PROPOSAL FOR RECONNAISSANCE SURVEY (G-4 STAGE) FOR REE AND ASSOCIATED MINERALIZATION IN SAIYEDPAR BLOCK (AREA: 135.45 SQ KM), KACHCHH BASIN, DISTRICT- KACHCHH, GUJARAT

COMMODITY: REE AND ASSOCIATED MINERALS

BY

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PLACE: NAGPUR

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

GENERAL INFORMATION ABOUT THE BLOCK

	Features	**Details**
	Block ID	Saiyedpar Block
	Exploration Agency	Mineral Exploration and Consultancy Limited (MECL)
	Commodity	REE and associated minerals
	Mineral Belt	Kachchh basin
	Completion Period with entire Time schedule to complete the project	10 months
	Objectives	Based on the evaluation of geological data available, the present exploration program has been formulated to fulfill the following objectives: i. To carry out Geological & Structural mapping on 1:12500 scale for identification of REE mineral bearing formation with the structural features to identify the surface manifestation and lateral disposition of the mineralized zones. ii. To collect bedrock, stream sediment samples (from positive catchment area) for analyses of REEs and only bedrock samples for limestone to decide further course of exploration program. iii. To identify the REE enriched soil horizon, 05 nos of orientation pitting will be carried out. Soil samples will be collected from all the soil horizon and bedrock separately by panning for heavy mineral separation. iv. To further determine the REE mineralised zone in the proposed block, auger drilling will be carried out and samples will be collected from targeted soil horizon established by orientation survey. v. To establish the reconnaissance resources for REE bearing minerals as per UNFC norms & Minerals (Evidence of Mineral Contents) Rules-2015. vi. To ascertain the quality of limestone present inside the block by collecting bedrock samples. vii. The outcome of this exploration will decide further exploration strategy for upgradation of block to Preliminary (G-3) Exploration.

	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: 60 Days (HQ)
1	**Location**	

The coordinates of corner points of proposed Saiyedpar Block are as follows:

Points	Latitude	Longitude
A	23° 11' 59.17" N	069° 46' 33.64" E
B	23° 11' 59.98" N	069° 52' 38.31" E
C	23° 04' 51.96" N	069° 52' 39.72" E
D	23° 04' 55.62" N	069° 46' 36.91" E

	Villages	Saiyedpar, Gandher, Varli, Chandiya
	Tehsil/ Taluk	Bhuj and Anjar
	District	Kachchh
	State	Gujarat
2.	**Area (hectares/ square kilometers)**	
	Block Area	135.45 sq km
	Forest Area	The proposed block area was checked in PM Gatishakti Portal, where the block was said to be free from Eco sensetive Zone and Wildlife Sanctuary.
	Government Land Area	Data Not Available
	Private Land Area	Data Not Available
3.	**Accessibility**	

	Nearest Rail Head	Bhuj (22 km west 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 State Highway-46 connecting Bhuj to Anjar passes through the block through Saiyedpar village.
	Airport	Bhuj (22 km west of the block)
4	**Hydrography**	
	Local Surface Drainage Pattern (Channels)	Most of the streams passing though the area are seasonal and fed by monsoon rains. They remain dry, with little amount of underflow, for greater part of the year.
	Rivers/ Streams	The area is mainly drained by the tributaries of the Churwa nadi, Song nadi and Sarkar nadi.
5	**Climate**	
	Mean Annual Rainfall	Maximum Rainfall: 200-300 mm (July and August)
	Temperatures (December) (Minimum) Temperatures (June) (Maximum)	Maximum Temperature: 45°C (May) Minimum Temperature: 7°C (January) Maximum Rainfall: 300 mm (July and August)
6	**Topography**	
	Toposheet Number	41E/16
	Physiography of the Area	The area shows undulatory topography. The average elevation of the area is around 120 m with a gradual decrease in height from south to north. The physiography of the area is controlled by lithology and structure. The northern part of the area forms a relatively flat ground with average elevation of 120 m, above sea level.
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/16 have been used to compute LREE, HREE & Total REE geochemical anomaly maps presented as plates in the proposal.
	Geophysical Map	**Not Available**
8.	**Justification for taking up Reconnaissance Survey / Regional Exploration**	i) NGCM Stream Sediment Sample data points fall in the proposed Saiyedpar Block. The total REE, LREE and HREE values have been calculated and the geochemical anomaly map for the same has been prepared. The proposed Saiyedpar block has a

		maximum total REE value of 1360 ppm followed by 1070 ppm. The maximum total HREE value in proposed Saiyedpar block is 81.61 ppm of which the major contributing elements is Gadolinium (maximum 33.62 ppm). The maximum LREE value in Saiyedpar block is 1180.44 ppm and the major contributing element is Cerium (maximum 566.02 ppm). The NGCM stream sediment samples carried out by GSI show highly anomalous values for REE in toposheets 41E/11,12,15 & 16, therefore the proposed Saiyedpar Block can be taken up for reconnaissance survey for REE. ii) The Bhuj Formation which in the proposed block mainly comprises of Ferruginous Sandstone and Feldspathic sandstone, with few intercalated bands of sandy clay, grey-black pyritous shales, siltstone, carbonaceous shale, white kaolinitic clay were also reported by earlier workers. REEs can get adsorbed into clay bands. The REE deposits in the clay bands of Southern China particularly in Jiangxi, Guangdong, Fujian, Hunan, Guangxi, and Yunnan have total REE content ranging between 500 ppm to 2000 ppm in oxides. Similar to the ion adsorption clay deposit in Southern China provinces, the proposed blocks has intercalated clay layers within the ferruginous sandstone of Bhuj Formation. From the line graph of HREE concentration, it can be observed that the proposed block has higher concentration of Gadolinium. Hence the intercalated clay bands within the ferruginous sandstone of Bhuj Formation can be the possible source of REE in the proposed block. iii) Kachchh is a E-W oriented peri-cratonic rift basin which comprises of thick sediment accumulation from Mesozoic to Cenozoic Era. Numerous studies on the provenance of these thick sedimentary columns are being done continuously. Chaudari et al. (2018) presented a detailed study of the provenance of Kachchh sandstones. The Mesozoic Kachchh Basin with southwesterly palaeoslope was bounded by two prominent highs, the Nagar Parkar Uplift to the north (formed

		as one of the horsts of the rift basin) and the Aravalli Highlands to the east. Most of the studied siliciclastic sediments were possibly sourced from these two highs. Samples of Lower Cretaceous Bhuj Formation indicate transitional continental provenance signatures. Thus, upliftment along the Kachchh Mainland Fault in the Early Cretaceous (Biswas 2005) possibly had a major impact on sediment transportation paths in the Kachchh Mainland. The Nagar Parkar igneous complex comprises the Late Proterozoic granites, rhyolites, acidic and basic dykes (Ahmad and Chaudhry 2008; Laghari et al. 2013). These rocks were uplifted and exposed by the Nagar Parker Fault in the Early Jurassic. The highlands formed by the rocks of the Proterozoic Aravalli and Delhi Supergroups in the east expose various grades of metasedimentary rocks, granite gneisses and metabasics (Ramakrishnan and Vaidyanadhan 2008). Chaudhari in her account mentioned that majority of the sandstones of Bhuj Formation are arkoses with a few sub-arkoses, consisting of sub-angular to sub-rounded grains fabric. Common heavy minerals in these sandstones include both transparent (zircon, rutile, tourmaline, garnet, ilmenite, monazite, apatite and epidote) and opaque (Ilmenite & garnet) varieties. Chaudhuri presented a detailed study of garnet and ilmenite chemistry to conclude multiple sources for these sediments including felsic igneous and metabasic rocks. Almost all zircon grains observed are prismatic with sub-rounded to well-rounded grain indicating a polycyclic origin and sediment transport from a faraway source. Enriched TiO2 content (> 50%) and depleted MnO content (< 2%) in ilmenite grains of Bhuj Formations indicate metabasic provenance lithotype. The abundant garnet grains in Bhuj Formation indicate a source from high grade meta-basic rocks. Meta-basic rocks are absent in the Nagar Parker uplift thus the parent meta-basic source is from the East i.e. from the highlands of Aravalli and Delhi Supergroup for the sedimentary rocks of Bhuj Formation.

Predominant sediment source from eastern highlands during the late syn-rift to post-rift stage may possibly be related to upliftment along the Kachchh Mainland Fault, which prevented sediment supply from north in the Kachchh Mainland.

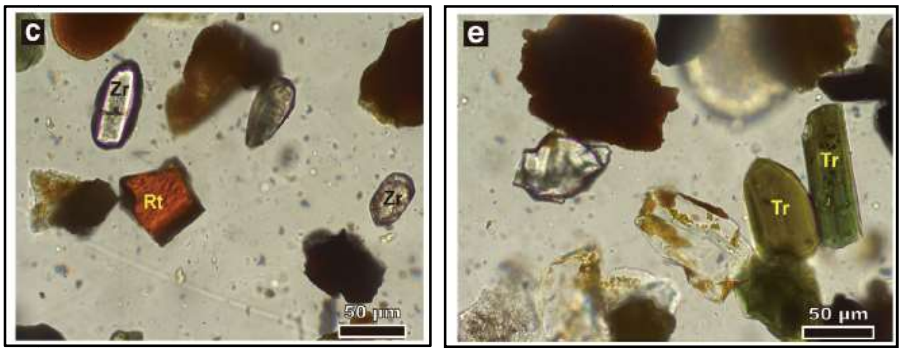


Fig- Photomicrographs of heavy minerals separated from sandstones of Bhuj Formation in PPL showing the sub-rounded grains of Rutile & Zircon (Rt- Rutile, Zr- Zircon & Tr- Tourmaline); Chaudhari et al., 2018

