PROPOSAL FOR RECONNAISSANCE SURVEY (G-4 STAGE) FOR GLAUCONITIC SANDSTONE IN MUDHAN-KHATIYA BLOCK, DISTRICT- KACHCHH, GUJARAT (AREA 129 Sq. Km)

COMMODITY: GLAUCONITIC SANDSTONE

BY

MINERAL EXPLORATION AND CONSULTANCY LIMITED
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PLACE: NAGPUR
DATE: 14.08.2024

SUMMARY OF THE BLOCK FOR RECONNAISSANCE SURVEY (G-4 STAGE) FOR GLAUCONITIC SANDSTONE IN MUDHAN-KHATIYA BLOCK, DISTRICT- KACHCHH, GUJARAT

Features	Details
Block ID	MUDHAN-KHATIYA BLOCK
Exploration Agency	Mineral Exploration and Consultancy Limited (MECL)
Commodity	Glauconitic Sandstone
Mineral Belt	The proposed exploration block falls in the northern part of Kachchh Basin. Kachchh Basin mainly consists of Pachcham, Chari, Katrol and Umia Formations. Presence of glauconitic sandstone is identified in the Umia (Bhuj) Formation and Katrol Formation. The block is predominantly occupied by lithounits of Katrol Formation of Late Jurassic - Early Cretaceous age. Katrol formation is present in the proposed block area. Katrol formation consists of Glauconitic Sand Stone, Oolitic Limestone, Shale with Calcareous Sandstone, Sandstone, Shale Intercalated, Shale with Trigonia Fossils, Conglomerate, Fossiliferous Shale with Intercalated Limestone, Shale with Plant Fossils. Mudhan-Khatiya Block is a part of Glauconitic sandstone Belt situated in the Kachchh District, Gujarat and falls in the Survey of India Toposheet no. 41A/13, 41A/14 and 41 E/02.
Completion period with entire Time schedule to complete the project	15 Months
Objectives	The exploration scheme of Mudhan-Khatiya Block for Glauconitic sandstone is formulated with the following objectives: 1. To carry out Geological & structural mapping on 1:12,500 scale for demarcation of Glauconitic sandstone with the structural features to identify the surface manifestations along with the lateral and vertical disposition of the mineralized zones. 2. To assess the quality of the glauconitic sandstone surficial by collecting surface samples (bedrock, channel and Trench) which will further shape up the future course of exploration. 3. To establish the surface continuity of the mineralisation i.e. concealed below the soil cover, pitting and trenching will be carried out. 4. Based on the outcomes of the above activities, drilling of boreholes will be carried out in a systematic grid pattern. The drilling program will establish the mineralisation vertically and laterally along with the qualitative and quantitative. 5. To estimate resources as per UNFC norms Minerals (Evidence of Mineral Contents) Amendment Rules 2021. 6. To upgrade the block to the higher level of 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.
Number of Geoscientists	Nos. of Geoscientists: 2

Expected Field days(Geology, Geophysics, surveyor)	Geologist Party days: 180 (At field) & 60 at HQ
	Survey Party days: 0

1.	**Location**	
	Latitude - Longitude	<table><tr><th>Point</th><th>Latitude</th><th>Longitude</th></tr><tr><td>A</td><td>23° 46' 12.991" N</td><td>68° 53' 50.019" E</td></tr><tr><td>B</td><td>23° 46' 12.872" N</td><td>68° 54' 39.022" E</td></tr><tr><td>C</td><td>23° 45' 28.622" N</td><td>68° 59' 5.794" E</td></tr><tr><td>D</td><td>23° 44' 55.905" N</td><td>68° 59' 7.614" E</td></tr><tr><td>E</td><td>23° 43' 55.898" N</td><td>69° 1' 22.062" E</td></tr><tr><td>F</td><td>23° 38' 30.045" N</td><td>69° 1' 25.780" E</td></tr><tr><td>G</td><td>23° 38' 29.437" N</td><td>68° 57' 5.088" E</td></tr><tr><td>H</td><td>23° 38' 58.270" N</td><td>68° 57' 3.375" E</td></tr><tr><td>I</td><td>23° 38' 55.003" N</td><td>68° 55' 38.118" E</td></tr><tr><td>J</td><td>23° 44' 48.611" N</td><td>68° 55' 28.777" E</td></tr><tr><td>K</td><td>23°44'51.53"N</td><td>68°53'53.72"E</td></tr></table>
	Villages	Mudhan, Atdo, Taraf Manjali, Jara, Khatiyun (Khatiya), Lakhapar, Amiya, Haroda, Jumara, Meghpar, Junachay villages
	Tehsil/Taluk	Lakhpat
	District	Kachchh
	State	Gujarat
2.	**Area (hectares/ square kilometres)**	
	Block Area	129 sq.km
	Forest Area	The block area is partially under Forest Area and partially Non-Forest area.
	Government Land Area	Data not available
	Charagaha	Data not available
	Private Land Area	Data not available
3.	**Accessibility**	
	Nearest Rail Head	Nearest railway station to the study area is Bhuj at about 115 km in south.
	Road	The area is well connected by all-weather metalled roads. National Highways 754K is approx. 09km from the block area which connects via Gaduli village to Lakhapar village through metalled road. Lakhpat Tehsil is 27 kms from the block.
	Airport	The nearest airport is Rudramata, Bhuj.
4.	**Hydrography**	
	Local Surface Drainage Pattern (Channels)	The dendritic drainage.
	Rivers/ Streams	The area is drained by Gandi Nadi and other small 2nd/3rd order streams. Drainage in the study area is dendritic and trellis pattern.
5.	**Climate**	
	Mean Annual Rainfall	The average rainfall in the Kachchh area is 456mm.
	Temperatures	The average annual temperature ranges from approximately 42°C during summer and approximately 10°C during winter.
6.	**Topography**	
	Toposheet No.	41A/13, 41A/14 and 41 E/02

	Morphology of the Area	The block area forms planar and gently undulating terrain.
7.	**Availability of baseline geoscience data**	Geological Map, is available at 1:50,000 scale in Bhukosh/NGDR.
	Geochemical Map	Available
	Geophysical Map	Not Available
8.	**Justification for taking up Reconnaissance Survey/ Regional Exploration**	1. Today most of the potash demand is met through bedded marine evaporite deposits such as sylvite, carnalite, kainite, polyhalite, surface and sub-surface potash-rich brines. India is fully dependable on import to meet the requirement of Potash. It is considered necessary to look for non-traditional source of potash such as glauconitic sandstone and potash rich shales. **Hence, potash recovery from glauconitic sandstone is essential.** 2. Glauconite comes in the category of critical minerals and Government of India is presently focusing and simultaneously carrying out the auctioning of potential Critical and Strategic Mineral blocks. So, the exploration of Glauconite prospects of the country is the need of the hour. 3. The present Reconnaissance survey in Mudhan-Khatiya Block has been proposed in the SE of GSI's report titled "Detailed Investigation for Potash in Glauconite Bearing Shale and Sandstone around Guneri Village of Kachchh District, Gujarat. G-4 block (FSP 2014-15) for potash, where the glauconite bearing shale and sandstone of Katrol and Bhuj Formations of Kachchh basin is found to be present. 4. NGCM data (Stream sediment samples, C-Horizon Soil Sample and Regolith Samples) suggests the presence of Glauconite in the block. A total of 25 stream sediment samples, 1 Soil samples from C horizon and 1 Soil Regolith samples of NGCM falls within the proposed block. Values of K2O is varying between 0.74% - 3.05%. Similar range of values is present in the adjacent north of the proposed block where GSI block for Glauconitic Sandstone is present. 5. Considering the consistency of glauconitic sandstone in the GSI block, the present exploration programme is planned to prove the continuity of the glauconitic sandstone in the SE extension part.

