First, each Bed rock sample of 2-3 kgs collected from the field was crushed. After crushing, the crushed samples were mixed thoroughly and reduced the sample size to 500 gm by coning and quartering. This representative samples were powdered and completely passed through (-) 200 mesh size sieves from which 100 g sample packed in polythene sample pouch and send for chemical analysis for 34 elements by ICP-MS. The remaining 400 g sample has been preserved for future reference.

12.3.0 Quality control procedures adopted during sampling

12.3.1 The samples have been prepared under the supervision of geologist and qualified sampling technician. All the samples collected from the field were packed properly in the polythene sample bag with proper tag. Then the entire

samples were transported to central sample processing unit located in Nagpur. It has been thoroughly checked that none of the sample bags were damaged during the transportation.

- 12.3.2 Further measures have been taken during sieving and pounding/grinding of samples. The sieve and containers have been cleaned after processing of each sample to avoid contamination and measures have also been taken to avoid loss of powder in air.

12.4.0 Measures taken to ensure that the sampling is representative

- 11.4.1 It is very important to submit the representative sample of collected material for geochemical analyses. As discussed in the previously, initial sieving have been carried out on the soil and stream sediment samples to collect the natural fraction. Further after pounding and passing samples of soil and stream sediment through (-)200 mesh sieve and crushing, grinding and passing through (-) 200 mesh sieves for Bed rock samples, quantity of the samples has been reduced to 500 gm by coning and quartering method after thoroughly mixing to maintain the homogeneity of the samples. Hence it can be assumed that the samples remain representative in nature of in situ material collected.

12.5.0 Appropriateness of grain size

- 12.5.1 In accordance with the standard sampling procedures, it has also been observed that smaller the particle size, higher the homogeneity of the sample as well as higher the dissolvability during the chemical analysis. As per the standard practice, samples are generally pounded to (-)200 mesh size for analysis through ICP-MS.

CHAPTER - XIII

13.0.0 DRILLING TECHNIQUE AND DRILL SAMPLING EMPLOYED

13.1.0 The integrated outcome of geological mapping and chemical analyses was placed before the 25th Meeting of TCC-II, NMEDT. After detailed technical deliberation, the Committee recommended for the conclusion of the exploration work at the present stage, as the available geological and analytical data do not warrant advancement to the next stage of exploration, i.e, subsurface Core Drilling. Hence the drilling work has not been taken up during the investigation.

CHAPTER - XIV

14.0.0 SUB-SAMPLING TECHNIQUES AND SAMPLE PREPARATION

14.1.0 As drilling was not taken up at present exploration work, hence drill core samples has not been generated in the present project. The sampling technique of bed rock and trench samples has been discussed in Chapter XII.

CHAPTER - XV

15.0.0 QUALITY OF ASSAY DATA AND LABORATORY TEST

15.1.0 The nature, quality and appropriateness of Chemical analysis

15.1.1 All the 50 Nos of primary samples for 34 elements, i.e., Sc, V, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Zr, Y, Nb, Sn, Hf, Ta, W, Pb, Th, U and REEs (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) by ICP-MS instrument. 5 Nos of primary samples from Diorite/granodiorite unit have also analysed for PGE by Ni-S fire assay technique and the same samples were also analysed for Ni and Cr by sequential AAS method as per the approved quantum of work.

15.1.2 Methodology of Chemical Analyses by ICP-MS

Chemical Laboratory, MECL, Nagpur is having Agilent make ICP-MS 7800 model for elemental analyses. ICP-MS (inductively coupled plasma-mass-spectrometry) is a technique to determine low-concentrations (ppb = parts per billion = $\mu\text{g/l}$) and ultra-low-concentrations of elements (ppt = parts per trillion = ng/l). ICP-MS can also measure elements at concentrations up to 100s or even 1000s of parts per million (ppm). Accuracy and precision (standard deviation) for 34 of these elements is either excellent (<5%) or good (5–10%).

Methodology for analysing 34 elements: A simple HCL-HF-HNO₃ dissolution in screw top Teflon bombs is used in microwave Digester for sample preparation. ICP-MS instrumental sensitivity is measured by external solutions (Tuning solution provided by Agilent), with surrogate calibration for 4 elements (Li, Co, Y). Matrix correction is made by use of standard CRM (Certified reference material).

