MINERAL EXPLORATION PROJECT PROPOSAL
(MEPP)

FOR

Preliminary Exploration (G3)
for Graphite mineralisation

in Arasanur (East) Block, Shivaganga Graphite Belt, Shivaganga District, Tamil Nadu
(Block ID: KIOCL_50_TN_AGB (E))

Date of Submission: 18th Mar 2024

Submitted by:

KIOCL LIMITED,
(Notified *Exploration Agency*)
BLOCK II, KORAMANGALA,
SARJAPURA ROAD,
BANGALURU 560 034.
(www.kioclltd.in)

To:

The DDG & CHAIRMAN,
TCC-NMET,
Geological Survey of India,
State Unit: Karnataka and Goa,
GSI Complex, Vasudha Bhavan,
Kumaraswamy Layout,
Bangalore 560 078.

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I. SUMMARY

BLOCK ID	**KIOCL_50_TN_AGB (E)**
Title of the project	Preliminary Exploration (G3) for Graphite mineralisation in Arasanur (East) Block, Shivaganga Graphite Belt, Shivaganga District, Tamil Nadu
Exploration Agency	**KIOCL LIMITED, BANGALORE** ***Notified Exploration Agency***
Commodity	Graphite
Mineral Belt	Shivaganga Graphite Belt
Completion period with entire Time Schedule to complete the project	16 months
Objective	i) To map - Detailed geological mapping on 1: 2,000 scale covering an area of 1.93 Sq. Km to target potential zones for Graphite mineralisation. ii) To delineate the targeted mineral potentiality zones based on the surface Geochemical Sampling. iii) Geophysical mapping to know the depth persistence for planning of sub surface exploration. Plan for drilling on appropriate spacing, to intersect the graphite bearing loads at 2 different levels of intersection.
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	The work will be carried out solely by the Geologists of proposed agency ie., KIOCL, with its HQ at Bangalore.
Name/ Number of Geoscientists	THREE (03) Nos or more from Mineral Exploration Department, KIOCL Limited, Bangalore.
	Large Scale Geological Mapping (06 months) **Geologist Party Days** : 100 days - 75 days (Field) - 25 days (HQ) **Drilling** (06 months) Geologist Party Days: 100 days - 75 days (Field) a. 25 days (HQ)
Location	
Latitude	**Annexure 04**

Longitude	**Annexure 04**
Villages	Arasanur
Tehsil/ Taluk	Shivaganga
District	Shivaganga
State	Tamil Nadu
Area (hectares / Square Kilometres	
Block Area	1.93 Sq. Km
Forest Area	Nil
Government Land	1.56 Sq.Km
Private Land	0.37 Sq.Km
Accessibility	
Nearest Rail Head	Sivaganga
Road	Sivaganga to Arasanur
Airport	Madurai
Hydrography	
Local Surface Drainage Pattern Channels / Rivers / Streams	Nill
CLIMATE	
Mean Annual Rainfall	900mm
Temperature	37 °C
Topography	
Toposheet No	58K/5
Morphology of the Area	Nill
Availability of the Baseline Geoscience Data	
Geological Map (1:50 K)	yes
Geochemical Map	Nill
Geophysical Map (Aero/ Ground, Regional/ Local Scale)	Nill

Justification for taking up Preliminary Exploration (G3 Stage) for Graphite Mineralisation in Arasanur East Block, Shivaganga Graphite Belt, Shivaganga District, Tamil Nadu.

i. The word *graphite* is derived from the Greek word for writing, ***graphein,*** which reflects the long use of graphite (mixed with clay) for the ***lead*** in pencils.

ii. Graphite, which is a soft form of elemental carbon, is an industrial commodity that is produced only in small amounts globally, worldwide production of approximately 1 million metric tons of graphite concentrate was reported as yearly production from 2010 to 2012 (Olson, 2012, 2013).

iii. Graphite is a form of pure carbon that generally occurs as black crystal flakes and masses, as amorphous variety. Graphite has important properties, such as chemical inertness, thermal stability, high electrical conductivity, and lubricity that make it suitable for many industrial applications. The industrial applications are in electronics, lubricants, metallurgy, and steelmaking. Steelmaking and refractory applications in metallurgy use the largest amount of graphite produced.

iv. The emerging technology uses in large-scale fuel cell, battery, and lightweight high-strength composite applications could substantially increase world demand for graphite in future.

v. In India, especially in Tamil Nadu, the Khondalite group of rocks are the main rock types that are hosting the graphite mineralisation.

vi. Arasanur Block forms a part of the migmatised Khondalite and Charnockite Groups of Southern Granulite Terrain (SGT) comprising mainly biotite gneiss and quartzo-feldspathic gneiss with graphite gneiss bands, thin bands of ferruginous quartzite and small lenses of pyroxene granulite and charnockite.

vii. GSI (1969) has reported the occurrence of promising graphite deposits in the Shivaganga area. It is located about 7 Km. N.W. of Sivaganga town between the east of Puvandi, Kamalipatti and Puduppatti (2 Kms. on Sivaganga - Melur road) in Ramanathapuram district. The graphite bearing quartzites and the quartzo felspathic gneisses have been noticed somewhat discontinuously over a stretch of about 16 Km from Near Kamalipatti on the east to Puvandi on the west in a roughly east-west direction.

viii. GSI (2004-06) has carried out a P-II state exploration in the Arasanur area, for tracing the graphite bearing zone in the graphite bearing biotite gneiss, the authors have named it as "graphite gneiss' in the GSI field season programme of Tamil Nadu for year 2004-06 and submitted a report titled *"Report on the Exploration for Graphite in Arasanur Block, Western Sector, Shivaganga Graphite Belt, Shivagangai District, Tamil Nadu (P-IIStage)" by the Authors K. Duraisamy, T. Mullaivendan and P. Sundarrajan.*

ix. In the western sector around Kiranur, GSI in their field season programme for the FS 2006-07 has carried out P-II stage exploration for graphite titled *"Exploration for Graphite in Arasanur and Kiranur blocks of Sivaganga graphite belt, Shivagangai district and Terku kallikulam Area, Tirunelveli district, Tamil Nadu (**P-II STAGE**)" by the Authors K. Duraisamy, and T. Mullaivendan.*

x. Later on, GSI in their field season 2014-17 has also carried out Mineral Exploration for Graphite, covering an area of 0.07 Sq. Km area in the Arasanur East Block, and augmented the resources. This area is excluded from the proposed exploration.

xi. A prominent graphite gneiss band having medium to high grade band traced for a strike length of 690m, with a width ranging from 5 to 23m with average width of 16.82m on the basis of trench sections and surface exposures. The Fixed Carbon content of graphite gneiss band ranges upto 25.54%.

xii. An indicated resource of 0.464 MT of graphite ore with average F.C. contents of 13.06% has been estimated for 690 m length (with area of influence on either side) and upto a depth of 20m below the lateritic soil cover. The graphite gneiss of Sivaganga Graphite Belt is amenable for beneficiation to higher grades upto 96% F.C. as being practiced in the Eastern Sector by TAMIN.

xiii. The trench sections and the scanty outcrops of graphite gneiss in the vicinity of Arasanur village indicate that the graphite gneiss is likely to continue both towards

west and east. It is recommended to trace the continuity of the graphite gneiss band by trenching.

xiv. KIOCL geoscientists has carried out the Pre-field studies in the area, the Graphite mineralization is mainly confine and hosted in the graphite bearing biotite gneiss. There are three mineralised bands traced in the area. These bands vary in thickness on the surface from 8 to 10m, and extends along east – west strike direction with dip towards south in the *Arasanur East Block. These bands were sampled and the analytical results from the rocks shows the fixed Carbon content varies from 12 to 24%.* The mineralization is structurally controlled and it is confine within gneissic structure as well as the shears and fault / fold closures. The area is covered by lateritic and soil.

Graphite is considered a critical and strategic mineral because of its essential applications in the aerospace and energy sectors, and its occurrence in meagre scale globally. (The above are the basis and justifications for mounting a proposal to carry out G3 stage exploration for Graphite Mineralisation in the Arasanur east block, excluding an area of 0.07 sq. km area, which was already covered by GSI in their field season 2014-17.

