PROPOSAL FOR RECONNAISSANCE SURVEY (G-4 STAGE) FOR REE, AND ASSOCIATED MINERALS IN NAKCHIAREA (166.26 SQ KM), DISTRICT-ANGUL, ODISHA

COMMODITY: REE AND ASSOCIATED MINERALS

BY

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SEMINARY HILLS

PLACE: NAGPUR
DATE: AUGUST 2025

Summary of the Block for Reconnaissance Survey (G-4 Stage)

GENERAL INFORMATION ABOUT THE BLOCK

	Features	**Details**
	Block ID	Nakchi Area
	Exploration Agency	Mineral Exploration and Consultancy Limited (MECL)
	Commodity	REE and associated minerals
	Mineral Belt	Eastern Ghat Mobile Belt, Odisha
	Budget & Time schedule to complete the project	143.85 lakhs, 10 months
	Objectives	The main objective of the investigation is to search the REE & RM mineralization in rocks of EGMB, Kamthi formations of Upper Gondwana group as well as secondary enrichment of REEs in soil and stream sediments. Delineation of REE-enriched zone through LSM, followed by pitting and thereby systematic collection of samples from different media such as bedrock, pit, regolith, stream sediment, auger drilling. After the positive outcomes of the above activities scout drilling will be carried out to intersect REE bearing rocks in subsurface at 30m vertical depth. In addition, assessment of quality and quantity of the resources (334) if any as per UNFC norms & Minerals (Evidence of Mineral Contents) Rules- 2015 will be carried out.
	Whether the work will be carried out by the proposed agency or through outsourcing and details thereof. Components to be outsourced and name of the outsource agency	Work will be carried out by the proposed agency.
	Name/ Number of Geoscientists	Three nos. of Geoscientist (2 Field + 1 HQ)
	Expected Field days (Geology) Geological Party Days	Geologist Party Days: 200 Days (Field) Geologist Party Days: 45 Days (HQ)
1	**Location**	

	The coordinates of corner points of proposed Nakchi area are as follows:	
	Villages	Gurujang, Nakchi, Handapa, Luthamunda, Urukula, Turuda, Angapada, Kundali and others.
	Tehsil/ Taluk	Athamalik
	District	Angul
	State	Odisha
2.	**Area (hectares/ square kilometers)**	
	Block Area	166.26 sq km
	Forest Area	The proposed block area was checked in PM GatishaktiPortal, where the block was said to be free from Eco sensetive Zone and Wildlife Sanctuary. However, 40% of the block is falling in forest land.
	Government Land Area	Data Not Available
	Private Land Area	Data Not Available
3.	**Accessibility**	
	Nearest Rail Head	Nearest railway station is Boinda which located 05 km east to the block. Broad gauge line connecting Cuttack-Sambalpur of ECoR passes through the central part of the block.
	Road	All the villages in the area are well connected to each other and to the highways by motorable roads and tracks. The National Highway-55 connecting Cuttack-Sambalpur passes through the block in the central part.
	Airport	Bhubaneswar (200 km south-east of the block)
4	**Hydrography**	
	Local Surface Drainage Pattern (Channels)	The block is part of the catchment area of the Mahanadi river system showing dendritic pattern drainage system.
	Rivers/ Streams	Mahanadi
5	**Climate**	
	Mean Annual Rainfall	The average annual rainfall is about 160 cm (Mid-

Sl. No.	Point	DMS Coordinate (DMS)		UTM Zone: 45N (m)	
		Latitude	Longitude	Northing	Easting
1	A	21° 00' 0.57" N	84° 30' 0.35" E	2324197.64	240126.68
2	B	21° 00' 0.84" N	84° 42' 42.96" E	2323875.98	262157.03
3	C	20° 56' 54.1" N	84° 42' 40.7" E	2318132.66	262009.68
4	D	20° 56' 56.15" N	84° 35' 43.65" E	2318372.47	249959.00
5	E	20° 54' 42.18" N	84° 35' 43.88" E	2314250.99	249903.67
6	F	20° 54' 43.04" N	84° 29' 59.52" E	2314429.50	239950.17

		June to October)
	Temperatures (December) (Minimum) Temperatures (June) (Maximum)	May is usually the hottest month when the mean daily temperature varies around 33-38°C and often rises upto 42°C. December is the coldest month of the year with the mean daily minimum temperature of 10-15°C.
6	**Topography**	
	Toposheet Number	73D09
	Morphology of the Area	North and northeastern part of the block represent highly rugged terrain with NW-SE trending ridges exhibiting a undulating topography. In the central and south part are represented by flat terrain exhibiting the pediment-pediplain where cultivation is carried out. The maximum elevation is in the north and northeastern part which is 538mRL and the minimum elevation is in the southern part i.e 167mRL.
7	**Availability of baseline geosciences data**	
	Geological Map (1:50K/ 25K)	1:50000 (Bhukosh)
	Geochemical Map	Stream sediment sample results from NGCM, Bhukosh, GSI for TS 41E/07have been used to compute LREE, HREE & Total REEgeochemical anomaly mapspresented as plates in the proposal.
	Geophysical Map	**Not Available**
8.	**Justification for taking up Reconnaissance Survey / Regional Exploration**	1. A total of 43 stream sediment samples from the proposed block were collected during the NGCM programme. Of these, 30 samples (~70%) contain more than 1,000 ppm ∑REE, covering about 80% of the block. High-grade anomalies include 6 samples exceeding 2,000 ppm and 14 samples over 1,500 ppm. Analytical data show LREE concentrations ranging from 383.08 to 6,907.66 ppm (avg. 1,350.94 ppm), HREE from 85.85 to 266.37 ppm (avg. 128.86 ppm), and TREE from 473.73 to 7,174.03 ppm (avg. 1,479.80 ppm), indicating widespread REE enrichment and the presence of high-grade zones. 2. The block spans two geological domains — the Eastern Ghats Mobile Belt (EGMB) in

		the Central and Southern parts, and the Upper Gondwana Group in the North. Both show REE enrichment in stream sediment geochemistry. During FSP 2023–24, GSI's G4 exploration to east of the proposed block confirmed secondary REE enrichment, particularly in ferruginous sandstones of the Kamthi Formation, derived largely from khondalite rocks of the EGMB. Petrographic and SEM studies identified monazite and zircon as the main REE-bearing minerals. The proposed block lies within this proven geological framework, and NGCM data further supports its enrichment potential. 3. In the EGMB portion, previous studies have identified primary REE sources hosted in pyroxene-bearing syenite, syenite, and pyroxenite intrusions. The pyroxenites are often apatite-bearing or cut by apatite-rich veins, both REE-rich. 4. The selection of this block is based on strong NGCM anomalies, earlier exploration successes, and confirmed REE-hosting lithologies. The favourable geology, combined with high geochemical values, established mineral phases, and strategic importance of REEs, makes this area a highly prospective target for detailed exploration.

JUSTIFICATION FOR TAKING UP THE AREA FOR REE EXPLORATION

1 A total of 43 stream sediment samples within the proposed block were collected during the NGCM programme. Of these, 30 samples (≈70%) contain more than 1,000 ppm of ∑REE, covering approximately 80% of the block area. Notably, 6 samples record concentrations exceeding 2,000 ppm, and 14 samples show values greater than 1,500 ppm. The NGCM dataset for the block reveals anomalous concentrations of individual REE components compared to regional background levels. The analytical summary is as follows:

Type of REE	Min. (ppm)	Max. (ppm)	Avg. (ppm)
LREE	383.08	6907.66	1350.94
HREE	85.85	266.37	128.86
TREE	473.73	7174.03	1479.80

These results highlight both widespread REE enrichment and the presence of high-grade anomalies, indicating strong potential for further exploration.

2 The proposed block falls within two distinct geological domains — the Eastern Ghats Mobile Belt (EGMB), comprising both Central and Southern parts, and the Upper Gondwana Group in the Northern part. In both these formations, stream sediment geochemical data indicate enrichment of rare earth elements (REEs).

3 During the FSP 2023–24, the Geological Survey of India (GSI) conducted G4-level exploration for REEs to the east of the proposed block in upper Gondwana domain, establishing secondary enrichment potential. In the UpperGondwanas, significant REE enrichment is observed in the ferruginous sandstones of the Kamthi Formation. Provenance studies indicate that the Kamthi sediments were derived predominantly from khondalite rocks of the EGMB. Petrographic and SEM analyses confirm that monazite and zircon are the principal REE-bearing mineral phases in this area. Further, investigation in the area and surrounding with similar geological set up has been recommended.

4 The proposed block lies within this same geological framework, and National Geochemical Mapping (NGCM) data further supports the potential for REE enrichment.

5 In the EGMB portion of the block, past REE assessment projects have established primary mineralization sources, which are currently under further evaluation and resource upgradation. The EGMB rock suite in the area is intruded by pyroxene-bearing syenite, syenite, and pyroxenite, which serve as the primary host rocks for REEs. The pyroxenite bodies are either apatite-bearing or traversed by apatite-rich veins, both of which are known to be REE-rich.

6 The area has been selected based on anomalous NGCM values, the results of earlier exploration, and their positive outcomes, thereby establishing both the primary sources and the secondary enrichment potential of REEs within the block. The combination of a proven mineralizing geological environment, strong geochemical anomalies, confirmed REE-bearing mineral phases, and strategic importance of REEs makes the proposed area a highly prospective target for detailed REE exploration.

PROPOSAL FOR RECONNAISSANCE SURVEY (G-4 STAGE) FOR REE AND ASSOCIATED MINERALS IN NAKCHI AREA, DISTRICT –ANGUL, STATE -ODISHA (AREA: 166.26 SQ. KM.)

1.0.0 INTRODUCTION:

1.0.1 The rare-earth elements (REE), also called the rare-earth metals or rare earths, and sometimes the lanthanides or lanthanoids (although scandium and yttrium, which do not belong to this series, are usually included as rare earths), are a set of 17 nearly indistinguishable lustrous silvery-white soft heavy metals. Scandium and yttrium are considered rare-earth elements because they tend to occur in the same ore deposits as the lanthanides and exhibit similar chemical properties, but have different electrical and magnetic properties. The term 'rare-earth' is a misnomer because they are not actually scarce, although historically it took a long time to isolate these elements. REEs are not rare in terms of overall abundance in the Earth's crust, but they are rarely found in large, concentrated deposits that are economically viable to mine.

1.0.1 Rare earth elements are characterized by high density, high melting point, high conductivity and high thermal conductance with distinctive electrical, metallurgical, catalytic, nuclear, magnetic and luminescent properties make them indispensable for a variety of emerging high end and critical technology applications which are relevant to India’s energy security i.e., clean energy, defense, civilian application, environment and economic areas. REE demand is expected to continue its growth, especially for their use in low carbon technology. The ever-increasing demand for these REE necessitates a concerted effort to augment the resource position of our country.

1.0.2 The Rare earth elements (REE) are a collection of 17elements in the periodic table , namely scandium, yttrium and lanthanides (15 elements in the periodic table with atomic numbers 57 to 71 namely: lanthanum (La), cerium (Ce), praseodymium(Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb) and lutetium (Lu). In spite of its low atomic weight Yttrium (atomic no. 39) has properties more similar to the heavy lanthanides and is included with this group. Scandium (atomic no. 21) is found in a number of minerals although it may also occur with other rare earth elements (REE).

1.0.3 Although these elements tend to occur together, the lanthanide elements are divided into two groups. The light rare earth elements (LREE) are those with atomic numbers 57 through 62(La, Ce, Pr, Nd, Pm, Sm) and the heavy rare earth elements (HREE) are those with atomicnumbers from 63 to 71 (Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu) and Y, Sc. However, because of their geochemicalproperties, rare earth elements are typically dispersed and not often found concentrated as rareearth minerals in economically exploitable ore deposits.

1.0.4 Generally, the light rare earth elements (LREE) are more abundant in the earth's crustand easily extracted than heavy rare earth elements (HREE). It was the very scarcity of these minerals (previously called "earths") that led to the term "rare earth". The first such mineral discovered was gadolinite, a compound of cerium, yttrium, iron, silicon and other elements. This mineral was extracted from a mine in the village of Ytterby in Sweden; several of the rare earth elements bear names derived from this location.

1.0.5 Critical minerals are those minerals that are essential for economic development and national security. The lack of availability of these minerals or concentration of extraction or processing in a few geographical locations may lead to supply chain vulnerabilities and even disruption of supplies. The future global economy will be underpinned by technologies that depend on minerals such as lithium, graphite, cobalt, titanium, and rare earth elements. These are essential for the advancement of many sectors, including high-tech electronics, telecommunications, transport, and defence. They are also vital to power the global transition to a low carbon emissions economy, and the renewable energy technologies that will be required to meet the 'Net Zero' commitments of an increasing number of countries around the world. Hence, it has become imperative to identify and develop value chains for the minerals which are critical to our country.