The following Precautions are followed in the laboratory while doing chemical analysis.

- Safety goggles (department approved) and apron dress must be worn in the lab at all times.
- Use of fume hoods for dangerous or irritating chemicals.
- Label all containers to identify their contents.
- Never put anything back into a reagent bottle. Once a reagent has passed the mouth of its container, it has passed the point of no return. Always take

as little of a chemical as possible. Use only clean, dry spatulas for removing chemicals from bottles. Properly dispose of excess chemicals.

- Avoid touching hot objects. Burns are a common accident in the chemistry lab. Be careful when using hot plates and objects which have been heated on them. Use beaker tongs to remove hot containers from the hot plate.
- Rinse off any chemicals spilled on the skin immediately with large amounts of water.
- Clean up broken glassware immediately. Place it in the labelled crock at the front of the lab.
- Properly dispose of waste chemicals. Certain liquids can be poured into the sink and flushed with water while others are poured into designated waste containers. Most solid wastes are placed in designated crocks.

15.1.3 Methodology of Platinum group of Elements (PGE) analysis

Platinum Group Element (PGE) analysis was carried out at MECL, Nagpur using the Nickel Sulphide (NiS) Fire Assay technique followed by ICP-MS determination, which is regarded as the most reliable and definitive method for low-level PGE estimation. Prior to analysis, all samples were prepared to ensure complete passage through a 200-micron IS sieve. Approximately 2–10 g of pulverized sample was mixed with nickel powder, sulphur, sodium carbonate, and borax flux in ceramic crucibles and fused at temperatures exceeding 1100°C for about two hours. During fusion, the silicate matrix was converted into a borosilicate slag, while nickel and sulphur formed a dense nickel sulphide melt that quantitatively collected platinum group elements. After cooling, the NiS matte bead formed at the bottom of the crucible was separated from the slag and dissolved in 6.2N hydrochloric acid under reducing conditions at approximately 110°C. The recovered PGE concentrate was subsequently processed either through membrane filtration and aqua regia digestion or by tellurium co-precipitation followed by aqua regia digestion. Final determination of platinum, palladium, rhodium, ruthenium, iridium, and osmium concentrations was carried out using Inductively Coupled Plasma–Mass Spectrometry (ICP-MS). Bead recovery was consistently maintained above 85%, ensuring efficient collection of PGEs from the sample matrix.

15.1.4. Quality Assessment for Platinum group of Elements (PGE)

A comprehensive Quality Assurance and Quality Control (QA/QC) programme was implemented by MECL, Nagpur to ensure the accuracy, precision, and reliability of analytical results. All laboratory procedures were conducted in accordance with ISO/IEC 17025 standards under controlled environmental conditions. Particular emphasis was placed on contamination control, and all fusion reagents, including nickel powder and sulphur, were certified as PGE-free analytical-grade materials. A total QC insertion rate of 15% was maintained throughout the analytical programme, comprising Certified Reference Materials (CRMs), analytical blanks, and duplicate samples at an insertion frequency of one each per twenty routine samples. SARM 7B was used as the certified reference material to monitor analytical accuracy, while flux blanks were employed to assess potential contamination during sample preparation and fusion. Pulp duplicates were analyzed to evaluate analytical precision and repeatability. Analytical batches were accepted only when CRM values fell within ± 2 standard deviations of their certified concentrations and blank values remained below five times the lower limit of detection for the target elements. Any batch failing to satisfy the prescribed acceptance criteria was subjected to detailed investigation, and the affected samples were re-fused and re-analyzed. These stringent QA/QC measures ensured the generation of high-quality, reproducible, and defensible PGE analytical data suitable for mineral exploration and resource evaluation.