PROPOSAL FOR RECONNAISSANCE SURVEY (G-4 STAGE) FOR GLAUCONITIC SANDSTONE IN MUDHAN-KHATIYA BLOCK, DISTRICT- KACHCHH, GUJARAT

1. INTRODUCTION

1.1. Along with nitrogen and phosphorus, potassium is one of the most essential macronutrients and is required in agriculture in relatively large amounts for plant's healthy growth. After the growing recognition of potassium as one of the key nutrient in plant growth, subsequent development of potash industry was resulted. Reaching an estimated value of one million tonnes in 1921, production of potassium continues to increase consistently and reach to almost 34.6 million tonnes in 2013 (United State Geological Survey, 2013a, 2013b) expecting to raise 37.8 million tons in 2022 with the growth rate of about 2.9% annually (Rawashdeh et al., 2016).

1.2. Today most of the potash demand is met through bedded marine evaporite deposits such as sylvite, carnalite, kainite, polyhalite, surface and sub-surface potash-rich brines. These minerals are mixture of soluble salts, mainly potassium chloride or sulfates. More than 90% of these deposits are mainly concentrated in countries like Canada, Russia, Belarus, Brazil, China, Chile, Germany and USA (Anderson, 1985; The New York Times Editorial Board, 2013; Rawashdeh and Maxwell, 2014) on which rest of the world is dependent for supply of potash fertilizer.

1.3. In order to sustain crop production and to ensure self-sufficiency, exploration and investigation of alternative resource for potassium such as K-bearing silicates could be one of the options to meet the future demand (Manning, 2010; Manning, 2012; Ciceri et al., 2015).

1.4. In absence of mineable evaporite potash deposit in India, it was considered necessary to look for non-traditional source of potash such as glauconitic sandstone and potash rich shales. In many countries deficient in the conventional evaporite deposits insoluble potash used 'to be extracted out of silicate and non silicate minerals. Thus alunite in Bulla dealah in New castle, (Australia) containing 5% to 10%. K_2O was commercially exploited. Extraction of potassium from shales has also been discussed by Everest et al. (1964), similarly glauconite has been used in USSR as a source of potassium fertilizer's (GSI, CGPB report, 1978 p. 94).

1.5. Out of different non-conventional sources, glauconitic sandstones deposits are available in plenty and are considered as one of the indigenous resources for potassium in India. India has vast reserves of more than 3,000 million tonnes of glauconitic sandstone containing 4 to 8% K_2O occurring in States like Madhya Pradesh, Uttar Pradesh, Bihar. Chhattisgarh, Rajasthan and Gujrat (Kumar and Bakliwal, 2005).

2. BACKGROUND

2.1. Exploration for strategic, critical, precious, rare earths and PGE are given top priority by Govt. of India, after amendment of MMDR Act, 2015 and it's subsequent amendments up to 2023. Government of India is presently carrying out the auctioning of Critical and Strategic Mineral blocks through different tranche in which MECL is playing the role of the Nodal Agency. In the 1st Tranche of auction, 20 critical and strategic mineral blocks were put on auction platform, out of that 6 blocks has been successfully auctioned. Presently, the process of auctioning of 18 (2nd tranche), 7 (3rd tranche) and 21 (4th tranche) critical and strategic mineral blocks are under progress. Keeping in view that Glauconite comes in the category of critical minerals, the present proposal has been prepared and being put up for Reconnaissance Survey for NMET funding and execution.

3. LOCATION AND ACCESSABILITY

3.1. Mudhan-Khatiya Block is situated in the Lakhpat Taluka, Kachchh District, Gujarat and falls in the Survey of India toposheet no. 41A/13, 41A/14 and 41E/02. The block can be reached from district head quarter Bhuj via Deshalpar, Nakhtarna, Rawapar, Gaduli Road through NH-754K to Lakhapar-Khatiyun. National Highway-754K is approx. 09 km from the block area which connects via Gaduli village to Lakhapar village through metalled road. Lakhpat Tehsil is 27 kms from the block. District headquarter Bhuj is 108 km in SE direction. Nearest railway station to the study area is Bhuj at about 115 km in SE. Bhuj railway station is a Class-A railway station on the Western line of the Western Railway network. Bhuj Airport is the nearest airport from the block which is 114 km in SE direction from the block. Block boundary corner points of Mudhan-Khatiya Block block is given below:

Co-ordinates of Cardinal Point of Mudhan-Khatiya Block for Glauconite
District: Kachchh, Gujarat

Point	Latitude	Longitude	Area (sqkm)
A	23° 46' 12.991" N	68° 53' 50.019" E	
B	23° 46' 12.872" N	68° 54' 39.022" E	
C	23° 45' 28.622" N	68° 59' 5.794" E	
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4. PHYSIOGRAPHY AND DRAINAGE

4.1. The block area exhibits gently undulating topography. The regional slope of the area is towards north and northeast. The highest elevation of the area is 233m in the western part of the Block. The lowest elevation of the area is 15m in the northern and eastern part of the block.

4.2. The area is drained by Gandi Nadi and other small $2^{nd}/3^{rd}$ order streams. Drainage in the study area is dendritic and trellis pattern.

5. CLIMATE

5.1. The climate is overall hot in the district. The season can be divided into three parts during the year

1. Hot and moist season from July to September.
2. Cool and dry season from October to February.
3. Hot and dry season from March to June.

5.2. Due to High Hills and Lack of Forest, the seasonal winds are not governed and the monsoon seasons last for a very short span only. In every ten years, Scarcity is faced for 2-3 years, 4-5 years are weak monsoon or semi-scarcity years, only 2-3 years are good monsoon years. There is almost no pre or post monsoon rains in the district. Average rainfall for the District During the year 2016, the maximum temperature recorded 45.60°C at Bhuj, whereas the minimum temperature recorded was 11.50 °C.

6. REGIONAL GEOLOGY

6.1. Regionally, proposed block falls in the Northern part of Kachchh Basin and lithostratigraphically forms part of Katrol Formation belonging to Late Jurassic - Early Cretaceous age. The Rann of Kachchh and Kachchh Peninsula covered an area of 45612 sq km in north western parts of our country. Physiographically, Kachchh is divided mainly into hill ranges, gently sloping peripheral coastal tracts and dissected coastal erosional plains, and younger deltaic plains, tidal flats, spits and marginal accretionary zones.