II. DETAILED DESCRIPTIONS

A. BLOCK SUMMARY

The mineral Graphite is one of four forms of crystalline elemental carbon. The others are carbon nanotubes, diamond, and fullerenes. The word graphite is derived from the Greek word for writing, **graphein**, which reflects the long use of graphite mixed with clay for use as **lead** in pencils. Graphite crystallizes in the hexagonal system, with rhombohedral symmetry, commonly forming six-sided tabular crystal flakes. It occurs naturally majority of the case in metamorphic rocks and in some igneous rocks. Well-crystallized graphite flakes have a black metallic lustre, whereas microcrystalline material is black and earthy with an amorphous appearance. Graphite, which is a soft form of elemental carbon, is an industrial commodity that is produced only in small amounts globally. The worlds' inferred resources are believed to be 800 MT of recoverable reserves. Turkey accounts for 36%, Brazil 29%, China 22% Mozambique 5% and India 3%. The worlds production of graphite was 2.17 million tones in 2015. China continued to be the leading producer with a share of about 83% followed by India 6% and Bazil 3% (Source: India Minerals Year book 2016 quoted by GSI (New insights on mineral exploration concepts and guidelines 2018 p 548).

The recently published document by Ministry of Mines – Critical Minerals for India states that the mineral Graphite is considered as clean energy mineral and being used in Batteries, Lubricants, fuel cells for EVs, Electric Vehicle.

The India sets ambitious targets for its EV ecosystem by 2030. To reach these ambitious targets, the Indian government has created policies and programs like the National Electric Mobility Mission Plan (NEMMP), a broad plan to encourage the adoption of electric vehicles in India.

In the presence economic, environmental and climate change, every country is striving to moderate in the use of conventional fuel for industrial and transport purposes. In the given situation, Graphite is played an important role in the emerging noncarbon energy sector and is used in several new energy applications. In energy production applications, graphite is used

in pebbles for modular nuclear reactors and in high-strength composites for wind, tide, and wave turbines. In energy storage applications, graphite is used in bipolar plates for fuel cells and flow batteries, in anodes for lithium-ion batteries, in electrodes for supercapacitors, in high-strength composites for fly wheels, in phase change heat storage, and in solar boilers.

Therefore, considering its application and utility in wider industrial and energy sectors and saving the earth from the carbon emissions. It is necessary to look and explore for such minerals not only for the country but also in contributing to the global scenario in saving the earth to some extent from the carbon emissions.

1. Physiography

The Arasanur East Block is situated just southwest of the Arasanur village, having gently sloping towards the south. It is almost a plain ground with gentle sloping towards south with elevations ranging from 82m above MSL in the south to 103 m above MSL in the north. Two irrigation tanks are located in the east and western extremities of the exploration Block. The area is mainly cultivated land using the source of water from the irrigation tanks, and there are small dense clusters of Acacia plants are common in the area. The area experiences dry weather for most major part of the time. It receives rain mainly from northeast monsoon during October to December and the average annual rain fall is around 900mm. **(Plate-01).**

2. Back Ground Geology & Regional Geology of the Block

Regional Geology :

The area has been studied largely by the geoscientist of GSI for more than several decades. The lithology of the area proposed the exploration of Graphite forms part of migmatised Khondalite and Charnockite Group of rocks. The pioneering work in the area in the form of geological mapping and the regional geological setting (SGB) was brought out by previous workers Gopal (1952). Systematic mapping over an area of 210 Sq. Km. in the south-eastern parts of Madurai district covering the areas around Tiruvadur and Varichiyur in parts of 58 K/5 has brought out the presence of an argillaceous, calcareous and arenaceous assemblage

of rocks, metamorphosed to granulite facies and migmatised. These are represented by the sillimanite gneiss + graphite biotite gneiss garnetiferous quartz felspar-granulite, calc-gneiss, quartzite and charnockite. *The graphite bearing zone is 50 m wide and extends over a strike length of 1 km in ENE-WSW direction and is traceable beyond the area mapped.* (Ramachandran K.R and Shirvastava S.K 1979). Sundaram (1980-81) also mapped part of the Shivaganga, tirupattur and Ramanathapuram districts of Tamil Nadu. Sundaram (1984), Muthu and Sundar Rajan (1996-97) the area forms a part of the migmatised Khondalite and Charnockite Groups of Southern Granulite Terrain (SGT).

The rocks of the area between the Usilampatti in the east and Kiranur in the west are of crystalline in nature and form part of Archaean complex. The different rock units that are existing in the east west strike and dipping towards south are quartzite, quartz-graphite schists, calc-gneiss, amphibolites, quartzo-feldspathic gneiss, granite gneiss and pegmatites are striking E-W and dipping towards south. A prominent shear zone is noticed for a strike length of about 5 Km. between Kamaliamman Temple and Meenakshipuram village and again for about 1.5 Km between Arasanur and Keeranur villages. The quartzites, quartz-graphite schist and granite gneiss in this area are highly sheared and altered. The younger granites and pegmatites have intruded along the fracture planes and also along the joints in the above rocks. The maximum width of the sheared zone is about 120m. and the average can be taken as 60m.

The dominant rocks are biotite gneisses of Khondalite Group with bands of quartzo-feldspathic gneiss of Migmatite Group. Within the migmatitic rocks, occur enclaves of linear bands and lenses of

I. Quartzite, calc granulite, garnetiferous sillimanite gneiss and biotite graphite gneiss of Khondalite Group and
II. Charnockite and pyroxene granulite of Charnockite Group. Younger intrusive includes smaller bodies of pink granite and pink pegmatites seen within the above rocks. Regional trend of the rocks is ENE-WSW with steep dips of 70° to 80° towards southeast to sub-vertical. The rocks have been folded into tight isoclinal synforms and antiforms. Extensive shearing accompanied by epidotisation, brecciation, mylonitisation, etc. have been observed in the rock types. The rocks underlie a thick blanket of lateritic soil of quaternary age.

The Sivaganga Graphite Belt is a 16 Km long trending along ENE-WSW direction is located to the north of Sivaganga-Madurai State highway. Upper river flowing towards SSE in the central portion divides the Graphite Belt into Eastern Sector (6.5Km) between Meenakshi Puram and Puduppatti and western Sector (9.5 Km) between Puvandi and Usilampatti. Major part of the Belt lies in Sivaganga District and minor part in Madurai District.

A generalised stratigraphic succession of the rocks of the area is as follows GSI

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Lithology	Group	Super group	Age	Era
Colluvial and alluvial Soil Kankar Laterite			Quaternary	
----Unconformity-----				

Conglomerate, grit, shale and sandstone	Sivaganga	Gondwana	Cretaceous	Lower Mesozoic
----Unconformity-----				
Pink pegmatite Pink granite White trondhjemite / Granite	Younger Intrusives			Upper Proterozoic
Whitequartzo-feldspathic gneiss Biotite gneiss ± hornblende ± garnet	Migmatite Group	Peninsular Gneissic Complex		Achaean
Intermediate to acid charnockite and pyroxene granulite	Charnockite Group	EasternGhat Super Group		
Graphite gneiss Garnetiferous sillimanite Gneiss Calc granulite/ limestone Quartzite	Khondalite Group			

3. Geology of the Area

Geology of the Block :