15.1.5. Methodology for Ni-Cr by AAS methode

Nickel (Ni) and Chromium (Cr) analyses were carried out at MECL, Nagpur using Atomic Absorption Spectroscopy (AAS) following Aqua Regia–HF–Perchloric Acid digestion. Approximately 0.5000 g of pulverized sample (-200 mesh) was weighed into a PTFE beaker and digested using a mixture of Aqua Regia (HCl_3 ; 3:1), hydrofluoric acid (HF), and perchloric acid (HClO_4). The digestion was performed on a hot plate at 90–120°C until near-total decomposition of the sample matrix was achieved. After cooling, dilute nitric acid was added to dissolve soluble salts, and the solution was filtered and made up to a final volume of 100 mL using 2% HNO_3 prepared with deionized

water. Calibration standards for Ni and Cr were prepared from certified standard solutions using the same acid matrix as the samples. The resulting solutions were analyzed by Atomic Absorption Spectroscopy (AAS) using an air-acetylene flame at wavelengths of 232.0 nm for Ni and 357.9 nm for Cr. Calibration curves were established using appropriate standards, and elemental concentrations were determined by comparison with the calibration data. Samples exceeding the calibration range were suitably diluted and re-analyzed to obtain accurate results.

15.1.6. Quality Assessment for Ni-Cr by AAS

A comprehensive Quality Assurance and Quality Control (QA/QC) programme was implemented by MECL, Nagpur to ensure the accuracy, precision, and reliability of analytical results. Each analytical batch included one reagent blank, Certified Reference Materials (CRMs) such as EURONORM CRM No. 690-1 and BCS-369, and one repeat sample for every 25 routine samples analyzed. Reagent blanks were used to monitor potential contamination arising during sample preparation and instrumental analysis. Certified Reference Materials were analyzed to assess analytical accuracy, and the obtained values were required to fall within the certified limits. Repeat samples were included to evaluate analytical precision and reproducibility, and the results were required to meet established laboratory acceptance criteria. Calibration verification standards were also analyzed periodically throughout the analytical sequence to monitor instrument stability and ensure the validity of the calibration. These QA/QC measures ensured the generation of accurate, precise, and reliable Ni and Cr analytical data suitable for mineral exploration and geochemical investigations.

15.2.0 Quality control procedure

- 15.2.1 The standard procedure of quality control has been adopted during the chemical analysis in Chemical laboratory, MECL, Nagpur which includes
- (i) Analysis of Certified reference materials/measurement standards
 - (ii) Analysis of blind samples
 - (iii) Use of QC samples and control charts
 - (iv) Analysis of blank samples

- (v) Analysis of spiked samples
- (vi) Analysis in duplicate samples.

15.3.0 External Check Analyses

- 15.3.1 In accordance to the standard practice of quality assurance and quality control, 5 numbers of primary samples (10% of Primary samples) were subjected for analysis at JNARDDC, Nagpur as external check samples for 34 elements. The details of External check sample analysis has been provided in Annexure-X. It has been observed the analytical result of external check sample is close to the primary analysis. As, only the 5 Nos of samples are analysed as external check sample, detail statistics has not been prepared due to small sample size for statistical evaluation.

15.4.0 Security and chain of control of samples

- 15.4.1 The samples have been prepared at centralized mechanized sampling unit with proper labeling and tag and sent to chemical laboratory in supervision of qualified sampling technician.
- 15.4.2 The samples has been transported from field to sample processing unit with proper sealing of sampling bags and the same has been verified in the sampling unit before opening the bags.
- 15.4.3 At the sampling unit, standard procedure has been followed and all the precautionary measures have been taken to avoid the contamination. Further the remaining samples are propoerly preserved with sample tags for any future reference under the custody of the company.

CHAPTER - XVI

16.0.0 MOISTURE

16.1.0 Method of determination of the moisture content.

16.1.1 All the analysis has been carried out with natural moisture. Moisture content has not been determined.

CHAPTER - XVII

17.0.0 BULK DENSITY

17.1.0 Method of determination and result

- 17.1.1 Drilling of scout boreholes was not recommended due to non-encouraging results for REE in the area. So, resource estimation was not carried out. As a result, bulk density or specific gravity has not been determined.

CHAPTER - XVIII

18.0.0 BENEFICIATION STUDIES AS MAY BE REQUIRED

18.1.0 Details of beneficiation studies

- 18.1.1 Beneficiation studies have not been carried out in the present exploration as it was out of the scope of the approved quantum of work.