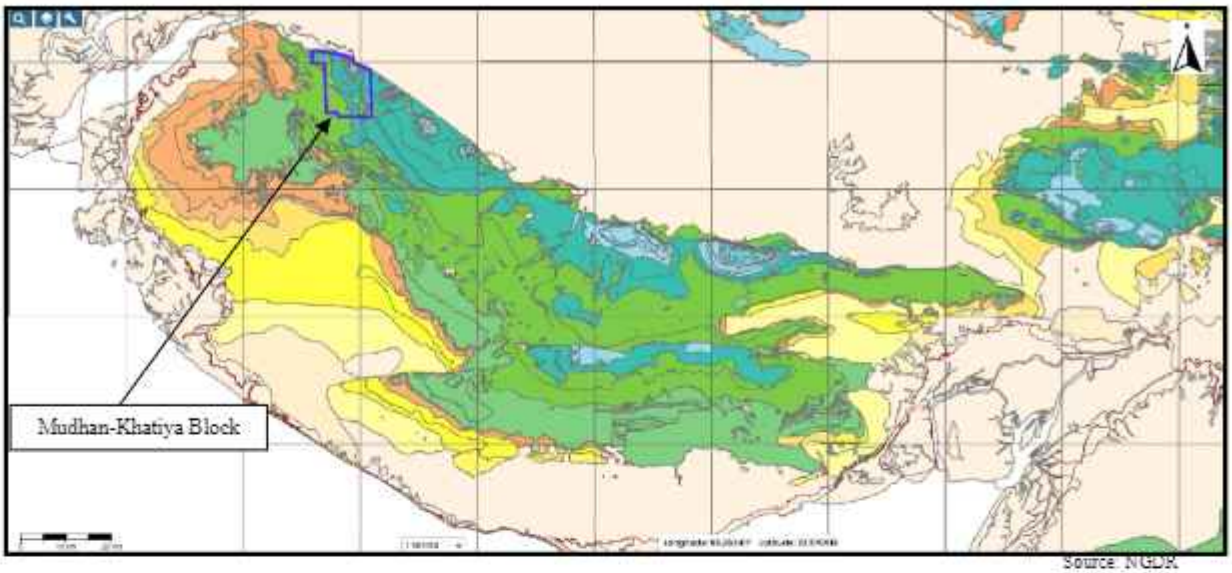
6.2. Kachchh, peri-cratonic rift basin of western India, represents a complete sequence of strata ranging in age from Middle Jurassic to Holocene (Fig.5.1). The Mesozoic and Cenozoic rocks of Kachchh are separated by a period of non-deposition, followed by diastrophism, erosion and volcanism, during the close of Cretaceous period. The Mesozoic rocks consist of marine sediments from Bathonian to Tithonian (Portlandian) and non-marine sediments in Cretaceous. These sediments were deposited in a sheltered gulf in sub littoral to deltaic environments in two major cycles: Middle Jurassic transgressive cycle and Late Jurassic-Early Cretaceous regressive cycle (Biswas, 1981). These sediments were laid down on a

Precambrian granitic basement which is exposed only in the Nagar Parkar Hills in Pakistan. The Mesozoic sediments were uplifted, folded, intruded and covered by the Late Cretaceous-Early Palaeocene Deccan trap. The terrestrial volcano-clastic sediments represent the Palaeocene sediments while the Early Eocene transgression and subsequent Tertiary deposits filled the peripheral lows bordering the Mesozoic highs as well as the lows between them.

6.3. The Mesozoic sediments of Kachchh are represented by Pachchham, Chari, Katrol and Umia Formations (after Krishnan, 1982). Krishnan (1982) classified the Mesozoic succession of Kachchh as presented in the below table-

Regional Stratigraphic sequence of Litho units (after Krishnan, 1982)

Age	Unit	Sub-division	Lithology
Post-Aptian	UMIA (1000 m)	Bhuj beds (Umia Plant beds)	Sandstone and shale
Aptian		Ukra beds	Marine calcareous shale
Upper Neocomial		Umia beds	Barren sandstone and shale
Valanginian		Trigonia beds	Barren sandstone
Upper Tithonian		Umia ammonite beds	Shale and sandstone
Middle Tithonian	KATROL (300 m)	Upper Katrol Shales	Shale
Middle Tithonian		Gajansar beds	Shale
Lower Tithonian		Upper Katrol (Barren)	Sandstone
Middle Kimmeridgian		Middle Katrol	Red sandstone
Upper Oxfordian		Lower Katrol	Sandstone, shale, marl
Oxfordian	CHARI (360 m)	Dhosa Oolite	Green and brownoolitic limestone
U. Callovian		Athleta beds	Marl and gypseous shale
Middle Callovian		Anceps beds	Limestone and marl
Middle Callovian		Rehmani beds	Yellow limestone
Lower Callovian	PATCHAM (300 m)	Macrocephalus beds	Shales with calcareous bands and golden oolites
Lower Callovian		Coral bed	Shale and limestone
Lower Callovian to Bathonian		Patcham shell limestone Patcham basal beds (Kuar Bet beds)	Limestone, shale and marl



Source: NGDR

REGIONAL GEOLOGICAL MAP OF KACHCHH BASIN

7. GEOLOGY OF THE STUDY AREA

7.1. The proposed block area consists of Holocene age to Jurassic age lithounits of Chari, Katrol, Bhuj and Rann Formations. The Holocene Rann Formation is the topmost unit of the block area which partially falls in the northern part of the block. Rann formation consists of the lithology of Calcareous Clay and Silty Marl.

7.2. Early Cretaceous age of Bhuj formation consists of Sand Stone, Shale, Clay, Trigonia Fossil & Conglomerate. Lithounits of Bhuj formation is exposed in the northern part, NW to western part of the block area.

7.3. Late Cretaceous-Palaeocene age, Daccan Trap is also present in the South to SE part of the block, which consists of Basalt, Dayapar Intrusives.

7.4. Late Jurassic - Early Cretaceous age, Katrol formation covers maximum part of the study area and is characterised by the presence of Shale with Calcareous Sandstone, Sandstone, Shale Intercalated, Shale with Trigonia Fossils, Glauconitic Sand Stone Oolitic Limestone, Shale, Conglomerate, Fossiliferous Shale with Intercalated Limestone, Shale with Plant Fossils.

7.5. Middle - Late Jurassic age, Chari formation of lithounits are exposed in NE part of the block area. Chari formation consists of Shale with Fossiliferous Limestone, Shale with Calcareous Nodules, and Sandstone with Ironstone Bands.

7.6. Regional strike of the bedding plane is parallel to the Guneri dome which varies from NE-SW, E-W to NW-SE. Rock beds are horizontal to gently dipping with general dip towards SE, Sand SW and exhibit gradational contact. The tentative stratigraphic sequence of litho units exposed in the Block area (After GSI) is given in below Table.

