

**PROPOSAL FOR RECONNAISSANCE SURVEY (G-4)
FOR MANGANESE ORE IN
ANTAPALI BLOCK
(2.30 SQ.KM AREA)
DISTRICT- BALANGIR, ODISHA**

COMMODITY: MANGANESE

**BY
MINERAL EXPLORATION CORPORATION LIMITED
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SEMINARY HILLS**

PLACE: NAGPUR

DATE: 12th October 2020

Summary of the Block for Reconnaissance Survey (G-4)
GENERAL INFORMATION ABOUT THE BLOCK

Features	Details
Block ID	Antapali Block
Exploration Agency	Mineral Exploration Corporation Limited (MECL)
Commodity	Manganese
Mineral Belt	Eastern Ghats Mobile Belt, Balangir District, Odisha
Completion period with entire Time schedule to complete the project	12 Months
Objectives	The present exploration programme (G4) has been formulated on the basis of previous regional data available, data provided by Directorate of Geology, Govt. of Odisha and the data collected by MECL team during the field visit to fulfil the following objectives: i) To carry out geological mapping on 1:12,500 scale and demarcate the rock types of manganese bearing formations with the structural features i.e. strike, dip, lineations / foliations etc. ii) To carry out surface geophysical survey (Gravity and Magnetic) to demarcate concealed manganese ore bodies. iii) To carry out trenching/pitting to expose manganese body under soil & lateritic cover. iv) To drill scout boreholes in the geophysical anomaly zone to prove the existence and establish persistence of manganese ore bodies over a promising strike length. v) To estimate manganese ore resources (334) in the block as per UNFC norms & Minerals (Evidence of Mineral Contents) Rules- 2015.
Whether the work will be carried out by the proposed agency or through outsourcing and details thereof. Components to be outsourced and name of the outsource agency	Work will be carried out by the proposed agency.
Name/Number of Geoscientists	Geoscientist (1 Field + 1 HQ)
Expected Field days (Geology, Geophysics, Surveyor)	Geologist Party days: 120 days Survey Party days: 30 days

1. Location	The block proposed for exploration lies in the parts of Survey of India Toposheet No 64 P/05 and is bounded by latitude 20°46'15" to 20°46'46" and longitude 83°17'20" to 83°18'15" (Plate No I). The area is connected by fair weather road from the State High-way No. 1 (Balangir-Patanagarh Road). The fair weather road crosses Suktel River through a ford north of Khuntapalli village and is open to traffic from January to June. During the peak of Monsoon, Kumiapali block can be approached from Balangir via Chandanbhati by an all weather pucca road. The intermittent villages are connected by fair weather jeepable unmetalled roads. The nearest railhead is Balangir.	
Latitude	A	20° 46' 15.734" N
	B	20° 46' 46.020" N
	C	20° 46' 21.756" N
	D	20° 46' 15.259" N
Longitude	A	83° 17' 19.641" E
	B	83° 17' 54.394" E
	C	83° 18' 15.464" E
	D	83° 18' 12.980" E
Villages	Kumiapali, Kapilbahal, Rengali, Bagdungri, Antapali, Banchorpali, Dunguripali, Mudalsar, Tamiya, Bijapati, Biarpali, Babja etc.	
Tehsil/Taluk	Balangir	
District	Balangir	
State	Odisha	
2. Area (hectares/ square kilometres)		
Block Area	2.30 sq.km	
Forest Area	Mostly Non-Forest area.	
Government Land Area (Bilanam)	Data not available	
Charagaha	Data not available	
Private Land Area	Data not available	
3. Accessibility		
Nearest Rail Head	Balangir (280 km from Raipur and 310 Km from Bhubaneswar),	
Road	The intermittent villages in the area are connected by fair weather jeepable metalled / unmetalled roads. The nearest railhead is Balangir.	
Airport	Raipur (225 km)	
4. Hydrography		
Local Surface Drainage Pattern (Channels)	The general slope of the country is towards southwest and the drainage is collected by south-westerly flowing nalla ultimately draining into Suktel River.	

		The area has got dendritic pattern of drainage. The block area is surrounded by Kayaghat reserve forest on south-western part and other area mostly by Non-forest and Agricultural lands. Rain-fed south-easterly flowing Suktel River in the southern part of the block.
	Rivers/ Streams	Suktel River
5.	Climate	
	Mean Annual Rainfall	Average annual rainfall is 100 cm
	Temperatures (December) (Minimum) Temperatures (June) (Maximum)	Minimum temperatures 10°C (Dec-Feb), Maximum temperatures up to 46°C (March-June)
6.	Topography	
	Toposheet Number	64P/05
	Morphology of the Area	The area is almost flat terrain and covered with agriculture land. The average height of the area is 220m above MSL.
7.	Availability of baseline geoscience data	
	Geological Map (1:50K/25K)	Regional Geological map, Geological Survey of India (1:12,500 scale)
	Geochemical Map	Not available.
	Geophysical Map (Aeromagnetic, ground geophysical, Regional as well as local scale GP maps)	Available.
8.	Justification for taking up Reconnaissance Survey/ Regional Exploration	1. The Govt. of India enacted the MMDR Amendment Act-2015 duly introducing the system of auction for allocation of Mineral Concessions. Bauxite, Iron Ore, Manganese and Limestone have been categorized in the Fourth Schedule which needs prospecting and exploration by the State Govt. before auctioning of blocks. 2. In view of this, Govt. of India directed State Governments to speed up exploration work for different mineral commodities in their respective states. Accordingly directorate of Geology, Government of Odisha requested MECL to take up exploration work for manganese Blocks in Balangir District of Odisha under NMET funding. Antapali Block may be the prospective manganese blocks identified for auction. MECL decided to take up the G-4 stage of exploration work in Antapali Block through NMET fund.