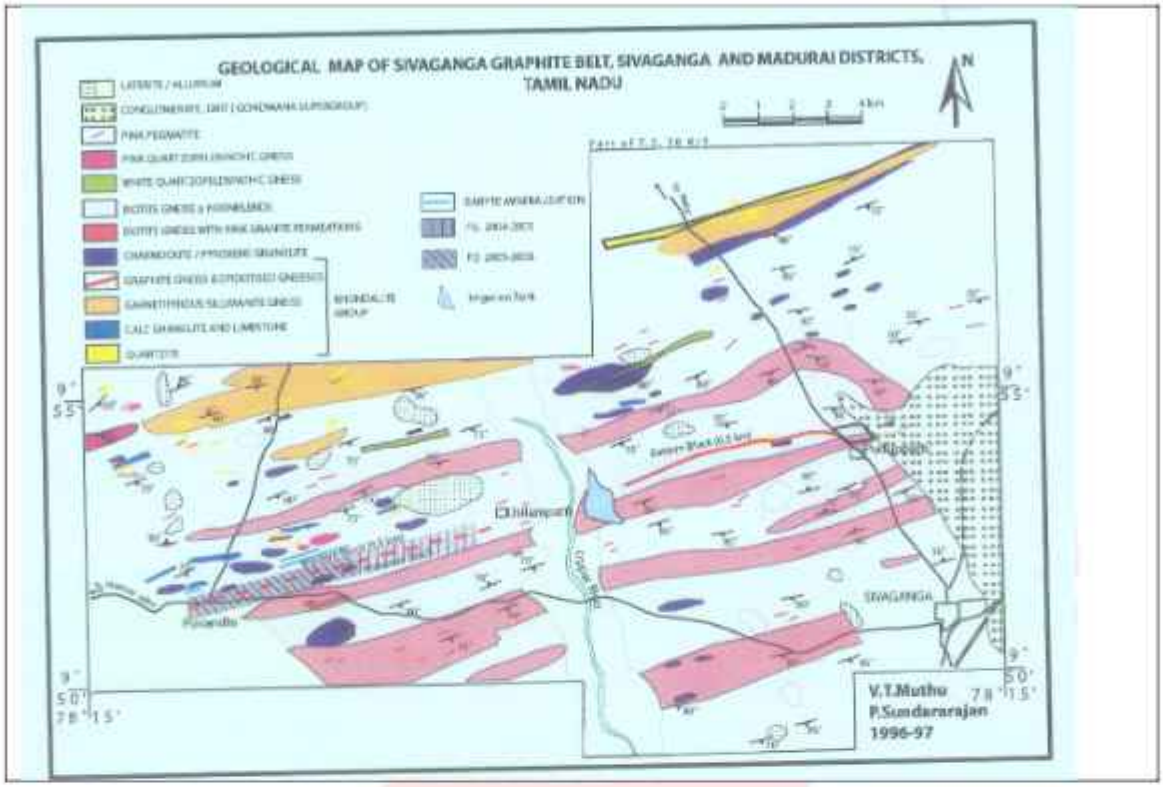
The area of the block falls part of the Archaean – Proterozoic complex, having a plain country with gentle slope towards south. The block is made up of metasedimentary rocks represented by quartzite, garnetiferous sillimanite gneiss and biotite gneiss of Khondalite Group rocks. However, graphite is mainly concentrated in graphite bearing biotite gneiss, is otherwise referred as ***graphite gneiss*** as per the classification by GSI. The graphite is remobilised by later migmatitic activity and subsequent shearing processes. Due to remobilisation, it is also seen in quartzo-feldspathic rock. The graphite gneiss bands occur as linear lensoidal bodies along both strike wise and dip wise probably due to shearing.

The rocks of this area are of crystalline nature and forms part of Archaean Proterozoic complex. The different rock units are quartzite, quartz-graphite schists, calc-gneiss, amphibolites, quartzo- feldspathic gneiss, granite gneiss and pegmatites. A prominent shear zone is noticed for a strike length of about 5 Km between Kamaliamman Temple and Meenakshipuram village and again for about 1.5 Km between Arasanur and Kiranur villages (GSI Note on graphite mineralisation). The quartzites, quartz-graphite schist and granite gneiss in this area are highly sheared and altered. The younger granites and pegmatites have intruded along the fracture planes and also along the joints in the above rocks. The maximum width of the sheared zone is about 120m.

The State Geology Department of Tamil Nadu has carried out detailed prospecting and drilling for Graphite in this area since early 1969 to the middle of 1971. The detailed prospecting work and drilling have indicated that graphite bearing zones do not confine to any set pattern and are often irregular in shape and nature. Though the style of mineralisation is discontinuous in nature, the graphite zones have been proved to persist for a strike length of 5.61 Km in an almost East-West direction with each zone varying in width from about a metre to a maximum of 12m. Individual zones are seldom more than 250 metres, in length and roughly extends for about 700 metres. The graphite bearing rocks occur almost as parallel bands and three such parallel zones could be noticed in this area, during the prefield studies also noticed. The graphite zones pinch, swell and branch into minor stringers.

The graphite bearing schist and gneisses have been deeply decomposed by weathering to a soft mass consisting chiefly quartz, graphite, mica and clay (altered feldspar). *The graphite being impervious to weathering as it is chemically inert, thermally stable, high electrical conductivity, and lubricity it shows up as bright flakes in the altered and weathered rocks.* 'The concentration of graphite also varies from band to band and again within the, band there is a lateral variation in quality which is largely dependent upon the extent of shearing, fracturing, effects of intrusion and also may be the original nature of sediments prior to metamorphism and deformation. In general, the concentration of graphite in the rock varies from 10 to 32% of which 75 to 80% could be recovered by simple froth flotation methods. The P.O. in the concentrates varies from 70 to 87%. The graphite is lonely associated with quartz, feldspars and ruby mica (*Brief note on the Graphite Deposit near Sivaganga by GSI 1969*).

The origin of graphite of Sivaganga may perhaps to be attributed to two different processes. The regional metamorphism of the carbonaceous impurities in the original argillaceous sediments may be one of the causes for the formation of graphite in this area. In addition, the contact Metasomatism of the earlier calcareous sediments may have also yielded graphite. The shear, fracture and joints have provided the avenues for the younger intrusives like the granites and pegmatites to traverse the earlier rocks and produce the resultant cale-gneisses and calc-granulites seen to be attacked with the resultant formation of graphite by disassociation of the carbonates. The composition and structure of the earlier rocks like the quartzites, garnetiferous biotite gneisses etc. are also affected by shearing and later intrusive effects. The intrusions which are contemporaneous with the shearing may have aided the formation of the graphite with in the shear zone. The contact metasomatic effects are also evidenced by the distinctive high temperature non-metallic mineral assemblages like wollastonite, epidote, grossularite, andradite (garnet), diopside, chondrodite etc. and the erratic nature and irregular pattern of the deposit. Unlike the rocks in the neighbourhood the rocks within the shear zone are highly altered duo to the tectonic effect of intrusions. The feldspathic gneisses themselves due to shearing effects are rendered schistose in structure and the feldspars are also altered to kaolin the feldspar and mafic minerals are altered to meet Silicates like epidote. A few fractures perpendicular to the strike of the graphite bearing rocks could be traced within the shear zone.



4. Mineral Potentiality based on Geology, and Ground Geo Chemistry:

GSI between 2004-06 and 2006-07 has carried out trenching works in the Arasanur – Kiranur sector has indicated that there is 9m thick medium to high grade graphite gneiss band exposed in M/s V. Thirunavukkarasu Mines pinches out in the east. Further eastwards also, only thin bands of low-grade graphite gneiss bands occur with thick intercalations of country rocks. However strong SP and EM anomalies have been recorded in this Block during the geophysical surveys carried out by GSI *1970-71 by Bahulayan and Murali.* The geophysicists have inferred from the geophysical data that the graphite bearing zones are persistent to deeper levels. Though the prospecting done at shallow level has not indicated any encouraging results, presence of thick graphite gneiss bands at deeper level is not ruled out since, thickness of graphite gneiss vary vertically and laterally due to pinching and swelling nature. In view of the strong geophysical anomalies recorded from this part of the Block, exploratory boreholes over this zone will throw light on the potentiality of the mineralisation at deeper levels *(K. Duraisamy and T. Mullaivendhan 2009).*

The terms flaky and amorphous variety of graphite are the commercial terminologies to refer the crystalline and microcrystalline type of graphites. In general, for well-developed crystal platelets of graphite that are between 40 micrometers (μm) and 4 centimeters (cm) generally less than or equal to 1 cm) in size and that are disseminated in beds of carbonaceous sediments that have been subjected to granulite grade regional metamorphism in the present case. On the contrary for the earthy to compact fine-grained graphite that generally results from thermal metamorphism are referred as Amorphous variety.

5. Scope for proposed Exploration:

The recently published document by Ministry of Mines – Critical Minerals for India states that the mineral Graphite is considered as clean energy mineral and being used in Batteries, Lubricants, fuel cells for EVs, Electric Vehicle.

The India sets ambitious targets for its EV ecosystem by 2030. To reach these ambitious targets, the Indian government has created policies and programs like the National Electric Mobility Mission Plan (NEMMP), a broad plan to encourage the adoption of electric vehicles in India.

The mineral graphite has physical and chemical properties of both metals and nonmetals, which make it ideally suited for many industrial and technology applications. The metallic properties include high thermal and electrical conductivity. The non-metallic properties include inertness to most chemical reagents (strong acids, bases, solvents, and fluxes), high thermal resistance, low thermal expansion, and excellent cleavage and lubricity. In a nonoxidizing atmosphere, graphite remains stable to temperatures above 3,000 °C. Graphite has a hardness of 1 to 2 on the Mohs scale and is thus extremely soft.

The proposed area of exploration is falling in part of the western Sector between Puvandi and Usilampatti for a strike extension of 9.5 Km. The proposed block is exactly lying in the middle of this sector.

