Report on Reconnaissance Survey (G4 stage) for Rare Earth Elements (REE) and RM (Sc & Nb) in

Samalpatti block,

Krishnagiri(Dist), Tamil Nadu.

(Block ID : KIOCL_57_TN_SREE)

Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXURES

LIST OF PLATES

1. Executive summary

The International Union of Pure and Applied Chemistry (IUPAC), described that the rare earth elements (REEs) constitute a group of seventeen elements, including scandium (Sc), yttrium (Y), and the lanthanide series (fifteen elements from Lanthanum (La) to Lutetium (Lu) (Damhus et al. 2005). Generally, REEs can be divided into two groups as Light REEs (LREEs, including Lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), and europium (Eu) and Heavy REEs (HREEs), including gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), Lu, Sc, and Y. REEs find extensive use in various consumer products due to their indispensability in electronic, optical, magnetic, aerospace, biomedicines, energy storage, quantum information sciences, and catalytic applications (Atwood, 2013; Binnemans et al., 2013; Zhou et al., 2017; Goodenough et al., 2018; Balaram, 2019). Additionally, they play a crucial role in energy efficiency improvement, environmental protection, and the advancement of digital technology.

Major REE ore deposit types

REE ore deposits are generally categorized into two main types as a). ***Primary Deposits*** formed through hydrothermal and igneous processes and b). ***Secondary Deposits*** resulting from weathering and sedimentary processes (Walter et.al 2010).

i. Carbonatite-related deposits
ii. Deposits associated with alkaline igneous rocks
iii. Magmatic-hydrothermal deposits
iv. Residual weathering deposits
v. Placers
vi. Offshore sedimentary deposits
vii. REEs in coals

The global distribution of REE deposits and some major REE deposits have been identified in over 34 countries, with a total estimated 130 million metric tons of global REEs reserves based on REO content furnished in Table below. The leading countries in terms of reserves are China (~33.8%), Vietnam (~16.9%), Brazil (~16.2%), Russia (~16.2%), India (~5.3%), Australia (~3.2%), and the USA (~1.8%) (*USGS. 2023*). Since the late 1990s, China has been dominating the REE market, both in the supply of raw ores and processed/purified products, accounting for over 90% of global production from the 2000s to the early 2010s (*Drobniak and Mastalerz 2022*). In recent years, due to adjustments in the international REE market, there has been an increase in REO production outside of China. As shown in Table, China's contribution has now fallen to the range of 55%–70% of global production (*US Geological Survey, 2021, 2023*), while the production in the United States, Vietnam, and Thailand is increasing year by year.

Table 1: Country wise REE production and reserves.

Name of Country	**Mine Production**		**Reserves**
	2022	**2023**	
United States	42,000	43,000	1,800,000
Australia	18,000	18,000	105,700,000
Brazil	80	80	21,000,000
Burma	12,000	38,000	NA
Canada	-	-	830,000
China	11210,000	11240,000	44,000,000
Greenland	-	-	1,500,000
India	2,900	2,900	6,900,000
Madagascar	960	960	NA
Malaysia	80	80	NA
Russia	2,600	2,600	10,000,000
South Africa			790,000
Tanzania			890,000
Thailand	7,100	7,100	4,500
Vietnam	1,200	600	22,000,000
World total (rounded)	300,000	350,000	110,000,000

Source : U.S. Geological Survey, Mineral Commodity Summaries, January 2024

Below table (table 2) shows REE mineral used in a variety of applications;

Table 2: REE minerals used in various application

Area	**Applications**
Electronics	Television screens, computers, cell phones, silicon chips, monitor displays, long-life rechargeable batteries, camera lenses, light emitting diodes (LEDs), compact fluorescent lamps (CFLs), baggage scanners, marine propulsion systems.
Manufacturing	High strength magnets, metal alloys, stress gauges, ceramic pigments, colorants in glassware, chemical oxidizing agent, polishing powders, plastics creation, as additives for strengthening other metals, automotive catalytic converters.
Medical Science	Portable X-ray machines, X-ray tubes, magnetic resonance imagery (MRI) contrast agents, nuclear medicine imaging, cancer treatment applications, and for genetic screening tests, medical and dental lasers.
Technology	Lasers, optical glass, fiber optics, masers, radar detection devices, nuclear fuel rods, mercury-vapor lamps, highly reflective glass, computer memory, nuclear batteries, high temperature superconductors.
Renewable Energy	Hybrid automobiles, wind turbines, next generation rechargeable batteries, biofuel catalysts.
Others	The europium is being used as a way to identify legitimate bills for the Euro bill supply and to dissuade counterfeiting. An estimated 1 kg of REE can be found inside a typical hybrid automobile. Holmium has the highest magnetic strength of any element and is used to create extremely powerful magnets. This application can reduce the weight of many motors.

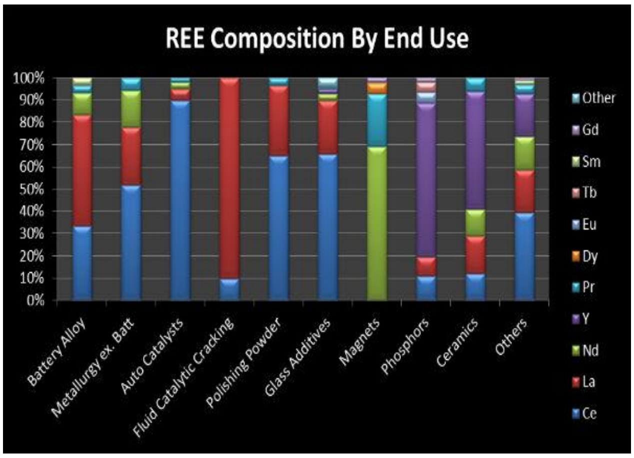


Figure 1: REE composition by end use

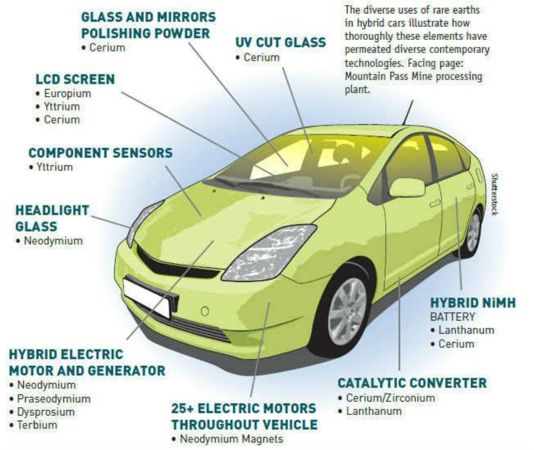


Figure 2: REE in automobile

GSI in their field season 1992-93, carried out prospecting in and around the syenite carbonatite complex. Carbonatites are the primary source of niobium and rare earth elements (REEs), in particular the light REEs, including La, Ce, Pr, and Nd. Carbonatites are a relatively rare type of igneous rock composed of greater than 50 vol % primary carbonate minerals, primarily calcite contain the highest concentrations of REEs of any igneous rocks.

In the Samalpatti area, carbonatite complex is spread over 100 sq.km, constitutes, ultramafites, pyroxenite bodies are intruded by intricate network of carbonatite veins, veinlets and stringers.

Field relationship, mineralogy and texture, are some of the criteria based on which identified various types of syenites as fine grained grey syenite, coarse grey syenite, whitish grey garnet syenite, grey hornblende syenite, coarse leuco hornblende syenite, greyish white to pale pinkish syenite, grey and pink syenite, porphyritic syenite, syenitoidal syenite, etc., Similarly, the authors have also applied same criteria of field relationship, colour and texture recognised few varieties of carbonatites as dark grey carbonatite, green (chromiferous) carbonatite, whitish grey carbonatite, brownish grey carbonatite, white sovite type carbonatite. The previous work in the area 33 samples were studied and analysed for trace REE and major elemental geochemistry.

As the area consists of both carbonatites as discrete veins and veinlets and syenites of various kinds, KIOCL has attempted to collect some samples specifically to analyse the lanthanoid elements. The analytical results of 09 samples of carbonatites have yielded 0.22 to 0.56% of TREE and one sample of Nepheline Syenite and 2 samples of Pegmatoidal syenite show TREE value of 0.03% and 0.02% respectively during Pre-field studies.

This forms the basis for mounting an G4 stage exploration program by KIOCL for delineating the different varieties of both syenites and carbonatites of Samalpatti area and to target the potential zones for REE mineralisation in the area.

KIOCL submitted a proposal to explore 90 sq. km area around Samalpatti for REE and RM mineralisation in the Samalpatti Alkaline-Carbonatite Complex. Since the GSI had already studied the region for PGE mineralisation on a 1:12,500 scale in 2018, the 69th meeting of the TCC - NMET, approval was granted for G4-level mineral exploration focusing on areas with notable REE values and carbonatite presence. Consequently, as per the directions of TCC-NMET area of 28.5 sq. km was carved out to update geological mapping, incorporating carbonatite and associated rocks. This area was divided into three sub-blocks (8.88, 4.32, and 15.3 sq.km) to gather detailed information on carbonatite bodies, their extent and their contact relationships with surrounding rocks.

The area mapped is dominated by syenite, with minor occurrences of pyroxenite, dunite, pegmatoidal syenite, and scattered carbonatite bodies. Outcrops of carbonatite appear as linear or lensoid forms, showing intrusive relation with syenite. Pyroxenite enclaves within syenite also display sharp intrusive contacts. A significant band of crystalline limestone extends over 850m along strike, with a width of 80m. Overall, syenite maintains sharp boundaries with surrounding rock types and carbonatite consistently exhibits intrusive features, with thin veinlets permeating into syenite.

Samalpatti alkaline carbonatite complex is being studied for Rare Earth Element (REE) mineralisation associated with carbonatite and syenite intrusions. The carbonatite bodies occuring discontinuously as small outcrops, forming bands were traced after trenching for 220–340m strike length and ~10m width, trending east–west and north–south in the sub blocks 1 and 2 respectively.

15 carbonatite bands across three sub-blocks, showing a significant range in Rare Earth Element (REE) concentrations, from 531 ppm to a high of 13,917 ppm are observed, Among these 15 numbers of carbonatite bodies, 2 bands viz Band 1 and 2 occurring in Sub block 01 & 02 were observed to be having substantial dimensions with higher TREE values of 3,996ppm and 3,121ppm respectively. Band 1 is located at a distance of around 800m towards east of Ettipatti village and Band 2 is located at a distance around 400m north of Jogipatti village. These 2 bands were targeted for subsurface investigation through trenching and boreholes.

Surface signs of REE mineralisation in such terrains includes distinctive geological, geochemical, and mineralogical features. REE-bearing minerals like bastnäsite, monazite, and parisite are typical but difficult to identify visually, as all appear yellow-brown with resinous lustre.

Carbonatites are known to host REE-bearing minerals, with light REEs preferentially incorporated into carbonate and fluorocarbonate structures such as bastnäsite, monazite, xenotime and synchysite. Petrographic studies confirm REE and RM minerals mainly occur in fluorocarbonate, monazite, ancylite-group phases, and Sr-rich calcite, with monazite being a key resistant LREE ore.

The study area (three sub-blocks) is mostly a covered terrain with limited rock exposure, making carbonatite identification difficult. Small outcrops and calcrete remnants guided trenching locations.

In the Sub-block 1, out of 15 BRS collected, 12 BRS were from carbonatite, whose T-REE values ranges from 308.38ppm to 6,962ppm with mean value of 3,725.88 ppm. In the Sub-block 2, 16 BRS collected from carbonatite bodies have indicated T-REE values ranging from 1,514.24ppm to 13,916.83pm with mean value of 3958.9 ppm.In the Sub-block 3, out of 25 BRS collected, 17 samples are from carbonatite bodies, indicated T-REE values ranging from 291.34ppm to 12,411.12 ppm with mean value of 4,545.70ppm.

Four trenches were excavated to test continuity and width of two major carbonatite bodies (N–S in Sub-block 1, E–W in Sub-block 2). Trench 1 and Trench 2 excavated in Sub block 1 over carbonatite band 1 are analysed TREE value of 6,647.23ppm over 9m(1 -9m) and 3,864.52ppm over 10m(3-13m) respectively. Trench 3 and Trench 4 in Sub block 2 over carbonatite band 2 analysed TREE value of 4993.18ppm over 4m(5-9m) and 4339.03 ppm over 21m (0-21m) respectively. Strong surface mineralisation showing high values of REE, justified drilling to confirm depth persistence.

The first Borehole SRB-01 was drilled to test the depth continuity of the carbonatite band in the sub block-1 confirmed that the subsurface is dominated by syenite with limited carbonate vein intrusions with zone of fenitised syenite and pyroxenite having dolomite carbonatite. The continuity of Carbonatite Body 1 was not significantly established at this level, as syenite remained the prevailing lithology throughout the drilled section.

The second borehole SRB-02 intersected fenitised hybrid rock with calcic carbonatite traced in the sub block-2 has confirmed a pattern similar to SRB-01, dominated by fenitised syenite with limited carbonate vein intrusions.

The carbonatite petrography of the block shows both dolomitic and calcitic types with REE values much more than that of the mixed zones along with substantial high barium (Ba) content in carbonatites is typically linked to late-stage magmatic differentiation and alkali-rich mineral phases such as K-feldspar, biotite, and barite. It is assumed that the calcitic and dolomitic carbonatite covering the entire length of the drilled column with intermittent mixed zones of syenite and pyroxenites. The boreholes SRB 01 and SRB 02 drilled on Band 1 and Band 2 are indicating weighted avg TREE values in the range of 3,409.27ppm & 3,815.22ppm respectively, suspected to be derived from carbonatite zones.

Using a cutoff of 1000ppm of TREE, resource has been estimated to the tune of 2.948 million tonnes with weighted average TREE value of 3,723ppm in the block under UNFC classification of 334 category by cross section method.

It is recommended to upgrade the block to G3 stage with the aid of close space drilling and detailed mapping for a better understanding of the resource, grade and controls of REE localization in carbonatite and fenite zones of the area.

कार्यकारी सारांश

अंतर्राष्ट्रीय शुद्ध एवं अनुप्रयुक्त रसायन संघ (IUPAC) ने उल्लेख किया है कि दुर्लभ पृथ्वी तत्व (REEs) सत्रह तत्वों के एक समूह का गठन करते हैं, जिसमें स्कैंडियम (Sc), येट्रियम (Y), और लैंथेनाइड श्रृंखला (लैंथेनम (La) से ल्यूटेटियम (Lu) तक पंद्रह तत्व (Damhus et al. 2005) शामिल हैं। आम तौर पर, आरईई को दो समूहों में विभाजित किया जा सकता है जैसे लाइट आरईई (LREEs, जिसमें लैंथेनम (La), सेरियम (Ce), प्रेजोडायमियम (Pr), नियोडिमियम (Nd), प्रोमेथियम (Pm), समरियम (Sm), और यूरोपियम (Eu) और भारी आरईई (HREEs, गैडोलीनियम (Gd), टर्बियम (Tb), डिस्प्रोसियम (Dy), होल्मियम (Ho), एर्बियम (Er), थुलियम (Tm), येटरबियम (Yb), Lu, Sc और Y शामिल हैं। आरईई इलेक्ट्रॉनिक में अपनी अपरिहार्यता के कारण विभिन्न उपभोक्ता उत्पादों; ऑप्टिकल, चुंबकीय, एयरोस्पेस, बायोमेडिसिन, ऊर्जा भंडारण, क्वांटम सूचना विज्ञान और उत्प्रेरक अनुप्रयोग में व्यापक उपयोग पाते हैं। (Atwood, 2013; Binnemans et al., 2013; Zhou et al., 2017; Goodenough et al., 2018; Balaram, 2019)। इसके अतिरिक्त, वे ऊर्जा दक्षता में सुधार, पर्यावरण संरक्षण और डिजिटल प्रौद्योगिकी की उन्नति में महत्वपूर्ण भूमिका निभाते हैं।

प्रमुख आरईई अयस्क भंडार प्रकार

आरईई अयस्क भंडारों को सामान्यतः दो मुख्य प्रकारों में वर्गीकृत किया जाता है: क) जलतापीय और आग्नेय प्रक्रियाओं द्वारा निर्मित **प्राथमिक निक्षेप** और ख) अपक्षय और अवसादी प्रक्रियाओं के परिणामस्वरूप निर्मित **द्वितीयक निक्षेप**। (Walter et.al 2010)।

viii. कार्बोनेटाइट-संबंधित निक्षेप
ix. क्षारीय आग्नेय शैलों से संबंधित निक्षेप
x. मैग्मैटिक-हाइड्रोथर्मल निक्षेप
xi. अवशिष्ट अपक्षय निक्षेप
xii. प्लेसर
xiii. तटवर्ती अवसादी निक्षेप
xiv. कोयले में REEs

आरईई निक्षेपों के वैश्विक वितरण और कुछ प्रमुख आरईई निक्षेपों की पहचान 34 से अधिक देशों में की गई है, जिसमें आरईओ सामग्री के आधार पर कुल अनुमानित 130 मिलियन मीट्रिक टन वैश्विक आरईई भंडार नीचे दी गई तालिका में प्रस्तुत किया गया है। भंडार के मामले में अग्रणी देश चीन (~33.8%), वियतनाम (~16.9%), ब्राजील (~16.2%), रूस (~16.2%), भारत (~5.3%), ऑस्ट्रेलिया (~3.2%), और संयुक्त राज्य अमेरिका (~1.8%) (*USGS. 2023*) हैं। 1990 के दशक के उत्तरार्ध से, चीन कच्चे अस्कोजों और संसाधित/शुद्ध उत्पादों दोनों की आपूर्ति में आरईई बाजार पर हावी रहा है, जो 2000 के दशक से 2010 के दशक की शुरुआत तक वैश्विक उत्पादन का 90% से अधिक है (*Drobniak and Mastalerz 2022*)। हाल के वर्षों में, अंतरराष्ट्रीय आरईई बाजार में समायोजन के कारण, चीन के बाहर आरईओ उत्पादन में वृद्धि हुई है। जैसा कि तालिका में दिखाया गया है, चीन का योगदान अब वैश्विक उत्पादन (*US Geological*

Survey, 2021, 2023) के 55% -70% की सीमा तक गिर गया है, जबकि संयुक्त राज्य अमेरिका, वियतनाम और थाईलैंड में उत्पादन साल दर साल बढ़ रहा है।

तालिका 1: देशवार आरईई उत्पादन और भंडार

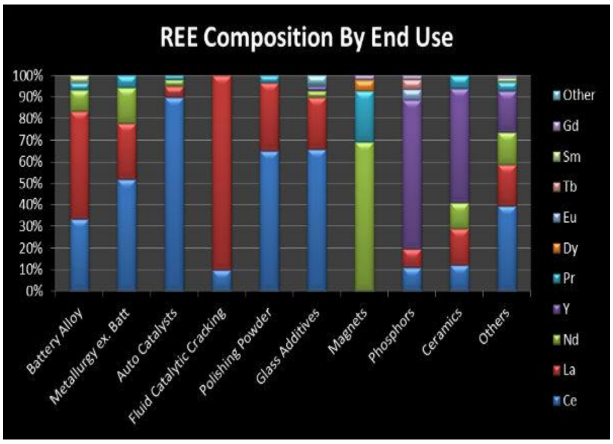
देश का नाम	**खदान उत्पादन**		**भंडार**
	2022	**2023**	
संयुक्त राज्य अमेरिका	42,000	43,000	1,800,000
ऑस्ट्रेलिया	18,000	18,000	105,700,000
ब्राज़िल	80	80	21,000,000
बर्मा	12,000	38,000	NA
कनाडा	-	-	830,000
चीन	11210,000	11240,000	44,000,000
ग्रीनलैंड	-	-	1,500,000
भारत	2,900	2,900	6,900,000
मेडागास्कर	960	960	NA
मलेशिया	80	80	NA
रूस	2,600	2,600	10,000,000
दक्षिण अफ्रीका			790,000
तंजानिया			890,000
थाईलैंड	7,100	7,100	4,500
वियतनाम	1,200	600	22,000,000
विश्व कुल (पूर्ण)	300,000	350,000	110,000,000

स्रोत : U.S. Geological Survey, Mineral Commodity Summaries, January 2024

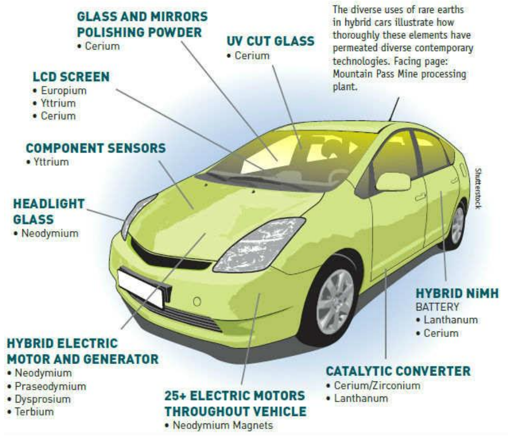
नीचे एक तालिका दी गई है, जो विभिन्न अनुप्रयोगों में उपयोग होने वाले आरईई खनिजों को दर्शाती है;

तालिका 2: विभिन्न अनुप्रयोगों में प्रयुक्त आरईई खनिज

क्षेत्र	**अनुप्रयोग**
इलेक्ट्रॉनिक्स	टेलीविजन स्क्रीन, कंप्यूटर, सेल फोन, सिलिकॉन चिप्स, मॉनिटर डिस्प्ले, लंबे समय तक रिचार्जेबल बैटरी, कैमरा लेंस, प्रकाश उत्सर्जक डायोड (एलईडी), कॉम्पैक्ट फ्लोरोसेंट लैंप (सीएफएल), बैगेज स्कैनर, समुद्री प्रणोदन प्रणाली।
उत्पादन	उच्च शक्ति मैग्नेट, धातु मिश्र धातु, तनाव गेज, सिरेमिक पिगमेंट, कांच के बने पदार्थ में रंग, रासायनिक ऑक्सीकरण एजेंट, पॉलिशिंग पाउडर, प्लास्टिक निर्माण, अन्य धातुओं, मोटर वाहन उत्प्रेरक कन्वर्टर्स को मजबूत करने के लिए एडिटिव्स के रूप में।
चिकित्सा विज्ञान	पोर्टेबल एक्स-रे मशीन, एक्स-रे ट्यूब, चुंबकीय अनुनाद इमेजरी (एमआरआई) कंट्रास्ट एजेंट, परमाणु चिकित्सा इमेजिंग, कैंसर उपचार अनुप्रयोग, और आनुवंशिक स्क्रीनिंग परीक्षण, चिकित्सा और दंत लेजर के लिए।
टेक्नोलॉजी	लेजर, ऑप्टिकल ग्लास, फाइबर ऑप्टिक्स, मेसर, रडार डिटेक्शन डिवाइस, परमाणु ईंधन की छड़, पारा-वाष्प लैंप, अत्यधिक चिंतनशील ग्लास, कंप्यूटर मेमोरी, परमाणु बैटरी, उच्च तापमान सुपरकंडक्टर्स।
नवीकरणीय ऊर्जा	हाइब्रिड ऑटोमोबाइल, पवन टर्बाइन, अगली पीढ़ी की रिचार्जेबल बैटरी, जैव ईंधन उत्प्रेरक।
अन्य	यूरोपियम का उपयोग यूरो बिल आपूर्ति के लिए वैध बिलों की पहचान करने और जालसाजी को रोकने के तरीके के रूप में किया जा रहा है। अनुमानित 1 किलो आरईई एक विशिष्ट हाइब्रिड ऑटोमोबाइल के अंदर पाया जा सकता है। होल्मियम में किसी भी तत्व की उच्चतम चुंबकीय शक्ति होती है और अत्यंत शक्तिशाली चुंबक बनाने के लिए उपयोग किया जाता है। यह आवेदन कई मोटरों के वजन को कम कर सकता है।



चित्र *3:* लक्षित उपयोग द्वारा आरईई संरचना



चित्र *4:* ऑटोमोबाइल में आरईई

जीएसआई ने अपने फील्ड सीजन 1992 -93 में, सायनाइट कार्बोनेटाइट कॉम्प्लेक्स में और उसके आसपास पूर्वेक्षण किया। कार्बोनेटाइट, विशेष रूप से La, Ce, Pr और Nd सहित हल्के आरईई सहित, नाइओबियम और दुर्लभ पृथ्वी तत्वों (आरईई) का प्राथमिक स्रोत है। कार्बोनेटाइट अपेक्षाकृत दुर्लभ प्रकार की आग्नेय चट्टान है जिसमें 50 से अधिक परिमाण % प्राथमिक कार्बोनेट खनिज होते हैं, मुख्य रूप से कैल्साइट में किसी भी आग्नेय चट्टान की तुलना में आरईई की उच्चतम सांद्रता होती है।

सामलपट्टी क्षेत्र में, कार्बोनेटाइट कॉम्प्लेक्स 100 वर्ग किलोमीटर के क्षेत्र में फैला हुआ है; इसमें अल्ट्रामाफाइट्स और पाइरोक्सीनाइट पिंड शामिल हैं, जिनमें कार्बोनेटाइट की शिराओं, छोटी शिराओं और पतली धारियों का एक जटिल जाल फैला हुआ है।

क्षेत्रीय संबंध, खनिज विज्ञान और बनावट, कुछ ऐसे मापदंड हैं जिनके आधार पर विभिन्न प्रकार के साइनाइट्स की पहचान की गई है, जैसे कि बारीक दानेदार ग्रे साइनाइट, मोटे दानेदार ग्रे साइनाइट, सफ़ेद-ग्रे गार्नेट साइनाइट, ग्रे हॉर्नब्लेंड साइनाइट, मोटे ल्यूको हॉर्नब्लेंड साइनाइट, ग्रे-सफ़ेद से हल्के गुलाबी रंग के साइनाइट, ग्रे और गुलाबी साइनाइट, पोरफाइरिटिक साइनाइट, साइनाइटॉइडल साइनाइट, आदि। इसी तरह, लेखकों ने क्षेत्रीय संबंध, रंग और बनावट के उन्हीं मापदंडों को लागू करते हुए कार्बोनेटाइट्स की कुछ किस्मों की भी पहचान की है, जैसे कि गहरे ग्रे रंग का कार्बोनेटाइट, हरे रंग का (क्रोमियम-युक्त) कार्बोनेटाइट, सफ़ेद-ग्रे कार्बोनेटाइट, भूरे-ग्रे रंग का कार्बोनेटाइट, और सफ़ेद सोवाइट-प्रकार का कार्बोनेटाइट। इस क्षेत्र में किए गए पिछले कार्यों के दौरान, 33 नमूनों का अध्ययन किया गया था और उनमें मौजूद सूक्ष्म REE (दुर्लभ मृदा तत्व) तथा प्रमुख तत्वों की भू-रसायनिक संरचना का विश्लेषण किया गया था।

चूँकि इस क्षेत्र में अलग-अलग शिराओं और छोटी शिराओं के रूप में कार्बोनेटाइट और विभिन्न प्रकार के सायनाइट, दोनों ही पाए जाते हैं, इसलिए केआईओसीएल ने विशेष रूप से लैंथेनॉइड तत्वों का विश्लेषण करने के लिए कुछ नमूने इकट्ठा करने का प्रयास किया है। कार्बोनेटाइट के 09 नमूनों के विश्लेषणात्मक परिणामों से 0.22 से 0.56% तक TREE प्राप्त हुआ है, जबकि नेफेलाइन सायनाइट के एक नमूने और पेग्मेटॉइडल सायनाइट के 2 नमूनों में TREE का मान क्रमशः 0.03% और 0.02% पाया गया है।

यह केआईओसीएल द्वारा G4 चरण का अन्वेषण कार्यक्रम शुरू करने का आधार बनता है, जिसका उद्देश्य समलपट्टी क्षेत्र के सायनाइट और कार्बोनेटाइट—दोनों की विभिन्न किस्मों की पहचान करना और इस क्षेत्र में आरईई खनिज-भंडार की संभावना वाले क्षेत्रों को लक्षित करना है।

केआईओसीएल ने समलपट्टी अल्कलाइन-कार्बोनेटाइट कॉम्प्लेक्स में REE और RM खनिज-भंडारों की खोज के लिए, समलपट्टी के आसपास 90 वर्ग किलोमीटर क्षेत्र का अन्वेषण करने हेतु एक प्रस्ताव प्रस्तुत किया। चूंकि जीएसआई ने पहले ही 2018 में 1:12,500 पैमाने पर पीजीई खनिजकरण के लिए क्षेत्र का अध्ययन किया था, टीसीसी-एनएमईटी की

69वीं बैठक में, उल्लेखनीय आरईई मूल्यों और कार्बोनेटाइट उपस्थिति वाले क्षेत्रों पर ध्यान केंद्रित करते हुए जी4-स्तरीय खनिज अन्वेषण के लिए मंजूरी दी गई थी। नतीजतन, टीसीसी के निर्देशों के अनुसार, कार्बोनाइट और संबंधित चट्टानों को शामिल करते हुए भूवैज्ञानिक मानचित्रण को अद्यतन करने के लिए 28.5 वर्ग किमी के एनएमईटी क्षेत्र को तैयार किया गया था। इस क्षेत्र को कार्बोनाइट निकायों, उनकी सीमा और आसपास की चट्टानों के साथ उनके संपर्क संबंधों के बारे में विस्तृत जानकारी एकत्र करने के लिए तीन उप-ब्लॉकों (8.88, 4.32 और 15.3 वर्ग किमी) में विभाजित किया गया था।

मैप किए गए क्षेत्र में साइनाइट का प्रभुत्व है, जिसमें पाइरोक्सेनाइट, ड्यूनाइट, पेग्माटोइडल साइनाइट और बिखरे हुए कार्बोनाइट निकायों की अल्पमात्रा में प्राप्ति है। कार्बोनाइट के आउटक्रॉप्स रैखिक या लेंस नुमा रूप में दिखाई देते हैं, जो साइनाइट के साथ दखल देने वाले संबंध दिखाते हैं। साइनाइट के भीतर पाइरोक्सेनाइट एन्क्लेव भी तेज दखल देने वाले संपर्क प्रदर्शित करते हैं। क्रिस्टलीय चूना पत्थर का एक महत्वपूर्ण बैंड 850 मीटर की चौड़ाई के साथ 80 मीटर से अधिक तक फैला हुआ है। कुल मिलाकर, सायनाइट आस-पास की चट्टानों के प्रकारों के साथ स्पष्ट सीमाएँ बनाए रखता है, और कार्बोनेटाइट लगातार अंतर्वेधी (intrusive) विशेषताएँ प्रदर्शित करता है, जिसमें पतली शिराएँ सायनाइट के भीतर तक फैली होती हैं।

कार्बोनाइट और साइनाइट हस्तक्षेप से जुड़े दुर्लभ पृथ्वी तत्व (आरईई) खनिजकरण के लिए समलपट्टी क्षारीय कार्बोनेटाइट कॉम्प्लेक्स का अध्ययन किया जा रहा है। कार्बोनाइट निकाय छोटे आउटक्रॉप्स के रूप में असंगत रूप से होते हैं, कुछ कार्बोनेटाइट बैंड को स्ट्राइक लंबाई में 220-340 मीटर और चौड़ाई में ~ 10 मीटर के लिए ट्रेंचिंग के बाद ट्रेंचिंग के बाद पता लगाया गया था, जो क्रमशः उप ब्लॉक 1 और 2 में पूर्व-पश्चिम और उत्तर-दक्षिण की प्रवृत्ति रखते हैं।

तीन उप-ब्लॉक में 15 कार्बोनेटाइट बैंड देखे गए हैं, जो दुर्लभ पृथ्वी तत्व (आरईई) सांद्रता में एक महत्वपूर्ण सीमा दिखाते हैं, जो 531 पीपीएम से लेकर 13,917 पीपीएम तक है। इन 15 कार्बोनेटाइट निकायों में से, उप ब्लॉक 01 और 02 में पाए जाने वाले 2 बैंड क्रमशः 3,996 पीपीएम और 3,121 पीपीएम के उच्च ट्री मूल्यों के साथ पर्याप्त आयाम वाले पाए गए। बैंड 1 एट्टीपट्टी गांव के पूर्व में लगभग 800 मीटर की दूरी पर स्थित है और बैंड 2 जोगीपट्टी गांव के उत्तर में लगभग 400 मीटर की दूरी पर स्थित है। इन 2 बैंडों को ट्रेंचिंग और बोरहोल के माध्यम से उपसतह जांच के लिए लक्षित किया गया था।

ऐसे इलाकों में आरईई खनिजकरण के सतही संकेतों में विशिष्ट भूवैज्ञानिक, भू-रासायनिक और खनिज विशेषताएं शामिल हैं। बास्टनासाइट, मोनाजाइट और पैरिसाइट जैसे आरईई-असर वाले खनिज विशिष्ट हैं लेकिन नंगी आंखों से इन्हें पहचानना मुश्किल है, क्योंकि सभी रालदार चमक के साथ पीले-भूरे रंग के दिखाई देते हैं।

कार्बोनाइट्स को आरईई-असर वाले खनिजों की मेजबानी करने के लिए जाना जाता है, हल्के आरईई को अधिमानतः कार्बोनेट और फ्लोरोकार्बोनेट संरचनाओं जैसे कि बास्टनासाइट, मोनाजाइट, ज़ेनोटाइम और सिंकाइसाइट में शामिल किया जाता है। पेट्रोग्राफिक अध्ययन पुष्टि करते हैं कि आरईई और आरएम खनिज मुख्य रूप से फ्लोरोकार्बोनेट, मोनाजाइट, एंसिलाइट-समूह चरणों और सीनियर-समृद्ध कैल्साइट में होते हैं, जिसमें मोनाजाइट एक प्रमुख प्रतिरोधी एलआरईई अयस्क है।

अध्ययन क्षेत्र (तीन उप-ब्लॉक) ज्यादातर सीमित चट्टान जोखिम के साथ कवर किए गए इलाके हैं, जिससे कार्बोनाइट की पहचान मुश्किल हो जाती है। छोटे बहिर्वाह और कैल्क्रीट अवशेषों ने ट्रेंचिंग स्थानों को निर्देशित किया।

उप-ब्लॉक 1 में, एकत्र किए गए 15 बीआरएस में से, 12 बीआरएस कार्बोनेटाइट से थे, जिनके टी-टीईईई मान 308.38 पीपीएम से 6,962 पीपीएम तक थे, जिसका औसत मान 3, 725.88 पीपीएम था। उप-ब्लॉक 2 में, कार्बोनेटाइट निकायों से एकत्र किए गए 16 बीआरएस ने 1,514.24 पीपीएम से 13,916.83 पीपीएम तक टी-टीईईई मान दर्शाया है, जिसका औसत मान 3958.9 पीपीएम है।

उप-ब्लॉक 3 में, एकत्र किए गए 25 बीआरएस में से, 17 नमूने कार्बोनेटाइट निकायों से हैं, जिनमें टी-टीईईई के मान 291.34 पीपीएम से 12,411.12 पीपीएम तक हैं, जिसका औसत मान 4,545.70 पीपीएम है।

दो प्रमुख कार्बोनेटाइट निकायों (उप-ब्लॉक 1 में एन-एस, उप-ब्लॉक 2 में ई-डब्ल्यू) की निरंतरता और चौड़ाई का परीक्षण करने के लिए चार खाइयां खोदी गईं। उप ब्लॉक 1 में खोदी गई खाई 1 और खाई 2 कार्बोनेटाइट बैंड 1 पर क्रमशः 9 मीटर (1 -9 मीटर) पर 6647.23 पीपीएम और 10 मीटर (3 -13 मीटर) पर 3864.52 पीपीएम के टीआरईई मूल्य का विश्लेषण किया गया है। उप ब्लॉक 2 में कार्बोनेटाइट बैंड 2 पर खोदी गई खाई 3 और खाई 4 क्रमशः 4 मीटर (5 -9 मीटर) पर 4993.18 पीपीएम और 21 मीटर (0 -21 मीटर) पर 4339.03 पीपीएम के टीआरईई मूल्य का विश्लेषण किया गया है। उच्च मूल्यों के साथ मजबूत सतह खनिजीकरण, आरईई, गहराई की दृढ़ता की पुष्टि करने के लिए ड्रिलिंग को उचित ठहराता है।

पहले बोरहोल एसआरबी -01 को उप ब्लॉक -1 में तांबे के कण की गहराई की स्थिरता का परीक्षण करने के लिए ड्रिल किया गया था, जिससे पुष्टि हुई कि उपसतह में सीमित तांबे के कण हस्तक्षेप के साथ सीनाइट का प्रभुत्व है, जिसमें फेनाइट युक्त सीनाइट और डोलोमाइट तांबे के कण वाले पाइरोक्साइटाइट का क्षेत्र है। इस स्तर पर तांबे के कण बॉडी 1 की स्थिरता महत्वपूर्ण रूप से स्थापित नहीं की गई थी, क्योंकि पूरे ड्रिल किए गए खंड में तांबे के कण प्रमुख लिथोलॉजी बनी रही।

दूसरे बोरहोल SRB-02 ने फेनिटाइज़्ड हाइब्रिड चट्टान को काटा, जिसमें सब-ब्लॉक-2 में कैल्सिक कार्बोनेटाइट के निशान मिले; इसने SRB-01 जैसा ही एक पैटर्न होने की पुष्टि की है, जिसमें फेनिटाइज़्ड सायनाइट की प्रधानता है और कार्बोनेट शिराओं का प्रवेश सीमित मात्रा में है।

इस ब्लॉक की कार्बोनेटाइट पेट्रोग्राफी में डोलोमिटिक और कैल्सीटिक, दोनों तरह के प्रकार दिखाई देते हैं। इसमें REE (दुर्लभ मृदा तत्व) के मान मिश्रित क्षेत्रों की तुलना में काफी अधिक हैं, और कार्बोनेटाइट में बेरियम (Ba) की मात्रा भी काफी अधिक है। यह आमतौर पर मैग्मा के बनने के अंतिम चरण में होने वाले विभेदन और K-फेल्डस्पार, बायोटाइट और बैराइट जैसे क्षार-समृद्ध खनिज चरणों से जुड़ा होता है। ऐसा माना जाता है कि कैल्सीटिक और डोलोमिटिक कार्बोनेटाइट, ड्रिल किए गए पूरे स्तंभ को घेरे हुए हैं, जिनके बीच-बीच में सायनाइट और पाइरोक्सीनाइट के मिश्रित क्षेत्र भी मौजूद हैं। बैंड 1 और बैंड 2 पर ड्रिल किए गए बोरहोल SRB 01 और SRB 02, क्रमशः 3,409.27ppm और 3,815.22ppm की सीमा में भारित औसत TREE मान दर्शा रहे हैं; ऐसा संदेह है कि ये मान कार्बोनेटाइट क्षेत्रों से ही प्राप्त हुए हैं।

TREE के 1000ppm की कट-ऑफ सीमा का उपयोग करते हुए, क्रॉस-सेक्शन विधि द्वारा UNFC वर्गीकरण की श्रेणी 334 के अंतर्गत आने वाले ब्लॉक में, 3,723ppm के भारित औसत TREE मान के साथ, 2.948 मिलियन टन संसाधन का अनुमान लगाया गया है।

इस क्षेत्र के कार्बोनेटाइट और फेनाइट ज़ोन में REE के जमाव के संसाधन, ग्रेड और नियंत्रणों को बेहतर ढंग से समझने के लिए, सघन ड्रिलिंग और विस्तृत मैपिंग की सहायता से ब्लॉक को G3 चरण तक अपग्रेड करने की अनुशंसा की जाती है।

2. Details of the qualified person(s)/ Exploration agency

Details of the KIOCL's officials involved in the project are provided below;

Table 3: Details of Personnel involved in execution of works.