	3. The proposed study area falls in the south-east of Rengali Manganese block and showing continuity of manganese ore body in southern part of Rengali (G-4) block. The old manganese quarries are also nearby the proposed area. Apart from this, exploration in Biarpali, Babja and Dunguripali blocks is in progress. Already explored small deposits of Tamiya (G-2) and Rengali (G-2) blocks with Net in situ geological Manganese ore resource of 0.6327 mt with average grade of 0.23.04% Mn and 0.328 mt with average grade of 21.37% Mn respectively are present in the vicinity of Antapali block and can be exploited together in cluster mining approach. 4. Since most of the block area is covered with soil, geophysical survey (gravity & magnetic survey) will be carried out in the block to demarcate the geophysical anomaly/mineralized zones of manganese, which will help in the formulation of exploration programme. 5. The exploration will be helpful in estimation of Reconnaissance (334) Resources and will help in planning G3/G2 level of exploration programme which in turn will lead to estimation of indicated (332) category resources and will facilitate the State Govt. Odisha for auctioning of blocks.
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**PROPOSAL FOR RECONNAISSANCE SURVEY (G-4) FOR
MANGANESE ORE IN ANTAPALI BLOCK,
DISTRICT-BALANGIR, ODISHA**

1.0.0 INTRODUCTION

- 1.1.1 In order to sustain the current level of production of Mn ores and to meet the future demands, the exploration of Manganese ore is the need of the hour.
- 1.1.2 In India the Manganese Ore deposits mainly occurs as metamorphosed bedded sedimentary deposits associated with Gondite Series (Archaeans) of Madhya Pradesh (Balaghat, Chhindwara & Jhabua districts), Maharashtra (Bhandara & Nagpur districts), Gujarat (Panchmahal district), Odisha (Sundargarh district) and Kodurite Series (Archaeans) of Odisha (Ganjam & Koraput districts) and Andhra Pradesh (Srikakulam & Vishakhapatnam districts).
- 1.1.3 The total resources of Manganese ore in the country as on 01-04-2015 are placed at 495.87 million tonnes as per UNFC system (IBM Mineral Year Book-2018). Out of these resources 93.47 million tonnes are categorised as reserves and the balance 402.40million tonnes are in the remaining resources category.
- 1.1.4 State wise, Odisha tops the total reserves/resources with 44% share followed by Karnataka 22%, Madhya Pradesh 12%, Maharashtra & Goa 7% each, Andhra Pradesh 4% and Jharkhand 2%. Rajasthan, Gujarat, Telangana and West Bengal together shared the remaining about 2% resources.
- 1.1.5 The Govt. of India enacted the MMDR Amendment Act, 2015 duly introducing the system of auction for allocation of Mineral Concessions. Bauxite, Iron Ore, Manganese and Limestone have been categorized in the Fourth Schedule which needs prospecting and exploration by the State Govt. before auctioning of blocks
- 1.1.6 During the geological mapping of Rengali G-4 manganese block, it is observed that the manganese ore mineralisation is continued towards south of Rengali G-4 block. On the basis of continuity of manganese mineralization, Antapali G-4 block has been demarcated in the south of Rengali G-4 block.
- 1.1.7 Subsequently, MECL prepared a proposal for reconnaissance survey (G-4) in Antapali G-4 block, district -Balangir, Odisha and submitted to NMET for taking up for discussion in the upcoming TCC.

1.2.1 Location & Accessibility of the Area

The block under exploration lies in the parts of Survey of India Toposheet No 64 P/05 (Plate No I).

The coordinate of cardinal points of block boundary are as follows:

CARDINAL POINT	WGS-84		UTM	
	longitude	latitude	Easting	Northing
A	83° 17' 19.641" E	20° 46' 15.734" N	738279.753	2298496.456
B	83° 17' 54.394" E	20° 46' 46.020" N	739271.936	2299442.324
C	83° 18' 15.464" E	20° 46' 21.756" N	739892.121	2298704.652
D	83° 18' 12.980" E	20° 46' 15.259" N	739849.417	2296658.170

The area is connected by fair weather road from the State High-way No.1 (Balangir-Patanagarh Road). The fair weather road crosses Suktel River through a ford north of Khuntapalli village and is open to traffic from January to June. During the peak of Monsoon, Rengali & Tamiya blocks can be approached from Balangir via Chandanbhati by an all weather pucca road. The intervening villages are connected by fair weather jeepable unmetalled roads. The nearest railhead is Balangir.

1.2.2 Physiography & Drainage

The area comprises of wide spread plain land, folded ridges, hillocks and mounds. The maximum height of the ridge is 372m and minimum height of the valley is 194m above MSL. Rain-fed easterly flowing Suktel River with network of streams drains the area. The drainage is sub-parallel to sub-dendritic controlled by ridges and lineaments. Thick alluvium accumulated due to the Suktel has helped extreme cultivation in the area.

1.2.3 Climate

The area has a sub-tropical climate with torrential rainfall between June and September. The temperature ranges between 10⁰ C in winter and 46⁰ C in summer season and the average annual rainfall is around 100 cm. This part of Orissa is very hot in summer with occasional extreme hotness in comparison to other parts of the state.

