PROPOSAL FOR GENERAL EXPLORATION (G2) IN AMALGAMATED VELLAKKAL CLUSTER (12.0 Sq.km area) FOR MOLYBDENUM, UTTANGARAI SECTOR, HARUR-UTTANGARAI BELT (HUB), KRISHNAGIRI DISTIRCT: STATE- TAMIL NADU.

Molybdenum

By

Mineral Exploration & Consultancy Limited
(A Government of India Enterprise)
A Mini Ratna Company
Seminary Hills, Nagpur – 440006, Maharashtra

Place: Nagpur
Date: 15th Oct, 2024

Summary fo General Exploration (G2) In Amalgamated Vellakkal Cluster (12.0 Sq.Km Area) For Molybdenum, Uttangarai Sector, Harur-Uttangarai Belt (HUB), Krishnagiri Distirct: State- Tamil Nadu.

Features	Details
Block ID :	Amalgamated Vellakkal Cluster
Exploration Agency	Mineral Exploration And Consultancy Limited (MECL)
Previous Exploration Agency	GSI
Commodity	Molybdenum
Mineral Belt :	Harur-Uttangarai Molybdenum Belt of Tamil Nadu
Budget &Time Schedule to complete the project	Rs. 3056.86 Lakhs; 22 months
Objectives:	Amalgamated Vellakkal Cluster area is part of Uttangarai sector of Harur Uthangarai Molybdenum belt (HUB) and comprises of four sub blocks namely Vellakkal North Block, Central Block, South Block & West Block. G3 stage exploration already carried out in Vellakkal Central block (FS 2019-20) and remaining three blocks viz.Vellakkal North Block, South Block & West Block were covered by Reconnoitary exploration with limited scout boreholes by GSI (FS 1998-2000). The present G2 level Exploration planned to estimate the Mo resource under 332 category of UNFC in the amalgamated Vellakkal Block. Objectives of present exploration is as follows. **For Vellakkal Central Block** 1. To establish strike & depth persistence of molybdenum mineralisation at close spaced interval considering the data of previous G-3 stage exploration. 2. Drill infilling 1st level & 2nd level boreholes at 50m spacing interval (up to 100m V.D.) and 3rd level boreholes spaced at 100m interval (up to 150m V.D.) to prove the strike and depth persistence of Mo mineralisation throughout the 1130m strike of the block. 3. To carry out the geotechnical studies for assessment of strength of rocks occurring in the block. 4. To ascertain the amenability of the molybdenum ore through bench scale beneficiation studies. 5. To assess the quality and quantity of the resources (332) as per UNFC norms & Minerals (Evidence of Mineral Contents) Rules- 2021.

	For Vellakkal North, South, & West Block (Phase-I) 1. To carry out Detailed geological mapping on 1:2000 scale with surface geochemical samples (Bedrock/channel) from the area. 2. To carry out Topographical survey at 2m contour interval in the entire block area. 3. To carryout ground geophysical survey (Induced Polarization (I.P) cum Resistivity, S.P. & Magnetic method) to delineate the sub-surface continuity of Molybdenum bearing areas. 4. To carry out Trenching work (300 cu.m) in the identified anomalous areas at suitable profiles. 5. To carryout Phase-I exploratory drilling to establish the strike and depth persistence of ore zones at 1st at 100m spacing interval and 2nd level at 200 m spacing interval throughout the strike of ore body. 6. Based on the outcome of Phase-I drilling further course of action shall be taken up.
	The work will be carried out by MECL.
Name/ Number of Geoscientists :	Geologist: 01 Nos. at HQ (60 days) Geophysicist: 01 Nos. at HQ (30 days)
Expected Field days (Geology, Surveyor)	Geologist: 02 Nos. at Field (780 days) Surveyor : 30 days
1. Location:	
Location	Vellakkal Cluster area is part of Haru-Uttangarai Molybdenum Belt , krishnagiri district of Tamilnadu and is located 21 KM towards South from Dharmapuri, 10 KM from Nallampalli and 309 KM from state capital Chennai.
Block boundary coordinate	Vellakkal Block (12.0 sq.km) is bounded by following corner cardinal cardinal points

Corner cardinal point	LATITUDE	LONGITUDE
A	12° 12' 59.8439" N	78° 25' 32.0023" E
B	12° 12' 54.5640" N	78° 26' 17.6396" E
C	12° 14' 24.7903" N	78° 26' 39.3675" E
D	12° 14' 17.0027" N	78° 27' 26.7700" E
E	12° 12' 50.2797" N	78° 27' 14.0888" E
F	12° 11' 28.9498" N	78° 26' 48.2344" E
G	12° 11' 30.2792" N	78° 26' 14.2319" E
H	12° 11' 24.8265" N	78° 26' 01.4886" E
I	12° 11' 26.7622" N	78° 25' 28.5841" E
J	12° 12' 17.7176" N	78° 25' 26.0865" E

Villages :	Vellakkal Block falls in and around Vellakkal,Vedapatti, Kattusirinpatti, Chandrapatti, Perumalnayakkanpatti and Papichettipatti in Krishnagiri District of Tamil Nadu State
Tehsil/ Taluk :	-
District :	Krishnagiri
State :	Tamil Nadu
2. Area (hectares/ square kilometres)	
Block Area :	12.0 sq.km
Forest Area :	Part of area falls in Vellakkal R.F.
Government Land Area	-
Private Land Area	-
3. Accessibility	Vellakkal Block falls in and around Vellakkal,Vedapatti, Kattusirinpatti, Chandrapatti, Perumalnayakkanpatti and Papichettipatti in Krishnagiri District of Tamil Nadu State, India. Vellakkal is a small Village/hamlet in Nallampalli Block in Krishnagiri District of Tamil Nadu State, India. It comes under Dokkubothanahalli Panchayath. It is located 21 KM towards South from Dharmapuri, 10 KM from Nallampalli and 309 KM from state capital Chennai.
Nearest Rail Head :	The Jolarpettai – Salem section of the Chennai – Coimbatore Broad Gauge line of the Southern Railway passes through the area. Morappur is the nearest Railway Station, located at about 25 km from Uttangarai and Jolarpettai railway station is located around 37.5 km from the study area
Road :	The Vellakkal Block is located is located 48 km towards South from District head quarters Krishnagiri, 12 Km from Uthangarai and 254 Km from State capital Chennai. Uttangarai is the Taluk headquarter and is well connected by all-weather roads with Krishangiri (57km), Dharmapuri (52 km), Salem (93 km) and Tiruppattur (31 km).
Airport :	The nearest airport is Bengaluru at a distance of about 185 Km from the study area.
4. Hydrography	
	The general slope of the country is towards south and the drainage is collected by easterly flowing Ponnaiyar River. The area shows the dendritic pattern of drainage.
Rivers/ Streams	Ponnaiyar River is outside of the block flowing towards south of the block
5. Climate	
Mean Annual Rainfall :	The area receives major portion of the rain from NE monsoon between September and December. Occasional showers are experienced during south west monsoon. Average annual rainfall is 850 mm
Temperatures	The area experiences typical tropical climate with the temperature fluctuating between 35°- 44°C.
6. Topography	
Toposheet Number	57L/8

	The area forms an undulating terrain with a number of NNE- SSW trending ridges, mounds and isolated hillocks. The general ground level drops from 400m above mean sea level (MSL) in the west to about 340m in the east. Maximum elevation of 397m above MSL is attained in the northwestern part of the Harur- Uttangarai Belt near Perumalnayakanpatti. The area is drained by an ephemeral river Ponnaiyar, which has an easterly flow. It has several northeasterly and southeasterly flowing tributaries.
7	**Availability of baseline geoscience data**
Geological Map	i. Detailed Geological Map (1:2000 scale) of GSI (F.S. 2019-20) for Vellakkal Central Block. ii. Traverse geological Map (1:2000 scale) of GSI (F.S. 2000-01) for Vellakkal North, South & West Blocks
Geochemical Map and Geophysical Map	Surface plan showing data of Geochemical and Geophysical Traverses on scale: 1: 2000 available for Vellakkal Central Block (GSI: 2015-16) & Geochemical (Soil/Trench) profiles available for Vellakkal North, South & West Block (GS:2000-01)
8. Historical work	1.The Vellakkal block area is part of Haur-Uttangarai Molybdeum Belt (HUB) of Tamil nadu and the area was previously explored by various workers of GSI The list of available reports of the area as listed below. 2. Report on the Reconnoitory Exploration for Molybdenum in the Extension areas of Uttangarai Sector, Harur-Uttangarai Belt, Dharmapuri Dist, Tamil Nadu, (GSI, 2002) 3. Balasubramanian, E 2007 Report on the concept oriented drilling in Vellakkal Central Block, Harur-Uttangarai Molybdenum Belt (HUB), Dharmapuri district, Tamil Nadu (FS 2001-2002) 4. Raju K. 2012 A Report on the Detailed Exploration for Molybdenum in the Vellakkal Central Block, Harur-Uttangarai Molybdenum Belt, Dharmapuri district, Tamil Nadu (FS 2010-2012) 5. Final Report on Preliminary Exploration for Molybdenum and associated mineralisaiton in Vellakkal Central Block, Segment-A, Harur-Uttangarai Molybdenum Belt, Krishnagiri District, Tamil Nadu (G3 stage).(2021)
9 Justification for taking up G3 stage mineral exploration.	➢ Amalgamated Vellakkal Cluster area is part of prominent Haur-Uttangarai Molybdenum Belt (HUB) of Tamil Nadu. During F.S.1998-2000, GSI carried out Reconnoitory exploration in Vellakkal sub block areas viz. Vellakkal North Block (390.10m in scout 4 Bhs), Central Block (300.05m in scout 3Bhs), South Block (350.25m in scout 4 Bhs) & West Blocks (275.75m in scout 3 Bhs) under an MoU with TAMIN. Based on Soil, Trench and BH core sample analysis

	data, anomalous zones for Molybdenum identified and three priority areas over 1.5 line km demarcated and recommended further exploration. ➢ During F.S. 2001-02 & F.S. 2010-11 GSI carried out concept oriented drilling program with 4 boreholes (804.45m) and 7 Boreholes (2114.55m) in Vellakkal Central Block respectively and confirmed the shear controlled molybdenum mineralisation at depth. ➢ Subsequently, GSI carried out G-3 stage exploration in Vellakkal Central Block (VLC-A) to delineate the strike and establish depth continuity of molybdenum bearing quartz vein and estimate resource. Total 7 infilling 1st level Boreholes at 100m interval and 5 nos. 2nd level boreholes at 200m interval (Total 1732m) carried out. Resource has been estimated for 1025m strike length. Total Inferred Mineral Resource (333 code of UNFC) of molybdenum ore estimated by cross section method between 364.4m to 240.0m R.L. at 0.01% cut off is 1.439 m.t. with average grade of 243.63 ppm molybdenum; 0.35 m.t. with 389.57 ppm molybdenum at 0.03% cut-off and 0.117 m.t. with 537.92 ppm molybdenum at 0.05% cut-off. ➢ GSI recommended to carry out further exploration by drilling for 2nd level and 3rd level to delineate the deeper mineralisation for higher level of confidence with additional resource in Vellakkal Central Block. Also, recommended to carryout G3 stage exploration in adjacent potential Vellakkal south block and both the blocks can be amalgamated for G2 exploration for a sizable strike length of 2.0km. ➢ The Vellakkal Central Block has been kept for auction in 1st trench by Ministry of Mines (MoM), Govt. of India during 2023-24. However, due to small size of the block with low resources/other reasons resulted in poor participation of bidders and the block was annulled. Subsequently, MoM advised to amalgamation of nearby adjoining blocks for auction in future and accordingly 4 sub-blocks pertaining to Vellakkal area handed over to MECL for amalgamation and investigate further up to G2 stage exploration. ➢ Considering the potentiality of the block, poor participation in auction of bidders and advice from Ministry of Mines, Govt. of India for amalgamation and auction of the block, MECL has amalgamated Vellakkal Central Block with adjacent

	North Block, South Block & West Block and carved out Vellakkal Block over 12.0 sq.km. to carryout exploration activities (G2) in phased manner and to estimate the resources up to G2 stage to auction the block and also fulfil the demand of Molybdenum ore in the country. ➢ The present G2 stage exploration has been formulated for the entire amalgamated Vellakkal Cluster area over 12.0 sq.km. area where G2 stage close spaced exploratory drilling planned to upgrade the resource from 333 to 332 category of UNFC. Simultaneously, Detailed Geological mapping (1:2000 scale), surface sampling, Trenching and Ground geophysical survey and followed by Phase-I exploratory drilling in the adjoining Vellakkal North Block, South Block & West Block to establish strike and depth continuity of shear controlled molybdenum mineralisation. ➢ The present exploration at G2 stage in the Amalgamated Vellakkal Cluster area would be helpful to estimate the resource under 332 category of UNFC and facilitate the Govt. to auction the block.

Proposal for General Exploration (G2) In Amalgamated Vellakkal Cluster (12.0 Sq.Km Area) For Molybdenum, Uttangarai Sector, Harur-Uttangarai Belt (HUB), Krishnagiri Distirct: State- Tamil Nadu.

1. 0 INTRODUCTION

1.1.1. Molybdenum (Mo) is a versatile alloying and refractory strategic metal mainly used as alloying agent in the special steel, cast iron, nickel, cobalt and titanium base alloys. It is cost effective alloying agent usually considered as an alternate material to replace tungsten and other metals, having wide range of applications in defence products. Roasted molybdenite concentrate, generally known as "tech-oxide", is the principal product for adding molybdenum to alloy and stainless steel. Molybdenite (MoS_2) is the principal ore of molybdenum.