Stratigraphic sequence of the Mudhan-Khatiya Block for Glauconite
District: Kachchh, Gujarat
(After GSI)

Age	Formation	Lithology
Holocene	Rann	Calcareous Clay and Silty Marl
Early Cretaceous	Bhuj	Sandstone
		Sst, Shale, Clay, Trigonia Fossil & Conglomerate
		Sandstone, Shale, Clay, Conglomerate
Late Cretaceous-Palaeocene	Deccan Volcanism	Basalt, Dayapar Intrusives
Late Jurassic - Early Cretaceous	Katrol	Shale with Calcareous Sandstone
		Sandstone, Shale Intercalated
		Sandstone, Shale With Trigonia Fossils
		Glauconitic Sst Oolitic Lst. Shale, Conglomerate
		Fossiliferous Shale with Intercalated Limestone
		Sandstone, Shale with Plant Fossils
Middle - Late Jurassic	Chari	Shale with Fossiliferous Limestone
		Shale with Calcareous Nodules
		Sandstone with Ironstone Bands

8. PREVIOUS WORK

8.1. Eminent workers of Geological Survey of India carried out diverse nature of studies in the area which are listed below.

8.2. Z.G.Ghevariya, carried out works and prepared a report on investigation for bentonite deposits in Kutch district Gujarat during FS 1978-80 in the Toposheet Nos- 41 R10, 11, 14 & 15.

8.3. Kulkarni and Desikan (1965-66), Kulkarni and Agarwal (1963-64), Vijaya Sarthi and Sable (1984-85), Ghevariya (1980-81) and Ghevariya and Srikarni (1990-91) have reported about the occurrence of glauconite from the Mesozoic and Tertiary rocks of Kachchh.

8.4. Jain, RL (1994-95) carried out investigation of 100 sq km area on 1:25,000 scale for potash in glauconite bearing shale and sandstone in Kachchh district, Gujarat and estimated 0.02 million tonnes reserve of glauconite with 5.33% K2O on the basis of a glauconite bearing band having cumulative thickness of 1.5m up to a depth of 2m and strike continuity of 3 to 4km.

8.5. Sarkar and Banerjee (2011) pointed out an authigenic origin of the glauconite of Naredi Formation. K-Ar dating of glauconite of Ukra member was carried out by Rathore, SS et.al (Proceedings of Indian academy of sciences, No.1, March 1999, pages 49 to 55) and 4 samples shows an age of 105.2± 1.3 Ma.

8.6. Ajaya Kumar Sahu, Dhananjai Verma, et al. carried out the Reconnaissance survey for lateritic bauxite and lithomargic clay around Umarsar and Guneri areas (Toposheet nos- 41A/13), Western Kachchh, Gujarat (G4) during FS 2016-17 and estimated the total reconnaissance

mineral resource of bauxite at 30% Al2O3 cut-off grade is 3042417 tonnes (3.04 MT) with average grade 38.40% Al2O3 and average of 18.42% SiO2. The total reconnaissance mineral resource for lithomargic clay is 101840.92 tonnes with average grade of 36.62 % Al2O3. 2 nos of glauconite samples (LB/2016-17/K1) and analysed K2O ranging from 5.07% to 7.27% in the explored block.

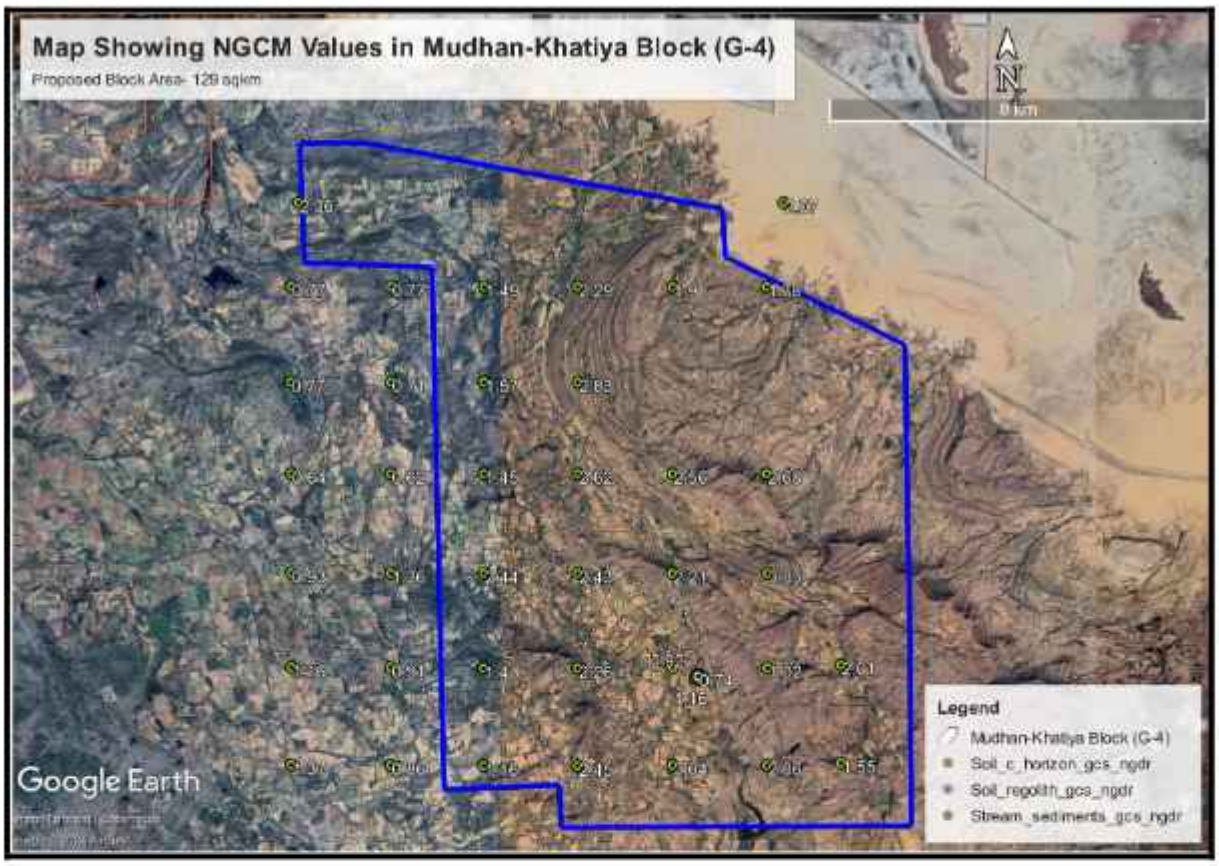
8.7. Basheer, H. K. and Kumar, A, (2014-15), carried out the detailed investigation for potash in glauconite bearing shale & sandstone around Guneri village of Kachchh district, Gujarat during FS 2014-15 and estimated a total of 852.84 metric tons of glauconite is estimated in the study area with K2O ranging from < 2%. A total of 1244.002 metric tons of glauconite is estimated in the study area with K2O ranging from 2 to 4%. A total of 3339.195 metric tons of glauconite is estimated in the study area with > 4% K2O. Based on the exploration results, block is in auction platform.