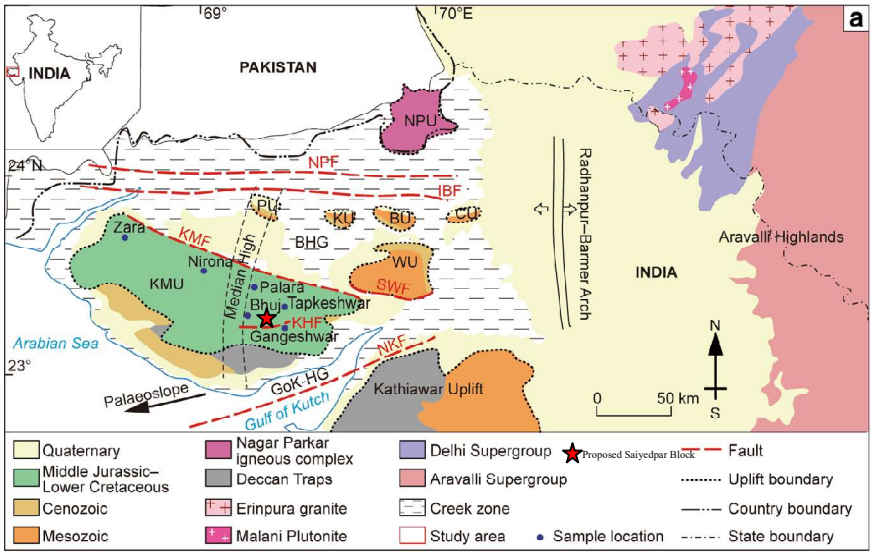


Fig: Tectonic elements and inferred palaeoslope of the Mesozoic in the Kachchh Basin (modified after Biswas 1991). PU = Patcham Uplift; KU = Khadir Uplift; BU = Bela Uplift; CU = Chorad Uplift; WU =Wagad Uplift; KMU = Kachchh Mainland Uplift; NPU = Nagar Parkar Uplift; NPF = Nagar Parkar Fault; IBF = Island Belt Fault; SWF = South Wagad Fault; KMF = Kachchh Mainland Fault; KHF = Katrol Hill Fault; NKF = North Kathiawar Fault; BHG = Banni Half Graben; GoK-HG = Gulf of Kachchh Half Graben (Chaudhari et al., 2018).

iv) It was inferred by previous workers that the diagenetic reactions with Fe-Mn oxides from the parent volcanic rocks, the hydrothermal activity related to volcanism and later groundwater leaching might have released the REEs from the source rocks and redeposited them in the sandstones of Bhuj Formation.

v) The Kachchh Basin has experienced multiple sea-level fluctuations since the Mesozoic era. The basin contains

		Mesozoic to Cenozoic sedimentary rocks formed from the weathering of earlier intrusives, Precambrian granites and surrounding rocks. Marine transgression might have introduced REE-rich sediments in the Bhuj formation and regression phases possibly expose these deposits to weathering and secondary concentration. vi) A fossiliferous and calcareous limestone lies in the middle of the proposed block. 19 NGCM Stream Sediment Sample data points fall in the proposed Saiyedpar Block and the maximum CaO value analysed in the stream sediment samples is 5.50%. Hence few bedrock samples are kept to ascertain the quality of the limestone. With above justifications, the current proposed block may be studied for REE and associated mineralization at G-4 level of exploration.

PROPOSAL FOR RECONNAISSANCE SURVEY (G-4 STAGE) FOR REE AND ASSOCIATED MINERALIZATION IN SAIYEDPAR BLOCK, DISTRICT –KACHCHH, STATE -GUJARAT (AREA 135.45 SQ. KM.)

1.0.0 INTRODUCTION:

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 63(La, Ce, Pr, Nd, Pm, Sm, Eu) and the heavy rare earth elements (HREE) are those with atomicnumbers from 64 to 71 (Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu). However, because of their geochemical properties, rare earth elements are typically dispersed and not often found concentrated as rare earth minerals in economically exploitable ore deposits.

1.0.4 Generally the light rare earth elements (LREE) are more abundant in the earth's crust and 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.

1.2.0 BACKGROUND

1.2.1 On enactment of MMDR Amendment Act- 2015, Minerals (Evidence of Mineral Contents) Rule 2015 and Mineral Auction Rules 2015, Govt. of India directed State Government to speed up exploration work for different Mineral Commodities in the respective states. Accordingly MECL has prepared the proposal for Reconnaissance (G4) level involving identification of mineralized areas worthy of further investigation towards deposit identification.

1.2.2 The Exploration for strategic, critical, rare metals, rare earths elements, PGE and precious metals is given top priority by Govt. of India after amendment of MMDR act 2015. Keeping this in view, the present proposal is being put up for Reconnaissance Survey (G-4) for REEs and associated minerals in Saiyedpar Block, Kachchh District, Gujarat.

1.2.3 MECL has prepared the proposal for G-4 level exploration for REE & associated minerals in Saiyedpar Block, Kachchh district, Gujarat to put up for approval in the forthcoming meeting of Technical cum Cost Committee (TCC-II) of NMET.

1.3.0 LOCATION AND ACCESSIBILITY

1.3.1 The proposed Saiyedpar Block comprises of 135.45 sq km area and lies in Bhuj and Anjar Tehsil of Kachchh District (Toposheet No. 41E/16), Gujarat. The major villages falling within the proposed block are Saiyedpar, Gandher, Varli and Chandiya. All the villages in the area are well connected to each other and to the highways by motorable roads and tracks. The State Highway-46 connecting Bhuj to Anjar passes through the block through Saiyedpar village. The district headquarter Bhuj is about 22 km west of the block. The

nearest railway station and airport is at Bhuj which are at about 22 km west of the proposed block. The location map of the proposed block is provided as Plate No- I. The detailed location of the boundary points are given in Table 1.

Table 1: Coordinates of Corner Points of Proposed Saiyedpar Block, Kachchh District, Gujarat

Points	Latitude	Longitude
A	23° 11' 59.17" N	069° 46' 33.64" E
B	23° 11' 59.98" N	069° 52' 38.31" E
C	23° 04' 51.96" N	069° 52' 39.72" E
D	23° 04' 55.62" N	069° 46' 36.91" E

1.4.0 PHYSIOGRAPHY

1.4.1 The area shows undulatory topography. The average elevation of the area is around 120 m with a gradual decrease in height from south to north. The physiography of the area is controlled by lithology and structure. The northern part of the area forms a relatively flat ground with average elevation of 120 m, above sea level.

1.5.0 DRAINAGE

1.5.1 Streams to the north flows northerly and easterly and those to the south flows southerly and south-easterly. Major part of the drainage in the initial stages is controlled by structure and litho-logical variation of the area. The area is mainly drained by the tributaries of the Churwa nadi, Song nadi and Sarkar nadi. Most of the streams passing though the area are seasonal and fed by monsoon rains. They remain dry, with little amount of underflow, for greater part of the year.

1.6.0 CLIMATE

1.6.1 The area falls under the arid-semi-arid climatic zone receiving annual precipitation between 200-300 mm. The area is quite fertile and sustains a viable population on account of the copious supply of ground water provided by Bhuj Sandstone Formation aquifer. In a region of less rainfall, orchards of mango, sapota and coconuts are found. The temperatures in this region are typically extreme with summer scorching up to 45°C. The oppressive heat conditions persist from April to June. Winters are mild with temperature ranging from 7°C to 10°C.

1.7.0 FLORA AND FAUNA

1.7.1 Except for the areas which are hilly and bouldery, rest of the area is mostly under extensive and intensive cultivation. The main crops of the area are maize, cotton,

groundnut and Aloe vera. Other floras commonly seen in the area are ber, acacia and cactus.

1.7.2 Other flora commonly seen in the area are ber, acacia and cactus. Important fauna present in the area include chinkara, antelope, fox, jackal, rabbit, varanus, etc.

2.0.0 REGIONAL GEOLOGY

2.1.0 Regionally, the area exibits Cretaceous- Jurassic rocks which are the oldest rocks except for some patches of Precambrians. They are fringed by Deccan Traps to the south and the saline marsh of Great Rann of Kachchh to the north. The Cretaceous- Jurassic rocks have an estimated thickness of about 2000 m and in three anticlinal ridges (N to S) trending in E-W direction. Owing to E-W faults, i.e. Kachchh Mainland Fault (KMF), Katrol Hill Fault (KHF), the whole sequence is repeated along N-S. The southernmost chain forms a 65 km long Katrol hill range in the south of Bhuj town. Mesozoic rocks of Kachchh, comprises of four formations i.e. Pachchham, Chari, Katrol and Bhuj in order of superposition.

Pachchham Formation: The Pachchham Formation of Jurassic age comprises 300m thick sequence of intercalated sequence of siltstone / shale, calcareous sandstone and fossiliferous conglomerate with minor coralline and algal limestone bands in the lower part, followed by limestone and sandstone with plant fossils in the middle part and intercalated sequence of gypseous shale /siltstone, fossiliferous calcareous sandstone and grey-khaki coloured gypseous shale, siltstone and limestone in the upper part.

Chari Formation: The Chari Formation of Jurassic age unconformably overlies the Pachchham Formation and comprises of 400m thick sequence of polymicitic conglomerate, fossiliferous gypseous marly shale, fossiliferous calcareous gritty sandstone, shale and oolitic limestone. In Katrol hill range they form half domes cut by Katrol hill fault.

Katrol Formation: The Katrol Formation of Creta-Jurassic age unconformably overlies the Chari Formation and comprises of 400m thick sequence of ammonite bearing marl & shales, calcareous and quartzitic sandstone, brown to dark grey shale and conglomerate bands with belemnites and gastropods and ochreous nodular horizons. The shale and sandstone are glauconitic and carbonaceous.

Bhuj Formation: Bhuj Formation of Cretaceous age forms a vast E-W trending stretch and abuts against the Chari and Katrol Formations along the E-W trending Katrol hill fault. It conformably overlies the Katrol Formation and comprises of 1000m thick

succession of conglomerate, sandstone, shale, siltstone with cyclically repetitive sequence of ironstone, shale and feldspathic sandstone. The basal part comprises sequence of gypseous shale, clay, black and carbonaceous shale with coal bands and glauconitic fossiliferous sandstone with plant beds. The upper part contains glauconitic shale, feldspathic and burrowed sandstone and clay. Rhythmic intercalations of ironstone and conglomerates with pebbles of basalt with thick bands of marine and plant fossils are also found.

Deccan Trap: The Deccan Traps of Creta – Eocene age, exposed mainly in the southern parts of Kachchh overlies the Bhuj Formation. The flows are of olivine basalt and alkali olivine basalt affinity in basal part, tholeiitic in middle and andesitic in upper part. Thin intertrappean horizons within the basalts comprise clay, sandstone, shale, limestone and chert. Associated with the basaltic flows are several basaltic / doleritic plugs, sills and dykes.