The mineral graphite is not produced by many countries, Production of natural graphite is dominated by China, India, and Brazil. Graphite is played an important role in the emerging noncarbon energy sector and is used in several new energy applications. In energy production applications, graphite is used in pebbles for modular nuclear reactors and in high-strength composites for wind, tide, and wave turbines. In energy storage applications, graphite is used in bipolar plates for fuel cells and flow batteries, in anodes for lithium-ion batteries, in electrodes for supercapacitors, in high-strength composites for fly wheels, in phase change heat storage, and in solar boilers.

Duraisamy, Mullaivendan and Sundarrajan (2004-06) A prominent graphite gneiss band having 16.82m average width has been traced for a strike length of 565 m on the basis of trench sections and surface exposures. An *inferred resource of **0.464 MT** of graphite ore with average F.C. contents of 13.06% has been estimated for 690 m length (with area of influence on either side) and upto a depth of 20m below the lateritic soil cover. The graphite gneiss of Sivaganga Graphite Belt is amenable for to higher grades upto 96% F.C.* as being practiced in the Eastern Sector by TAMIN. The trench sections and the scanty outcrops of graphite gneiss in the vicinity of Arasanur village indicate that the graphite gneiss is likely to continue both towards west and east. It is recommended to trace the continuity of the graphite gneiss band by trenching.

Duraisamy, Mullaivendan (2009) The graphite mineralisation in Arasanur Block is very encouraging and is open ended. It needs to be traced both towards west and east by trenching. They recommended drilling to probe the depth persistence of the graphite mineralisation.

The prefield studies carried out in the area shows highly potential in nature, there are three bands of graphite bearing mineralised zones within the biotite gneiss, varying in thickness on surface from 1 to 10m in width and extending along east dipping towards south. The nature of graphite in the area is mainly the flaky variety however, the amorphous variety is not ruled

out. The analytical results of the samples collected from these area shows the fixed carbon range from 6.57%, in one sample, the remaining *4 samples has yielded the results of 12.68%, 13.77%, 19.36% and 24.91%*.

The SP method has long been known to be effective for assessing minerals such as graphite, sulphide, iron and manganese in massive ore bodies (Corry, 1985; Reynolds, 1997; Telford et al., 1990).

T. Mullaivendhan and K. Raju (2007-08) recommended that, as the *graphite gneiss bands occur scattered over extensive length and width, geophysical surveys may be undertaken to decipher the geometry of the graphite gneiss bands occurring at the depth in the Blocks.* In Arasanur block only two boreholes were drilled in the central part and reserves could be estimated only for 200 m strike length assuming 50 m strike influence on either side of the borehole. *Further drilling can be carried out in the remaining part of the block, for a strike length of about 1 km including eastern and western part of Arasanur block.*

Considering the Govt priority, and need for clean energy mineral, and as the block is falling in the Shivaganga Graphite Belt, G3 level of Mineral Exploration works is proposed. The area shows potential in displaying three different bands on the surface having sufficient strike and width of the graphite bearing zones and the analytical results of high-grade graphite. The area assumes significance for carrying out detailed exploration.

6. Recommendations of G4 level Mineral Exploration Reports:

Previous exploration activities by officers of GSI was stretched to 3 such periods between 2004-06, 2006-07 and 2008-09, their recommendations are furnished below

i) *Duraisamy, Mullaivendan and Sundarrajan (2004-06)* A prominent graphite gneiss band having 16.82m average width has been traced for a strike length of 565 m on the basis of trench sections and surface exposures. An *inferred resource of **0.464 MT** of graphite ore with average F.C. contents of 13.06% has been estimated for 690 m length (with area of influence on either side) and upto a depth of 20m below the lateritic soil cover. The graphite gneiss of Sivaganga Graphite Belt is amenable for to higher grades upto 96% F.C.* as being practiced in the Eastern Sector by TAMIN. The trench sections and the scanty outcrops of graphite gneiss in the vicinity of Arasanur village indicate that the graphite gneiss is likely to continue both towards west and east. It is recommended to trace the continuity of the graphite gneiss band by trenching.

ii) *Duraisamy, Mullaivendan (2009)* The graphite mineralisation in Arasanur Block is very encouraging and is open ended. It needs to be traced both towards west and east by trenching. They recommended drilling to probe the depth persistence of the graphite mineralisation.

iii) *T. Mullaivendhan and K. Raju (2007-08) recommended that,* as the *graphite gneiss bands occur scattered over extensive length and width, geophysical surveys may be undertaken to decipher the geometry of the graphite gneiss bands occurring at the depth in the Blocks.* In Arasanur block only two boreholes were drilled in the central part and reserves could be estimated only for 200 m strike length assuming 50 m strike influence on either side of the borehole. *Further drilling can be carried out in the remaining part of*

the block, for a strike length of about 1 km including eastern and western part of Arasanur block.

iv) The prefield studies carried out in the area shows highly potential in nature, there are three bands of graphite bearing mineralised zones within the biotite gneiss, varying in thickness on surface from 1 to 10m in width and extending along east dipping towards south. The nature of graphite in the area is mainly the flaky variety however, the amorphous variety is not ruled out. The analytical results of the samples collected from these area shows the fixed carbon range from 6.57%, in one sample, the remaining *4 samples has yielded the results of 12.68%, 13.77%, 19.36% and 24.91%*.

v) The SP method has long been known to be effective for assessing minerals such as graphite, sulphide, iron and manganese in massive ore bodies (Corry, 1985; Reynolds, 1997; Telford et al., 1990).

7. Objectives:

i) To map - Detailed geological mapping on 1: 2,000 scale covering an area of 1.93 Sq. Km to target potential zones for Graphite mineralisation.
ii) To delineate the targeted mineral potentiality zones based on the geological, surface Geochemical Sampling and geophysical surveys.
iii) Plan for drilling on appropriate spacing 200m, to intersect the graphite bearing loads at 3 different levels of intersection. The mineral being graphite which is strategic, critical and clean energy mineral, more over the area has undergone three phases of deformation. Hence planned to intersect at 30m, 60m and 90m as first, second and third level vertical intersections of the orebody at depth.
iv) ME Works shall be confirming to
   - ✓ MMDR Act-1957 and Amendments,
   - ✓ Minerals (Evidence of Mineral Contents) Rule- 2015 and Amendments,
   - ✓ Mineral (Auction) Rules-2015 and Amendments
   - ✓ IBM GUIDELINES

B. PREVIOUS WORKS

V. Gopal GSI (1952) The geology of parts of the Sivaganga and Tirupattur taluks, Ramanad districts, Madras State has reported the occurrence of graphite for the first time in the Puvandi area.

Directorate of Geology and Mining (DGM), Govt. of Tamil Nadu (1969-71, 1975-77 and 1992-95) carried out exploration for graphite in the Shivaganga Graphite Belt.

Sevugan Chetty (1969) DGM Tamil Nadu Preliminary investigation for graphite was carried out in Kiranur - Arasanur and Puvandi areas of SGB.

Srinivasan and Vaikuntam (1969-71) Systematic exploration of SGB was started in the Eastern Sector by the DGM detailed mapping on 1:2,000, 1:8,000 and 1:10,000 scales using village maps, pitting and trenching and drilling.

Paramasivam, Srinivasan and Vaikuntam (1972) have recorded persistence of graphite zone between Minakshipuram and Komalippatti (Eastern Sector).

.

Vaikuntam (1992) assessed graphite reserves occurring in a1.20 km stretch within the TAMIN leasehold below 15 m depth, by second level drilling.

Bahulayan and Murali (1970-71) of GSI carried out geophysical surveys by SP and EM methods in the SGB. In the 1.4 km long area surveyed in Arasanur block, SP anomaly was recorded for the entire length from W 1000m to E 400m.

Rajagopal (1975-76), DGM, Tamil Nadu carried out exploration of graphite

Rajagopal, Shanmugam and Ansari (1976-77), DGM, Tamil Nadu

K.R.Ramchandran, and S. K. Shirvastava (1976-77) geology of the area around Tiruvadur and Varichiyur Melur taluk, Madurai district, Tamil Nadu (58 k/5)

Kothandaraman, Selvan, and Vaikuntam, (1993, 93-94) DGM, Tamil Nadu

Manavalan, Rajagopal, and Rajanna, (1994-95) of DGM, investigated for graphite by trenching and by drilling three shallow angular boreholes in the non-leaseholds in Puvandi - Arasanur area.