1.0.6 Considering important parameters such as resource/ reserve position in the country, production, import dependency, use for future technology/ clean energy, requirement of fertilizer minerals in an agrarian economy, the Committee has identified a set of 30 critical minerals. These are Antimony, Beryllium, Bismuth, Cobalt, Copper, Gallium, Germanium, Graphite, Hafnium, Indium, Lithium, Molybdenum, Niobium, Nickel, PGE, Phosphorous, Potash, REE, Rhenium, Silicon, Strontium, Tantalum, Tellurium, Tin, Titanium, Tungsten,

Vanadium, Zirconium, Selenium and Cadmium. *(Critical Minerals for India, Report of the Committee on Identification of Critical Minerals, Ministry of Mines, June 2023)*

1.1.0 BACKGROUND

1.1.1 In light of above, emphasis has been given to explore prospective areas for critical and strategic minerals especially REE and RM. Mineral Exploration and Consultancy Limited (MECL) plays a crucial role in India's mineral exploration sector, serving as a premier public sector enterprise under the Ministry of Mines. New areas are being explored to align the national objective. Nakchi area (166.26 Sq. Km) Angul District, Odisha part of the SOI toposheet 73D09 and within the Eastern Ghat Mobile Belt (EGMB) by MECL through NMET funding is an approach towards the same.

1.1.2 Adjacent to the proposed block, GSI in its field season 2022-23 has established occurrences of REE and RM with in the EGMB part of the SOI toposheet 73H/4 where apatite veins, which transected a suite of syenite-pyroxenite bodies, intruding the charnockites of Eastern Ghats Mobile Belt.

1.1.3 The maximum total REE NGCM value in the proposed block is 7174 ppm followed by 3142 ppm and 3064 ppm which is highly anomalous.Keeping this in view, the present proposal is being put up for Reconnaissance Survey (G-4) for REEand associated minerals in Nakchi area, Angul District, Odisha for approval in the forthcoming meeting of Technical cum Cost Committee (TCC) of NMET.

1.2.0 LOCATION AND ACCESSIBILITY

1.2.1 The proposed Nakchi Block over an extent of 166.26 sq km and lies in AthamalikTehsil in Angul District, Odisha (Toposheet No. 73D09). The major villages falling within the proposed block are Gurujang, Nakchi, Handapa, Luthamunda, Urukula, Turuda, Angapada, Kundali and others. All the villages in the area are well connected to each other and to the highways by motorable roads and tracks. Nearest railway station is Boinda which located 05 km east to the block. Broad gauge line connecting Cuttack-Sambalpur of ECoR passes through the central part of the block. The National Highway-55 connecting Cuttack-Sambalpur passes through the block in the central part. Location map of the area is provided in the Plate I and co-ordinates of the boundary corner points in the following table.

Table 1: Coordinates of Corner Points of Proposed Nakchi area over an extent of 166.26 sq km, Angul District, Odisha.

Sl. No.	Point	DMS Coordinate (DMS)		UTM Zone: 45N (m)	
		Latitude	Longitude	Northing	Easting
1	A	21° 00' 0.57" N	84° 30' 0.35" E	2324197.64	240126.68
2	B	21° 00' 0.84" N	84° 42' 42.96" E	2323875.98	262157.03
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6	F	20° 54' 43.04" N	84° 29' 59.52" E	2314429.50	239950.17

1.3.0 PHYSIOGRAPHY

1.3.1 North and northeastern part of the block represent highly rugged terrain with NW-SE trending ridges exhibiting a undulating topography. In the central and south part are represented by flat terrain exhibiting the pediment-pediplain where cultivation is carried out. The maximum elevation is in the north and northeastern part which is 538mRL and the minimum elevation is in the southern part i.e 167mRL.

1.4.0 DRAINAGE

1.4.1 The drainage network is dendritic to sub-dendritic in the central and southern regions, indicating underlying metamorphic basement rocks with moderate structural control. In the northern hilly terrain, streams are structurally guided, giving rise to sub-parallel to trellis. Primary drainage trends are towards the ESE and SE, ultimately joining larger river systems beyond the proposed area. Several small streams originate from the hill ranges in the north and converge in the central lowland zones.The Purna Pani RF area and Khondaljani hills act as watershed divides between north-flowing and south-flowing tributaries. Drainage density is high in the northern rugged terrain due to steep slopes and impermeable bedrock and lower in the southern plains where slopes are gentler and alluvial cover may be present.

1.5.0 CLIMATE

1.5.1 The area experiences sub-tropical to tropical climate, characterized by high temperature, high humidity and medium to high rainfall with short and mild winters. The south-west monsoon normally occurs between June and September. The annual rainfall in the area is 1421 mm. December is the coldest month with mean daily minimum temperature of 11°C. Both day and night temperatures increase rapidly from March and by May the mean daily

maximum temperature reaches 42°C, while the mean minimum temperature is 26.8°C. October to February is the most suitable time for fieldwork as the temperature is mild. Occasional dense fog occurs in the cold seasons causing poor visibility..

Maximum Temperature: 42°C (May)
Minimum Temperature: 9°C(December)
Annual Rainfall: 1421mm (July and August)

1.6.0 FLORA AND FAUNA

1.6.1 A surrounding area and some part of the block, especially the hilly areas, is covered with dense forests. The plains are also covered by thick vegetation. Common flora found in the area are Neem (Azadirachtaindica), Mango (Mangiferaindica), Jack fruit (Artocarpusheterophyllus), Pipal (Ficusreligiosa), Date palm (Phoenix dactylifera), Sal (Shorearobusta), Mahuwa (Madhucalongifolia), Turmeric (Curcuma longa), Kendu (Diospyrosmelanoxylon), Bamboo (Bambusa vulgaris) etc.

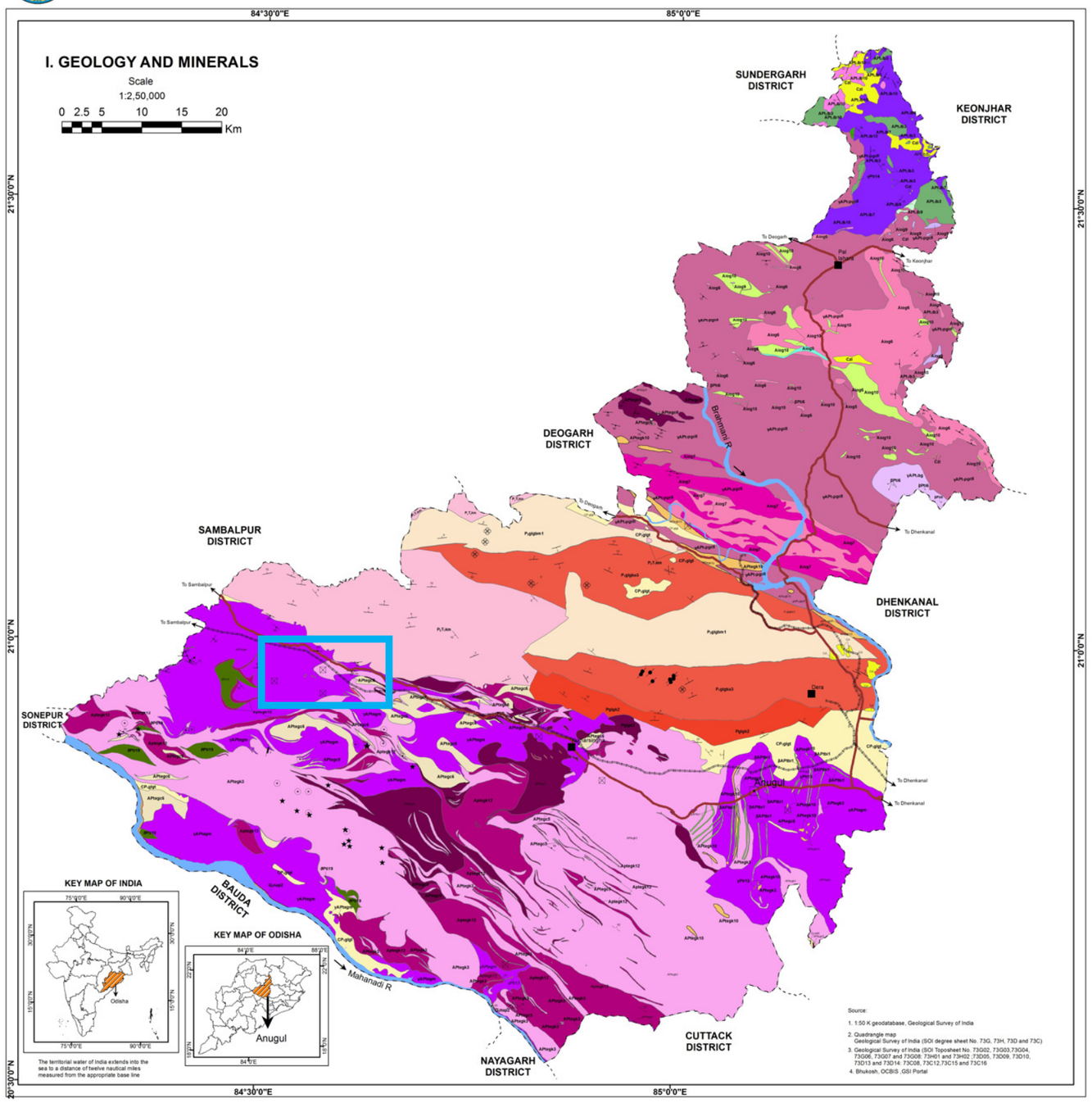
1.6.2 The wild animals found in jungles are bear (Melursusursinus), elephants (Elephasmaximusindicus), jackal (Canisauresindicus), fox (Vulpesbengalensis), hyena (Hyena hyena) etc.

1.7.0 REGIONAL GEOLOGY

1.7.1 The proposed block falls within two distinct geological domains — the Eastern Ghats Mobile Belt (EGMB), comprising both Central and Southern parts, and the Upper Gondwana Group in the Northern part. Regional geological map of the area is provided in the Text Figure 1. Descriptions of both the domains are as follows:

1.7.2 The present area of investigation forms the northern part of the Eastern Ghats Mobile Belt (EMGB). The Eastern Ghat Mobile Belt (EGMB) is a NE- SW trending arcuate Proterozoic fold belt of high-grade rocks, extends for about 900 km strike length from Brahmani River in Odisha to Ongole in Andhra Pradesh with maximum width of about 300 km in Odisha in the north. The mobile belt is located in juxtaposition with three major cratonic blocks such as Bastar to the west, Singhbhum to the north and Dharwar to the south. The mobile belt changes its trend NE-SW to WNW-ESE in the north. The northern contact of EGMB with Singhbhum craton is marked by Northern Boundary Shear Zone (NBSZ includes Barkote-Akul shear zone to the north, Kerajang shear zone to the south) and Sileru Shear Zone (SSZ) marks the western contact of EGMB with Bastar Craton.

जिला सम्पदा मानचित्र
DISTRICT RESOURCE MAP



अनुगुल, ओडिशा
ANUGUL, ODISHA

LEGEND

	LITHOLOGY	FORMATION	GROUP	SUPER GROUP	AGE
Q,ualp2	Sand, Silt, Clay	Present Day Deposit			Meghalayan
Q,oabl	Lateritic Soil	Bolgarh Formation			Pleistocene
Cal	Laterite				Cenozoic
P,T,km	Shale, Sandstone and Clay	Upper Kamthi	Upper Gondwana	Gondwana	Late Permian to earlyY Triassi
P,qlgbm1	Ferruginous Sandstone, Shale, Iron Stone	Barren Measure			Late Permian
P,qlgr2	Sandstone, Shale with Coal Seam	Raniganj			LatePermian
P,qlgbs3	Sandstone, Siltstone, Shale with Coal	Barkar Formation	Lower Gondwana		Early Permian
P,qlgkh2	Carboniferous Sandstone, Shale with Minor Coal	Karharbari Formation			Permian
CP,qlgt	Shale, Sandstone, Conglomerate	Talchir Formation			Carboniferous to early Permia
βPt6	Dolerite	Intrusives			Proterozoic
γPt13	Pegmatite				
γPt14	Quartz Vein				
βPt15	Gabbro / Norite / Anorthosite				
γAPtegn	Granite Gneiss		Migmatite	Easternghat	Archaean to Proterozoic
APtegc	Acid to Intermediate Charnockite		Charnockite		
APtegc6	Pyroxene Granulite/ Basic Charnockite				
Aqtgk12	Leptynite		Khondalite		
APtegk10	Quartzite				
APtegk3	Quartz-Garnet-Sillimanite-Graphite Schist				
βAPtbt1	Newer Dolerite	Instrusives			Archaean Palaeo proterozoic
γAPt,bg	Granite				
APt,lb3	Basic Meta Volcanics		Lower Bonai		Archaean to Palaeo Proterozoi
APt,lb7	Quartzite				
APt,lb9	Slate, Phylite, Mica Schist				
APt,lb10	Conglomerate				
APt,lb12	Amphibolite Hornblende Schist, Chlorite Schist				
γAPt,pgn8	Granite Gneiss	Peninsular Gneissic Complex			Archaean to Palaeo Proterozoic
Aiog5	Tremolite Actinolite Schist		Gorumahishani	Archaean	
Aiog6	Mica Schist, Quartz Mica Schist				
Aiog7	Quartzite				
Aiog9	Slate and Phyllite				
Aiog10	Hornblende Schist, Chlorite Schist, Metabasic Rocks				

STRUCTURAL FEATURES

- Antiformal Axis
- Bedding
- Fold Axis
- Foliation
- Joint Plain
- Lineation
- Schistosity

MINERAL OCCURENCES / DEPOSIT

- Coal
- Graphite
- Manganese
- Dimension Stone
- Fire Clay

GEOGRAPHIC / OTHERFEATURES

- District Headquarter
- Locality
- Railway Line
- Roads (NH)
- Rivers / Streams
- District Boundary

Text Figure : 1

Source: District Resouce Map of Angul (GSI)

Location of Nakchi Block

The northern boundary of the EGMB with SinghbhumCraton is considered as a narrow transition zone (Banerji et. al., 1987) like that of the western margin.