1.1.2. About two-thirds of global molybdenum production is as by-product of copper mining and only about one third is obtained from primary molybdenum mines. In India, by-product concentrates of molybdenum are produced intermittently from uranium ore of Jaduguda mine belonging to Uranium Corporation of India Ltd (UCIL) in Jharkhand. The internal demand for molybdenum and its products is met mostly through imports (IMYB, 2022) and is dependent on China, US, Congo and other countries.

1.1.3 In order to sustain the current level of production of Molybdenum Ore and to meet the future demands, geological assessment of areas and exploration of Molybdenum Ore is the need of the hour.

1.1.4 In India, molybdenum is associated generally with copper, lead and zinc ores. Rakha copper deposit in Jharkhand contains 45 to 48ppm molybdenum. Malanjkhand copper deposit in Madhya Pradesh contains 0.04% recoverable molybdenum. Dariba-Rajpura lead-zinc deposit in Rajasthan contains molybdenum besides bismuth, arsenic and cadmium. The multimetal deposit at Umpyrtha in Khasi and Jaintia Hills, Meghalaya, reportedly contains molybdenum in association with copper, lead and tungsten. Molybdenum deposit in Karadikuttam in Madurai district, Tamil Nadu, contains 0.02 to 0.14% recoverable molybdenum.

1.1.5 As per NMI database as on 1.4.2020, based on UNFC System, the resources of molybdenum ore in the country have been estimated at 27.20 million tonnes containing about 16,891 tonnes MoS2 . The above resources of ore are located in Tamil Nadu (17.88 million tonnes), Madhya Pradesh (8 million tonnes) and Karnataka (1.32 million tonnes) (Indian Mineral Year Book 2022). The world reserves of

molybdenum are at 12 million tonnes, located mainly in China (31%), USA (22%), Peru (20%), Canada (11%) and Russia (3%) (Indian Mineral Year Book 2022).

1.1.6 Primary molybdenite of some significance is reported in (i) Karadikuttam area, Dindigul district, (ii) Alangayam area in Vellore district and (iii) Harur-Uttangarai Belt, Dharmapuri district, Tamil Nadu. The internal demand of Molybdenum and its products is met mostly through the imports. In future, the demand for Molybdenum will be increasing in India and this internal demand of Molybdenum will continue to be met through imports unless indigenous production is made within the country.

1.1.7 The molybdenum mineralisation in Harur-Uttangarai Belt extends from Velampatti in south to Nochchipatti in north over a strike length of 22 km. The belt comprises a main shear zone along the full strike length trending NNE-SSW with minor warping and two parallel mineralized shear zones having cumulative strike length of around 6.2 km in the west of main shear zone in the Vellakal Reserved Forest area. The belt is divided into two sectors namely Harur Sector lying south of Ponnaiyar River and Uttangarai Sector to the north of Ponnaiyar River. Geological Survey of India (GSI) & MECL carried out exploration for molybdenum by drilling in 20 blocks of Harur & Uttangarai sector of HUB.

1.1.9 In the Uttangarai Sector the mineralisation is spread over three different sub areas namely Uttangarai sub-area, Vellakal sub-area and Vellakal Reserved Forest sub-area. The Uttangarai sub-area lying along the main shear zone comprising five exploration blocks over a strike length of 8.25 km. These blocks are Ponnaiyar North Block, Mannadipatti South Block, Mannadipatti Central Block, Mannadipatti North Block and Nochchipatti Block. The Vellakal sub-area extending over a strike length of around 5 km, lying at the 4 km west of the main shear zone, comprising 4 blocks namely Vellakkal South Block, Vellakkal Central Block and Vellakkal North Block. Vellakkal West Block is the only one exploration block existing in the Vellakal Reserved Forest sub-area, lying 1 km west to the Vellakal sub-area having a strike length of about 1.2 km.

2.0. BACKGROUND INFORMATION:

2.1.1 During F.S.1998-2000, GSI carried out Reconnoitory exploration in Vellakkal sub block areas viz. Vellakkal North Block, Central Block, South Block & West Blocks under an MoU with TAMIN. Based on Soil, Trench and BH core analysis data anomalous zones for Molybdenum identified and three areas over 1.5 line km demarcated and recommended further exploration.

2.1.2 During F.S. 2001-02 & F.S. 2010-11 GSI carried out concept oriented drilling program in Vellakkal Central Block and confirmed the shear controlled molybdenum mineralisation at depth.

2.1.3 Subsequently, GSI carried out G-3 stage exploration in Vellakkal Central Block (VLC-A) to delineate the strike and establish depth continuity of molybdenum bearing quartz vein and estimate resource. Resource has been estimated for 1025m strike length. Total Inferred Mineral Resource (333 code of UNFC) of molybdenum ore estimated by cross section method between 364.4m to 240.0m R.L. at 0.01% cut off is 1.439 m.t. with average grade of 243.63 ppm molybdenum; 0.35 m.t. with 389.57 ppm molybdenum at 0.03% cut-off and 0.117 m.t. with 537.92 ppm molybdenum at 0.05% cut-off. GSI Recommended further drilling in the block and to carryout G3 stage exploration in adjacent Vellakkal south block. Based on results, both the blocks can be amalgamated for G2 exploration for a sizable strike length of 2.0km.

2.1.4 The Vellakkal Central Block has been kept for auction in 1st trench by Ministry of Mines (MoM), Govt. of India during 2023-24. However, due to small size of the block with low resources/other reasons resulted in poor participation of bidders and the block was annulled.

2.15 A meeting was held on 07/08/2024 through VC, chaired by Shri Dheeraj Kumar, Deputy Secretary, Ministry of Mines along with officials from GSI & MECL. Proposal for amalgamation of Molybdenum blocks discussed and mutual consent and agreement between GSI and MECL have led to the result that Vellakkal North (17), Vellakkal Central (18), Vellakkal South (19) and Vellakkal West (20) of the Vellakkal area handover to MECL to investigate under G3/G2 stage and amalgamate.

2.1.6 Considering the potentiality of the block, poor participation in auction of bidders and advice from Ministry of Mines, Govt. of India for amalgamation and auction of the block, MECL has amalgamated Vellakkal Central Block with adjacent North Block, South Block & West Block and carved out Vellakkal Cluster (12.0 sq.km.) to carryout G2 stage exploration in phased manner and to estimate the resources under 332 category of UNFC to auction the block and fulfil the demand of Molybdenum ore in the country.

3.0 LOCATION AND ACCESSIBILITY

3.1.1 The Vellakkal Block is part of Uttangari Sector of Harur Uttangarai Belt (HUB) lies in the southeastern part of Krishnagiri. Vellakkal Block area falls in and around Vellakkal,Vedapatti, Kattusirinpatti, Chandrapatti, Perumalnayakkanpatti and Papichettipatti in Krishnagiri District of Tamil Nadu State. The total extent of the amalgamated Vellakkal cluster area is 12.0 sq.km and falls under the parts of Survey of India Toposheet No 57L/8 and is bounded by latitudes 12° 11' 24.8265" N to 12° 12' 59.8439" N and longitudes 78° 25' 26.0865" E to 78° 25' 26.0865" E to 78° 27' 26.7700" E (Plate-I). Block boundary coordinates are given below **Table 1.1.**

Table-1.1
Co-ordinates of the corner points of the block boundary of Vellakkal Block, Harur-Uthangarai molybdenum Belt, Krishnagiri District, Tamilnadu

Corner cardinal point	LATITUDE	LONGITUDE
A	12° 12' 59.8439" N	78° 25' 32.0023" E
B	12° 12' 54.5640" N	78° 26' 17.6396" E
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I	12° 11' 26.7622" N	78° 25' 28.5841" E
J	12° 12' 17.7176" N	78° 25' 26.0865" E

3.3.2 Vellakkal Block area is located 48 km towards South from District head quarters Krishnagiri, 12 Km from Uthangarai and 254 Km from State capital Chennai. Uttangarai is the Taluk headquarter and is well connected by all-weather roads with Krishangiri (57km), Dharmapuri (52 km), Salem (93 km) and Tiruppattur (31 km). The Jolarpettai – Salem section of the Chennai – Coimbatore Broad Gauge line of the Southern Railway passes through the area. Morappur is the nearest Railway Station, located at about 25 km from Uttangarai and Jolarpettai railway station is located around 37.5 km from the study area.

4.0 Physiography, Drainage, Climate and Vegetation

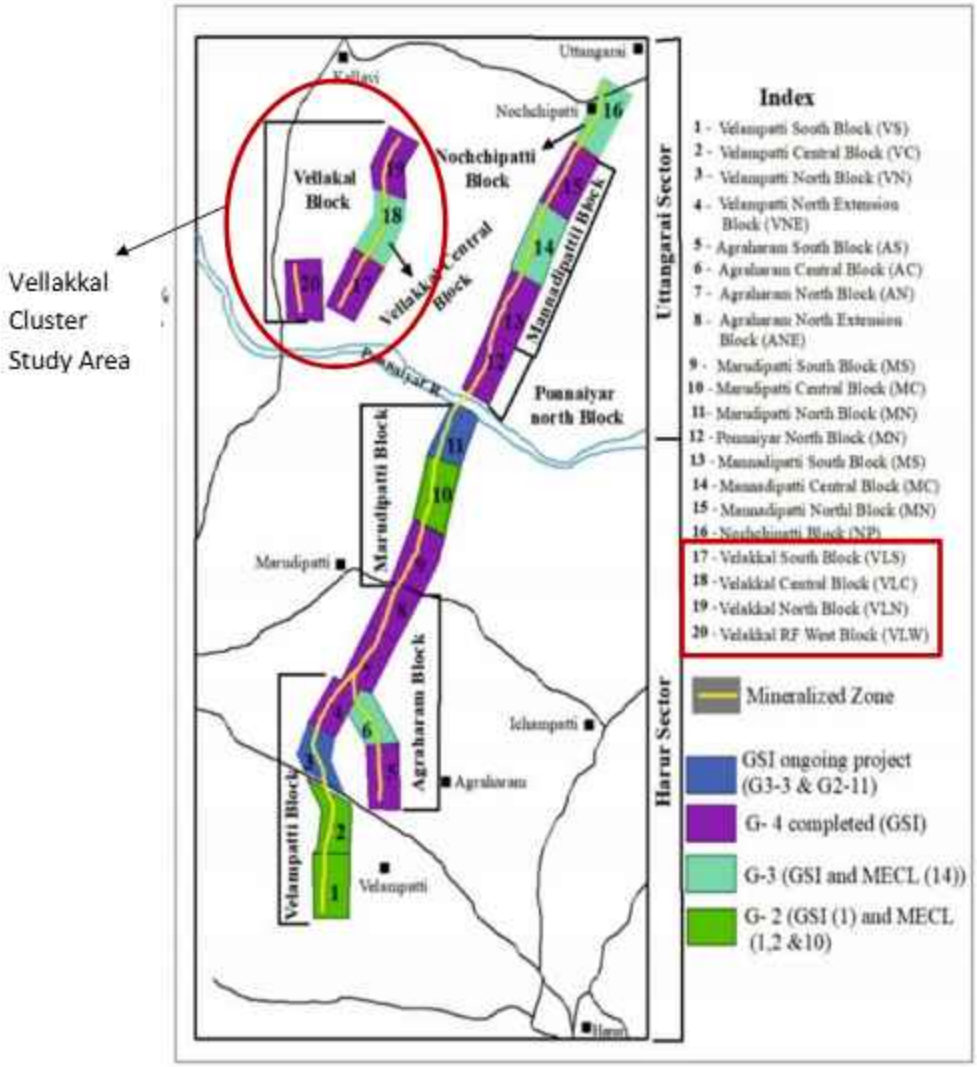
4.1.0 The study area shows gently undulating topography. The undulating terrain is partly covered by shrubby and tropical vegetation and reserve forest areas. The soil is mostly in-situ in nature, earthy and pale reddish in colour. The soil derived from gneiss and quartzo- feldspathic gneiss is mostly brownish to earthy reddish colour. The soil derived from charnockite is reddish in colour. The thickness of soil profile varies from 0.2 to 2 m.

4.1.1 The area experiences a hot semi-arid climate to tropical savanna climate . The temperature averages at 36 °C and annual rainfall averages 794 millimetres. There are three distinct seasons that is observed in the area. Monsoon season brings substantial amount of rainfall in short intervals to this region. However, the rainfall is erratic, uneven and uncertain in distribution causing frequent draught in summer. Winters are generally very warm but dry. Summer is from the months of March to June. During this time temperatures are hot to sweltering and mercury rise up to around 44°C and dipping a minimum of 32 °C April and May are generally the hottest months of the year. Depth to water table in VS block varies from 10m to 20m.

4.1.2 The area of the block falling under Vellakkal reserve forest is occupied by thorny bushes, scrub vegetation and scattered trees. The important trees in the area are margosa, mango and tarmarind. The area on either side of the HUB is occupied by cultivable lands, main crops being paddy, maize, ragi, cotton, sugarcane and groundnut. The fauna found in the area are rabbits, dears, wild boars, kraits and pythons.