V.T.Muthu and P. Sundarrajan in 1996-97 Geological mapping of the Shiganga Graphite Belt was mapped on 1 : 25,000 Scale.

R. Sundaram (1980-81) Geology of parts of Sivaganga, Tirupattur taluks, Ramanathapuram district, Tamil Nadu.

Duraisamy, Mullaivendhan and Sundarrajan (2007) Report on the Exploration for Graphite in Arasanur Block, Western Sector, Shivaganga Graphite Belt, Shivagangai District, Tamil Nadu (P-II Stage)

Duraisamy and Mullaivendhan (2009) Exploration for Graphite in Arasanur and Kiranur blocks of Sivaganga graphite belt, Shivagangai district and Terku kallikulam Area, Tirunelveli district, Tamil Nadu (P-II Stage).

T. Mullaivendhan and K. Raju (2007-08) Progress Report on the Exploration for Graphite in Arasanur, Arasanur west and Usilampatti west blocks, western sector, Sivaganga graphite belt, Shivagangai district, Tamil Nadu (E-I Stage)

PRELIMINARY FIELD INSPECTION BY KIOCL:

KIOCL geoscientists has carried out the Pre-field studies in the area, between 26th to 31st December 2023 for finding out the suitability of the area for exploration of graphite in both arasanur west and east block. The geologists have traced the graphite bearing zones within the biotite granulite. Graphite mineralization is mainly confine and hosted in the graphite bearing biotite gneiss. There are three mineralised bands traced in the area. These bands vary in thickness on the surface from 8 to 10m, and extends along east – west strike direction with dip towards south in the *Arasanur East Block. These bands were sampled and the analytical results from the rocks shows the fixed Carbon content varies from 12.12 to 24.91%.* The mineralization is structurally controlled and it is confined within gneissic structure as well as the shears and fault / fold closures. The area is covered by lateritic and soil.

The nature of graphite mineralisation in the area is flaky, and thickness varies from 0.5m, 2-4m to 10m as seen from the surface exposures as well as the old pits excavated in the area for the mineralisation purpose by GSI.
Details of the BRS analysis results and field photographs collected during PFI works conducted by KIOCL are provided below;

Sample No.	Inherent Moisture %	Volatile Matter %	Ash %	Fixed Carbon %
50BRS-01	0.52	0.94	98.24	0.30
50BRS-02	0.47	1.45	85.96	12.12
50BRS-03	1.17	1.15	83.04	14.64
50BRS-04	1.54	2.37	86.00	10.09
50BRS-05	1.28	2.57	87.86	8.29
50BRS-06	0.86	2.12	82.59	14.43
50BRS-07	0.81	1.14	85.68	12.37
50BRS-08	1.11	5.64	80.57	12.68
50BRS-09	1.09	2.99	80.81	15.11
50BRS-10	1.37	3.82	69.90	24.91

Graphite mineralisation in the Biotite Gniess

Graphite mineralisation in Biotite Gneiss

Graphite bearing gneiss

Hand specimen showing Graphite mineralisation in Biotite Gneiss

Graphite bearing gneiss

Old pit showing zone of graphite mineralisation - exploited

C. BLOCK DESCRIPTION:

The boundary coordinates of the proposed block are given in table @ Annexure 05.

D. PLANNED METHODOLOGY

i. Detailed Geological mapping of 2.7 Sq. Km area (Measuring 2.7 Km along the strike and 550m along the down-dip side and 250m along the up-dip side) on 1: 2,000 scale with 1m contour interval.

ii. Geochemical sampling of 50m X 20m grid (Along base line 50m and along the traverse line 20m covering the graphite bearing zones and bed rock sampling in the graphite zones and adjoining areas on the geological map.

iii. Pitting and trenching in the areas covered by the soil / laterite to expose, map and sample the mineralised zones or host rock.

iv. Geophysical mapping on the same scale of geological map. Employing Gravity, Magnetic, Resistivity, SP and IP methods.

v. Integration of Geological, Geochemical and Geophysical data sets, planning of boreholes along the favourable anomalous zones / profiles.

vi. 14 No. of boreholes - *First* level of intersection of the ore body at 30m vertical depth, keeping the borehole spacing at 200m as per the UNFC. The *second* level boreholes are drilled at positive first level intersections 14 No. of boreholes will be planned to intersect the same mineralised zones at depth of 60m vertical depth. The *Third* level boreholes are drilled at positive first and second level intersections 10 No. of boreholes will be planned to intersect the same mineralised zones at depth of 90m vertical depth.

vii. Total drilling meterage of 60m X 14BH=***840m***, 100m X 14BH = ***1400m*** and 140m X 10BH = ***1400m*** cumulative drilling target of ***3,640m***.

viii. Borehole core logging, sampling of the borehole cores, delineation of mineralised zones across the boreholes and correlation of the mineralised zones based on their fixed carbon content values.

ix. Geometry / configuration of the ore body (length, width, thickness, and depth below the surface etc.,) will be derived.

x. Estimation of the resources keeping minimum stoping width of 1.2m and appropriate cutoff grade on the UNFC classification.

xi. Generate the Geological report on the outcome of the exploration activities carried out in the area, by systematic documentation of all the data sets so generated for this project.

E. NATURE, QUANTUM, AND TARGET

Quantum of work proposed is provided @ Annexure No - 02.

F. TIME LINES

Total period proposed for G4 level Mineral Exploration works is 16 months.

Time Schedule Chart is provided @ Annexure No – 01

G. BREAKUP OF EXPENDITURE:

H. Total estimated cost is **Rs. 7,32,51,549/- (including GST @ 18%).**

Cost estimate is provided @ Annexure No – 03

I. TERMS OF PAYMENT

- KIOCL shall raise invoice for the quantum work executed and completed in accordance with the approved MEPP, as per NMET guidelines, for payment.
- Projected cost estimates are based on the SOC of NMET circulated vide Office Memorandum dtd. 31st Mar 2020. However, cost of execution will be claimed with appropriate escalation as per procedure.

****

TIME SCHEULE
KIOCL LIMITED, BANGALORE

(Notified Exploration Agency)

MEPP – G3 LEVEL MINERAL EXPLORATION FOR Graphite mineralisation in ARASANUR (EAST) Block, Shivaganga Graphite Belt, Shivaganga District, Tamil Nadu (Block ID: KIOCL_51_TN_AGB (W))

Annexure – 01

TIME SCHEDULE CHART (G3 Level)

Sl	Details of Works	Duration in months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	**CAMP SETTING**	01	↔						Review											
2	**LARGE SCALE GEOLOGICAL MAPPING** (Includes 1.93 sq km of DM + 75 nos of BRS + 150 cum Trenching)	05		↔																
	2.1 Geologist Party days (01 Party)			60 working days																
	2.2 Laboratory Works	05		↔ 90 days																
3	**Surface Drilling**																			
	3.1 Preparatory works for drilling (Approach road making)	01								↔										
	3.2 Drilling works (01 rig - 3640m 38 Bhs)	08									↔									
	4.3 Geologist Party days (01 Party)										90 days									
	4.3 Laboratory Works	07											↔							
													90 days							
4	**Survey Works**																			
	4.1 Topographic Survey works	08										↔								
	4.2 DGPS survey works of 42 points (38BHs+4 Boundary = 42 nos)	01																	↔	
6	**Camp Winding**	01																		↔
7	**Preparation of Reports and Maps**	01																		↔

ANNEXURE 02

QUANTITY OF WORK

Sl	Stage	Components		Unit	Qty		Remarks
1	Detailed Geological Mapping (1:2,000)	Detailed Geological Mapping		sqkm	1.93		
2		Bed Rock Samples		nos	75		
3		Trenching works		cum	150		
4	Geophysical Surveys	IP, SP, Resistivity and Magnetic Survey for 2 sqkm (2.7km X 0.8km)		line km	5.4		2 lines of 2.7 km length
5	Survey works	Topographic Survey works (2m interval)		sqkm	1.93		
6		DGPS Survey for fixing up of borehole points		nos	42 nos		(38BHs+4 Boundary = 42 nos)
7	Drilling works	No of Boreholes		nos	38		
8		Core Drilling (NQ series)		m	3640		
9		Detailed core/ sample logging including supply of core/ sample boxes		m	3640		
10		Drill core preservation		m	1250		(@ 30m per BH X 37 BHs + 140m (1 complete BH))
11	Lab works Sample analysis	Primary Analysis (4 radicals : VM,FC, Moisture & Ash)	BRS	nos	75	1400	
12			Trench samples	nos	75		
13			Drill Core	nos	1250		
14		Internal Check sample analysis (5%) (4 radicals)	BRS	nos	4.0	70	
15			Trench samples	nos	4.0		
16			Drill Core	nos	62.0		
17		External Check sample analysis (10%) (4 radicals)	BRS	nos	8.0	140	
18			Trench samples	nos	8.0		
19			Drill Core	nos	124.0		
20		ICPMS / ICP-OES (34 elements analysis)		nos	20.0	20	
21		REE analysis of 14 elements ICPMS		nos	10.0	10	
22	Sample preparation & handling			nos	1640		
23	Petro studies	Preparation of Standard Thin section		nos	10		
24		Petrographic studies		nos	10		
25		Preparation of Polished Thin section		nos	10		
26		Ore micoscopic studies		nos	10		
27		Mineragraphic studies		nos	10		
28		XRD Studies		nos	40		
29	Determination of Insitu bulk density			nos	10		
30	Report preparation			nos	1		