1.7.3 EGMB dominantly constituted of high grade metamorphites, para and orthogneisseswith intrusive massif anorthosites and feldspathoidal alkaline plutons. This belt issubdivided longitudinally (Ramakrishnan et.al, 1998) on the basis of lithologicalassociation into:

1. Western Charnockite zone (WCZ): It is about 20-30km wide and characterized dominantly by charnockite massifs, basic granulite and BIF.

2. Western Khondalite Zone (WKZ): It is about 30-80 km wide and characterizedby metasediments of Khondalite group of rocks.

3. Central Migmatite Zone (CMZ): It is about 40-100 km wide and characterized by migmatitic gneiss (including leptynite), enclaves of khondalite group rocks, charnockites with basic granulite enclaves and garnetiferousgranitoids.

4. Eastern Khondalite Zone (EKZ): Essentially characterized by migmatised garnet-sillimanite gneiss.

1.7.4 Regional Structure: Khondalites and granulites of EGMB preserve imprints of multiple phases ofdeformation. The general trend in the EGMB is dominantly NE-SW in the southern part(Koraput dist.), gradually changes to N-S in the western part (Kalahandi dist.) and then toENE-WSW through NE-SW in the northern part. The first generation folds (F1)are observed to be tightly appressed isoclinals and rootless intrafolial type with axial planeof NE-SW, second generation folds (F2) are isoclinal to commonly overturned in nature,coaxial with F1 and forms a hook shape interference pattern of folding with F1. The thirdgeneration folds (F3) are represented as locally developed fracture and shear cleavageswith varying attitude and geometry (Sarkar et.al., 1981; Halden et al., 1982; Bhattacharyaet.al., 1994; Biswal et.al., 1998). S3 schistosity related to F3 folding represents thedominant structural fabric along which ductile shear zone has taken place (Gupta et.al.2000). The interference of F2 & F3 folds resulted dome and basin patterns.EGMB of Odisha sector has been dissected by several brittle-to-brittle ductile shearbelts (Moharana, 1982; Chetty and Murthy,1998; Ramakrishnan et.al., 1998;Mahalik,1994; Sarkar et.al., 2000). The prominent shear belts are as follows:

1. NE-SW trending:a.Sonepur-Koraput-Kolab-Machkund (Sileru shear zone)
   b. Rairakhol-Penthbahal-Kankarkhol shear zone
2. E-W trending: Mahanadi and Angul-Dhenkanal shear zone

3. ENE-WSW trending: Aska-Taptapani, Bhanjanagar, Gohira, Tikra shear zone
4. N-S trending: Tel, Nagavalli shear zone and
5. NNW-SSEtrending:Vamsadharashearzone

1.7.5 Gondwana: In Odisha, Gondwana rocks are exposed over an area of 5843 sq. km along a NW – SE trending linear belt in the Mahanadi valley. There are mainly two coal bearing major basins (Talcher, Ib river), and six other Gondwana basins, as small patches/ outliers (Athgarh, Katiringia, Gaisilat, Athmalik, Chhatarpur, Jajpur in the districts of Angul, Dhenkanal, Sambalpur, Sundargarh, Phulbani, Baudh, Bolangir, Cuttack, Khurda, Puri, jajpur and Ganjam) that expose Gondwana rocks in Odisha (Fig 5.A.2.1). Talcher coalfield is located at the southeastern end of the NW-SE trending Son Mahanadi master basin. It represents the southeastern end member of the Lower Gondwana basin within the Mahanadi valley graben. It occurs as a detached basin surrounded by Rengali Provinces to the north and Eastern Ghat Mobile belt to the west, south and east. It occupies an area of about 1800 sq km bounded by latitudes 20°53'40" & 24°12'00" and longitudes 84°20'00" & 85°23'00". having an elliptical outline with its longer axis about 110 km long along WNW-ESE direction and maximum width of about 25 to 35 km as observed in the west central part of the coalfield. The coal mines and other industrial establishments are mostly located on the eastern and southeastern part of the coalfield except the recent development of Chhendipada mine in the central part and Jindal power plants along Angul-Chhendipada road. Mining in this coalfield commenced sometimes during the year 1923.

1.7.6 The sedimentary pile in Talcher basin has been classified into five formal lithostratigraphic units, viz. Talchir Formation at the base successively overlain by Karharbari, Barakar, Barren Measures and Kamthi Formation. No confirmed occurrence of Raniganj Formation has yet been established in Talcher Coalfield.

1.7.7 Metamorphism and structure Talchir coalfield is located towards the south eastern periphery of the Mahanadi Valley basin. The Talcher coalfield occurs along a linear zone of major down faulting within the Precambrian basement marked by the approximately WNW-ESE trending Mahanadi valley. It occupies an intermediate position with reference to the radially arranged system of Peninsular Gondwana grabens bounded by E-W trending Damodar valley in the north and the NNW-SSE trending Wardha-Godavari valley in the south. The sedimentary basin has been affected by severe a slaught of tectonic activities which have been reflected mainly as faults and also have close bearing on the

sedimentation and development of coal horizons. The Talcher basin is charcterised by a nearly WNW-ESE trending northern boundary fault along which it is juxtaposed against the Precambrian basement. The regional strike of theGondwana sediments in Talcher Coalfield is nearly E-W but shows local variation from ENE-WSW to WNW-ESE. The dip varies from 2°-10°, mostly towards north and rolling at places. Local dips are varying due to the presence of faults. The average trend of the major faults is NE - SW, NW - SE and ENE - WSW. Surface and sub-surface data from previous report established the presence of at least three major sets of intra-basinal faults. One of the sets is more or less E-W trending i.e., parallel to the strike of the Gondwana sediments and also parallel to the strike of northern boundary fault. The other later two sets are oblique/ transverse to the first set. The multiple sets of faults have segmented the coalfield into a number of horst and graben blocks. It is likely that some, if not most, of these faults are actually basement faults with multiple phases of activation history. The down throw in most of the cases is towards south though some have down throw in the opposite direction also. There is one strike fault of regional dimension cutting through the basin across which there is repetition of the Barakar Formation on the northern and southern side of the basin. Non-diastrophic structures observed in the Talcher basin include bedding of various types/ dimensions: cross bedding, flaser bedding, lenticular bedding etc., found in the sandstones of all formations, particularly Barakar Formation. Micro cross lamination, rhythmic lamination, convolute lamination and slump structure are also observed, more commonly in Talchir Formation. Palaeocurrent directions, as observed in the different formations, are generally towards north or northwest and, locally, towards south and northeast. The litho packages of Talcher Gondwana basin does not undergo any metamorphism.

1.7.8 Surface indication of mineralization, and nature of host rock The Talcher Coal Field is very popular for coal reserve and it is mainly restricted to lower Gondwana group of rocks. NGCM was carried out in OGP areas of Odisha which includes the Mahanadi Valley Gondwana Basin. As the outcome of the NGCM programme, the linear trend of high incidence of REE values are reported over Gondwana Supergroup in stream sediments. The surface indication of mineralization is manifested in the form of heavy minerals found particularly in ferruginous sandstones and stream sediments of 1st, 2nd or higher order. These are concentrated in the stream mechanically by weathering from the bed rock. Therefore, these heavy minerals can be seen sometimes in a dispersed manner in a

particular layer of the bed rock. However, this heavy mineral concentration in regolith is very low.

1.7.9 Generalised stratigraphy of the area is provided in the following table.

Table No. 2
Regional stratigraphy of the area
(Panda and Patra (1990) proposed the following stratigraphic succession for the area)

Age	**Supergroup**	**Group**	**Lithology**
Recent			Alluvium, Soil,
Quarternary			Ash bed, pebble, sand and clay beds
Permo-Carboniferous	Gondowana Supergroup		Sandstone, Siltstone, Conglomerate
Precambrian	Eastern Ghat Supergroup	Intrusives	Peridotite, Pegmatite, quartz vein, nephelinesyenite gneiss, syenite pegmatite veins, porphyroblastic granite gneiss, garnetiferous granite gneiss, migmatite, leptynite
		Charnokite Group	Charnokite gneiss, pyroxene granulite and amphibolite
		Khondalite Group	Quartzite, calc granulite, sillimanitegarnet-magnetite schist and garnet-Quartz-feldspar-sillimanite+ biotite+ graphite (Khondalite) schist/gneiss

1.8.0 GEOLOGY OF THE BLOCK

1.8.1 Based on the available geological map on 50K scale, the area falls in the Western Khondalite Zone and northern segment of the EGMB. The area is bounded between Mahanadi Shear zone in the south and Kerajang Fault zone in the north. The major part of the block is covered by Granite Gmeiss of Migmatite group intruded by leptynites, khondalites and charkonites, to the north eastern part a considerable part of the block area is covered by Upper Kamthi formation of Upper Gondwana supergroup. Central, eastern and southern part of the area is occupied by lateritic soil. Adjacent to the southern boundary granite gneiss and small patches of charnockite occupied the area. The general strike of the area is E-W and dips at an angle of 65 to 90 degrees. Geological map of the area in 50K scale is provided in the Plate III.

1.9.1 PREVIOUS WORK - OBSERVATION AND RECOMMENDATIONS

1.9.1 Jayaram B.N. during the field season 1956-57, carried out systematic geological mapping in 295 sq miles area of the Athmallik sub division of the Dhenkanal district in parts of toposheet no 73D09, 73D10, 73C08 and 73C12.The khondalite suite of rocks were observed to be the predominant rocks of Archaean formation into which a series of basic and acidic invasions took place giving rise to basic chernockites, leptynitic-gneisses and injections-gneisses. The younger rocks of the area belong to the Gondwana era represented by typical freshwater sediments of both the lower and upper divisions of the formation. The general strike of the Archaean formations conforms with the Mahanadi Strike i.e. WNW-ESE and the Gondwana formations show a regional conformity with the trend of the meatmorphics. Graphite occurrences in the Talaipathar Reserved Forest area were examined where couple of very small pockets of graphite schists were observed but no bigger pockets or indications of graphite occurrences were found. Ferruginous grits and shales from the Mehadeva formations were reported as local sources of iron-ore, ancient smelting activities were also noted. Transported blocks of psilomelane and other manganiferous material were observed, however attempts to trace the source only revealed narrow pockets of manganese ore in highly sheared khondalites. Charnokite rocks and gondowana sandstone were used as local building materials.

1.9.2 Subramanian K.S., during the field season 1961-62, carried out investigation of the graphite occurrences in the Athmallik sub-division, Dhenkanal district covering an area of 325 sq km. The study area was represented by parts of toposheets 73 C/8, 73 D/5, 73 D/9 and 73 D/10. Mapping was carried out in a scale of 1:63,360 and pits, trenches were put down to collect representative samples wherever necessary. Twelve occurrences of graphite at Kamalpur, Dandatapa, Bhuasuninalk, hillock 2873, Adeswar, Girida, Akharkata, Tileswar, Gobindpur, Lanchi, San Rohilla and Polamahul were examined by pitting in detail. Graphite samples collected from near Kamalpur, Adeswar and Dandatapa mine show Fixed Carbon contents to be exceeding 50 per cent. But the extension of these graphite veins in the strike and depth were not known.It was suggested that graphite in the area is syngenetic in origin and occurs mostly as disseminated flakes and sometimes as amorphous variety.

1.9.3 Dash C. and Behera S.N. during the field season 2005-06, carried out large scale mapping on 1:12,500 scale over an area of 100 km2 with trial excavation of 51.5 m3 in parts of toposheet no: 73D/5/NW, 73D/5/SE, 73D/5/NE, 73D/9/SW and 73D/9/NW. 55 no of trench samples, 53 no of bed rock samples, 40 no of petrology samples and 25 samples for

analysis of Mg, Zn, Pb, Cu, Mo, V, Co, Ni, As and Na2O were collected and analysed from the study area.Thedelineated manganiferous zone/ horizon in the study area is characterized by intimate association of quartzite, garnetiferousquartzo-feldspathic sillimanite schist/ gneiss and calc-silicate, confined to regional synforms near to the contact with granitoidsand at F2 fold closures.The ore bodiesstrikes NW-SE to WNW-ESE with NE dip at moderate to steep angles. The manganese ore bodies were mainly observed to be syngenetic and strata bound,however few evidences of replacement mode were also noted. Pyrolusite, psilomelane-cryptomelaneare major manganese ore minerals with associated gangue minerals being quartz, garnet, goethite, apatite and graphite. Four blocks at Bhagwanpur, Santipur, Dandatapa-Talaipathar and Tentalapanicontaining manganese ore-bands / bodies having over 20% Mn content (VE) were identified.Further exploration in the identified potential blocks by detail mapping, close space sampling and scout drilling was recommended

1.9.4 Soumya J. Brahma S.J., Singh N. and Rout D. during the field season 2022-23 carried out reconnaissance survey for Graphite in Thakurgarh-Mindol area of Angul district, Odisha to delineate potential zones of graphite. Large Scale Mapping on 1: 12,500 scale (100 sq km), pitting-trenching (60 cu.m) and bed rock sampling (50 nos, 43 pit/ trench sampling were taken up in part of Survey of India Toposheet No. 73D09.Khondalitic suite of rocks, mafic granulites, charnockites, garnetiferousbiotite gneiss and leptynite, are the dominant rock types and khondalite schist is the host rock for graphite minerlisation. The study area is structurally complex comprising four phases of deformation and mylonitisation. The general trend of the lithounits varies fron NS to NW-SE to E-W. Graphite occurs as fine to coarse flakes along the foliation planes and the fold hinges of thin khondalitic bands.Four BRS showed fixed carbon values of 22.0%, 6.37%, 3.29% and 25.98% from Mindol area, while three pit samples showed FC values of 24.15%, 8.41% and 22.32%, channel sample values in trenches showed a 2.10 m zone with 2.70% average FCand 1.8m zone with 1.45% average FC. Further detailed exploration work at; Mindol, Badabar and Teleipathar, Khadagabahal and Barham was recommended.