Tertiary Rocks: The tertiary sediments were deposited over the Mesozoic sedimentary rocks and Deccan Traps along the coastal strip of Kachchh Mainland. The Tertiary rocks are exposed all along the western, southern, southwestern and southeastern part of Kachchh. The Tertiary Formation of Kachchh consists of three distinct facies – the lower one is altered volcanics and is represented by the Matanomadh Formation, the middle is marine transgressional facies i.e. represented by the Fulra, Khari Nadi, Gaj formations and the upper part is fluviatile and is represented by the Manchar Formation. The Matanomadh Formation of Palaeocene age comprises 50m thick sequence of saprolite, ash, bentonite clay, lateritic bauxite, laterite, conglomerate, tuffaceous sandstone, kaolinitic clay, grit and unconformably overlies the lava flows & the older sedimentary rocks. Fulra formation of lower to upper Eocene age conformably overlies the Matanomadh Formation and comprises foraminiferal limestone, glauconitic shale and clay. Khari Nadi Formation of Oligo-Miocene age conformably overlies the Fulra Formation and comprises 60-70m thick sequence of variegated shale, fossiliferous limestone with marl, limestone and shale. Gaj Formation of lower Micoene age comprises variegated shale, clay, fossiliferous marl and limestone. Manchar Formation conformably overlies the Khari Nadi Formation and comprises 50m thick sequence of micaceous sandstone, clay, and conglomerate.

Table No. 2.1
Regional stratigraphy of the area (After GSI)

Age	Group	Formation	Lithology
Holocene/ Recent		**Recent**	Sand, Silt
		Mahuva	Younger tidal flat and Marsh deposit
		Rann Clay	Older tidal flat and Marsh deposit
		Rann	Rann Clay and mud deposit
		Varahi	Younger Flood Plain, Channel fill and Deltaic Deposit
		Katpur	Older Flood Plain, Channel fill and Deltaic Deposit
		Jantral	Unstabilised sand sheet and sand dune deposit
Lower Pleistocene	**Porbandar**	**Miliolite**	Miliolite limestone, shell limestone, calcareous sandstone, pebbly limestone, conglomerate.
Lower Pleistocene		**Kothara**	Pebbly sandstone, Conglomerate, gravel and sand
Pliocene		**Sandhan**	Micaceous sandstone, mottled clay, siltstone, conglomerate, calcareous clay with marl
Lower to Middle Miocene		**Gaj**	Shale interbedded with fossiliferous marl
Early Miocene		**Khari Nadi**	Varigated Siltstone, Gypseous claystone
Middle to Upper Oligocene		**Maniyara Fort**	Calcareous and Gypseous claystone/ siltstone, clay, coral limestone, sandstone
Eocene		**Fulra**	Fossiliferous marl and limestone, Glauconitic Shale and Clay
Lower Eocene		**Kakdi Nadi**	Gypseous, lignite bearing shale, fossiliferous nodular limestone and clay, ferruginous shale and clay with intercalated marl.
Early Palaeocene		**Matanomadh**	Laterite, Sandstone, Conglomerate, Bentonitic and Kaolinitic Clay
Unconformity			
Upper Cretaceous to Eocene	**Deccan Trap Super Group**	**Anjar Volcanics**	Basalt, amygdular basalt and basic intrusive dykes
		Dayapar Volcanics	Basalt
		Khambhaliya Volcanics	Basalt
Intrusive Contact			
Lower Cretaceous		**Bhuj**	Feldspathic sandstone, ferruginous sandstone, gritty sandstone, ferruginous gritty sandstone, quartzite and shale – siltstone in alternation
Conformable			
Upper Jurassic to Lower Cretaceous		**Katrol**	Calcareous sandstone, gritty sandstone, khakhi shale – siltstone, gypseous shale, ash coloured shale, pink sandstone, pink siltstone, dark shale, fossiliferous limestone, ferruginous sandstone, quartzite
Unconformity			

Age	Group	Formation	Lithology
Middle to Upper Jurassic		**Chari**	Fossiliferous oolitic marl, calc arenite / calc quartzite, fossiliferous conglomerate, pink sandstone, gypseous shale – siltstone, ash colour shale – brown colour siltstone, arenite, bouldery sandstone, fossiliferous sandstone, ferruginous sandstone, gritty sandstone
Middle Jurassic		**Pachchham**	Gypseous Shale, Siltstone, Limestone, Sandstone, Conglomerate
Basement not exposed			

3.0.0 GEOLOGY OF THE BLOCK

3.1.0 The proposed block area represents the southern part of the Kachchh Basin which is an east-west oriented pericratonic rift basin. Geologically the block comprises of sediments belonging belonging to the Lower Cretaceous Bhuj Formation, minor volcanics of Upper Cretaceous to Eocene Deccan Trap and Lower Pleistocene Miliolite Formation. The Bhuj Formation almost entirely covers the proposed block represented by lower feldspathic sandstone and grit, which commonly shows current bedding and upper ferruginous sandstone which are gritty and quartzitic. Patches of shale within the feldspathic sandstone were observed were observed by earlier workers. The Deccan Traps have intruded the Bhuj Formation at places, which are represented by litholigies like basalt, olivine basalt and dolerite. The tertiary sediments i.e. Miliolite Limestone has deposited at the fringes of Deccan Traps. Numerous dolerite dykes are intruded throughout all the lithologies present inside the block. Small scale faults are also present.

Table- 2.2
The generalized stratigraphic succession of the proposed block. (After GSI)

Age	Super Group	Formation	Lithology
Pleistocene to Recent	Porbandar Group	Miliolite	Miliolite limestone, shell limestone
Late Creataceous	Deccan Trap Supergroup	Anjar Volcanics	Basalt, Olivine basalt, Dolerite
Early Cretaceous		Bhuj	Ferruginous sandstone and grit, Feldspathic sandstone
Late Jurassic to Early Cretaceous		Katrol	Calcareous Sandstone, Siltstone, Limestone Fossiliferous Limestone

4.0.0 PREVIOUS WORK

4.0.1 Detailed systematic mapping of the Mesozoics and associated rocks commenced with the long-term project for the study of Mesozoic and Cenozoic sediments in the different field season by GSI.

4.0.2 Biswas (1971, 74) proposed a comprehensive lithosrtatigraphic classification of Mesozoic and Tertiary rocks of Kachchh in accordance with the code of stratigraphic nomenclature of India. He subdivided the Mesozoic rocks in to Jhurio, Jhumara, Jhuran and Bhuj Formations in ascending order. Biswas (1982) has discussed the sequential development of the Kachchh basin and its regional tectonic framework. The Jhurio, Jhumara and Jhuran Formations in Biswas' classification approximately correspond to Patcham, Chari and Katrol Formations of Waagen respectively. Lower part of Umia series of Waagen is included with Jhuran Formation of Biswas. He included the nonmarine sequence with Bhuj Formation and the boundary between Jhuran and Bhuj Formation is based on first appearance of Iron Formation or last appearance of calcareous sandstone.

4.0.3 Ghevariya. (1978-79, 1984-85, and 1986-87, 1988) and Ghevariya Z.G. & Srikarni. C, (1986-87). Ghevariya Z.G. and Srikarni C., (1986-87) mapped the Mesozoic rocks belonging to Chari (Jumara), Katrol (Jhuran) and Bhuj Formations in the current study area. Deccan Trap is represented by interstratified volcano sedimentary sequence and lava flows. Tertiary Formations are represented by Madh, Mandaviya and Antarjal Formations. Quaternary is represented by grapestone and Miliolite limestone. Important finds by them include dinosaurian foot prints and tracks in Katrol & Bhuj Formation, reptilian/dinosaurian eggs, dinosaurian, teeth from Intertrappeans avian egg shell fragments from Pliocene sediments. A transition zone between Katrol and Umia Formation has been recognized which contains numerous trace fossils and fossil fish impressions.

4.0.4 Rana, & Banerjee, (1996-1998) systematically mapped the Mesozoic sedimentaries, lava flows and associated inter-trappeans in 41I and 41E.

4.0.5 Rana R.S., (1996-97-& 1997-98) carried out mapping in 1:25000 scale and reported presence of 7 flows and 4 intertrappean bed. The flows at the bottom show alkali affinity but the flows on the upper part show a quartz-tholeiite affinity.

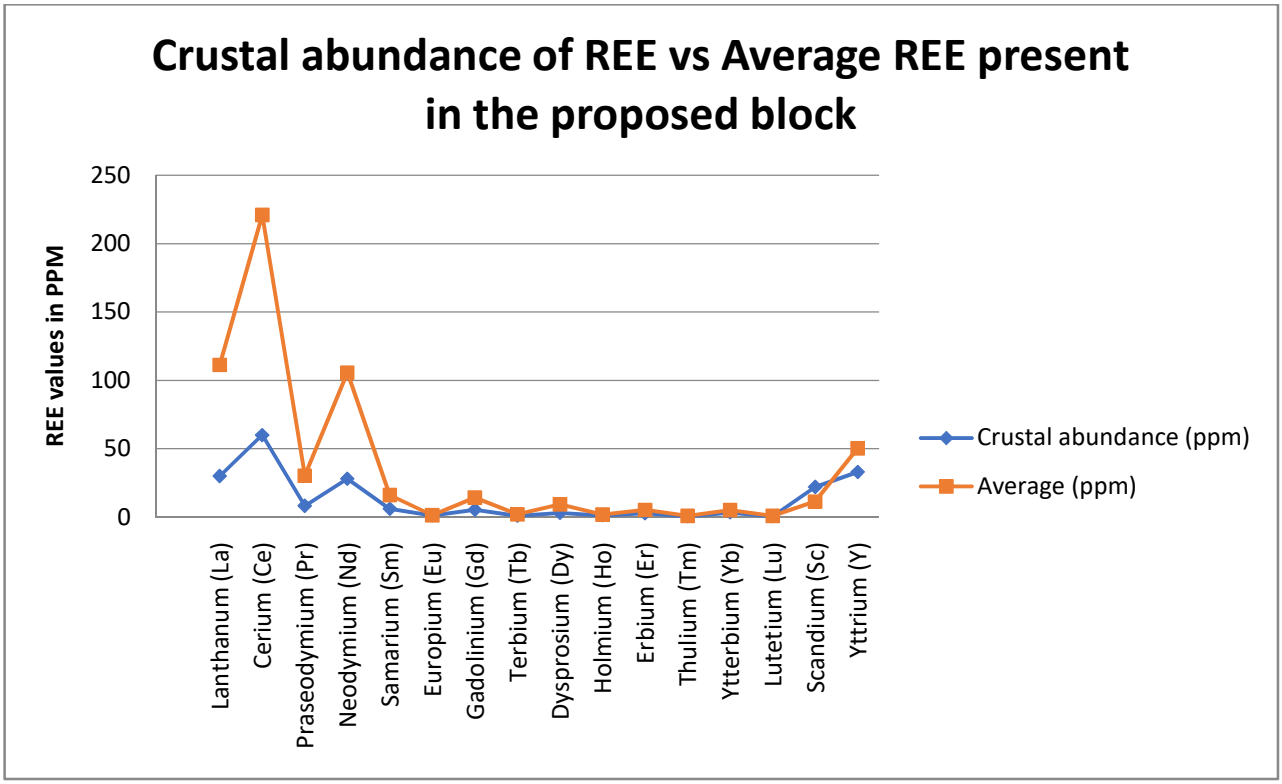
4.0.6 Basu and Harshawardhini (2021-22) carried out Specialized Thematic Mapping of Inter-Trappean beds of Anjar Volcanics, in and around Anjar, Kachchh District, Gujarat, with