1.2.4 Flora and Fauna

The areas under exploration are sparse to densely vegetated. Kayaghat reserve forest covers part of the Rengali Block. The floral assemblage includes Sal (*Shorea robusta*), Shishu (*Dalbergia latifolia*), Neem (*Nekua indica*), Tamarind (*Tamarindus indica*), Jackfruit (*Autocarpus intergrifolia*), Kendu (*Diaspyros melanxylon*), Mango, Amla, Harida, Bahada, Boula, Simili, Berries and Bel etc. Wild animals are scarcely observed in this area. The faunal assemblages include bears, rabbits, snakes, wild boars, jackals, peacocks, wild hens and host of birds.

1.3.0 Previous Work

- 1.3.1 B.C. Roy (1940) first reported the manganese ore deposits in Balangir district. He observed that: (i) the manganese ore deposits occupy summits and plains (ii) the manganese ore bodies have definite strike and dip (iii) the manganese ore comprises mainly of pyrolusite and psilomelane as ore minerals with chert, limonite and wad, (iv) the ore bands are associated with calc-granulites and garnetiferous gneisses.
- 1.3.2 Later on, Jhingran (1947) investigated and Krishnaswamy (1950) estimated the ore reserve to the tune of 650 thousand tonnes up to 1.5 m depth. Later on, host of workers from Geological Survey of India have carried out field work from 1962-65 and onwards. Finally, investigation aided by drilling was taken up in 1994-95. The average grade of ores from Balangir district range from 19-39% Mn, 10-28% Fe, 4-46% SiO₂ and 0.12-0.48% P.
- 1.3.3 A.G. Jhingran (1947) envisaged that the Dunguripalli manganese ore deposit (T. S. No. 64 P/5) was of considerable magnitude. Shri S. Krishnaswamy (1950) observed numerous occurrences of Mn ore mainly as lenses and pockets in calc-silicates, being parallel to regional foliation trend and assessed a reserve of 6,60,000 tonnes up to a depth of 15 m in T.S. P/1 & 5. M.W. Tak (1964-65), P. Bose (1965-66) and D. Mitra (1964-65) had mapped on 1:63,360 scale in Toposheet No. 64 P/5 & 9, 64 P/5, and 64 P/1 & 5 respectively.
- 1.3.4 M.W. Tak carried out mapping in the northern part of the present area and found that Mn mineralisation is associated with calc-gneiss, diopside granulite and highly weathered khondalite. P. Bose (1967) observed numerous lensoidal and pocket type deposits within khondalite and partly in calc-silicate rocks. D. Mitra observed the occurrences of Mn ore within khondalite suite of rocks. He envisaged that the presence of quartz-garnet-rhodonite association in deposits indicate probably a gonditic rock and closeness of calc-silicate within ore deposits suggest a calc-magnesian association common in sedimentary environment.
- 1.3.5 Patel, N.K. et al. (1983) of D.M.G., Orissa carried out systematic mapping of 60 sq. km on 1:25, 000 scale in Babja-Dumerijharam area and 2.5 sq. km detailed mapping on 1:2000 scale in Bijapatti east of Belpali-Bhaludungri area. He computed the total probable reserve of all grades to be 95,677 tonnes up to a depth of 3m. They observed that Mn ores occurs at the contact of khondalite and calc-granulites in the form of discontinuous bands and pockets of irregular dimensions. Twelve numbers of Mn ore occurrences were reported in the area such as: near southeast of Banipali, NW of

Dandapani, NW of Dumerijharam, NE of Gerdi and SE of Thakurpalli. Besides, disintegrated manganese float ores were reported near Barkani, Babja and Uchhabpalli. They had done 410 cu.m of trenching and pitting and 249 nos. of channel and grab sampling.

- 1.3.6 Jena, S.K. et al. (1993-94) carried out large scale mapping on 1:25,000 scale in Gadashankar-Dandapani area of Balangir district between latitude $20^{\circ} 44'$ to $20^{\circ} 55'N$ and longitude $83^{\circ} 15'$ to $83^{\circ} 21'E$ and delineated four major ore zones.
- 1.3.7 Patel, M.C. (1996) initiated preliminary exploration work by drilling in 1994-95 F.S. Mishra U.S. and Hussain, A. (1997) carried out E-1 stage (G-3 of UNFC, Ref: letter No 2692/K-1(Vol-II)/TC/ODS/2017 dated 07/11/2017 of GSI) exploration work over four blocks, viz., Biarpalli, Khagsabahal. Tabalbanji and Dunguripalli (north) blocks aided by detailed mapping and drilling in Toposheet No. 64 P/5 & 6.
- 1.3.8 Behera, S.N. (1996-97) carried out large scale mapping of an area of 115 sq.km on 1:25,000 scale in Babja ($20^{\circ}50'00''-83^{\circ}20'36''E$) - Thelkuchhapur ($20^{\circ}50'15''N-83^{\circ}46'00''E$), Dandapani, Tamiya and adjoining areas under P-II stage investigation to study manganese occurrences viz-a-viz their nature & grade and to identify potential blocks for detailed exploration.
- 1.3.9 During F.S.P. 1997-98 and 1998-99, Hussain et al. carried out exploration of manganese deposits in Dunguripalli, Dandapani and Rengali blocks and had taken up E-1 Stage exploration in these three blocks along with Tamiya block during F.S.P 1999-2000 & 2000-2001 by Stage Review Committee's recommendation in 1998.