1.9.5 Subhadarshini S. and Bhattacharya D. carried out reconnaissance survey for REE mineralization in parts of Toposheet no 73C12, 73C16, 73D13 and 73D09 with an objective to search REE mineralization in Gondowana Sediments of Talchir basin. 100 sq km area was mapped in 1:12500 scale collecting 55 stream sediment samples, 81 soil regolith samples, 20 BRS, 5 pit-trench samples, 20petrological samples, 5 EPMA samples

and heavy minerals were collected from 4 panned concentrate of stream sediments. The study area was dominantly covered by reddish ferruginous sandstone, inter-banded by siltstone and conglomerate of Kamthi Formation. Monazite and Zircon were the main contributing mineral phases for REE mineralization. The maximum total REE values in BRS, stream sediment samples, soil regolith samples, pit-trench samples are 350.78 ppm, 17658.07 ppm, 2538.34 ppm and 842.93 ppm respectively. The concentration of ΣREE in Bedrock was very less, moderate in Regolith/soil and very high in stream sediments. It was inferred that the mineralization of REE occurred in the form of alluvial placer as a secondary enrichment in soil and stream medium. As staurolitewas identified under EPMA within Kamthi ferruginous sandstone, the provenance was considered from Eastern Ghat Mobile Belt. The concentration of heavy minerals increased from EGMB rocks to sedimentary rock (mainly Ferruginous Sandstone) to present day sediments (alluvial placer) due to mechanical enrichment under different hydrodynamic condition. The REE mineralization occurs as heavy mineral concentration within alluvial placer in this area which is encompassed within the Kamthi and Barakar Formation. Analysis of clay particles for REE occurrences in ion adsorption clay were recommended. Two anomalous zones were delineated to carry out further detailed study.

1.9.6 Rana G. and Roy Chowdhury K. carried out reconnaissance survey for REE in alkaline and associated pegmatites in part of toposheet no 73C/08 with an objective of demarcating REE mineral blocks in alkaline bodies and pegmatites. 100 sq km area was mapped in 1:12500 scale collecting 155 bedrocks, 50 stream sediment, 50 trench samples, 10 SEM-EDX, 10 EPMA, 10 XRD samples. The alkaline rocks: nepheline syenite and syenite occurs as intrusives to quartzite, khondalites and gneiss. Surface indications of REE/ RM could not be traced in the area, however SEM-EDX & EPMA study revealed occurrences of such minerals along the grain boundaries of major silicates, accessory minerals such as apatite, in association with titanite and zircons. They are also found along the cracks developed in amphiboles and apatite suggesting hydrothermal origin. The occurrences of REE mineral phases of allanite, perrierite, monazite & Y+REE phosphate are mainly observed in nepheline syenite and syenite intrusives. Bed rock samples from syenite gave 725 & 2108 ppm respectively, 1 sample from mafic granulite gave 1369 ppm, 3 ample from nepheline syenite gave 385 – 476 ppm value. 3 trench samples show >500 ppm value (maximum is 895 ppm), 4 sediment samplesshow>500 ppm value (maximum is 7399 ppm, stream

sediment sample from mafic granulite). The mafic granulites and syenites around Beldihi village, syenites of Kusarimunda were recommended for detailed exploration.

1.9.7 MECL has studied NGCM data from NGDR portal, GSI of Toposheet No. 73D09. The total REE, LREE, HREE values in stream sediments falling in the proposed block was calculated and it was observed that the maximum total REE value in the proposed block was 7174 ppm followed by 3142 ppm and 3064 ppm. The maximum and minimum range for each element is given in the below table.

Table-3

Data showing NGCM Stream Sediment results for Proposed Nakchi area (43 numbers of samples) (Source: NGDR portal GSI)

Crustal abundance (ppm) of rare earth elements (After Mason and Moore 1982)			Summary of Stream sediment sample data falling in Proposed Block		
Group	**Element**	**Crustal abundance (ppm)**	**Minimum (ppm)**	**Maximum (ppm)**	**Average (ppm)**
LREE	Lanthanum (La)	30	82.11	1692.86	317.13
	Cerium (Ce)	60	182.06	3224.93	651.36
	Praseodymium (Pr)	8.2	21.61	373.65	71.19
	Neodymium (Nd)	28	83.34	1425.29	268.99
	Samarium (Sm)	06	13.95	190.93	42.26
HREE	Europium (Eu)	1.2	1.89	4.37	2.66
	Gadolinium (Gd)	5.4	13.06	147.03	36.19
	Terbium (Tb)	0.9	1.59	10.83	3.46
	Dysprosium (Dy)	03	7.91	27.19	13.10
	Holmium (Ho)	1.2	1.52	4.57	2.26
	Erbium (Er)	2.8	4.16	12.64	6.03
	Thulium (Tm)	0.5	0.64	2.06	0.95
	Ytterbium (Yb)	3.4	3.95	13.72	6.02
	Lutetium (Lu)	0.5	0.61	2.07	0.92
	Scandium (Sc)	22	10	26	15.16
	Ytrium (Y)	33	29	78	42.12
LREE			**383.08**	**6907.66**	**1350.94**
HREE			**85.85**	**266.37**	**128.86**
TREE			**473.73**	**7174.03**	**1479.80**

1.10.1 PLANNED METHODOLOGY

1.10.1 Reconnaissance survey for REE mineralization in Nakchi area, Angul District, Odisha has been proposed to search for REE mineralization in Gondwana sediments of Talchir basin and EGMB. Delineation of REE-enriched zone through LSM, followed by pitting and

thereby systematic collection of samples from different media, like, bedrock, pit, regolith, stream sediment and heavy minerals separation will be carried out. After the positive outcomes of the above activities auger drilling and core drilling will be carried out for systematic soil sampling and to intersect REE bearing rocks in subsurface at 30m vertical depth espectively. In addition, assessment of quality and quantity of the resources (334) if any as per UNFC norms & Minerals (Evidence of Mineral Contents) Rules- 2015 will be carried out.The details of different activities to be carried out are presented in subsequent paragraphs.

1.10.2 **GEOLOGICAL MAPPING**: Geological mapping will be carried out in the 166.26 sq.km area on 1:12,500 scale. Rock types, their contact, structural features will be mapped. Surface manifestations of the REE mineralisation along with their surface disposition will be marked on map. 10 numbers of surface samples of various lithounits will be studied each for petrography and 05 samples will be studied for mineragraphy.

1.10.3 **BEDROCK SAMPLING**: A total of 50 nos. of bedrock samples have been proposed to collect from the surface exposures / mineralized area to know the REE distribution within the block area. Bedrock samples will be collected by means of chips/ channels and analysed for 34 elements including 17 elements of REE by ICPMS method. 10% of primary samples i.e. 05 external check samples will be sent to NABL External Labs for analysis.

1.10.4 **STREAM SEDIMENT:** Total 50 nos of stream sediment/ slopewash samples have been proposed based on the drainage pattern of the area. The samples will be collected systematically primarily from 2nd and 3rd order streams, which have a larger catchment area. Sediment samples will be analyzed for for 34 elements including 17 elements of REE by ICPMS method. Proposed location of stream sediments in the area is provided in the Plate VII.

1.10.5 **PITTING:** In the central, south and eastern part of the area is covered by soil. NGCM data shows REE anomalous values more than 1000 ppm. At places is more than 2500ppm. To assess the secondary nature of mineralization or expose the mineralized host rock under soil cover, 10 nos. of pits (30cu m) have been proposed in the said area to sample the regolith zone systematically. Depth of the pits will be 3m considering the thick soil cover in the area. These pits will serve as orientation pits for future course of action. A total of 30

samples will be generated from the 10 pits which will be analyzed for REE, Ti, Zr, Hf, Nb, Ta, Th and U by ICPMS method to identify high REE bearing zones.

1.10.6 **AUGER DRILLING:** On the basis of outcomes of the analytical results of the pit samples auger drilling will be carried out in the block which is covered by thick soil. The auger drilling will be carried out in a systematic grid pattern of 2X2 km. At each point the depth of drilling will be 3 to 5m, based on thickness of soil cover. Proposed Auger Drilling Points of 43 nos has been marked tentatively. A total of 250 m will be involved. For each auger drilling sampling will be carried out at 1m interval from the mineralized portion and 100 nos. of samples will be generated. The generated samples will be analyzed for REE, Ti, Zr, Hf, Nb, Ta, Th and U by ICPMS method to identify high REE bearing zones. Proposed auger drilling location is provided in Plate VIII along with the geological map of the area. Location of data points may change after large scale mapping and anomalous values obtained from geochemical samples.

1.10.7 **EXPLORATORY DRILLING**: Based on the positive outcomes of geological mapping, bedrock samples, petrographic and minerographic studies, EPMA and establishment of the host rock for REE mineralization boreholes will be planned to establish subsurface continuity of mineralization. Scout drilling of 250 m have been proposed. Number and location of boreholes will be determined after the LSM and mineralized zone established in the area. 50 nos. of borehole samples have been proposed to generated during the drilling from the mineralized area and will be analyzed for REE, Ti, Zr, Hf, Nb, Ta, Th and U by ICPMS method to identify high REE bearing zones. Mineralized zones to be intersected in the boreholes will be sampled at 1m interval or depending on the nature of mineralization and host rock and any other.

1.10.8 **CORE LOGGING**: The borehole cores would be logged systematically. Viz. details of the litho units, colour, structural feature, texture, mineralization, besides the recovery, rock quality designation (RQD) and graphite ore type would be recorded.

1.10.9 **EPMA STUDIES:** A total of 10 representative samples, comprising both polished thin sections of host rocks and heavy mineral concentrate mounts, will be subjected to Electron Probe Micro-Analyzer (EPMA) studies. The purpose is to identify and characterize REE- and HFSE-bearing mineral phases (monazite, xenotime, allanite, zircon, titanite, apatite,

etc.) and to obtain quantitative in-situ mineral chemistry. In host rock sections, EPMA will help establish the mineral paragenesis and textural context of REE-host minerals, whereas in heavy concentrates, it will facilitate rapid identification and chemical characterization of accessory REE minerals that are otherwise present in trace proportions. Approximately 20 analytical spots per sample are planned, along with selective elemental mapping of representative grains, requiring an estimated 40 instrument hours in total. The outcome will be precise micro-chemical data to constrain the host mineralogy of REE, their substitution mechanisms, and potential sources of enrichment.

1.10.10 **XRD Analysis**: Stream sediment samples will be processed through Wilfley table concentration followed by magnetic separation to obtain heavy mineral fractions enriched in REE-bearing phases. The separation will allow concentration of non-magnetic to weakly magnetic accessory minerals such as monazite, xenotime, zircon, and allanite, which are the primary hosts of REEs and HFSEs. XRD analysis of these concentrates will enable precise identification of crystalline mineral phases that control REE distribution in the drainage system. This approach minimizes dilution from common rock-forming minerals, thereby enhancing the chances of detecting REE-bearing minerals that occur only in minor proportions. The outcome will be a clearer understanding of detrital REE-hosts derived from upstream bedrock versus secondary phases formed during sedimentation, which will directly support vectoring towards prospective source terrains. A total of 20 samples will be analysed through XRD.

1.10.12 **PETROLOGICAL STUDIES:** 10 nos of Petrographic studies will be carried out on representative thin sections of the bedrock samples collected from the Eastern Ghat Group and Kamthi Formation to establish their mineralogical framework, textural relationships, and potential REE-bearing phases. Special emphasis will be given to locating and characterizing REE-bearing accessory phases such as allanite, monazite, xenotime, zircon, apatite, and titanite within the host rocks. Petrography will also aid in distinguishing between primary magmatic/ metamorphic minerals and secondary alteration products, thereby providing critical information on the possible source, mobility, and concentration of REEs.

1.10.13 **MINERAGRAPHIC STUDIES:** Mineragraphic investigations will be carried out on 05 representative heavy mineral concentrate samples obtained from stream sediments. For each sample, polished sections (polished grain mounts in epoxy resin) will be prepared to

ensure proper surface quality for reflected light microscopic examination. These sections will be systematically studied under reflected light to identify opaque and semi-opaque heavy minerals, with emphasis on REE- and HFSE-bearing phases such as monazite, xenotime, zircon, allanite, and ilmenite, along with accessory oxides and sulfides. Grain morphology, size, inclusion features, alteration textures, and intergrowth relationships will be documented to evaluate paragenesis and provenance of the heavy minerals. This study will not only establish the heavy mineral assemblage but will also provide guidance for targeted EPMA analysis and XRD confirmation of key mineral phases.