Sl.	NAME (S/Sri)	EXPERIENCE
1	Shiva Kumar M, Assistant General Manager (ME)	>24 years in mining and mineral management.
2	D Mohan Raj, Rtd ADG GSI Consultant (ME)	>33 years in Geological mapping and mineral exploration in GSI .
3	Palani Murugan A, Sr. Manager (ME)	>20 years in mining and mineral management.
4	Dnyaneshwar Gaonkar, Dy.Manager(Geo)	>12 years of experience in Mineral Exploration.
5	V K Moorthy. Deputy Manager (PC), MEL	>25 years in Chemical laboratory.
6	Dr Hema, Geologist	>05 years of experience in Mineral Exploration and GIS platform
7	Dr. Dinesh, Asst Geologist	>05 years of experience in Mineral Exploration.
8	Narayana T, Deputy Manager (Survey)	>05 Years of Experience in Mine Surveying.
9	Kotresh, Asst Surveyor	>01 years of experience in Surveying.

3. Title and ownership

3.1 Name of the explorer:

M/s KIOCL Limited

(A Govt. of India Enterprise under Ministry of Steel, GoI),

Block II, Koramangala, Sarjapura Road,

Bengaluru 560 034, Karnataka-India, Website: **www.kioclltd.in**

(Notified Exploration Agency under Second provision of Sub Section (1) of Section-4 of the Mines and Minerals (Development and Regulation) Act 1957 vide Ministry of Mines (MoM), Govt of India notification no. 16/08/2015-MVI dated 16.02.2015,)

Represented by:

The Director (Production and Projects)

KIOCL Limited, Bengaluru 560 034, Karnataka-India

e-Mail: **dpp@kioclltd.in**; **bmed@kioclltd.in;**

Ownership: Department of Geology and Mining, Government of Tamil Nadu.

3.2 Details of the period of prospecting

The exploration works including Large scale Geological mapping, Trenching and Core drilling works along with sample analysis were carried out from Sept 2024 to Dec 2025. The project was reviewed in 78th, 83rd and 88th meeting of TCC- NMET.

4. Details of the area under study

4.1 Location of the block

The present exploration block falls in part of the Survey of India (SoI) toposheet No. 57L/7, Samalpatti area, Uthangarai Taluk, Krishnagiri District, Tamil Nadu. The proposed block has been named after the prominent nearby town, Samalpatti, which is situated along National Highway–77 (NH-77). NH-77 that connects Krishnagiri with Tindivanam via Uthangarai and Tiruvannamalai, providing good regional connectivity to the project area. Samalpatti town lies directly on this highway and is located approximately 40 km from Krishnagiri and about 10 km from Uthangarai.

Geologically, the Samalpatti area forms part of the Southern Granulite Terrain of India and is considered prospective for Rare Earth Elements (REE) and Rare Metal (RM) mineralization, particularly associated with alkaline to syenitic intrusive bodies, pegmatitic phases, and related metasomatic alterations. Earlier regional studies and reconnaissance-level investigations have indicated the presence of REE-bearing accessory minerals within syenitic and calcite-rich lithologies, justifying systematic exploration under G4 level to delineate mineralized zones and assess their potential.

The nearest airport is Salem Airport, a domestic airport located approximately 75–85 km from the block. The nearest major railway stations are located at Jolarpettai and Morappur, providing additional transport facilities. The schematic diagram of the block demarcated on the District / State / India map is presented in the below figure (fig 5) and enclosed as Plate 01 (Key Map).

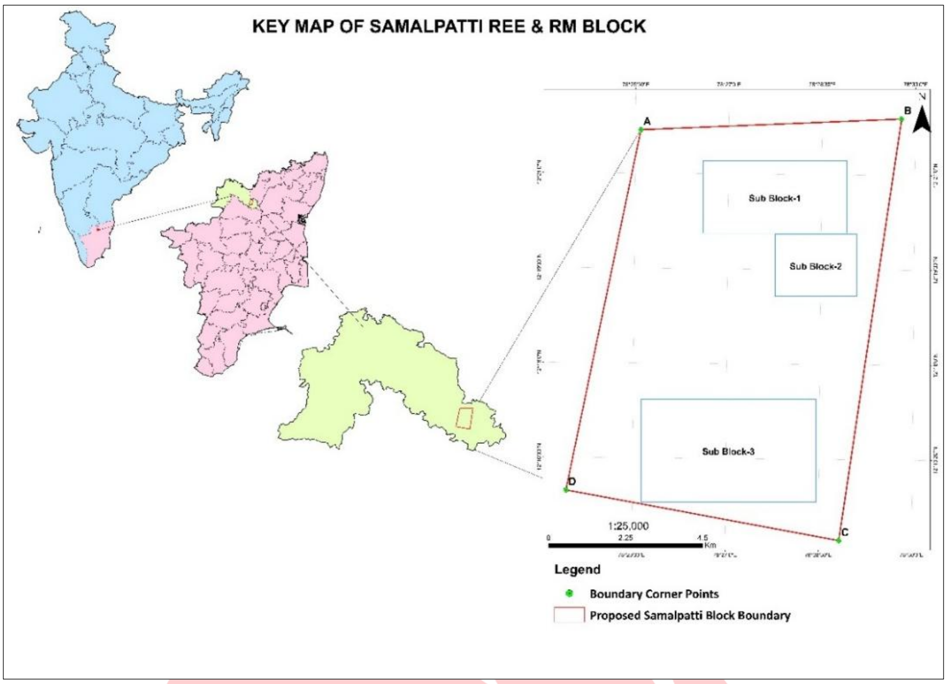


Figure 5: Key Map

4.2 SoI toposheet number, DGPS coordinates of corner points and borehole points.

The block boundary marked on SoI toposheet 57L/07 in 1:50,000 scale is provided in the below figure (fig 6) and enclosed as Plate 02 (Topo Map). Block lies almost in South eastern part of the Survey of India (SoI) toposheet. The block boundary marked on 1:50K GSI geological map is enclosed as Plate 03.

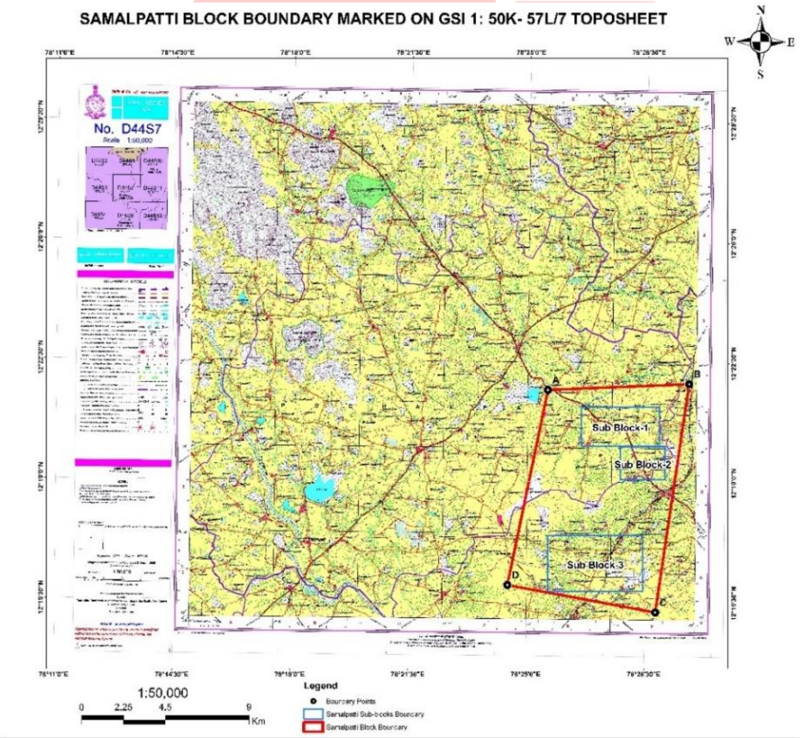


Figure 6:The Block demarcated and shown on SoI TS No. 57L/07.

4.3 Details of the project :

KIOCL vide letter no. KIOCL/MED/2023/647 Dtd 18.01.2023 has requested the office of Commissionerate of Geology and Mining for providing consent for carrying out G4 Level exploration works over an extent of 90sq.km in Samalpatti Block, Krishnagiri (Dist), Tamil Nadu.

In reply to above, vide letter no. 175/MMD.1/2024-1, Dtd 13.03.2024 received from the Office of Additional Chief Secretary to Government (FAC), Natural Resources (MMD.1) Department, Secretariat, Govt of Tamil Nadu, Chennai informed KIOCL to undertake G4 stage of exploration for REE over an extent of 90 sqkm in Samalpatti Block, Krishnagiri (Dist), Tamil Nadu under NMET funding.

Up on the receipt of consent from Govt of Tamil Nadu, KIOCL has conducted Preliminary Field Inspection (PFI) in the month of April 2024. Abstract details of PFI are provided below;

- Traverses were conducted in and around Samalpatti area with the primary objective to trace carbonatite, syenite bodies, pegmatites, aplite and felsite veins in the area.
- The rock types observed in the area are Pyroxenite, Dunite, Syenite, Pegmatoidal Syenite, Carbonatites, Gneiss and Charnokite. .
- The lithologies in the area observed with strike of NE –SW with dip varying from 60 to 70 degrees towards southeast.
- Multiple bodies of carbonatite measuring 3 to 4m in width and strike length of 150m were identified.

After completing the PFI works, KIOCL vide letter Dtd. 13th Aug 2024, submitted Mineral Exploration Project Proposal (MEPP) of Samalpatti REE Block to TCC- NMET.

KIOCL's proposal of undertaking G4 level of Mineral Exploration works over an extent of 90 sqkm with block boundary points A to D in figure 5 was discussed in 68th & 69th meeting of TCC – NMET held in the month of Aug and Sept 2024.

Against the above, during the 69th meeting of the TCC - NMET, approval was granted for G4-level mineral exploration covering an area of 28.5 sqkm to KIOCL (Sub block boundaries E to P).The primary objective of this work is incorporation of carbonatite bodies into the Geological Survey of India (GSI) 1:12,500 scale maps, aligning with the Field Season Programme (FSP) 2016-17. This designated area of 28.5sqkm with 3 sub blocks (as provided in fig 7 with boundary points from E to P) was carved out from 90sqkm proposed by KIOCL's Preliminary Field Investigation (PFI) results. The pictorial representation of 3 sub blocks with an extent of 28.5sqkm distributed across 3 distinct sub-blocks positioned within the original 90 sq. km overlaid on GSI's geology (FSP 2016-17) in 1:12,500 scale is provided below figure (fig 7);

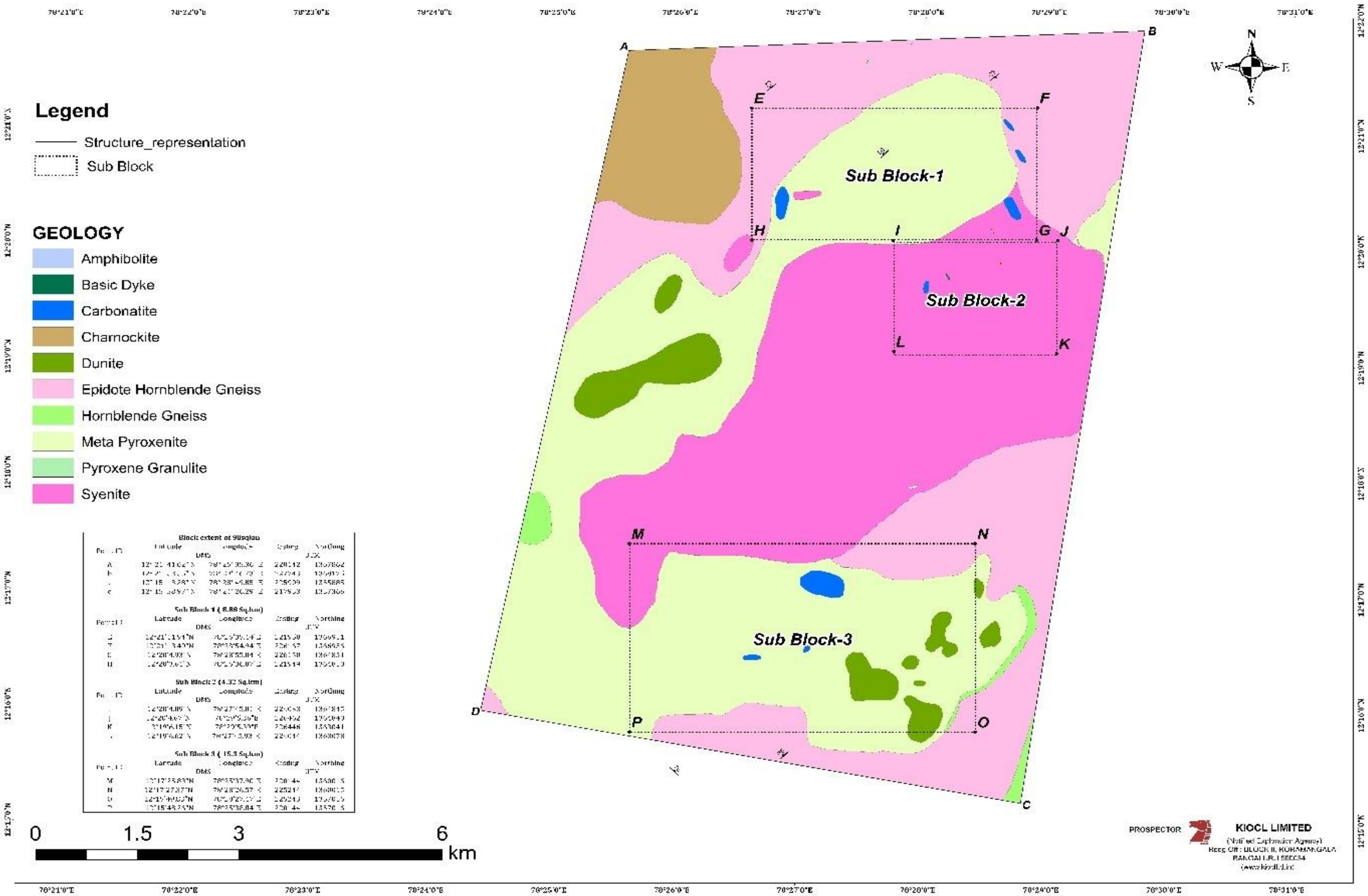


Figure 7: Pictorial representation of sub blocks

GPS Geo- Coordinates of the boundary points of the 3 sub blocks is tabulated in table 5;

Table 4:Geo-Coordinates of Boundary Points of the block extent of 90 sq.km proposed by KIOCL to TCC- NMET.

Block extent of 90sqkm				
Point ID	Latitude	Longitude	Easting	Northing
	DMS		UTM	
A	12° 21' 41.02" N	78° 25' 35.36" E	220142	1367862
b	12° 21' 53.55" N	78° 29' 46.73" E	227743	1368175
c	12° 15' 13.28" N	78° 28' 49.85" E	225909	1355885
d	12° 15' 58.97" N	78° 24' 26.29" E	217953	1357366

Table 5:Geo-Coordinates of Boundary Points of the 3 sub blocks with extent of 28.5 sqkm approved by TCC- NMET

Sub Block 1 (8.88 Sq.km)				
Point ID	Latitude	Longitude	Easting	Northing
	DMS		UTM	
E	12°21'11.94"N	78°26'35.44"E	221950	1366951
F	12°21'13.40"N	78°28'54.94"E	226167	1366956
G	12°20'4.93"N	78°28'55.04"E	226150	1364851
H	12°20'3.61"N	78°26'36.07"E	221949	1364850

Sub Block 2 (4.32 Sq.km)				
Point ID	Latitude	Longitude	Easting	Northing
	DMS		UTM	
I	12°20'4.09"N	78°27'45.01"E	224033	1364845
J	12°20'4.67"N	78°29'5.36"E	226462	1364840
K	12°19'6.15"N	78°29'5.39"E	226446	1363041
L	12°19'6.62"N	78°27'45.93"E	224044	1363078

Sub Block 3 (15.3 Sq.km)				
Point ID	Latitude	Longitude	Easting	Northing
	DMS		UTM	
M	12°17'25.83"N	78°25'37.90"E	220144	1360016
N	12°17'27.37"N	78°28'26.57"E	225244	1360015
O	12°15'49.83"N	78°28'27.47"E	225243	1357016
P	12°15'48.26"N	78°25'38.84"E	220144	1357016

4.4 Land use pattern

The area comprises a combination of Government land (poromboke land) and private patta land, with no forest land falling within the block. Land use in the area is predominantly agricultural, interspersed with habitations and open scrub land. The southern part of the block is characterized by undulating terrain with isolated hillocks, notably Senraya Malai reaching an elevation of about 554 m RL, and a cluster of small mounds near Kanjanur with elevations of approximately 432 m and 419 m RL. These topographic features influence local land use, drainage, and accessibility, while the remaining area consists of gently sloping plains suitable for cultivation and related activities.

4.5 Accessibility and demographic profile of the block

The study area is well connected by all weathered motorable roads to Bangalore in the west, Salem in the South, Chennai-Tiruvannamalai in the east and Tiruppattur in the North. Utangarai, the taluk headquarters is located about 10 km south-east of Samalpatti. Samalpatti Railway station falling in Chennai-Salem, broad gauge railway line is located about 250 km from Chennai and 90 km from Salem. Rail network provides link between important localities. The important National and State Highways connectingBengaluru-Krishnagiri-Uthangarai–Tiruvanamalai-Puducherry-Chennai and Salem-Tirupattur are passing through the operational area. Besides, there are several metalled and un-metalled roads connecting the interior parts of the villages in the area. The nearest railway stations are Jolarpetttai, Tirupattur, Salem and Tiruvannamalai Junctions, Southern Railway. Bangalore is the nearest airport and is about 150 km from the operational area.

Within a 10-km radius of the Samalpatti exploration block, several villages are located, some of which fall entirely within the buffer zone. These villages collectively represent mixed rural population with varying population sizes.

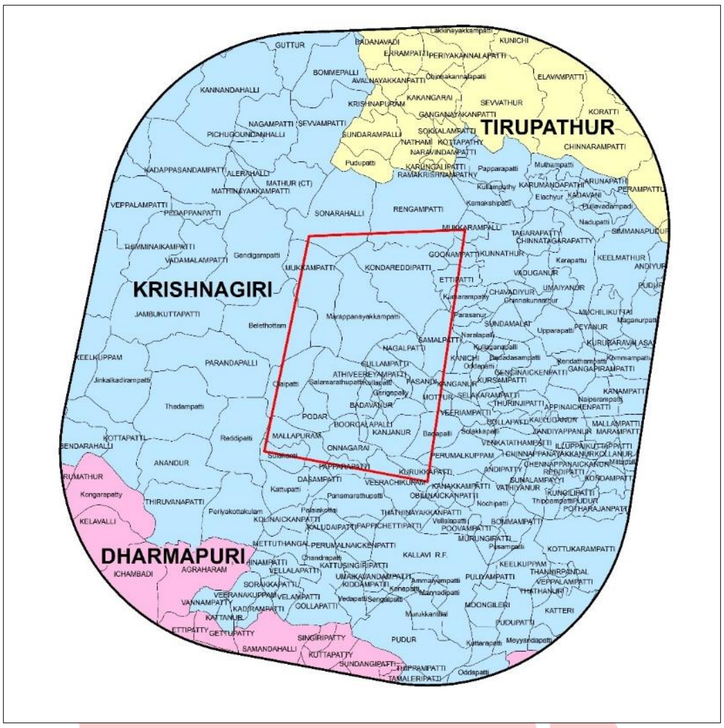


Figure 8: Villages within the buffer zone 10Km of the block (Source : SOI)

Table 6: Demographic Profile of villages in the block

Sl. No.	Village Name	District	Population (Census 2011)
1	Samalpatti	Krishnagiri	4,001
2	Chinnakunnathur	Krishnagiri	1,399
3	Chavadiyur	Krishnagiri	611
4	Parasanur	Krishnagiri	591
5	Kumarampatty	Krishnagiri	1,196
6	Ettipatti	Krishnagiri	2,318
7	Kanichi	Krishnagiri	573
8	Oddapatti	Krishnagiri	397
9	Naralepalle	Krishnagiri	501
10	Kullaganapalli	Krishnagiri	225
11	Badadasampatti	Krishnagiri	735
12	Singarapettai	Krishnagiri	2,253
13	Marampatti	Krishnagiri	1,087

4.6 Mineral(s) under investigation

REE and RM (Sc & Nb)

5. Physiography and environment

The area forms an undulatory terrain with an average elevation of about 400m, with a gentle gradient towards south with isolated mounds and hills, the heights of which are ranging from A 419 m to A 554 m. The area occupied by the charnockite epidote hornblende gneiss, metapyroxenite and carbonatite forms a plain to undulatory terrain whereas, dunite and syenite form small mounds and hills. Mattur River is flowing in west to east direction lies in the northern western part of the block. Also, several ephemeral streams occurring in dendritic pattern drain the area.

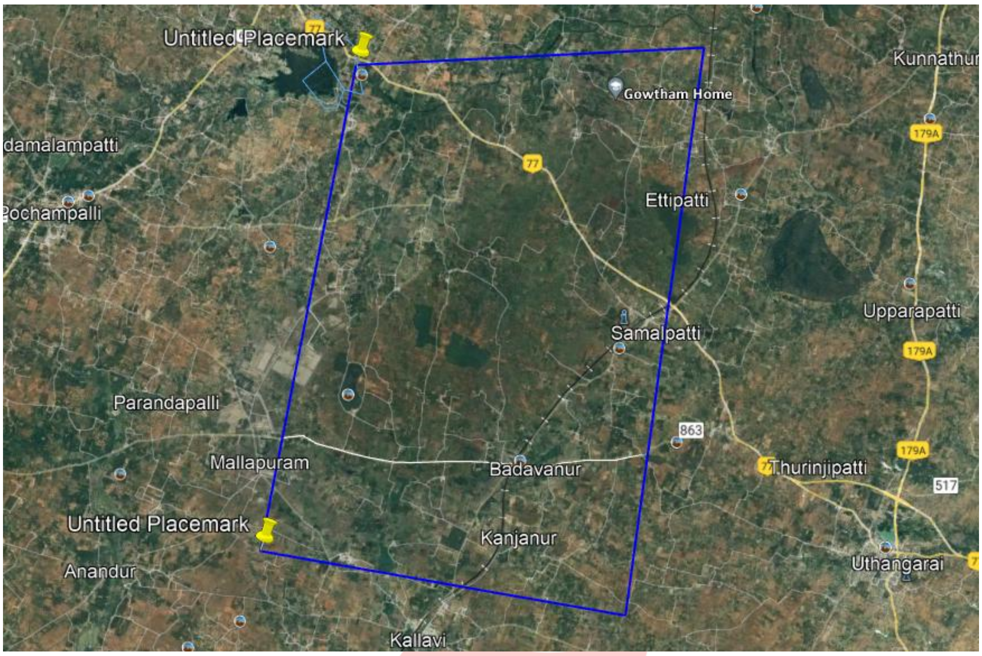


Figure 9: Google Earth Image of the block

5.1 Relief of the area with minimum and maximum elevation, drainage pattern, natural water courses, reservoirs etc

Geomorphologically, the Samalpatti block is characterized by gently undulating plains interspersed with isolated hillocks and low ridges. The terrain reflects prolonged weathering and erosion of hard crystalline rocks, resulting in pediplains and residual hills. Structural features such as joints and fractures influence drainage and landform development. The area forms an undulatory terrain, gently sloping towards the south with isolated mounds and hills and the elevation value ranges from Δ 419 m to Δ 554 m.

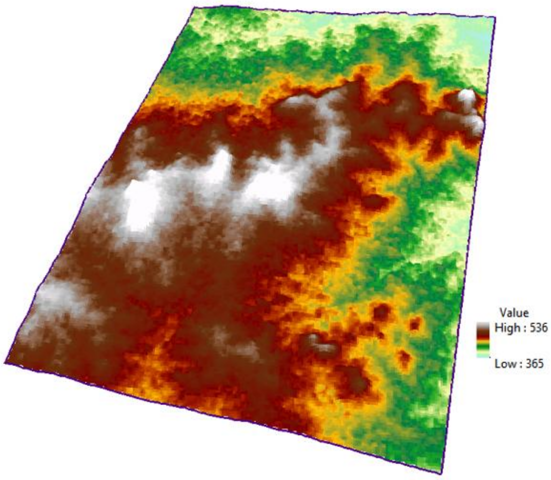


Figure 10: 3D Perspective View Digital elevation Model (DEM) of the block (90sqkm).

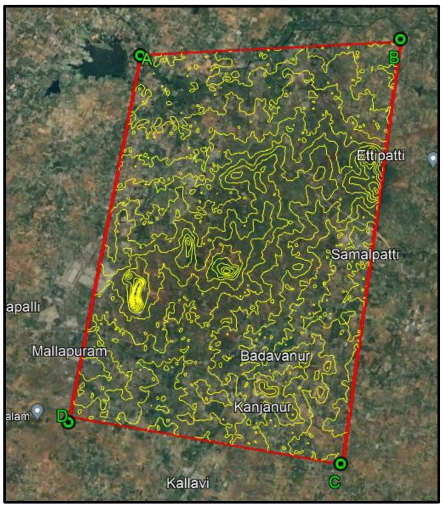


Figure 11: Block of 90sqkm shown on Google Earth with contours.

5.2 Roads, Railway track, Electric transmission line, Telephone line etc

The block is well connected by NH-77, state highways, district roads and village roads. Samalpatti is a town in Uthanagarai Taluk in Krishnagiri district, Tamil Nadu, India. Samalpatti is a main railway station in Krishnagiri district. It lies in NH 77. It is 40 km from Krishnagiri and 10 km from Uthangarai.

5.3 Host population

Samalpatti is a village in Uthangarai tehsil in district of Krishnagiri, Tamil Nadu, India. As per the data provided by Census of India in 2011, total population of Samalpatti was 4,001 which includes 1,962 males and 2,039 females.

(Ref https://villageinindia.com/india/tamil-nadu/krishnagiri/uthangarai/samalpatti/)

5.4 Socio demographic profile of the area and nearby

The host population within and around the exploration block mainly depends on agriculture, livestock rearing, and small-scale trade for livelihood. Seasonal migration for employment is also observed. The population is accustomed to mineral exploration activities carried out in nearby areas.

5.5 Historical sites and archaeological monuments, places of worship, public utilities etc. within or nearby.

No notified archaeological or historical monuments of national or state importance are reported within the Samalpatti exploration block or its immediate buffer zone.

5.6 Forest, Sanctuaries, National park and Wild life sanctuary

There are no national parks, wildlife sanctuaries, biosphere reserves, or other notified environmentally sensitive areas located within or near the Samalpatti exploration block. The proposed G4-level exploration activities are not expected to have any significant impact on the regional environment.

5.7 Flora and Fauna

The flora of the area mainly consists of dry deciduous vegetation, scrub forest species, and scattered trees along agricultural fields and hill slopes. Common species include neem, tamarind, acacia, and shrubs adapted to semi arid conditions. Faunal presence is limited and mostly comprises common terrestrial species. Occasional sightings of fauna such as the Indian blackbuck (Antilope cervicapra) and bonnet macaque (Macaca radiata) have been reported in the broader region.

5.8 Water bodies such as River, Nala, Stream, Reservoir, etc

The Samalpatti exploration area does not contain any perennial rivers or major surface water bodies. The hydrological regime is mainly controlled by seasonal rainfall and local topography. Surface water is limited to seasonal nalas and small streams that flow during the monsoon period and remain dry for most of the year. Groundwater occurs predominantly within the weathered and fractured zones of the hard crystalline rocks and is accessed through open wells and bore wells for domestic and agricultural purposes. Groundwater levels show seasonal fluctuations, with recharge taking place during the monsoon months and gradual decline during the dry season. The drainage is dendritic to sub-dendritic, controlled by local topography and lithology. Streams are seasonal in nature.

Figure 12: Drainage pattern in Samalpatti Block (90 sqkm)

5.9 Climate and Rainfall data

The Samalpatti region experiences a tropical climate characterized by hot summers and moderate winters. The summer season generally extends from March to May, with higher temperatures recorded during April and May. Winters are mild and extend from December to February. The area receives rainfall mainly during the South-West monsoon (June to September) and the North-East monsoon (October to November), with the latter contributing significantly to the annual rainfall. Overall, the climatic conditions are conducive for carrying out geological exploration activities for most of the year, except during periods of intense monsoonal rainfall.

Table 7: Summary of Meteorological Data Observed at IMD

Sl	Parameters	Observed/ Average values
1	Average Daily Max. Temperature	32°C – 38°C
2	Average Daily Min. Temperature	18°C – 22°C
3	Average Annual Rainfall (mm)	750 – 900 mm
4	Average relative humidity (%)	55 – 75 %

The average annual rainfall in the Samalpatti region ranges between 750 mm and 900 mm. Rainfall is unevenly distributed and largely confined to the monsoon months. Occasional heavy downpours contribute to short-term surface runoff and groundwater recharge.

6. Local infrastructure

The region around Samalpatti is supported by basic infrastructure facilities including roads, electricity supply, schools, primary health centres, and local markets. Samalpatti and nearby towns provide banking, postal, and communication facilities required for exploration activities.

The Samalpatti area is a selection grade panchayat and is well connected by road, telecommunication, having municipality office, one government higher secondary school, one upgraded health centre, few numbers of public and private sector banks with population of about few thousand.

7. Geology

7.1 Regional geological set up of the area with stratigraphy, structure and metamorphism.

The Samalpatti alkaline–carbonatite complex (SACC) is located within the Southern Granulite Terrain (SGT) of peninsular India, forming part of a Proterozoic alkaline magmatic province in northern Tamil Nadu (Ramakrishnan and Vaidyanadhan, 2008; Ackerman et al., 2017). The complex occurs in proximity to the Koratti–Attur lineament, a major crustal-scale shear/fault system that has been repeatedly reactivated and is considered a principal control for alkaline magmatism (GSI, 2006; Leelanandam et al., 2006).

The SACC is emplaced into a polydeformed granulite facies basement characterised by well-developed gneissic foliation. These structures define the regional structural grain, trending predominantly NE–SW, and have played a fundamental role in controlling the emplacement of alkaline and carbonatitic magmas (Ramakrishnan and Vaidyanadhan, 2008; Leelanandam et al., 2006). While the carbonatite bodies themselves are largely discordant and structurally controlled by fractures and shear zones, local alignment along foliation planes and minor deformation features such as boudinage indicate limited syn- to post-emplacement tectonic influence (Ackerman et al., 2017).

Investigations by the Geological Survey of India have documented that the Samalpatti–Sevattur region represents a cluster of alkaline–carbonatite intrusions aligned along NE–SW to ENE–WSW trending lineaments (GSI, 2006; GSI, 2011). The carbonatites occur as dykes, lenses, and irregular pods closely associated with pyroxenite and syenite bodies (Ackerman et al., 2017; Leelanandam et al., 2006). The intrusive suite shows multiphasic emplacement, comprising early ultramafic (dunite–pyroxenite), followed by syenitic phases and late-stage carbonatite intrusions (Leelanandam et al., 2006; Srivastava et al., 2005). Extensive fenitisation zones have been mapped around carbonatite bodies, characterised by alkali metasomatism (Na–K enrichment) and development of aegirine, riebeckite, and feldspathoids (Leelanandam et al., 2006; Ackerman et al., 2017). Carbonatite bodies are often discontinuous and structurally controlled, rather than forming large continuous outcrops (Ackerman et al., 2017). These observations strongly support a fracture-controlled intrusive system with intense metasomatic overprint.

Regional Stratigraphic Succession

The stratigraphy of the Samalpatti region, as established through GSI mapping and regional synthesis, is summarised below:

Table 8: Regional stratigraphic succession

Age	Lithounit	Description
Recent–Quaternary	Alluvium / soil cover	Thin veneer of transported material, laterite patches
Proterozoic (younger)	Dolerite dykes	Post-tectonic mafic intrusives along fractures
Neo- to Mesoproterozoic	**Alkaline–carbonatite complex**	Syenite, nepheline syenite, pyroxenite, dunite, carbonatite (calcic & dolomitic)
Palaeoproterozoic (?)	Basic intrusives / amphibolites	Metamorphosed mafic dykes/sills
Archaean (basement)	Hornblende–biotite gneiss, charnockite, granulites	High-grade metamorphic rocks of SGT

Table 9: The generalised stratigraphic succession (Shanmugam and Kumaraguru and Srinivasan and Renganathan)

<table>
<tr><th colspan="2">Shanmugam and Kumaraguru (1991-92)</th><th colspan="2">Srinivasan and Renganathan (1995)</th></tr>
<tr><td>Quartz Vein</td><td></td><td></td><td></td></tr>
<tr><td>Sheared quartz vein</td><td></td><td></td><td></td></tr>
<tr><td>Syenite – pegmatite</td><td rowspan="5">Ultramafic Alkaline Carbonatite complex.</td><td>Carbonatites</td><td rowspan="3">Syenite Carbonatite Complex</td></tr>
<tr><td>Carbonatite</td><td>Syenites, Felsites/Aplites</td></tr>
<tr><td>Syenite</td><td>Ultramafites-pyroxenites-felspathic Pyroxenites</td></tr>
<tr><td>Dunite</td><td></td><td></td></tr>
<tr><td>Basic dyke</td><td>Fine grained basic dyke</td><td></td></tr>
<tr><td>Epidote hornblende gneiss</td><td rowspan="2">Bhavani Gneissic complex</td><td>Epidote hornblende gneiss</td><td rowspan="2">Uttangarai Terrane</td></tr>
<tr><td>Grey hornblende gneiss.</td><td>Charnockite with gabbro-norite- pyroxenite association</td></tr>
</table>

<table>
<tr><td>Meta pyroxenite (with or without feldspathic injections</td><td rowspan="2">Charnockite Group</td><td>Pyroxene granulite</td><td>Arcot Terrane</td></tr>
<tr><td>Charnockite</td><td>Dolerite/Gabbro dyke</td><td rowspan="8">Krishnagiri Terrane</td></tr>
<tr><td></td><td></td><td>Hornblende agmatite gneiss</td></tr>
<tr><td></td><td></td><td>Hornblende migmatite gneiss</td></tr>
<tr><td></td><td></td><td>Banded biotite-hornblende gneiss</td></tr>
<tr><td></td><td></td><td>Charnockite with enclaves of granulose/schistose amphibolites</td></tr>
<tr><td></td><td></td><td>Banded magnetite quartzite</td></tr>
<tr><td></td><td></td><td>Pyroxene granulite</td></tr>
<tr><td></td><td></td><td>Pyroxenites</td></tr>
</table>

Sub blocks marked on 1:50k GSI geology is presented as Plate 3 and Fig 13.