8.8. The present Reconnaissance survey in Mudhan-Khatiya Block for Glauconite has been proposed in the SE extension of GSI's explored Guneri Block (FSP 2014-15) for Glauconite, where the Glauconite bearing shale and sandstone of Bhuj formation is found to be present. As per the GSI findings, Bhuj Formation consists of Ferruginous sandstone, glauconitic sandstone (Hard and compact, intercalated and sandy to clayey) and feldspathic sandstone. It suggests that the area is very much suitable for the exploration of fertilizer minerals.

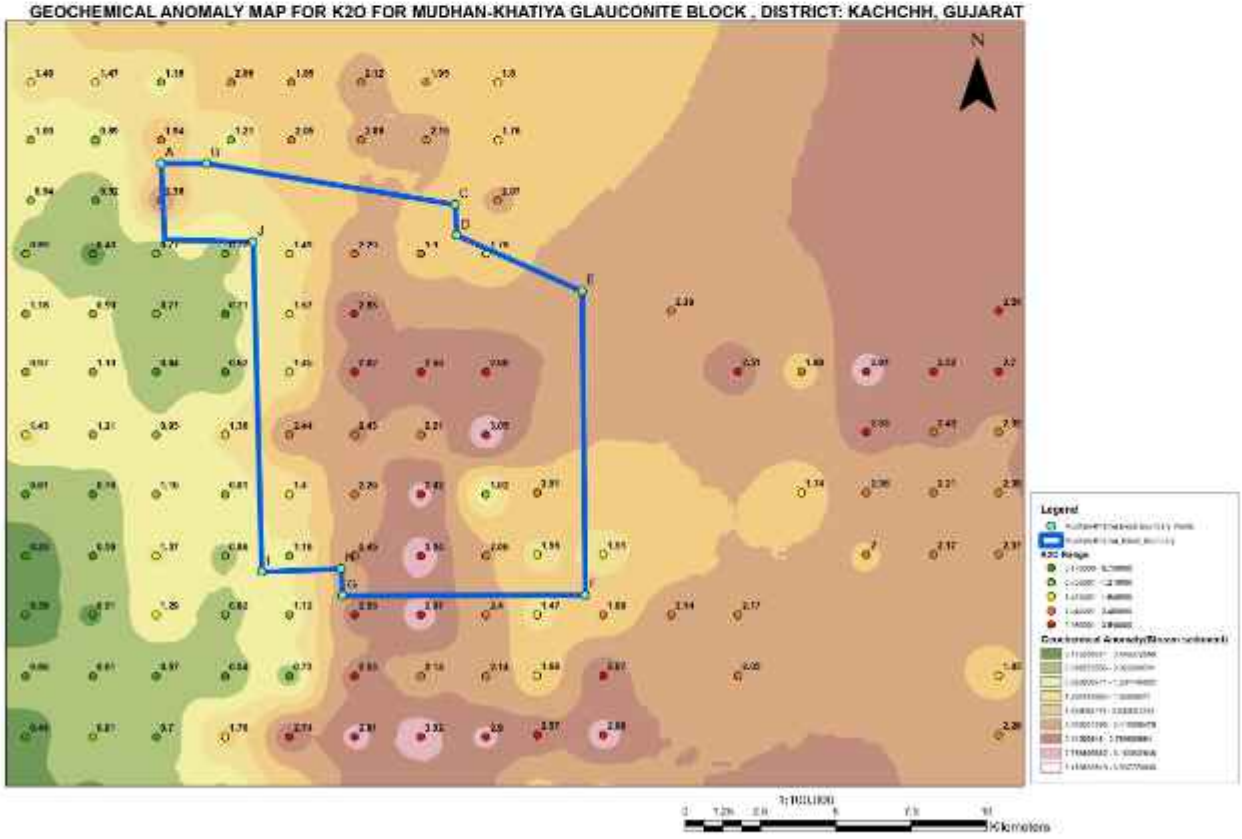
8.9. **NGCM INVESTIGATIONS**

8.9.1. Geological Survey of India under National Geochemical Mapping program systematic stream sediment sampling was carried out in the study area in 2 km X 2 km interval in grid pattern.

8.9.2. NGCM data (Stream sediment samples, C-Horizon Soil Sample and Regolith Samples) suggests the presence of Glauconite in the block. A total of 25 stream sediment samples, 1 Soil samples from C horizon and 1 Soil Regolith samples of NGCM falls within the proposed block. Values of K2O is varying between 0.74% - 3.05%. Similar range of values is present in the adjacent north of the proposed block where GSI block for Glauconitic Sandstone is present.



K_2O Anamoly Showing in Google Imagery for Geochemical Samples as per NGCM data of part of Toposheet No. 41A/13, 41A/14 and 41E/02 along with proposed Mudhan-Khatiya Block for Glauconitic Sandstone



9. PROPOSED SCHEME OF EXPLORATION

9.1. **Geological mapping:** Geological & structural mapping on 1:12,500 scale will be carried out in the proposed block for demarcation of Glauconitic sandstone with the structural features to identify the surface manifestations and lateral and vertical disposition of the mineralized zones

9.2. **Survey:** DGPS survey will be done for determining co-ordinate and reduced level (RL) of all the borehole locations.

9.3. **Surface Geochemical sampling (Bed Rock/Channel/Chip Sample):** During the course of Geochemical Sampling, around 260 nos. of bed rock /Channel/Chip samples shall be collected from the suitable surface locale. A total of 260 nos. of primary and 26 nos. of external check surface samples will be analysed for 9 radicals (K_2O, SiO_2, MgO, CaO, K_2O, Na_2O, P_2O5, Al_2O_3 & Fe_2O_3). 10% of Primary samples (26 Nos) will be sent to NABL External Labs as External Check Samples.

9.4. **Exploratory Mining (Trenching/Pitting):** Trenching (Excavation) shall be carried out in the potential zones identified based on the results of geological mapping and geochemical sampling. A provision of trenching/pitting of 200 cubic meter has been planned. Trenching work will be carried out by excavating trenches of 1m width and up to 2m depth in the area to expose the source rock and mineralization. Locations of pits/trenches on ground will be decided by field geologist based on field observations. Trenches will be geologically mapped thoroughly by the field geologist. Around 200 nos. of trench samples shall be collected. A total of 200 no of primary and 20 no of external check trench samples will be analysed for 9 radicals (K_2O, SiO_2, MgO, CaO, K_2O, Na_2O, P_2O5, Al_2O_3 & Fe_2O_3). 10% of Primary samples will be sent to NABL External Labs as External Check Samples.

9.5. **Drilling:** If phase-I exploration data will give anomalous values, 30 Nos. boreholes on 1600m grid spacing will be drilled. The boreholes will be planned judicially after the completion of phase-I exploration and will be presented for review before the TCC for final approval.

9.6. **Drill core logging:** Geological core logging will be carried out systematically by recording carefully the minute details and physical/lithological characters of the rock formations including colour, core recovery, grain size, weathered zone, texture, banding, mineralogical composition, micro-structural/structural details, lithological variations along with visual estimate in respect of Potash content encountered in boreholes. As per the requirement the

Rock quality designation (RQD) shall also be carried out, while logging drill cores. On the basis of these parameters, grade of glauconite can be broadly assessed and it will also be helpful in sampling/demarcating the mineralised zones.