Text Figure-1: Location of the Amalagmated Vellakkal Cluter Area,

Harur-Uttangarai Molybdenum Belt, Tamil Nadu



5.0 REGIONAL GEOLOGY AND STRUCTURE

5.1.0 The Southern Indian Peninsular Shield (SIPS) comprises the Archaean Granite–Greenstone terrains of Dharwar Craton in the north and the high-grade Southern Granulite Terrain (SGT) in the south. The SGT is separated from the Dharwar Craton by the orthopyroxene isograd identified by Fermor , which essentially separates the charnockitic and non-charnockitic terrains in the shield (Fermor,1936) . The SGT south of the transition zone is traversed by a set of major faults/ or shear zones, the most prominent are the shear systems of Moyar– Bhavani, Palghat–Cauvery and the Achankovil-Thenmalai. The high-grade domain to the north of the Palghat–Cauvery shear zone (PCSZ) is referred to as the "Northern Block" and the domain to the south of the PCSZ is referred as the "Southern Block". The northern block is further sub divided into four major tectonic blocks namely, Chittor Block (CB), Tattakkarai-Krishangiri Block (TKR), Madras Block (MB) and Dharmapuri Suture rift zone (DSRZ) in which Alkaline Carbonatite complex has been emplaced during 770±30 M.y (Gopalakrishnan et al, 1991 and Gopalakrishnan , 1994). The alkaline carbonatite complex is a NNE-SSW trending 200 km long and 40 to 50 km wide Alkaline – Carbonatite litho tectonic belt, extending from Gudiyattam in the north to Bhavani in the south and it is bounded by two major lineaments – the Harur lineament in the east and Dharmapuri lineament in the west (E Balasubramaniam, 2002).

5.1.1 Towards the eastern part of the Salem block, there are many alkaline ring complexes occuring along a linear zone bounded between Mettur and Jawadi hill lineaments (Renjith et al., 2016) and REE exploration recently carried out by Renjith et al, 2019 and Jayapal, S. et al, 2019has indicated promising mineralisation in the alkalinecarbonatites in the areas

5.1.2 The alkaline carbonatite complex is characterised by a number of sub-parallel NNE SSW trending shear zones. Harur-Uttangarai Molybdenum Belt (HUB) is one among them, falling in the Survey of India toposheet NO. 57 L/8. The Harur-Uttangarai molybdenum belt (HUB) extends for 28 km between Velampatti in the south and Nochchippatti in the north. The entire belt has been divided into three zones viz. i) Harur-Uttangarai shear zone of 22 km length ii) the Vellakkal Reserve Forest shear zone of 5 km length (Vellakkal sub area) and iii) the Vellakkal west shear zone of one km length .The rock types exposed in the area are primarily epidote-hornblende gneiss and quartzo-feldspathic gneiss which are contemporaneous in nature. Enclaves of pyroxene granulite, metapyroxenite, meta-gabbro and charnockite are noticed within the gneisses. The quartz veins, emplaced along the shear zone are the youngest rock type in the area

5.1.3 The area is marked by three prominent structural fabrics trending NE-SW, NW-SE to WNW-ESE and N-S to NNE-SSW. The north-easterly fabric with moderate to steep north westerly dips characterise the regional gneissosity of the rock type. Foliation is well developed in the gneisses, which show a general strike of NNE-SSW. The mineralised shear zone trends in NNE-SSW direction with 45° to 60° SE dips and is marked by the emplacement of reef quartz, well developed shear planes, wall rock

alteration in form of development of sericite, epidote etc.. Occurrence of sulphide minerals such as molybdenite, galena, pyrite and development of limonite are conspicuous in the shear zone.

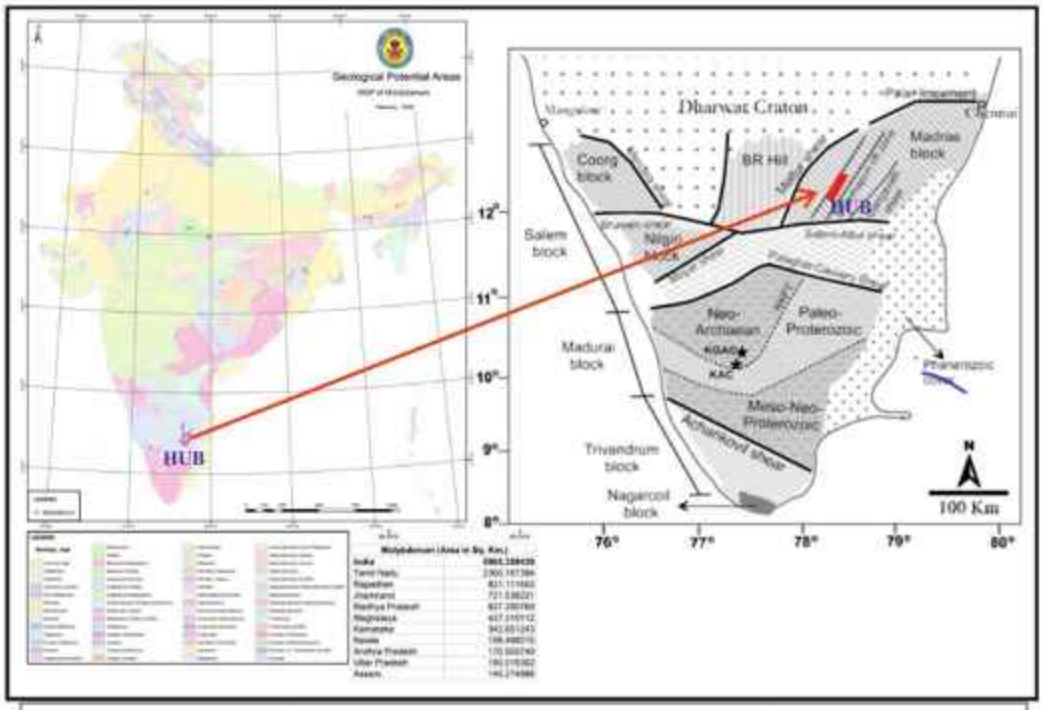


Fig. Location of the study area in regional geological set up map

5.1.4 A generalised stratigraphic sequence for this litho-tectonic belt as worked out is as follows (Gopalakrishan K, 1991).

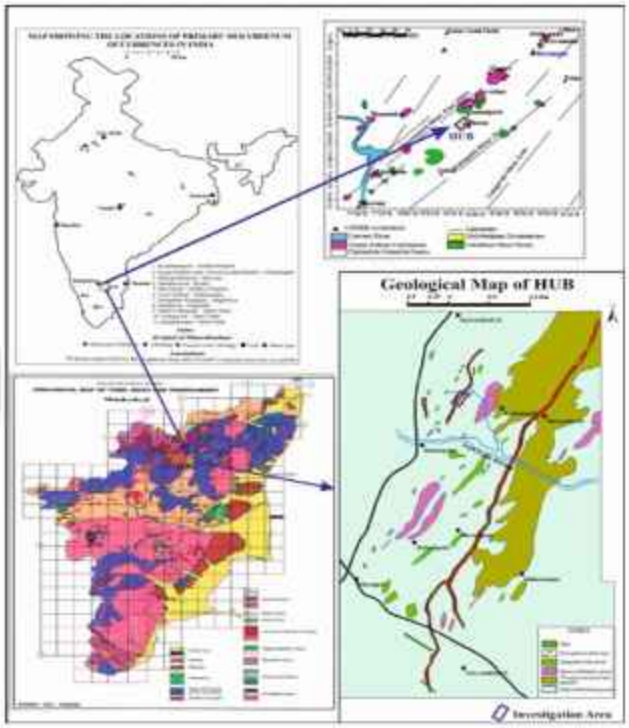
Younger intrusives	Quartz / Pegmatite vein, Pink Granite
Alkaline-Carbonatite Complex	Carbonatite / Ankerite bearing Gneiss, Felsite dyke/Lamprophyre Alkali Granite, Syenite, Dunite, Alkali Pyroxenite
Gneissic Complex	Coarse granular hornblende Gneiss / Epidote hornblende gneiss / Quartzo-feldspathic gneiss
Basic intrusive	Basic dykes – gabbro / dolerite
Peninsular Gneissic Complex (PGC-II)	Pink granite, white granite, Agmatite gneiss, Augen gneiss, Grey biotite gneiss
Charnockite Group	Charnockite, Pyroxene granulite, Meta pyroxenite, Meta-gabbro, Magnetite quartzite, Norite
Sathyamangalam Group	Quartzite, Ferruginous quartzite, Amphibolite

5.1.5 The present investigation area is a part of Dharmpauri shear zone, which well characterized by retro grade metamorphism by fenitisation of charnockite into hornblende gneiss ± epidote, here from the higher temperature mineral lower temperature mineral are forming. The metamorphic imprints can be studied from alteration of charnockite in the terrain. The area is a part southern granulite terrain,

where the existing lithology is subjected into granulite facies of metamorphism. They are mainly by epitotized hornblende gneiss in the area, which is also linked with sulphide mineralization in the terrain. The terrain has granulite facies metamorphism occurred at c. 2500 Ma (Harris et al.1994). The study of Harriset.al, 1994, from carbon– isotope composition in fluid inclusions from the charnokite of this SGT region (−4% to −12%) and suggested that the Archean granulite facies metamorphism is associated with the volatiles released at the subduction zone. This study supports the presence of a subduction zone and the associated formation of charnockites at this zone and the evolution of the granulites in the region may thus be related to the collision process. Thus, the metamorphic history can be reviewed for the northern SGT, which also includes the present study area.

5.1.6 Many shear zones trending NNE-SSW are present well within the major shear zone (DSZ). The Dharmapuri shear zone trends NNE-SSW of 200 km long and 50 km wide, which bounded by Mettur shear in the west and Javadu lineament in the east. The shear zone is parting by Pambar lineament in the west. Many alkaline carbonatites are occurred as rift related tectonic activity in the area.

5.1.7 Regionally the Dharmapuri shear zone has been reported for strategic mineral such as Molybdenum, base metals, Uranium and REE. The shear zones present within the DSZ are evidenced by surface indication of sulphide mineralization by injection of quartz-barite vein form south to north of the shear zone. The limonitic stains, ferruginisation and red to maroon colour strains for indications of molybdenum mineralization over the quartz veins are reported. The HUB is one among them to study the presence of molybdenum mineralization, which is well revealed by surface indication of mineralization.



6.0 GEOLOGY & STRUCTURE OF THE BLOCK AREA

6.1.0 The area exposes a parallel mineralized shear zone over a strike length of 5 km (Vellakkal North Block, Central Block & South Block) and 1.2 km strike length in Vellakkal West Block. The study area belongs to three stratigraphic divisions viz. charnockite group (meta pyroxenite and meta-gabbro), gneissic complex (hornblende gneissic ± epidote and quartzo feldspathic gneiss) and younger intrusive of quartz vein/reef. The general foliation of the lithology in the area is NNE-SSW (N15-30°E-S15-30°W) with moderate to steeply (35° to 70°) dipping mostly towards east. Away from shear zone, it is dipping moderately towards west depends on shear intensity, which is similar to regional foliation. The area exposes quartz, felsite, Ankerite gneiss, Basic dyke, quartzo feldspathic gneiss, Hornblende gneiss +-epidote, Charnockite, meta ultramafite/meta pyroxenite, meta gabbro. Hornblende gneiss +- epidote is the major rock type exposed in the area. The shear zone comprised the lithology of quartz, hornblende and quartzo feldspathic gneiss.

6.1.1 Nature and control of mineralization and its surface distribution clearly shows that the Mo mineralisation in the HUB is controlled by shear. the study area is characterized by a prominent Zone of shearing. The zone of shearing is a broadly demaracated zone within which, the rocks are mostly sheared to varying intensitites and contitues potential loci for mineralisation under favourable conditions. The zone of shearing traced from 0.5km n of Ponnaiyar River to Perumalnayakkanpattai for a strike distance of about 5kn. the zone, which trends N300E-S300W in the southern half veers to $N10^0E$-$S10^0W$ in the northern half. the width of the zone varies from 18m to 100m. in the Vellakkal West area the zone of shearing comparatively of limited extent, traced from about 1.2 km strike length, trenching $N10^0E$-$S10^0W$.

6.1.2 In Vellakkal central block, the major quartz vein is occurring as discontinues pattern with pinch and swell pattern, other than this few small lenses of sheared quartz veins mapped parallel to major vein. The density of exposure in the investigation block is limited, are dominated of quartz vein and few patches of, quartzo-feldspathic gneiss, epitotised hornblende gneiss, meta-gabbro and meta pyroxenite. Surface alteration was noticed in the form (kaolinite and illite) limonite and ferruginisation as a secondary iron oxides associated with mineralisation within shear zone. Strong shear indications and fluid activities have been reflected in the area from quartz and gneiss, are suggestive a strong shearing followed by hydrothermal activities took place in the area.

Table 5.2. Local stratigraphy of the study area (after GSI)

Lithology	Formation	Group	Age
Quartz reef, quartz veins	Younger intrusives	Uttangarai Gneiss	Younger
Hornblende gneiss ± epidote, Quartzo feldspathic gneiss	Uttangarai Gneiss	Gneissic Complex	Middle to Upper Proterozoic
Meta-pyroxenite, meta gabbro		Charnockite Group	Archaean

7.0 MINERALISATION

7.1.0 Sulphide mineralisation is mainly confined to NNE-SSW trending quartz reef/veins and sheared gneiss (mylonitised, chloritized hornblende and quartzo-feldspathic gneiss) in the block . Sulphides such as chalcopyrite and galena occurred as specks along the fracture planes, whereas the visible molybdenum mineralization is not present, but ferri-molybdenite is occurred along the fracture planes in the sheared quartz vein. Otherwise, Surface evidence of primary sulphide mineralisation (galena, pyrite, molybdenite) is observed in the quartz vein. Alteration is prominent such as limonitisation, ferruginisation and sulphide stains with ferri-molybdenite (Fig.7.1A,B,C&D) are observed as surface encrustation along the shear and fracture planes over the altered quartz vein. Presence of vugs quartz, cavities and box work structure formed due to the removal of sulphides give indirect evidence of sulphide mineralization of hydrothermal process. The fluid movement along the fracture planes are clearly noticed over the sheared quartz vein (Fig.7.1.C).