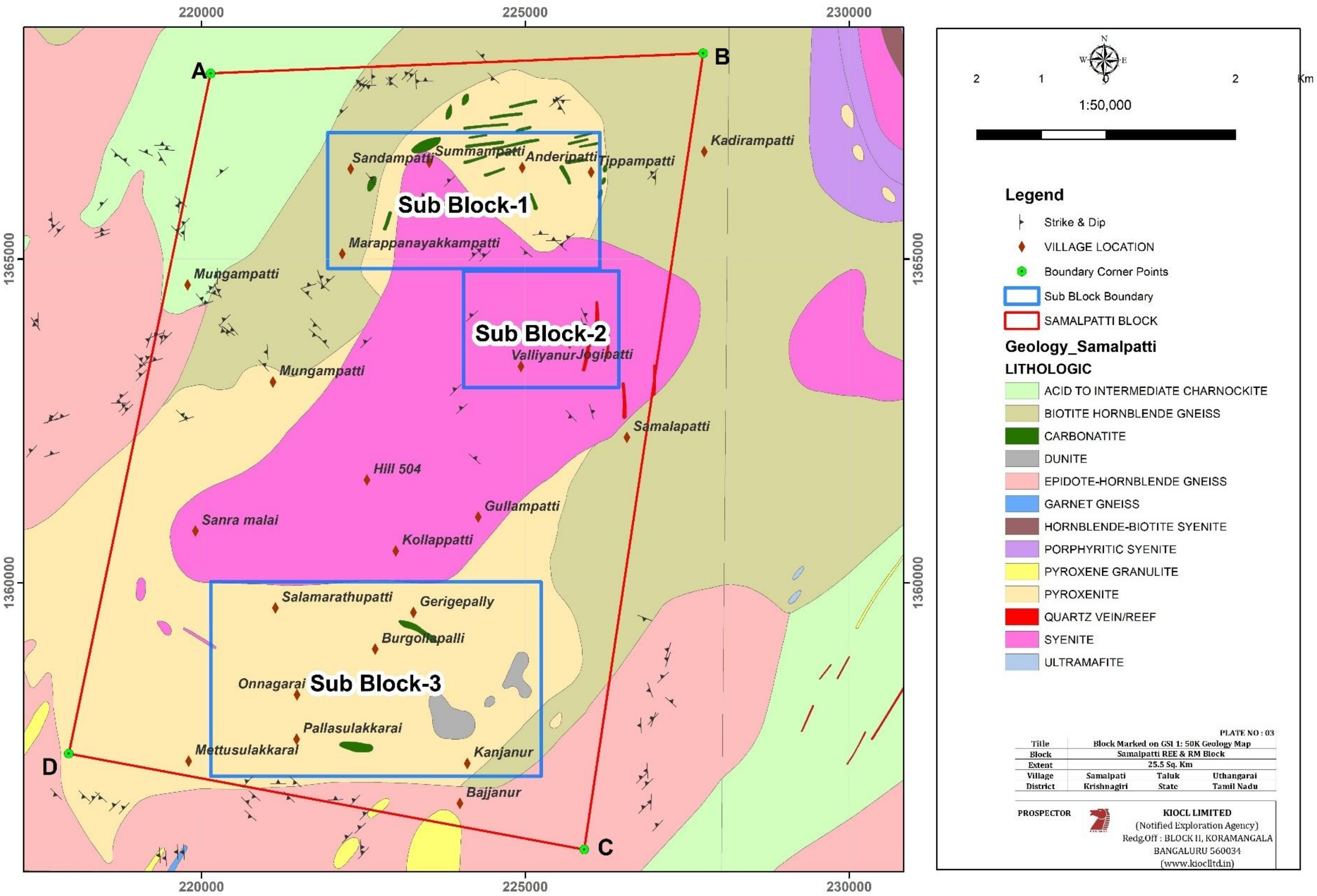


Figure 13: Samalpatti block (90 sqkm) marked on regional geology map (1:50k map of GSI)

Structural Framework

The structural architecture of the Samalpatti complex is dominated by deep-seated lineaments and shear zones, which have played a decisive role in magma emplacement (Leelanandam et al., 2006; GSI, 2011).

The region is traversed by NE–SW trending shear/fault systems linked to the Koratti–Attur lineament. These structures act as conduits for mantle-derived alkaline melts and pathways for late-stage hydrothermal fluids (Leelanandam et al., 2006). Carbonatites are emplaced along fractures, shear planes and dilation zones. Structural features observed include fracture-controlled dykes and vein networks, boudinaged and discontinuous carbonatite bodies, intense jointing and brecciation, and evidence of multiple deformation phases with reactivation of older structures (Ackerman et al., 2017; GSI, 2011).

Metamorphism and Metasomatism

The host rocks belong to a granulite facies terrain, but the alkaline–carbonatite intrusion is associated with localized thermal and metasomatic effects rather than regional metamorphism (Ramakrishnan and Vaidyanadhan, 2008).

Key features reported by GSI and other workers include development of fenite zones around carbonatites, Na–K metasomatism, and growth of alkali amphiboles and pyroxenes (Leelanandam et al., 2006; Ackerman et al., 2017). Hybrid rocks are developed due to interaction between carbonatite-derived fluids and host rocks, with overprinting relationships showing replacement of primary igneous textures by metasomatic assemblages (Ackerman et al., 2017). Both calcic carbonatite (sövite type) and dolomitic/magnesian carbonatite (late-stage, fluid-influenced) have been reported (Leelanandam et al., 2006; Srivastava et al., 2005).

Mineralisation

Samalpatti and associated complexes are recognised as REE-bearing carbonatite systems (Ackerman et al., 2017; Leelanandam et al., 2006). REE enrichment is particularly strong in LREE (La, Ce, Nd), consistent with global carbonatite systems (Woolley and Kjarsgaard, 2008).

Mineralisation occurs as disseminations within carbonatite, vein-controlled concentrations, and enrichment in fenitised zones (Ackerman et al., 2017). Associated minerals include apatite (P), pyrochlore (Nb), magnetite, barite, fluorite, and REE-bearing phases such as monazite and bastnäsite (Leelanandam et al., 2006; Woolley and Kjarsgaard, 2008).

REE mineralisation is polygenetic, involving primary magmatic concentration and secondary hydrothermal enrichment, and is strongly controlled by fractures and shear zones acting as fluid pathways (Ackerman et al., 2017; Leelanandam et al., 2006).

8. Previous work

Details of previous works carried out by GSI are provided below;

- The pioneering work (*Iyengar and Seshadri (1958)*, in the form of systematic geological mapping and mineral investigation in parts of Salem area to collect Iron ore samples from Kanjamalai, near Salem. They, reported the *intrusion of syenites as major occurrence in the area*. In addition, it was also reported that there are outcrops of Pegmatites, aplite with thin quartz veins, west of Samalpatti.
- *Narasimhan and Sundaram (1968),* reported that the Sevathur *carbonatite complex consists of fenite, syenite, pyroxenite and carbonatites.*
- *P. Shanmugam and P. Kumaraguru (1991-92), GSI* on the reporting of DGM, govt TN. carried out Geochemical investigation to delineate the Cu-Ni mineralisation. As part of their studies, geological mapping was carried out by traverse mapping on 1:25,000 scale and brought out charnockite, meta pyroxenite, grey hornblende gneiss, epidote-hornblende gneiss, basic dykes, dunite, syenite, carbonatite, syenite-pegmatite, sheared quartz vein and basic intrusive. Charnockite occurs as a major outcrop in the area. Their map has revealed that, the meta pyroxenite forms a horse-shoe shaped body and occurs within the epidote hornblende gneiss. A gradational relationship exists between the grey hornblende gneiss and epidote bearing hornblende gneiss. Sharp contact relations between pyroxenites and syenites show brecciation and shearing, with emplacement of pink feldspathic injections. The younger intrusives in the form of dunite, syenite and carbonatite occur within the meta pyroxenite showing sharp contact relationship. Syenite occurs as a massive body in the central part of the area surrounded by meta pyroxenites. The authors have also recognised different varieties of syenites in the order of younger. (1) pink porphyritic pyroxene syenite (2) Medium grained leucocratic syenite, (3) coarse to pegmatoidal syenite containing crystals of ilmenorutile and reibeckite (4) Pyroxene syenite (5) pegmatoidal syenite and (6) Aplitic syenite. Thin lensoid bodies of carbonatite occur as younger intrusives within meta pyroxenite, grey hornblende gneiss and syenite four kilometres SW of Samalpatti. The contact of carbonatite with the meta pyroxenite is marked by the development of garnets, epidote, vesuvianite and secondary calcite. Four phases of

carbonatite are recognised which are given in the order of younging viz. (1) ribbed (2) explosive (3) foliated/banded and (4) massive carbonatites. Xenoliths of meta pyroxenite, syenite and epidote hornblende gneiss are noticed in the explosive carbonatite.

Authors has identified four phases of deformation. The regional foliation of rock types is represented as F1 and occasional tight isoclinal folds in meta pyroxenites and epidote hornblende gneiss are recognised in the area. The major synformal fold with fold axis trending in N-S to NNE-SSW direction from Mettuthangal to Senramalai is represented by F2. Sympathetic meso folds of same directions are seen on either side in epidote hornblende gneiss, cherty looking sheared quartz vein (Q1) trending in NNE-SSW direction appears to be related to this phase deformation. Sulphide and molybdenum mineralisation occurring in the cherty looking sheared quartz vein and its contact zone. F3 deformation shows a swing of foliation from NNW-SSW (F2) to ENE-WSW (F3) direction and marked by a number ENE-WSW trending shears and are noticed along Mattur river, NW of Parandapalli.

Quarrying of carbonatites for quick lime purposes have been observed at Sunnampatti, around Kottapallanur and east of Onnakkarai. The kankeritised ultramafites north of Kanjanur are suspected to carry basemetal and Ni mineralisation. Sulphide mineralisation was noted as minor disseminations, specks and thin stringers of chalcopyrite, pyrite and pyrrhotite is noticed in meta pyroxenites, associated with the grey and pink quartzo-feldspathic and feldspathic injections and also associated with veinlets of quartz occurring within the meta pyroxene enclaves in grey hornblende gneiss and epidote hornblende gneiss, around Gargappalli, Kollapalli, Sunnampatti, Subramanya Nagar, Kallavi, Mettusulakkarai, Tippampatti, Nochchippatti and Perumalnayakkanpatti.

- On the contrary, the subsequent year, (*Srinivasan and Renganathan 1992-93),* prospecting in and around syenite carbonatite complex around Samalpatti and Uttangarai area to study the nature and distribution of trace elements was taken up. The mapped area consists of banded biotite hornblende gneiss, epidote hornblende gneiss with quartzofeldspathic injections traversed by fine grained dyke. The epidote hornblende gneiss shows relict patches of charnockite and enclaves of gabbro/norite/pyroxenite. A suit of ultramafite pyroxenites-feldspathic pyroxenites, syenites and carbonatites belonging to Venkatasamudram and Samalpatti syenite-carbonatite complex are found to be intrusive into the above rocks. The Samalpatti syenite-carbonatite complex is traced over an area of 100 sq. km to the west of Samalpatti. The ultramafites-pyroxenite bodies are often affected by very close and intricate network of magnesite/carbonatite veins, veinlets and stringers in the southern part of the area.

The authors have brought out a number of syenite bodies, classified and named them after their locales of presence based on different criterion. The criterion applied by the authors for classification of the syenites and carbonatites of the area viz., colour, mineralogy, texture and most importantly their field relation adopted for distinguishing the type of syenite and carbonatites. In Sunnampatti the syenite is fine grained and grey in colour, where as in Salamarathupatti two different varieties of syenites identified as coarse grained syenite grey in colour and other pink syenite varieties. The whitish grey garnet syenite is found in the Senra Malai area, in the hill 504 grey hornblende syenite of coarse-grained nature recorded. Around the same hill there is also the presence of coarse-leuco-hornblende syenite has been identified. In Jogipatti area the syenite is light greyish or pale pinkish white, in Valliyanur it is grey syenite, in Tippampatti the syenite is pink porphyritic, in addition to these various syenites the syenitoidal pegmatite, riebeckite dykes, felsite and aplite are reported in the area.

The area also shows exposures of carbonatites of various nature, to north west and south east of Samalpatti. The authors have identified and differentiated various types of carbonatites in the area by applying the same criterion which was applied to syenites and named them as a) dark grey carbonatite, b) green coloured carbonatite (chromiferous), c) whitish grey carbonatite, d) brownish grey carbonatite, e) epidotised white carbonatite veins and f) pure white sovite type carbonatite.

- *Shanmugam and Kumaraguru (1993)* while carrying out Geochemical surveys over the Samalpatti-*Mettusulakkarai* area for Cu and Ni sulphide mineralisation, they have also mapped the syenites, carbonatites, syenitoidal pegmatite etc., in the area.
- *Srinivasan and Renganathan (1995)* exploring for tin and tungsten mineralisation in the area has reported suites of ultramafic pyroxenites, feldspathic pyroxenites, syenites and carbonatites of Venkatasamudram and Samalpatti areas as intrusives into the country rocks.

  Authors have identified the retrograde metamorphism in the area. The pyroxenites possibly belonging to Sakarshanahalli group seen as enclaves in hornblende migmatite

/agmatite gneiss have suffered migmatisation and retrogression by the later different phase of quartzofelspathic injections and pink permeations. The pyroxenite is retrogressed to a granulose and schistose amphibolite, chlorite and biotite schist. The entire material has been transferred into gneisses of different types. The pyroxenite in the eastern part of the area is also affected by a later white to bluish grey quartzofelspathic material with lit-par-lit injection and ultimately giving rise to a dark grey banded biotite hornblende gneiss. The charnockite has also been affected by a white quartzofelspathic material, epidote-pink vein activity and hydrothermal solution activity which however has ultimately have given rise to a coarse-grained epidote hornblende gneiss by the process of retrogression.

The WNW trending pegmatite veins intruding the hornblende migmatite gneiss on .465 hill west of Sandur, north of Tadanur and on .603 hill are found to carry a few crystals of collumbite-tantalite is also seen as floats in the soil cover near syenitoidal pegmatite vein around Sandur and Penyajoggippatti. Sulphide and molybdenum mineralisation occurring in the cherty looking sheared quartz vein and its contact zone.

- *Nathan and Srinivasan (1999)* The major granites and pegmatites in the central Tamil Nadu were studied in detail to assess the potentiality for rare metals and REE mineralisation. The Bhavani - Punjai Puliyampatti sector they carried out close-spaced Scintillometer surveys in delineating a 750 m × 250 m zone of high radioactivity in the northern part of the Punjai Puliyampatti granite pluton. Within this zone, certain portions record very high radioactivity measuring 8-10 times above background value. The pink granite of Karamadai area show rich concentration of allanite and it analyses high LREE values. The pegmatites exposed in Dumanur area of Coimbatore district contain significant amount of beryl, mica and gemstones and they appear to hold good potential for Rare Metal mineralisation.
- *Jayapal and Nirupa Charchi (2018)* A reconnaissance survey for delineation of carbonatite bodies in the Koratti complex. The systematic sampling on 100m x 50m interval to evaluate the potentiality of the carbonatite for RM and REE with 59 samples collected from the carbonatite body. 18 samples represent the regolith. The analytical result of the 59 samples, inferred that ΣREE value ranging from 600ppm to 2637ppm. The ΣREE is mostly representing LREE especially La, Ce, Pr and Nd. Out of 59 samples, 05 samples show ΣREE values more than 2000 ppm, 08 samples show ΣREE between 1500 to 2000 ppm, 19 samples showing ΣREE between 1000 to 1500ppm and 11

samples showing ΣREE 600 to 1000ppm. The dimension of carbonatite body and encouraging REE values, the area is recommended for further exploration by close spaced sampling and drilling to assess the REE potentiality in the area.

- *Sastry and Livingston (2000-2001)* NGPM programme of GSI, the area in and around Dharmapuri has been covered by the ground magnetic and gravity surveys. The authors observed that Bouguer gravity contour map has brought out significant highs and lows with associated structural features correlating the mapped geology and structures. The bouguer gravity map also brought out a prominent gradient zone with a swerve near south of Dharmapuri possibly indicating a strike slip nature of the fault zone with segmented faults.
- *V.Chandramouli (PT) & Ranjith.A, S.Paranjothi, T.Essakimuthu (2016) GSI has carried out* G4 investigation on "Reconnaissance Survey for Platinum Group of Elements in Samalpatti Complex, Krishnagiri District of Tamil Nadu (G4)" to delineate ultrabasic / ultramafic rocks and to carry out preliminary search for PGE in ultrabasic and ultramafic rocks of the area.
    - The major rock types mapped in the study area are amphibolite, charnockite, pyroxene granulite, meta-pyroxenite ± feldspathic injections, grey hornblende gneiss, hornblende gneiss ± epidote, dunite, gabbro, syenite, carbonatite, basic dyke, and pegmatite and quartz veins.
    - A total of 150 no's of BRS samples & 50 nos of PTS samples were collected from Samalpatti area covering around 175 sq.km. Overall, the samples from Samalpatti area has resulted 5 ppb to 170 ppb of Pt with an average of 12.77 ppb and 5 ppb to 284 ppb of Pd with an average of 11.83 ppb.
    - Out of 150 nos of samples collected for PGE analysis, 2 Carbonatite samples were analyzed for REE which resulted Σ LREE value from 146.41 ppm to 201.63 ppm with an average value of 174.02 ppm and Σ HREE values ranges from 39.79 ppm to 86.54 ppm with an average value of 63.17 ppm
- *Chittaranjan Behera and Atul Bhatia (2021)* Carried out investigation for delineation of carbonatite bodies and REE mineralised zones in the Kambammettu and Kambam area. In their work they have delineated three mineralised zones as MZ-I, MZ-IA and MZ-III. The demarcated Carbonatite Body-1, where MZ-I has maximum strike length 980 metre and maximum width 270m and MZ-IA has maximum strike length 257 metre and maximum width 183 metre. Mineralised zone in carbonatite body-1 ΣREE (La to Lu) ranges from 1292.40 to 5976.99 ppm with mean value of 2284.99 ppm.

Mineralised zone MZ-III in Carbonatite body-3 has maximum of strike length of 850 metre and maximum width of 500 metre. Mineralised zone in carbonatite body-3 ΣREE (La to Lu) ranges from 2044.36 to 8559.07 ppm, with mean value of 5272.17 ppm. Their study culminated in the delineation of the mineralised zones (MZ-I, MZ-IA, MZ-III) to evaluate the resource, recommended for G3 stage exploration.

9. Aerial ground geophysical exploration

Aerial reconnaissance component is not required for this investigation as per NQT.

However, NGCM and NGPM surveys carried out by GSI has provided as important geochemical and geophysical framework for the block. Stream sediment sample contour map / 2D interpolation is carried out using Geosoft software for the NGCM data which is downloaded from NGDR portal to analyse the concentration of the LREE and TREE in the Samalpatti block.

It is noted from the analysis that around 54 sqkm (60% of the total block extent of 90sqkm) is having LREE concentration > 500 ppm. The peak LREE value observed in the block is 7,702ppm. Map indicating LREE concentration as per NGCM Stream Sediment Sample data with sub blocks demarcated is provided below (Fig.14) ;

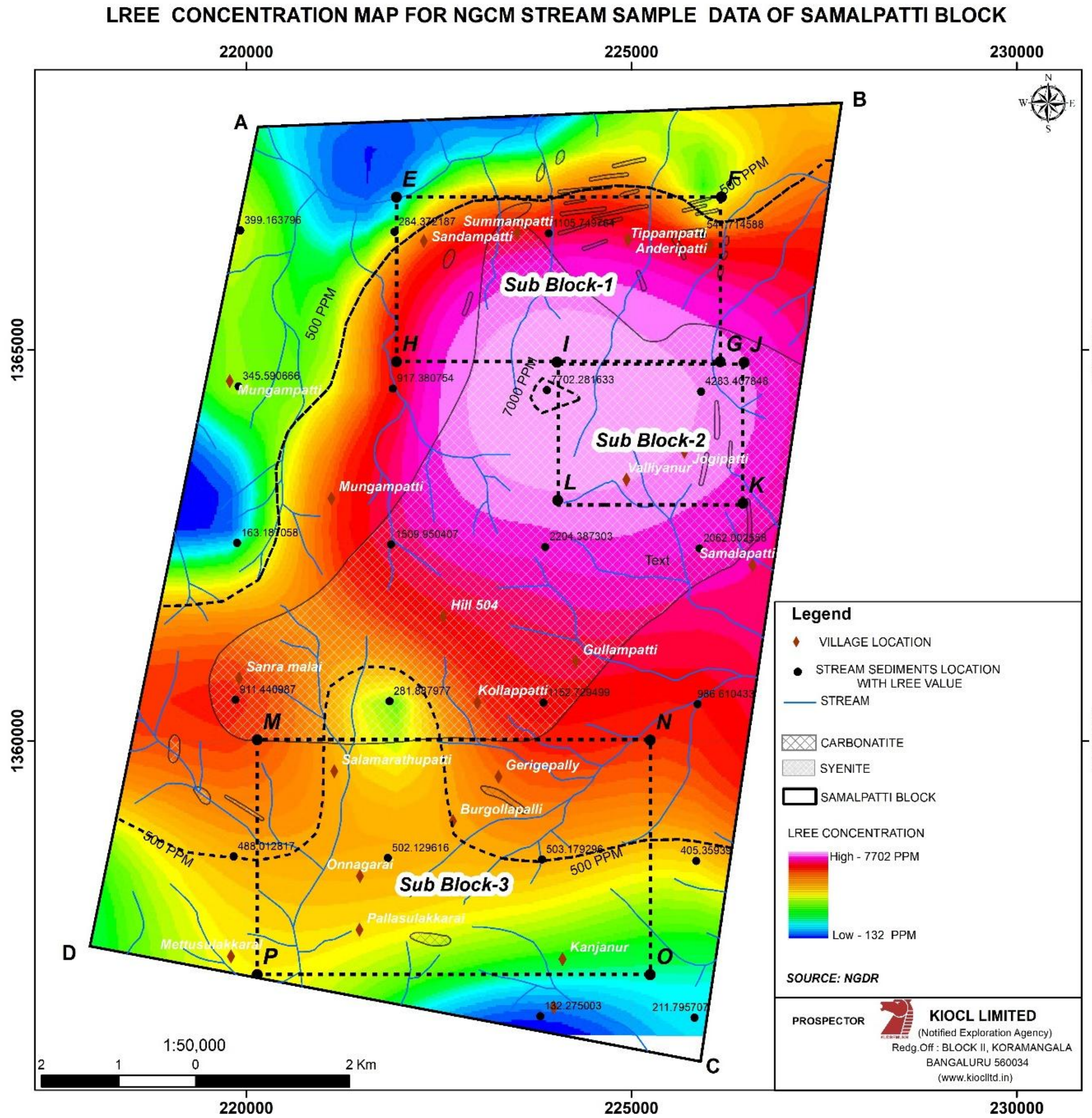


Figure 14: LREE concentration map as per NGCM Stream Sediment Sample data.

Around 61 sq.km (67 % of the total block extent of 90sqkm) is having TREE concentration > 500 ppm and the peak TREE value observed in the block is 7,838ppm. Map indicating TREE concentration as per NGCM Stream Sediment Sample data with sub blocks demarcated is provided below (Fig.15) ;

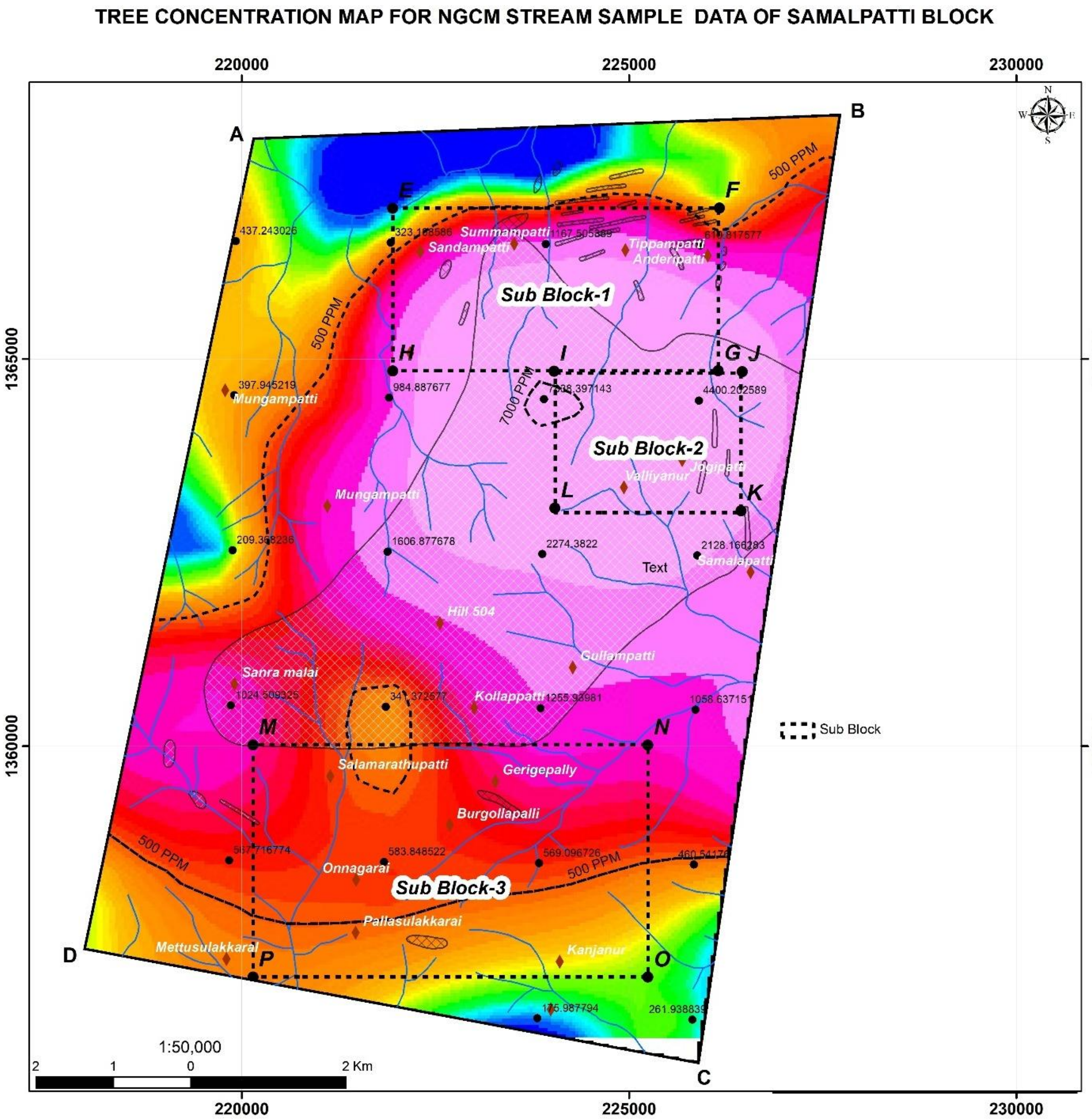


Figure 15: TREE concentration map as per NGCM Stream Sediment Sample data.

NGPM data interpretation with Observed Gravity Data (Bouguer gravity) downloaded from NGDR portal was carried. Bouguer gravity map data with sub blocks demarcated is provided below (Fig. 16)

Interpreted map indicates that the large portions of Sub Block-1, Sub Block-2 and Sub Block-2 are dominated by high gravity values with peak gravity values of 978188, 978181 and 978200 mGal respectively. This suggests the presence of dense alkaline intrusive bodies like carbonatite and Syenite.

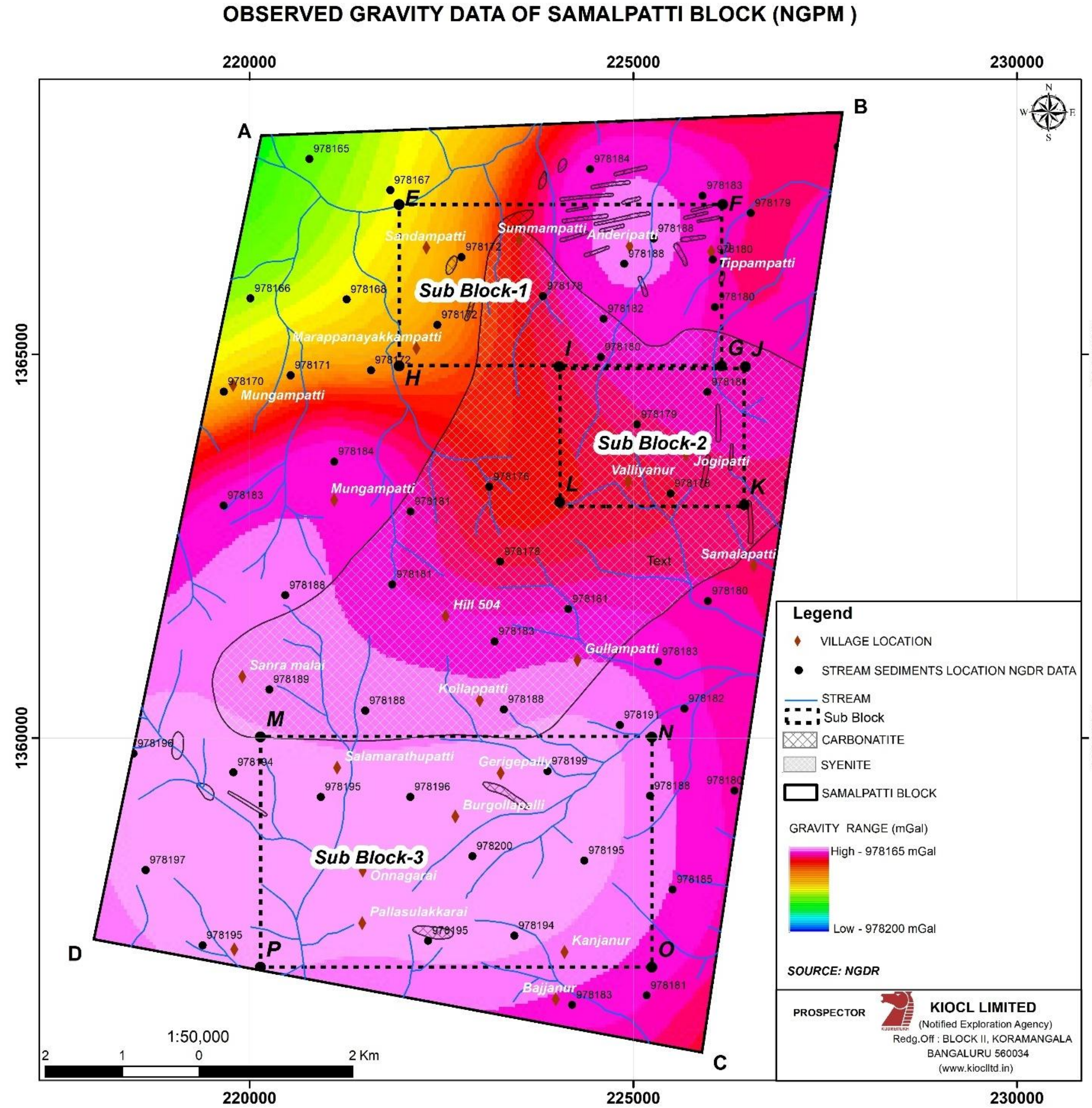


Figure 16: Gravity data map as per NGPM data.

10. Exploration undertaken during current investigation

10.1 Objectives of the investigation

Initially, proposed an area of 90 sq.km for taking up a G4 stage exploration, targeting the REE and RM mineralisation in the Alkaline-Carbonatites Complex around Samalpatti area. The area along with adjoining area has already been investigated by GSI for PGE mineralisation on 1: 12,500 scale in 2018. As per the discussions held in the meeting of TCC- NMET an area of 28.5 sqkm was carved out based on the presence of carbonatite bodies and total REE values (NGCM data) for updating of geological map with incorporation of carbonatite and other associated rocks with the existing large scale geological map on 1: 12,500 scale (GSI).

The area of 28.5 sq.km has been divided into three sub blocks as Sub Block-1, Sub Block-2 and Sub Block-3 respectively measuring 8.88, 4.32 and 15.3 sqkm totalling 28.5 sq.km. These three blocks were taken up for updating additional information on the carbonatite bodies, their extent and its contact relation with rock in which it is intruded. Details of the works executed against the NMET approval are provided in the below table (Table no 10);

Table 10: Details and nature and quantum of work approved vs achievement

SI	Item of Work		Unit	Quantity approved in 78th meeting of TCC- NMET	Quantity executed	
					Qty	Mode of execution
INCORPORATION OF CORBONOTITE BODIES IN GSI's 12.5k MAP (FSP 2016-17)						
1	Large Scale geological mapping works		sqkm	28.5	28.5	Inhouse
2	Collection of BRS, Channel, Regolith & Trench samples		nos	150	115	Inhouse (BRS, Channel & Regolith (57 nos) +Trench (58 nos))
3	Pits/ Trenching works		cum	100	80	Inhouse
SURVEY WORKS						
4	Demarcation of borehole and determination of coordinates and RL by DGPS		nos	5	2	Inhouse
DRILLING						
5	Drilling		m.	500	140	Outsourced through GeM portal
6	Core preservation		m	250	140	Inhouse
LABORATORY STUDIES						
7	34 elemental analysis by	Primary	nos	300	225	Inhouse (BRS, Channel & Regolith : 57 nos +Trench : 58 nos+ Drill core: 110 nos)

8	ICPOES (Sequential technique)	External Check (10%)	nos	30	18	Outsourced through GeM portal
9		Estimation of major oxides	nos	10	10	Inhouse
10	Petro studies	Preparation of Standard Thin section	nos	15	8	Outsourced to IIT Bombay
11		Complete Petrological Report of rock sample	nos	15	8	
12		Preparation of Polished Thin section	nos	15	8	
13		Mineragraphic studies	nos	15	8	
14		XRD for Mineral phase analysis	nos	10	8	
15		EPMA	hrs	8	8	
16	Preparation of GR		nos	1	1	Inhouse
17	Peer review of GR		nos	1	1	-

10.2 Updating of Large-Scale Geological mapping

The Samalpatti carbonatite complex includes nearby carbonatite occurrences, namely Pallasulakkarai, Onnakarai, and Garigapalli carbonatite. Carbonatite occurs as isolated mounds, dykes, veins, or lenses within pyroxenite and syenite host rock and hornblende-epidote bearing basement gneisses (Viladkar and Subramanian, 1995; Schleicher et al., 1998; Pandit et al., 2002 quoted by Debajyoti Paul et al., 2020). The Samalpatti, Jogipatti, Sevathur, Sundamalai, Sivamalai and Pakkandu has given an emplacement age of 833-572 Ma (Debajyoti Paul et al., 2020).

The mapped area is mostly occupied by syenite, pyroxenite, crystalline limestone, dunite, pegmatoidal syenite and carbonatite bodies (as linear and lensoidal bodies). The relationship between the syenite and carbonatite is intrusive with sharp contacts. There are enclaves of pyroxenite within the syenite also maintains a sharp contact relationship indicating its intrusive relation with each other. The contact between the syenite with other rock type is sharp and the carbonatite showing intrusive relationship.

The mapped area exposes a number of Carbonatites bodies occuring as small plug-like bodies, or as dykes, and veins. Majority of them are of plug like out crops and only two upon trenching found has dykes measuring 220m and 340m respectively in the sub blocks 1 and 2.

The petrographic studies of the carbonatite have revealed that majority of them as calcitic carbonatite and dolomitic carbonatite is not uncommon.

Description of rock types

The rock types exposed in the mapped area for the updating the existing geological map is pyroxenites, Dunite, syenites, carbonatites and pegmatoidal syenites are traced and mapped.

Pyroxenites

Pyroxenite in this area occur as scattered outcrops, it is fine to medium grained, dark black colour and mostly covered by brownish to reddish soil. Near Sunampatti pyroxenite is exposed and shows injection of quartz carbonate veins containing fresh sulphides (pyrite).

The pyroxenites show a sharp contact relation with the syenites indicating the intrusive nature, gradational relationship with grey hornblende gneiss at some places, and it is not clear as major part of the area is covered with soil due to intense weathering.

The general trend of the pyroxenite is NE- SW with south easterly dip of 65°.The pyroxenite also occurs as enclaves within the syenites and is traced as small out crops. It is a dark green, medium to coarse grained rock made up of ortho and clinopyroxenes. At places it is ramified with thin venations of epidote and quartz which are mostly due to the effect of shearing.

Dunite

The dunite occur as small out crop and are brownish to dark grey in colour with a highly pitted surface due to weathering. In the weathered area the kankar is a common feature noticed and the soil cover over the dunite is dark grey to brown in colour. The fresh dunite is greyish green to olive green homophanous massive rock with the development of magnesite veinlets. At places there are alterations of dunite to serpentine noticed. (Fig. 20 E,F)

Pegmatoidal syenite

The area exposes a number of pegmatoidal syenite bodies occurring within the syenite as younger intrusives and are confined to dunites and syenites. They trend generally in ENE-WSW direction and consist of laths of white and pink feldspars of size up to 3 cm with minor amount of quartz and mafics. These rocks are highly sheared and brecciated.

Syenite

Syenite is wide spread rock occurring almost the entire parts of all three sub blocks mapped and found as bouldery outcrops. They occur as elongated body trending northeast-southwest occupying small mounds of Senramalai Δ 554m, Δ 504m north of Kollapalli, Δ 464 m northeast of Jogippatti. There is a characteristic pink to buff coloured, sandy soil denotes the weathered portion of the syenite.

Syenite is medium to coarse grained, leucocratic and homophanous and shows occasional primary foliation, marked by the preferred orientation of feldspar laths. Leucocratic homophanous syenite is the major type of syenite mapped in the area.

Figure 17: Syenite core photograph

The petrographic study of the rock shows that the rock is a medium to coarse-grained, consisting dominantly of subhedral to anhedral crystals of microcline, orthoclase, plagioclase, quartz, and aegirine-augite The characteristic cross hatched twinning pattern is observed in microcline, while orthoclase is recognized from its cloudy appearance, low relief in PPL, simple Carlsbad twinning, and first order grey interference colour in XPL (Fig. 18 b and d). Alkali-feldspars are the most abundant phases in the rock, constituting more than 80–85 modal % of the rock. Nearly 10–15 modal % of the rock is plagioclase, while quartz makes up around 5–7 modal % and aegirine-augite about 3–4 modal %. In addition to the above minerals, trace amounts of carbonate probably, Ca-bearing strontianite and titanite are also present (Fig.18 A–D). The rock shows signs of alteration, such as carbonate and a rim consisting probably of REE-(fluor) carbonates or (Ca, Sr, and Ba)-bearing REE carbonates or baryte or celestine or a combination of the above around it, is observed to have replaced aegirine-augite grains and formed titanite (Fig. 18 e and f). Presence of the Ca-, Sr-, and Ba-, REE-bearing carbonates, baryte, and celestine is inferred from the Ca, Sr, Ba, and REE counts observed in EPMA X-ray meter. Deducing from the above observations, the rock is interpreted as Aegirine-augite and quartz-bearing Syenite.