1.10.14 **HEAVY MINERAL SEPARATION:** It is proposed to collect 20 bulk samples from the different regolith horizons for the concentration of heavy minerals contributing for heavy mineral concentration. After separation the same will be chemically analyzed for 34 elements by ICPMS and XRD studies for chemistry of individual grains, structural fingerprint of bulk separates or hand-picked REE minerals. Together, they confirm mineral identity (XRD) and quantify composition + zoning (EPMA).

6.1.0 PROPOSED QUANTUM OF WORK

6.1.1 Details of the particular, Quantum and the targets are tabulated in Table No.-6.1.

Table No-4
Quantum of proposed work in proposed Devpur REE and Glauconite Block

Sl. No.	Item of Work	Unit	Target
1	**Geological Mapping** (on 1:12,500 Scale)	Sq km	166.26
2	**Geochemical Sampling**		
i	Bedrock samplesforREE (34 elemental analysis BY ICPMS includes REE, Sc, Y, Hf, Ta, Nb, Th, U, Zr, Ti, Ni, V, Ba, Ge, Ga, Cr, Sr, B)	Nos	50
ii	Stream Sediment samples for REE (34 elemental analysis BY ICPMS includes REE, Sc, Y, Hf, Ta, Nb, Th, U, Zr, Ti, Ni, V, Ba, Ge, Ga, Cr, Sr, B)	Nos	50
3	**Exploratory Mining**		
i	Orientation Pitting	Cu.m	30
ii	Orientation Pit -For REE (34 elemental analysis BY ICPMS includes REE, Sc, Y, Hf, Ta, Nb, Th, U, Zr, Ti, Ni, V, Ba, Ge, Ga, Cr, Sr, B)	Nos	30
4	**Drilling**		
i	Auger Drilling in 43 boreholes (Targeting Regolith/Soil Horizon)	m	150
	Scout Drilling in 5 boreholes (Targeting Primary Hard Rock)	m	250
ii	Auger Drilling samples for REE (34 elemental analysis BY ICPMS includes REE, Sc, Y, Hf, Ta, Nb, Th, U, Zr, Ti, Ni, V, Ba, Ge, Ga, Cr, Sr, B)	Nos	100
iii	Core Samples- For REE (34 elemental analysis BY ICPMS includes REE, Sc, Y, Hf, Ta, Nb, Th, U, Zr, Ti, Ni, V, Ba, Ge, Ga, Cr, Sr, B)	Nos	50

Sl. No.	Item of Work	Unit	Target
5	**Laboratory Studies**		
i	Heavy Mineral Separation (5 Stream Sediment Samples + 15 Orientation Pit Samples)	Nos	20
ii	Heavy concentration- For REE (34 elemental analysis BY ICPMS includes REE, Sc, Y, Hf, Ta, Nb, Th, U, Zr, Ti, Ni, V, Ba, Ge, Ga, Cr, Sr, B)	Nos	20
6	External Check samples 10%	Nos.	30
7	**Petrographic Samples**	Nos	10
8	**Mineragraphic Studies Heavy concentration**	Nos	5
9	**XRD Mineral phase analysis**	Nos	20
10	**EPMA Studies (10 samples)**	Hrs.	40
11	**Report Preparation (5 Hard copies with a soft copy)**	Nos.	1
12	**Preparation of Exploration Proposal (5 Hard copies with a soft copy)**	Nos.	1

6.2.0 BREAK-UP OF EXPENDITURE

6.2.1 Tentative Cost has been estimated based on Schedule of Charges (SoC) of projects funded by National Mineral Exploration Trust (NMET) w.e.f. 01/04/2020. The total estimated costis**Rs. 143.85 Lakhs.** The summary of cost estimates for Reconnaissance Survey (G-4 Level) is given in **Table No. –5** and details of cost estimates is given in **Annexure –I**

Table No. 5: Summary of cost estimates for Reconnaissance survey (G-4) in Nakchi Area for REE, District- Angul, Odisha.

Sl. No.	Item	Total
1	Geological Work	3,119,224
2	Trenching and Pitting	114,000
3	Drilling	4,738,880
4	Laboratory Studies	3,392,985
	Sub total	**11,365,089**
5	Report	568,254
6	Peer Review	30,000
7	Proposal Prepration	227,301.78
	Total	**12,190,645**
8	GST (18%)	2,194,316.14
Total cost including 18% GST		**14,384,961**
SAY, in Lakhs		**143.85**

6.3.0 TIMELINE

6.3.1 The entire project is planned tentatively for 10 months. Initially, geological mapping and surface bedrock sampling along with stream sediment sampling and pitting shall be carried out. Based on the positive results obtained in the first phase of sampling auger drilling and scout drilling will be carried out for respective commodities.

Table No. 6

Estimated time schedule for Reconnaissance Survey (G-4) for REE and associated minerals in Nakchi Area, District: Angul, State: Odisha [Block area- 166.26 sq. km; Schedule timeline- 10 months]														
Sl.	**Particulars**	**Months**	**1**	**2**	**3**	**4**		**5**	**6**	**7**	**8**		**9**	**10**
1	Camp Setting/ mobilization	Months					PHASE-I REVIEW					PHASE-II REVIEW		
2	Geologist days (Mapping, Sampling, Orientation Pitting, Auger and Scout Drilling)	days												
4	Orientation Pitting	days												
5	Drilling (1 rig) Auger and Core Drilling	m												
6	Sampling days	days												
7	Camp winding	Months												
8	Laboratory Studies	days												
9	Geologist days, HQ	days												
10	Report Writing with Peer Review	days												

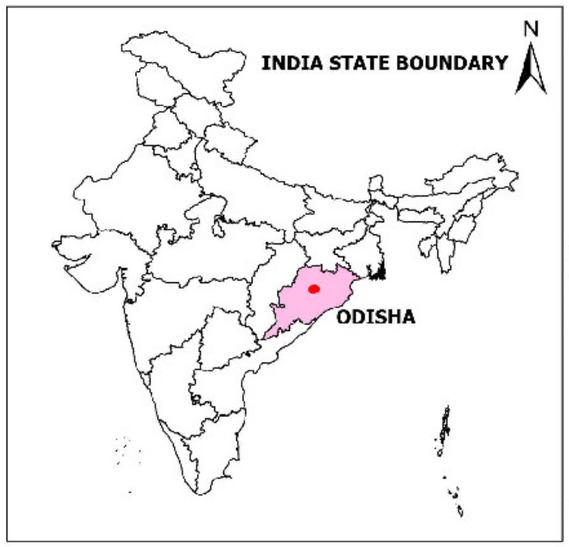
List of Plates

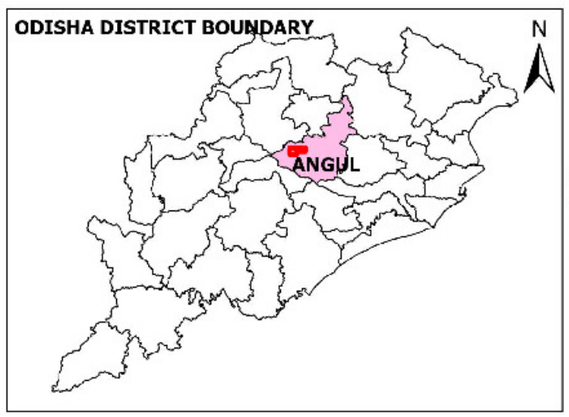
1. Plate –I: Location Map of Proposed Nakchi area, District: Angul, State: Odisha (Source: NGDR Portal, GSI).
2. Plate–II: Regional Geological Map showingProposed Nakchi area, District: Angul, State: Odisha (Source: NGDR Portal, GSI).
3. Plate–III: Geological Map showingProposed Nakchi area, District: Angul, State: Odisha (Source: NGDR Portal, GSI).
4. Plate–IV: LREE anomaly map with total LREE values in Proposed Nakchi area, District: Angul, State: Odisha (Source: NGDR Portal, GSI).
5. Plate–V: HREE anomaly map with HREE values in proposed Nakchi area, District: Angul, State: Odisha (Source: NGDR Portal, GSI).
6. Plate–VI: Total REE anomaly map with total REE values in proposed Nakchi area, District: Angul, State: Odisha (Source: NGDR Portal, GSI).
7. Plate–VII:Proposed stream sediment sample location, auger drilling location with drainage map in proposed Nakchi area, District: Angul, State: Odisha (Source: NGDR Portal, GSI).

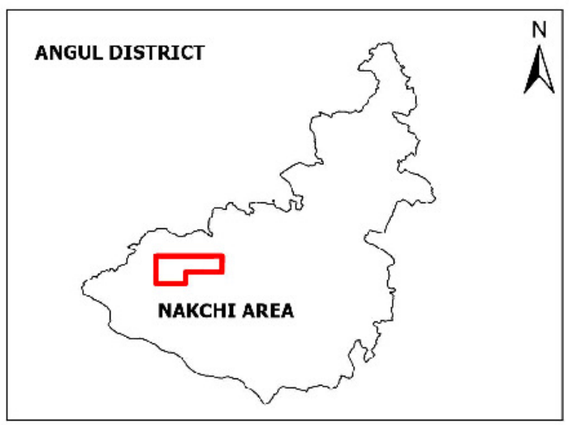
Estimated cost for Reconnaisance Survey (G-4) for REE and associated minerals in Nakchi Area, District: Angul, Odisha. [Block area- 166.26 sq. km; Auger Drilling: 150 m (43 nos); Core Drilling-250m (5 nos.), Borehole depth range: 40 to 50 m; Schedule timeline- 10 months, Review after: 4 and 8 months]							
S. No.	**Item of Work**	**Unit**	**Rates as per NMET SoC 2020-21**		**Estimated Cost of the Proposal**		**Remarks**
			SoC-Item -Sl No.	**Rates as per SoC**	**Qty.**	**Amount (Rs)**	
A	**GEOLOGICAL WORK**						
1	**Geological Mapping (1:12,500)**						
i	Charges for one Geologist- Field	day	1.2	11,000	200	2,200,000	
ii	Charges for one Geologist - HQ	day	1.2	9,000	45	405,000	
iii	2 labours/ party (As per rates of Central Labour Commissioner)	day	5.7	541	400	216,400	Amount will be reimbursed as per the notified rates by the Central Labour Commissioner or respective State Govt. whichever is higher
iv	Sampling -1 Samplers Labour charge not included	day	1.5.2	5,100	41	209,100	
v	4 labours/ party (As per rates of Central Labour Commissioner)	day	5.7	541	164	88,724	Amount will be reimburse as per the notified rates by the Central Labour Commissioner or respective State Govt. whichever is higher
				Sub Total- A		**3,119,224**	
B	**TRENCHING AND PITTING IN PHASE-I**						
ii	Orientation Pitting: 10 pits	Cu. M.	2.1.2	3800	30	114,000	
				Sub Total- B		**114,000**	
D	**DRILLING IN PHASE-II**						
i	Drilling upto 300m (Hard Rock) (1 rig)	m	2.2.1.4a	11,500	250	2,875,000	5 Scout Boreholes, 50 m each in Phase-II
ii	Land / Crop Compansation	per BH	5.6	20,000	5	100,000	Amount will be reimburse as per actuals or max. Rs. 20000 per BH with certification from local authorities
iii	Construction of concrete Pillar (12"x12"x30")	per borehole	2.2.7a	2,000	5	10,000	
iv	Transportation of Drill Rig & Truck associated per drill	Km	2.2.8	36	1,300	46,800	Certification in this regard is required to be provided
v	Monthly Accomodation Charges for drilling Camp (up to 2 Rigs)	month	2.2.9	50,000	3	150,000	
vi	Drilling Camp Setting Cost	Nos	2.2.9a	250,000	1	250,000	
vii	Drilling Camp Winding up Cost	Nos	2.2.9b	250,000	1	250,000	
viii	Approach Road Making (Flat Terrain)	Km	2.2.10a	22,020	4	88,080	Road Making will be considered as per the requirement and Road Making Charges will be reimbursed later
ix	Core Preservation: One complete borehole plus mineralised cores of all the remaining Bhs	m	5.3	1,590	100	159,000	This amount will be reimbursed after successful delivery of the cores to concerned libraries/ authorities
x	Auger Drilling	m	2.2.2	4,760	150	714,000	
i	Bore Hole Fixation and determination of co-ordinates & Reduced Level of the boreholes by DGPS	Per Point of observation	1.6.2	19,200	5	96,000	5 Scout Boreholes in Phase-II
				Sub Total- D		**4,738,880**	
F	**LABORATORY STUDIES**						
1	**Chemical Analysis**						
	a- Analysis for 34 elements (REE, RM, Radioactive elements) by ICPMS method	Nos	4.1.14	7,731	300	2,319,300	Bedrock: 50, Pit Samples: 30, Stream Sediment Samples: 50, Auger samples: 100, Drillcore Samples: 50, Heavy Mineral Concentration: 20 (Including Radioactive minerals)
	b- External (10%) Check samples from NABL Lab by ICPMS method for 34 elements (REE, RM, Radioactive elements)	Nos	4.1.14	7,731	30	231,930	
2	**Physical & Petrological Stusies**						
i	Heavy Mineral Seperation by Gravity and Magnetic	Nos	4.3.6 a & b	16,200	20	324,000	Phase-I
ii	XRD analysis for identification of mineral phase	Nos	4.1.15a	4,000	20	80,000	Phase-I Heavy Mineral Concentration/ Mineralised host rock
iii	Preparation of thin section	Nos	4.3.1	2,353	10	23,530	Phase-I
iv	Complete petrographic study report	Nos	4.3.4	4,232	10	42,320	Phase-I
v	Preparation of polished section	Nos	4.3.2	1,549	5	7,745	Phase-I
vi	Complete mineragraphic study report	Nos	4.3.4	4,232	5	21,160	Phase-I
vii	Digital Photographs	Nos	4.3.7	280	5	1,400	Phase-I
x	EPMA studies	Hrs	4.4.1	8,540	40	341,600	Phase-I
				Sub Total- F		**3,392,985**	
D				**Total A to F**		**11,365,089**	
E	**Geological Report Preparation**		**5.2**	For the projects having cost exceeding Rs. 50 lakhs and less than Rs. 150 lakhs - A minimum of Rs. 2.5 lakhs or 5% of the value of work whichever is more		**568,254**	Reimbursement will be made after submission of the final Geological Report in Hard Copies (5 Nos) and the soft copy to NMET.
F	**Peer review Charges**		**As per EC decision**			**30,000**	
G	**Preparation of Exploration Proposal (5 Hard copies with a soft copy)**	**5 Hard copies with a soft copy**	**5.1**	2% of the Cost or Rs. 5 Lakhs whichever is lower		**227,302**	EA has to submit the Hard Copies and the soft copy of the final proposal along with Maps and Plan as suggested by the TCC-NMET in its meeting while clearing the proposal.
H	**Total Estimated Cost without GST**					**12,190,645**	
I	**Provision for GST (18% of I)**					**2,194,316**	GST will be reimburse as per actual and as per notified prescribed rate
J	**Total Estimated Cost with GST**					**14,384,961**	***or Say Rs. 143.85 Lakh***
Note:							
1	If any part of the project is outsourced, the amount will be reimbursed as per the Paragraph 3 of NMET SoC and Item no. 6 of NMET SoC. In case of execusion of the project by NEA on its own, a Certifiate regarding non outsourcing of any component/project is required.						