2.0.0 Regional Geology

- 2.1.1 The exploration area lies in the northern part of the Eastern Ghats Super Group of rocks belonging to the meta-sedimentary sequence of Precambrian khondalite. The sequence of para-metamorphic is made up of pelitic, psammitic and calcareous formations, which are represented by khondalite, quartzite and calc-silicate rocks. These have been intruded by granites. All the hill ranges in this area are composed of either khondalite or garnetiferous quartzite or both. Calc-silicate bands adjoining to the ore horizons form denudational hillocks or mounds and are 1 to 2m thick. Granite gneiss occupies the valleys. The whole sequence has been metamorphosed to granulite facies. Structurally the area exhibits a complex picture.
- 2.1.2 On the basis of contact relationship, presence of xenoliths/caught up patches of one particular unit within the other & structural and stratigraphical relationship, the tentative stratigraphic succession of the area may be given as follows:

Age	Formation	Lithology
Quaternary	-	Alluvium, soil and latsol
Tertiary	-	Laterite
Precambrian (Eastern Ghat Supergroup)	-	Aplite, Pegmatite and Quartz veins
	Granitoids	Equigranular, non-garnetiferous granite gneiss, garnetiferous granite gneiss and granulite, leptinitic gneiss Migmatite
	Charnockite Suite	Hypersthene bearing gneisses and granulites (mostly acid to intermediate charnockitic type)
	Khondalite Suite	Pyroxene granulite, quartzite, Khondalite with manganiferous horizons Calc-silicate rocks with manganese ore
Base Not Seen		

2.2.0 Geology of Study Area

- 2.2.1 The rock types exposed in the area are calc-silicate, quartzite (Mn bearing), granite gneiss, amphibolite and quartz and pegmatite vein. From the disposition of individual members of khondalite it is difficult to ascertain the stratigraphy, as the units have been subjected to different cycles of sedimentation as well as deformation. Description of different litho units is given below.
- 2.2.2 **Calc-silicate rocks:** The calc-silicate rocks occur as bands and lenses within khondalite and also with Mn-ore bearing silicate-carbonate rock in the form of denudational hillocks and mounds and are intricately folded and exhibit rib and furrow weathering structure and crude layering. Their trend generally confirms the regional foliation direction and the contact of these rocks with khondalite and granite is sharp. The calc-silicate bands are 100m to 1km in length and 20 to 50 m in width. The calc-silicate rock is usually a dark grey to greenish, fine to medium grained, hard and massive to foliated. It contains green diopside, hornblende, plagioclase (andesine), garnet (grossularite), scapolite, sphene and quartz. Accessories include zircon, calcite, apatite and epidote.
- 2.2.3 **Khondalite** (quartz- feldspar- garnet- sillimanite + graphite schist/gneiss): It occurs typically in bouldery outcrops (highly weathered) on narrow, steep hill ranges and low lying mounds and in valley interbanded with quartzite and calc-silicate rocks. This is coarse grained, brownish yellow to reddish grey coloured, foliated and highly weathered rock. Due to varying degree of weathering its colour changes to

pinkish/purplish at places, when highly kaolinised, it becomes very light. It is highly sheared and mylonitised at places. The rock is manganiferous and secondary manganese minerals occur along the foliation, fracture and joints planes. The rock is intimately associated with quartzite and both grade into each other along as well as across the foliation. They are highly migmatised and the quartzofeldspathic neosome bands that have traversed the rock along the regional foliation plane of the rocks.

- 2.2.4 **Quartzite:** The quartzites is medium to coarse grained, white to buff coloured, granular to faintly schistose in nature and are invariably garnetiferous. Pegmatite and quartz veins traverse the rock along foliation planes. Quartzite grades laterally to khondalite. It is predominantly made up of large xenoblastic grains of quartz with pale pink garnet and clusters of sillimanite. Quartzite is highly brecciated in a number of places such as in Dandapani block. Brecciated quartzite, in general contains ore bodies. Manganese mineralisation is noticed within brecciated and feldspathised quartzite at places. Manganiferous quartzite is exposed in Dandapani and Dunguripalli (south) blocks.

- 2.2.5 **Granulite:** It is coarse grained black massive rock and occurs as small lenticular inclusions parallel to foliation within granite gneiss and at places occur in boulder form along small ridges in association with khondalite and quartzite. It is mainly a plagioclase (andesine-labradorite)-pyroxene rock with subordinate amount of amphibole, biotite, garnet, perthite and quartz and accessories include sphene, ilmenite, zircon and apatite.

- 2.2.6 **Migmatite:** Migmatite occupy the low lying areas in the east of Bijapati and around Dunguripalli. It exhibits gneissose structure and the palaeosome includes hypersthene, diopside and biotite and the neosome comprises of K-feldspar and plagioclase.

- 2.2.7 **Granite Gneiss:** This is medium to coarse grained rock occupying low-lying areas with migmatite, consisting mainly of quartz, plagioclase, K-feldspar, biotite, garnet, epidote and few opaques. The whole sequence has been metamorphosed to granulite facies. The alkali-feldspar gneiss is fine to coarse grained and contains porphyroblasts of microcline and perthite within quartz-feldspar-garnet aggregates.