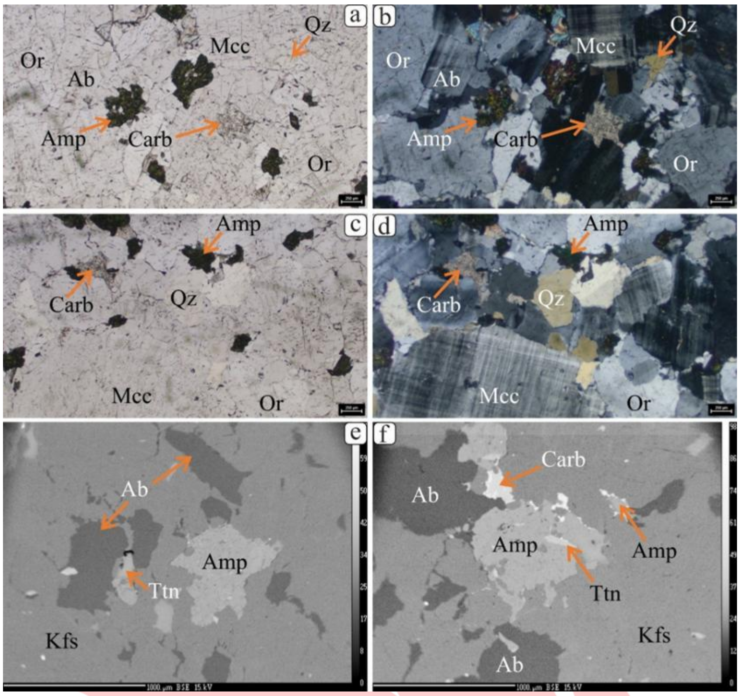


Figure 18: Representative photomicrographs (a–d) and BSE images (e and f) of the syenite showing the major and accessory phases. Note the alteration of amphibole and its replacement by carbonates (probably Sr-bearing calcite and strontianite) in 'f'. Abbreviations: albite = Ab, Amphibole = Amph, carbonate = Carb, K-feldspare = Kfs, microcline = Mcc, orthoclase = Or, quartz = Qz, titanite = Tt

Carbonatite

A number of small out crops of carbonatite bodies are mapped in the sub blocks 1, 2 and 3. Among these, 15 carbonatite bodies with lengths varying from 2m to 340m and widths varying from 1m to 21m trending along North-South and East-West are observed. Details of the carbonatite bodies observed in the sub blocks with average TREE value is provided in the below table (Table 11);

Table 11: Dimensions of carbonatite bodies with TREE values.

Carbonatite Band No.	Sub Block	Length(m)	Width(m)	Trend	Average Total REE value (ppm) based on BRS value
1	1	220	15	North-South	3,996
2	2	340	21	East -West	3,121
3	1	50	2	North-South	4,361
4	1	10	1	East -West	1,865
5	2	10	1	East -West	4,412
6	2	15	2	East -West	4,057
7	2	30	2	North-South	2,494
8	2	10	2	East -West	13,917

9	3	45	2	North-South	5,064
10	3	15	2	NNE-SSW	3,164
11	3	70	1	NNE-SSW	6,946
12	3	3	1	-	2,173
13	3	2.5	1	NNE-SSW	531
14	3	3.5	1.5	East -West	3,749
15	1	2	1	East -West	3,712

Band wise values of the bands with respective HREE, LREE and TREE values are provided in Annexure 02.

Among these 15 numbers of carbonatite bodies, 2 bands viz Band 1 and 2 occurring in Sub block 01 & 02 were observed to be having substantial dimensions with higher TREE values of 3,996ppm and 3,121ppm respectively. Band 1 is located at a distance of around 800m towards east of Ettipatti village and Band 2 is located at a distance around 400m north of Jogipatti village.

Immediate contact area of syenite and pyroxenite show extensive alterations with development of carbonate veins and alkali altered leading to formation of Fenite zone. it shows mafic enrichment and containing minerals like biotite, calcite , chalcopyrite, pyrite , fibrous minerals aegirine and magnetite.

Under microscope the fenite is medium to coarse grained and represents a zone of intense fenitization driven by alkali rich fluid derived from carbonatite melt. It occurs between the dolomitic carbonatite and the syenite and comprises abundant of andradite , aegirine augite, phases characteristics of such zones of metasomatism. Fig (19)

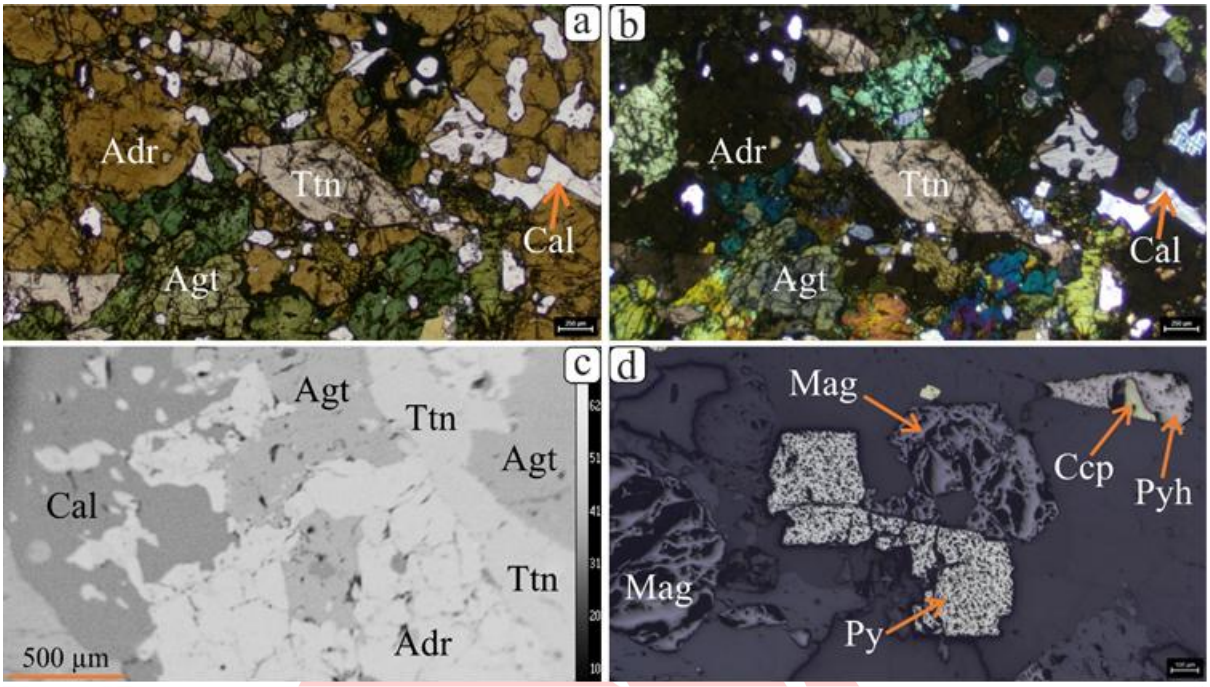


Figure 19: Representative photomicrograph (a, b, d) and BSE image (c) of the fenite containing abundant andradite (Adr), aegirine-augite (Agt) with minor interstitial calcite

Most of the carbonatite is white to light greyish in colour, some are grey in colour, medium to coarse grained, at times massive, majority of the cases it is weathered. There are both dolomitic and calcitic carbonatites present which are difficult to differentiated in the (Fig. 22 a,b,c,d). The petrographic studies have shown that majority of them are of dolomitic type and some are calcitic.

Under microscope, the rock is medium to fine-grained, carbonate dominant rock, constituting abundant dolomite and calcite. The former occurs as subrounded, globular bodies, accounting for about 60–70% as modal % of the rock, while the latter occurs as randomly oriented globular bodies, comprising about 30–35 modal % (the distinction is clearly observed in BSE images). The rock also contains numerous phases having higher average Z-contrast in BSE images than dolomite and calcite. These phases occur within calcite or at the dolomite-calcite boundaries, but never within dolomite (Fig. 20 b and f). Based on the Ca, Sr, Ba, and REE counts SEM-BSE they can be REE-(fluor-carbonates) Fluro-apatite or (Ca, Sr, and Ba)-bearing REE carbonates or baryte or celestine or ancylite or a combination of the low temperature reequilibration of dolomite. During re equilibration and calcite exsolution, the incompatible elements within dolomite were exsolved, forming the observed high Z-contrast phases in calcite. Moreover, the carbonatite is altered, as evident from the occurrence of calcite-bearing crosscutting vein and precipitation of fibrous richterite and rare phlogopite along it. Other alteration features include occurrence of pits and vugs within calcite and dolomite, and their filing by monazite together with the other REE phases, above. Based on mineral modal abundances, the rock can be termed as a **Dolomite Carbonatite**.

The coexistence of richterite aegirine augite + monazite in dolomitic carbonatite indicates highly enriched fluid rich alkalies carbonatite system where REE mineralization is largely hydrothermal in origin.

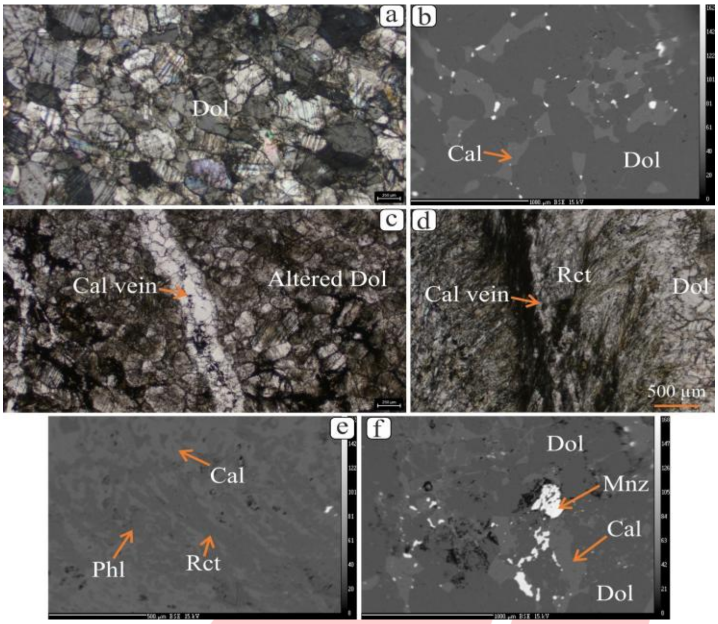


Figure 20: Representative photomicrographs (a, c, and d) and BSE images (b, e, and f) of the dolomite carbonatite intruded by calcite-bearing vein, which led to alteration and precipitation of fibrous aegirine-augite and monazite. Abbreviations: calcite = Cal, dolomite = Dol, richterite = Rct, monazite = Mnz, phlogopite = Phl.

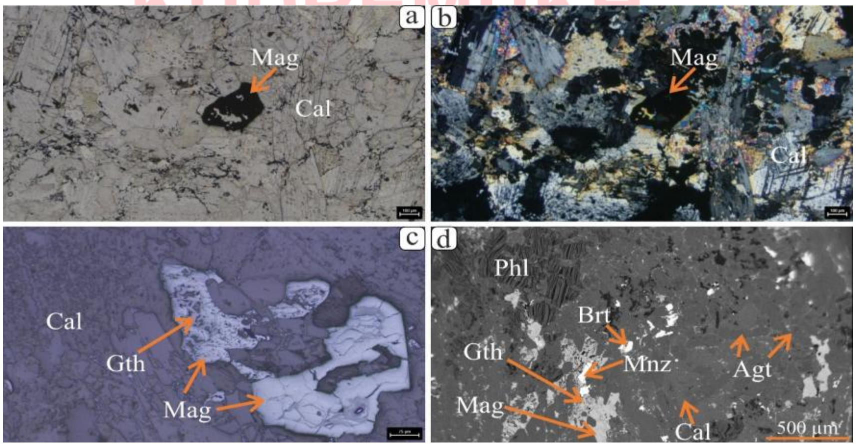


Figure 21: Representative photomicrographs (a–c) and BSE image (d) of the calcite carbonatite. Abbreviations: baryte = Brt, calcite = Cal, magnetite = Mag, monazite = Mnz, goethite = (Gth).

A: Carbonatite (Location: E225414, N1364482)

B: Carbonatite (Location: E225480, N1365038)

C: Carbonatite(Location: E225524, N1364532)

D: Carbonatite(Location: E225370, N1364473)

E: Dunite (Saprolite)

(Location: E224502, N1357550)

F: Dunite

(Location: E223960, N1357910)

Figure 22: Field photographs of Carbonatite bodies

Based on the total silica and alkali content, Total Alkali Silica (TAS) diagram E. A. K. Middlemost (1994) were plotted for core samples from the study area (Fig. no 23.).

Core samples samples fall in the diorite, granodiorite field, only one sample falls in foid monzo-syenite field composition.

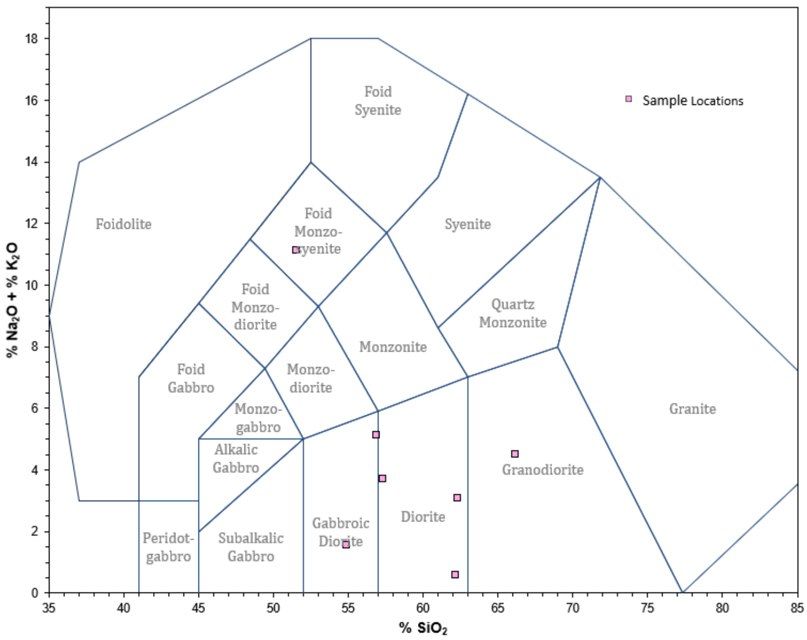


Figure 23: (TAS) diagram E. A. K. Middlemost (1994)

Major oxides Samples of BRS, Trench and Drill core of shows CaO content varying from 8.61 to 46.19 wt% and SiO2 content ranging between 4.54 to 66.19 wt%. MgO content varies from 0.12 to 1.85 Wt%.

The ternary plot of CaO MgO- FeO(t)+MnO (Woolley; 1982) for carbonatite shows that the BRS samples falls in Calcio carbonatite zone (Fig.24), trench samples some are Calcio carbonatite and 2 samples falls in magnesio carbonatite. (Fig 25) Drill core samples majority of samples falls in magnesio carbonatite and few samples in Ferruginous-calciocarbonatite to Calcio-carbonatite (Fig.26).

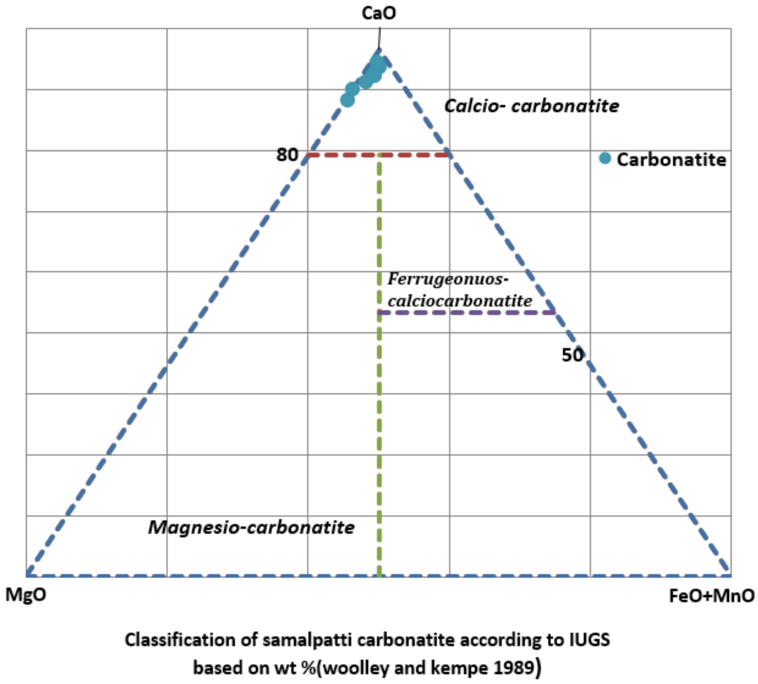


Figure 24: Classification of Samalpatti carbonatite BRS (Woolley and kempe 1989)

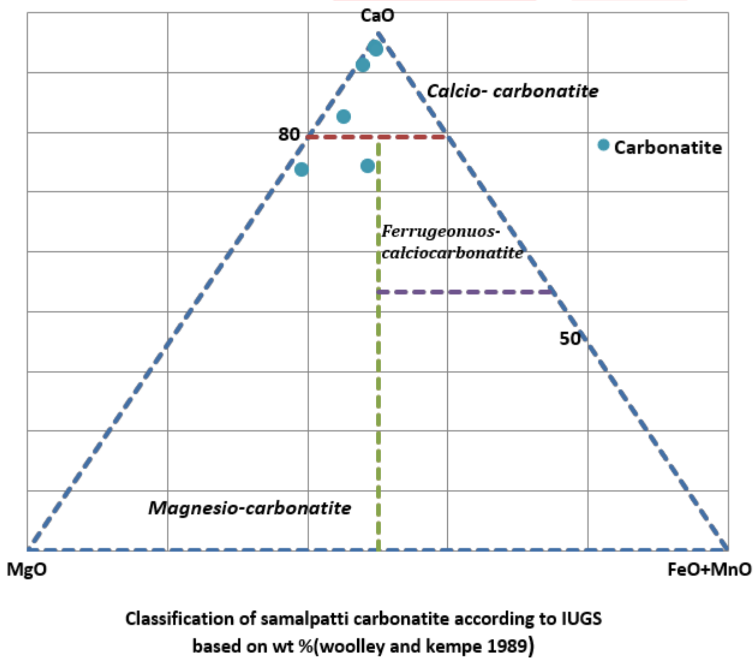


Figure 25: Classification of Samalpatti carbonatite Trench Samples (Woolley and kempe 1989)

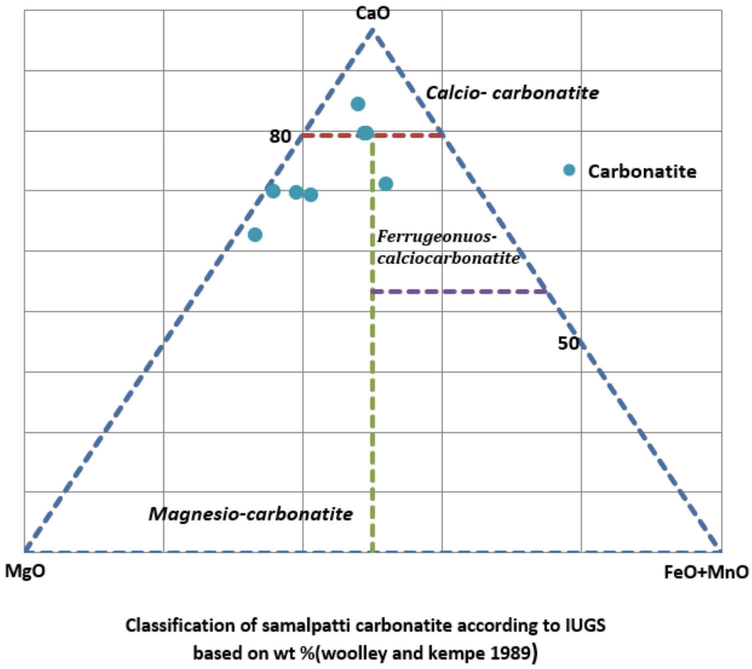


Figure 26: Classification of Samalpatti carbonatite core samples (Woolley and kempe 1989)

Crystalline limestone:

A prominent outcrop of crystalline limestone was observed in the Samalpatti area, occurring within the sub block 3. The outcrop extends approximately 850m in strike length with an average exposed width of about 80m. The location and extent of the outcrop are shown in Plate 4(b). The rock is trending NE-SW direction with southeasterly dip of 60 °.

The rock is greyish white in colour, medium grained, and exhibits a well-developed crystalline texture indicative of recrystallization. The limestone is compact, massive, and moderately hard in nature.

Three representative samples were collected from different locations across the outcrop for chemical analysis. The analytical results indicate CaO ranging from 43.18% to 47.11% with average Cao of 45.52% which is above the IBM threshold value of 34%. The analytical results are presented in table no.12 below;

Table 12: Chemical analysis of Crystalline limestone

Sample No.	Fe	Fe_2O_3	LOI	SiO_2	Al_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	Mn	MnO_2	P	P_2O_5	S	SO_3
57BRS-36	0.73	1.04	32.54	8.12	3.15	**43.18**	3.63	2.05	0.62	0.22	0.11	0.174	0.15	0.344	0.10	0.250
57BRS-01	0.67	0.96	38.34	5.91	0.96	**46.27**	2.42	0.21	0.88	0.07	0.13	0.206	0.29	0.664	0.091	0.228
57BRS-02	0.90	1.29	35.69	5.99	2.25	**47.11**	2.82	0.43	1.83	0.11	0.14	0.222	0.24	0.550	0.11	0.275
Average						**45.52**	**2.95**									

Figure 27: Field photographs of crystalline limestone Outcrop

Bed rock sample analytical results:

In the present block, though the area exposes limited outcrops amid the agricultural and orchard land, systematic Bed rock sampling / pedogeochemical sampling on grid pattern was adopted. Wherever the exposures are available bed rock samples were collected to understand the mineral assemblage and chemical variation in the rocks to assess the metal content and to identify the indicator minerals to trace the zones of mineralisation.

During LSM work, a total of 57 bed rock samples was collected from 3 sub blocks over various lithologies viz., the carbonatite, pyroxenite, crystalline limestone, pegmatoidal syenite, dunite and saprolite and regolith. Out of 57 samples, 45 samples belongs to carbonatite and balance 12 samples covering other rock types mentioned above.

In the Sub-block 1, a total of 15 BRS were collected. Out of which, 12 BRS were collected from carbonatite, whose analytical data has indicated T-REE values ranging from 308.38ppm to 6,962.00ppm with mean value of 3,725.88ppm. Statistical analysis is provided below (Table 13);

Table 13: Statistical analysis of BRS collected from carbonatite bodies from Sub block 01.

	T-HREE (ppm)	T-LREE (ppm)	T-REE (ppm)
Mean	292.22	3,433.66	3,725.88
Median	288.80	3,310.42	3,654.41
Range	414.18	6,239.44	6,653.62
Minimum	48.82	259.56	308.38
Maximum	463.00	6,499.00	6,962.00
Count	12.00	12.00	12.00

In the Sub-block 2, total 16 BRS were collected from carbonatite bodies. Analytical data has indicated T-REE values are ranging from 1,514.24ppm to 13,916.83ppm with mean value of 3958.90ppm. Statistical analysis is provided below (Table 14);

Table 14: Statistical analysis of BRS collected from carbonatite bodies from Sub block 02

	T-HREE (ppm)	T-LREE (ppm)	T-REE (ppm)
Mean	260.16	3,698.73	3,958.90
Median	255.56	2,840.06	3,090.23
Range	392.34	12,104.20	12,402.60
Minimum	121.75	1,298.56	1,514.24
Maximum	514.08	13,402.75	13,916.83
Count	16.00	16.00	16.00

In the Sub-block 3, total 25 BRS were collected, out of which 17 samples are collected from carbonatite bodies. Analytical data has indicated T-REE values are ranging from 291.34 ppm to 12,411.12 ppm with mean value of 4545.70ppm. Statistical analysis is provided below (Table 15);

Table 15:Statistical analysis of BRS collected from carbonatite bodies from Sub block 03

	T-HREE (ppm)	T-LREE (ppm)	T-REE (ppm)
Mean	382.99	4162.72	4545.70
Median	358.39	3153.24	3694.27
Range	832.10	11813.33	12119.78
Minimum	51.93	239.41	291.34
Maximum	884.04	12052.73	12411.12
Count	17	17	17

Lab Chemical analysis report of Bedrock Samples (BRS) is enclosed in Annexure 01.

LS map of sub block 01, 02 and 03 is provided in below figures (Fig 28 & 29) and enclosed at plate 04(a) and 04(b).

Some of the isolated carbonatite bodies as indicated by GSI in sub block 1,2 and 3 during G4 level works for PGE during 2018, were not traced in field due to extensive anthropological activities. However, these carbonatite bodies as identified by GSI are retained in geology map.

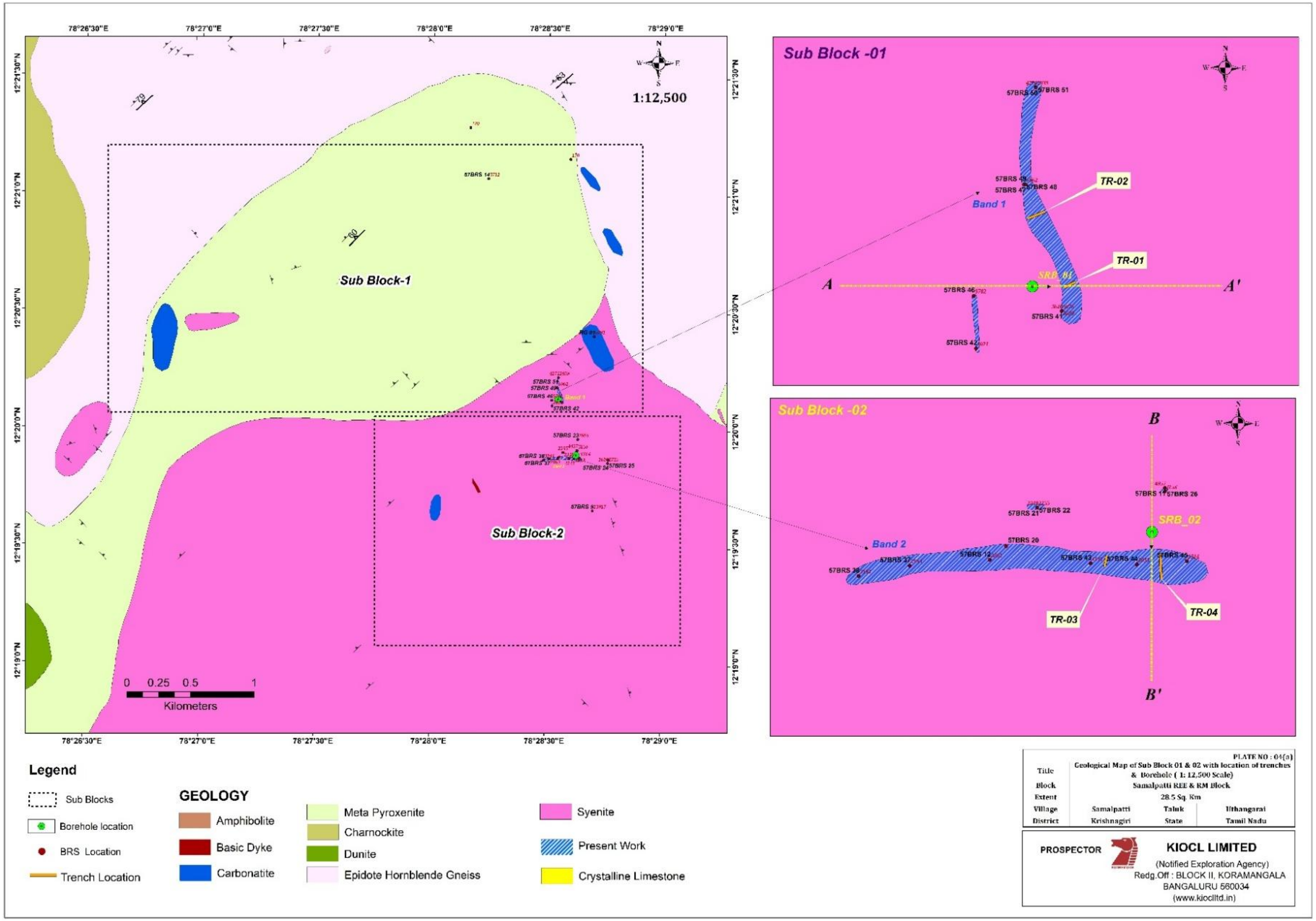


Figure 28: Geology map of Sub block 1 & 2

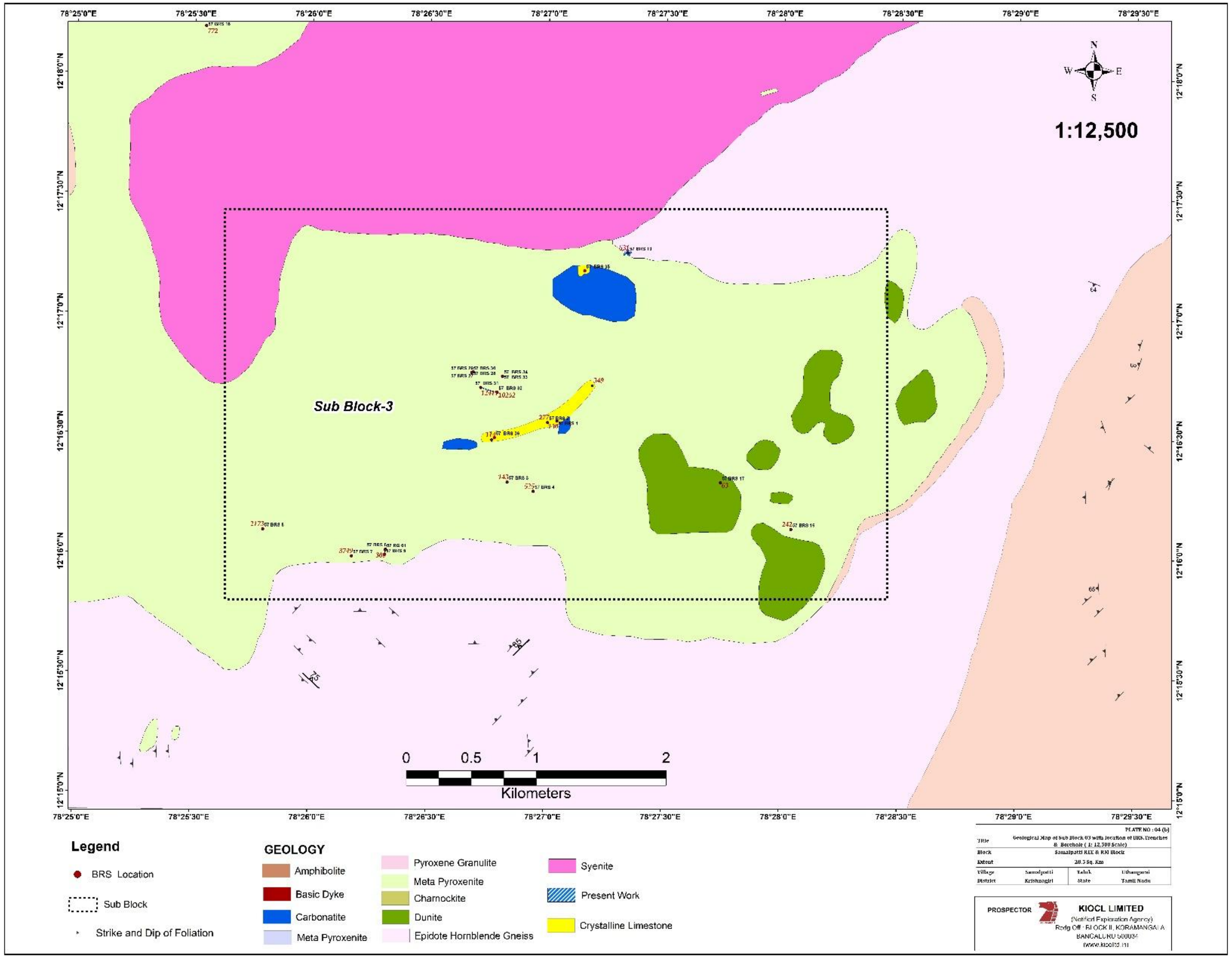


Figure 29: Geology map of Sub block 3.

10.3 Surface indication:

The current work in the Samalpatti alkaline carbonatite complex is carried out for identification of Rare Earth Element (REE) based on the occurrence of carbonatite and syenite. These rocks are considered as possible source of REE mineral occurrences. These intrusive bodies mostly occur in a discontinuous pattern as small out crops, some of them were traced for a strike length of 220m to 350m with an average width of 15- 20 in two different sub blocks trending along east – west and north - south.

Surface indications of REE mineralisation in alkaline carbonatite terrains often manifest through distinctive geological, geochemical, and mineralogical features. It is practically difficult to identify the REE bearing minerals through naked eye, the bastnasite, monazite and parisite, these are some of the LREE minerals characteristic of carbonatite and in alkaline complexes. Bastnäsite often looks greasy, monazite may be slightly more reddish, parisite tends to form tabular aggregates, all three are yellow-brown with resinous lustre, making them hard to distinguish by naked eye alone.

The presence of outcrops of carbonatite are prime hosts for REE mineralisation world over, for example Mountain Pass, (USA), the surface indication is carbonatite dykes with bastnasite visible in outcrops, early prospectors noted unusual carbonate-rich rocks and strong radioactivity from thorium-bearing minerals. Soil and rock chip sampling confirmed REE enrichment, and became one of the world's largest bastnasite deposits producing significant LREE.

Similarly in Bayan Obo, (China), Large carbonatite–alkaline complex with visible monazite and bastnäsite occur in weathered zones. Systematic mapping of carbonatite intrusions, revealed geochemical assays showing high LREE concentrations, and radiometric surveys detecting thorium anomalies. It is again the world's largest REE deposit, with both light and heavy REEs, plus iron and niobium.

The Indian example is Amba Dongar, Carbonatite ring complex with fenitisation halos and visible apatite and barite. Soil geochemistry revealed REE anomalies, petrographic studies identified bastnäsite and monazite, and trenching exposed mineralised zones. This has confirmed as a significant REE-bearing carbonatite complex in India.

10.4 Mode of occurrence, nature and control of mineralisation:

Though the REE bearing minerals are not identifiable by naked eye in the field, it is assumed that the carbonatite must be containing the REE minerals as known from other carbonatite complexes elsewhere. Light REEs are more compatible in carbonate and fluorocarbonate structures. Minerals like bastnäsite and monazite preferentially incorporate LREEs due to ionic radius and charge balance. The petrographic studies have revealed that the REE and RM minerals are mainly confined in association with fluorocarbonate, monazite, ancylite-group phases, and Sr-rich calcite. Monazite is an important REE bearing mineral, it is a highly resistant mineral and an important LREE ore. Ancylite group phase consists of hydrated strontian REE carbonates, Calcite lattice incorporates Sr and sometimes REEs, usually a minor REE host but can be significant in Sr-rich systems.

10.5 Pitting and trenching

The area of three sub blocks (sub blocks-1, 2 and 3) is mainly a soil covered terrain, with very minimal exposures of rocks, further the cultivated land and orchards pose problem of locating the carbonatite bodies. Presence of small out crops of the carbonatite, and the weathered remnants as calcretes are the clues to lay trenching locations.

A total of four trenches were excavated in the study area to establish the strike continuity and width of the 2 major carbonatite bodies trending North - South and East – West directions in sub block 1 and 2 respectively. The trenches were strategically positioned across Sub-Block 01 (Carbonatite band 1) and Sub-Block 02 (Carbonatite Band 2) based on geological mapping and surface indications. (Figure 28)

All trenches were logged systematically at 1m intervals to record lithological variations, structural features, and mineralization characteristics.

Against the total NMET approved quantity of 100 cum, trenching work was completed with 80 cum. A total of 58 trench samples were collected at 1m intervals and analysed for Total Rare Earth Elements (TREE), Scandium (Sc), and Niobium (Nb). Lab trench sample analytical report, Trench sample analysis report indicating REE and RM and Details of trench lithological logs data are provided in Annexure 03,04 & 05.

Details of the trenches executed along with respective geo coordinates are provided in the below table (Table 16).

Table 16: Details of the trenches

Trench No	Sub block	Location				Length (m)	Width (m)	Depth (m)	No. of samples collected for analysis	Volume in Cum
		Easting	Northing	Latitude	Longitude					
1	1	225509	1364963	12°20'8.38"N	78°28'33.80"E	11	1	1.5	11	16.5
		225517	1364967	12°20'8.51"N	78°28'34.06"E					
2	1	225482	1365007	12°20'9.80"N	78°28'32.89"E	14	1	1	14	14
		225495	1365011	12°20'9.93"N	78°28'33.32"E					
3	2	225583	1364492	12°19'53.08"N	78°28'36.39"E	11	1	1.5	11	16.5
		225581	1364480	12°19'52.69"N	78°28'36.33"E					
4	2	225630	1364493	12°19'53.13"N	78°28'37.95"E	22	1	1.5	22	33
		225631	1364474	12°19'52.51"N	78°28'37.98"E					
Total volume in cum										**80**

Location of the trenches marked on Geological map is provided figure (Fig 28);

Trenches on Carbonatite band 1 in Sub block 01:

Two numbers of trenches were excavated in sub block 01 in order to establish continuity of Carbonatite band 1. The band measuring 220m X 10m was traced and sampled.

a) **Trench 57TR01:**

- Trench 57TR01 was excavated in Sub-Block 01 to trace the N-S trending carbonatite band where the BRS-39, BRS-40, BRS-41 has given a total REE value range between 3,078 to 3,689 ppm, based on this value the trench TR-01 was selected for excavation with a total strike length of 11m with width of 1m and depth of 1m and is oriented in an E–W direction.

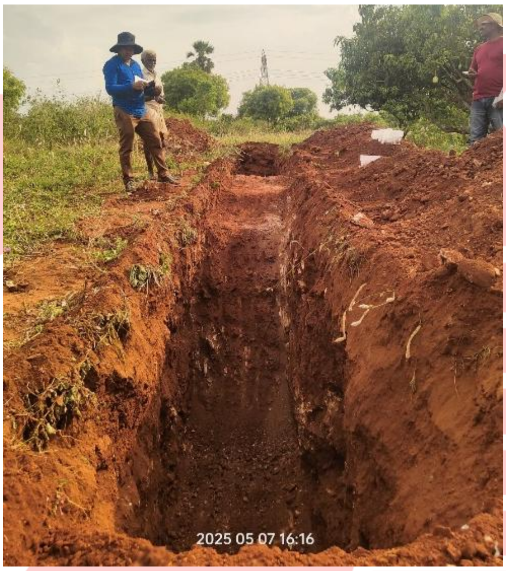


Figure 30: Field photograph of Trench 01

- A total of 11 groove samples were collected at 1m interval. The trench exposed syenite from 0–1m and 9–11m, while carbonatite was encountered continuously between 1–9 m, indicating a carbonatite width of approximately 8m in this trench. The analytical results indicate that the weighted average of Total REE (TREE) for trench 57TR01 carbonatite zone is **6,647.23 ppm (1 to 9m)** and syenite zone for 1 m (from 0 to 1 m) with TREE value of **8,352ppm**. The trench section along with the variation of TREE values across the sampled interval is presented in Figure 31.