9.7. **Drill core sampling:** For preparation of samples, the borehole core will be splitted into two equal halves by using core splitter. One half will be powdered to 100 mesh size and the other half will be kept for future studies. The powdered material will be mixed thoroughly and about 100 gram of samples will be taken for chemical analysis by successive coning and quartering as primary samples and rest of the material (-100 mesh size) will be kept as duplicate half for future reference. It will generate about 600 Nos of **primary samples** and 60 Nos of **External Check samples** (10% of Primary samples). External Check samples will be sent to NABL Lab for analysis. **Composite samples** will be prepared borehole wise based on the analytical results of primary sample at every 8m interval (8m bench height). Composite samples shall be prepared from the entire borehole in which glauconitic sandstone bands will be intersected. This will generate about 90 nos. of composite samples. Each sample should be marked at every 1m length in case of continuance of similar mineralogical composition down the borehole. The sample length towards the floor marked by non-ore zone needs also to be adjusted as per variations of the litho-units. Even if the floor is distinctly differentiated by the presence of non-mineralized zone, at least two nos. samples after the Glauconite zone need to be drawn to mark the floor of the Glauconite zone decisively.

9.8. **Chemical Analysis:** All the primary samples and 10% of the Primary samples as External check samples will be analyzed for 9 radicals (K_2O, SiO_2, MgO, CaO, K_2O, Na_2O, P_2O5, Al_2O_3 & Fe_2O_3). About 10% of primary samples will be sent to NABL external laboratory as External check samples for analysis of 9 radicals (K_2O, SiO_2, MgO, CaO, K_2O, Na_2O, P_2O5, Al_2O_3 & Fe_2O_3). Total 106 nos of composite samples will be analyzed for trace element studies (34 elements).

9.9. **Petrological and Mineragraphic Studies:** Thin and polished section studies on drill cores samples would be done for ascertaining the petrographic and mineragraphic characteristics. These samples would be drawn from ore zones and host rocks. A provision of 10 specimens for petrographic and 10 specimens for mineragraphic studies has been proposed in the block.

9.10. **XRD Study:** To know the different mineral phases, for recovery of potash, XRD study will be performed in 5 samples of glauconitic sandstone.

9.11. **Determination of Bulk density:** To calculate the resource, volume of the ore body need to be multiplied with a density factor. Hence, 5 nos. of samples will be drawn from the glauconitic sandstone for determination of Bulk density.

10. QUANTUM OF WORK

10.1 The following quantum of work have been proposed for Reconnaissance Survey (G-4 stage) for glauconite bearing formations in Mudhan-Khatiya Block:

Sl. No.	Item of Work	Unit	Target
1	Geological Mapping (1:12500 scale)	Sq. Km	129
2	Surface Geochemical sampling (Bed Rock/Channel/Chip Sample)	Nos.	260
3	Exploratory Mining (Trenching/Pitting)	Cu M.	200
4	DGPS Survey for Borehole fixation	Nos	30
5	Drilling (Core)	m.	1500
6	Sample Preparation & Chemical Analysis		
A.	Surface samples (Bedrock/Channel/Chip/Pit/BH Samples)		
	i) Primary samples for 4 radicals viz. for 9 radicals (K_2O, SiO_2, MgO, CaO, K_2O, Na_2O, P_2O5, Al_2O_3 & Fe_2O_3)	Nos.	1060 (260 + 200+ 600) (Surface+Pit+BH)
	ii) 10% External check samples for 9 radicals (K_2O, SiO_2, MgO, CaO, K_2O, Na_2O, P_2O5, Al_2O_3 & Fe_2O_3)	Nos.	106
	iii) Trace Element (34 element)	Nos.	106
7	Petrological Studies (10 samples)	Nos	10
8	Mineragraphic Studies (10 samples)	Nos	10
9	XRD Study	Nos.	5
10	Determination of Bulk Density	Nos.	5
11	Geological Report preparation	Nos.	1

11. TIME SCHEDULE AND ESTIMATED COST

11.1 The proposed exploration programme envisages geological mapping, Surface sampling, Trenching, core drilling, sample preparation and laboratory studies, which will be completed within 15 months, geological report preparation and peer review, will take 4 months with two month overlapping with lab works.

Therefore, a total of 15 months is planned for completion of the entire proposed programme.

Timeline Reconnaissance survey (G4) for Glauconitic Sandstone in Mudhan-Khatiya Block for Glauconite, District: Kachchh, Gujarat [Block area- 129 sq. km; Schedule timeline- 15 months]																	
S. No.	Particulars	Month/ Days	1	2	3	4	5	6	7	8	9		10	11	12	13	14	15
1	Camp Setting	months																
2	Geological Mapping	months																
3	Survey days	days																
4	Trenching/Pitting	cu.m																
5	Drilling (1 rig)	m																
6	Geologist days	days										Review						
7	Sampling days,	days																
8	Camp winding	months																
9	Laboratory Studies	months																
10	Geologist days, HQ	days																
11	Report Writing with Peer Review	months																

11.2. Cost has been estimated based on actual schedule of rates mandated in the circular OM No. 61/1/2018/NMET dated 31st March 2020 for NMET funded Projects. The total estimated cost is Rs. 380.40 Lakhs. The summary of cost estimates for this reconnaissance survey (G4) is given below:

Sl. No.	Item	Total
1	Geological Work	**33,02,604**
2	Pitting & Trenching	**6,66,000**
3	Drilling	**1,43,21,476**
4	Laboratory Studies	**58,23,036**
	Sub total	**2,41,13,116**
5	Report	**7,23,393**
6	Peer Review	**30,000**
7	Proposal Prepration	**4,82,262.32**
	Total	**2,53,48,772**
8	GST (18%)	**45,62,778.92**
Total cost including 18% GST		**2,99,11,551**
SAY, in Lakhs		**299.12**

List of Plates:

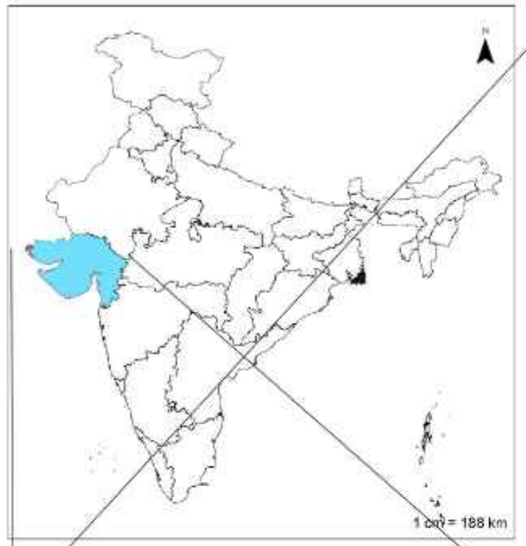
1. Plate-I: Location Map of the Proposed Mudhan-Khatiya Block is situated in the Lakhpat Taluka, Kachchh District, Gujarat