7.1.1 Sulphide mineralization in the Vellakkal central block, segment-A is lucidly exposed in sub-surface. The distribution of molybdenum mineralisation is spread out in the mylonitised quartz vein and quartzo-feldspathic gneiss within the shear zone (Fig 7.2.A).The molybdenum mineralisation occurs in the form of disseminations,smears, veinlets and fracture filling in quartz vein (Fig 7.2.C.D &E). The chalcopyrite and galena are occurred as specks, veinlets and fracture filling. The mineralized quartz vein has mafics inclusion of gneiss and meta-gabbro and the sulphide mineralisation only confined to the shear zone and here the shear zone control the sulphide mineralisation(Fig 7.2.A&B) in the area.

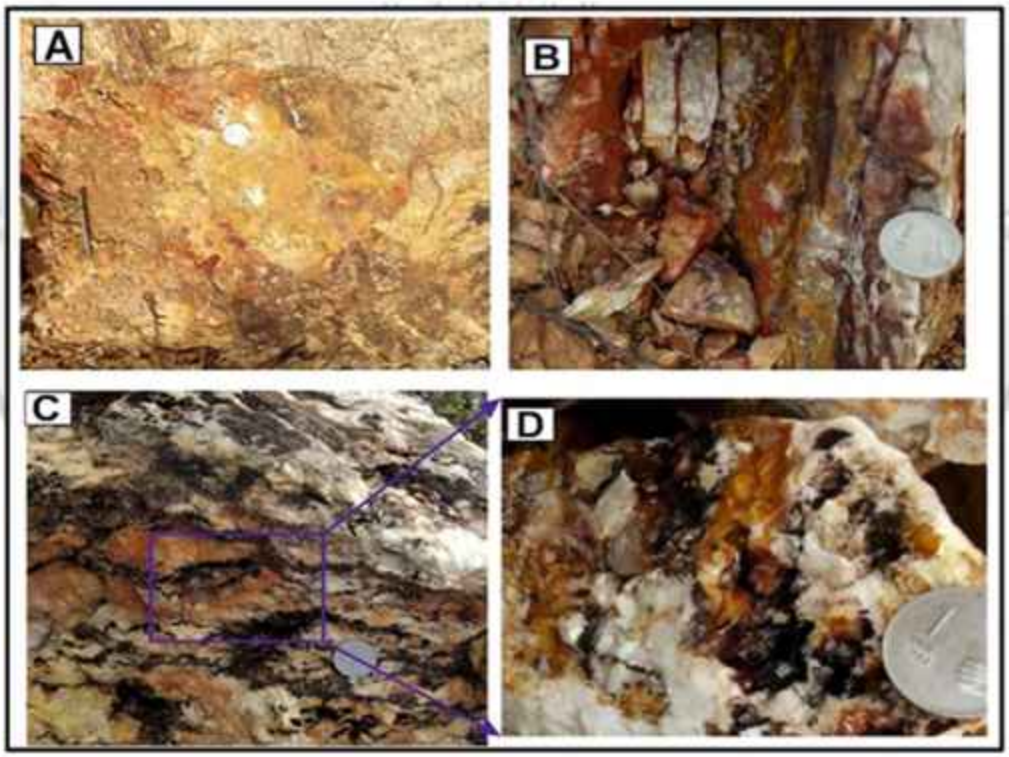


Figure.7.1.Photographs showing surface manifestation of sulfide mineralization: (A & B): Limonitisation and ferruginisation along the shear and fracture planes (C& D): Oxidised sulphide minerals over the sheared quartz veins.

7.1.2 In VLC-A block, molybdenum mineralisation occurs in the NNE-SSW trending quartz vein as well as in the sheared and sericitised gneiss intruded by the vein. Molybdenite occurs as, fine granular aggregates and disseminated grains and occupies the hairline fractures prevalent in the quartz veins. Better concentration of molybdenite is seen at the branched quartz veins with fracture filled mafic inclusion as well as contact between quartz stringers and the sheared and hydrothermally altered rocks, along the shear planes and all along the boundaries of the caught up patches of sheared country rock within quartz vein. Molybdenite is commonly associated with galena, chalcopyrite and pyrite.

7.1.3 The mineralized quartz vein are bordered by a wide envelope of pervasive alteration zones, manifested by chloritisation, sericitisation and silicification. The mineralisation appears to be hydrothermal in origin as indicated by wall rock alteration and silicification and its nature of occurrence within the host rock. The shear zone marked by its close spaced shear planes had provided favourable pathways for hydrothermal fluids to travel along and localize the mineralization within it.

Figure.7.2.(A&B): Photographs of core sample shows the distribution of sulphide mineralisation in quartz vein with intercalated patches of mafic minerals. C: The dispersion/dissemination of minute molybdenite, chalcopyrite and pyrite grains within the quartz vein. (D-1). Veinlets of molybdenite along the fracture plane in associated with galena. (D-2). Specks of galena in association with molybdenite and pyrite within quartz vein. (E).Molybdenite occurring as smears like a thin coating on the shear plane. (F-1): Veinlets of chalcopyrite along the fracture planes in quartz veins (F-2) Specks of chalcopyrite. (F-3) Segregation of galena in association with pyrite and minor amount of chalcopyrite. (G) Fracture filling of chalcopyrite and galena with minor amount of molybdenite.

8.0 PREVIOUS WORK

8.1.0 Harur-Uthangarai Molybdenum Belt (HUB) is NNE-SSW trending shear zone located in the eastern part of DSRZ (Dharmapuri Suture Rift Zone) and the presence of molybdenum has been well established within it. Vellakkal Block is a part of the HUB.

8.1.1 **Iyengar (1961)** reported the occurrence of hornblende gneiss as the predominant lithology in the Harur-Uttangarai belt. Though, the first work for molybdenum prospect was carried out by Rao (1977) and Selvan (1979) who traced the quartz vein west of Velampatti village to locate possible molybdenum occurrences.

8.1.2 **Swaminarayanan and Jayabalan (1994)** conducted geological and geochemical surveys in the extension areas of Harur molybdenum belt and brought out Pudur – Nochchipatti quartz vein on 1:25,000 scale. West of this quartz vein, another parallel quartz vein extending over for 5 km along NE–SW direction with galena, chalcopyrite, pyrite and molybdenite were also located by them in the Kallavi – Vellakkal Reserve Forest.

8.1.3 **Srinivasan B.V et al, (1998-2000) of GSI** carried out Reconnoitory exploration for molybdenum in Uttangarai Sector and Vellakkal subareas under an MoU with TAMIN, a Govt. of Tamil Nadu undertaking. The objective of Reconnoitory exploration was to prioritize areas within the 14.45 km long Uttangarai Sector for further detailed work. Geological mapping, soil sampling, trenching and trench sampling were carried out on the surface to delineate the anomaly zone for Mo. The anomaly zone so delineated were tested for depth continuation up to 50m below ground level by scout drilling on selected profiles in Vellakkal North Block (390.10m in scout 4 Bhs), Central Block (300.05m in scout 3Bhs), South Block (350.25m in scout 4 Bhs) & West Blocks totaling 275.75m in scout 3 Bhs.

8.1.4 In Vellakkal sub areas (Vellakkal North, Central & South blocks), considering Mo values of >8ppm (threshold) in soil profiles a cumulative 2.9 line k.m. comprising nine disconnected segments ranging from 100 m to 700m and 300m in two separate segments ranging in length from 100m to 200m are delineated as anomalous. In respect of trench samples, considering Mo values of >20 ppm (anomaly value) a cumulative length of 2.45 line k.m. comprising seven disconnected segments ranging in length from 200 to 950m is demarcated as anomalous. In Vellakkal RF sub Area (west block), the results of trench samples show anomalous value over a strike length of 500m. Considering intersection of a minimum of 0.01 % Mo over 1m as anomalous in respect of drilling results, three segments of 0.2, 0.2 and 0.7 km in Vellakkal area are delineated as anomalous. Total three priority areas over cumulative 1.550km strike length demarcated in Vellakkal sub areas.

8.1.5 **Balasubramanian (2007),** carried out a concept oriented drilling programme (G-4) in the Vellakkal Central Block. An area of 0.65sq.km was mapped on 1:2,000 scale. Four boreholes including two orthogonal boreholes viz, VLC-4 and VLC-5 and two vertical boreholes viz, VLC 6 and VLC-7 were drilled in a single profile (P10-P10') total depth of 804.45 m and established successive sub-horizontal lensoidal/sigmoidal mineralised zones. The analytical result shows that boreholes VLC-5 intersected 1.5m Mo lode with average grade of 150ppm, BH: VLC-4 intersected 2.78 m Mo lode with average grade of 331 ppm, BH: VLC-6 had intersected 4m Mo lode with average grade of 129.72ppm at 100 ppm cut-off and BH:VLC-7 had not intersected any lode at 100 ppm cut-off. Other sulphides viz., Cu value ranges from 6 to 141ppm; and Pb value ranges from 10ppm to 1.34%. Representative core samples (20 nos.) were analyzed for Rhenium (Re) from Manadipatti Central and South, Vellakkal Central and Ponnaiyar Blocks of which 15 samples show more than 4.0 ppm of Re with highest values of 8.3 ppm.

8.1.6 **Raju K (2012),** carried out a concept oriented exploration (G-4) carried out with drilling in Vellakkal Central Block (VLC Block) for the strike length of 1.7 km with width up to 150m. Out of seven boreholes drilled, two boreholes viz, AVLC-1 and AVLC-4 were drilled as orthogonal boreholes at 50m vertical intersection and five boreholes viz, AVLC-2, AVLC-3, AVLC-5, AVLC-6 and AVLC-7 were drilled along the Shear zone in profile lines P20-P20',P8 P8',P14-P14',P16-P16'and P12-P12' respectively. Three Mo lodes were intersected in BH AVLC-4 with an average thickness of 1.5 m and an average grade of 240 ppm of Mo. Along shear zone boreholes have intersected 3 to 10 numbers of Mo lodes with average thickness of 3 m and average grade 250 ppm of Mo. The maximum thickness of lode is 4.9 m with maximum Mo value of 832 ppm. Based on the analytical results of the core samples, resource has estimated for molybdenum at 100ppm, 300ppm and 500ppm cut off in Vellakkal Central Block considering boreholes AVLC-5, AVLC-6 and AVLC-7 for 250m strike length. The estimated resources as follows (i) 47,986 tonnes with an average Mo grade of 0.0518% for a cut-off of 500 ppm of Mo, ii) 84,966 tonnes with an average Mo grade of 0.0339% for a cut-off of 300 ppm of Mo and iii) 2,10,032 tonnes with an average Mo grade of 0.0223% for a cut-off of 100 ppm of Mo . The resource estimated for copper ore is 20,210 tonnes with average grade of 0.3%Cu for strike length of 175 m and the lead ore is 56,133 tonnes with an average grade of 1.15% Pb for strike length of 175 m.

8.1.7 **G3 Stage Exploration in Vellakkal Central Block (FS 2019-20):** In Vellkkal central block, reconoitary exploration with test borehole and subsequently, two concept oriented drilling programms were carried out in G-4 stage and molybdenum resource was estimated for 250m strike length from three shear along boreholes. Therefore, next stage of G3 exploration planned for establishing molybdenum mineralisation for entire block. During FS 2019-20, GSI carried out G3 stage Preliminary exploration for molybdenum and associated mineralisation (G-3 stage) in Vellakkal Central block, Segment-A (VLC-A block), Krishnagiri District, Tamil Nadu with objectives to delineate the strike continuity and establish the depth persistence of molybdenum bearing quartz vein and also to estimate the resource of molybdenum. The work in the VLC-A block was mainly comprised of 1734 meter of drilling and core sampling, pitting and trenching with sampling, systematic bed rock sampling, ground geophysical survey, geophysical logging and components of laboratory studies viz. petrological studies of thin sections, ore microscopy, SEM-EDX studies, EPMA and fluid inclusion studies to understand the mode of occurrence, nature of mineralisation and its genesis. Total seven infilling I level boreholes at 100m spacing was planned to check the continuity of the subsurface geometry of shear zone with Mo mineralisation. Subsequently based on promising mineralised zones intersected in I level boreholes, five II level boreholes were drilled along five profiles with 200 m spacing, and a cumulative of 1734m drilling was achieved. Based on borehole data zones were delineated at 100ppm, 300ppm and 500ppm cut-off over 1.0m thickness. Zone details reproduced from GSI report as below.

Table.8.6. Details of mineralised zones/ ore zones of all boreholes (at 100ppm cut off-grade) in Vellakkal Central block, Segment-A, HUB.

Profile	Borehole Name	Level	Lode	From (m)	To(m)	Thickness (m)	Average grade of (Mo) in ppm
P0-P0'	TNKVCA-7	I	1	69	70.5	1.45	154.73
	TNKVCA-12	II	1	113.5	115	1.48	481.88
P2-P2'	TNKVCA-1	I	1	77.5	79	1.48	563.3
P4-4'	TNKVCA-2	I	1	67.9	73.3	5.38	160.8
			2	77.2	78.7	1.48	399.32
			3	79.7	81.3	1.54	146.9
	TNKVCA-8	II	1	122	124	1.5	104.14
P8-P8'	TNKVCA-3	I	1	61.4	65.1	3.68	221.62
			2	79.25	80.75	1.49	141.46
			3	85.3	91.5	6.17	239.78
	TNKVCA-9	II	1	113.55	121.9	8.06	479.55
			2	134.5	136.2	1.69	m
P10-P10'	VLC-4*		1	59.1	61.35	2.17	331.55
	VLC-5*		1	34.6	36.05	1.45	150.07
	VLC-6*		1	71.2	75.7	4.07	129.72
P12-P12'	TNKVCA-4	I	1	61.5	63	1.49	110.13
			2	65	69	3.98	308.66
			3	75.5	77	1.49	106.41
			4	79.5	82	2.49	158.08
	TNKVCA-10	II	1	111	114.5	3.45	177.21
P14-P14'	VLC-2*		1	38.5	42.9	4.25	154.1
	AVLC-4*		1	76.5	79.5	2.81	190
			2	90	92	1.81	247
			3	93	94.5	1.48	240
P16-P16'	TNKVCA-5	I	1	87.3	94.5	7.06	256.02
		II	1	163.5	165	1.48	112.51
P18-P18'	TNKVCA-6		1	94	98.5	4.23	234.14
P20-P20'	AVLC-1*	I	1	103.95	105.5	1.52	154.84

*Previous Borehole

Table 8.7. Details of mineralised zones/ ore zones of all boreholes (at 300ppm cut off-grade) in Vellakkal Central block, Segment-A, HUB.