CHAPTER - XIX

19.0.0. RESOURCE ESTIMATION TECHNIQUES

The REE mineral is mainly confined in few sporadic places. Hence drilling has not been taken up in the present stage of exploration in Umprikhola Block, as a result resource has not been estimated in the block.

CHAPTER - XX

20.0.0. REPORTING OF RESOURCE

As mentioned in the Chapter – XIX, resource has not been estimated in the present stage of exploration.

CHAPTER - XXI

21.0.0 SUMMARY AND RECOMMENDATIONS

21.1.0 Summary

21.1.1 The present investigation was undertaken as a Preliminary Exploration (G-3 level) programme to assess the potential of Rare Earth Elements (REE) and associated critical minerals in the Umprikhola Block covering approximately 4.8 sq. km around Umprikhola, Tanduk, and Rohana villages. The exploration programme included detailed geological mapping on a 1:4,000 scale, petrographic and mineragraphic investigations, and geochemical analyses through ICP-MS, Fire Assay, and AAS techniques. The primary objective was to delineate lithological units, understand structural controls, characterize mineralization, and evaluate the distribution of REE, PGE, Ni, Cr, and associated trace elements within the block.

21.1.2 The geological framework of the area is dominated by Granite Gneiss, Biotite Gneiss, Diorite (petrographically classified as Meta-Granodiorite), Pink Granite, Quartzo-Feldspathic Veins, and Pegmatitic Veins. Granite Gneiss forms the most extensive lithological unit and exhibits well-developed gneissic banding with numerous quartzo-feldspathic veins. Diorite constitutes the second most dominant lithology and occurs in fine-, medium-, and coarse-grained varieties, commonly associated with quartz veining and sulphide mineralization. Pink Granite occurs as a minor felsic intrusive body, while pegmatitic and quartzo-feldspathic veins represent late-stage intrusive phases emplaced along fractures and foliation planes. Pegmatitic veins are particularly notable for their coarse quartz, feldspar, and biotite assemblages and their close association with REE enrichment.

21.1.3 Geochemical investigations through ICP-MS reveal that REE enrichment is primarily associated with evolved felsic intrusive phases and accessory mineral concentrations. Granite Gneiss contains total REE values ranging from 185.00 to 522.32 ppm (average 324.41 ppm) and displays strong LREE enrichment with pronounced negative Eu anomalies indicative of feldspar fractionation. Diorite (Meta-Granodiorite) exhibits moderate REE concentrations characterized by fractionated LREE-enriched patterns, with La

values reaching 248.28 ppm and Ce up to 399.51 ppm. Pink Granite records a total REE content of 276.83 ppm and also displays significant LREE enrichment. Milky Quartz Veins contain comparatively lower REE concentrations, whereas Quartzo-Feldspathic Veins show variable REE distributions with both negative and positive Eu anomalies reflecting complex magmatic-hydrothermal processes.

- 21.1.3 Among all lithological units, Pegmatitic Veins represent the most prospective host for REE mineralization, recording total REE concentrations ranging from 72.48 ppm to 2197.63 ppm, with several samples exceeding 1000 ppm TREE. These veins exhibit extremely fractionated LREE-enriched signatures, with La values reaching 446.63 ppm and Ce values up to 847.32 ppm. The pegmatites are also characterized by anomalously high tungsten concentrations ranging from 8.37 ppm to 774.28 ppm, indicating significant late-stage magmatic-hydrothermal activity and highlighting their importance as the principal REE-bearing lithology within the block.
- 21.1.4 Nickel and Chromium analyses indicate only minor enrichment within the investigated lithologies. Granite Gneiss contains Cr values ranging from 61.82–283.04 ppm and Ni values from 21.12–72.72 ppm, while Pegmatitic Veins contain Cr values between 28.41–218.63 ppm and Ni values between 5.62–74.38 ppm. AAS analyses of dioritic rocks further confirm low concentrations of these transition metals. The overall geochemical data suggest that although mafic contributions are present, the concentrations are significantly below economic thresholds, indicating no economically viable Ni-Cr mineralization within the block.
- 21.1.5 Petrographic study reveal that the Granite Gneiss consists predominantly of quartz, feldspar, biotite, and hornblende with granoblastic to gneissose textures. Importantly, it hosts REE-bearing accessory minerals such as monazite and zircon, along with apatite and sphene. Diorite samples, petrographically identified as Meta-Granodiorite, display hypidiomorphic granular textures comprising plagioclase, quartz, microcline, biotite, and hornblende, together with accessory zircon, monazite, apatite, and sphene. The presence of monazite and zircon in both lithologies confirms the source of