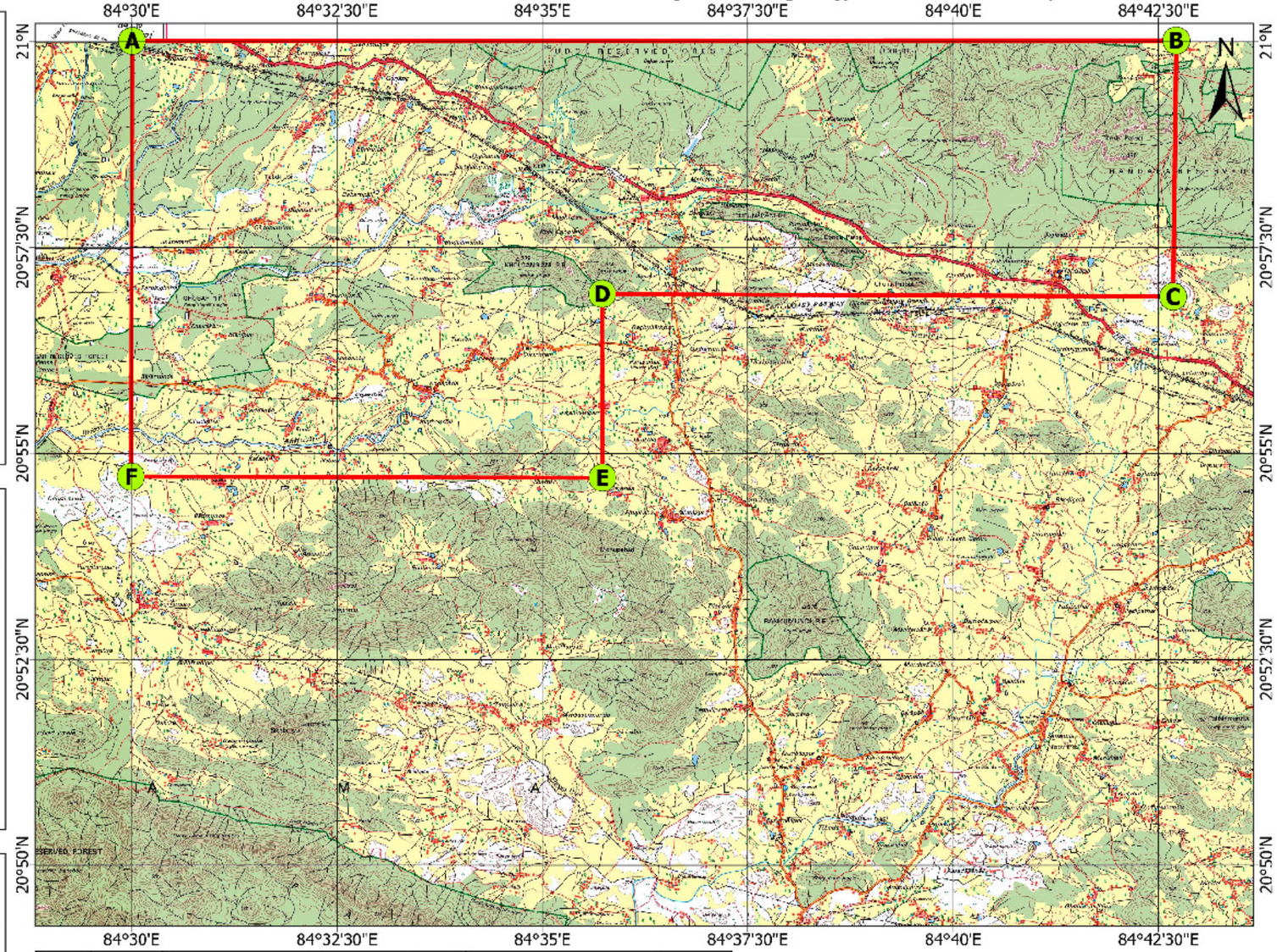
PLATE I

LOCATION MAP SHOWING PROPOSED NAKCHI AREA FOR RECONNAISSANCE SURVEY OF REE (166.26 SQ KM), ANGUL DISTRICT, ODISHA









Sl. No.	Point	DMS Coordinate (DMS)		UTM Zone: 45N (m)	
		Latitude	Longitude	Northing	Easting
1	A	21° 00' 0.57" N	84° 30' 0.35" E	2324197.64	240126.68
2	B	21° 00' 0.84" N	84° 42' 42.96" E	2323875.98	262157.03
3	C	20° 56' 54.1" N	84° 42' 40.7" E	2318132.66	262009.68
4	D	20° 56' 56.15" N	84° 35' 43.65" E	2318372.47	249959.00
5	E	20° 54' 42.18" N	84° 35' 43.88" E	2314250.99	249903.67
6	F	20° 54' 43.04" N	84° 29' 59.52" E	2314429.50	239950.17