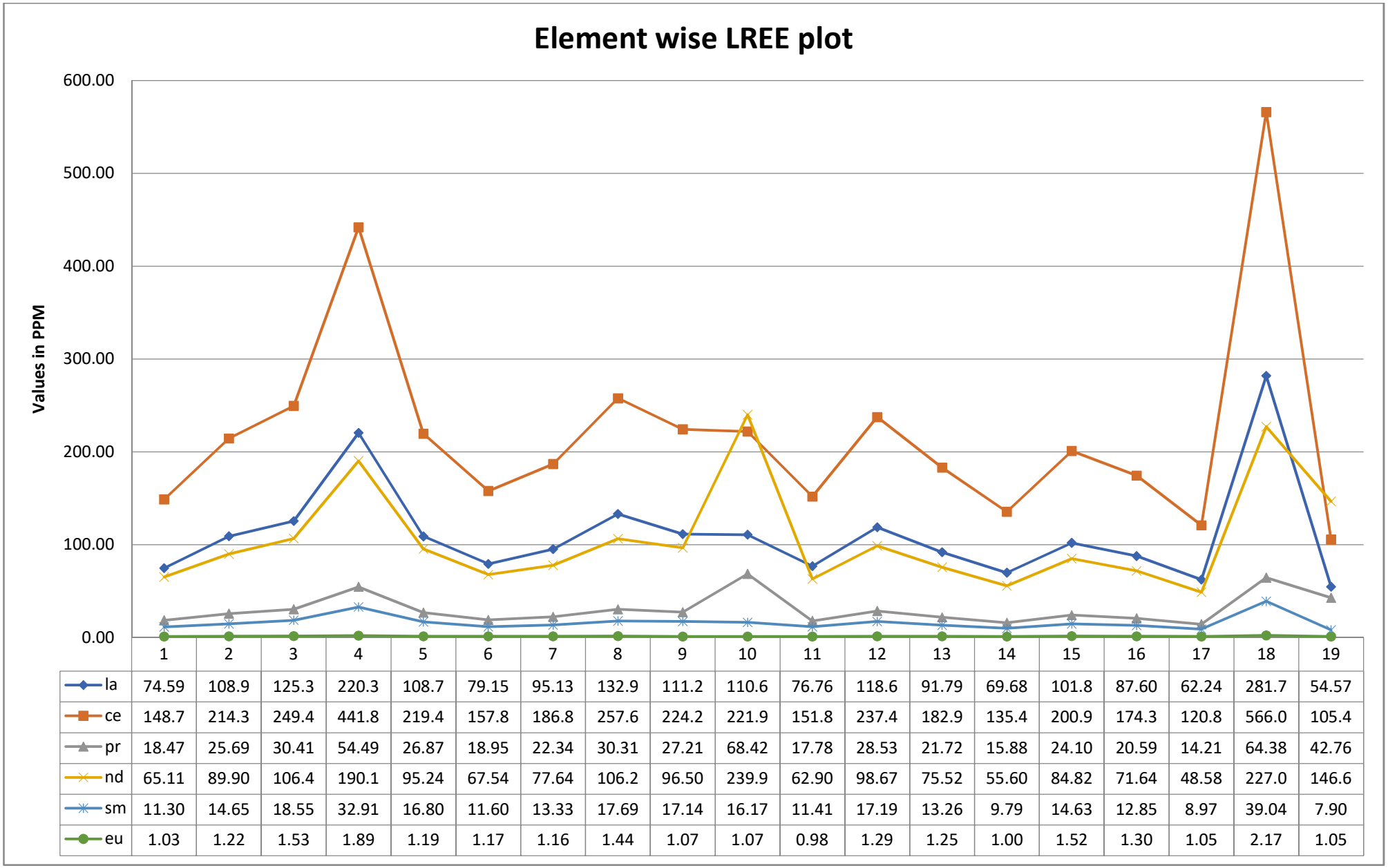
Special Investigation on Sedimentology and Vertebrate Paleontology. They identified clay horizon of Matanomadh formation and one sample yielded 2983 ppm of REE.

4.0.7 MECL has downloaded NGCM data from NGDR portal, GSI of Toposheet No. 41E/16. 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 1360 ppm. The maximum and minimum range for each element is given in below table. On the basis of anomalous stream sediment NGCM data the block is proposed for Reconnaisance Survey of REE.

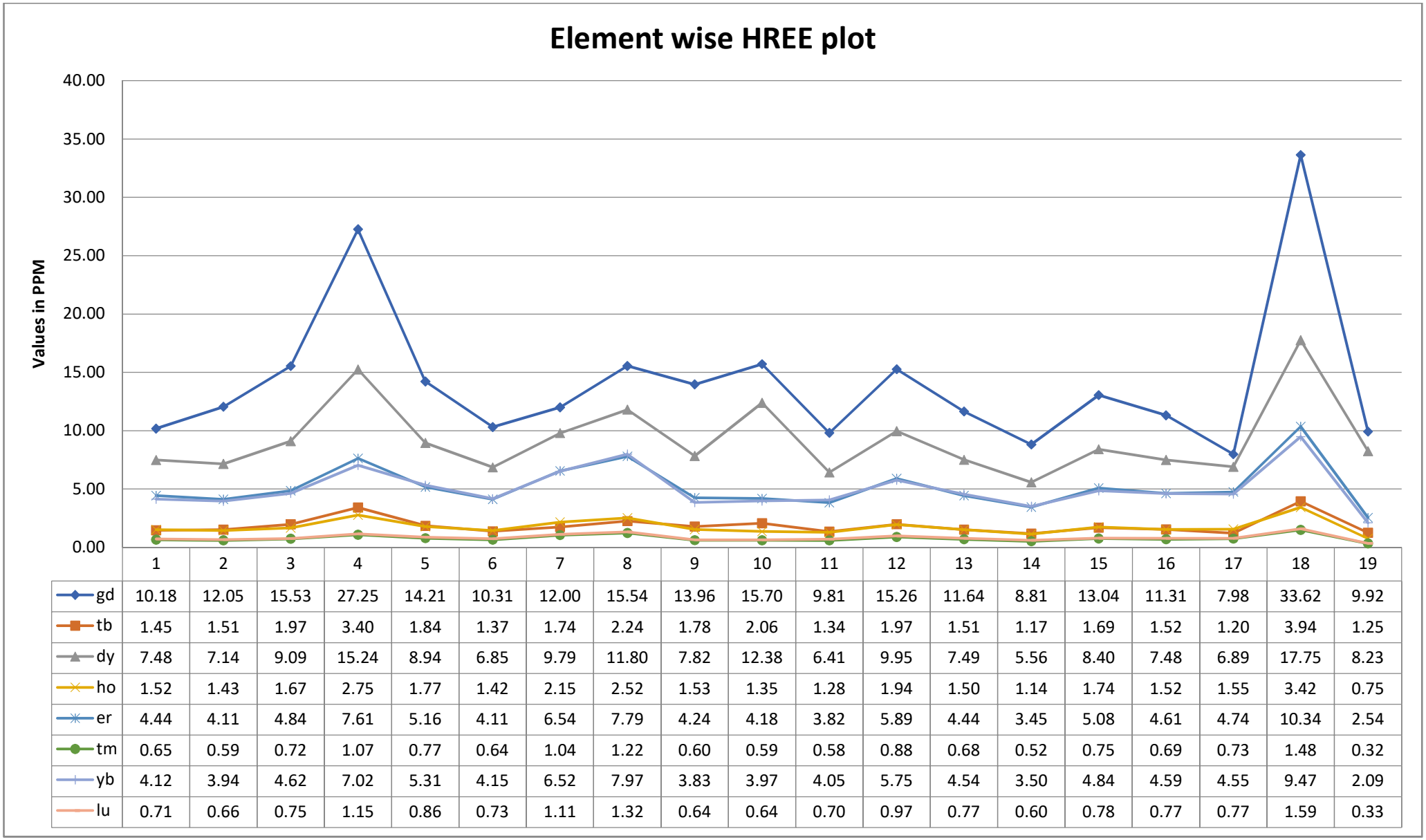
Table-2
Data showing NGCM Stream Sediment results for Proposed Saiyedpar Block (19 numbers of samples) (Source: NGDR portal GSI)

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)	30.00	54.57	281.75	111.16
	Cerium (Ce)	60.00	105.42	566.02	220.93
	Praseodymium (Pr)	8.20	14.21	68.42	30.16
	Neodymium (Nd)	28.00	48.58	239.96	105.59
	Samarium (Sm)	6.00	7.90	39.04	16.06
	Europium (Eu)	1.20	0.98	2.17	1.28
HREE	Gadolinium (Gd)	5.40	7.98	33.62	14.11
	Terbium (Tb)	0.90	1.17	3.94	1.84
	Dysprosium (Dy)	3.00	5.56	17.75	9.20
	Holmium (Ho)	1.20	0.75	3.42	1.73
	Erbium (Er)	2.80	2.54	10.34	5.15
	Thulium (Tm)	0.50	0.32	1.48	0.76
	Ytterbium (Yb)	3.40	2.09	9.47	4.99
	Lutetium (Lu)	0.50	0.33	1.59	0.83
	Scandium (Sc)	22.00	6.00	22.00	11.21
	Yttrium (Y)	33.00	27.00	86.00	50.26
LREE					485.18
HREE					38.62
TREE+Sc+Y					585.28


Crustal abundance of REE vs Average REE present in the proposed block
REE values in PPM
250
200
150
100
50
0
Lanthanum (La)
Cerium (Ce)
Praseodymium (Pr)
Neodymium (Nd)
Samarium (Sm)
Europium (Eu)
Gadolinium (Gd)
Terbium (Tb)
Dysprosium (Dy)
Holmium (Ho)
Erbium (Er)
Thulium (Tm)
Ytterbium (Yb)
Lutetium (Lu)
Scandium (Sc)
Yttrium (Y)
Crustal abundance (ppm)
Average (ppm)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
la	74.59	108.9	125.3	220.3	108.7	79.15	95.13	132.9	111.2	110.6	76.76	118.6	91.79	69.68	101.8	87.60	62.24	281.7	54.57
ce	148.7	214.3	249.4	441.8	219.4	157.8	186.8	257.6	224.2	221.9	151.8	237.4	182.9	135.4	200.9	174.3	120.8	566.0	105.4
pr	18.47	25.69	30.41	54.49	26.87	18.95	22.34	30.31	27.21	68.42	17.78	28.53	21.72	15.88	24.10	20.59	14.21	64.38	42.76
nd	65.11	89.90	106.4	190.1	95.24	67.54	77.64	106.2	96.50	239.9	62.90	98.67	75.52	55.60	84.82	71.64	48.58	227.0	146.6
sm	11.30	14.65	18.55	32.91	16.80	11.60	13.33	17.69	17.14	16.17	11.41	17.19	13.26	9.79	14.63	12.85	8.97	39.04	7.90
eu	1.03	1.22	1.53	1.89	1.19	1.17	1.16	1.44	1.07	1.07	0.98	1.29	1.25	1.00	1.52	1.30	1.05	2.17	1.05