- 2.2.8 **Pegmatite and quartz veins:** Pegmatite and quartz veins traverse the rocks at a number of places close to manganese mineralisation in all the rock types both along and across the foliation. At places pegmatite contains few crystals of beryl which are of less significance.

- 2.2.9 **Laterite:** Laterite is developed mainly over khondalite and granite gneiss and is very common in areas close to manganese mineralised zones as in Dunguripalli (south)

Block. Extensive development of laterite over laterite has been developed in northeast of Rengali.

2.3.0 Regional Structure

The entire area covered by detailed mapping exhibits a complex structural fabric as the whole sequence has been subjected to multiple cycles of deformation. As a result, the existing structural elements are completely altered rendering it difficult to decipher the complete structural geometry. However, the secondary planar structural elements like, foliation and gneissosity and joints are well preserved in the rock types of the area. The different structural features as observed are described below:

- 2.3.1 **Primary structures:** The primary structures have been mostly obliterated due to granulite facies metamorphism. However, relict bedding is observed along the contact between khondalite, quartzite and calc-silicates. Interbanding of different litho units within the Khondalite Group is seen clearly in many outcrops.
- 2.3.2 **Secondary structures:** The secondary planar structures such as foliation, gneissosity, schistosity, joint and cleavages are well preserved in rocks. S1 is defined by compositional banding, preferred orientation of prismatic, acicular and flaky minerals in the rock.
- 2.3.3 **Foliations:** Foliation (S1) is most pervasive and trends in NNW-SSE to NE-SW direction with moderate to steep easterly to south-easterly dip. Planar arrangement of minerals like garnet, biotite, sillimanite, graphite, quartz and feldspar mark the foliation plane in khondalite, quartzite, calc-silicate rocks and granite.
- 2.3.4 **Joints:** Altogether, two sets of joints are observed in the blocks under exploration. These are E-W dipping 70° to 80° to south and N 65° E-S 65° W dipping 60° - 80° to southeast.
- 2.3.5 **Lineation:** Two types of lineation are noted in the area:
(i) slickenside lineation: This is observed in manganiferous quartzite and calc-silicate rocks. (ii) Mineral lineation: The mineral lineation is defined by minerals like sillimanite, biotite and garnet.
- 2.3.6 **Folding:** The area exhibits at least three generations of folding. The first generation of folds (F1) is tight isoclinal, intrafolial, upright and reclined in nature. The F1 folds are developed conspicuously in calc-silicate rocks and to a lesser extent in quartzite. The axial planes of F1 folds have a general trend in NNW-SSE direction. The second generation of folds (F2) is moderate to steeply plunging, open and broad type on NE-SW axis and third generation fold (F3) is characterised by upright, open to broad warps with E-W trend.

2.3.7 Faults and Shear: Faulting and shearing are evidenced by brecciation, silicification, vug filling, slickensides and mylonitisation in quartzite and khondalite. Quartzite and khondalite are intensely silicified and brecciated resembling chert breccia in the vicinity of manganese ore bands in a number of places such as west of Bijapali village in Dunguripalli south block. Shifting and missing of ore bands are due to local fault and pinching and swelling nature of ore bodies in the area.

2.4.0 Metamorphism

2.4.1 High grade metamorphism under granulite facies conditions characterise the Eastern Ghats Super Group of rocks. The mineral assemblages of khondalite (quartz-feldspar-garnet-sillimanite+graphite), granulite (plagioclase-hypersthene-diopside) and calc-silicate (diopside-plagioclase-calcite-quartz-scapolite) indicate pyroxene granulite sub-facies under granulite facies of Eskola.

2.5.0 Mineralization (Surface manifestation)

2.5.1 On the surface the Mn ore mineralization presents a rugged bouldery outlook. In general, oxide minerals show granoblastic to granulitic fabric. Gravity filling, stalactitic, botryoidal, box work and colloform structures are commonly observed within the ore. The ore is in general steel grey to dull grey in colour and is soft or powdery in nature. Pyrolusite, psilomelane and cryptomelane are seen replacing each other. Silica in rhodonite is seen replaced by the manganese oxides.

2.5.2 Manganese ore bodies occur as bands, lenses, pockets, veins, tabular bodies and disseminations within the khondalite group of rocks. The ore is more enriched at the central part. The lensoidal/discontinuous ore bodies are arranged in an en-echelon pattern. These are lateritic and have been weathered to a considerable depth along with the enclosing rocks.

2.5.3 The ore bodies are conformably interstratified with and enclosed in different stratigraphic levels with calc-granulite at its contact with khondalite. Detailed mapping and available subsurface data suggest that the ore is concentrated along the fold axes of minor and mesoscopic folds. Intense brecciation, shearing, fracture form the important loci for mineralisation and the granitic intrusion have influenced the depth persistence of the ore. The lensoidal discontinuous ores owe their origin to the flowage or drag folds. Hence it may be concluded that manganese ores are both lithologically and structurally controlled.

3.0.0 Proposed programme for Exploration

The present exploration programme (G4) has been formulated on the basis of previous regional data available and the data collected by MECL team during the field visit to fulfil the following objectives:-

3.1.1 Objective of the proposed Reconnaissance Survey (G4):

- i) To carry out geological mapping on 1:12,500 scale and demarcate the rock types of manganese bearing formations with the structural features i.e. strike, dip, lineation / foliations etc.
- ii) To carry out surface geophysical survey (Gravity and Magnetic) to demarcate concealed manganese ore bodies.
- iii) To carry out trenching/pitting to expose manganese body under soil & lateritic cover.
- iv) To drill scout boreholes in the geophysical anomaly zones to prove the existence and establish persistence of manganese ore bodies over a promising strike length.
- v) To estimate manganese ore resources (334) in the block as per UNFC norms & Minerals (Evidence of Mineral Contents) Rules- 2015.