Profile	BOREHOLE	Level	Lode	From (m)	To(m)	True thickness(m)	Average grade (Mo) in ppm
P0-P0'	TNKVCA-12	II	1	113.5	115	1.48	481.88
P2-P2'	TNKVCA-1	I	1	77.5	79	1.48	563.3
P4-P4'	TNKVCA-2	I	1	77.2	78.7	1.48	399.32
P8-P8'	TNKVCA-3	I	1	87.3	91.5	4.18	312.85
	TNKVCA-9	II	1	113.55	122.4	8.45	479.55
P10-P10'	VLC-4*		1	59.1	61.35	2.17	331.55
P12-P12'	TNKVCA-4		1	65	69	3.98	308.66
P14-P14'	AVLC-4*		1	90	91.5	1.48	306.66
P16-P16'	TNKVCA-5	I	1	89.75	94.5	4.67	330.23

* *Previous Borehole*

Table.8.8. Details of mineralised zones/ ore zones of all boreholes (at 500ppm cut off-grade) in Vellakkal Central block, Segment-A, HUB.

Profile	Borehole Name	Level	Lode	From (m)	To(m)	Thickness (m)	Average grade of (Mo) in ppm
P2-P2'	TNKVCA-1	I	1	77.5	79	1.49	563.3
P8-P8'	TNKVCA-3		1	87.3	88.8	1.49	579.31
P8-P8'	TNKVCA-9	II	1	114.5	121.9	7.14	524.96
P16-P16'	TNKVCA-5	I	1	90.5	92.5	1.97	534.41

8.1.8 Resource has been calculated for 1025 m strike length with adaptation of two methods in the area. The total inferred resource of molybdenum ore estimated by cross section method between 364.4m to 240.00 m R.L. at 0.01 % cut off is 1.439 million tonnes with average grade of 243.63 ppm molybdenum ; 0.35 million tonnes with average grade of 389.57 ppm molybdenum at 0.03% cut-off and 0.117 million tonnes with average grade of 537.92 ppm molybdenum at 0.05% cut-off. Inferred resource of molybdenum ore estimated by L-V section method between 364.4m to 240.00 m R.L. is 1.21 million tonnes with average grade of 234.2 ppm Mo at 0.01% cut-off ; 0.31 million tonnes with average grade of 387.20 ppm Mo at 0.03% cut-off and 0.097 million tonnes with average grade of 538.18 ppm Mo at 0.05% cut-off . As per UNFC guidelines, the revised resource estimated in Vellakkal Central block, Segment-A area is coming under 333 or inferred resource category.

9.0 OBSERVATIONS & RECOMMENDATIONS OF PREVIOUS WORK

9.1.0 Reconnoitory Exploration (FS1998-2000) carried out in Vellakkal sub areas by GSI recommended that boreholes may be drilled at a strike interval of atleast 100m to establish the strike continuity and variations in nature of mineralisation along the strike. It is also suggested that a few second level boreholes may be drilled to test the mineralization at 100m vertical depth. During the course of detailed exploration by close spaced drilling a few boreholes may be oriented to study the disposition of the quartz bodies, which form the second order control of mineralisation to arrive at a meaningfull resource potential. The presence of Rhenium (Re) to the tune of 5.3 ppm in the borehole core samples of mineralized shear zones significantly add value to the prospect. The entire sheared mineralized zone must be subjected to detailed analysis for Re.

9.2.0 G3 stage exploration of GSI (FS 2019-20) carried out in Vellakkal Central Block reported that the molybdenum mineralisation was intersected in almost all I and II level borehole with nos. of lodes ranging from 1 to 3 except one second level boreholes. Therefore, 100m spacing of II level boreholes and 200m spacing of III level boreholes are recommended to delineate the deeper mineralisation with higher level of confidence for additional resource in the block.

With this outcome, Vellakkal south block (adjacent block of VLC-A block) can be proposed for G-3 stage of exploration to establish the continuity of molybdenum mineralisation in the Vellakkal Central shear zone to arrive an amalgamation resource bearing block. If the south block shall be promising, then Vellakkal central and south blocks can be amalgamated for proposing G-2 stage of exploration for a sizable strike length about 2 km.

10.0 MINERAL POTENTIALITY

10.1 Amalgamated Vellakkal Cluster area (12 sq.km.) comprising of 4 sub blocks (Vellakkal central, North, South & West block) is part of prominent Harur-Uttangarai Molybdenum Belt of Tamil Nadu. Previous work of GSI established Molybdenum resource up to G3 stage in Vellakkal Central Block and Reconnoitory exploration with few scout boreholes in adjacent Vellakkal North block, South Block and West Block indicated presence of molybdenum mineralization along the zone of shearing. Further work is warranted to prove the strike and depth continuity of mineralisation. Hence, the amalgamated Vellakkal Cluster area hold potential to carryout exploration up to G2 stage.

10.2 Keeping in view the present critical mineral demand for Mo, potentiality of the prospect and advise by MoM, the present G2 Exploration program has been formulated for the amalgamated Vellakkal Block (12 sq.km.) to prove the strike and depth continuity of Molybdenum mineralisation and to estimate the resource up to G2 stage with higher confidence level and to facilitate the Govt. for auctioning of the block.

11.0 PRESENT WORK

11.1 The present G2 level Exploration shall be carried out in the Amalgamated Vellakkal Block (12.0 sq.km.) in phased manner. Present work comprises of G2 stage Exploratory drilling work with allied activities, laboratory studies in Vellakkal Central Block. Simultaneously, Detailed geological mapping with surface geochemical sampling, topographic survey, trenching work, ground geophysical survey followed by Phase-I drilling work and associated laboratory studies in Vellakkal North Block, South Block and West Block. Based on the outcome of Phase-I drilling, further course of action shall be taken up for Phase-II drilling after review with TCC.

The present G2 level Exploration planned to estimate the Mo resource under 332 category of UNFC in the amalgamated Vellakkal Block. Objectives of present exploration is as follows. The Objectives of present exploration (G2) is as follows.

For Vellakkal Central Block:

- To establish strike & depth persistence of molybdenum mineralisation at close spaced interval considering the data of previous G-3 stage exploration.
- Drill infilling 1st level & 2nd level boreholes at 50m spacing interval (up to 100m V.D.) and 3rd level boreholes spaced at 100m interval (up to 150m V.D.) to prove

the strike and depth persistence of Mo mineralisation throughout the 1130m strike of the block.

- To carry out the geotechnical studies for assessment of strength of rocks occurring in the block.

- To ascertain the amenability of the molybdenum ore through bench scale beneficiation studies.

- To assess the quality and quantity of the resources (332) as per UNFC norms & Minerals (Evidence of Mineral Contents) Rules- 2021.

For Vellakkal North, South, & West Block (Phase-I)

- To carry out Detailed geological mapping on 1:2000 scale with surface geochemical samples (Bedrock/channel) from the area.
- To carry out Topographical survey at 2m contour interval in the entire block area.

- To carryout ground geophysical survey (Induced Polarization (I.P) cum Resistivity, S.P. & Magnetic method) to delineate the sub-surface continuity of Molybdenum bearing areas.

- To carry out Trenching work (300 cu.m) in the identified anomalous areas at suitable profiles.

- To carryout Phase-I exploratory drilling to establish the strike and depth persistence of ore zones at 1st at 100m spacing interval and 2nd level at 200 m spacing interval throughout the strike of ore body.

- Based on the outcome of Phase-I drilling further course of action shall be taken up.

12.0 PLANNED METHODOLOGY

During previous exploration of GSI, Vellakkal North Block, South Block and West Block covered by Reconnoitory Exploration with limited number of scout boreholes and confirmed the Mo mineralization in depth. Moreover, G3 stage exploration carried out by GSI (FS2014-15) in Vellakkal Central Block and estimated Mo resource. The present exploration strategy planned to carry out exploration up to G2 stage in all four sub blocks (Vellakkal North block, Central Block, South Block & West Block) in the the amalgamated Vellakkal Block.

The proposed G2 Exploration program for Molybdenum ore in the amalgamated Vellakkal block (12.0 sq.km.) comprises of Detailed Geological mapping on (1:2,000

scale), ground geophysical survey and exploratory drilling (phased manner) along with associated survey, chemical analysis, physical analysis, beneficiation studies and Report preparation. The Exploration shall be carried out as per Minerals (Evidence of Mineral Content) Rule-2015. Accordingly, the following scheme of exploration is formulated in order to achieve the objectives. The details of different activities to be carried out in sub-blocks under G2 stage are presented in subsequent paragraphs.

12.2. VELLAKKAL CENTRAL BLOCK:

12.1.2 Geological Mapping & Survey:

Detailed Geological Map on 1:2000 scale prepared during G3 stage exploration (GSI) is available for Vellakkal central block. During the present exploration the geological map shall be updated with available features and utilise for drilling work. Topographical contour map of Vellakkal Central block at 1.0m contour interval is already available. During the present investigation the block area shall be referenced with survey stations and update the features if any.

12.1.2 Drilling:

During the previous G3 stage exploration (GSI), boreholes were drilled for 1st level and 2nd level intersections at 100m spacing interval. The present G2 stage exploration is planned to fill up the gap areas by close spaced drilling at 50m strike interval and to intersect molybdenum mineralization for 1st and 2nd level at 50m interval and for 3rd level at 100m spacing interval to prove the strike and depth continuity of molybdenum mineralisation over 1150 m strike length in Vellakkal Central Block. Total 6390 m drilling in 35 boreholes planned for 1st, 2nd and 3rd level intersections. Out of these, 9 boreholes (1090m) planned targeting to intersect 1st level intersection at 50m spacing interval up to 50m vertical depth, total 13 Boreholes (2300m for 2nd level intersections at 50m spacing interval upto 100m vertical depth and 11 boreholes (2740m) planned for 3rd level intersections at 100m spacing interval up to 150m vertical depth from surface. 1st level and 2nd level at 50m interval are infilling boreholes while 3rd level boreholes at 100m interval targeted to prove deeper level Mo mineralisation in the area. The present exploration at G2 stage would be helpful to upgrade the resource to 332 category of UNFC. The details of proposed boreholes in Vellakkal Central Block of Vellakkal block are given in below **Table 12.1.**

Table No.12.1:

Details of proposed boreholes in Vellakkal Central Block of Vellakkal Block (G2 Stage)

S.No.	Sectio No.	Proposed BH No.	Proposed Depth (m)	Inclination (^{0})	Azimuth	Level
1	P1	PBH01	110	45	N60^{0}W	1st
2	P3	PBH02	130	45	N60^{0}W	1st
3	P5	PBH03	120	45	N60^{0}W	1st
4	P7	PBH04	130	45	N60^{0}W	1st
5	P9	PBH05	120	45	N60^{0}W	1st
6	P11	PBH06	120	45	N60^{0}W	1st
7	P13	PBH07	120	45	N60^{0}W	1st
8	P15	PBH08	120	45	N60^{0}W	1st
9	P17	PBH09	120	45	N60^{0}W	1st
10	P21	PBH10	110	45	N60^{0}W	1st
11	P1	PBH11	190	50	N60^{0}W	2nd
12	P2	PBH12	160	50	N60^{0}W	2nd
13	P3	PBH13	200	50	N60^{0}W	2nd
14	P5	PBH14	180	50	N60^{0}W	2nd
15	P6	PBH15	170	50	N60^{0}W	2nd
16	P7	PBH16	180	50	N60^{0}W	2nd
17	P9	PBH17	180	50	N60^{0}W	2nd
18	P10	PBH18	170	50	N60^{0}W	2nd
19	P11	PBH19	180	50	N60^{0}W	2nd
20	P13	PBH20	180	50	N60^{0}W	2nd
21	P15	PBH21	180	50	N60^{0}W	2nd
22	P17	PBH22	170	50	N60^{0}W	2nd
23	P18	PBH23	160	50	N60^{0}W	2nd
24	P21	PBH24	170	50	N60^{0}W	2nd
25	P0	PBH25	270	50	N60^{0}W	3rd
26	P2	PBH26	230	50	N60^{0}W	3rd
27	P4	PBH27	230	50	N60^{0}W	3rd
28	P6	PBH28	240	50	N60^{0}W	3rd
29	P8	PBH29	280	50	N60^{0}W	3rd
30	P10	PBH30	240	50	N60^{0}W	3rd
31	P12	PBH31	270	50	N60^{0}W	3rd
32	P14	PBH32	240	50	N60^{0}W	3rd
33	P16	PBH33	260	50	N60^{0}W	3rd
34	P18	PBH34	230	50	N60^{0}W	3rd
35	P21	PBH36	230	50	N60^{0}W	3rd
		Total	**6390**			

Note: The location of proposed boreholes and their depths are tentative and may subject to vary as per actual field and geological conditions. The actual positions of boreholes shall be decided by the site geologist in the field to fulfil the objectives of exploration.

12.1.4. Borehole Deviation Survey

All drilled boreholes (6390m in 35 Bhs) shall be subjected to Borehole Deviation survey by multi shot camera. Borehole depth wise deviation path shall be recorded for its azimuth and inclination.