ANNEXURE 03

COST ESTIMATES

Sl	Item of Work	Unit	Rates as per NMET SoC 2020-21		Year 2021-22			Remarks
			SOC Item No	Rates as per SOC	Qty	Amount (Rs)		
(a)	(b)	(c)	(d)	(e)	(f)	(g)=(e)*(f)		
1	**LARGE SCALE GEOLOGICAL MAPPING WORKS (1:2000 scale :1.93sq km)**							
1.1	Geologist Party days - Field	days	1.2	11,000	150.0	16,50,000		
1.2	Geologist Party days - HQ		1.2	9,000	50.0	4,50,000		
1.3	Labour charges @ 2nos per Geologist	days	5.7	494	300.0	1,48,200		
2	**TRENCHING WORKS**							
2.1	Trenching works	cum	2.1.2	3,800	150.0	5,70,000		
3	**Survey works**							
3.1	Demarkation of Lease boundary and fixation of borehole and determination of coordinates and RL by DGPS	Per point of observation	1.6.2	19,200	42.0	8,06,400	**42,41,160**	(38BHs+4 Boundary = 42 nos)
3.2	Survey party days (1 party) without Labour for contouring (2m interval)	days	1.6.1.a	8,300	60.0	4,98,000		
3.3	Labour for Survey (4 Nos)	days	5.7	494	240.0	1,18,560		Amount will be reimbursed for unskilled labour as per the notified rates by the Central Labour Commissioner (Rs.504/- per day) or respective State Govt. whichever is higher)

4	**Geophysical Surveys (Outsourcing)**								
4.1	IP, SP, Resistivity and Magnetic Survey for 2 sqkm (2.7km X 0.8km)		line km	3.4b	14,48,693	5.4	78,22,942	**78,22,942**	2 lines of 2.7 km length
5	**DRILLING**								
5.1	Surface Drilling (01 rig - Medium Hard Rock) **(Outsourcing)**		m.	2.2.1.3	10,100	3640.0	3,67,64,000	**3,87,51,500**	Total drilling meterage of 60m X 14BH = 840m, 100m X 14BH = 1400m and 140m X 10BH = 1400m cumulative drilling target of 3,640m.
5.2	Core preservation		m	5.3	1,590	1250.0	19,87,500		@ 30m per BH X 37 BHs + 140m (1 complete BH)
6	**LABORATORY STUDIES**								
6.1	Sample processing works- 1400 Nos (1250 BHs+75 Trench + 75 BRS)	Sampler charges	days	1.5.2	5,100	234.3	11,94,857	**16,57,806**	@ 1400 samples / 7 samples per day
6.2		Labour charges	days	5.7	494	937.1	4,62,949		Amount will be reimbursed for unskilled labour as per the notified rates by the Central Labour Commissioner (Rs.504/- per day) or respective State Govt. whichever is higher)
6.3	Proximate Anlalyses for graphite (4 radicals : VM,FC, Moisture & Ash)	Primary	per sample	4.1.16	3,000	1400.0	42,00,000	**50,38,420**	1400 Nos (1250 BHs+75 Trench + 75 BRS)
6.4		Internal Check (5%)		4.1.16	3,000	70.0	2,10,000		
6.5		External Check (10%)		4.1.16	3,000	140.0	4,20,000		
6.6		ICPMS / ICP-OES (34 elements analysis)		4.1.14	7,731	20.0	1,54,620		

6.7		REE analysis of 14 elements ICPMS		4.1.13	5,380	10.0	53,800		
6.8	Petro studies	Preparation of Standard Thin section	nos	4.3.1	2,353	10.0	23,530	3,01,360	
6.9		Complete Petrological Report of rock sample	nos	4.3.4	4,232	10.0	42,320		
6.10		Preparation of Polished Thin section	nos	4.3.2	1,549	10.0	15,490		
6.11		Mineragraphic studies	nos	4.3.4	4,232	10.0	42,320		
6.12		XRD Studies	nos	4.5.1	4,000	40.0	1,60,000		
6.13	Determination of Insitu bulk density		nos	4.10	3,540	5.0	17,700		
7	**Sub Total (1+2+3+4+5+6)**						**5,78,13,188**	**5,78,13,188**	
8	**Peer review of report**		lumpsum		MoM Office Memorandum Dtd 12 July 2023		30,000	30,000	
9	Preparation of Exploration Project Proposal		lumpsum	5.1	2% of approved project cost subject to minimum of ₹ 2 lakh and maximum of ₹ 5 lakh"		5,00,000	5,00,000	
10	Exploration Report (5% of (Sl 9 + Sl 10))		lumpsum	5.2(iv)	Detailed exploration with cost of work exceeding Rs.300 Lakh: A min. of Rs.9 Lakh or 3% of the value of work whichever is more subject to a max. amount of Rs.20Lakhs and Rs.10000/- per each additional copy		17,34,396	17,34,396	

11	Tender processing Cost	lumpsum	2.3	One time in case of outsourced component(s) of project work (2% of the approved project cost or 5 lakh whichever is lower)	5,00,000	5,00,000	Tendering Cost = Rs 4,45,86,942/- (Drilling : Rs 3,67,64,000 + Geophysics: Rs 78,22,942)
12	Operational Charges (Reimbursement of cost in case of outsourced components of project work)	lumpsum	6(iii)	Rs 8.75 lakhs + 5% of balance amount outsourced in excess of Rs 1 Crore. (Maximum of Rs 15 Lakhs)	15,00,000	15,00,000	
13	**GRAND TOTAL (7 to 12)**				**6,20,77,584**	**6,20,77,584**	
14	**GST 18%**				**1,11,73,965**	**1,11,73,965**	GST will be reimbursed as per actual and as per notified prescribed rate
15	**Grand Total (with GST 18%)**				**7,32,51,549**	**7,32,51,549**	

ANNEXURE 04

BOUNDARY CO-ORDINATES OF THE BLOCK

Boundary Point	Latitude (dd mm ss)	Longitude (dd mm ss)
A	9° 52' 10.08"	78° 20' 33.05"
B	9° 52' 19.10"	78° 20' 54.60"
C	9° 52' 22.10"	78° 20' 53.40"
D	9° 52' 13.51"	78° 20' 32.39"
E	9° 52' 25.29"	78° 20' 30.04"
F	9° 52' 49.56"	78° 21' 58.09"
G	9° 52' 26.78"	78° 22' 5.38"
H	9° 52' 3.61"	78° 20' 34.38"

ANNEXURE 05

CONSENT LETTER RECEIVED FROM DEPT OF MINING & GEOLOGY, GOVT. OF TAMILNADU

Natural Resources (MMD.1) Department, Secretariat, Chennai – 600 009

Letter No.17/MMD.1/2024-1, Dated 14-02-2024

From
Thiru K. Phanindra Reddy, I.A.S.,
Additional Chief Secretary to Government (FAC)

To
The Assistant General Manager (Mineral Exploration),
Tvl.KIOCL Limited, II Block Koramangala,
Bengaluru – 560034.

Sir,

Sub: NRD – Mines and Minerals – Exploration – Exploration – Proposal submitted by Tvl.KIOCL Limited – G3 Level of Exploration - Graphite – Arasanur East Block – 1.93 Sq.km - Sivagangai District - Consent requested to carry out survey – Under NMET fund – Regarding.

Ref: 1. From the Assistant General Manager (Mineral Exploration), Tvl.KIOCL Limited letter No.KIOCL/MED/2023/636, dated 07.11.2023 and email dated 30.01.2024.