4.0.0 Methodology of Proposed Exploration

4.1.0 In accordance to the objectives set for reconnaissance (G-4) survey in Antapali Block, District- Balangir, Odisha, geological mapping, geophysical survey and scout drilling programme associated with other geological, sampling and analytical work is proposed in the block. The exploration shall be carried out as per Mineral (Evidence of Mineral Contents) Rule-2015 and Mineral Auction Rule-2015.

Accordingly, the details of different activities to be carried out are presented in subsequent paragraphs.

4.2.0 Topographic Surveying

4.2.1 The prospect area would be tied up with the triangulation network and the surface features will be picked up and marked on a map on 1:12,500 scale. The reduced levels and co-ordinates of boreholes would be determined.

4.3.0 Geological Mapping:

- 4.3.1 Large scale geological mapping on 1:12,500 scale will be carried out in the entire block by taking geological traverses. The contacts of different formations, identification of different rock formation, structural features, etc., will be carried out in detail. The geophysical survey data could help in updating of map. The geological map on 1:12,500 scale will be generated based on the large scale geological mapping of the block and interpretation of exploration data.

4.4.0 Channel Sampling:

- 4.4.1 During the G-4 stage exploration, trenching work will be carried out for by cutting trenches of 1m width and 2 m depth directly on the fresh outcrop/rock exposures across the Mn ore body involving 200 cubic meter excavation. The channel of 5cm x 2cm dimension will be cut on the floor of the trenches to collect the channel samples. The length of each channel sample will be kept as 0.50m uniformly in the same type of lithology, whereas, the length of the sample may be adjusted with variation/change in lithology. The length of channel sample may not exceed 1.00 m in any case. The representative powdered samples of (-) 200 # size will be obtained by stage wise grinding of the chips collected from the channels and by reducing the weight of sample by repeated coning and quartering. A final finished sample of 500 gram (- 200 mesh) will thus be prepared. One part around 100gm sample will be sent to chemical laboratory for analysis, second part will be preserved in the camp as duplicate sample, the third part will be utilized for preparing composite sample for individual ore band and the fourth part will be kept as either check sample or sample to be used for any other specific purpose. Thus total 100 nos of primary channel samples will be generated. 5% of Primary channel samples (5 no samples) will be sent to Chemical Laboratory, MECL, Nagpur for analysis as internal check samples. Around 10% of primary samples (10 no samples) will be sent to NABL accredited External Laboratory for analysis. All primary, internal check and external check channel samples will be analyzed for 6 radicals. (Mn, SiO₂, P₂O₅, Fe₂O₃, MnO₂ and Insolubles.)
- 4.4.2 Mineralized zones will be delineated at cut off grade based on the chemical results of primary channel samples. Composite samples would be prepared from the mineralized zones of primary channel samples for each channel. It is expected that 15 Nos. of composite sample would be generated and will be analyzed for 6 radicals i.e. Mn, SiO₂, P₂O₅, Fe₂O₃, MnO₂ and Insolubles.

4.5.0 Geophysical Survey:

4.5.1 The proposed area (Antapali) consists of sequence of para-metamorphic made up of pelitic, psammitic and calcareous formation, which are represented by Khondalite, quartzite and Calc-Silicate rocks. From the earlier geological reports it seems there are few Mn exposures which strike NNW and SSE with dipping around 60°- 65° westerly. The rock types exposed in the area are calc-silicate, quartzite (Mn bearing), granite gneiss, amphibolites and quartz and pegmatite vein.

4.5.2 Physical properties of Manganese ore and expecting host rocks are given in below table

Ore/ rock	Chemical composition	Mn content	Density (g/cc)	Magnetic Susceptibility. 10^{-3} CGS
Pyrolusite	MnO ₂	63%	4.70-5.00	Paramagnetic
Psilomelane	MnOMn ₂ OH ₂ O		3.70-4.70	
Braunite	Mn ₂ O ₃ Mn ₆ O ₂	64.3%	4.75-4.82	
Rhodonite	MnSiO ₃	41.8%	3.40-3.6	Paramagnetic
Rhodochrosite	MnCO ₃	47.8%	3.40-3.60	100
Jacobsite	MnFe ₂ O ₄		4.95	200-300
Quartz			2.6-2.8	.00063
Mica			2.15	

4.5.3 In addition to above the resistivity contrast between Manganese ore and host rocks is also remarkable. Based on the above physical properties of the manganese ores and its host rocks in typical geological settings the Magnetic and Density properties of the manganese ore deposit varies significantly in order of magnitude, which depends on the chemical composition and Mn content. In view of these physical properties of rock type we propose the Magnetic and Gravity survey in the area for demarcating the manganese ore mineralization zones.

4.5.4 Geophysical traverses are laid in North 46° East direction which is perpendicular to strike direction at 200m traverse interval with station spacing of 20m for Gravity and Magnetic survey. Total number of stations proposed is 500 no each for Gravity and Magnetic survey. A period of 3 working months is required for completing and submitting the report (1 month for acquiring data and 2 month for processing and interpretation).