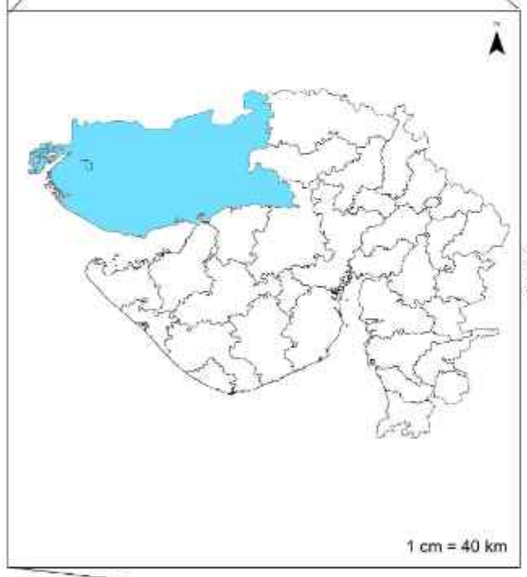
2. Plate-II: Regional Geological Map with Proposed Mudhan-Khatiya Block is situated in the Lakhpat Taluka, Kachchh District, Gujarat

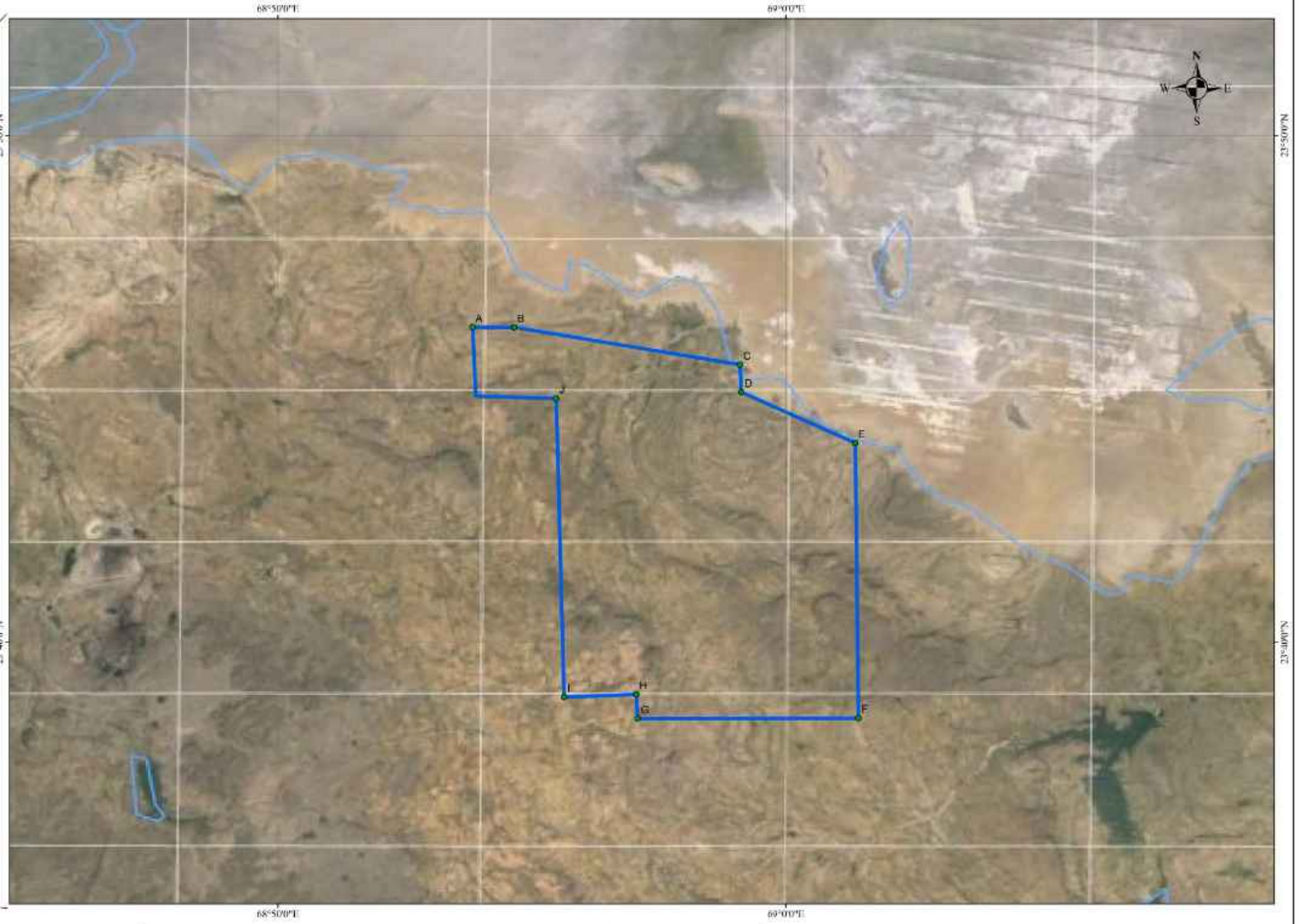
Location Map of Proposed Mudhan-Khatiya Blocks (129 sq km) Kachchh district, Gujarat

1:75,000

2.5 1.25 0 2.5 5 7.5 10 Kilometers







Legend

- Mudhan-Khatiya Block Boundary Points
- Mudhan-Khatiya Block Boundary

Co-ordinate of corner points of the proposed Mudhan-Khatiya Block for Glauconite (G-4)

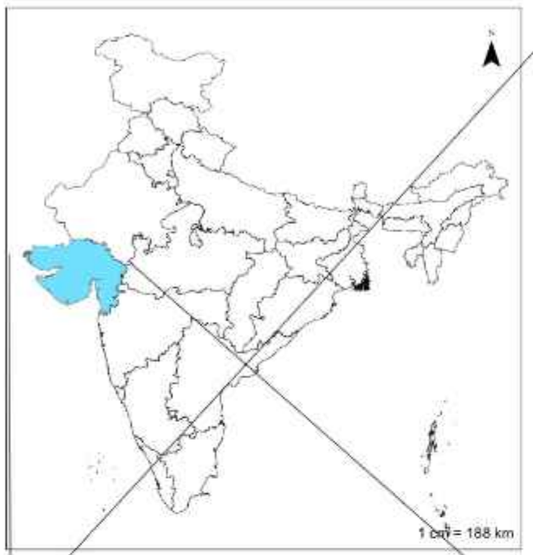
Points	Longitude	Latitude	Points	Longitude	Latitude
A	68° 53' 50.019" E	23° 46' 12.991" N	F	69° 1' 25.780" E	23° 38' 30.045" N
B	68° 54' 39.022" E	23° 46' 12.872" N	G	68° 57' 5.088" E	23° 38' 29.437" N
C	68° 59' 5.794" E	23° 45' 28.622" N	H	68° 57' 3.375" E	23° 38' 58.270" N
D	68° 59' 7.614" E	23° 44' 55.905" N	I	68° 55' 38.118" E	23° 38' 55.003" N
E	69° 1' 22.062" E	23° 43' 55.898" N	J	68° 55' 28.777" E	23° 44' 48.611" N