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
gd	10.18	12.05	15.53	27.25	14.21	10.31	12.00	15.54	13.96	15.70	9.81	15.26	11.64	8.81	13.04	11.31	7.98	33.62	9.92
tb	1.45	1.51	1.97	3.40	1.84	1.37	1.74	2.24	1.78	2.06	1.34	1.97	1.51	1.17	1.69	1.52	1.20	3.94	1.25
dy	7.48	7.14	9.09	15.24	8.94	6.85	9.79	11.80	7.82	12.38	6.41	9.95	7.49	5.56	8.40	7.48	6.89	17.75	8.23
ho	1.52	1.43	1.67	2.75	1.77	1.42	2.15	2.52	1.53	1.35	1.28	1.94	1.50	1.14	1.74	1.52	1.55	3.42	0.75
er	4.44	4.11	4.84	7.61	5.16	4.11	6.54	7.79	4.24	4.18	3.82	5.89	4.44	3.45	5.08	4.61	4.74	10.34	2.54
tm	0.65	0.59	0.72	1.07	0.77	0.64	1.04	1.22	0.60	0.59	0.58	0.88	0.68	0.52	0.75	0.69	0.73	1.48	0.32
yb	4.12	3.94	4.62	7.02	5.31	4.15	6.52	7.97	3.83	3.97	4.05	5.75	4.54	3.50	4.84	4.59	4.55	9.47	2.09
lu	0.71	0.66	0.75	1.15	0.86	0.73	1.11	1.32	0.64	0.64	0.70	0.97	0.77	0.60	0.78	0.77	0.77	1.59	0.33

5.0.0 PLANNED METHODOLOGY

Based on the evaluation of geological data available, the present exploration program has been formulated to fulfill the following objectives:

i. To carry out Geological & Structural mapping on 1:12500 scale for identification of REE mineral bearing formation with the structural features to identify the surface manifestation and lateral disposition of the mineralized zones.

ii. To collect bedrock, stream sediment samples (from positive catchment area) for analyses of REEs and only bedrock samples for limestone to decide further course of exploration program.

iii. To identify the REE enriched soil horizon, 05 nos of orientation pitting will be carried out. Soil samples will be collected from all the soil horizon and bedrock separately by panning for heavy mineral separation.

iv. To further determine the REE mineralised zone in the proposed block, auger drilling will be carried out and samples will be collected from targeted soil horizon established by orientation survey.

v. To establish the reconnaissance resources for REE bearing minerals as per UNFC norms & Minerals (Evidence of Mineral Contents) Rules- 2015.

vi. To ascertain the quality of limestone present inside the block by collecting bedrock samples.

vii. The outcome of this exploration will decide further exploration strategy for upgradation of block to Preliminary (G-3) Exploration.

4.0.2 The details of different activities to be carried out are presented in subsequent paragraphs.

5.1.0 GEOLOGICAL MAPPING

5.1.1 Geological mapping will be carried out in the entire 135.45 sq.km area on 1:12,500 scale. Rock types, their contact, structural features will be mapped. Surface manifestations of the mineralization (REE) available along with their surface disposition will be marked on map.

5.1.2 75 nos. of bedrock samples will be collected from the various lithounits present in the area, to identify the host REE bearing formation. The Bhuj Formation which in the proposed block mainly comprises of Ferruginous Sandstone and Feldspathic sandstone, but few intercalated bands of sandy clay, grey-black pyritous shales,

siltstone, carbonaceous shale, white kaolinitic clay were also reported by earlier workers. REEs can get adsorbed into clay bands, thus these lithounits will be sampled and analysed for REE bearing minerals. 34 element ICPMS studies will be carried out for the 75 bedrock samples collected from various lithounits, 10% of primary samples i.e. 08 external check samples will be sent to NABL External Labs for analysis.

5.1.3 For identification of limestone bearing mineral horizon, a provision of 25 bedrock samples have been proposed. The samples collected for limestone will be analysed for major oxides Cao, Mgo, K2O, SiO2, Na2O, P2O5, Al2O3, Fe2O3, SO3 & LOI by XRF method. Around 10% of Primary samples i.e. 03 samples for limestone will be sent to NABL External Labs for analysis of major oxide studies by XRF method.

5.1.4 10 nos. of surface samples from various lithounits will be studied for petrography and minerography.

5.2.0 GEOCHEMICAL SAMPLING (Stream Sediment Sampling)

5.2.1 During the course of Geological mapping stream sediment samples will be collected from 1st order and 2nd order streams to identify the positive catchment area for REE mineralization. The stream sediment sample will be commenced from the positive catchment area identified by NGCM samples having total REE value greater than 500 ppm.

5.2.2 Total 45 stream sediment samples will be collected from the proposed block and all 45 samples will be subjected to heavy mineral separation by panning and the heavies from the remaining samples will be collected by natural faction method. The final heavies collected methods will be powdered and sent to laboratory for 34 element ICPMS analysis of REE. 05 external check samples will be analyzed for assay of 34 elemental analysis includes Nb, Sr, Ta, W, Mo, Sn, Rb, Be, Ba, Cs, Li & REE.

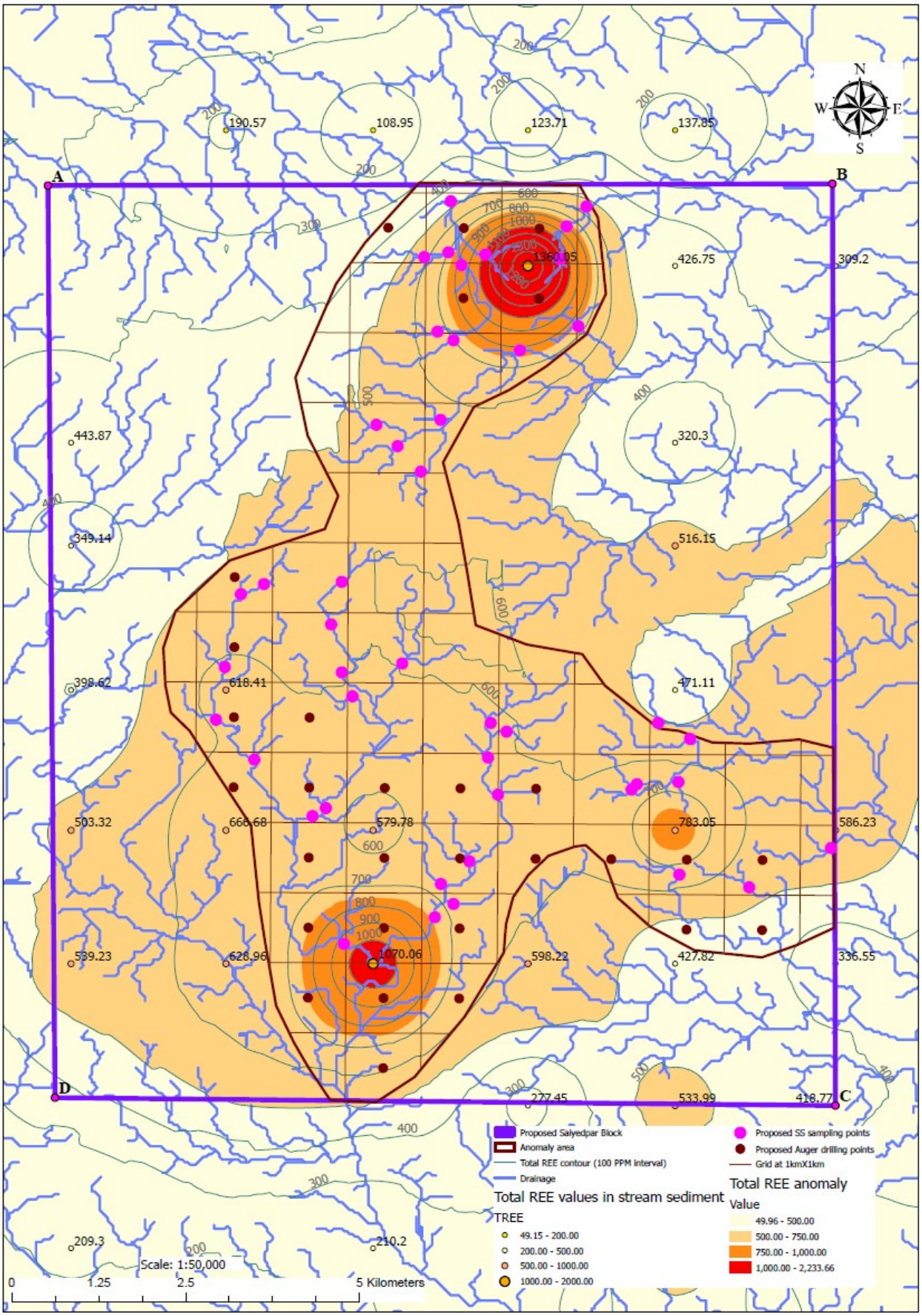
5.3.0 EXPLORATORY MINING (Pitting & Trenching):

5.3.1 Orientation pitting will be carried out in positive catchment area identified on the basis of total REE NGCM values of GSI and analysis of stream sediment samples collected during proposed exploration. A provision of 05 nos of pitting on the identified anomalous zone (2.0 m wide X 2.0 m deep) with 20 cubic meters is kept. Pitting will

be carried from surface up to a depth of 2 m. Locations of pits will be decided by field geologist based on field observations.

5.3.2 20 orientation soil samples will be collected from 05 pits where separate samples would be collected from all the soil horizon and bedrock (if exposed) of each pit. The collected soil samples will be subjected to both heavy mineral separation by panning and by natural faction method. The orientation soil samples would help to decide the target soil horizon best suitable for REE mineralization. All heavies generated would be powdered and analysed for 34 elemental analysis including Nb, Sr, Ta, W, Mo, Sn, Rb, Be, Cs, Li & REE by ICPMS method. 10% of Primary Samples will be sent for external check in NABL External Labs by ICPMS method.