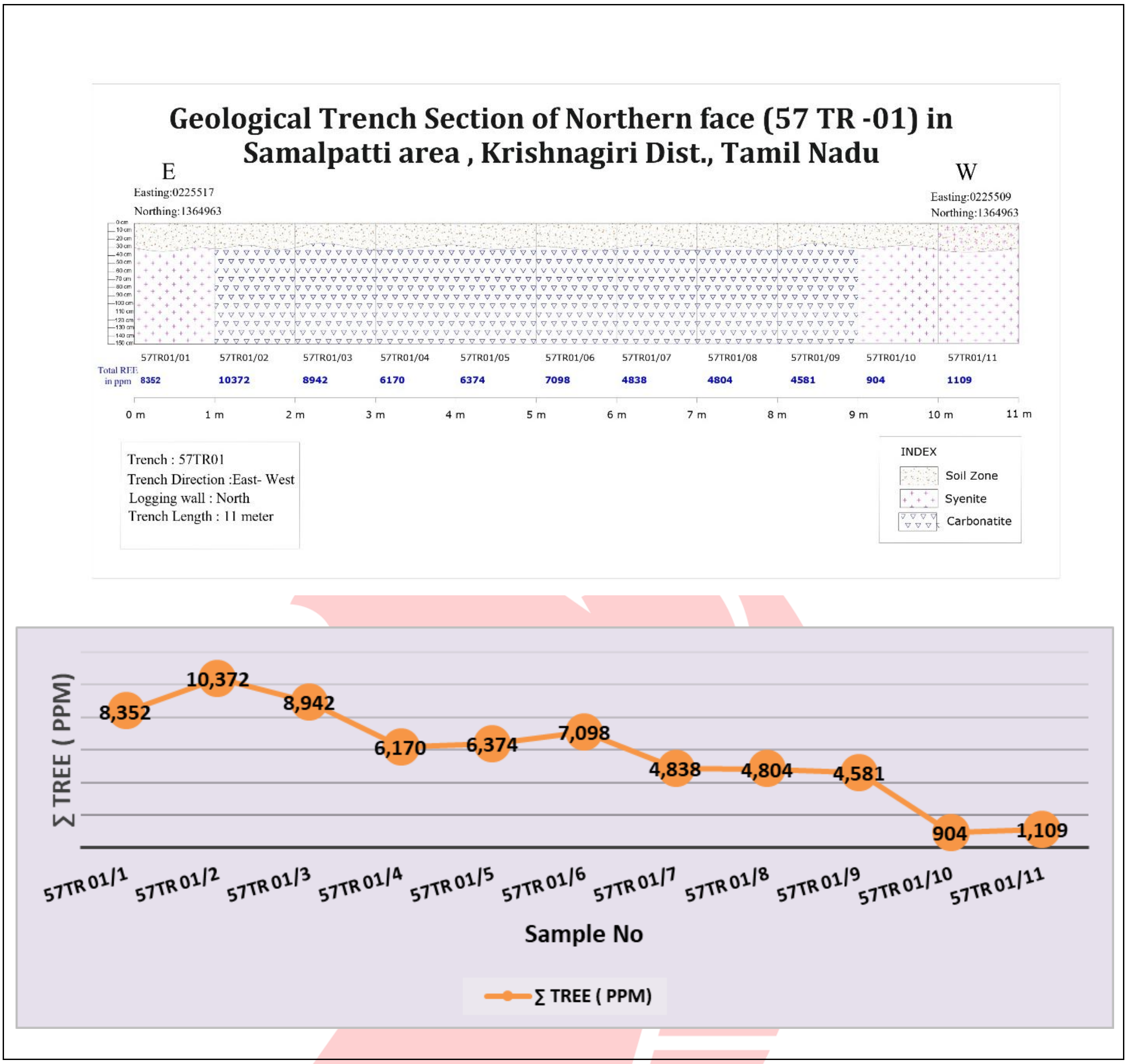


Figure 31: Trench wall Section of 57TR-01 showing different lithologies , sample details and analysis results.

b) Trench 57TR02

- The trench 57TR-02 was located 100m further north of the trench TR-01 to trace the continuity of the carbonatite band 01 exposed in the trench TR-01. Trench was excavated with a total length of 14 m, width of 1m and depth of 1m.

Figure 32: Field photograph of Trench 02

- Systematic channel sampling was carried out at 1m intervals across the trench. Lithological logging indicates the presence of syenite from 0–3 m and 12–14m, while carbonatite is exposed between 3–12 m, suggesting a carbonatite width of approximately 9 m within this trench.
- The analytical results demonstrate variation in TREE, concentrations within the carbonatite zone. The weighted average TREE value for trench 57TR02 in carbonatite zone is **3,864.52 ppm (3 to 13m)**. The trench lithology and geochemical variation are illustrated in Figure 33.

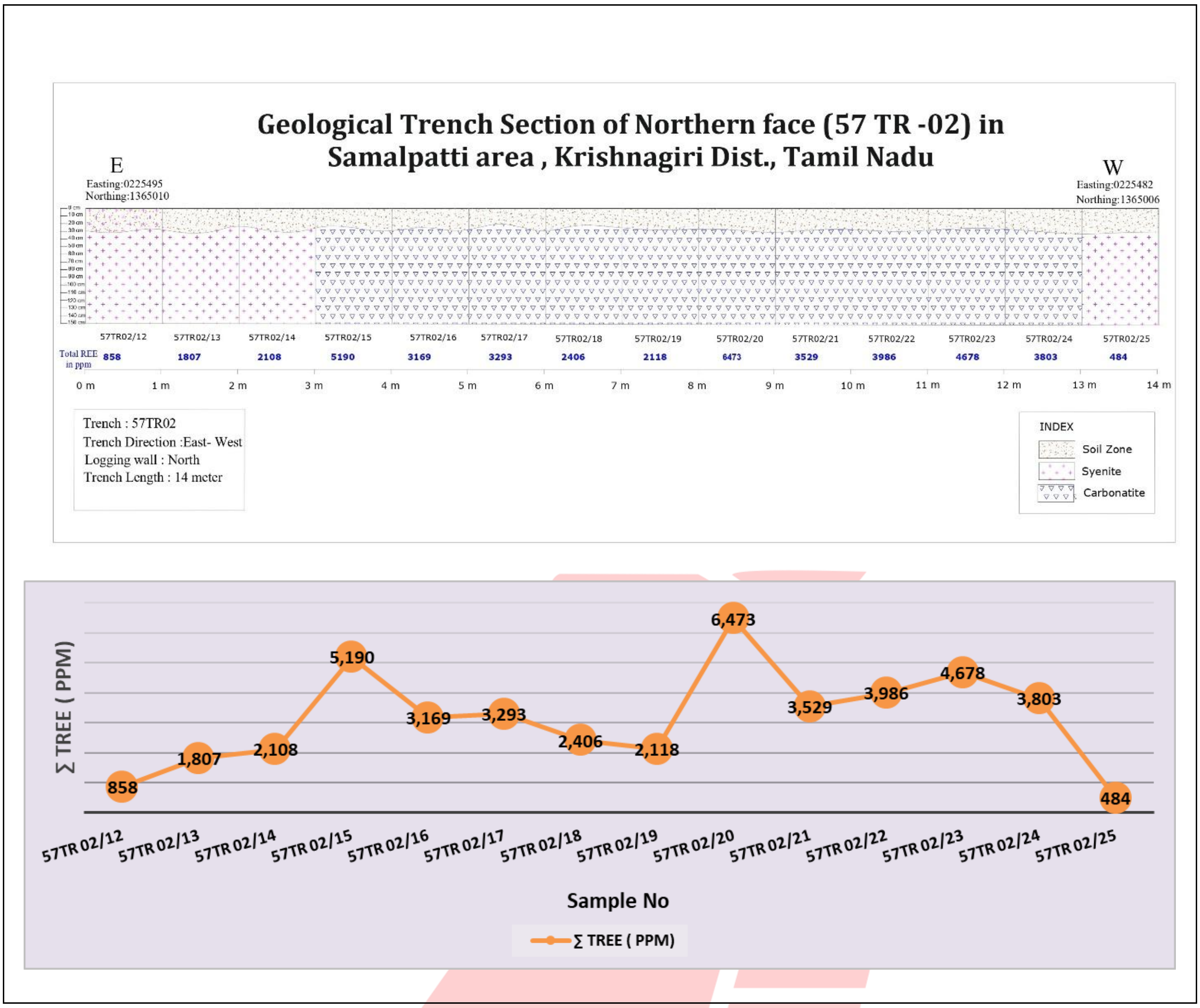


Figure 33: Trench Section of 57TR-02 showing different lithologies, sample details and analysis results.

Trenches on Carbonatite band 2 in Sub block 02:

Two numbers of trenches were made in sub block 02 in order to establish continuity of East west trending Carbonatite band 2 which is established to a length of 220m over width of 10m through LSM works.

a) **Trench 57TR03 (Sub-Block 02)**

- The trench TR-03 was located 100m further north of the BRS sample 57BRS-43, which as yielded the total REE value of 4,141 ppm, Trench 57TR03 was excavated with a total length of 11m width of 1m and depth of 1.5m and is oriented in a North- South Direction.

Figure 34: Field photograph of Trench 03

- The trench exposed syenite from 0–5 m and 9–11 m, whereas carbonatite occurs between 5–9 m, indicating a carbonatite width of 4 m in this trench.
- A total of 11 groove samples were collected at 1 m intervals and analysed for TREE. The analytical data reveal enrichment of REE values within the carbonatite zone. The weighted average TREE value for trench 57TR03 in carbonatite zone is **4,993.18 ppm (5 to 9m)**. The 7 samples of syenite indicated TREE value ranging from 704 to 4,512 ppm. The trench section and corresponding geochemical distribution are shown in Figure 35.

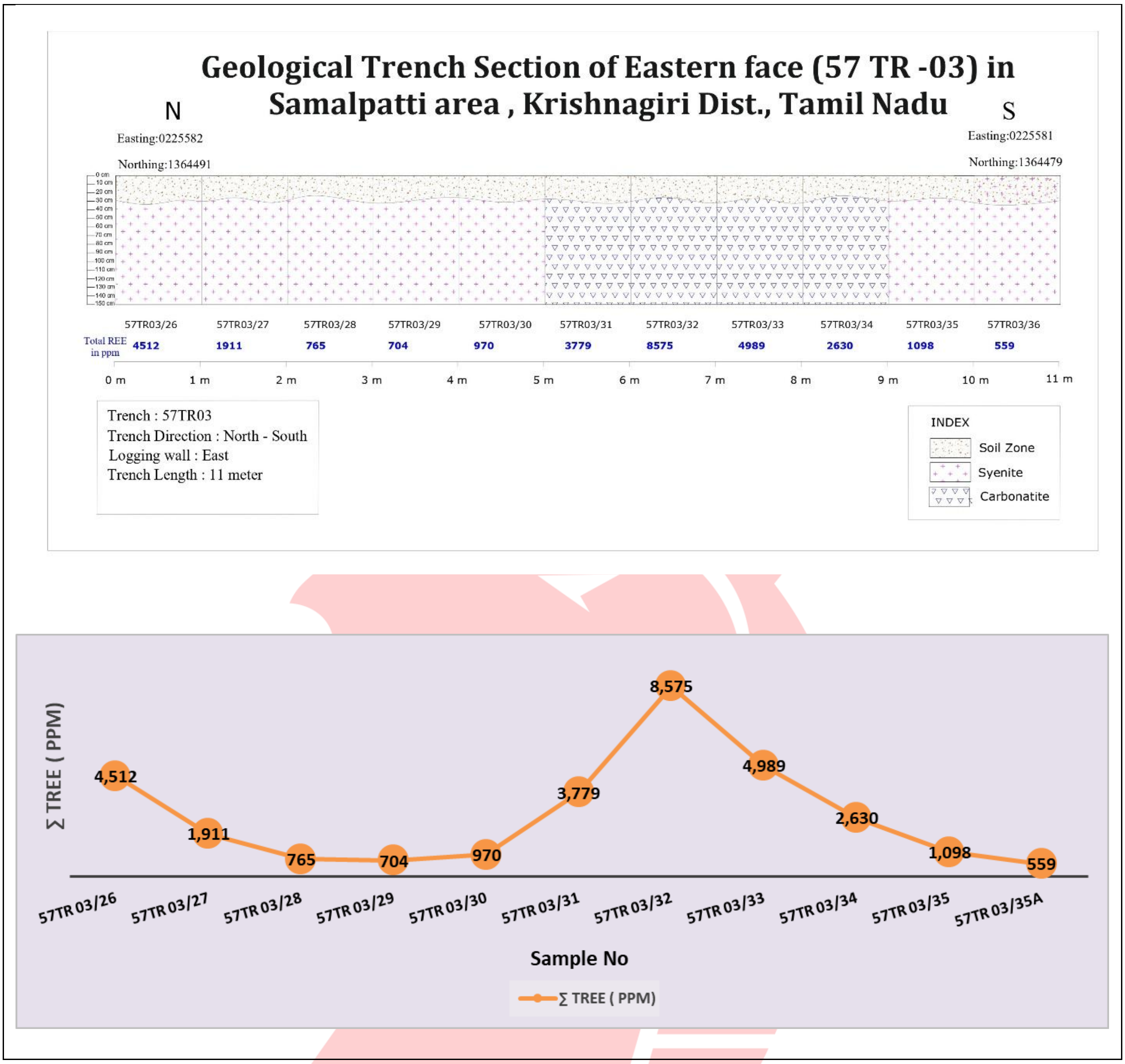


Figure 35: Trench Section of 57TR-03 showing different lithologies , sample details and analysis results.

b) Trench 57TR04 (Sub-Block 02)

- The trench TR-04 was chosen between BRS-44 and BRS-45 which are indicating BRS TREE value of 3,033 and 1,514 ppm respectively.
- Trench TR04 was excavated with a total length of 22 m with width of 1 and to a depth of 1.5m and is oriented in a North – South direction.

Figure 36: Field photograph of Trench 04

- The trench predominantly exposed carbonatite from 0–21 m, with syenite occurring at 21–22 m. This indicates a substantial carbonatite width of approximately 21 m in this trench, suggesting significant lateral continuity of the carbonatite body within Sub-Block 02.
- Systematic groove sampling at 1 m intervals was carried out across the trench. The analytical results indicate consistent REE mineralization within the carbonatite section. The weighted average TREE value for trench TR04 in carbonatite zone is **4,339.03 ppm (0 to 21m)**. The trench lithological section along with TREE variation is presented in Figure 37.
- Initial run meter of trench ie 0 to 1 and 1 to 2 m has indicated TREE value of 9,280ppm and 9,511ppm respectively. Full width of carbonatite – finite zone towards northern portion of trench was not established mainly due to presence of mango plantation and objections of land owners for further extension towards Northen direction.

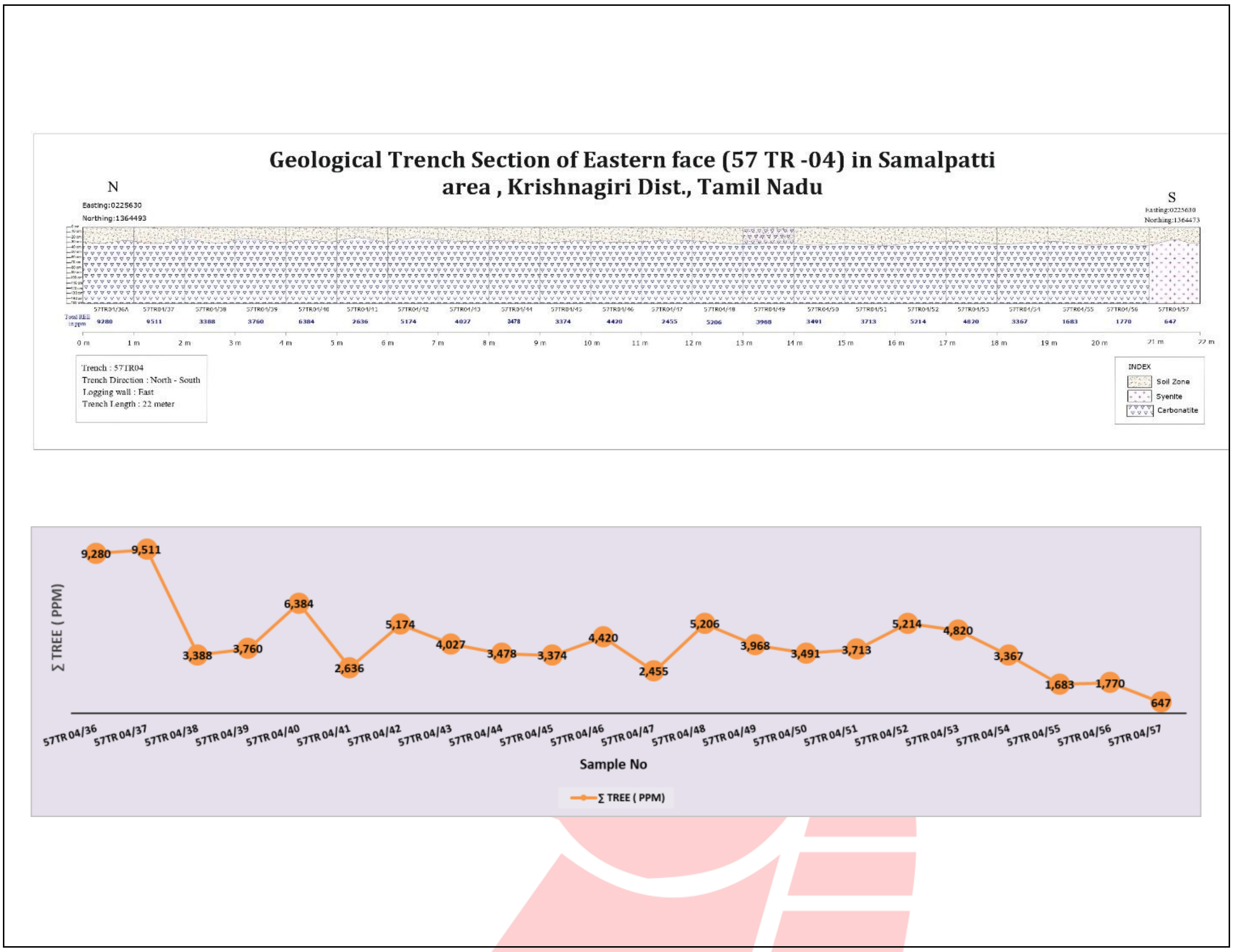


Figure 37: Trench Section of 57TR-04 showing different lithologies , sample details and analysis results.

10.6 Strike length and width of anomalies identified on the basis of geology, geochemical, geophysical exploration

Based on the Large-scale Geological mapping, trenching and corresponding chemical analysis, two carbonatite bodies viz Band 1 and Band 2 with dimension of 220m X 15m and 340m X 21m respectively are considered as anomalous zones for further investigation.

Statistical analysis of Carbonatite band 1 (BRS and trench sample values) shows mean TREE value ranging from 2,117.90ppm to 10,372.22ppm with mean value of 4,761.16ppm (Table 17).

Table 17: Statistical analysis of REE values of Carbonatite Band 1(BRS and Trench values).

	T-HREE (ppm)	T-LREE (ppm)	T-REE (ppm)
Mean	329.26	4,431.90	4,761.16
Median	317.23	3,825.73	4,135.79
Range	326.30	8,185.06	8,254.32
Minimum	165.70	1,809.27	2,117.90
Maximum	492.00	9,994.33	10,372.22
Count	26.00	26.00	26.00

Statistical analysis of Carbonatite band 2 (BRS and trench sample values) shows mean TREE value ranging from 1514.24 ppm to 9511.41 ppm with mean value of 4,187.75ppm (Table 18).

Table 18: Statistical analysis of REE Values of Corbonatite Band 2(BRS and Trench values).

	T-HREE (ppm)	T-LREE (ppm)	T-REE (ppm)
Mean	276.75	3,910.99	4,187.75
Median	253.00	3,490.40	3,760.10
Range	474.63	7,668.81	7,997.17
Minimum	121.75	1,392.49	1,514.24
Maximum	596.38	9,061.30	9,511.41
Count	31.00	31.00	31.00

From the bed rock sampling and trench sampling it was revealed that anomalous REE distribution is present in carbonatite and some times in syenite. Accordingly, the carbonatite zones are considered as REE mineralised zones and was planned to test the REE distribution at depths.

10.7 Ground Geophysical exploration: Ground geophysics is not the part of approved NMET quantum.

10.8 Topographic Survey: Topographic survey works is not the part of approved NMET quantity.

11. Location of data point.

11.1 Accuracy and quality of survey used to locate block boundary and drill holes.

Survey work of the block is carried out by establishing Base station (BASE) using IGA data of IISc Bangalore with 08 hrs observations. GS-16 rover (01 no), GS-18 rover (02 nos) and CS – 20 Controllers (03 nos) of Leica make are used for carrying out the survey works.

On completion of drilling work the boreholes were sealed with concrete and collar details were established. All borehole points were surveyed with DGPS instrument. DGPS survey was carried out from Base Station (BASE) which was set on north of Sub block 2 inside agriculture land. Each borehole points were established at Site by using DGPS static system with around 2 hours of observation. DGPS report of borehole points is enclosed at *Annexure 16*.

Figure 38: DGPS instrument established at Base point

Figure 39: DGPS instrument established at Borehole 1

Figure 40: DGPS instrument established at Borehole 2

11.2 Quality and adequacy of topographic control

The Block Base station (BASE) was established by DGPS instrument using IGA data of IISc Bangalore with around 8hrs observations. Borehole points were surveyed by DGPS with 2 hours of observations.

12. Sampling technique

Details with respect to nature and quality of sampling (eg. Cut channels, random chips, etc) and measures taken to ensure sample representation are provided in chapter no. 14.1 and 14.2.

13. Drilling technique and drill sampling employed

13.1 Drilling Planning

Based on the encouraging results obtained from geological mapping and trenching, a scout drilling programme was undertaken in Sub block 1 and Sub block 2 to further evaluate the carbonatite bodies (band 01 and 02) at depth. The primary objective of drilling was to intersect the carbonatite bands at an approximate vertical depth of 30m (1^{st} level of intersection) and to assess their continuity and grade variation below the surface.

In sub block 1, carbonatite body 1 was delineated over a strike length of about 220m with an average width of nearly 15m, trending in a north–south direction. Two trenches (Trench 1 & 2) excavated across this body yielded promising TREE values of 6647.23ppm to a length of 8m (from 1 to 9m) and 3864.52ppm to a length of 10m (from 3 to 13m). These results indicated significant surface REE values and justified the planning of drill holes to verify the depth persistence of carbonatite band traced on the surface and REE mineralization at depth and to better understand the geometry of the body.

Similarly, in Sub Block 2, Carbonatite Body 2 extends for approximately 340m along strike with an average width of about 21m, trending east–west. Trenching carried out across this body returned weighted average TREE values of 4,993.18ppm over 4m (5-9m) in Trench 3 and 4339.03ppm over 21m (0-21m) in Trench 4. The variation in trench grades suggested a reasonably consistent REE mineral bearing zone, warranting systematic drilling to evaluate its subsurface continuity and thickness and REE content in them.

Overall, the drilling programme was carefully designed to build upon the trench results, confirm the depth continuity of carbonatite bands beyond the 30m vertical depth from the surface and so also the REE mineralization, and generate reliable subsurface data for further resource estimation and exploration planning.

13.2 Methodology of drilling with type of drilling

The systematic drilling was taken up in block with the diamond core drilling to drill and intersect the mineralization zones at 1st level of intersections at 30m.

Figure 41: Core drilling machines deployed at site

13.3 Drill rod & casing setup

Drilling was carried out using rotary diamond core drilling with HQ and NQ core size.

13.4 Borehole planning (spacing of boreholes, level of intersection), co-ordinates and RL's of collar

Against the total NMET approved quantity of 500m, core drilling of the block is completed with 140m with 2 boreholes with 1st level of intersection (30m vertical depth). Details of the boreholes drilled along with respective meterage drilled and coordinates are provided in the below table (Table 19);

Table 19: Details of borehole drilled in Samalpatti block (DGPS data)

Sl	Sub block	BH No	BH Direction	BH Angle	Level of intersection	Section line	Easting	Northing	Latitude	Longitude	RL	Drilled meterage
1	Sub Block 1	SRB -01	90°	50°	1st (30m)	A-A'	225490	1364951	12° 20' 07.98402" N	78° 28' 33.18483" E	426.622	**70.0**
2	Sub Block 2	SRB -02	180°	50°	1st (30m)	B-B'	225630	1364509	12° 19' 53.65535" N	78° 28' 37.94150" E	426.775	**70.0**
3			**Total**									**140.0**

Geology plan with boreholes drilled location in sub block 01 and 02 is enclosed as Plate 4a.

Boreholes SRB 01 and SRB 02 were positioned on the southern and eastern peripheries of Bands 1 and 2 respectively. This placement was necessary as both bands are located within extensive mango plantations, where exploration activities were restricted due to local landholder objections. (Ref fig no 42)

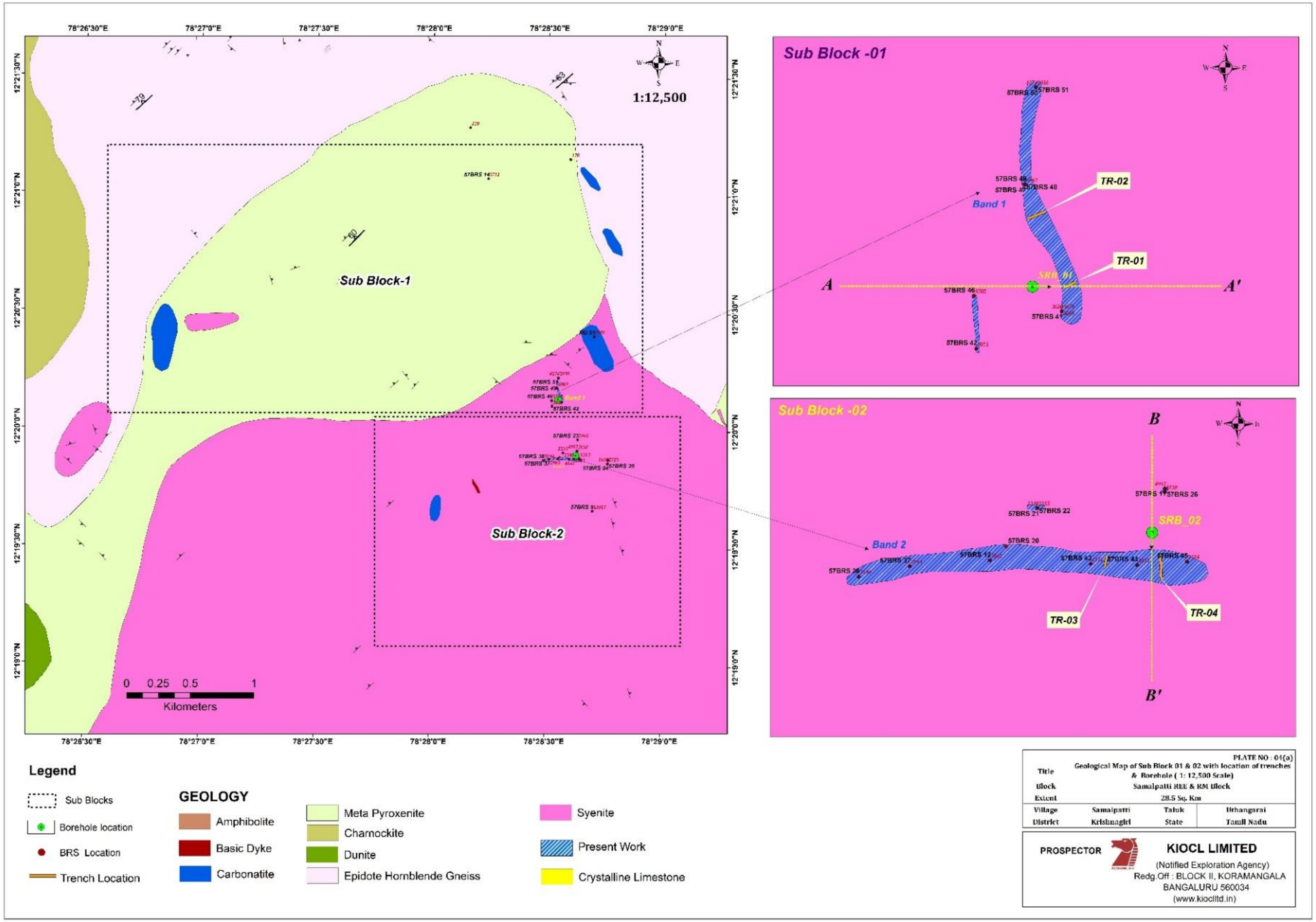


Figure 42: Geology map with drilled borehole locations

Borehole SRB-01

Borehole SRB-01 was planned and executed in Sub Block 1 to test the subsurface continuity of Carbonatite Body 1. The borehole was drilled for 1st level of intersection (30m) at an inclination of 50° with an azimuth of 90°. Borehole was drilled for total inclined depth of 70 m.

Hard rock was encountered from a borehole depth of 17m onwards. The lithology intersected is predominantly syenite, intruded by occasional minor carbonate veins. No significant variation in rock type was noted beyond these carbonate vein intrusions.

The summarized lithological details of Borehole SRB-01 are presented below (Table 20):

Table 20: Lithological Summary of SRB-01

LITHOLOGICAL SUMMARY: SRB 01		
From (m)	**To (m)**	Lithology
0.00	3.00	Red soil
3.00	17.00	Syenite + pyroxenite: Weathered pale brown to yellowish brown in colour. Medium to coarse grained rock, Feldspars show alteration to clay (kaolinization), chips of pyroxenite also observed at places. Carbonatite – brownish yellow, ankerite at depth (16.80- 17 m)
17	18	Syenite + pyroxenite: Greyish white medium grained rock containing quartz, occasional feldspar and green colour radiating amphibole minerals (aegirine, riebeckite) also veins of apatite with calcitic (4cm), fractures are filled with sulphides (pyrite and chalcopyrite)
18	70	Fenitised zone (altered syenite, dolomitic carbonatite) Greyish white, medium-grained rock showing mixed (hybrid) nature. Mainly composed of quartz and biotite, with occasional feldspar. Green coloured radiating amphibole minerals (aegirine) are present at places, fenitisation is observed. Frequent quartz veins and carbonate (calcite) veins observed. Apatite veins also seen in some sections. Rock shows variation — at places pyroxenite, at places syenitic, and occasional carbonatite patches. Core is fractured, and fractures are filled with sulphides (pyrite and chalcopyrite).

Totally 60 nos of core samples from 10m to 70m were analysed for REE and RM.

Statistical analysis of Borehole SRB 01 for REE indicates T-REE value ranging from 327.82ppm to 8,204.00ppm with mean value of 3,409.27ppm. It is observed that the T LREEs make up approximately 95% of the total REE content with mean value of 3,235.33ppm. Statistical analysis of borehole (SRB01) is provided in the below table (Table 21).

Table 21: Statistical analysis of Borehole SRB-01

	REE			RM			
	Total H-REE	**Total LREE**	**Total REE**	**Sc**	**Nb**	**Ta**	**Mo**
Mean	173.94	3,235.33	3,409.27	25.92	9.70	2.46	1.52
Median	168.09	2,888.87	3,076.50	22.41	8.73	2.06	1.06
Range	342.46	7,685.34	7,876.19	85.50	28.25	7.18	23.33
Minimum	47.67	280.14	327.82	3.09	1.75	0.50	0.17
Maximum	390.13	7,965.49	8,204.00	88.59	30.00	7.68	23.50
Count	60.00	60.00	60.00	60.00	60.00	60.00	60.00

The total LREE concentration of 3,235.33ppm is primarily driven by three key elements: **Cerium (1615.67 ppm)**, **Lanthanum (905.75 ppm)**, and **Neodymium (458.96 ppm)**. TLREE elemental pie chart of SRB -01 is provided below (Fig 43);

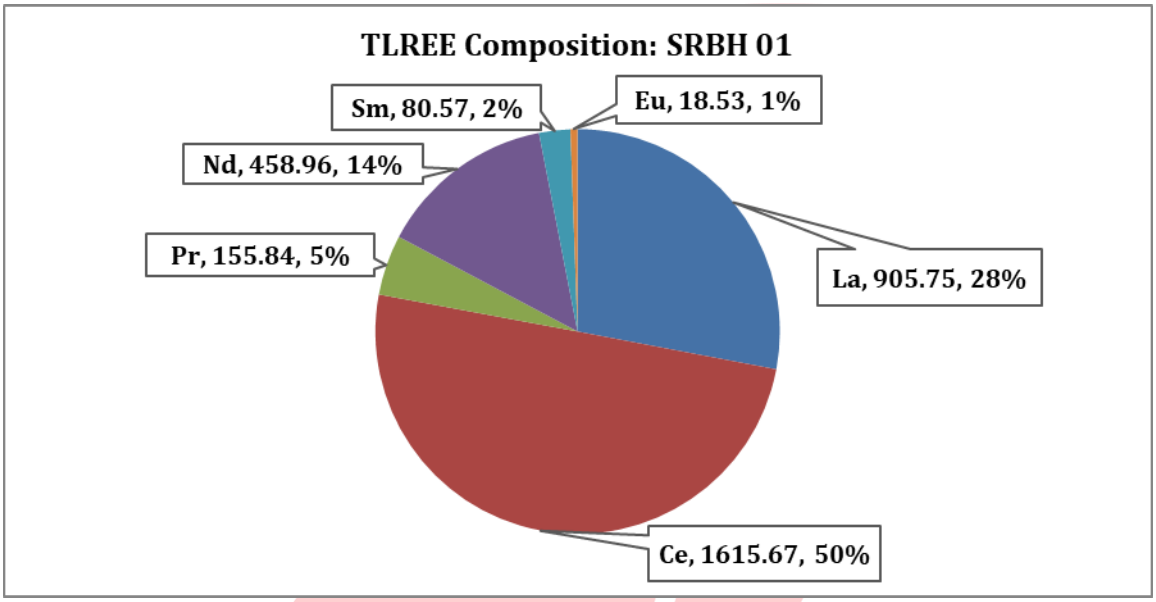


Figure 43: TLREE elemental pie chart of SRB 01

Borehole SRB-02

Borehole SRB-02 was planned and executed in Sub Block 2 to test the subsurface continuity of Carbonatite Body 2. An inclined borehole was drilled at 50 ° angle at an azimuth of 180 °to achieve a vertical intersection of approximately 30 m. Borehole was drilled for inclined depth of 70 m.

Hard rock was encountered from a borehole depth of 26 m onwards. The lithology intersected is predominantly syenite, with occasional minor carbonate veins observed within the host rock.

The summarized lithological details of Borehole SRB-02 is presented below (Table 22):

Table 22: Lithological Summary of SRB-02

LITHOLOGICAL SUMMARY: SRB 02		
From (m)	**To (m)**	**Lithology**
0.00	3.00	Red soil
3.00	24.00	Weathered syenite: pale brown to yellowish brown in colour. Medium to coarse grained rock, Feldspars show alteration to clay (kaolinization), chips of pyroxenite also observed at places.
24.00	27.00	pyroxenite
27.00	33.00	Mixed syenite + pyroxenite
33.00	43.00	Fenitised pyroxenite
43.00	70.00	Fenitised syenite _ Pyroxenite with calcic carbonatite :Greyish white, medium-grained rock showing mixed (hybrid) nature. Mainly composed of quartz and biotite, with occasional feldspar. Green coloured radiating amphibole minerals (aegirine/riebeckite) are present at places, fenitisation is observed. Frequent quartz veins and carbonate (calcite) veins observed. Apatite veins also seen in some sections. Rock shows variation, at places pyroxenite, at places syenitic, and carbonatite patches. Core is fractured, and at places fractures are filled with sulphides (pyrite and chalcopyrite).

Both the boreholes SRB 01 and SRB 02 were terminated at a depth of 70 m due to encountering hard rock from 50m onwards. Initial field logging data at end run meters (70m) of both the boreholes indicates syenite core with minor intercalations of calcite (showing very feeble effervescence) along with pyroxenite. Hence, no further drilling were continued. However, petrological analysis confirmed the lithology in SRB 02 at depth 53.00m to be calcitic carbonatite. Hence, entire hard core recovered from both the boreholes were sampled and analysed. End run meters (69 to 70m) of boreholes SRB 01 and 02 shows TREE values of 3472.75 ppm and 3,624.29 ppm respectively.

Totally 50 nos of core samples (from 12m to 16m and from 24m to 70m) were analysed for REE and RM. Statistical analysis of Borehole SRB 02 for REE indicates T-REE value ranging from 403.88ppm to 12,596.61ppm with mean value of 3,815.22ppm. It is observed that the T LREEs make up approximately 93% of the total REE content with mean value of 3,574.21ppm. Statistical analysis of borehole (SRB02) is provided in the below table (Table 23).