4.6.0 Exploratory Drilling

4.6.1 Based on the outcome of geological mapping, analytical results of surface channel samples and delineation of manganese ore body on the basis of surface geophysical survey by using Magnetic and Gravity methods, scout borehole is being proposed be drilled for intersection of mineralised zones. Approximately **400.00 m** of scout core drilling will be done in 5 scout boreholes. The borehole locations, azimuth, inclination and depth of proposed boreholes will be decided only after the delineation of the Mn ore body on the basis of geological mapping and geophysical survey.

4.7.0 Core Logging

- 4.7.1 The borehole cores would be logged systematically. Viz. details of the litho units, colour, structural feature, texture, mineralization, besides the recovery, rock quality designation (RQD) and manganese ore type would be recorded.

4.8.0 Core Sampling

- 4.8.1 The mineralized part of drill core will be sampled as Primary sample. The length of each sample will be kept 0.50m within the ore zone depending upon the width of particular type of manganese ore and its physical character. The representative powdered samples of (-) 200 # size will be obtained by stage wise grinding of the core sample collected from the borehole and by reducing the weight of sample by repeated coning and quartering. A final finished sample of 500 gram (- 200 mesh) will thus be prepared. One part around 100gm sample will be sent to chemical laboratory for analysis, second part will be preserved in the camp as duplicate sample, the third part will be utilized for preparing composite sample for individual ore band and the fourth part will be kept as either check sample or sample to be used for any other specific purpose. The primary core samples for manganese mineralisation will be analysed for 6 radicals' i.e. Mn, SiO₂, P₂O₅, Fe₂O₃, MnO₂ and Insolubles. The cores of rocks 3 m immediately on the footwall and 3 m immediately on the hanging wall of mineralized zones would be sampled at 1.0 m interval, as far as possible, depending upon the intensity of mineralization, change in lithology and core recovery etc.

- a) Around 115 no of core samples (100 No **Primary** & 5 No **Internal Check** & 10 No **External Check samples**) might be generated from the mineralized zone intersected in the boreholes. All the primary and internal check samples for manganese mineralisation will be analysed for 6 radicals' i.e. Mn, SiO₂, P₂O₅, Fe₂O₃, MnO₂ and Insolubles.
- b) Around 10% of Primary samples (10 nos) will be sent to NABL External Labs for analysis of manganese mineralization i.e. Mn, SiO₂, P₂O₅, Fe₂O₃, MnO₂ and Insolubles.
- c) Composite samples would be prepared from the mineralized zones of primary drill core samples of each borehole as well as from the mineralized zones demarcated in the channels. A total of 15 nos. of composite sample would be generated from drill cores and be analyzed for manganese mineralization i.e. Mn, SiO₂, P₂O₅, Fe₂O₃, MnO₂ and Insolubles.
- d) A total of 10 nos composite samples would be analyzed by X-ray diffraction to ascertain the presence of different mineral phases.
- e) A total of 10 nos composite samples would be analyzed by ICP-MS method to ascertain the presence of 14 no trace elements associated with the Manganese deposit i.e. Cd, Sn, W, Sb, Ce, Nb, Ba, La, Bi, Co, Ni, Sr, Mo, V

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

4.10.0 Specific Gravity Determination: To derive the tonnage factors, 10 nos. of samples in are proposed to be subjected for specific gravity determination. The samples are to be drawn from ore zones/ mineralized zones.

5.0.0 Quantum of work

5.1.0 The quantum of work proposed by MECL in Antapali Block is given in Table 5.1.

Table: 5.1 Proposed Quantum of Work in Antapali Block, District-Balangir, Odisha

Sl. No.	Item of Work	Unit	Proposed Quantum of work
1	Geological Mapping (on 1:12,500 Scale).	Sq. Km.	2.30
2	Geophysical Activity		
	Magnetic Survey	No of Stations	500
	Gravity Survey	No of Stations	500
3	Trenching (1m x 2m x 100m)	Cu.m	200
4	Core Drilling (5 to 6 no boreholes)	m.	400
5	Sample Preparation & Laboratory Studies		
A.	Primary samples (Channel Sample + Core Samples)		
	i) Chemical Analysis: Primary for 6 radicals i.e., Mn, SiO ₂ , P ₂ O ₅ , Fe ₂ O ₃ , MnO ₂ and Insoluble	Nos.	(100+100)= 200
	ii) Internal Check samples (5% of Primary samples) for analysis of 6 radicals i.e., Mn, SiO ₂ , P ₂ O ₅ , Fe ₂ O ₃ , MnO ₂ and Insolubles	Nos.	(5+5)= 10
	iii) External Check sample (10 % of Primary samples) for analysis of 6 radicals i.e., Mn, SiO ₂ , P ₂ O ₅ , Fe ₂ O ₃ , MnO ₂ and Insolubles	Nos.	(15+15)= 30
B.	Composite Samples (Channel Sample + Core Samples)		
	i) composite samples will be analyzed for 6 radicals i.e., Mn, SiO ₂ , P ₂ O ₅ , Fe ₂ O ₃ , MnO ₂ and Insolubles	Nos.	(15+15)=30
	ii) XRD study	Nos	10
	iii) Trace Element Study by ICP-MS Method (14 Elements)	Nos	10
6	Petrographic Studies	Nos	10
7	Mineragraphic Studies	Nos	10
8	Specific Gravity Determinations	Nos	10
9	Report Preparation (Digital format)	Nos.	1

6.0.0 Manpower Deployment

6.0.1 Manpower deployment List may be provided later.

7.0.0 Time schedule and Cost estimates

7.1.0 Time schedule:

The proposed exploration programme is planned for G-4 Level. The work activities like camp setting, survey and associated geological work, geophysical studies, drilling & laboratory work at G-4 level will be completed within 10 months' time. Report writing will take another 4 months' time with overlapping of 2 months of laboratory studies. Thus the total duration of the project shall be completed in 12 months from the date of commencement of the project.