Proposed stream sediment samples and auger drilling location points over TREE anomaly zones



5.4.0 EXPLORATORY DRILLING

5.4.1 Auger Drilling will be carried out in the REE anomaly area marked in the proposed block on the basis of total REE NGCM values of GSI and drainage map. The REE anomaly area will be redefined on the basis of geological mapping, bedrock sampling and stream sediment sampling carried out by MECL. Auger drilling will be carried out in a grid pattern of 1 km X 1 km.

5.4.2 Total 30 numbers of auger drilling boreholes have been proposed in the block each having a depth of 7 m. The total auger drilling carried out in the block will be 210 m. Based on the result of orientation pitting samples from auger drilling will be collected from targeted soil horizon and bedrock. 20% of the soil samples i.e. 30 samples generated during auger drilling will be subjected to panning and the 150 samples will be processed by natural faction in 120 mesh after sun drying. Total 150 nos of primary samples will be analysed for REE by 34 element ICPMS method. 10% of Primary Samples will be sent for external check in NABL External Labs by ICPMS method.

5.4.3 A provision of 300m drilling in 10 scout boreholes are kept to delineate the depth persistent of REE mineralization.

5.4.4 150 core samples will be analysed for REE by 34 element ICPMS method. 10% of Primary Samples i.e. 15 samples will be sent for external check in NABL External Labs by ICPMS method.

5.6.0 PETROLOGICAL & MINERAGRAPHIC STUDIES:

5.5.1 During the course of Geological mapping and sampling 10 nos. of samples from outcrops of various lithounits will be collected to carry out Petrography and Minerography. These samples would be drawn from ore zones and host rocks.

5.7.0 XRD STUDY

5.6.1 To know the different mineral phases which can possibly host REE, 20 samples will be studied by XRD method. The samples for XRD will be selected from the samples which will analyze anomalous values of REE in bedrock, stream sediment and auger drilling.

6.0.0 PROPOSED QUANTUM OF WORK

6.1.1 Details of the particular, Quantum and the targets are tabulated in **Table No.-5.1.**

Table No- 5.1

Envisaged Quantum of proposed work

Sl. No.	Item of Work	Unit	Target
1	**Geological Mapping** (on 1:12,500 Scale)	Sq km	135.45
2	**Geochemical Sampling**		
i	Bedrock samples for REE (34 elemental analysis By ICPMS includes Nb, Sr, Ta, W, Mo, Sn, Rb, Be, Cs, Li& REE)	Nos	75
ii	Stream Sediment samples for REE (34 elemental analysis by ICPMS includes Nb, Sr, Ta, W, Mo, Sn, Rb, Be, Cs, Li & REE)	Nos	45
iii	Bedrock samples for Limestone	Nos	25
3	**Exploratory Mining**		
i	Orientation Pitting (5 pits)	Cu.m	20
ii	Pit samples for 34 elemental analysis includes Nb, Sr, Ta, W, Mo, Sn, Rb, Be, Cs, LI & REE	Nos	20
4	**Auger Drilling for REE**		
i	Auger Drilling in 30 boreholes	m	210
ii	Auger Drilling samples for 34 elemental analysis includes Nb, Sr, Ta, W, Mo, Sn, Rb, Be, Cs, Li & REE	Nos	150
5	**Core Drilling for REE**		
i	Scout drilling	m	300
6	**Laboratory Studies**		
	i) Heavy Mineral Seperation (100% Stream Sediment Samples + 100% Orientation Pit Samples + 20% Auger Drilling Samples)	Nos	125
	ii) Bedrock samples for REE	Nos	75
	iii) Stream sediment samples for REE	Nos	45
	iv) Orientation Pit samples for REE	Nos	20
	v) Auger Drilling Samples for REE	Nos	150
	vi)Borehole samples for REE	Nos	150
	vi) 10% external check samples for REE	Nos	44

Sl. No.	Item of Work	Unit	Target
	vii) Bedrock samples for Limestone (Major oxides) by XRF (Cao, MgO, Al2O3, SiO2, Fe2O3, Na2O, K2O, P2O5, SO3 & LOI)	Nos	25
	vii) 10% external check samples for Limestone	Nos	3
7	**Petrological Samples (Surface Samples)**	Nos	10
8	**Mineragraphic Studies (Surface Samples)**	Nos	10
9	**XRD Mineral phase analysis**	Nos	20
10	**EPMA studies**	Hrs	10
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

7.0.0 BREAK-UP OF EXPENDITURE

7.0.1 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 cost is **Rs. 166.52 Lakhs.** The summary of cost estimates for Reconnaissance Survey (G-4 Level) is given in **Table No. - 5.2.** The detailed cost sheet is given as Annexure-I.

Table No. 5.2

Summary of cost estimates for Reconnaissance survey (G-4) in Saiyedpar Block, District-Kachchh, Gujarat

Sl. No.	Item	Total Estimated Cost (Rs.)
1	Geological Mapping (LSM), Other Geological Work	34,44,068
2	Trenching	76,000
3	Drilling	37,82,110
4	Laboratory Studies	58,58,246
	Sub Total (1 to 4)	**1,31,60,424**
5	Exploration Report Preparation	6,58,021
6	Proposal Preparation	2,63,208
7	Peer review charges	30,000
8	**Sub Total (1 to 7)**	**1,41,11,653**
9	GST 18%	25,40,098

Sl. No.	Item	Total Estimated Cost (Rs.)
10	**Total:**	**1,66,51,751**
	Say Rs. In Lakh	**166.52**

8.0.0 TIMELINE

8.0.1 The entire project is planned tentatively for 10 months. Initially, geological mapping and surface bedrock sampling along with soil sampling shall be carried out followed by auger drilling provided positive results are obtained in the first phase of sampling.

Table No. 5.4

Tentative Time schedule / Action plan

Estimated timeline for Reconnaissance Survey (G-4) for REE and associated minerals in Saiyedpar Block, Districts: Kachchh, State: Gujarat [Block area- 135.45 sq. km; Schedule timeline- 10 months]

S. No.	Particulars	Months/ Days	1	2	3	4	Review	5	6	7	8	9	10
1	Camp Setting	**months**											
2	Geological Mapping & BR sampling	**months**											
3	Trenching/Pitting	**cu.m**											
4	Auger Drilling	**m**											
5	Geologist days	**days**											
6	Sampling days	**days**											
7	Drilling (1 rigs)	**months**											
8	Camp winding	**months**											
9	Laboratory Studies	**months**											
10	Geologist days, HQ	**days**											
11	Report Writing with Peer Review	**months**											

9.0.0 JUSTIFICATION

9.1.0 19 NGCM Stream Sediment Sample data points fall in the proposed Saiyedpar Block. The total REE, LREE and HREE values have been calculated and the geochemical anomaly map for the same has been prepared. The proposed Saiyedpar block has a maximum total REE value of 1360 ppm followed by 1070 ppm. The maximum total HREE value in proposed Saiyedpar block is 81.61 ppm of which the major contributing elements is Gadolinium (maximum 33.62 ppm). The maximum LREE value in Saiyedpar block is 1180.44 ppm and the major contributing element is Cerium (maximum 566.02 ppm). The NGCM stream sediment samples carried out by GSI show highly anomalous values for REE in toposheets 41E/11,12,15 & 16, therefore the proposed Saiyedpar Block can be taken up for reconnaissance survey for REE.

9.2.0 The Bhuj Formation which in the proposed block mainly comprises of Ferruginous Sandstone and Feldspathic sandstone, with few intercalated bands of sandy clay, grey-black pyritous shales, siltstone, carbonaceous shale, white kaolinitic clay were also reported by earlier workers. REEs can get adsorbed into clay bands. The REE deposits in the clay bands of Southern China particularly in Jiangxi, Guangdong, Fujian, Hunan, Guangxi, and Yunnan have total REE content ranging between 500 ppm to 2000 ppm in oxides. Similar to the ion adsorption clay deposit in Southern China provinces, the proposed blocks has intercalated clay layers within the ferruginous sandstone of Bhuj Formation. From the line graph of HREE concentration, it can be observed that the proposed block has higher concentration of Gadolinium. Hence the intercalated clay bands within the ferruginous sandstone of Bhuj Formation can be the possible source of REE in the proposed block.

9.3.0 Kachchh is a E-W oriented peri-cratonic rift basin which comprises of thick sediment accumulation from Mesozoic to Cenozoic Era. Numerous studies on the provenance of these thick sedimentary columns are being done continuously. Chaudari et al. (2018) presented a detailed study of the provenance of Kachchh sandstones. The Mesozoic Kachchh Basin with southwesterly palaeoslope was bounded by two prominent highs, the Nagar Parkar Uplift to the north (formed as one of the horsts of the rift basin) and the Aravalli Highlands to the east. Most of the studied siliciclastic sediments were possibly sourced from these two highs. Samples of Lower Cretaceous Bhuj Formation indicate transitional continental provenance signatures. Thus, upliftment along the Kachchh Mainland Fault in the Early Cretaceous (Biswas 2005) possibly had a major impact on sediment transportation paths in the Kachchh Mainland. The Nagar Parkar igneous complex

comprises the Late Proterozoic granites, rhyolites, acidic and basic dykes (Ahmad and Chaudhry 2008; Laghari et al. 2013). These rocks were uplifted and exposed by the Nagar Parker Fault in the Early Jurassic. The highlands formed by the rocks of the Proterozoic Aravalli and Delhi Supergroups in the east expose various grades of metasedimentary rocks, granite gneisses and metabasics (Ramakrishnan and Vaidyanadhan 2008). Chaudhari in her account mentioned that majority of the sandstones of Bhuj Formation are arkoses with a few sub-arkoses, consisting of sub-angular to sub-rounded grains fabric. Common heavy minerals in these sandstones include both transparent (zircon, rutile, tourmaline, garnet, ilmenite, monazite, apatite and epidote) and opaque (Ilmenite & garnet) varieties. Chaudhuri presented a detailed study of garnet and ilmenite chemistry to conclude multiple sources for these sediments including felsic igneous and metabasic rocks. Almost all zircon grains observed are prismatic with sub-rounded to well-rounded grain indicating a polycyclic origin and sediment transport from a faraway source. Enriched TiO2 content (> 50%) and depleted MnO content (< 2%) in ilmenite grains of Bhuj Formations indicate metabasic provenance lithotype. The abundant garnet grains in Bhuj Formation indicate a source from high grade meta-basic rocks. Meta-basic rocks are absent in the Nagar Parker uplift thus the parent meta-basic source is from the East i.e. from the highlands of Aravalli and Delhi Supergroup for the sedimentary rocks of Bhuj Formation. Predominant sediment source from eastern highlands during the late syn-rift to post-rift stage may possibly be related to upliftment along the Kachchh Mainland Fault, which prevented sediment supply from north in the Kachchh Mainland.