12.1.5 Borehole Geophysical logging

Borehole geophysical survey covering components such as Induced Polarization, Self Potential, Magnetic Susceptibility, Resistivity/ Induction Sonde, Dual Density etc. shall be carried out for all the 35 boreholes drilled in the block having a total meterage of 6390 m.

12.1.6 Borehole Core Logging

Detailed drill core logging will be done with consideration of lithological details, structural features, e.g. joints, veins foliations, mineralization pattern, visual estimation of mineral content and other associated minerals in percentage etc. for entire length of all the holes and determination of Rock Quality Designations (RQD) for entire length of core in each borehole.

12.1.7 Borehole sampling (Primary & External analysis)

The mineralized part of drill core will be sampled as Primary sample. The length of each sample will be kept 0.5 m within the ore zone depending upon the thickness of particular type of Molybdenum Ore and its physical characters such as intensity of mineralisation, change in lithology and core recovery etc. The primary core samples will be analysed for Mo, W, Ni, Co, Ag, Cu, Pb and Zn.

i. A total of 840 no of primary core samples will be analysed for Mo, W, Ni, Co, Ag, Cu, Pb and Zn.
ii. Around 10% of Primary samples (84 numbers) will be sent to NABL External Labs for to check for any analytical bias. Samples shall be subjected for analysis of Mo, W, Ni, Co, Ag, Cu, Pb and Zn.

Additionally, 40 nos. composite samples shall be subjected to 34 elements analysis by ICP-MS method.

12.1.8 Petrography and Mineragraphy 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 5 specimens for petrographic &

mineragraphic studies has been kept. Petrographic & Mineragraphic study report includes 5 Nos. of digital photomicrographs of thin & polished sections.

12.1.9 **Specific gravity determination**

Total 05 nos. of selected samples shall be subjected to specific gravity determination studies.

12.1.10 **Beneficiation studies**

Laboratory scale beneficiation studies shall be carried out to ascertain the amenability of the molybdenum ore.

12.1.11 **Geotechnical studies**

Laboratory scale geotechnical studies shall be carried out to determine the different Physico-Mechanical properties viz. as bulk density (ρ), unconfined compressive strength (UCS), Young's modulus of elasticity (E), indirect tensile strength (ITS), cohesion(c,) angle of internal friction (ϕ) and Porosity (n) with analysis of data and test report.

12.2. VELLAKKAL NORTH BLOCK, SOUTH BLOCK & WEST BLOCK (G3):

12.1.1 Survey

The Amalgamated Vellakkal Block (12.0 sq.km area) boundary will be surveyed by DGPS in WGS-84 datum for demarcation of block boundary/corner points. Triangulation network will be laid down in the proposed block for the entire area of 12.0 sq.km. Topographical contour Surveying will be carried out in the demarcated potential areas of Vellakkal North Block, South Block & West Block at 2m/1 m contour interval and existing physical and manmade features in the area shall be surveyed. During exploratory drilling all Boreholes will be fixed on the ground whose RL's and co-ordinates will be determined by DGPS.

12.2.1 Detailed Geological Mapping & Surface sampling:

Scanned copy of Traverse geological map on 1:2000 scale (GSI: FS 2000-01) available for Vellakkal North Block, South Block & West Block. Georeferencing of these maps could not done as these maps have no geographic coordinates. However, based on few physical features and field datapoints/validations referencing of these maps attempted. Hence, Detailed geological mapping is planned on 1: 2000 scale along with topographical survey on 2m/1m contour interval in Vellakkal North Block, South Block

and West Block. Detailed Geological Mapping supported with surface geochemical samples (Bedrock/channel) will be carried out to demarcate the litho-units along with structural features. All the geological features will be recorded and litho-contacts will be plotted for finalization of Geological map taking into consideration of available previous geological maps. This map will be used as base map for drilling program.

During the course of geological mapping total 50 bedrock/channel samples shall be collected from available outcrops/exposures for analysis of Mo, W, Ni, Co, Ag, Cu, Pb and Zn by AAS method. Total 5 nos. External check samples (10% of primary samples) shall be analysed for Mo, W, Ni, Co, Ag, Cu, Pb and Zn at external NABL accredited laboratory to check for analytical bias if any.

Detailed geochemical exploration (soil sampling) not planned in present exploration as it was already carried out during previous exploration of GSI (FS 1998-2000). Previous data shall be utilised for data integration and interpretation.

12.2.2 Trenching:

Total 300 cu.m. trenching shall be carried out in the identified anomalous zones in three sub-blocks. Trenching/Pitting would be helpful to trace concealed extensions of mineralised bodies and also help to delineate the sub surface configuration and occurrence of mineralised zones. The location of trenches shall be decided by the site geologist based on the outcome of geological mapping and ground geophysical survey in the block area. During the course of trenching work total 200 nos. trench samples shall be collected for analysis of Mo, W, Ni, Co, Ag, Cu, Pb and Zn by AAS method. Total 20 nos. External check samples (10% of primary samples) shall be analysed for Mo, W, Ni, Co, Ag, Cu, Pb and Zn at external NABL accredited laboratory to check for analytical bias if any.

12.2.3 Ground Geophysical survey:

During G3 stage exploration (GSI, FS 2019-20) Ground geophysical survey (10Lkm) magnetic, IP, SP and Resistivity carried out in Vellakal Central block, Segment-A. Total 22 nos. of traverse line (1000 m length) were laid at every 50m interval perpendicular to the baseline and the baseline is almost aligned parallel to perpendicular to strike of the shear zone. Few anomaly zones in magnetic and chargeability survey identified. Borehole planning based on the integration of geological, geochemical and geophysical outcome which have yielded good mineralization of molybdenum in the drilled boreholes.

Ground geophysical survey would be helpful to demarcate potential areas for shear controlled molybdenum and also to figure out sub-surface concealed extensions of ore body. Therefore, keeping in view the nature and complexity of Mo mineralisation the

need of ground geophysical survey is felt. Hence, ground geophysical survey has been planned in present exploration (G3) to trace strike extensions of shear controlled Molybdenum mineralisation in line with Vellakkal Central block with adjoing Vellakkal North Block, South Block and West block. Phase-I Borehole planning shall be done in the area based on the integration of geological, geochemical and geophysical outcome.

Since Molibdinum is moderate magnetic and have a high chargeability so it can be identified by Magnetic survey along with I.P Resistivty and S.P. As per the Geology of the area the stike of the expected ore body is in NNE-SSW the layout was planned in N 100^0E which is perpendicualr to the stike direction. Magnetic, S.P, I.P and Resiitivty survey planned in 100 Lkm with Line interval of 50 mts and station interval of 10mts.

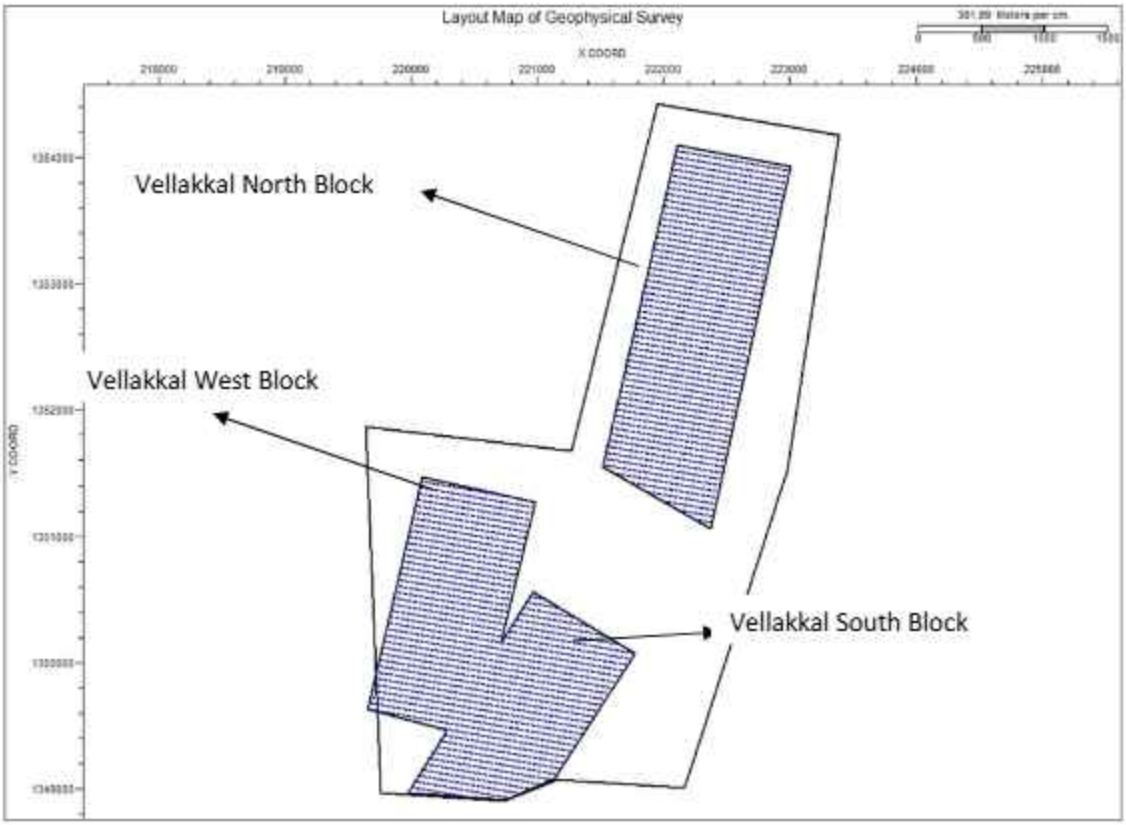


Fig. Layout map of Ground geophysical survey in Vellakkal North Block, South Block & West Block

12.1.2 Drilling:

Based on the outcome of geological mapping, surface geochemical sample results, trenching and ground geophysical survey results boreholes shall be drilled after review with TCC. However, the quantum of drilling has been worked out tentatively based on the available previous geological and scout borehole data in Vellakkal North block, South block and West block. Exploratory drilling shall be carried out in phased manner (Phase-I & II) with an objective to achieve G2 stage exploration in line with Vellakkal Central Block.

Phase-I Drilling: During Phase-I, boreholes shall be drilled at 100m spacing interval for 1st level (50m V.D.) and 2nd level (100m V.D.) at 200m spacing interval to establish the strike and depth continuity of Mo mineralisation throughout the strike of potential shear zone. Accordingly, altogether 8,000m drilling in 57 Bhs planned. Out of which, total 3,600 m (26 Boreholes) in Vellakkal North block, 2,700m (19 Boreholes) in Vellakkal South Block and 1,700m (12 Boreholes) in Vellakkal West Block worked out.

Based on the outcome of Phase-I and review with TCC, Phase-II exploratory drilling shall be taken up in the area. However, tentative envisaged quantum of Phase-II drilling worked out.

Phase-II Drilling: Phase-II drilling shall be targeted to fill up the gaps for 1st level and 2nd level at 50m spacing interval and drill boreholes for 3rd level at 100m spacing interval to prove the strike and depth continuity of molybdenum mineralisation at G2 stage in line with Vellakkal Central Block. Accordingly, altogether 29,150m drilling in 157 Bhs planned. Out of which, total 13,000 m (70 Boreholes) in Vellakkal North block, 9650m (52 Boreholes) in Vellakkal South Block and 6500m (35 Boreholes) in Vellakkal West Block worked out.

Keeping in view the project cost and timeline factors, only Phase-I Drilling quantum has been taken into consideration for cost estimates. Based on the outcome of Phase-I drilling and review with TCC further course of action shall be taken up for Phase-II drilling.

Summary of proposed drilling quantum for all three sub blocks viz. Vellakkal North block, South Block & West block is given below **Table 12.1**

Table No.12.1:Details of proposed boreholes in Vellakkal North Block, South Block & West Block of Vellakkal Cluster (G2 Stage)

Phase	Area Name	Vellakkal North Block			Vellakkal South Block			Vellakkal West Block			Total (Vellakkal North, South & West Block)
		No. of proposed Bhs	Proposed Depth (m)	Total meters	No. of proposed Bhs	Proposed Depth (m)	Total meters	No. of proposed Bhs	Proposed Depth (m)	Total meters	
	Target Strike Length (m)	2000m (40 sections)			1500m (30 sections)			1000m (20 sections)			
Phase-I	1st Level (50m V.D.) at 100m interval	16	100	1600	11	100	1100	7	100	700	
	2nd Level (100 V.D.) at 200m interval	10	200	2000	8	200	1600	5	200	1000	
	Sub Total (Phase-I)	**26**		**3600**	**19**		**2700**	**12**		**1700**	**8000m (57 Bhs)**
Phase-II (Based on the outcome of Phase-I)	1st Level (infilling) at 50m interval	20	100	2000	15	100	1500	10	100	1000	
	2nd Level (infilling) at 50m interval	30	200	6000	22	200	4400	15	200	3000	
	3rd Level (150m V.D.) at 100m interval	20	250	5000	15	250	3750	10	250	2500	
	Sub Total (Phase-II)	**70**		**13000**	**52**		**9650**	**35**		**6500**	**29150m (157 Bhs)**
	Grand Total	**96**		**16600**	**71**		**12350**	**47**		**8200**	**37150m (214Bhs)**

Note: 1. Proposed borehole depths are tentative and may subject to change as per actual geology/geophysics data and field contitions.
2. GSI (FS200-01) drilled 1st level 4 Bhs in Vellakkal North block, 4 Bhs in Vellakkal south Block & 3 Bhs in Vellakkal West Block and the same has been taken into consideration for present drilling quantum

Note: The location of proposed boreholes and their depths are tentative and may subject to vary as per actual field and geological conditions. The actual positions of boreholes shall be decided by the site geologist in the field to fulfil the objectives of exploration.