Scale: Not to Scale

Source: Survey of India Toposheet No. 73D09

Legend

- CORNER POINTS OF PROPOSED NAKCHI AREA
- PROPOSED NAKCHI AREA

PLATE II

REGIONAL GEOLOGY MAP SHOWING PROPOSED NAKCHI AREA FOR RECONNAISSANCE SURVEY OF REE, ANGUL DISTRICT, ODISHA

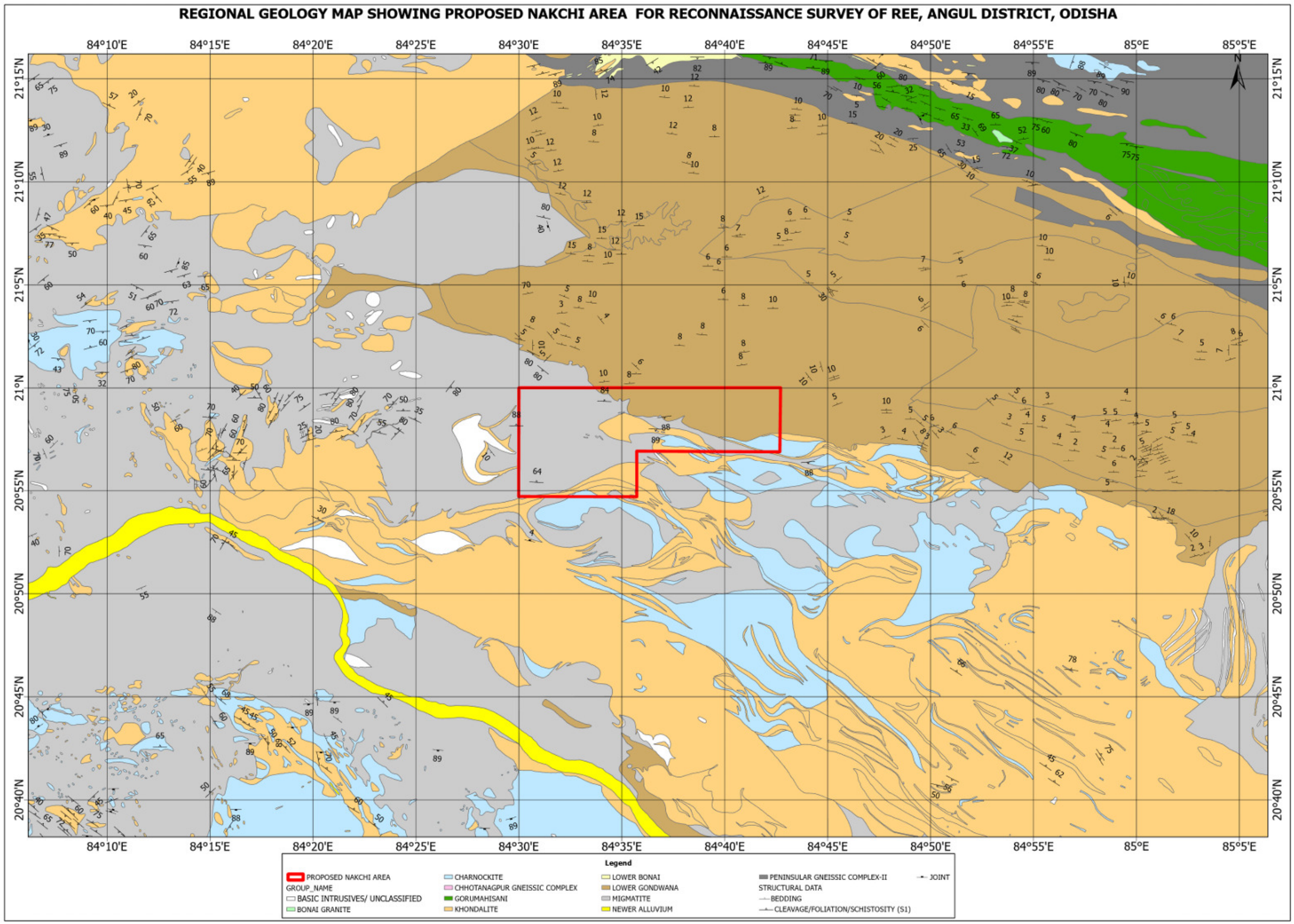


PLATE III

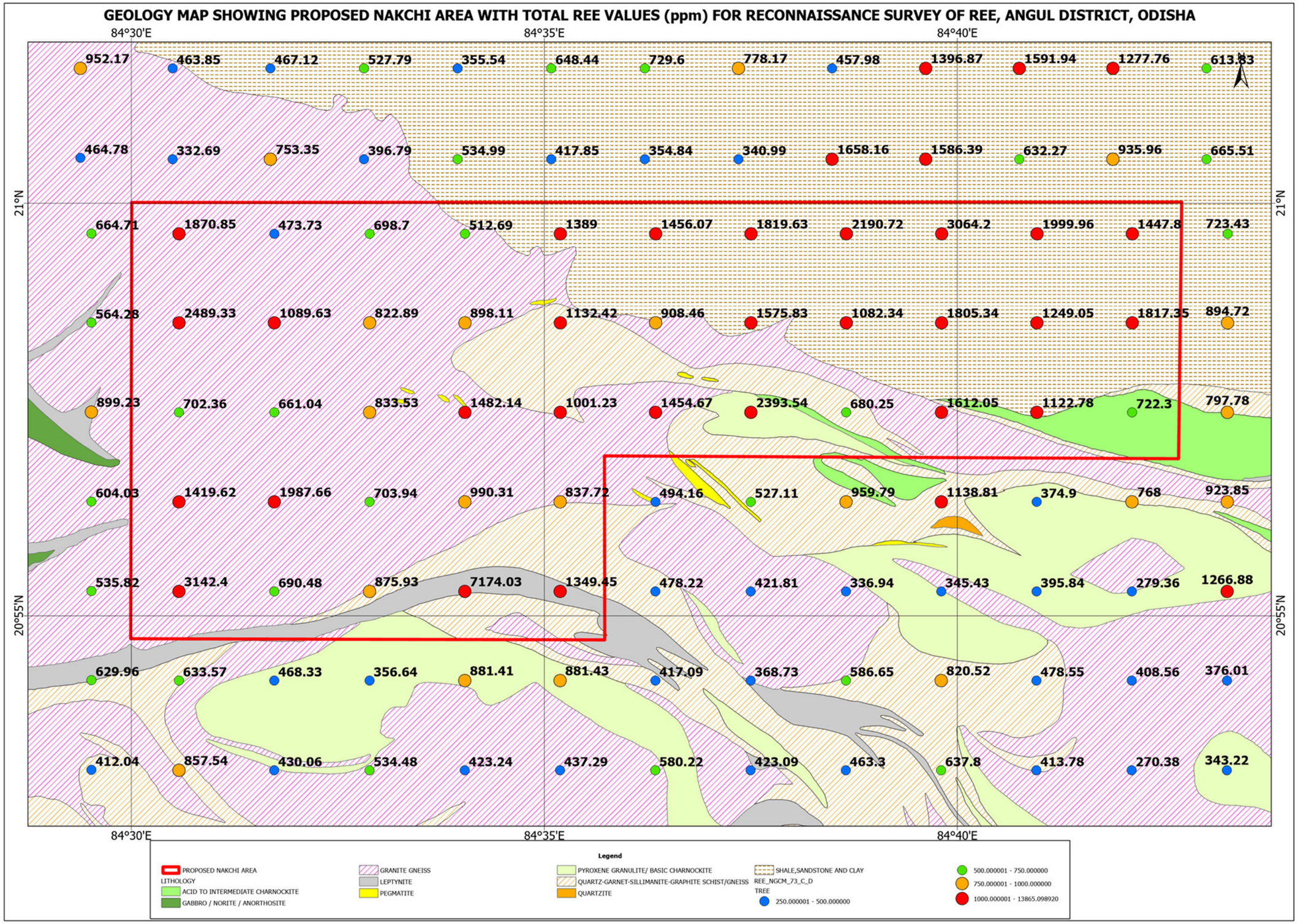

GEOLOGY MAP SHOWING PROPOSED NAKCHI AREA WITH TOTAL REE VALUES (ppm) FOR RECONNAISSANCE SURVEY OF REE, ANGUL DISTRICT, ODISHA
84°30'E
84°35'E
84°40'E
21°N
20°55'N
952.17 463.85 467.12 527.79 355.54 648.44 729.6 778.17 457.98 1396.87 1591.94 1277.76 613.83
464.78 332.69 753.35 396.79 534.99 417.85 354.84 340.99 1658.16 1586.39 632.27 935.96 665.51
664.71 1870.85 473.73 698.7 512.69 1389 1456.07 1819.63 2190.72 3064.2 1999.96 1447.8 723.43
564.28 2489.33 1089.63 822.89 898.11 1132.42 908.46 1575.83 1082.34 1805.34 1249.05 1817.35 894.72
899.23 702.36 661.04 833.53 1482.14 1001.23 1454.67 2393.54 680.25 1612.05 1122.78 722.3 797.78
604.03 1419.62 1987.66 703.94 990.31 837.72 494.16 527.11 959.79 1138.81 374.9 768 923.85
535.82 3142.4 690.48 875.93 7174.03 1349.45 478.22 421.81 336.94 345.43 395.84 279.36 1266.88
629.96 633.57 468.33 356.64 881.41 881.43 417.09 368.73 586.65 820.52 478.55 408.56 376.01
412.04 857.54 430.06 534.48 423.24 437.29 580.22 423.09 463.3 637.8 413.78 270.38 343.22
Legend
PROPOSED NAKCHI AREA
LITHOLOGY
ACID TO INTERMEDIATE CHARNOCKITE
GABBRO / NORITE / ANORTHOSITE
GRANITE GNEISS
LEPTYNITE
PEGMATITE
PYROXENE GRANULITE/ BASIC CHARNOCKITE
QUARTZ-GARNET-SILLIMANITE-GRAPHITE SCHIST/GNEISS
QUARTZITE
SHALE,SANDSTONE AND CLAY
REE_NGCM_73_C_D
TREE
250.000001 - 500.000000
500.000001 - 750.000000
750.000001 - 1000.000000
1000.000001 - 13865.098920

PLATE IV

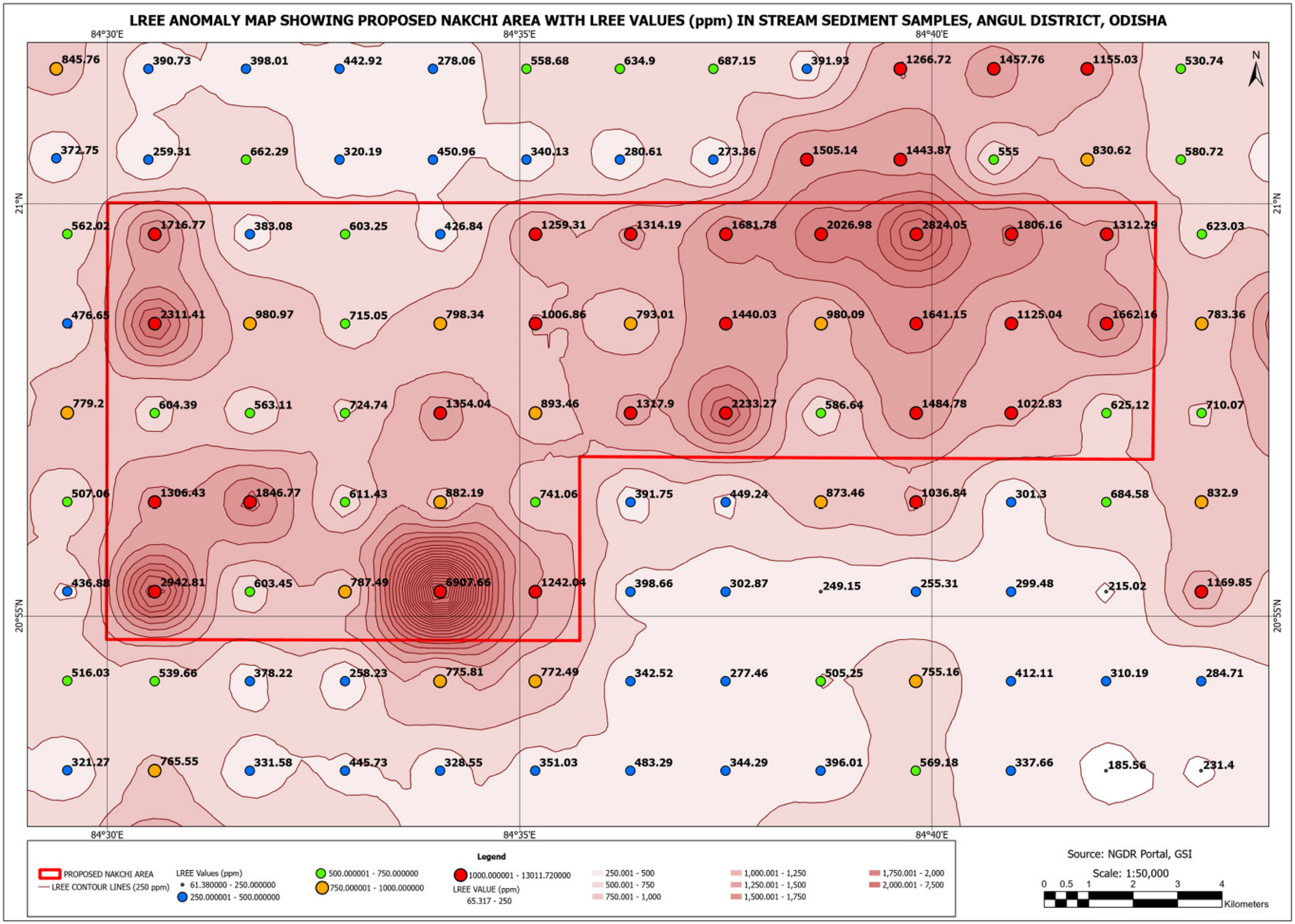

LREE ANOMALY MAP SHOWING PROPOSED NAKCHI AREA WITH LREE VALUES (ppm) IN STREAM SEDIMENT SAMPLES, ANGUL DISTRICT, ODISHA
84°30'E
84°35'E
84°40'E
21°N
20°55'N
N
845.76 390.73 398.01 442.92 278.06 558.68 634.9 687.15 391.93 1266.72 1457.76 1155.03 530.74
372.75 259.31 662.29 320.19 450.96 340.13 280.61 273.36 1505.14 1443.87 555 830.62 580.72
562.02 1716.77 383.08 603.25 426.84 1259.31 1314.19 1681.78 2026.98 2824.05 1806.16 1312.29 623.03
476.65 2311.41 980.97 715.05 798.34 1006.86 793.01 1440.03 980.09 1641.15 1125.04 1662.16 783.36
779.2 604.39 563.11 724.74 1354.04 893.46 1317.9 2233.27 586.64 1484.78 1022.83 625.12 710.07
507.06 1306.43 1846.77 611.43 882.19 741.06 391.75 449.24 873.46 1036.84 301.3 684.58 832.9
436.88 2942.81 603.45 787.49 6907.66 1242.04 398.66 302.87 249.15 255.31 299.48 215.02 1169.85
516.03 539.66 378.22 258.23 775.81 772.49 342.52 277.46 505.25 755.16 412.11 310.19 284.71
321.27 765.55 331.58 445.73 328.55 351.03 483.29 344.29 396.01 569.18 337.66 185.56 231.4
Legend
PROPOSED NAKCHI AREA
LREE CONTOUR LINES (250 ppm)
LREE Values (ppm)
61.380000 - 250.000000
250.000001 - 500.000000
500.000001 - 750.000000
750.000001 - 1000.000000
1000.000001 - 13011.720000
LREE VALUE (ppm)
65.317 - 250
250.001 - 500
500.001 - 750
750.001 - 1,000
1,000.001 - 1,250
1,250.001 - 1,500
1,500.001 - 1,750
1,750.001 - 2,000
2,000.001 - 7,500
Source: NGDR Portal, GSI
Scale: 1:50,000
0 0.5 1 2 3 4
Kilometers

PLATE V

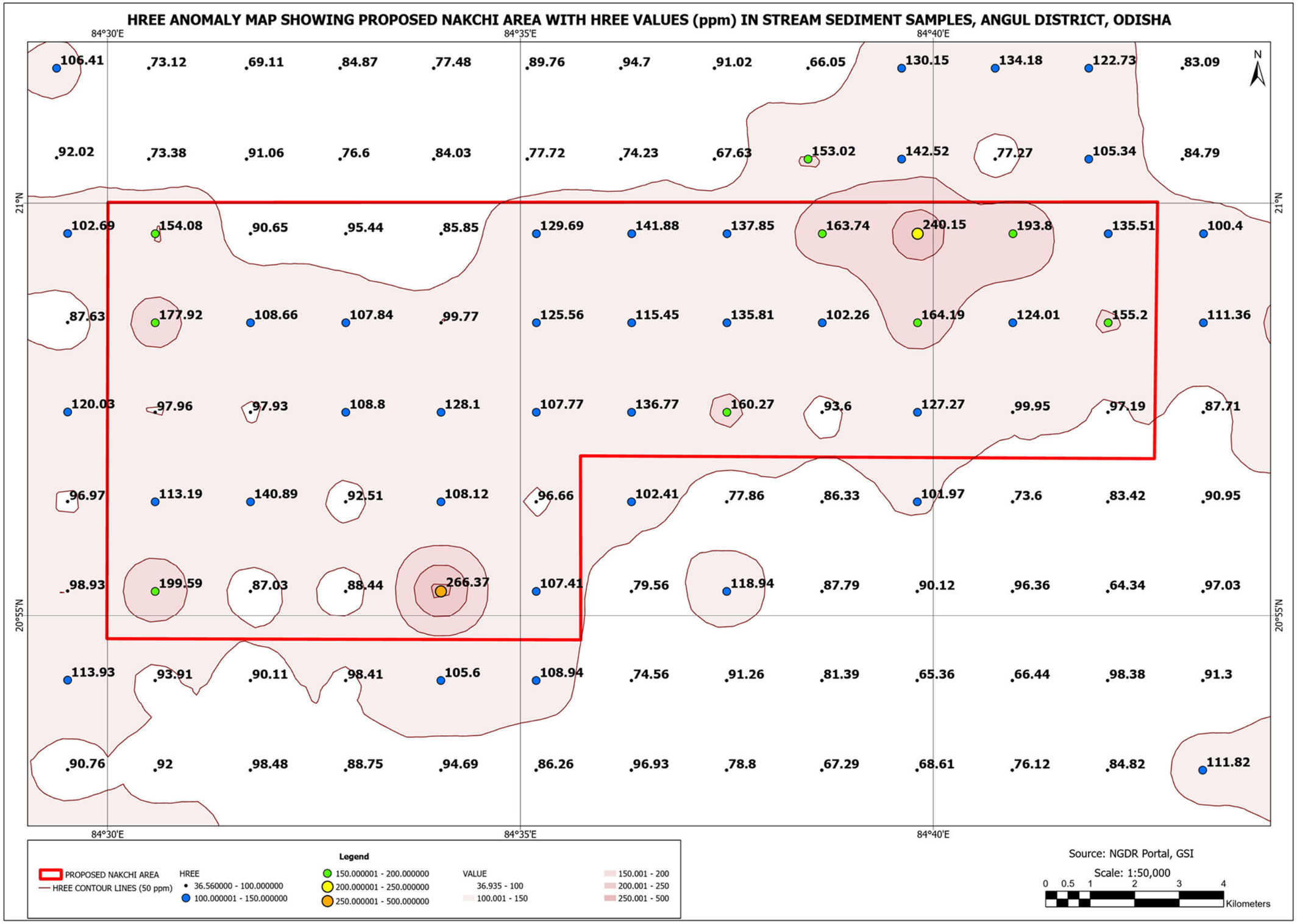

HREE ANOMALY MAP SHOWING PROPOSED NAKCHI AREA WITH HREE VALUES (ppm) IN STREAM SEDIMENT SAMPLES, ANGUL DISTRICT, ODISHA
84°30'E
84°35'E
84°40'E
21°N
20°55'N
N
106.41 73.12 69.11 84.87 77.48 89.76 94.7 91.02 66.05 130.15 134.18 122.73 83.09
92.02 73.38 91.06 76.6 84.03 77.72 74.23 67.63 153.02 142.52 77.27 105.34 84.79
102.69 154.08 90.65 95.44 85.85 129.69 141.88 137.85 163.74 240.15 193.8 135.51 100.4
87.63 177.92 108.66 107.84 99.77 125.56 115.45 135.81 102.26 164.19 124.01 155.2 111.36
120.03 97.96 97.93 108.8 128.1 107.77 136.77 160.27 93.6 127.27 99.95 97.19 87.71
96.97 113.19 140.89 92.51 108.12 96.66 102.41 77.86 86.33 101.97 73.6 83.42 90.95
98.93 199.59 87.03 88.44 266.37 107.41 79.56 118.94 87.79 90.12 96.36 64.34 97.03
113.93 93.91 90.11 98.41 105.6 108.94 74.56 91.26 81.39 65.36 66.44 98.38 91.3
90.76 92 98.48 88.75 94.69 86.26 96.93 78.8 67.29 68.61 76.12 84.82 111.82
Legend
PROPOSED NAKCHI AREA
HREE CONTOUR LINES (50 ppm)
HREE
36.560000 - 100.000000
100.000001 - 150.000000
150.000001 - 200.000000
200.000001 - 250.000000
250.000001 - 500.000000
VALUE
36.935 - 100
100.001 - 150
150.001 - 200
200.001 - 250
250.001 - 500
Source: NGDR Portal, GSI
Scale: 1:50,000
0 0.5 1 2 3 4
Kilometers