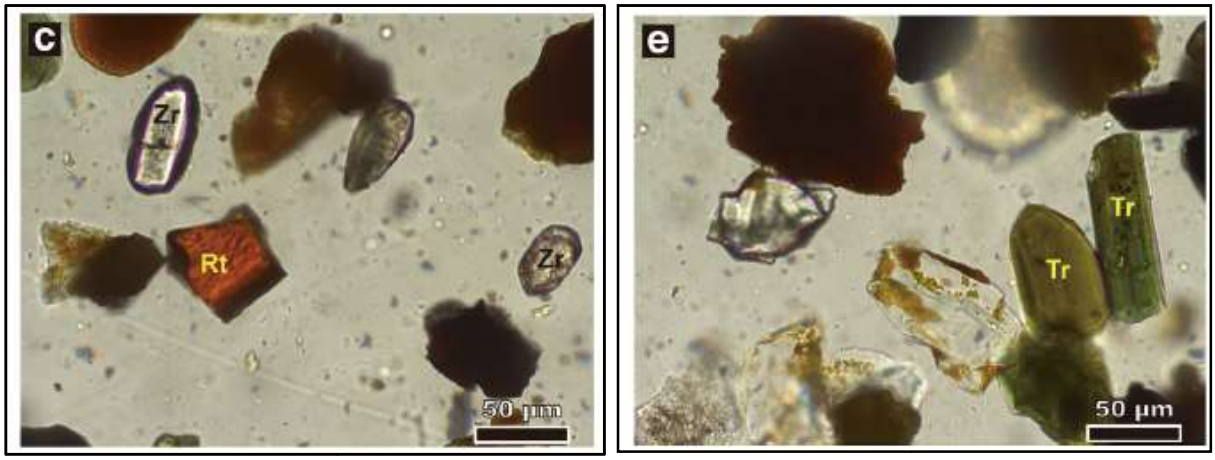


Fig- Photomicrographs of heavy minerals separated from sandstones of Bhuj Formation in PPL showing the sub-rounded grains of Rutile & Zircon (Rt- Rutile, Zr- Zircon & Tr- Tourmaline); Chaudhari et al., 2018

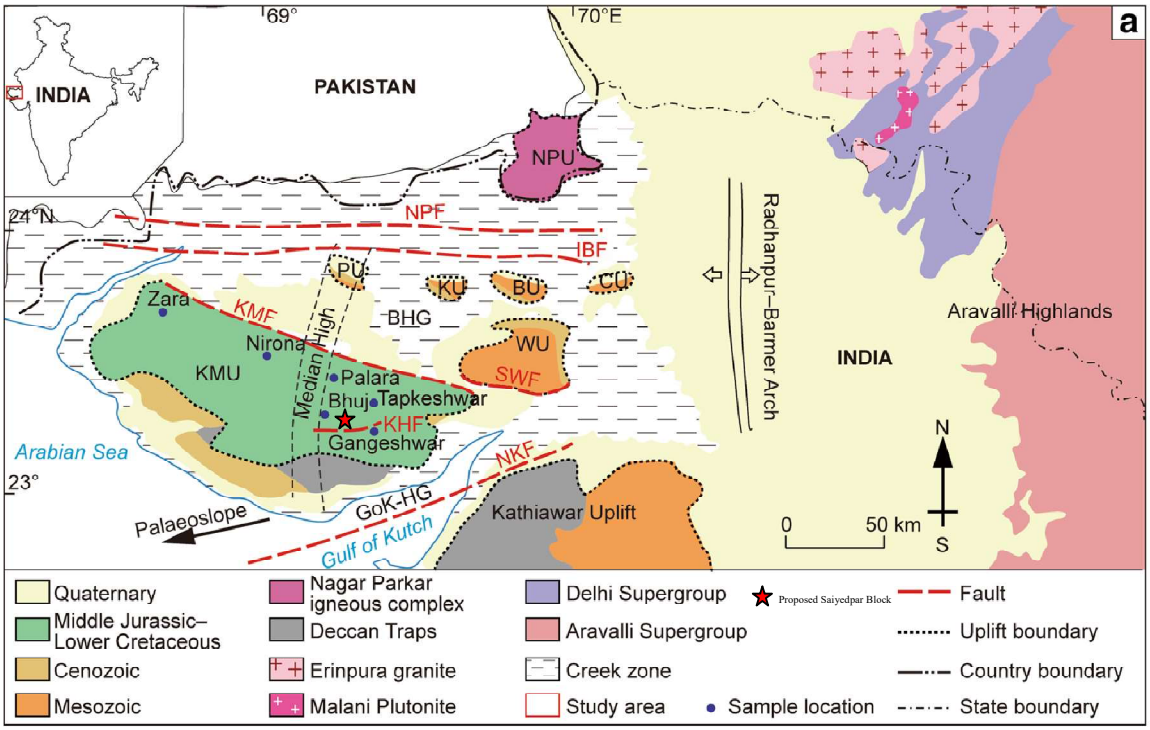


Fig: Tectonic elements and inferred palaeoslope of the Mesozoic in the Kachchh Basin (modified after Biswas 1991). PU = Patcham Uplift; KU = Khadir Uplift; BU = Bela Uplift; CU = Chorad Uplift; WU =Wagad Uplift; KMU = Kachchh Mainland Uplift; NPU = Nagar Parkar Uplift; NPF = Nagar Parkar Fault; IBF = Island Belt Fault; SWF = South Wagad Fault; KMF = Kachchh Mainland Fault; KHF = Katrol Hill Fault; NKF = North Kathiawar Fault; BHG = Banni Half Graben; GoK-HG = Gulf of Kachchh Half Graben (Chaudhari et al., 2018).

9.4.0 It was inferred by previous workers that the diagenetic reactions with Fe-Mn oxides from the parent volcanic rocks, the hydrothermal activity related to volcanism and later groundwater leaching might have released the REEs from the source rocks and redeposited them in the sandstones of Bhuj Formation.

9.5.0 The Kachchh Basin has experienced multiple sea-level fluctuations since the Mesozoic era. The basin contains Mesozoic to Cenozoic sedimentary rocks formed from the weathering of earlier intrusives, Precambrian granites and surrounding rocks. Marine transgression might have introduced REE-rich sediments in the Bhuj formation and regression phases possibly expose these deposits to weathering and secondary concentration.

9.6.0 A fossiliferous and calcareous limestone lies in the middle of the proposed block. 19 NGCM Stream Sediment Sample data points fall in the proposed Saiyedpar Block and the maximum CaO value analysed in the stream sediment samples is 5.50%. Hence few bedrock samples are kept to ascertain the quality of the limestone.

With above justifications, the current proposed block may be studied for REE and associated mineralization at G-4 level of exploration.

List of Plates

1. Plate –I: Location Map of Proposed Saiyedpar Block (135.45sq km), District: Kachchh, State: Gujarat.
2. Plate–II: Regional Geological Map showing Proposed Saiyedpar Block (135.45sq km), District: Kachchh, State: Gujarat (Source: NGDR portal).
3. Plate–III: Block Geological Map showing Proposed Saiyedpar Block (135.45sq km), District: Kachchh, State: Gujarat (Source: NGDR portal).
4. Plate–IV: Anomaly Map with LREE values in Proposed Saiyedpar Block (135.45sq km), District: Kachchh, State: Gujarat (Source: NGDR portal).
5. Plate-V: Anomaly Map with HREE values in Proposed Saiyedpar Block (135.45sq km), District: Kachchh, State: Gujarat (Source: NGDR portal).
6. Plate-VI: Anomaly Map with Total REE values in Proposed Saiyedpar Block (135.45sq km), District: Kachchh, State: Gujarat (Source: NGDR portal).
7. Plate-VII: Drainage Map with lithology and proposed stream sediment samples and auger drilling location points in Proposed Saiyedpar Block (135.45sq km), District: Kachchh, State: Gujarat.
8. Plate-VIII: Proposed stream sediment samples and auger drilling location points over TREE anomaly zones in Proposed Saiyedpar Block (135.45sq km), District: Kachchh, State: Gujarat.