12.1.4. **Borehole Deviation Survey**

All drilled boreholes (8000m in 57 Bhs) shall be subjected to Borehole Deviation survey by multi shot camera. Borehole depth wise deviation path shall be recorded for its azimuth and inclination.

12.1.5 Borehole Geophysical logging

Borehole geophysical survey covering components such as Induced Polarization, Self Potential, Magnetic Susceptibility, Resistivity/ Induction Sonde, Dual Density etc. shall be carried out for all the 33 boreholes drilled in the block having a total meterage of 8000 m.

12.1.6 **Borehole Core Logging**

Detailed drill core logging will be done with consideration of lithological details, structural features, e.g. joints, veins foliations, mineralization pattern, visual estimation of mineral content and other associated minerals in percentage etc. for entire length of all the holes and determination of Rock Quality Designations (RQD) for entire length of core in each borehole.

12.1.8 **Borehole sampling (Primary & External analysis)**

The mineralized part of drill core will be sampled as Primary sample. The length of each sample will be kept 0.5 m within the ore zone depending upon the thickness of particular type of Molybdenum Ore and its physical characters such as intensity of mineralisation, change in lithology and core recovery etc. The primary core samples will be analysed for Mo, W, Ni, Co, Ag, Cu, Pb and Zn.

iii. A total of 1400 no of primary core samples will be analysed for Mo, W, Ni, Co, Ag, Cu, Pb and Zn.

iv. Around 10% of Primary samples (140 numbers) will be sent to NABL External Labs for to check for any analytical bias. Samples shall be subjected for analysis of Mo, W, Ni, Co, Ag, Cu, Pb and Zn.

Additionally, 50 nos. of composite samples shall be subjected to 34 element analysis by ICP-MS method.

12.1.8 Petrography and Mineragraphy Studies

Thin and Polished section studies on drill cores samples would be done for ascertaining the petrographic and mineragraphic characteristics for surface and borehole core samples. These samples would be drawn from ore zones and host rocks. A provision of 10 specimens for petrographic & mineragraphic studies has been kept. Petrographic & Mineragraphic study report includes 10 Nos. of digital photomicrographs of thin & polished sections.

12.1.9 Specific gravity determination

Total 10 nos. of selected samples shall be subjected to specific gravity determination studies.

13.0 Quantum of Proposed Work

Table- 13.1 Nature and Quantum of proposed G2 stage exploratory Programme in Amalgamated Vellakkal cluster.

Sl.No	Description and Nature of Work	Unit	Proposed Quantum of work
	VELLAKKAL CENTRAL BLOCK (G2 STAGE)		
A	**DRILLING**		
1	Drilling up to 300m (Hard Rock)	m	6390
2	Borehole deviation Survey by Multishot Camera	m	6390
3	Borehole Geophysical logging	m	6390
	Bore Hole Fixation and determination of co-ordinates & Reduced Level of the boreholes and block boundary by DGPS	Per Point of observation	35
B	**Chemical Analysis**		
	i. Bh Core Primary samples		
	a. for Mo, W, Ni, Co, Ag, Cu, Pb and Zn	Nos	840
	ii. Bh Core External Check (10%)		
	a. for Mo, W, Ni, Co, Ag, Cu, Pb and Zn	Nos	84
	iii. Composite samples for 34 Elements by ICPMS	Nos	40
C	**Physical Analysis**		
1	**Mineragraphic Studies (BH Core Samples)**		
a	Preparation of polished section	Nos	5
b	Study of Polished Section	Nos	5
c	Digital Photographs	Nos	5
d	Specific gravity determination	Nos	5
2	**Beneficiation studies**	Nos.	1
3	**Geotechnical studies**	Nos.	1
	VELLAKKAL NORTH BLOCK, SOUTH BLOCK & WEST BLOCK (G2 STAGE): PHASE-I		

Sl.No	Description and Nature of Work	Unit	Proposed Quantum of work
A	**GEOLOGICAL & SURVEY WORK**		
1	Detailed Geological Mapping (1:2000 scale)	Sq. km	1:2000
2	Topographical Survey (2m/1m contour interval) in potential sub-block areas (about 6.0 sq.km out of 12.0 sq.km.)	Sq. km	6.0
B	**GROUND GEOPHYSICAL SURVEY**		
	IP. Induced Polarization (I.P) cum Resistivity S.P and Magnetic	Line km	100
C	**TRENCHING**		
1	Excavation of trenches along Borehole profiles	Cu.m.	200
D	**DRILLING**		
1	Drilling up to 300m (Hard Rock)	m	8000
2	Borehole deviation Survey by Multishot Camera	m	8000
3	Borehole Geophysical logging	m	8000
	Bore Hole Fixation and determination of co-ordinates & Reduced Level of the boreholes and block boundary by DGPS	Per Point of observation	57
E	**LABORATORY STUDIES**		
1	**Chemical Analysis**		
i)	**Primary samples (Bedrock/Channel & Trench)**		
	a. for Mo, W, Ni, Co, Ag, Cu, Pb and Zn	Nos	250
	b. Composite samples for 34 Elements by ICPMS	Nos	30
ii)	**External Check samples (10%) (Bedrock/Channel & Trench)**		
	a. for Mo, W, Ni, Co, Ag, Cu, Pb and Zn	Nos	25
iii)	**i. Bh Core Primary samples**		
	a. for Mo, W, Ni, Co, Ag, Cu, Pb and Zn	Nos	1400
	iii. Composite samples for 34 Elements by ICPMS	Nos	50
iv)	**ii. Bh Core External Check (10%)**		
	a. for Mo, W, Ni, Co, Ag, Cu, Pb and Zn	Nos	140
E	**Petrological samples (Surface Samples)**		
i	Preparation of thin section	Nos	10
ii	Study of Thin Section	Nos	10
F	**Mineragraphic Studies (Surface Samples)**		
a	Preparation of polished section	Nos	10
b	Study of Polished Section	Nos	10
c	Digital Photographs	Nos	10
G	Geological Report preparation (Digital and Hard Copy Format)	Nos	1

14.0 MANPOWER DEPLOYMENT

Manpower deployment List will be provided later.

15.0 BREAK-UP OF EXPENDITURE

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. **3057.32 Lakh**. The summary of tentative cost estimates for General Exploration (G2) is given in **Table No.-15.1** and details of tentative cost estimates is given in **Table No.–15.2**. Tentative Time schedule/action plan for proposed Exploration is given in **Table No. 15.3.**

Table- 15.1 Summary of Cost Estimates for G2 Exploration in Amalgamated Vellakkal Cluster Area, Krishnagiri District, Tamil nadu.

Sl.No.	Item of work	Estimated Cost (Rs.)
Vellakkal Central Block (G2 Stage)		
1	Geological work	5,277,810
2	Drilling	89,868,440
3	Survey work	864,000
4	BH Geophysical logging	3,976,178
5	Laboratory studies	3,624,674
6	Beneficiation studies	300,000
7	Geotechbical studies	588,050
	Sub Total -A	**104,499,152**
Vellakkal North Block, South Block & West Block (G2 Stage): Phase-I		
8	Geological work	**5,460,450**
9	Ground geophysical survey	**14,756,930**
10	Trenching work	**999,000**
11	Drilling	**112,829,920**
12	Survey work	**1,556,820**
13	BH Geophysical logging	**3,814,393**
14	Laboratory studies	**7,117,405**
	Sub Total -B	**146,534,918**
	Total A+B	**251,034,069**
15	Exploration Report	7,531,022
16	Proposal Preparation	500,000
17	Peer Review Charges	30,000
	Grand Total	**259,095,091**
	GST 18%	46,637,116
	Total:	**305,732,207**
	Say Rs. in Lakhs	**3057.32**

16.0 TIME SCHEDULE

16.1 The proposed G2 stage exploration in the amalgamated Vellakkal Cluster area envisages surveying, geological mapping, ground geophysical survey, exploratory drilling, deviation survey, borehole geophysical logging, sample preparation and laboratory studies including beneficiation and geotechnical studies and geological report preparation which will be completed within 22 months by deploying 4 drill rigs. Therefore, a total of 22 months is planned for completion of the entire program.

17.0 JUSTIFICATION

17.1.0 Amalgamated Vellakkal Cluster area is part of prominent Haur-Uttangarai Molybdenum Belt (HUB) of Tamil Nadu. During F.S.1998-2000, GSI carried out Reconnoitory exploration in Vellakkal sub block areas viz. Vellakkal North Block (390.10m in scout 4 Bhs), Central Block (300.05m in scout 3Bhs), South Block (350.25m in scout 4 Bhs) & West Blocks (275.75m in scout 3 Bhs) under an MoU with TAMIN. Based on Soil, Trench and BH core sample analysis data, anomalous zones for Molybdenum identified and three priority areas over 1.5 line km demarcated and recommended further exploration.

17.2.0 During F.S. 2001-02 & F.S. 2010-11 GSI carried out concept oriented drilling program with 4 boreholes (804.45m) and 7 Boreholes (2114.55m) in Vellakkal Central Block respectively and confirmed the shear controlled molybdenum mineralisation at depth.

17.3.0 Subsequently, GSI carried out G-3 stage exploration in Vellakkal Central Block (VLC-A) to delineate the strike and establish depth continuity of molybdenum bearing quartz vein and estimate resource. Total 7 infilling 1st level Boreholes at 100m interval and 5 nos. 2nd level boreholes at 200m interval (Total 1732m) carried out. Resource has been estimated for 1025m strike length. Total Inferred Mineral Resource (333 code of UNFC) of molybdenum ore estimated by cross section method between 364.4m to 240.0m R.L. at 0.01% cut off is 1.439 m.t. with average grade of 243.63 ppm molybdenum; 0.35 m.t. with 389.57 ppm molybdenum at 0.03% cut-off and 0.117 m.t. with 537.92 ppm molybdenum at 0.05% cut-off.

17.4.0 GSI recommended to carry out further exploration by drilling for 2nd level and 3rd level to delineate the deeper mineralisation for higher level of confidence with additional resource in Vellakkal Central Block. Also, recommended to carryout G3 stage exploration in adjacent potential Vellakkal south block and both the blocks can be amalgamated for G2 exploration for a sizable strike length of 2.0km.

17.5.0 The Vellakkal Central Block has been kept for auction in 1st trench by Ministry of Mines (MoM), Govt. of India during 2023-24. However, due to small size of the block with low resources/other reasons resulted in poor participation of bidders and the block was annulled. Subsequently, MoM advised to amalgamation of nearby adjoining blocks

for auction in future and accordingly 4 sub-blocks pertaining to Vellakkal area handed over to MECL for amalgamation and investigate further up to G2 stage exploration.

17.6.0 Considering the potentiality of the block, poor participation in auction of bidders and advice from Ministry of Mines, Govt. of India for amalgamation and auction of the block, MECL has amalgamated Vellakkal Central Block with adjacent North Block, South Block & West Block and carved out Vellakkal Block over 12.0 sq.km. to carryout exploration activities (G2) in phased manner and to estimate the resources up to G2 stage to auction the block and also fulfil the demand of Molybdenum ore in the country.

17.7.0 The present G2 stage exploration has been formulated for the entire amalgamated Vellakkal Cluster area over 12.0 sq.km. area where G2 stage close spaced exploratory drilling planned to upgrade the resource from 333 to 332 category of UNFC. Simultaneously, Detailed Geological mapping (1:2000 scale), surface sampling, Trenching and Ground geophysical survey and followed by Phase-I exploratory drilling in the adjoining Vellakkal North Block, South Block & West Block to establish strike and depth continuity of shear controlled molybdenum mineralisatioon.

17.8.0 The present exploration at G2 stage in the Amalgamated Vellakkal Cluster area would be helpful to estimate the resource under 332 category of UNFC and facilitate the Govt. to auction the block.

Table- 15.3: Time schedule for G2 Level Exploration for Molybdenum in Proposed Amalgamated Vellakkal Cluster Area (12.0 sq.km.)
District-Krishnagiri, Tamil Nadu

Sl. No.	Activities	Unit	MONTHS																							
			1	2	3	4	5	6	7	8	9	10		11	12	13	14	15	16	17	18	19		20	21	22
1	Camp Setting	Month																								
2	Survey work	Months																								
2	Surface Drilling (4 rig) & associated works	m.																								
	Geological mapping (1:2000 scale) over 12 sq.km. associated sampling	12 sq.km.																								
	Ground Geophysical survey	100 Lkm																								
	Geophysical Report	1											Review										Review			
	Trenching work	200 cu.m.																								
4	Geologist Party days in field (2 Party)	day																								
5	Sampling Party days, Core Sampling (1 party)	day																								
6	Camp Winding	Month																								
7	Laboratory Studies	Nos.																								
8	Geologist Party days in HQ (1 Party)	day																								
9	Geological Report Writing with Peer Review	Month																								

Note: 1. Commencement of project may be reckoned from the day the exploration acreage is available along with all statutory clearances.
2. Time loss on account of monsoon/agricultural activity/forest clearance/local law & order problem may be additional to above time line.

PLATES:

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7	Reproduced Scout Borehole sections for Vellakkal North Block, South Block & West Block (after GSI)	VII

References:

1. The Vellakkal block area is part of Haur-Uttangarai Molybdeum Belt (HUB) of Tamil nadu and the area was previously explored by various workers of GSI The list of available reports of the area as listed below.