PLATE VI

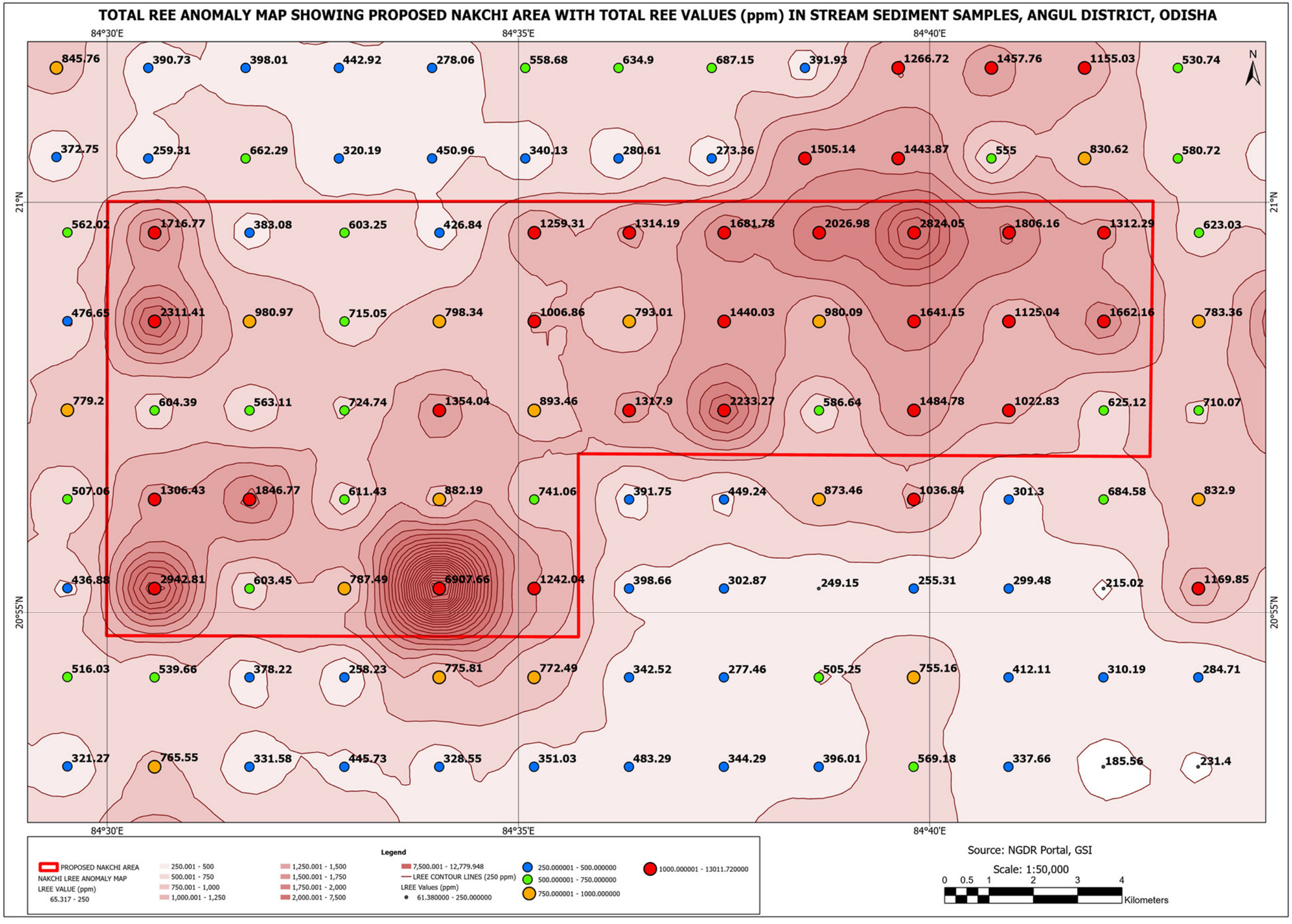
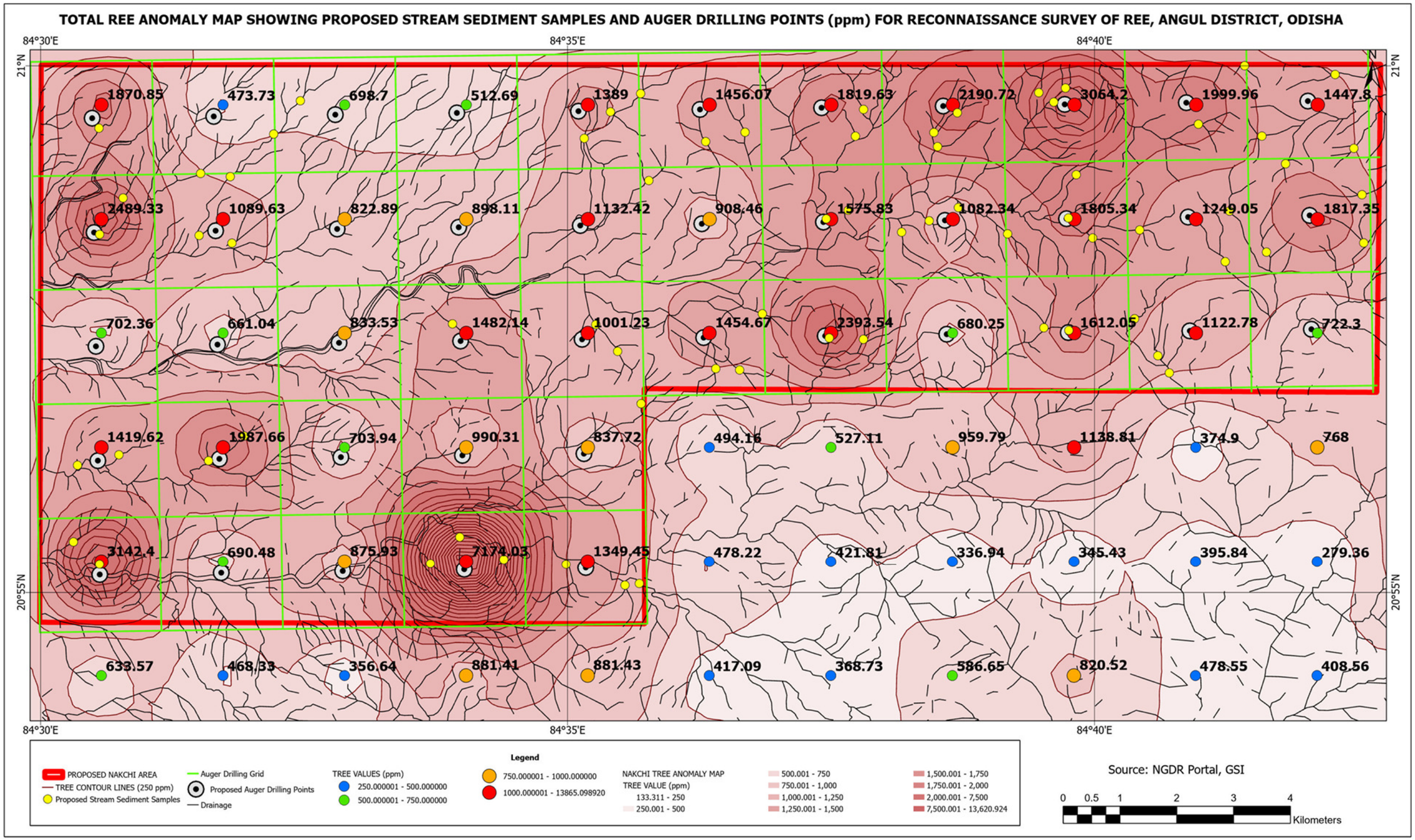

TOTAL REE ANOMALY MAP SHOWING PROPOSED NAKCHI AREA WITH TOTAL REE VALUES (ppm) IN STREAM SEDIMENT SAMPLES, ANGUL DISTRICT, ODISHA
84°30'E
84°35'E
84°40'E
21°N
20°55'N
N
845.76 390.73 398.01 442.92 278.06 558.68 634.9 687.15 391.93 1266.72 1457.76 1155.03 530.74
372.75 259.31 662.29 320.19 450.96 340.13 280.61 273.36 1505.14 1443.87 555 830.62 580.72
562.02 1716.77 383.08 603.25 426.84 1259.31 1314.19 1681.78 2026.98 2824.05 1806.16 1312.29 623.03
476.65 2311.41 980.97 715.05 798.34 1006.86 793.01 1440.03 980.09 1641.15 1125.04 1662.16 783.36
779.2 604.39 563.11 724.74 1354.04 893.46 1317.9 2233.27 586.64 1484.78 1022.83 625.12 710.07
507.06 1306.43 1846.77 611.43 882.19 741.06 391.75 449.24 873.46 1036.84 301.3 684.58 832.9
436.88 2942.81 603.45 787.49 6907.66 1242.04 398.66 302.87 249.15 255.31 299.48 215.02 1169.85
516.03 539.66 378.22 258.23 775.81 772.49 342.52 277.46 505.25 755.16 412.11 310.19 284.71
321.27 765.55 331.58 445.73 328.55 351.03 483.29 344.29 396.01 569.18 337.66 185.56 231.4
Legend
PROPOSED NAKCHI AREA
NAKCHI LREE ANOMALY MAP
LREE VALUE (ppm)
65.317 - 250
250.001 - 500
500.001 - 750
750.001 - 1,000
1,000.001 - 1,250
1,250.001 - 1,500
1,500.001 - 1,750
1,750.001 - 2,000
2,000.001 - 7,500
7,500.001 - 12,779.948
LREE CONTOUR LINES (250 ppm)
LREE Values (ppm)
61.380000 - 250.000000
250.000001 - 500.000000
500.000001 - 750.000000
750.000001 - 1000.000000
1000.000001 - 13011.720000
Source: NGDR Portal, GSI
Scale: 1:50,000
0 0.5 1 2 3 4
Kilometers

PLATE VII


TOTAL REE ANOMALY MAP SHOWING PROPOSED STREAM SEDIMENT SAMPLES AND AUGER DRILLING POINTS (ppm) FOR RECONNAISSANCE SURVEY OF REE, ANGUL DISTRICT, ODISHA
84°30'E
84°35'E
84°40'E
21°N
20°55'N
1870.85
473.73
698.7
512.69
1389
1456.07
1819.63
2190.72
3064.2
1999.96
1447.8
2489.33
1089.63
822.89
898.11
1132.42
908.46
1575.83
1082.34
1805.34
1249.05
1817.35
702.36
661.04
833.53
1482.14
1001.23
1454.67
2393.54
680.25
1612.05
1122.78
722.3
1419.62
1987.66
703.94
990.31
837.72
494.16
527.11
959.79
1138.81
374.9
768
3142.4
690.48
875.93
7174.03
1349.45
478.22
421.81
336.94
345.43
395.84
279.36
633.57
468.33
356.64
881.41
881.43
417.09
368.73
586.65
820.52
478.55
408.56
Legend
PROPOSED NAKCHI AREA
TREE CONTOUR LINES (250 ppm)
Proposed Stream Sediment Samples
Auger Drilling Grid
Proposed Auger Drilling Points
Drainage
TREE VALUES (ppm)
250.000001 - 500.000000
500.000001 - 750.000000
750.000001 - 1000.000000
1000.000001 - 13865.098920
NAKCHI TREE ANOMALY MAP
TREE VALUE (ppm)
133.311 - 250
250.001 - 500
500.001 - 750
750.001 - 1,000
1,000.001 - 1,250
1,250.001 - 1,500
1,500.001 - 1,750
1,750.001 - 2,000
2,000.001 - 7,500
7,500.001 - 13,620.924
Source: NGDR Portal, GSI
0 0.5 1 2 3 4
Kilometers