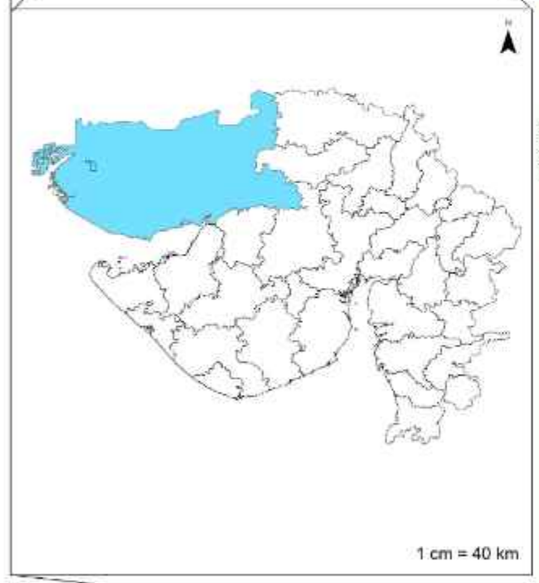
MECL

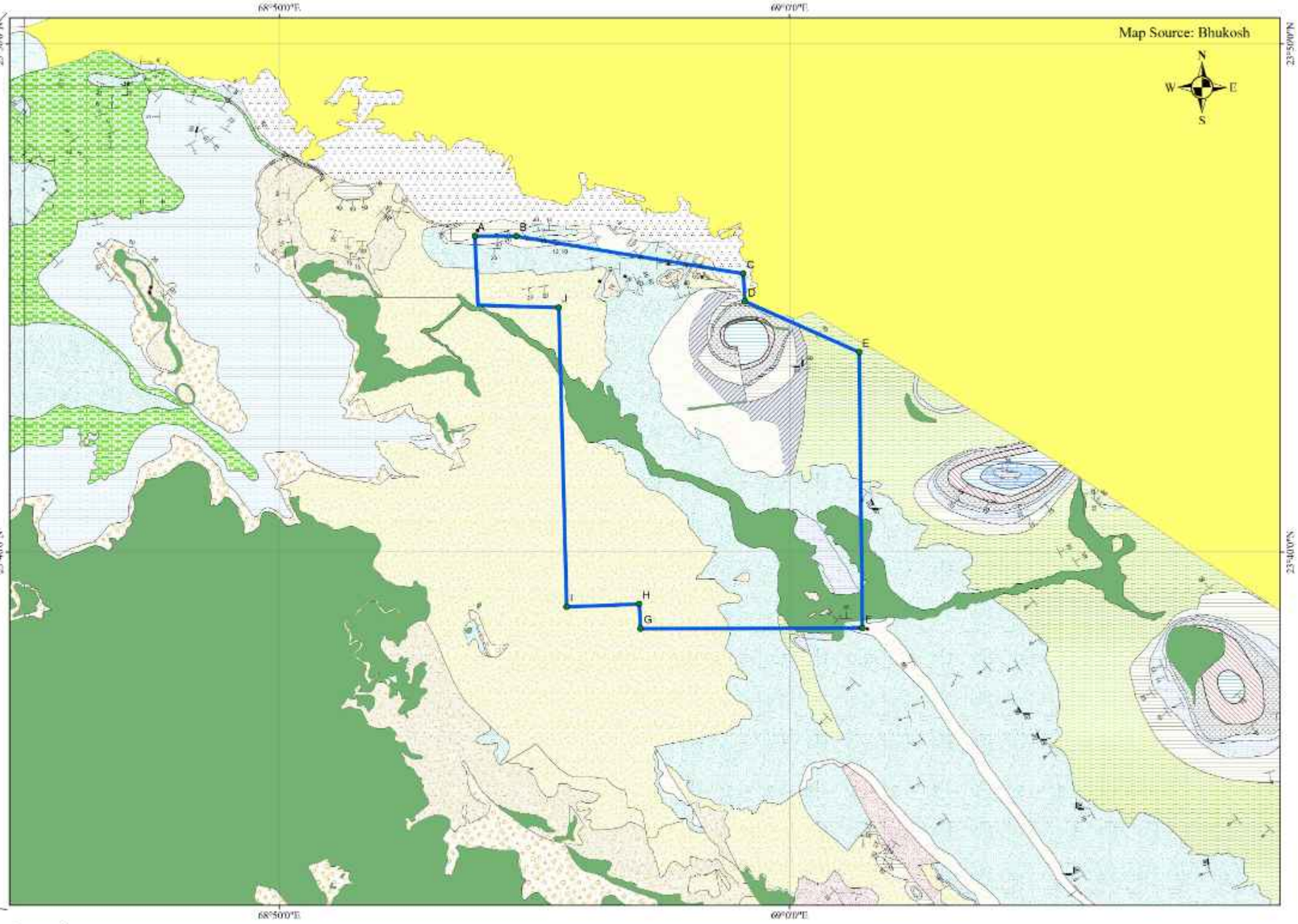
Location Map of Proposed Mudhan-Khatiya Blocks (129 sq km) Kachchh district, Gujarat

1:75,000

2.5 1.25 0 2.5 5 7.5 10 Kilometers







Legend

- Mudhan-Khatiya Block Boundary Points
- Mudhan-Khatiya Block Boundary

Point_type

- BEDDING
- JOINT

Legend

- AEOLIAN SAND, CLAY, MARL
- BASALT
- BASALT (UNCLASSIFIED)
- CALCAREOUS CLAY AND SILTY MARL
- CORALLINE LIMESTONE
- FERRUGINOUS SANDSTONE AND GRIT
- FORAMINIFERAL LST ARGILLACEOUS LST & CLAY
- FOSSILIFEROUS LIMESTONE, SHALE
- FOSSILIFEROUS OOLITIC LIMESTONE AND SHALE
- FOSSILIFEROUS SHALE WITH INTERCALATED LIMESTONE
- GLAUCONITIC SST OOLITIC LST, SHALE, CONGLOMARATE
- GLAUCONITIC SST,SHALE AND CORALLINE LIMESTONE
- LATERITE/BAUXITE WITH CLAY
- OLIVINE BASALT
- SAND WITH SHELL FRAGMENTS (YOUNGER TIDAL FLAT)
- SAND, SILT AND CLAY (YOUNGER TIDAL FLAT DEPOSITS)
- SANDSTONE
- SANDSTONE WITH IRONSTONE BANDS
- SANDSTONE, SHALE INTERCALATED
- SANDSTONE, SHALE WITH PLANT FOSSILS
- SANDSTONE, SHALE WITH TRIGONIA FOSSILS
- SANDSTONE, SHALE, CLAY, CONGLOMERATE
- SANDY CLAY WITH CALCAREOUS NODULES
- SHALE WITH CALCAREOUS NODULES
- SHALE WITH CALCAREOUS SANDSTONE
- SHALE WITH FOSSILIFEROUS LIMESTONE
- SHALE, SST, GLAUCONTIC SHALE, PEBBLES
- SST, SHALE,CLAY,TRIGONIA FOSSIL & CONGLOMARATE
- UNMAPPED
- VARIEGATED GYPSEOUS SHALE / CLAY WITH LIMESTONE