Table 23: Average chemical analysis value of Borehole (SRB-02)

	Total H-REE	Total LREE	Total REE	Sc	Nb	Ta	Mo
Mean	241.01	3,574.21	3,815.22	23.40	19.89	3.96	0.67
Median	227.67	2,468.90	2,739.42	15.49	11.40	3.10	0.50
Range	459.46	11,733.27	12,192.73	105.67	68.38	10.50	2.24
Minimum	51.11	352.77	403.88	1.33	2.62	0.50	0.00
Maximum	510.57	12,086.04	12,596.61	107.00	71.00	11.00	2.24
Count	50.00	50.00	50.00	50.00	50.00	50.00	50.00

The mean total LREE concentration of 3,574.21ppm is primarily driven by three key elements: **Cerium (1767.42 ppm)**, **Lanthanum (947.27 ppm)**, and **Neodymium (539.52 ppm)**. TLREE elemental pie chart of SRB -01 is provided below (Fig 44);

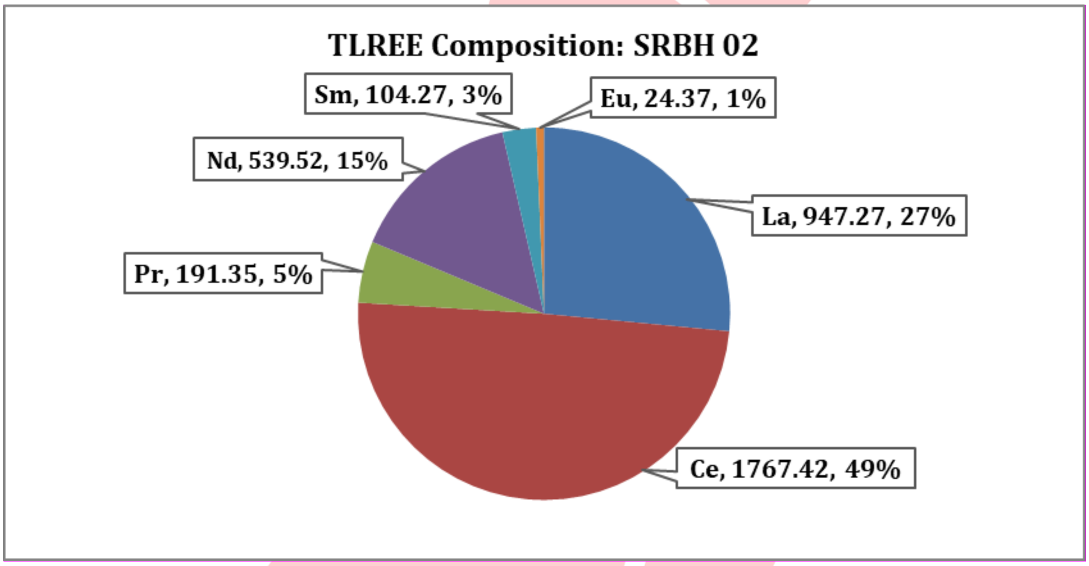


Figure 44: TLREE elemental pie chart of SRB 02

Lab chemical analysis report of borehole samples (SRB 01 & 02) and borehole sample analysis report indicating LREE & HREE is provided in Annexure 06 & 07.

The Grade Frequency Distribution for TREE for boreholes SRB 01 and SRB 02 indicates that a significant majority of samples fall within the 2,000–3,000 ppm range. Bar chart indicating the TREE grade frequency distribution for both boreholes is provided in the below figure (Fig 45).

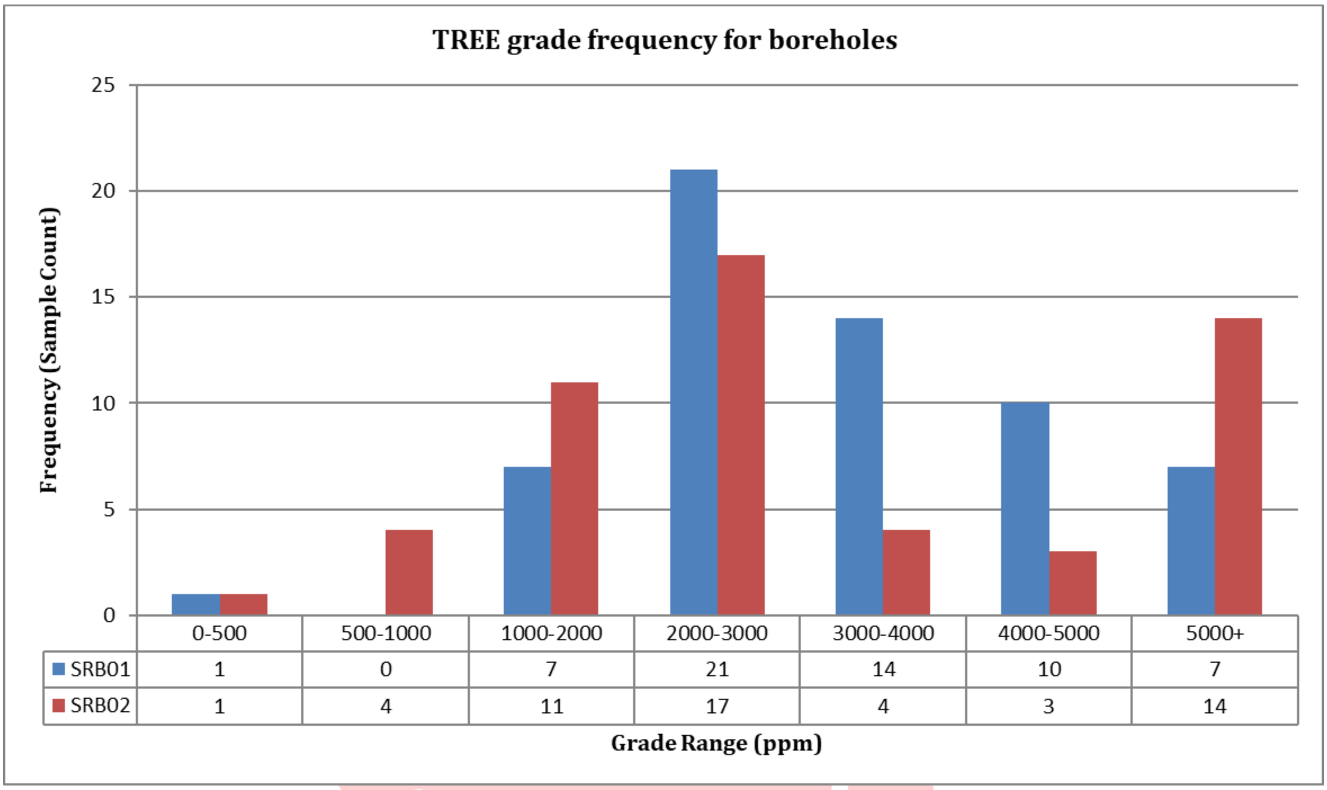


Figure 45: TLREE grade frequency for boreholes.

The available trench & borehole data indicates that REE mineralisation within the carbonatite–fenite zone is fairly uniformly distributed. REE values are generally highest in carbonatite-rich zones and show gradual reduction toward the adjacent wall rocks, such as syenite and pyroxenite, suggesting a zoned mineralised corridor rather than isolated patchy enrichment. The preliminary frequency distribution (Figure 45) also appears broadly 'bell-shaped', indicating a near-symmetric to only slightly skewed grade population towards left, although this requires further statistical validation.

The Nb-Ta Correlation plots display a positive linear relationship across both the boreholes, which is a diagnostic indicator of their common geochemical behaviour in these geological settings, confirming that these elements are likely hosted within the same mineral phases. Scattered plot indicating the correlation of SRB 01 and SRB 02 for Ta and Nb are provided in the below figures (Fig 46 & 47 respectively).

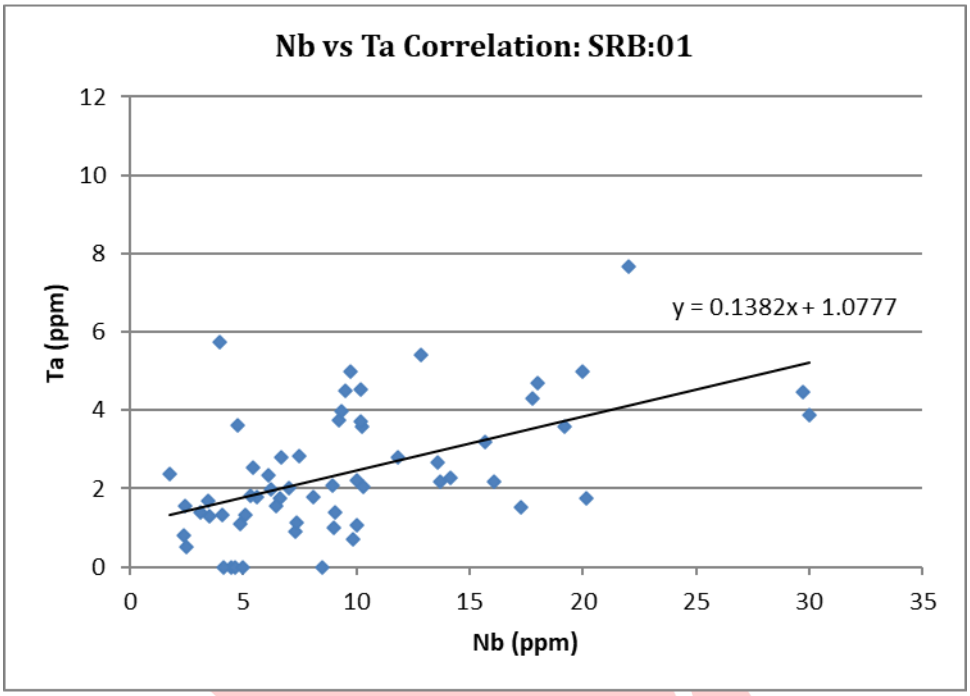


Figure 46: Ta & Nb correlation for SRB 01

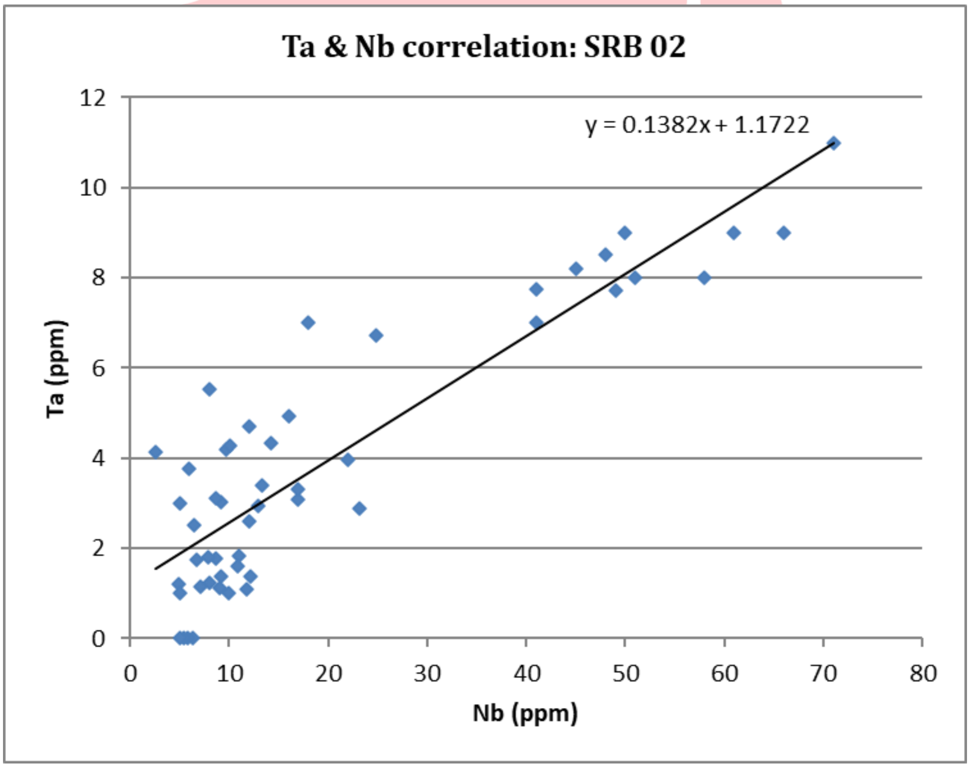


Figure 47: Ta & Nb correlation for SRB 02

The above graphs for both boreholes shows positive correlation indicating thick carbonatite in the vicinity.

The positive correlation between Total REE and Yttrium (Y) is observed for both boreholes. Scattered chart indicating correlation of TREE vs Y for SRB 01 and SRB 02 are provided in Figure no. 48 and 49 respectively.

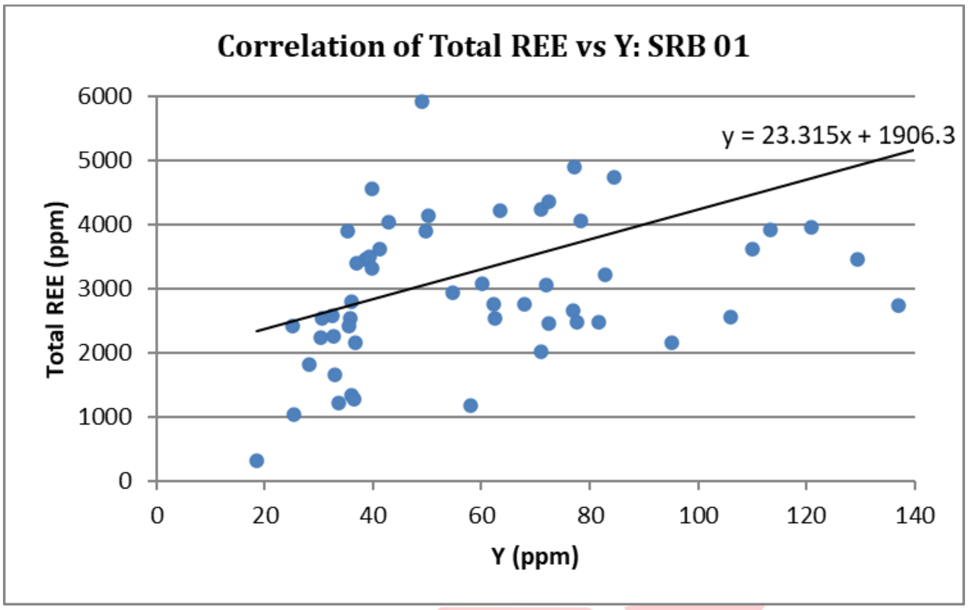


Figure 48: Correlation of TREE vs Y: SRB 01

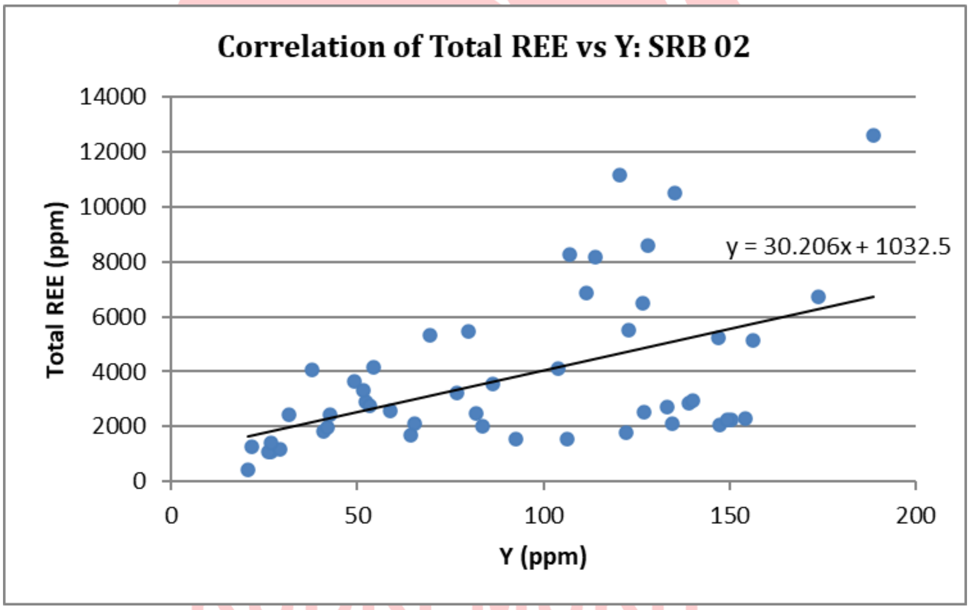


Figure 49: Correlation of TREE vs Y: SRB 02

SRB 01 indicates broad and dispersed pattern indicating weak to moderate positive trend. SRB 02 indicates strong positive correlation. Strong Nb- Ta correlation indicate magmatic nature, and weak correlation indicate hydrothermal activity or remobilisation.

Total REE Vs Y : REE enrichment in SRB 02 is primary magmatic and more continuous whereas that in SRB 01 is structurally controlled and remobilised.

The total REE vs. Depth profiles shows significant vertical heterogeneity, characterized by distinct zones of high-grade enrichment that suggest localized structural or stratigraphic control over mineralization. Together, these relationships imply that REE enrichment is not uniform but concentrated in specific geological horizons, where Yttrium acts as a pathfinder element for tracking the overall intensity of mineralizing events. Chart indicating comparison of TREE vs Depth of SRB 01 and 02 are provided in the below figures (Fig 50 & 51);

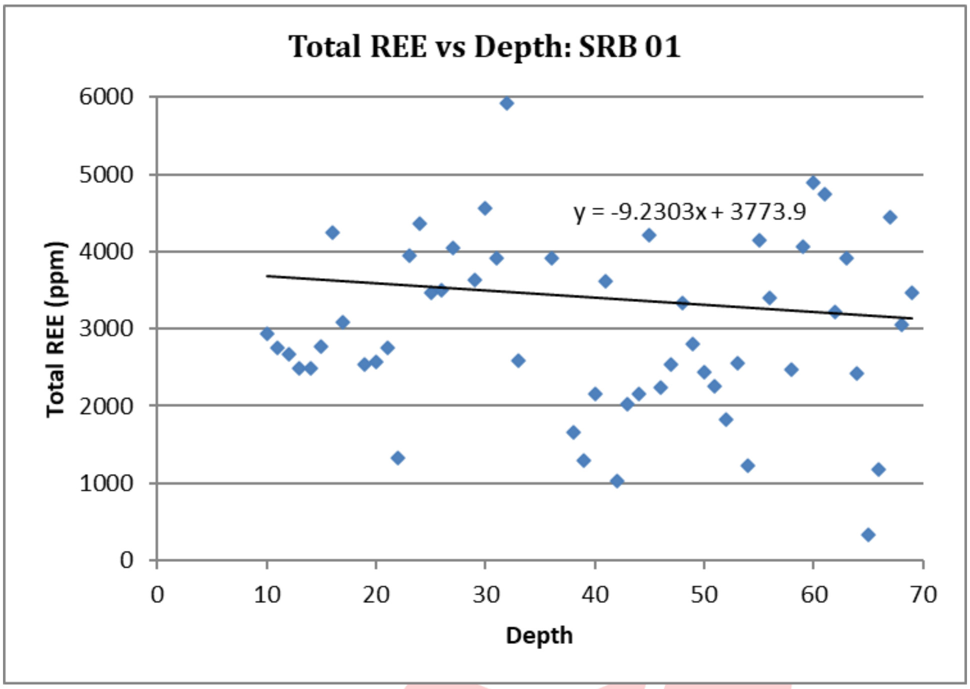


Figure 50: Comparison of TREE vs Depth: SRB 01

Irregular scatter broad negative slope no vertical zonation hence mineralisation is patchy, discontinues indicating a hybrid rock. (Fig 50)

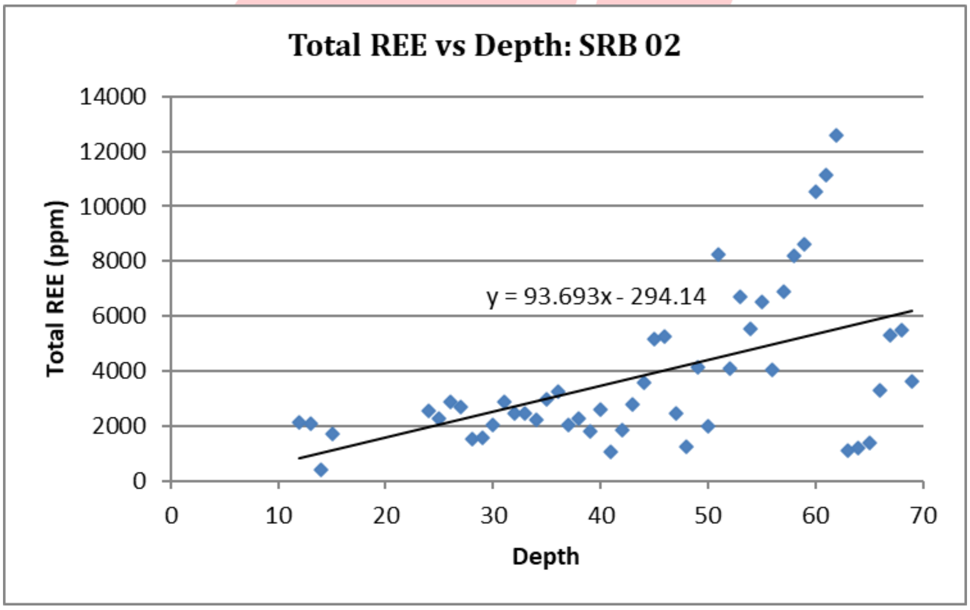


Figure 51: Comparison of TREE vs Depth: SRB 02

Positive trend enrichment with depth mineralization is systematic , magmatic with structurally control of with vertical grade zonation (Fig 51)

13.5 Borehole Logging

The cores are properly logged in detail for identifying lithology, mineralization, core recovery and structural features. The run length and RQD observation are recorded. Detailed lithological description of boreholes is provided in Annexure 14.

13.6 Core Recovery

Overall core recovery of 93.89% is achieved in both drilled boreholes. Core loss has occurred in starting run meters in weathered formation but the geological objective has been fulfilled. Details of average core recovery and average RQD% achieved is provided in table no 24.

13.7 Geotechnical studies on borehole core samples of mineralised zone.

In borehole SRB-01, the average Rock Quality Designation (RQD) is 51.23%, while in SRB-02 it is slightly lower at 48.29%. The core recovery is very good in both boreholes, averaging 93.78% in SRB-01 and 94% in SRB-02. The detailed borehole wise RQD (%) and core recovery (%) values obtained during drilling are given below (table 24).

Table 24 : Details of core recover and RQD achieved in boreholes

Sl	Borehole No	Drilled depth (m)	Recovery %	RQD %
1	SRB-01	70	93.78	51.23
2	SRB-02	70	94.00	48.29
3	**Total / Average**	**140**	**93.89**	**49.76**

Geotechnical logging data sheet of boreholes is provided in *Annexure 14* & photographs of drill core is provided in the *Annexure 15.*

13.8 Major oxide analysis

The major oxides analysis shows compositional transition between surface and subsurface environment. Bedrock and trench samples are characterized by a high carbonate content, with calcium oxide (CaO) averaging 28% and elevated loss on ignition (LOI) values, suggesting a near-surface mineralogy dominated by carbonate phases. CaO value of BRS and Trench 1 & 4 are ranging from 8.07 to 46.60%. (Ref Annexure 8).

The borehole data indicates a shift toward a more stable silicate-potassic composition at depth, where silica (SiO_2) levels rise to over 51% and potassium (K_2O) concentrations increase significantly, validating observed lithological variations

Statistical analysis of BRS, Trench samples and Borehole samples are provided in the below table (Table 25).

Table 25:Statistical analysis of Major Oxides

Oxide	BRS			Trench samples			Borehole samples		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
SiO2	3.12	62.23	29.88	4.54	64.78	24.62	29.50	66.19	51.28
CaO	2.25	46.60	27.69	8.07	46.19	28.21	2.00	16.15	9.03
Al2O3	0.35	1.81	0.76	0.30	4.05	1.54	0.92	7.49	2.41
Fe2O3	0.76	8.62	4.90	3.03	15.30	8.13	2.79	16.43	7.18
MgO	0.34	4.26	1.40	0.76	4.84	2.13	0.36	6.46	2.71
K2O	0.06	5.27	1.56	0.08	1.94	0.86	1.04	10.02	4.95
LOI	1.37	39.16	22.76	6.28	38.79	23.92	1.45	13.86	6.39

13.9 Barium (Ba) Analysis & REE Correlation Summary

Based on the geochemical analysis of borehole samples from SRB-01 and SRB-02, Barium (Ba) shows notable enrichment in both boreholes. The average Ba concentration is about 11,642 ppm in SRB-01 and 10,797ppm in SRB-02. The maximum values recorded are also significantly high, reaching 41,574 ppm (4.15%) in SRB-01 and 41,066 ppm (4.1 %) in SRB-02.

Further analysis indicates that Ba has a strong positive correlation with Cerium (Ce), which is one of the major light Rare Earth Elements (LREE) in the block. The overall correlation coefficient is 0.71, and it increases to 0.78 in SRB-02, indicating a strong relationship between the two elements.

Moderate to strong positive correlation between Ba and Ce indicates, Ba enrichment is genetically linked to REE mineralization. This suggests Ba bearing phases like Barite, celestine and Ba rich REE carbonates are formed during late stage carbonatite fluid evolution. (Table 26).

Table 26: Barium (Ba) Analysis & Correlation Summary

Parameter	SRB-01	SRB-02
Average Ba Concentration	11,642.795 ppm	10,797.675 ppm
Maximum Ba Value	41,574 ppm (4.15%)	41,066 ppm (4.1 %)
Minimum Ba Value	2,803 ppm	689 ppm
Correlation with Cerium (Ce)	0.60	0.78
Sample Count	60	50

13.10 Petro, XRD and EPMA studies of BRS and borehole samples:

The study area is characterized by an alkaline carbonatite complex consisting mainly of aegirine augite bearing syenite, dolomite carbonatite, and calcite carbonatite, with a surrounding fenitized zone.

Petrographic studies indicate medium to coarse grained magmatic textures. Syenite is dominated by alkali feldspars (about 80–85%), while the carbonatite units contain 80–90% dolomite.

Mineral chemistry indicates an alkaline affinity, with aegirine-augite enriched in Na, Ca, and Fe. Petrographic evidence suggests late stage hydrothermal alteration, formation of dolomite and secondary minerals such as potassic-richterite, fibrous phlogopite, and baryte.

REE mineralization is mainly associated with phosphate and carbonate phases, where REEs released during alteration of dolomite and fluorapatite have reprecipitated as monazite and REE carbonate.

Polished thin section, XRD studies report and EPMA report of IIT, Bombay is enclosed as Annexure 18.

List of samples indicating locations along with mineral phases established through EPMA studies is enclosed as Annexure 17.

13.11 REE Spider Diagram Normalized to McDonough & Sun (1995) CI Chondrite

13.11.1 Spider Diagram for Bed Rock Samples (BRS) and Trenches

The REE distribution in the BRS and trench samples, when normalized to the McDonough & Sun (1995) CI Chondrite standard, shows a distinctive geochemical profile characterized by extreme enrichment in LREE relative to HREE. Exhibit a steep, linear downward slope from Lanthanum (La) to Lutetium (Lu), with LREE enrichment reaching magnitudes over 2,000 times chondritic levels. The overall coherence of the spider patterns and the absence of significant Europium (Eu) anomalies suggest that the parent magma underwent minimal plagioclase fractionation and likely originated from a deep seated, mantle derived source. Spider Diagram for Bed Rock Samples (BRS) and Trenches is provided in Figure no 52 and 53 respectively.

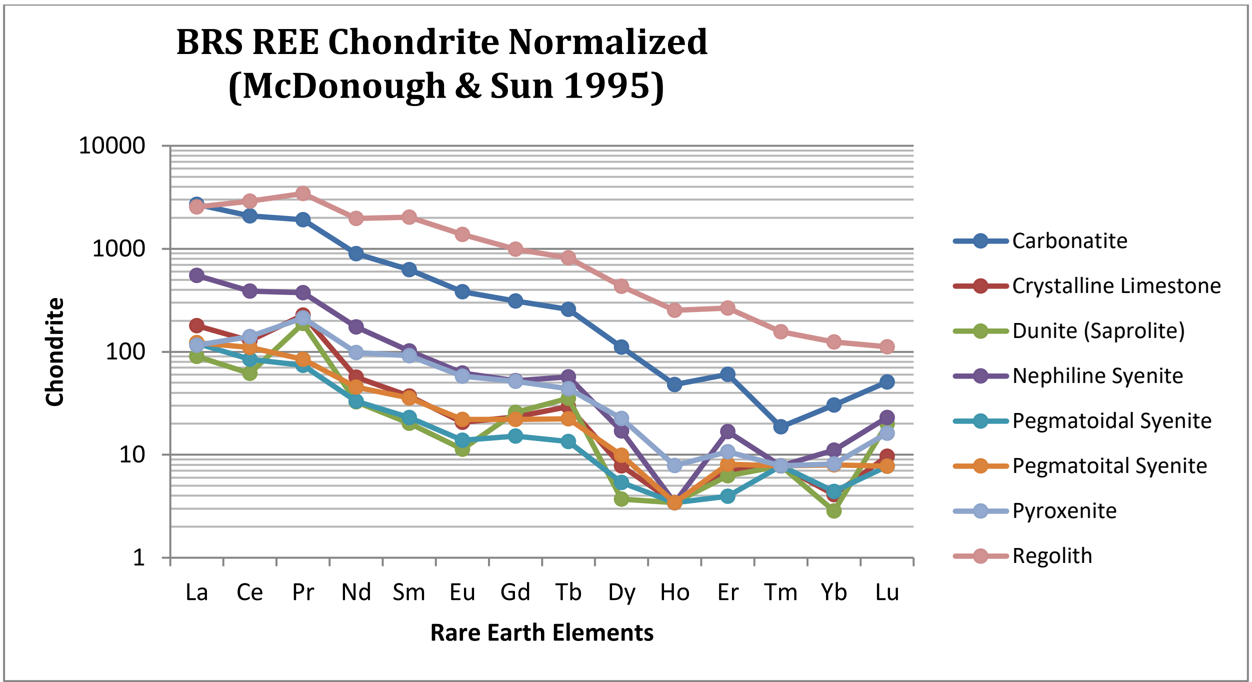


Figure 52: BRS samples Spider Diagram Normalized to McDonough & Sun (1995) CI Chondrite

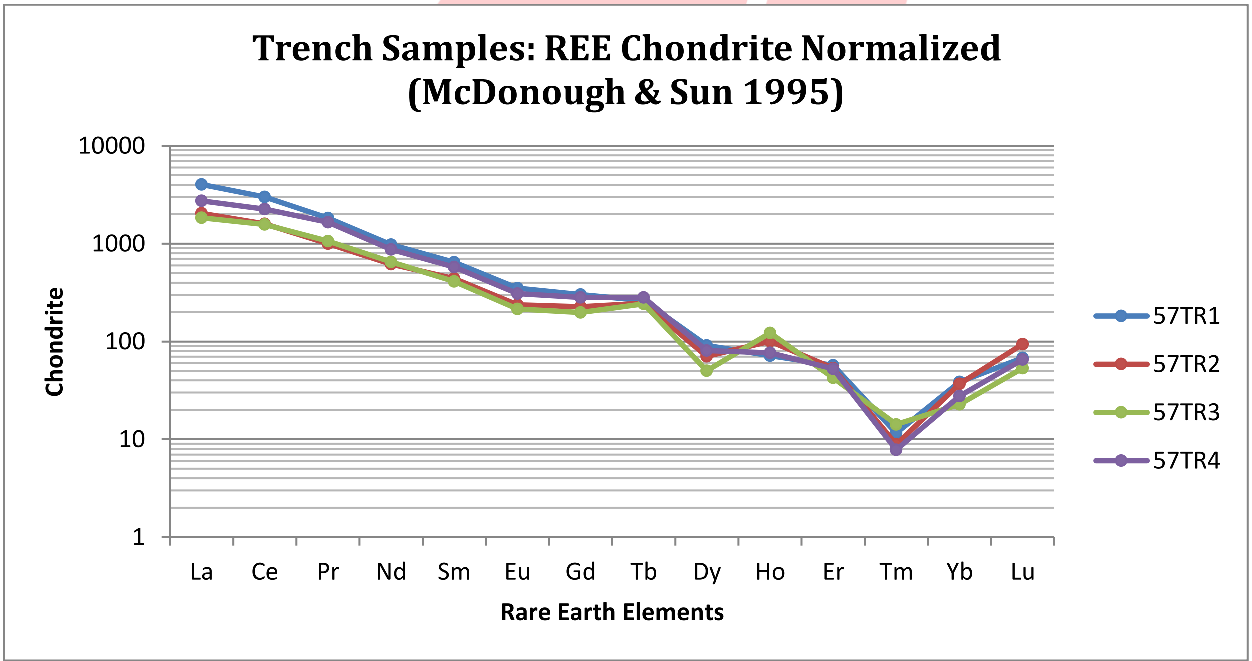


Figure 53: Trench Samples Spider Diagram Normalized to McDonough & Sun (1995) CI Chondrite

13.11.2 Spider diagram for boreholes

The Chondrite-Normalized Spider Diagrams demonstrate enrichment in Light Rare Earth Elements (LREE) relative to Heavy Rare Earth Elements (HREE), typical of fractionation patterns in the study area, while the Pie Charts highlight that Ce, La, and Nd dominate the LREE composition, whereas Y and Gd are the primary contributors to the HREE fraction. Spider Diagram for Borehole core samples is provided in the below figures (Figure 54 & 55).

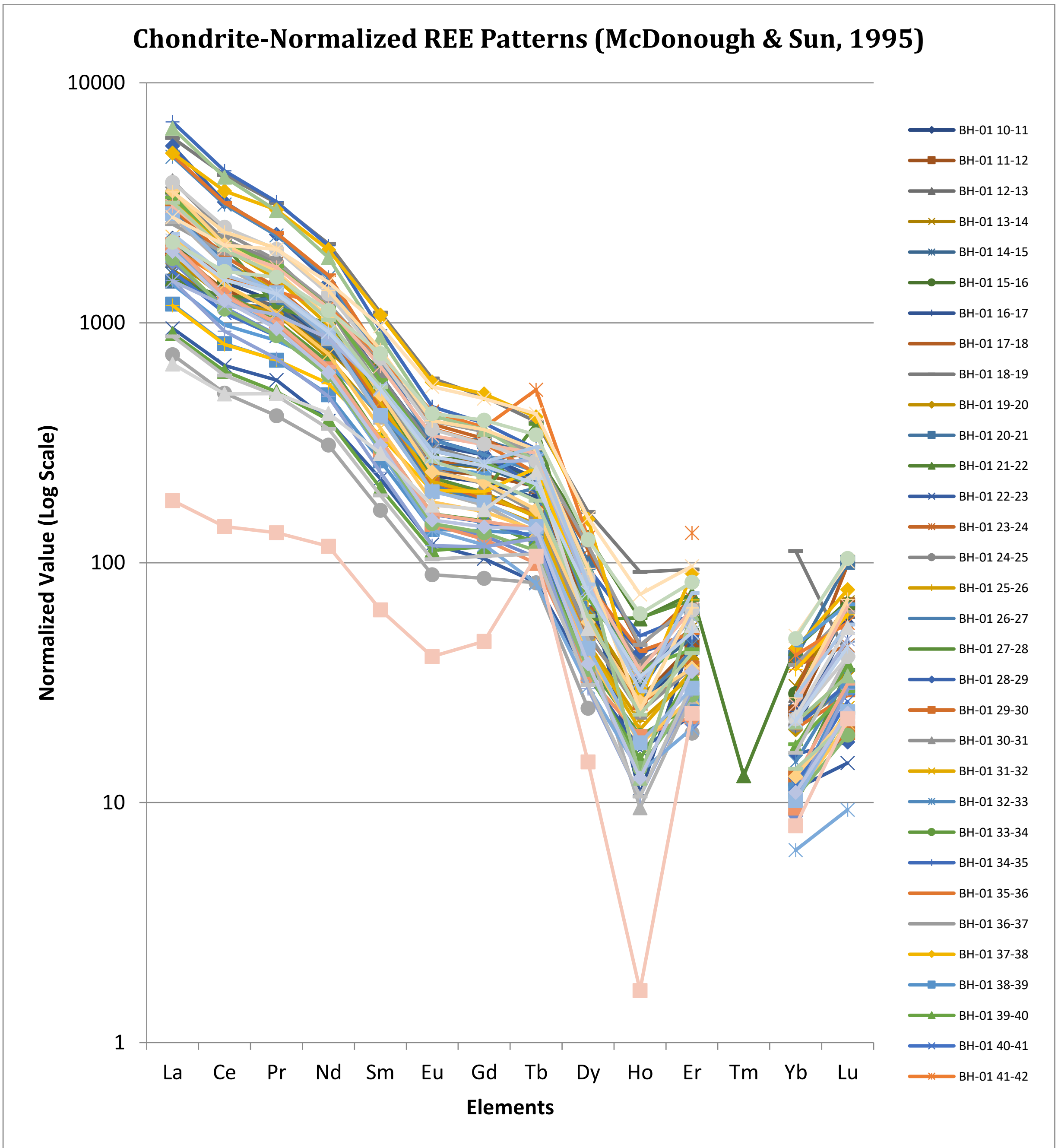


Figure 54: Borehole (SRB 01) Samples Spider Diagram Normalized to McDonough & Sun (1995) CI Chondrite

In a nutshell above plots refers to a strong LREE enrichment with steeping fractionated profiles associated with pronounced HREE depletion , the general similarly in pattern, shapes across the rocks of the block indicates a common genetic source modified by fluid related re distribution , overall the REE plots are of carbonatite – fenite hybrid zone.