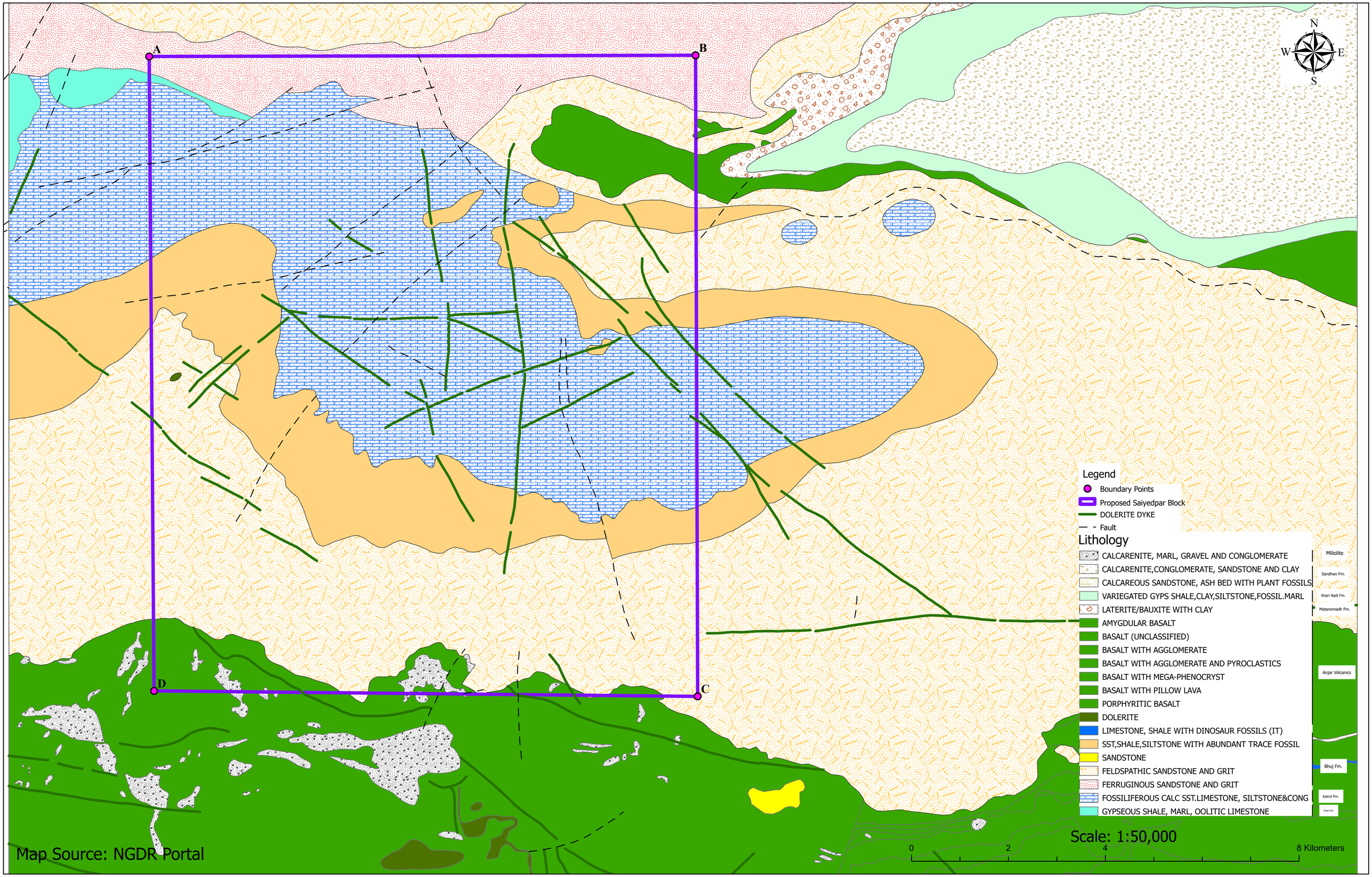
List of Annexure

I. Detailed Cost sheet of Saiyedpar Block, Kachchh, Gujarat.

Reference Paper

1. Chaudhuri A., Banerjee S. and Le Pera E. 2018. Petrography of Middle Jurassic to Early Cretaceous sandstones in the Kachchh Basin, western India: Implications on provenance and basin evolution. *Journal of Palaeogeography* 7:2.

Block Geological map of proposed Saiyedpar Block (Area- 135.45 sq km)
Dist-Kachchh, Gujarat



Regional Geology Map showing Proposed Saiyedpar Block

68°45'0"E 69°0'0"E 69°15'0"E 69°30'0"E 69°45'0"E 70°0'0"E 70°15'0"E

23°45'0"N 23°30'0"N 23°15'0"N 23°0'0"N 22°45'0"N

N

Vigodi Fault

Kachchh Mainland Fault

Katrol Hill Fault

Legend

PROPOSED SAIYEDPAR BLOCK

FORMATION NAME

- FULAI
- MAHUVA
- RANN
- VARAHI
- MILIOLITE
- KOTHARA
- DWARKA
- SANDHAN
- GAJ
- KHARI NADI
- MANIYARA FORT
- FULRA
- KAKDI NADI
- MATANOMADH
- ANJAR VOLCANICS
- DAYAPAR VOLCANICS
- BHUJ
- KATROL
- CHARI
- PACHCHHAM

- ANTICLINE (F1)
- ANTIFORM (F1)
- F1 FOLD
- SYNCLINE (F1)
- KACHCHH FAULTS

STRUCTURAL DATA

- BEDDING
- FAULT
- JOINT

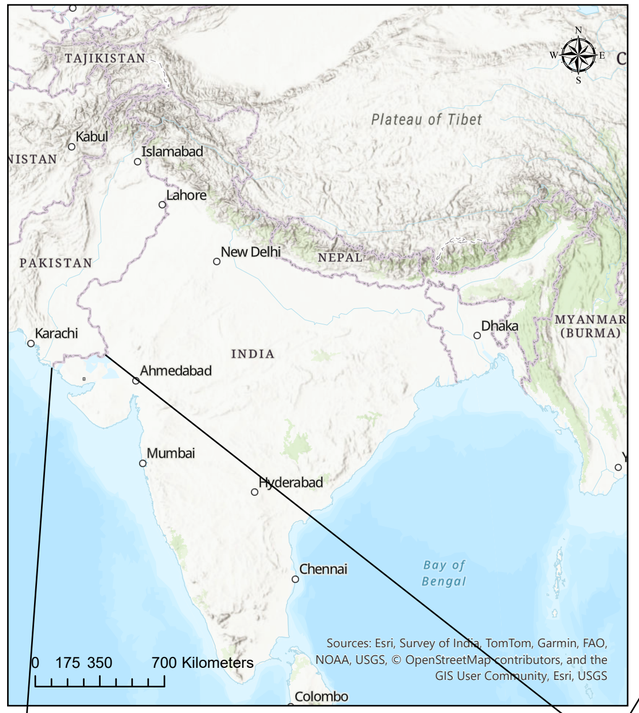
Source: NGDR Portal, GSI

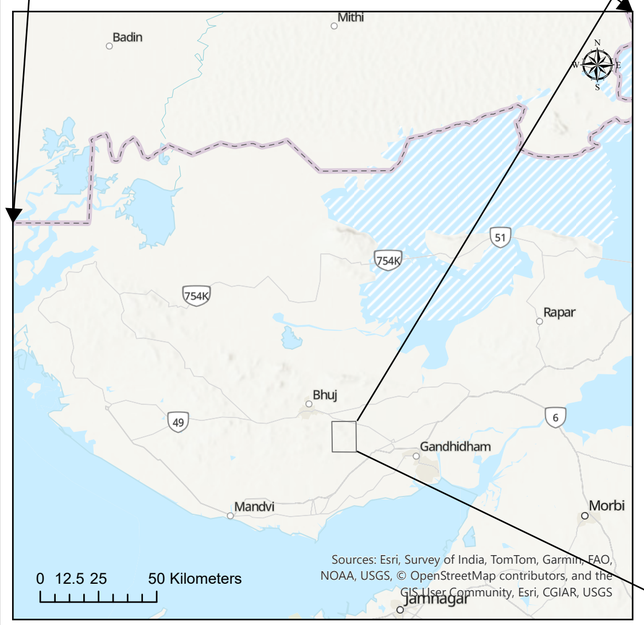
0 5 10 20 30 40 Kilometers

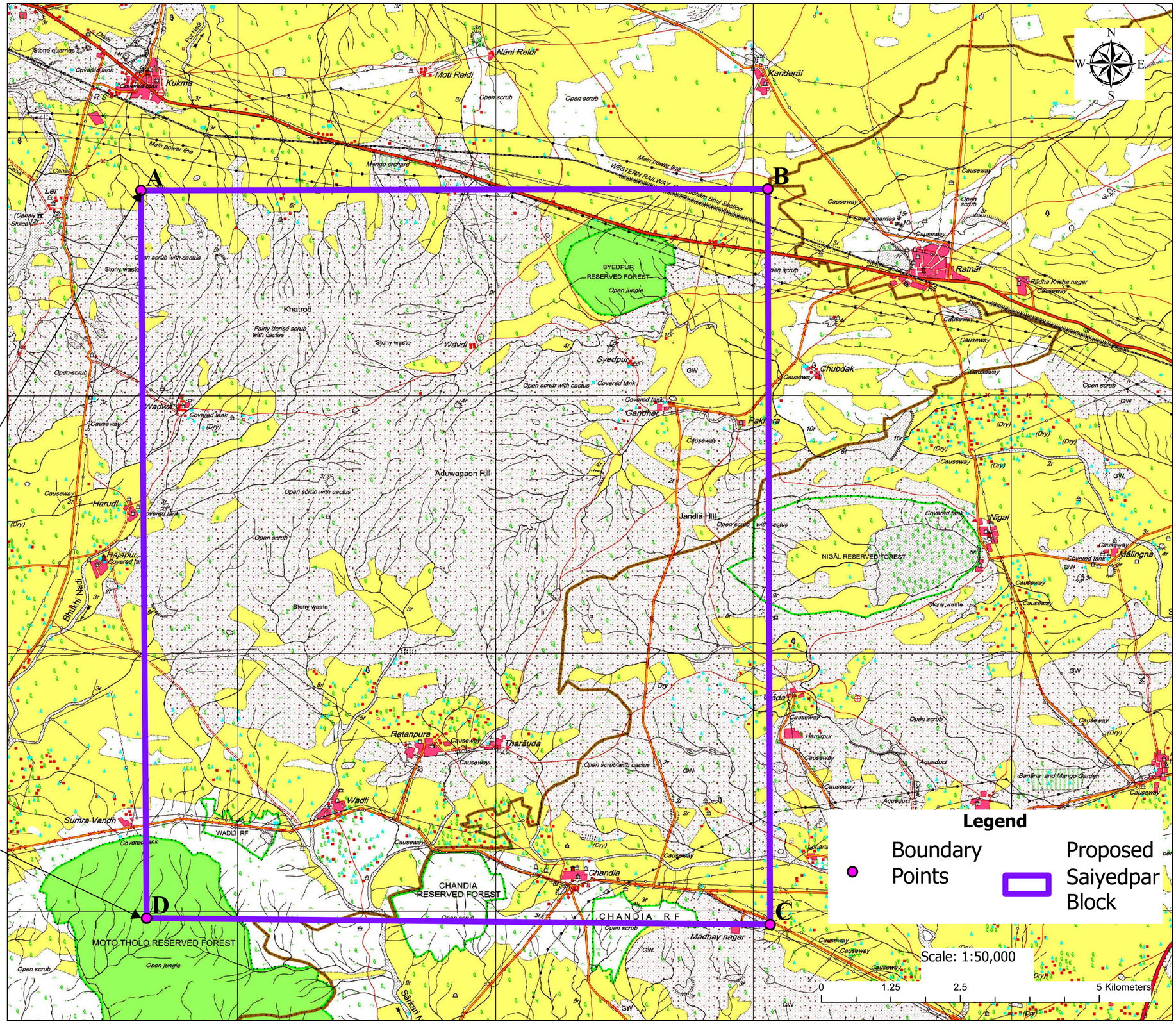
68°45'0"E 69°0'0"E 69°15'0"E 69°30'0"E 69°45'0"E 70°0'0"E 70°15'0"E

Location Map of Proposed Reconnaissance Survey (G-4) in Saiyedpar Block (135.45 sq km) for REE, RM & associated minerals
Dist- Kachchh, Gujarat
(Part of Toposheet no. 41E/16)

MECL







Points	Latitude	Longitude
A	23° 11' 59.17" N	069° 46' 33.64" E
B	23° 11' 59.98" N	069° 52' 38.31" E
C	23° 04' 51.96" N	069° 52' 39.72" E
D	23° 04' 55.62" N	069° 46' 36.91" E