2. From the Deputy Director General, GSI, letter No.1744/TC/26/DGM TN/TNP/2023, dated 23.11.2023.

3. From the Commissioner of Geology and Mining letter No.8674/MM11/2023, dated 07.02.2024.

*****

I invite attention to your letter 1st cited wherein you have requested the State Government of Tamil Nadu to accord necessary permissions to Tvl.KIOCL Limited for carrying out G3 level of mineral exploration works for Graphite around Arasanur East (2.0 sq. km) and Arasanur West (2.0 sq. km) area, Sivaganga District, Tamil Nadu.

2. I am to inform that with regard to the proposal of Tvl.KOICL Limited, GSI has been consulted and the Deputy Director General, GSI in his letter 2nd cited has informed that the State Government to consider giving consent to KIOCl Limited to take up exploration in PORS block without changing their area and up on marginal correction in exploration area excluding the part already covered by GSI either during FS 2023-2024 or FS 2024-2025. In the letter 3rd cited, the Commissioner of Geology and Mining has requested to accord consent to

Tvl.KIOCL Limited for carrying out G3 stage of exploration for Graphite in Arasanur East (EFGH) block in Sivagangai District covering over an extent of 1.93 Sq.km under NMET Fund.

3. Under the circumstances, based on the recommendations of Geological Survey of India (GSI) and the request of Commissioner of Geology and Mining, the Government of Tamil Nadu is according consent for carrying out G3 stage of exploration for Graphite in Arasanur East (EFGH) block in Sivagangai District covering over an extent of 1.93 Sq.km under NMET Fund.

Yours faithfully,

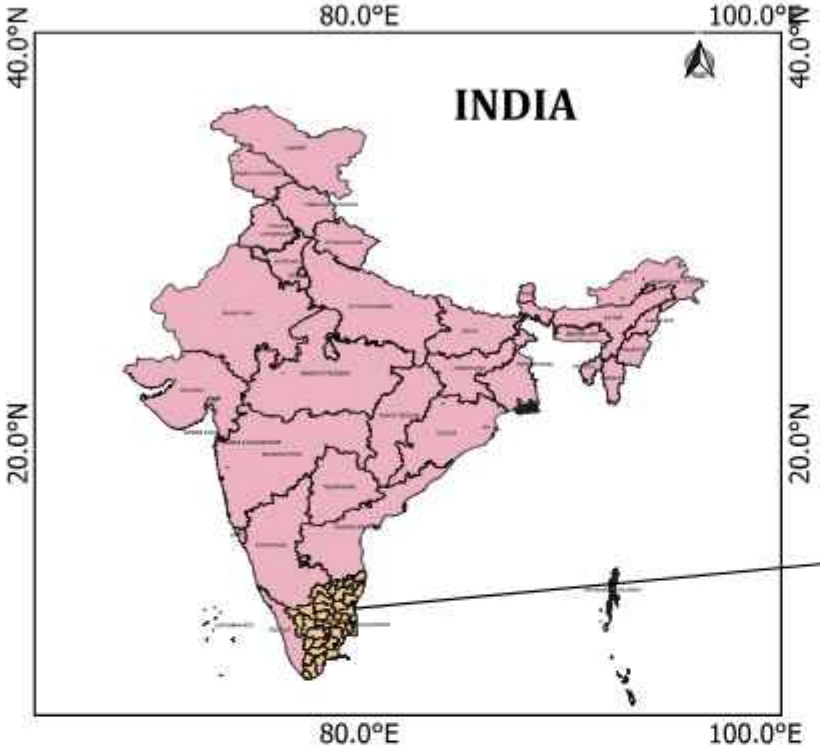
14/02/2024

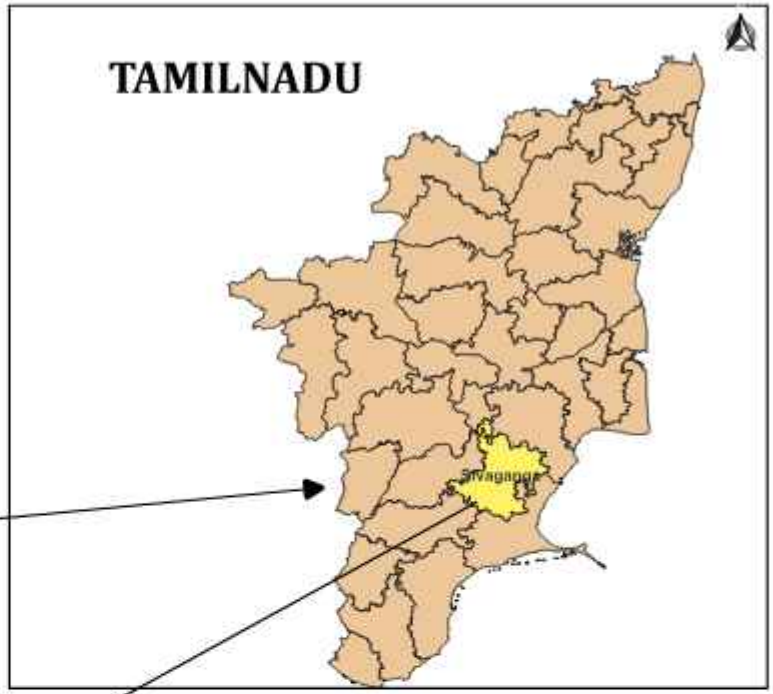
for Additional Chief Secretary to Government (FAC)

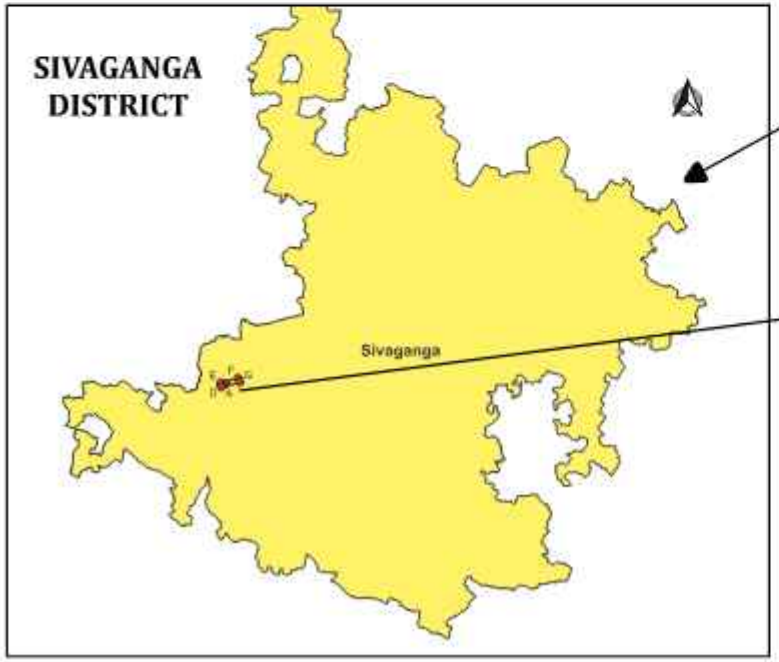
14.2.2024

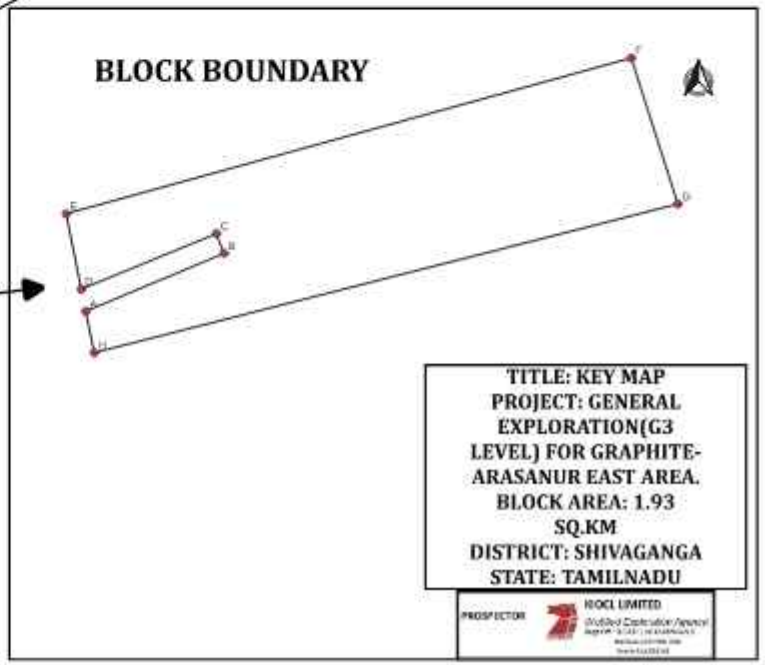
Copy to:
The Commissioner of Geology and Mining,
Guindy, Chennai – 600 032