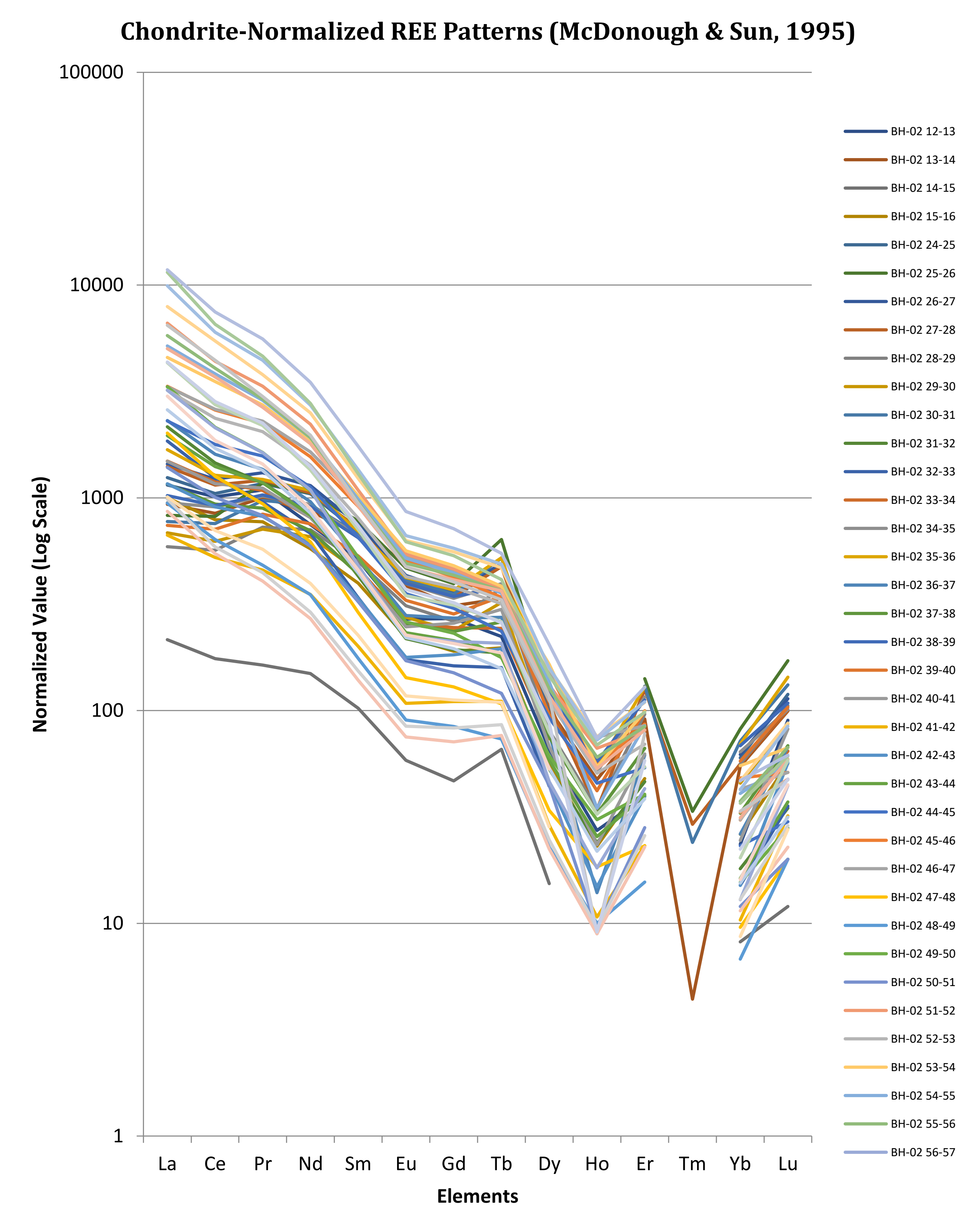


Figure 55: Borehole (SRB 02) Samples Spider Diagram Normalized to McDonough & Sun (1995) CI Chondrite

13.12 Additional Geochemical Diagrams

Additional geochemical plots attempted using borehole data for TREE Vs La,Yb,Sr, Sc &Nb to study the characterise nature of the carbonatite- finite system and associated REE mineralisation.

It is observed that plots for La shows positive trend. high TREE shows increase in element concentration of La, High concentration of both indicates primary carbonate enrichment. (Fig. 56)

Plot for TREE vs Yb shows weak correlation with significant scattering. (Fig.57). TREE Vs Nb plots no linear correlation is observed clusters occurs at Nb low levels. (Fig. 58)

In TREE vs Sc and TREE vs Sr diagram, there is moderate positive correlation Sc and scattered correlation in Sr. (Fig. 59 & 60)

In CaO vs SiO2 plot it is observed that the higher SiO_2 is towards fertile/hybrid type of rock and High CaO - low Silica is carbonatite. (Fig 61)

CaO vs TREE plot indicates enrichment of TREE values are more in CaO range of 15- 35 % and samples with low Cao shows low TREE values. (Fig.62)

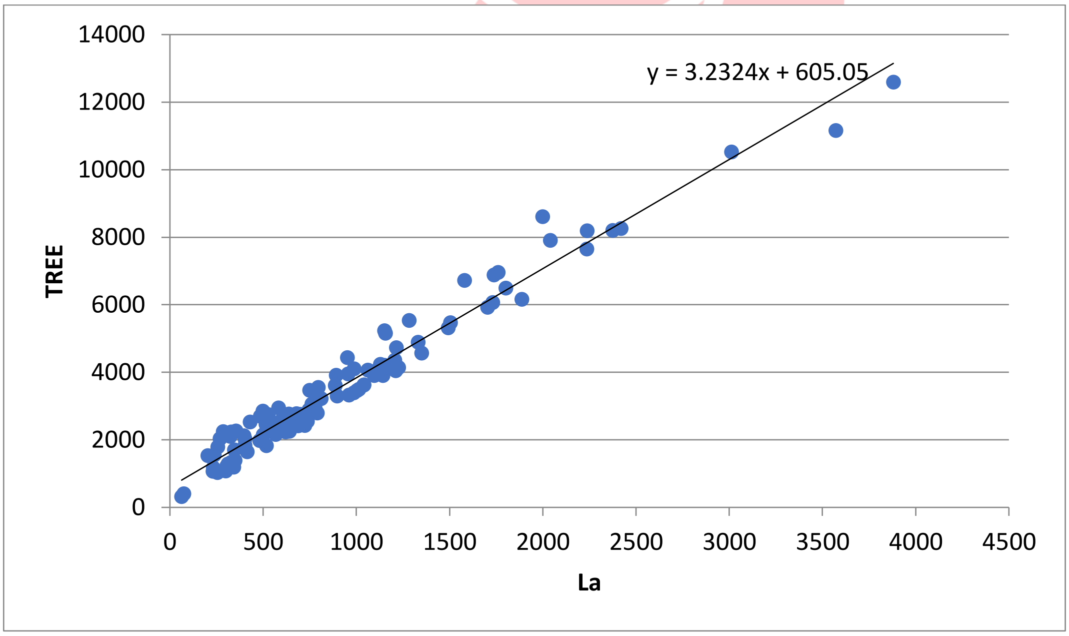


Figure 56: Scattered diagram comparing TREE Vs La

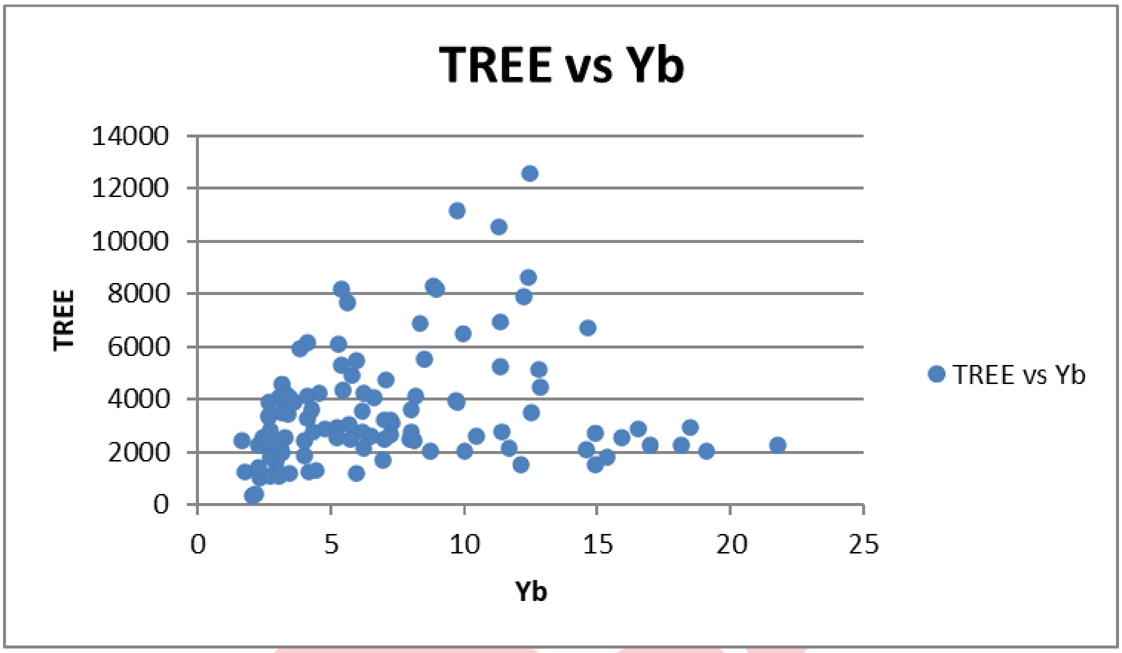


Figure 57: Scattered diagram comparing TREE Vs La

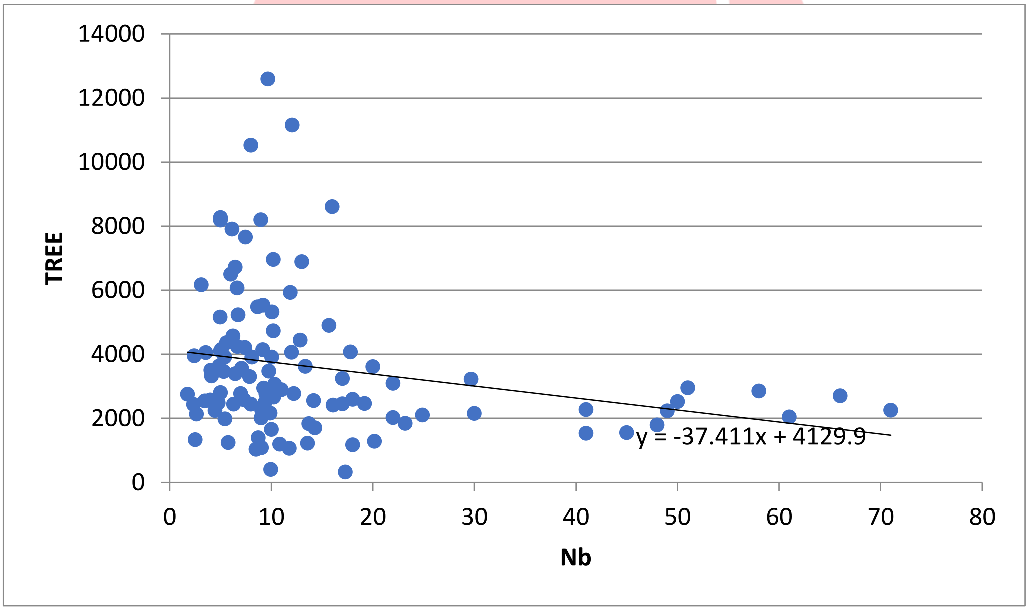


Figure 58 : Scattered diagram comparing TREE Vs Nb

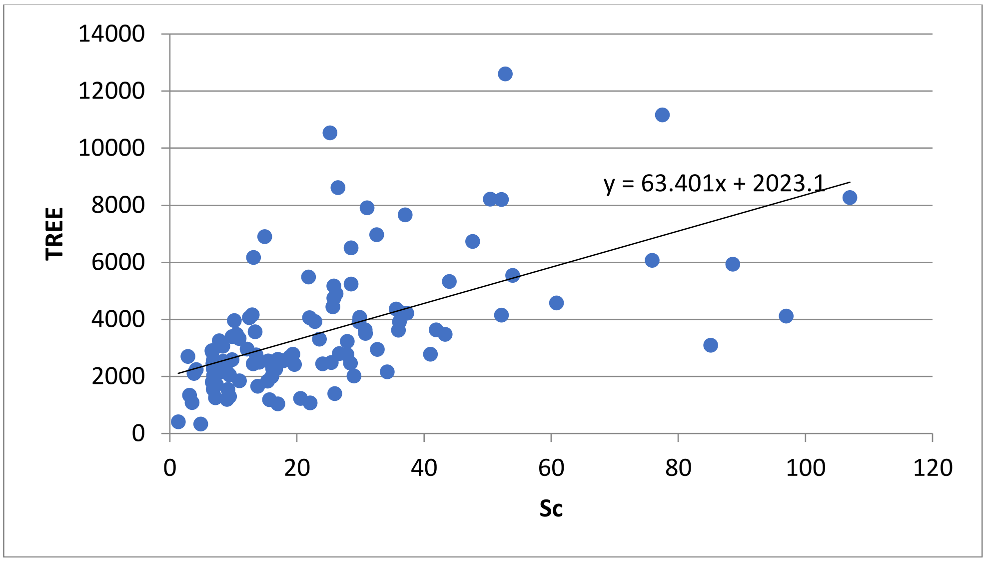


Figure 59: Scattered diagram comparing TREE Vs Sc

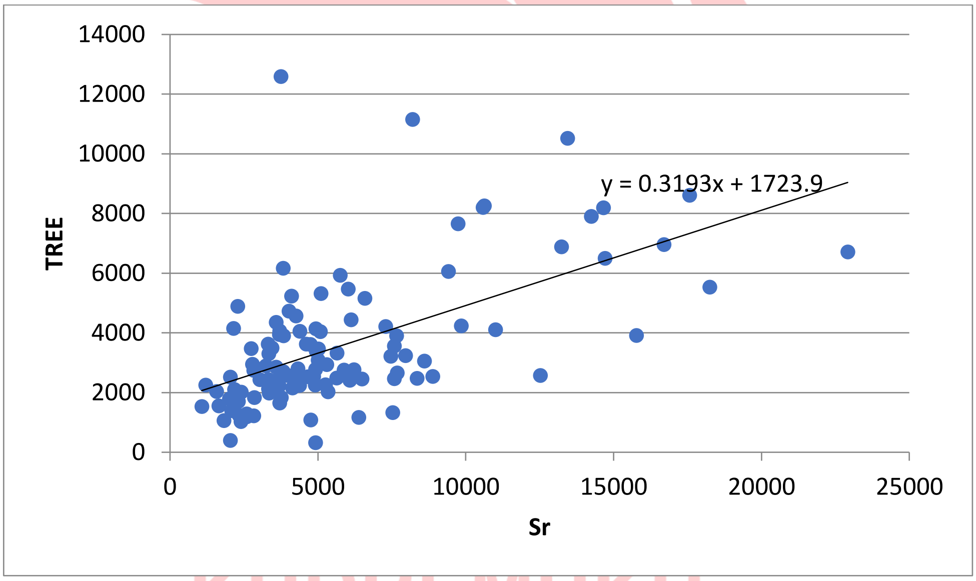


Figure 60: TREE Vs Sr

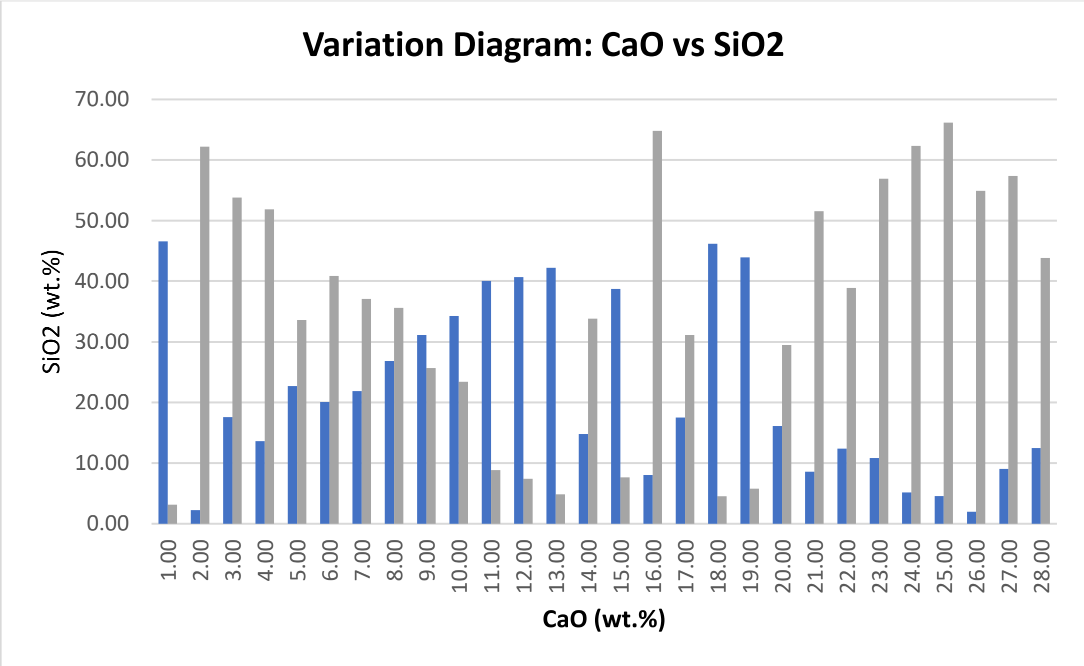


Figure 61: Variation diagram CaO Vs SiO_2

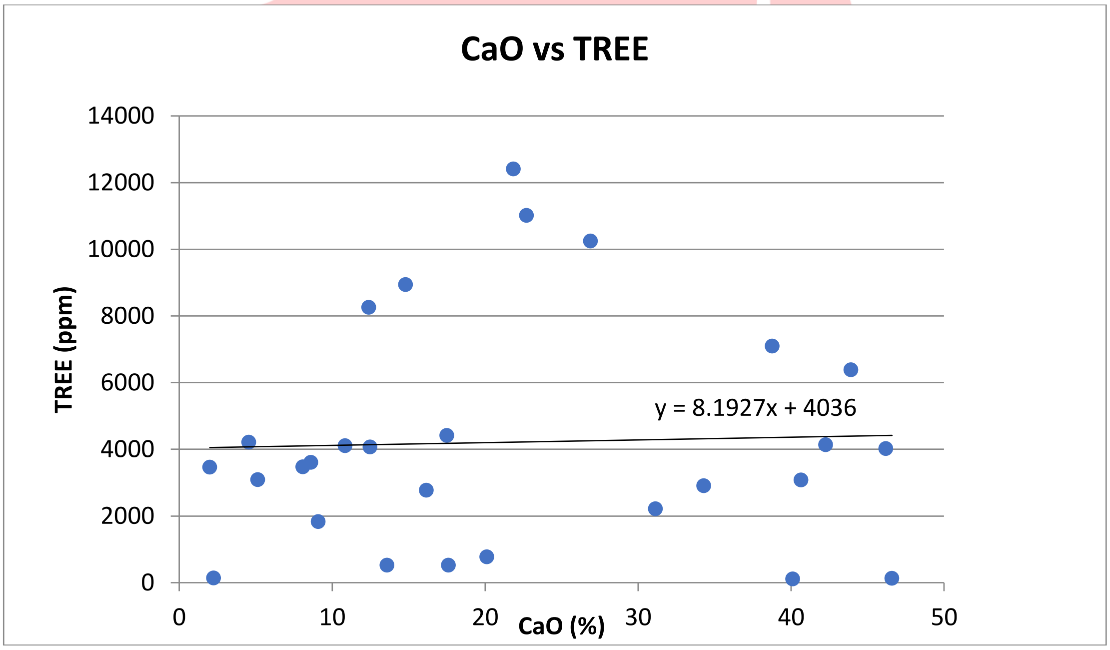


Figure 62: Scattered diagram CaO Vs TREE

14. Sub sampling techniques and sample preparation

14.1 Nature and quality of sampling (eg. cut channels, random chips, Drill core samples etc.) and measures taken to ensure sample representation.

During the Updation of L.S. Map, surface sampling was conducted in the form of Bed rock sampling, channel sampling & Regolith samples in order to delineate the probable carbonatite bodies. Based on the encouraging analytical results from these channel samples, the potential area within the block was identified for further investigation. As a result, trenching and drilling of boreholes to assess mineralization was carried out. At locations where mineralized zones were exposed on outcrops, systematic channel sampling was carried out across the strike of mineralization. In concealed areas, trenches were excavated to expose the mineralized zones, followed by systematic sampling. A total of 57 numbers of Bedrock, Channel & Regolith samples were collected and analysed. 4 numbers of trenches of approximately 80 cum were opened, yielding 58 samples for analysis.

During the geochemical sampling process, both channel and trench samples were meticulously collected. To maintain sample integrity, the weathered or oxidized portions of the outcrop were carefully removed, and samples were collected from the fresh and representative sections. Sampling was done at regular intervals to ensure uniform coverage and unbiased representation of the mineralized zones. Each sample, weighing approximately 1.0–1.5 kg, was carefully collected, labelled, and packed in durable cotton bags for transport and further chemical analysis.

During the second phase of exploration, drill core sampling was carried out to assess subsurface mineralization. After detailed core logging, probable zones were delineated based on the lithological features. Samples were collected from these identified zones at regular intervals of approximately 1m. However, depending on core recovery and lithological variation, the sample lengths were suitably extrapolated to ensure representative sampling.

The cores were cut using a hydraulic core splitter, ensuring that the mineralized portion was divided into two equal halves to maintain unbiased sampling. During sample preparation, adherence to standard operating procedures is paramount. Samples are powdered to -150-micron (100 mesh) size, using a Vibrating Mill. Rigorous cleaning procedures, including the Cups, sample tray, brush, and all tools, are implemented after each sample is processed, maintaining a contamination-free environment. Following the initial crushing, representative samples of around 100 grams are drawn through successive reduction using the coning and quartering method. This technique involves pouring the bulk sample onto a flat surface, forming a cone, and systematically dividing it into four quadrants. Two opposite quadrants are selected for further processing, and the method is repeated, reducing the sample size while preserving representatively. The resulting 300 grams are then packed into three separate packets, each containing 100 grams, for primary and check analyses. The remaining powdered samples are carefully stored for future reference, with preventive measures in place to avoid sample mixing. Thorough cleaning of all tools used in the sampling, drawing, and packaging processes further ensures the integrity of the collected samples.

14.2 Methodology of the ore zone sampling and sample preparation.

The core boxes with samples were transported with utmost care to avoid damage and contamination. The cores were split into two equal halves along the length to ensure it represents the mirror image of the other. Each metre/ half meter core was split into two halves along the predetermined marking using a hydraulic core splitter. One half was sent for sample preparation (pulverising and reducing). The other half is preserved in the core boxes with proper identification and meterage. The core boxes were stored in well protected area with proper identification. Logged Core boxes (with split balance core samples) are currently maintained at the "ME Core Library, KIOCL, Mangaluru", with a plan to be shifted to National Drill Core Library at Hyderabad or Core repository of Govt of Tamil Nadu at later stages as per the directions of NMET.

The sample for chemical analysis is prepared as per IS 1405: 2010. The half of the core for pulverising was subjected to size reduction by crushing in a jaw crusher to pass 2 mm size, followed by further crushing in a roller crusher to reduce the size to −1 mm. The crushed material was then pulverized in a vibrating mill to obtain a fineness of -150 microns (100 mesh) as per IS 1405. The pulverized sample was thoroughly mixed and reduced by the method of coning and quartering to obtain representative samples for chemical analysis, external check sample analysis, and reference sample for retention.

Adequate care was taken during crushing/ pulverising to minimize the loss of graphite fines.

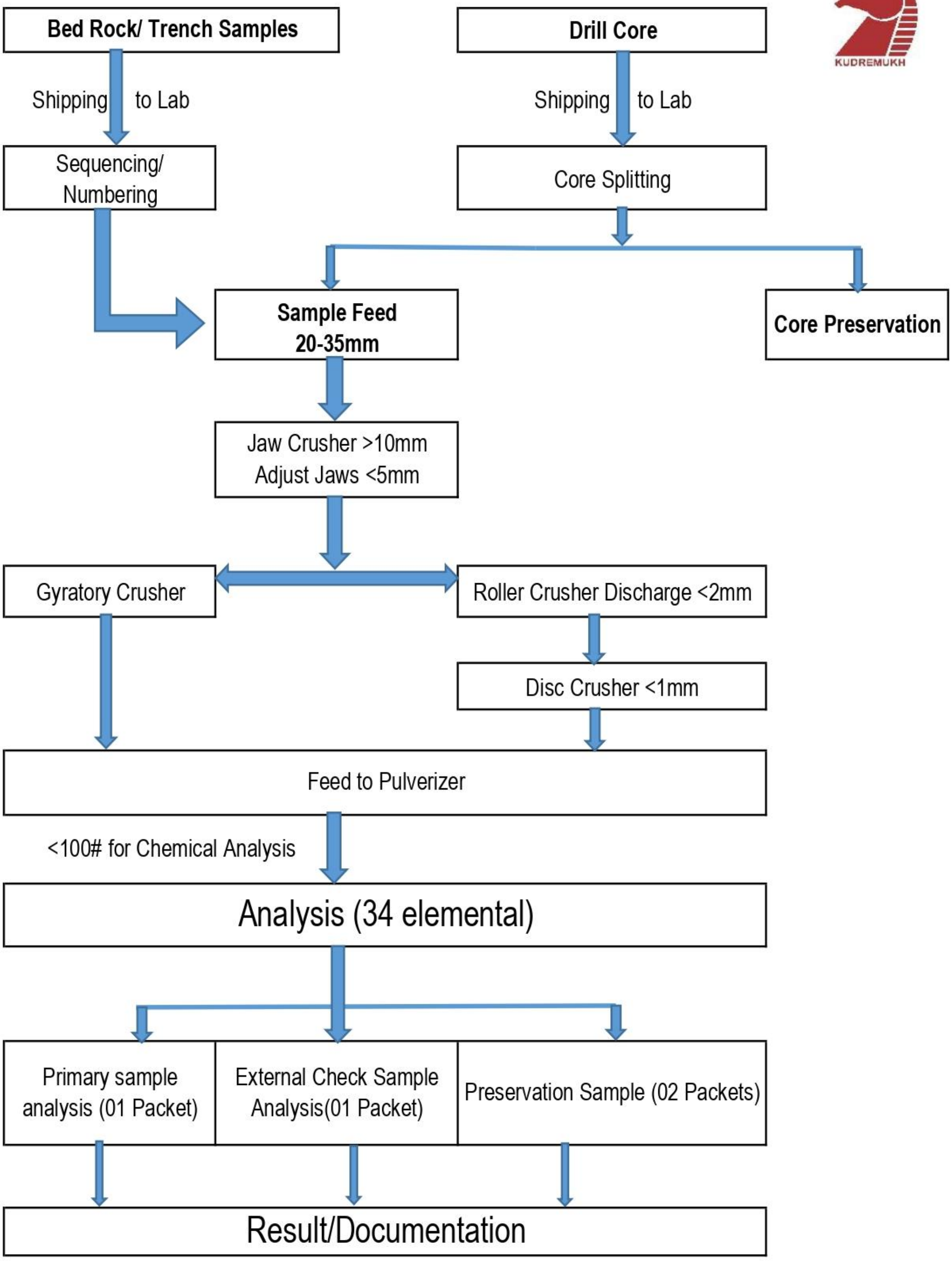


Figure 63: Flow chart indicating the sample preparation adopted at MEL, BFU, KIOCL Ltd., Mangalore.

Figure 64: Hydraulic core splitting machine available at MEL, KIOCL Ltd., Mangalore.

Figure 65: Core box of SRB-02 (BH-02) with run meter 53.00 to 58.00 m

14.3 If core, whether cut or sawn and whether quarter, half or all core taken.

The borehole cores of the block were split into two equal halves using a core splitter. One half was powdered to -150microns (100 mesh) for chemical analysis. While the other half was preserved for future reference and studies. The sample length was generally maintained at 1m interval, adjusted slightly based on lithological variations and core recovery. As the core recovery consistently exceeded 90%, the collected material is considered to be a reliable and accurate representation of the in-situ geological formation.

14.4 Nature, quality and appropriateness of the sample preparation technique.

The sample preparation technique adopted in the block is systematic, scientifically robust, and adheres to the standard protocols prescribed for REE mineralization studies. The overall procedure ensures that the collected samples are representative, contamination-free, and suitable for reliable chemical and geochemical analysis.

The nature of sampling encompasses both surface and subsurface investigations. At the surface, systematic channel and trench sampling was conducted across carbonatite bodies, ensuring unbiased representation of exposed mineralization. In the subsurface, drill core sampling targeted visually identified and collected at regular intervals and adjusted to lithological variations to capture true geological variability.

The sample quality has been maintained through rigorous handling and preparation procedures. Weathered and oxidized portions were removed prior to sampling to obtain fresh, representative material. Cores were split using a hydraulic core splitter, ensuring that mineralized portions were divided into equal halves to minimize sampling bias. Overall consistent sample lengths and more than 90% core recovery further validate the reliability of the samples.

During sample preparation, strict adherence to standard operating procedures (SOPs) was maintained. Method of sampling adopted as per IS standards are explained in chapter no 15.3.

To uphold analytical integrity, thorough cleaning of all tools and equipment—such as the mortar, pestle, trays, and brushes—was carried out after processing each sample, effectively eliminating any chance of cross-contamination. The samples were then packed in high-quality, labeled cotton bags, with additional precautions taken to avoid mixing or loss.

14.5 Quality Control Procedures

Stringent quality control measures were implemented at all stages of sub-sampling to ensure representativeness and accuracy:

Cleaning of all tools (mortar, pestle, sample tray, brush, and other equipment) after processing each sample to prevent contamination.

Coning and quartering technique was used for sample reduction, ensuring that the final sample size maintains representatively of the bulk material.

The final 300gram sample was divided into three equal portions (100 grams each) for primary analysis, check analysis, and storage as a reference sample.

14.6 Representativeness of sampling

The sampling methodology ensured that all collected material accurately represents the in-situ deposit. The high core recovery (>90%) guarantees minimal loss of material. Consistent sampling intervals were maintained to avoid bias.

The coning and quartering method was used for sub-sample selection, reducing bias and maintaining homogeneity.

14.7 Sample size appropriateness

The sample size was appropriate for the grain size of the material. The grain size of -150 microns (100 mesh) as specified in IS 1405 for chemical analysis. The final 100 gram sample size was adequate for accurate laboratory testing while preserving enough material for duplicate and future reference analyses.

15. Quality of assay data and laboratory tests.

15.1 The nature, quality and appropriateness of the assaying and laboratory procedures used and whether the technique is considered partial or total

Two types of assays have been performed in the in-house Mineral Exploration Laboratory, Mangalore. First type is Elemental Analysis of Ni, Rb, Sn, Sr, Ta, W, Zr, Ba, Be, Cu, Pb, Co, Ga, Hf, Mo, Nb, V and REE (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu Sc Y - 16 Elements) carried out by Inductively coupled Plasma optical emission spectroscopy (ICP-OES) Agilent 5800 VDV instrument. The second type is major Oxides determination with ED XRF – Epsilon 3^{X}.

The samples were prepared as per IS 1405, ground to -150 micron dried at 105^{0}C.

i. Elemental analysis by ICP-OES method

- **Preparation:** For the determination of elemental concentrations, 0.5–1.0 g of the finely powdered sample was accurately weighed and digested using a microwave digestion system with an acid mixture of nitric acid and hydrofluoric acid with 4 to 5 hrs of digestion.
- **Dilution & Filtration:** After digestion, the solution was filtered to remove particles that could clog the nebulizer through Whatman Grade 40 filter paper into a 100 mL volumetric flask. The residue was washed four to five times with hot distilled water, and all washings were combined with the filtrate. The final volume was made up to 100 mL with double-distilled water.
- **Analysis:** The liquid is introduced into the ICP-OES, where it is atomized and ionized in the argon plasma (5,000–10,000 K). Prior to sample analysis, the

instrument was calibrated using appropriate certified reference material (CRM) element standards. The concentrations of the analytes were determined using the ICP Expert software application, providing quantitative results for the elements under investigation

- **Measurement:** The instrument measures the intensity of emitted light at specific wavelengths, which correlates to the concentration of elements.

ii. **Analysis of major oxides:** Major oxides like SiO_2, Al_2O_3, Fe_2O_3, FeO, CaO, MgO, MnO_2, P_2O_5, TiO_2, Na_2O, K_2O were analysed with X-Ray spectrometer ED XRF Epsilon 3X.

- Sample was ground to a fine consistency to <75 microns (200 mesh) to achieve homogeneity. These are pressed into a pellet then placed in a sample cup.
- Initialized the spectrometer and allowed it to stabilize.
- Performed a detector performance check using certified reference materials (CRMs).
- Selected the appropriate calibration Graph for high-precision quantitative results.
- Final elemental concentrations are reported in percentages.

15.2 Nature of quality control procedures adopted (eg. standards, blanks, duplicates, external laboratory checks) and whether acceptable levels of accuracy and precision have been established

Below indicated typical Quality Control procedures adopted during the chemical analysis

(i) Analysis of Certified reference materials/measurement standards
(ii) Analysis of calibration blanks
(iii) Internal Check Analysis and External Check Analysis.

15.3 Primary chemical analysis and laboratory procedures.

Primary Sample Analysis: All the primary sample analyses were carried out at Mineral Exploration Laboratory, KIOCL Ltd., Mangalore.

KIOCL Ltd. is a central public sector undertaking under the ownership of the Ministry of Steel, Government of India, KIOCL Ltd. is having the inhouse lab facility to analyse Ores & Minerals with IS procedure and Spectrometry . KIOCL is accredited to maintain quality management system as per ISO 9001:2015. Copy of the Integrated Management System certification (ISO 9001:2015, ISO 14001:2015 & ISO 45001:2018) is enclosed at Annexure 13.

Total of 225 nos of primary samples (57 BRS + 58 Trench samples+ 110 Borehole samples) were analysed for 34 elements and 10 nos are analysed for 11 oxides. Details of the IS standard adopted for chemical analysis are provided below (table 27);

Table 27 : Details of IS standard adopted for chemical analysis.

Sl	Radicals	IS Standard
1	ICP-OES spectrometry (Elemental analysis of 33 elements)	Generalised Spectrometric analysis IS 9879 and IS 228-23
2	Major Oxides	ED XRF Spectrometry

34 elemental analyses were carried out along with the respective CRM in ICP OES. Reference Materials are Individual Element CRM, ICP Calibration Standard – ICM 103, Rare Earth element mix for ICP (67349). Calibration blank 5% HNO3 - 5190-7001.

Proper Documentation is available at MEL, BFU, Mangalore for sample logs with Time, date, identification of collecting person, handling, transportation, Analysis Reports and storage.

During approval of the project TCC- NMET (69th meeting) has recommended ICP-MS (Inductively Coupled Plasma Mass Spectrometry) method for carrying out 34 element analysis. KIOCL is equipped with ICPOES (Inductively Coupled Plasma Optical Emission Spectroscopy) (Fig 66) for measurement of parts per million (ppm)/ parts per billion (ppb) concentration of Base metals, Noble/Precious metals, REE (Rare Earth Elements) and RM (Rare Metals) at Mineral Exploration Laboratory (MEL), KIOCL Ltd., Mangalore.

Subsequently, 70th meeting of TCC- NMET approved for utilizing ICPOES available with KIOCL for the current project. Specification of ICP - OES machine available with MEL, KIOCL Ltd., Mangalore is provided below ;

- Model name : Agilent ICP - OES 5800 VDV
- Year of procurement: 2023
- Dual view (Radial & Axial)

- High TDS (up to 3%)
- Overall argon flow rate (8-17 L/min)
- Lesser deduction limit (<0.007 nm @200/202nm)

Figure 66: ICP-OES instrument available at Mineral Exploration Lab, Panambur, Mangalore.

15.4 External check sample analysis

10% of the total samples i.e., 18 nos. of samples were analysed for 34 radicals at M/s Shiva Analyticals Pvt. Ltd., Bengaluru as External check sample analysis works.

Statistical analysis to establish the agreement between primary and external check sample analysis of TREE is provided below.

- ➢ TREE (ppm) of all samples are falling within the best fit curve, which are having a slope of 1.0888 (Fig 67).
- ➢ Statistical analysis of TREE (ppm) shows mean difference of -289.01 ppm (Table 28) and concentration of primary samples shows a positive correlation with external check samples, with a correlation coefficient of 0.99.

Chemical analysis reports of external check sample analysis (lab report), External Check sample analysis report indicating LREE & HREE, Comparison of Primary sample vs external check sample analysis and NABL certificate of M/s Shiva Analyticals Pvt. Ltd. are enclosed at Annexure 9,10, 11 & 12 respectively.

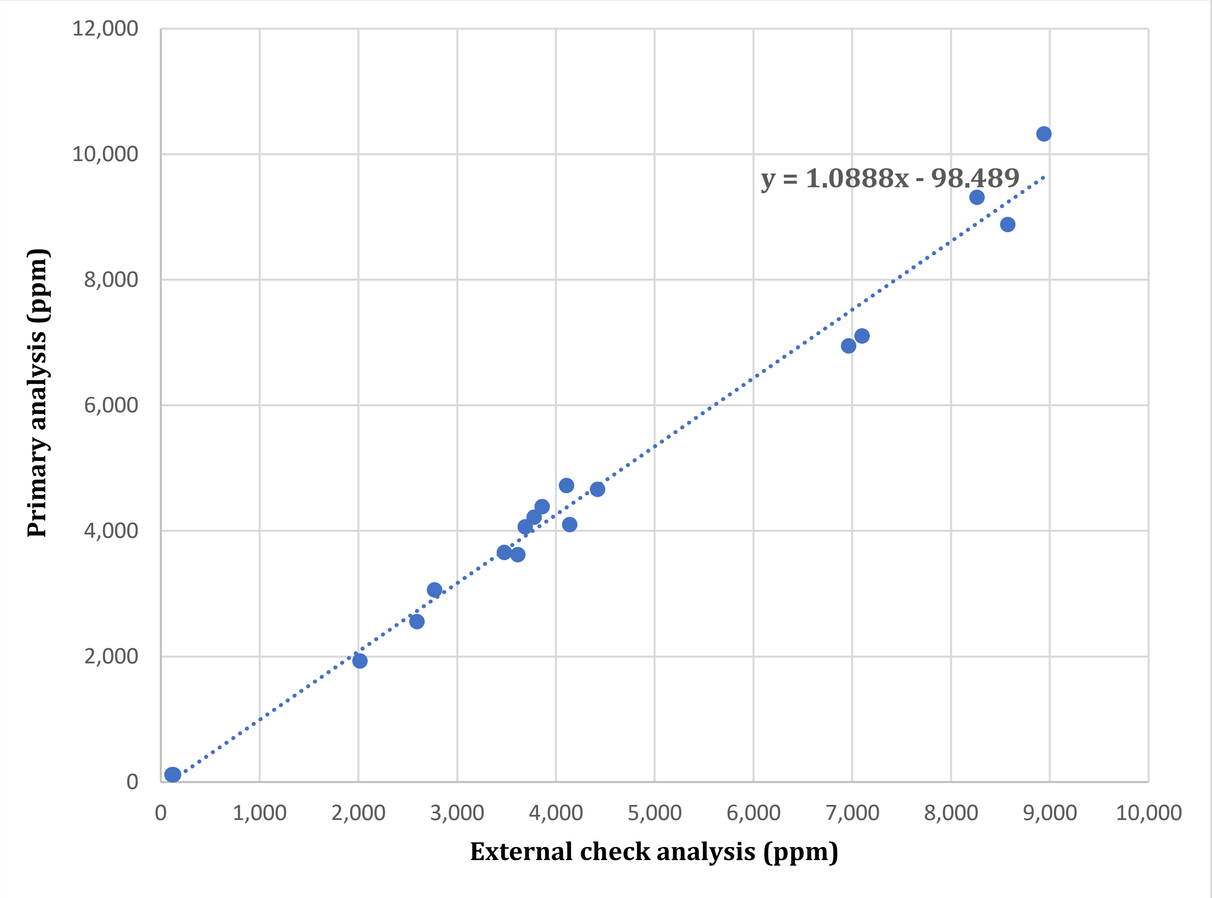


Figure 67: Graphical representation of comparison of primary and external check sample analysis for TREE (ppm).