REE enrichment observed in geochemical analyses and suggests that REE mineralization is controlled by accessory mineral concentrations within evolved felsic systems.

- 21.1.6 Mineragraphic studies indicate structurally controlled hydrothermal mineralization represented by disseminated sulphides, fracture fillings, and vein-hosted mineral assemblages. Pyrite and chalcopyrite are the dominant sulphides, with pyrite commonly altered to digenite and chalcocite under supergene conditions. Minor pyrrhotite occurs locally, while magnetite and ilmenite constitute the principal oxide phases. Magnetite occurs both as disseminations within fine-grained diorite and as coarse grains within quartzofeldspathic veins, whereas ilmenite is aligned parallel to the regional metamorphic fabric. These observations indicate a multi-stage hydrothermal and metamorphic history but do not suggest the presence of economically significant base-metal sulphide mineralization.
- 21.1.7 Fire Assay analyses of selected diorite/meta-granodiorite samples reveal extremely low concentrations of Platinum Group Elements (PGE), including Pt, Pd, Rh, Ru, and Ir, while Os is generally below detection limits. The absence of ultramafic intrusions, limited sulphide accumulation, and consistently low PGE values indicate that the geological environment is unfavorable for significant PGE mineralization. Consequently, no economically significant PGE potential has been identified within the Umprikhola Block.
- 21.1.8 Overall, the exploration results indicate that the Umprikhola Block possesses localized REE enrichment primarily associated with pegmatitic and evolved felsic intrusive phases, particularly within pegmatitic veins where TREE values locally exceed 2000 ppm. The presence of REE-bearing accessory minerals such as monazite and zircon, coupled with strong LREE enrichment and elevated tungsten concentrations, suggests a favorable magmatic-hydrothermal environment for REE concentration. Although presence of REE is confirmed, but due to absence of economically significant concentration, drilling in the block has not been carried out.

21.2.0 Recommendation

- 21.2.1 The present investigation has established localized REE enrichment mainly associated with pegmatitic veins, quartzo-feldspathic veins and evolved felsic intrusive phases within the Umprikhola Block. Although sporadic anomalous REE concentrations exceeding 1000 ppm $\Sigma\text{REE}+\text{Y}$ have been recorded in some pegmatitic veins, the mineralisation is discontinuous and lacks significant lateral continuity and subsurface persistence. Hence, further exploratory drilling within the present block is not recommended at this stage.
- 21.2.2 However, considering the favourable geological setup comprising evolved felsic intrusives, pegmatitic activity, structurally controlled emplacement and presence of REE-bearing accessory minerals such as monazite, zircon and sphene, adjoining areas exhibiting similar geological and structural characteristics, particularly pegmatitic and quartzo-feldspathic vein systems, may be evaluated for REE mineralisation.

CHAPTER - XXII

22.0.0. PLATES AND MAPS

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CHAPTER - XXIII

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23.1.0. List of Annexure

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CHAPTER - XXIV

24.0.0. ANY OTHER INFORMATION

24.1.0. Any other information as may be available or required by any authority as prescribed.

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CHAPTER - XXV

25.0.0 CERTIFICATION

This is to certify that geological report has been prepared in respect of Preliminary Exploration in Umprikhola Block, District Kamrup (Metro), State: Assam by Mineral Exploration and Consultancy Limited (MECL) on behalf of National Mineral Exploration and Development Trust (NMEDT). The report has been prepared in accordance with the Minerals (Evidence of Mineral Contents) Rule 2015 specified under Mineral Auction Rule, 2015 and amended up to 2021.

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