KEY MAP SHOWING AREA OF EXPLORATION

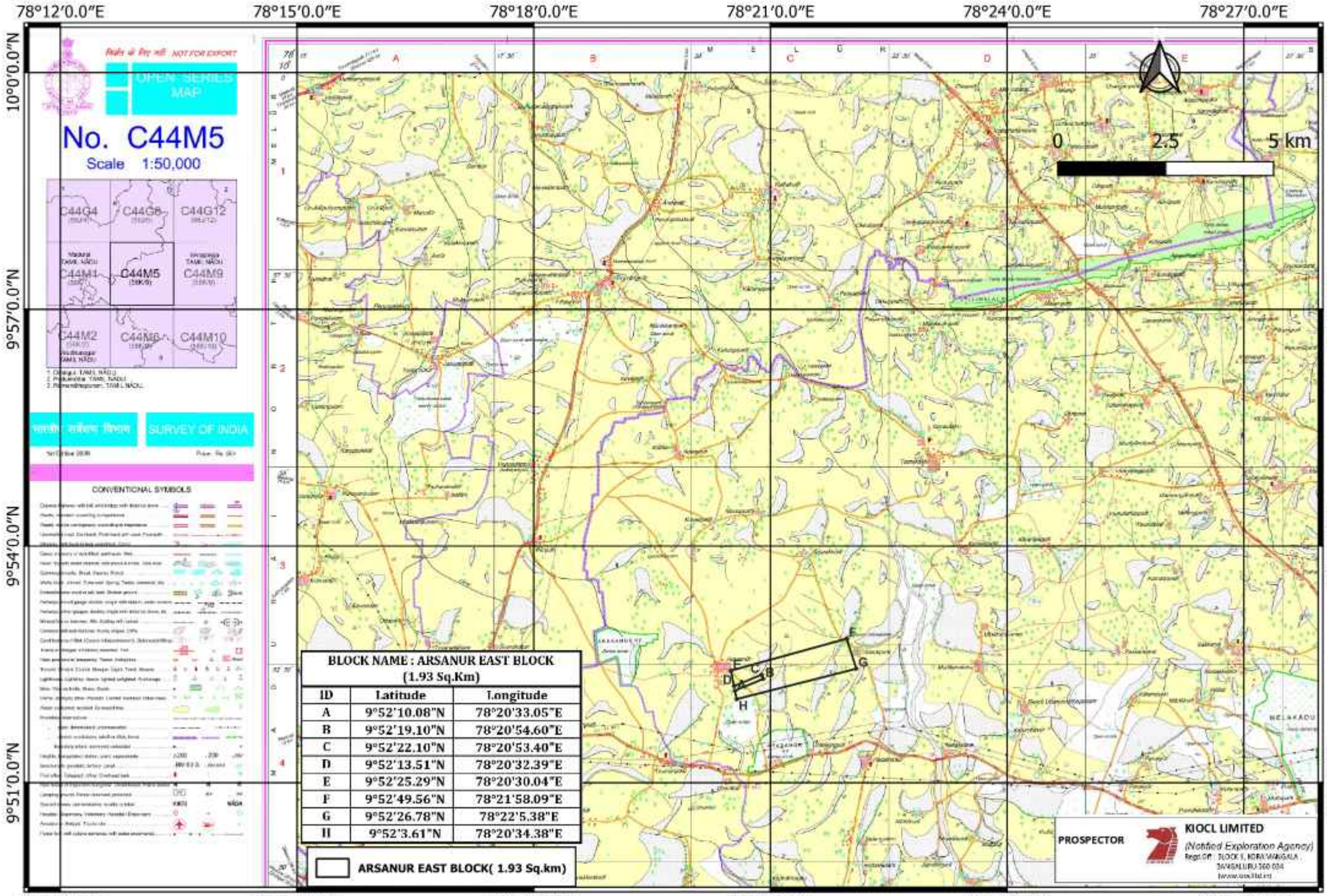




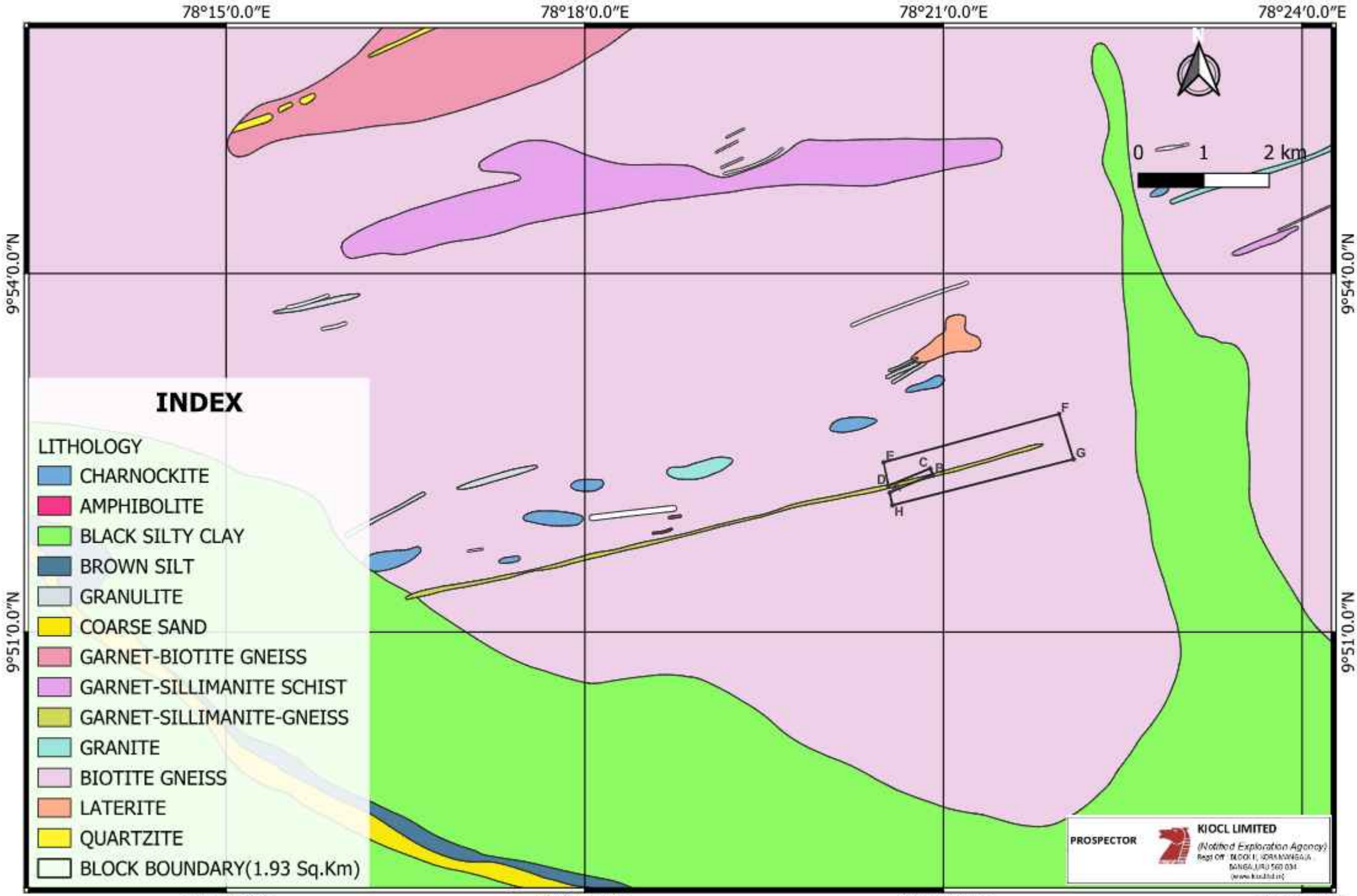




ARASANUR EAST GRAPHITE BLOCK MARKED ON SOI TOPOSHEET NO. 58K/5



ARASANUR EAST BLOCK (1.93 SQ.KM) MARKED ON GSI GEOLOGICAL MAP 1:50K



Geological Map of Arsanur East Block (1.93 Sq.km)