Table 28 : Comparison of primary and external check sample analysis for TREE (ppm).

	Primary sample at KIOCL lab	External Check at Shiva Analyticals	Difference
Mean	4364.23	4653.24	-289.01
Median	3820.50	4157.60	
Range	8829.00	10207.94	
Minimum	113.00	113.46	
Maximum	8942.00	10321.40	
Count	18.00	18.00	

15.5 Security and chain of control of samples should be clearly mentioned

The security and chain of control of samples from the project site's sampling unit to the chemical laboratory of KIOCL was executed in meticulous and well-organized process. The samples were prepared at the sampling unit, where a qualified sampling technician oversaw the entire process. The samples were meticulously labelled and tagged before being sent to the chemical laboratory under the direct supervision of the technician. The samples were securely sealed in bags and the integrity of the seals was verified at the sampling unit before the bags were opened. Adhering to standard procedures, the sampling unit implemented robust precautionary measures to prevent any potential contamination, ensuring the reliability of the sample analysis. Additionally, the remaining samples were appropriately preserved and tagged for future reference, highlighting a commitment to maintaining a secure and traceable chain of control under the company's custody.

16. Moisture

All the samples including bed rock samples, trench samples and boreholes samples are analysed after drying in an Oven at 1050c for 1 hour.

17. Bulk Density

No insitu bulk density or lab scale specific gravity tests were carried out.

The density of carbonatite typically ranges from 2.6 to 3.2 g/cm^3, with an average of approximately 2.9 g/cm^3 commonly used for fresh, un weathered rock. Hence 2.9 t/cum is considered for resource estimation purpose.

18. Beneficiation studies as may be required

No Beneficiation studies is carried out, as it was not mandatory at G4 Stage.

19. Resource estimation

19.1 Discussion on sufficient data density to assure continuity of mineralization and synthesis adequate data for assessment data base for estimation procedure used.

8 nos of surface samples collected from Band-1 (220 X 15m) in Sub block 1 is indicating TREE values ranging from 2,938 to 6,962 ppm with mean value of 3,996ppm

6 nos of surface samples collected from Band 2 (340 X 21m) in sub block 2 is indicating TREE value ranging from 1,514 to 4,141ppm with mean value of 3,121ppm.

Trench 1 and Trench 2 made on carbonatite band 1 are representing average TREE value of 6,647.23 ppm over 8m (from 1 to 9m) and 3,864.52ppm over 10m (from 3 to 13m).

Trench 3 and Trench 4 made on Carbonatite band 2 are representing average TREE value of 4,993.18 ppm over 4m (from 5 to 9m) and 4,339.03ppm over 21m (from 0 to 21m).

The above data are sufficient to assure continuity of mineralization and synthesis adequate data for assessment of data base for G4 level of investigation works.

19.2 Whether previous exploration data has been used and integrated with the current exploration data for assessment of the updated resources.

As this block has not been previously investigated by any other agency for REE, no legacy exploration sub surface data is available. Consequently, KIOCL utilized baseline datasets from the NGDR portal to guide the various activities of its exploration program.

19.3 The nature and appropriateness of the estimation technique(s) applied and key assumptions including treatment of extreme grade values, domaining, interpolation parameters, maximum distance of extrapolation from data points.

Resource estimation is done based on Cross section. As the strike length of the bands is lesser than 400m (Band 1: 220m and Band 2: 340m) the entire strike length of the band is considered for resource estimation.

19.4 The basis for the classification of the mineral resource into varying confidence classes.

The mineral resource estimated is classified as 334 under UNFC category. Only One borehole in each sections A-A' and B-B' are drilled as scout boreholes and as such the confidence level of 334 resources are poor.

19.5 Cut-off grade:

For Rare Earth Elements (REE) mineralisation in India, there are currently no specific, broad "threshold values" notified by the Indian Bureau of Mines (IBM).

In the absence of a unified national threshold for Rare Earth Elements (REE) set by the Indian Bureau of Mines (IBM), Standard Cut-off of 0.1% (1,000 ppm) TREE is used as the primary benchmark to capture the "strategic resource potential" of Samalpatti REE block.

"The Handbook on Geological Potential of North East India - June 2025", Ministry of Mines, GoI indicates the below indicated, REE concentration;

- Assam's Jashora and Samchampi alkaline complexes have demonstrated encouraging results through pedo-geochemical surveys and trench sampling. These complexes have returned REE concentrations ranging from 1,000 to 5,000 ppm, alongside associated elements such as Nb and Y.
- In Meghalaya, the Sung Valley ultramafic-alkaline-carbonatite complex has shown ΣREE values ranging between 3,646 and 5,100 ppm in titaniferous bauxite cappings.
- Located in Karbi Anglong, the Jashora complex drew interest for its soil geochemistry and alkaline lithology. GSI's FS 2020–22 investigations found phosphate-rich breccias (up to 35% P_2O_5) and REE enriched soils (up to 5,000 ppm).

Both the boreholes drilled on band 1 and 2 in Samalpatti block are representing weighted average TREE value of 3,409.27 and 3,815.22 ppm respectively. For the purpose of resource estimation for G4 level below indicated TREE grade classification was done (Table 29);

Table 29: Grade classification of TREE

Grade	TREE range in ppm
1	1000-2000
2	2,000- 3,000
3	3,000 -5,000
4	+5,000

19.6 Stopping width:

The stopping width is a crucial factor in the calculation of mineral resources of a deposit, it directly helps in the volume of ore which can be exploited. Stopping width also influences the efficiency of mining process, the wider stope can facilitate the movement of equipment and extraction of ore efficiently. Considering the above factors, minimum stopping width of 2m is considered for the resource estimation.

19.7 Ore Zone:

The ore zone is carbonatite and finitised zone. surface carbonatite was identified which changed into hybrid zone/ fenite. Zone is characterized by a greyish white, medium grained hybrid rock exhibiting significant lithological and mineralogical variation. The zone is marked by quartz veins and carbonate (calcite) veins, along with apatite bearing veins at places. The dominant mineral assemblage comprises quartz and biotite, with occasional feldspar, while green coloured radiating amphibole minerals (aegirine) occur at places, indicating well developed fenitisation alteration associated with alkaline metasomatism. (enriched in REE phases such as monazite , Ancylite and Flour carbonates)

The finitised zone formed by alkali rich fluids from the carbonate melt. It contains abundant metasomatic minerals including andradite , aegirine augite, and titanite (occurring as rims around andradite) interstitial calcite is present but not considered part of primary rock assemblage. Accessory sulphides pyrrhotite, chalcopyrite , pyrite and magnetite occur with alteration textures showing pyrrhotite replace by pyrite.

Analytical results of geochemical samples of carbonatite in trench 01 show avg ΣTREE of 6,647.23 ppm and in trench 04 show avg ΣTREE of 4,339.03 ppm, the finitezone in borehole 01 the ΣTREE is varying from 327.82 to 8204.00 ppm & in Borehole 02 the ΣTREE is varying from 403.88 to 12,596.61ppm.

Table showing various zones along with TREE value established through trenches and boreholes are provided in the below table (table 30)

Table 30: Various zones established through trenches and boreholes with TREE values

Sl	Trench/ Borehole No	Borehole Run meter	Zone	Average REE value in ppm		
				Total H-REE	Total L-REE	Total REE
1	Trench 1	-	Z1	396.90	6,439.77	6,836.67
2	SRB 01	10-16	Z2	182.73	2,503.09	2,685.83
3		16-19	Z3	257.22	4,825.01	5,082.23
4		19-23	Z4	202.44	2,097.28	2,299.72
5		23-34	Z5	152.88	4,039.81	4,192.69
6		34-38	Z6	270.97	6,016.44	6,287.41
7		38-40	Z7	96.76	1,373.31	1,470.07
8		40-55	Z8	125.93	2,300.35	2,426.29
9		55-65	Z9	182.25	3,909.07	4,091.32
10		65-70	Z10	217.56	2,278.13	2,495.69
11	Trench 4	-	Z11	272.87	4,066.16	4,339.03

12	SRB 02	12-28	Z12	259.26	1,825.95	2,085.21
13		28-30	Z13	244.51	1,300.05	1,544.56
14		30-41	Z14	250.27	2,200.27	2,450.55
15		41-43	Z15	103.29	1,351.51	1,454.80
16		43-45	Z16	188.82	2,979.75	3,168.58
17		45-47	Z17	365.91	4,833.09	5,199.01
18		47-51	Z18	105.15	2,350.63	2,455.79
19		51-63	Z19	338.40	7,425.44	7,763.83
20		63-66	Z20	73.10	1,150.87	1,223.97
21		66-70	Z21	179.48	4,252.62	4,432.10

19.8 Detailed description of the method used and the assumptions made to estimate tonnage and grade.

Resource estimation is carried out by Cross section method. Following assumptions are made while computing the resource:

(i) TREE value of individual sample of 1m length each by ICPOES method has been taken to represent assay value of the mineralised zone / host rock.

(ii) Resources have been calculated for the altered host rock / zone for various grade with TREE as indicated in the table number 30 (Grade classification)

(iii) Host rock / Mineralised zones with less than prescribed TREE grade occurring continuously / intermittently with richer zones have also been included in the calculations wherever possible, if the weighted average of the combined zone is above the prescribed grade.

(iv) Overall, a grade cutoff have been fixed in this case with lowest grade being 1,000ppm TREE which may include all zones > 1,000 ppm in carbonatite and finitised syenite in continuity.

(v) Based on the available data the geometry of 21 ore zones appears to be vertically extending body. at this stage the grades are considered to be extending laterally in horizontal pattern.

(vi) Isolated zones having true thickness less than 2m in length have not been taken into account for the calculation of resource irrespective of their TREE content.

(vii) The true thickness of the individual zones were calculated by multiplying the apparent width (drilled width) of each zone by Sin 50º (0.766), considering drilling angle of 50º and presuming carbonatite bodies shows 90 º dip amount;

(viii) Each zone is assumed to maintain the same grade for the area of influence calculated.

(ix) Influence of a bore hole (distance)/Sectional influence length for Band 1 and Band 2 are taken for the entire strike length of bands. (Band 1: 220m and Band 2: 340m).

(x) The hybrid zone as established in Trench 1 and Trench 4 are connected with Boreholes SRB 01 and 02 respectively. Assay value of TREE obtained in Trench 1 and 4 are projected up to vertical depth of 7.35 and 10m respectively and resource is estimated.

19.9 Description and correlation of lodes:

Correlation of lodes is not applicable as only One borehole is drilled for each band.

20. Reporting of resources

20.1 Resource estimation by Cross section method:

Resource estimation is done based on the 02 numbers of cross sections drawn along the profile A-A' and B-B' along borehole SRB 01 and SRB 02. Draftsight 2025 is used for generating the cross-sections.

The resource estimation for the block is based on limited trench data, scout boreholes, and supporting geological mapping. Given that the mineralisation appears to be structurally controlled and exhibits broad homogenous distribution, the lateral continuity assumed in the present estimation is subject to significant geological uncertainty. Accordingly, the resources computed at this stage should be regarded as highly conceptual in nature. The cross-sections used for resource estimation are therefore interpretative and schematic, as the controls on grade distribution are not yet fully understood. While structural features such as fractures and their intersections are likely to play an important role in the localisation of carbonatite emplacement and REE mineralisation, their geometry and continuity have not been adequately constrained at the present stage.

Full strike length of the bands exposed on surface has been taken for calculation and each of sectional areas has been multiplied by strike length of the bodies to arrive at volume.

Dip correction or true thickness of the mineralized zone is not considered for resource estimation as calculation of resources are made using sectional area method.

Cross section showing schematic assay constrained REE grade domains in Carbonatite-Fenite zones in boreholes and trenches is enclosed as plate 05.

Resource is estimated by using the formula,

Resource = Sectional area x Strike length of the bands x Density, and expressed in tonnes.

Cumulative resources of **2.948 million tonnes** is estimated in the block under UNFC classification of 334 category by cross section method. The estimated resource indicates;

- Weighted average TREE value of 3,723ppm.
- Weighted average TLREE value of 3,504ppm
- Weighted average Cerium (Ce) concentration of 1,742 ppm.
- Weighted average Lanthanum (La) concentration value of 943 ppm
- Weighted average Neodymium (Nd) concentration value of 523 ppm

Cross section (Fig 68) and Details of calculations (table 31 &32) are provided below;

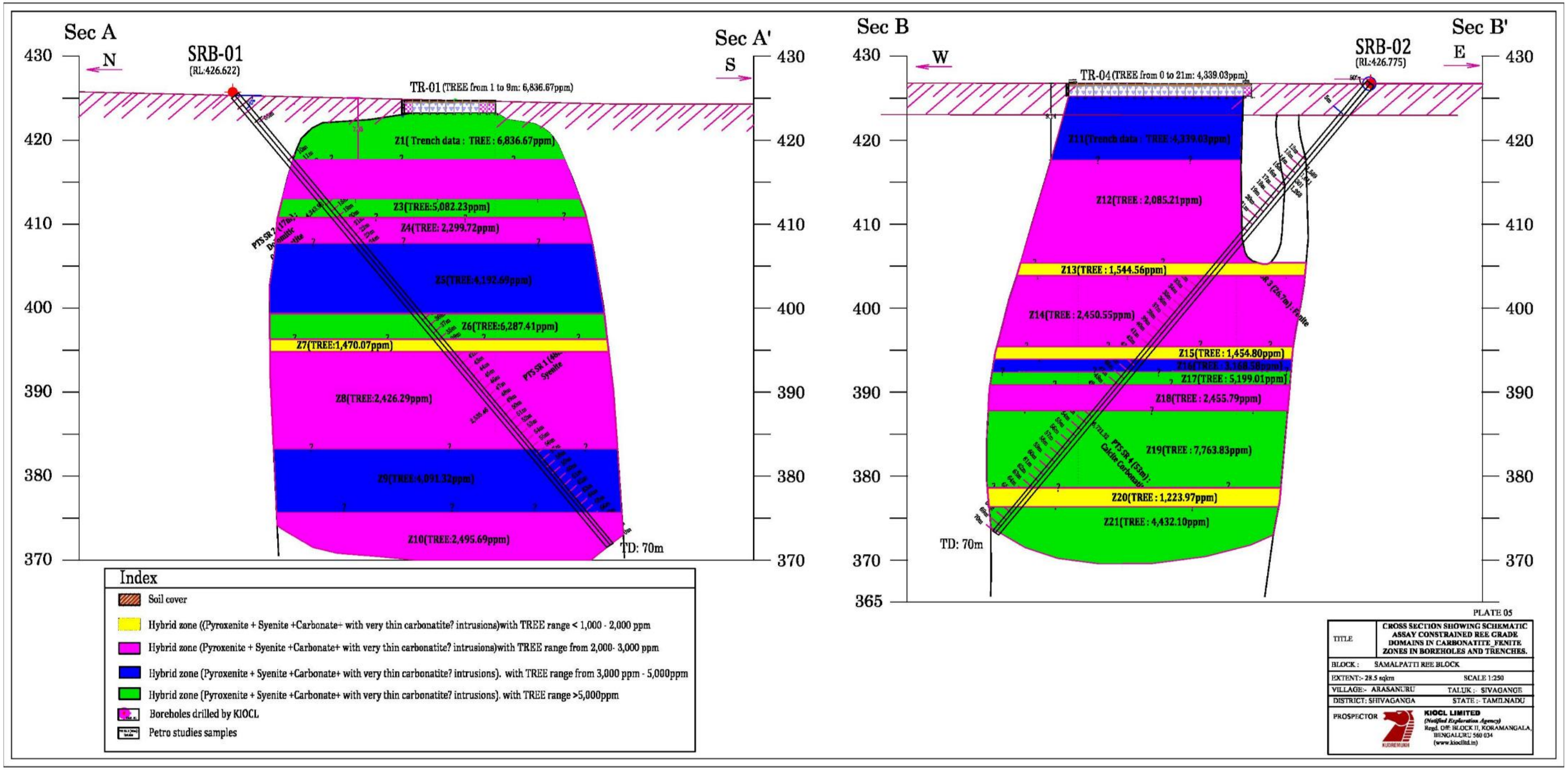


Figure 68: Cross section of boreholes.

Table 31: Resource calculation

Sl	Section	Trench/ Borehole No	Grade based on TREE (ppm)	Zone	Borehole run meter		Apperent Thickness	True Thickness	Cross sectional area (sqm)	Strike length (m)	Volume (cum)	Density (t/cum)	Resource (t)		Weighted average value (ppm)									
					From	To									TREE		TLREE		Ce		La		Nd	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)=(f)-(e)	(h)=(g)* (Sin50)	(i)	(j)	(k)=(i)*(j)	(l)	(m)=(k)*(l)		(n)		(o)		(p)		(q)		(r)	
1		TR 01	+5000	Z1	-	-	-	7.35	150.74	220.00	33,162.14	2.90	96,170		6,837		6,440		3,183		1,847		940	
2			2000-3000	Z2	10	16	6	4.60	158.89	220.00	34,956.68	2.90	1,01,374		2,686		2,503		1,236		645		393	
3			+5000	Z3	16	19	3	2.30	82.92	220.00	18,241.74	2.90	52,901		5,082		4,825		2,441		1,316		690	
4			2000-3000	Z4	19	23	4	3.06	114.11	220.00	25,105.08	2.90	72,805		2,300		2,097		1,034		504		349	
5			3000-5000	Z5	23	34	11	8.43	330.71	220.00	72,755.76	2.90	2,10,992		4,193		4,040		2,030		1,203		524	
6	A-A'	SRB 01	+5000	Z6	34	38	4	3.06	122.63	220.00	26,979.48	2.90	78,240	12,90,364	6,287	3,637	6,016	3447	3,029	1718	1,689	967	842	492
7			1000-2000	Z7	38	40	2	1.53	61.41	220.00	13,511.08	2.90	39,182		1,470		1,373		678		363		219	
8			2000-3000	Z8	40	55	15	11.49	475.64	220.00	1,04,640.80	2.90	3,03,458		2,426		2,300		1,149		658		317	
9			3000-5000	Z9	55	65	10	7.66	314.83	220.00	69,261.72	2.90	2,00,859		4,091		3,909		1,951		1,116		541	
10			2000-3000	Z10	65	70	5	3.83	210.63	220.00	46,338.60	2.90	1,34,382		2,496		2,278		1,103		551		396	
11		TR 04	3000-5000	Z11	-	-	-	9.14	166.95	340.00	56,763.00	2.90	1,64,613		4,339		4,066		2,110		944		678	
12			2000-3000	Z12	12	28	16	12.26	305.08	340.00	1,03,727.20	2.90	3,00,809		2,085		1,826		825		355		414	
13			1000-2000	Z13	28	30	2	1.53	53.05	340.00	18,038.02	2.90	52,310		1,545		1,300		557		220		340	
14			2000-3000	Z14	30	41	11	8.43	296.93	340.00	1,00,956.20	2.90	2,92,773		2,451		2,200		1,046		499		423	
15			1000-2000	Z15	41	43	2	1.53	54.51	340.00	18,533.40	2.90	53,747		1,455		1,352		669		317		238	
16	B-B'	SRB 02	3000-5000	Z16	43	45	2	1.53	52.75	340.00	17,935.00	2.90	52,012	16,57,559	3,169	3,790	2,980	3548	1,488	1762	736	924	486	546
17			+5000	Z17	45	47	2	1.53	57.33	340.00	19,492.20	2.90	56,527		5,199		4,833		2,427		1,153		800	
18			2000-3000	Z18	47	51	4	3.06	110.37	340.00	37,524.44	2.90	1,08,821		2,456		2,351		1,180		663		330	
19			+5000	Z19	51	63	12	9.19	328.24	340.00	1,11,601.60	2.80	3,12,484		7,764		7,425		3,751		2,134		937	
20			1000-2000	Z20	63	66	3	2.30	80.54	340.00	27,383.60	2.90	79,412		1,224		1,151		572		330		159	
21			+5000	Z21	66	70	4	3.06	193.33	340.00	65,732.20	2.80	1,84,050		4,432		4,253		2,134		1,233		560	
22	**Total/ Weighted avg**												**29,47,922**	**29,47,922**		**3,723**		**3,504**		**1,742**		**943**		**523**

Table 32: Grade wise resource calculation

Sl	Grade based on TREE (ppm)	Trench/ Borehole No	Zone	Borehole run meter		True Thickness	Resource in million tonnes		Weighted average value (ppm)									
				From	To				TREE		TLREE		Ce		La		Nd	
1	1000-2000	SRB 01	Z7	38	40	1.53	0.039	**0.225**	1,470	**1,397**	1,373	**1,272**	678	**610**	363	**307**	219	**231**
2		SRB 02	Z13	28	30	1.53	0.052		1,545		1,300		557		220		340	
3			Z15	41	43	1.53	0.054		1,455		1,352		669		317		238	
4			Z20	63	66	2.30	0.079		1,224		1,151		572		330		159	
5	2000-3000	SRB 01	Z2	10	16	4.60	0.101	**1.314**	2,686	**2,376**	2,503	**2,176**	1,236	**1,050**	645	**533**	393	**380**
6			Z4	19	23	3.06	0.073		2,300		2,097		1,034		504		349	
7			Z8	40	55	11.49	0.303		2,426		2,300		1,149		658		317	
8			Z10	65	70	3.83	0.134		2,496		2,278		1,103		551		396	
9		SRB 02	Z12	12	28	12.26	0.301		2,085		1,826		825		355		414	
10			Z14	30	41	8.43	0.293		2,451		2,200		1,046		499		423	
11			Z18	47	51	3.06	0.109		2,456		2,351		1,180		663		330	
12	3000-5000	TR 04	Z11	-	-	9.14	0.165	**0.628**	4,339	**4,114**	4,066	**3,917**	2,110	**1,981**	944	**1,069**	678	**567**
13		SRB 01	Z5	23	34	8.43	0.211		4,193		4,040		2,030		1,203		524	
14			Z9	55	65	7.66	0.201		4,091		3,909		1,951		1,116		541	
15		SRB 02	Z16	43	45	1.53	0.052		3,169		2,980		1,488		736		486	
16	+5000	TR 01	Z1	-	-	7.35	0.096	**0.780**	6,837	**6,348**	6,440	**6,050**	3,183	**3,043**	1,847	**1,715**	940	**812**
17		SRB 01	Z3	16	19	2.30	0.053		5,082		4,825		2,441		1,316		690	
18			Z6	34	38	3.06	0.078		6,287		6,016		3,029		1,689		842	
19		SRB 02	Z17	45	47	1.53	0.057		5,199		4,833		2,427		1,153		800	
20			Z19	51	63	9.19	0.312		7,764		7,425		3,751		2,134		937	
21			Z21	66	70	3.06	0.184		4,432		4,253		2,134		1,233		560	
22	**Total/Weighted avg**						**2.948**	**2.948**	**3,723**		**3,504**		**1,742**		**943**		**523**	

21. Summary and recommendations

Summary

a) The current studies were aimed to establish the carbonatite and to understand the nature of REE mineralisation and to confirm the depth continuity of the carbonatite. The investigation focused on identifying Rare Earth Elements (REE) and Rare Metals (Scandium & Niobium) within the Samalpatti Alkaline-Carbonatite Complex.

Area of 28.5 sq.km has been sub divided into three sub blocks as Sub Block-1, Sub Block-2 and Sub Block-3 measuring 8.82, 4.32 and 15.3 sqkm respectively totalling 28.5 sqkm. Major rock types observed in the subblocks are Pyroxenites, Dunite, Pegmatoidla syenite, Syenite, Carbonatite and Crystalline limestone.

Geological mapping across three sub-blocks (28.5sqkm) has identified 15 carbonatite bodies, with dimensions ranging from 2m to 340m in length and 1m to 21m in width. These bodies trend North-South and East-West, showing Total Rare Earth Element (TREE) values ranging from 531ppm to 13,917ppm. Of these, below indicated two specific bands have been prioritized for sub-surface exploration via trenching and drilling due to their significant size, favourable TREE values and acceptance of land owners.:

- Carbonatite Band 1 with dimension of 220mX15m located in Sub-block 01 indicating surface average TREE value of 3,996ppm.
- Carbonatite Band 2 with dimension of 340mX 21m located in Sub-block 02 indicating surface average TREE value of 3,121ppm.

To establish the continuity and mineral potential of the prioritized carbonatite bands, four trenches were excavated across these 2 bands. Abstract details of the trenches are provided below;

- Trench 57TR01 and Trench 57TR02 positioned on Carbonatite Band 1 have established 8m (1 to 9m) wide carbonatite zone with a weighted average TREE value of 6,647.23ppm and 10 m (3 to 13m) wide carbonatite zone with weighted average TREE value of 3,864.52 ppm respectively.
- Trench 57TR03 and Trench 57TR04 positioned on Carbonatite Band 2 have established 4m (5 to 9m) wide carbonatite zone with a weighted average TREE value of 4,993.18ppm and 21 m (0 to 21m) wide carbonatite zone with weighted average TREE value of 4,339.03 ppm respectively.

Based on the consistent strike length and width of the carbonatite bodies encountered in the trenches, and encouraging REE values over a consistent length in the trench section, these carbonatite bodies were qualified for depth probing by scout drilling.

Two boreholes one each over carbonatite bodies 1 & 2 were executed with 1st level of intersection (30m). The area is observed to be dominated by syenite with minor occurrences of pyroxenite, dunite, and scattered carbonatite bodies. **Hybrid zone (Pyroxenite + Syenite +Carbonate+ with very thin carbonatite)** as the primary source of REE in the region.

The boreholes SRB 01 and SRB 02 drilled on band 1 and band 2 are indicated weighted avg TREE values in the range of 3,409.27ppm & 3,815.22ppm respectively, suspected to be derived from small carbonatite lenses and thin veinlets within a dominant syenite matrix, lacking consistent high-grade zones.

Surface mapping shows exposed widths of 15m for Band 1 and 21m for Band 2. Data from borehole cores SRB-01 and SRB-02 confirm that these carbonatite bodies are widening at depth, indicating increasing thickness below the surface.

Statistical correlation analysis was applied to assess relationship between Ba and REEs.

SRB-01: Average Ba concentration 11,642.795 ppm, maximum 41,574 ppm (4.15%).

SRB-02: Average Ba concentration 10797.675 ppm, maximum 41,066 ppm (4.10%).

The sample shows significant Ba enrichment and with positive geochemical relationship between Ba and Ce. High barium (Ba) content in carbonatites is typically linked to late-stage magmatic differentiation and alkali-rich mineral phases such as K-feldspar, biotite, and barite. These minerals can incorporate Ba into their crystal structures, reflecting the geochemical evolution of carbonatite melts.

The average REE content in syenites and pyroxenites of the alkaline carbonatite complexes across the globe varies from 100 to 500ppm in syenites and <50ppm in pyroxenites. The petrographic studies have indicated that the carbonatites intersected in the borehole cores are of dolomitic and calcitic types, the magnesiocarbonatite dikes having higher REE concentration with significant enrichment in LREEs, and the calciocarbonatite dikes have an extremely high REE concentration and are most enriched in LREEs (Kuifeng Yang et al. 2019). Hence, it is assumed that the entire core length of both the boreholes is consisting of the dolomitic and calcitic carbonatite with intermittent syenites and pyroxenites based on the REE values indicated by the analytical results. The borehole cores also yielded high barium (Ba) content in carbonatites is typically linked to late-stage magmatic differentiation and alkali-rich mineral phases such as K-feldspar, biotite, and barite.

The main REE mineral phases identified in the Samalpatti block are Monozite, Fluorapatite, Bastnasite, Ancylite and Cerianite (Ref Page no 25 of Annexure 18 : Petrology studies). However, a total resource of **2.948 million tonnes** with a weighted **average TREE value of 3,723 ppm** has been estimated under the UNFC 334 category in hybrid zone by cross section method.

b) Carbonatites are carbonate-rich igneous rocks (>50% carbonate minerals, <10% SiO_2) that act as the world's most important hosts for rare earth element mineralisation. An attempt has been made to compare the Samalpatti carbonatite with the other Indian and global carbonatite complexes. In India, complexes like Amba Dongar (Gujarat) and Pakkanadu (Tamil Nadu) show REE enrichment comparable to global giants such as Bayan Obo (China) and Mountain Pass (USA) Palabora, (South Africa). The chemical components controlling REE mineralisation are dominated by Ca–Mg–Fe carbonates, alkalis, and accessory phases like apatite, monazite, fluorite, and bastnäsite.

Table 33: Carbonatite complexes with details of host rock

Carbonatite Complex	**Host Rock Type**	**Main REE Minerals**	**Key Associated Elements**
Samalpatti (India)	Calcite and Dolomite carbonatite	Flourappatite, Monazite, strontianite	Fourpartite and barite
Amba Dongar (India)	Sovite, ankeritic veins	Bastnasite, monazite	Fluorite, barite
Pakkanadu (India)	Carbonatite + silicate	Bastnasite, apatite	Hydrothermal REE fluids
Bayan Obo (China)	Carbonatite + iron ore	Bastnasite, monazite	Nb, Fe, fluorite
Mountain Pass (USA)	Calcite carbonatite	Bastnasite	LREE-rich, fluorite
Palabora (South Africa)	Carbonatite pipe	Bastnasite, monazite	Cu, Nb, P, F

The common key chemical elements that are associated with the carbonatite complexes in general are

Ca, Mg, Fe, Mn – dominant cations in carbonates.

Na, K – alkalis, often concentrated in late-stage fluids.

P, F, Cl, CO_2 – volatile components aiding REE mobility.

Nb, Ta, Th, U, Sc – critical metals often associated.

REE (especially LREE like La, Ce, Nd, Pr) – enriched due to incompatibility in early crystallising minerals.

In the amba Dongar carbonatite complex, the REE mineralisation is hosted in Sovite and Ankerite veins, the REE minerals are associated with bastnasite and monazite. In addition, it shows a strong association with fluorite and barite.

In the case of Pakkanadu carbonatite complex, it shows fractional crystallisation and immiscibility processes. The Hydrothermal fluids play a major role in concentrating REEs.

In the global scenario, the Bayan Obo, China, being the worlds largest REE deposit, the carbonatite is related with bastnasite and monazite as main REE minerals hosting the REE mineralisation, it is also rich in Nb, Fe and fluorite.

On the other hand, the Mountain Pass, USA, which has mainly of calcite carbonatite with bastnasite as the main and dominant REE bearing mineral having high grade LREE deposit.

The Palabora carbonatite complex of South Africa has REE enrichment linked to deep-seated magma chambers. Pressure and emplacement depth control REE concentration

The Indian carbonatites are smaller in scale but geochemically similar to global deposits. REE enrichment is controlled by fractional crystallisation, immiscibility, and hydrothermal alteration. Global giants like Bayan Obo and Mountain Pass show higher tonnage due to prolonged magma evolution and favourable emplacement depths.

Shuo Xue et al., 2026, according to them the emplacement depth is the primary factor controlling in the mineralization of carbonatite-hosted REE deposits. In deep crustal environments (> 0.3 GPa), the suppression of REE rich apatite crystallization and enhanced brine-melt formation collectively promote extreme REE enrichment in residual liquids. This mineralization style typically exhibits mineralogical transitions from burbankite to bastnäsite-group REE minerals, accompanied by fluid inclusion signatures of high salinity, homogenization temperatures and pressures.

The below table (table 34) indicates REE values from the Samalpatti block compiled and compared with corresponding data from well-studied Indian carbonatite complexes such as Ambadongar Carbonatite Complex and relevant global carbonatite occurrences. Only a few high values of La, Ce, Nd, Pr, and rare metals like the Sc and Nb were picked up for the comparative study.

Table 34: Table showing comparatively values of La, Ce, Nd, Pr, Sc and Nb(in ppm) across the carbonatite complexes in India and others

Name of the deposit	Type of sample	La	Ce	Nd	Pr	Sc	Nb	Total REE	Minerals contributing REE	Origin of carbonatite	Source
Samalpatti Alkaline complex	Avg Trench and Borehole core (Conducted by KIOCL in the current program)	987	1,845	551.51	182.66	33.8	13	3,914	Monozite, Fluorapatite, Bastnasite, Ancylite and Cerianite	Carbonatite dyke	
Ambadongar carbonatite complex	Sovite	6,593	7,329	948	-	-			Apatite and Barite	carbonatite diatreme	Viladikar 1981
	Ankeritic carbonatite	15,100	22,400	500	-	-				carbonatite diatreme	Viladikar 1981
	Carbonatite	1,237	1,991	296	-	-				carbonatite diatreme	Srinivas Viladikar 1981
	Carbonatite breccia	4,882	7,160	1,598	-	-				carbonatite diatreme	Jan Schulzki et al 2024
Mountain Pass carbonatite complex **(USA)**		7.6 wt%	10.8 wt%	2.5 wt%	0.8 wt%				Apatite and Monazite	Igneous and Metasomatic	Benson and Watts 2024
		54,900	79,200	5,960	16,300				Bastnäsite, Hydroxylbastnäsite, Parisite, Synchysite, Röntgenite,Sahamalite		Watts and Andersen 2026
Byan Obo deposit (China)	BODK1-12	33,370	46,670	17,380	4,173	79.8	161.1	1,04,562		Sedimentary carbonate rocks being metasomatised by mantle-derived fluids, likely derived from a REE-enriched carbonatitic magma	Yang et al 2008

Recommendations

It is recommended to carryout to

1) Based on the encouraging results obtained during the G4 stage investigation, it is recommended to upgrade the prospect to G3 stage for systematic inclination to establish continuity, geometry and grade distribution of the mineable carbonatite body with higher confidence aided by detailed mapping, trenching, geophysical surveys to delineate depth extension and to delineate possible thicker carbonatite bodies at depth after taking necessary clearance from land owners.
2) The borehole log data and cross-sections indicate that anomalous REE values in the range of 0.1– 0.3% continue up to the end of the drilled depth, suggesting that the mineralised zone remains open at depth. Further, comparison with trench data (Northern side of Trench 4 Ref plate 5 Sec B-B') indicates that the full width of the carbonatite–fenite zone has to be adequately exposed at surface by "master trenches" in future exploration programs.
3) Drilling and trenching confirm a soil profile of 1–3 metres across the alkaline terrain. A high-grade surface sample (57CH 01/05) north of Carbonatite Band 1 returned 6,891 ppm TREE, highlighting the region's potential for REE-bearing soil deposits. This suggests that the region's soil holds significant REE potential and warrants an future REE bearing Soil assessment as extraction technology advances.
4) The resource estimated at this stage is only a reconnaissance resource and needs further evaluation at higher levels of exploration with extensive data sets. All assumptions and estimations in the current report are based only on one borehole in each sub block and the entire length of the carbonatite body is taken into consideration while computing the resources. It is pertinent to mention that the Samalpatti carbonatite is also contains Sc and Nb (rare metals). With the increase of La and Ce the Sc and Nb also tends to increase showing relationship with each other. This to be considered in the next stage of exploration.
5) Considering the strategic importance of rare earth elements, the current exploration has yielded substantial length, width and depth continuity of the carbonatite dykes with sufficient REE values. In order to enhance domestic resource security, further detailed evaluation of the prospect is warranted to clearly reflect the need for a systematic and staged exploration programme to establish the continuity, geometry,

and grade distribution of the carbonatite-fenite mineralised system with a higher level of confidence.

6) A significant outcrop of crystalline limestone extends 850 m in strike length with an average width of 80 m is observed in Sub block 3 with an average CaO of 45.52% (well above the 34% IBM threshold). This zone could be further evaluated by depth probing in order to establish the industrial grade limestone.

22. Expenditure:

The project is executed under NMET funding with total amount of Rs. 0.62 crores (Including GST).

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24. Locality index

Table 35:Locality index

Sl.no	Village	Latitude			Longitude		
		°	'	"	°	'	"
1	Anderipatti	12	20	50	78	28	15
2	Badapalli	12	16	45	78	29	30
3	Bajjanur	12	15	30	78	27	45
4	Gargipalli	12	17	15	78	27	45
5	Jogipatti	12	19	15	78	28	45
6	Kanjanur	12	16	00	78	28	00
7	Kattumungampatti	12	19	00	78	26	10
8	Kollapalli	12	17	40	78	27	20
9	Mattur	12	23	00	78	25	00
10	Mettusulakarai	12	16	00	78	25	30
11	Mungampatti	12	19	45	78	25	30
12	Olapatti	12	10	40	78	25	10
13	Onnakarai	12	16	30	78	26	30
14	Pallasulakkarai	12	16	15	78	26	30
15	Palattur	12	24	00	78	25	00
16	Salamarattupatti	12	17	15	78	26	10
17	Samalpatti	12	18	30	78	29	00
18	Sonarhalli	12	21	40	78	25	30
19	Sunnampatti	12	20	45	78	27	39
20	Tippampatti	12	20	45	78	28	50
21	Δ 442	12	19	00	78	25	20
22	Δ 447	12	19	20	78	27	10
23	Δ 504	12	18	20	78	27	00

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