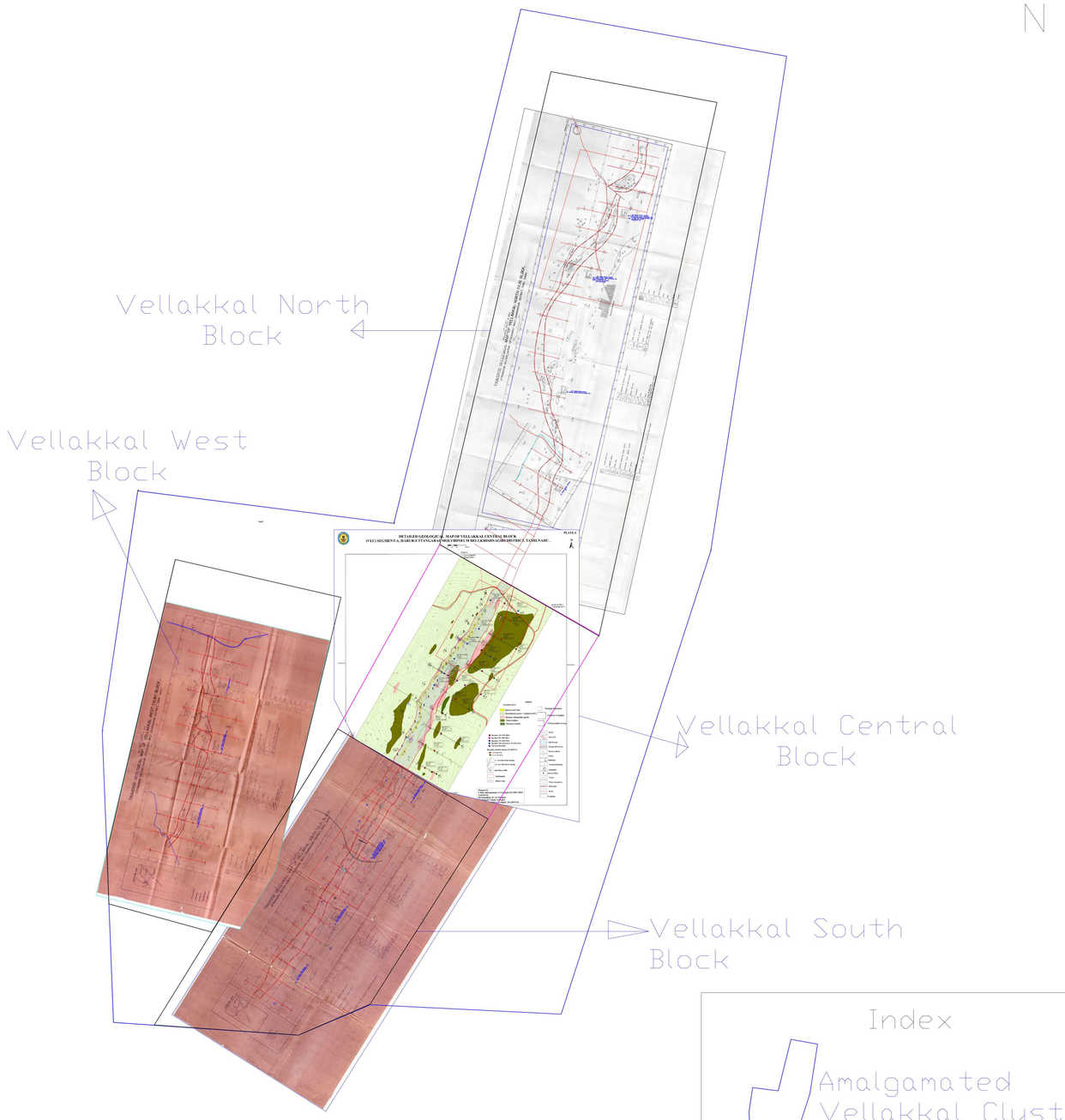
2. Report on the Reconnoitory Exploration for Molybdenum in the Extension areas of Uttangarai Sector, Harur-Uttangarai Belt, Dharmapuri Dist, Tamil Nadu, (GSI, 2002)

3. Balasubramanian, E 2007 Report on the concept oriented drilling in Vellakkal Central Block, Harur-Uttangarai Molybdenum Belt (HUB), Dharmapuri district, Tamil Nadu (FS 2001-2002)

4. Raju K. 2012 A Report on the Detailed Exploration for Molybdenum in the Vellakkal Central Block, Harur-Uttangarai Molybdenum Belt, Dharmapuri district, Tamil Nadu (FS 2010-2012)

5. Final Report on Preliminary Exploration for Molybdenum and associated mineralisaiton in Vellakkal Central Block, Segment-A, Harur-Uttangarai Molybdenum Belt, Krishnagiri District, Tamil Nadu (G3 stage).(2021)

Geological Map of Amalgamated Vellakkal Cluster (12.0 sq.km.) Krishnagiri District, Tamil Nadu



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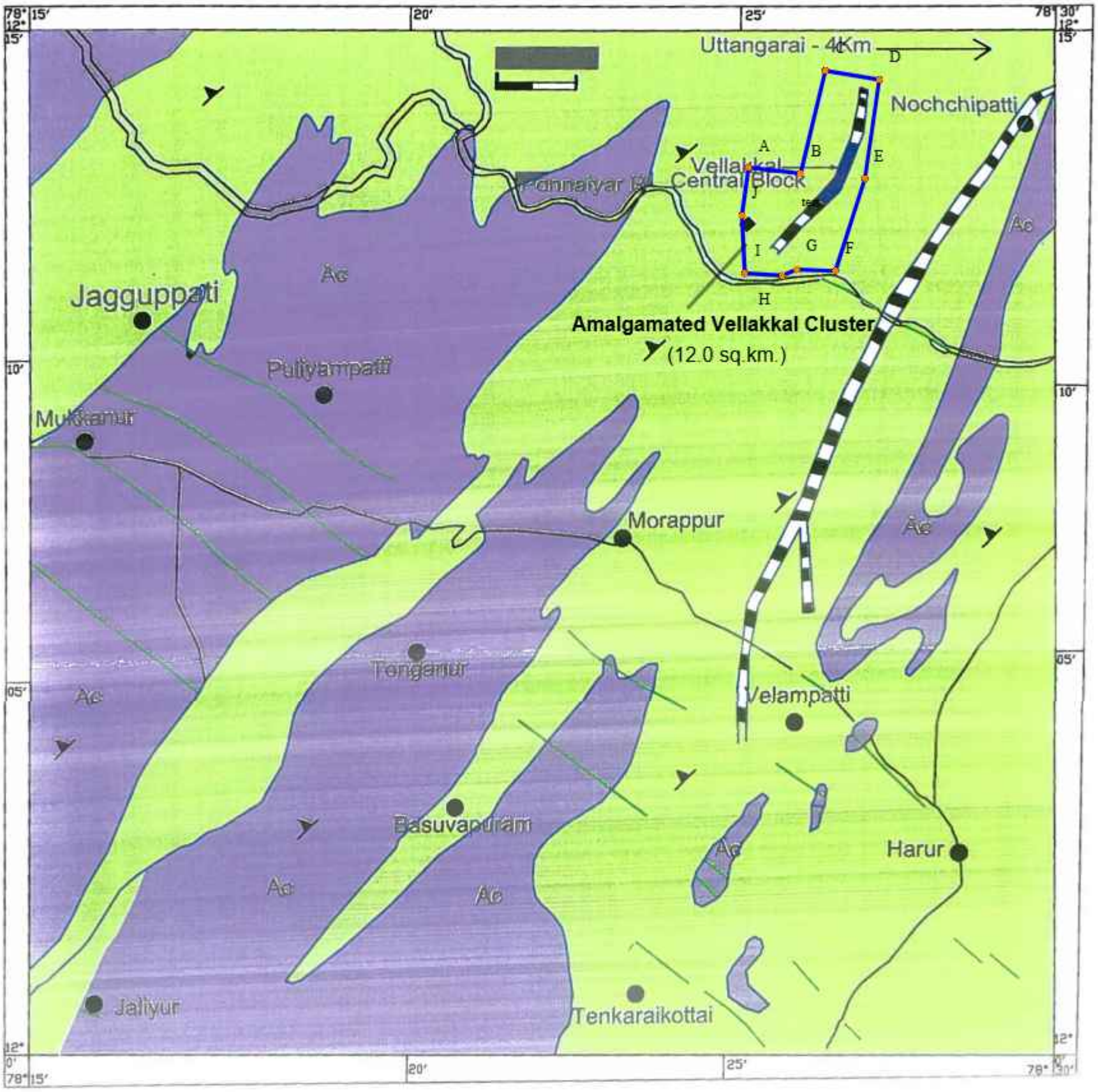
Amalgamated Vellakkal Cluster (12.0 sq.km.)

Plate No. VI

REGIONAL GEOLOGICAL MAP OF HARUR-UTTANGARAI MOLYBDENUM BELT WITH PROPOSED AMALGAMATED VELLAKKAL CLUSTER (12.0 sq.km.), KRISHNAGIR DISTRICT, TAMIL NADU (after GSI)

GEOLOGICAL MAP OF PART OF DHARMAPURI DISTRICT,TAMIL NADU



Charnockite

Epidote-Hornblende Gneiss

Dyke

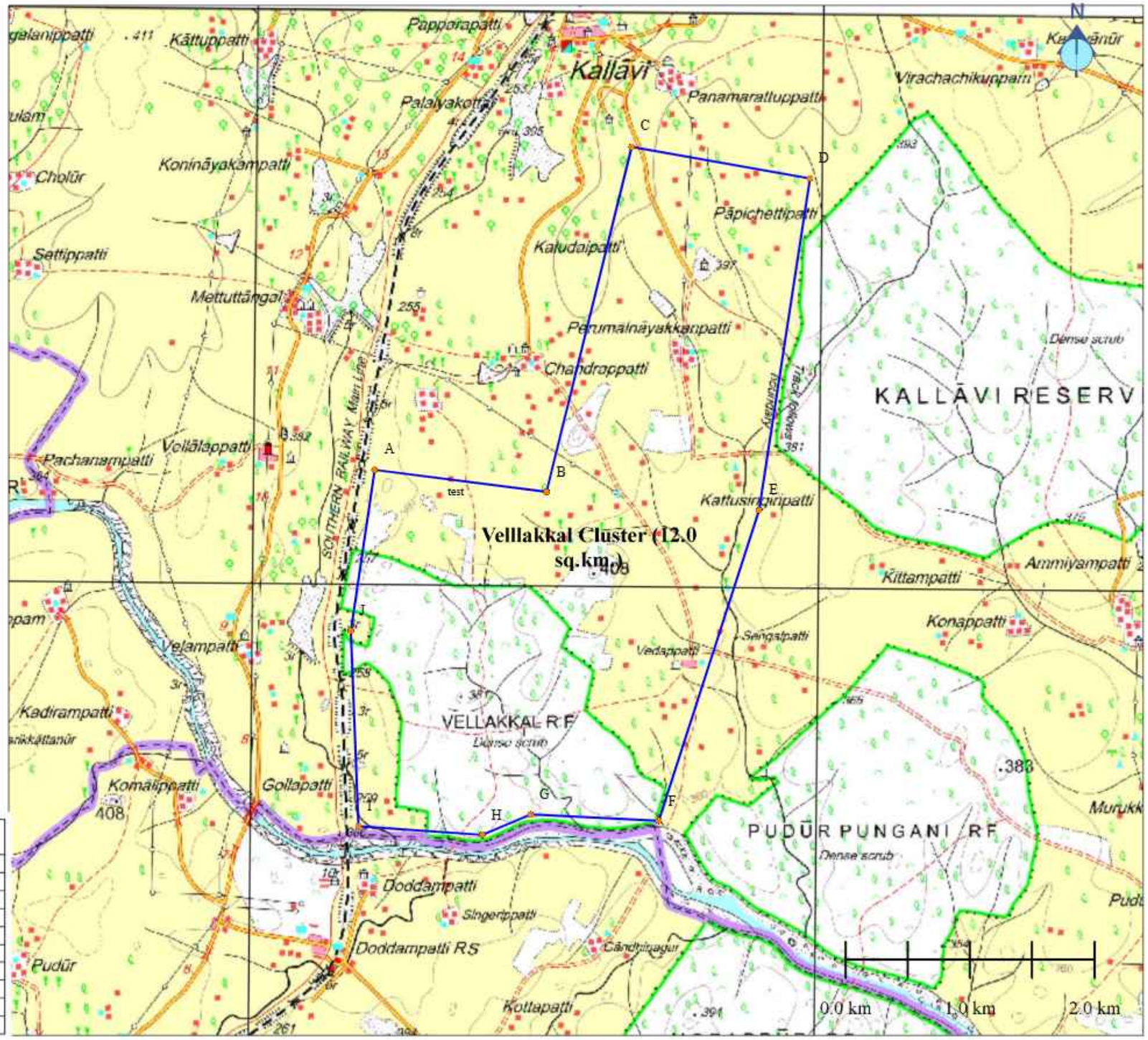
Harur-Uttangarai

Vellakkal Central Block

Map Compiled by
M&C Division
GSI(OP.TNPK)

PLATE No. II

LOCATION MAP OF AMALGAMATED VELLAKKAL CLUSTER (G2) OVER 12.0 sq.km) FOR MOLYBDENUM, KRISHNAGIRI DISTRICT, TAMIL NADU



Corner cardinal point	LATITUDE	LONGITUDE
A	12° 12' 59.8439" N	78° 25' 32.0023" E
B	12° 12' 54.5640" N	78° 26' 17.6396" E
C	12° 14' 24.7903" N	78° 26' 39.3675" E
D	12° 14' 17.0027" N	78° 27' 26.7700" E
E	12° 12' 50.2797" N	78° 27' 14.0888" E
F	12° 11' 28.9498" N	78° 26' 48.2344" E
G	12° 11' 30.2792" N	78° 26' 14.2319" E
H	12° 11' 24.8265" N	78° 26' 01.4886" E
I	12° 11' 26.7622" N	78° 25' 28.5841" E
J	12° 12' 17.7176" N	78° 25' 26.0865" E