The bar chart showing activities wise time schedule is placed at Table-6.1.

7.2.0 Cost estimates:

7.2.1 The Project cost with provisional escalation is estimated at **Say. Rs. 155.77 Lakhs** for G-4 level of exploration. The details of item wise cost estimate with inbuilt actual escalation as on 01.04.2020 and same has been considered for subsequent years for Geological and Laboratory studies and is given in Table No. 6.2 and the summary is given below:

Summary of Cost Estimates

Sl. No.	Item	Total Estimated Cost (Rs.)
1	Geological Activity	24,58,000
2	Geophysical Work	25,41,000
3	Pitting and Trenching	6,60,000
4	Drilling	57,48,900
5	Laboratory studies	9,95,680
6	Drill Core Preservation	1,59,000
7	Report Preparation	6,28,129
8	Peer Review	10,000
9	Subtotal (1-5)	1,32,00,709
10	GST-18%	23,76,128
	Total	1,55,76,837
	Say	155.77 Lakhs

8.0.0 Justification

- i. The Govt. of India enacted the MMDR Amendment Act-2015 duly introducing the system of auction for allocation of Mineral Concessions. Bauxite, Iron Ore, Manganese and Limestone have been categorized in the Fourth Schedule which needs prospecting and exploration by the State Govt. before auctioning of blocks.
- ii. In view of this, Govt. of India directed State Governments to speed up exploration work for different mineral commodities in their respective states. Accordingly directorate of Geology, Government of Odisha requested MECL to take up exploration work for manganese Blocks in Balangir District of Odisha under NMET funding. Antapali Block may be the prospective manganese blocks identified for auction. MECL decided to take up the G-4 stage of exploration work in Antapali Block through NMET fund.
- iii. The proposed study area falls in the south-east of Rengali Manganese block and showing continuity of manganese ore body in southern part of Rengali (G-4) block. The old manganese quarries are also nearby the proposed area. Apart from this, exploration in Biarpali, Babja and Dunguripali blocks is in progress. Already explored small deposits of Tamiya (G-2) and Rengali (G-2) blocks with **Net in situ** geological Manganese ore resource of 0.6327 mt with average grade of 0.23.04% Mn and **0.328 mt** with average grade of **21.37% Mn respectively** are present in the vicinity of Antapali block and can be exploited together in cluster mining approach.
- iv. Since most of the block area is covered with soil, geophysical survey (gravity, magnetic & resistivity survey) will be carried out in the block to demarcate the geophysical anomaly/mineralized zones of manganese, which will help in the formulation of exploration programme.
- v. The exploration will be helpful in estimation of Reconnaissance (334) Resources and will help in planning G3/G2 level of exploration programme which in turn will lead to estimation of indicated (332) category resources and will facilitate the State Govt. Odisha for auctioning of blocks.

9.0.0 References:

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Tak, M.W. (1966)	Report on systematic geological mapping in parts of Balangir-Patna and Sambalpur districts, Orissa, Unpubl. G.S.I. report (F.S. 1964-65)

List of Plates:

1. Plate-I: Block Location Map of Antapali Block in Toposheet no. 64P/05, Balangir District, Odisha State (Scale 1: 50,000).
2. Plate-II: Regional Geological Map of part of Eastern Ghat Belt (After GSI), Balangir District, Odisha State (Scale 1: 12,500).
3. Plate-III: Combined Geological Map of Rengali, Kumiapali and Antapali blocks, Balangir District, Odisha State (Scale 1: 10,000).
4. Plate-IV: Geological Map of Antapali Block (Scale 1: 4,000).

Cost Estimate for Reconnaissance Survey (G-4) for Manganese in Antapali Block, Distt. Balangir, Odisha
Total Area - 2.30sq km; Nos. of Borehole - 5 ; Borehole depth range - 80m avg ; Completion Time - 12 Months

S.N.	Item of Work	Unit	Rates as per NMET SoC 2020-21		Estimated Cost of the Proposal						Remarks
			SoC-Item Sl No.	Rates as per SoC	Year 2020-2021		Year 2021-2022		Total		
					Qty.	Amount (Rs)	Qty.	Amount (Rs)	Qty.	Amount (Rs)	
A	GEOLOGICAL WORK										
1	Bore Hole Fixation and determination of co-ordinates & Reduced Level of the boreholes by DGPS	Nos	1.6.2	19,200	-	-	5	96,000	5	96,000	
2a	Geologist Party days (1 party)-Field	day	1.2	11,000	-	-	120	1,320,000	120	1,320,000	
2b	Geologist Party days (1 party)-HQ	day	1.2	9,000	-	-	60	540,000	60	540,000	
2c	4 labours/ party (Rs 350/day/labour) (As per rates of Central Labour Commissioner)	day	5.7	1,400	-	-	80	112,000	80	112,000	Amount will be reimburse as per the notified rates by the Central Labour Commissioner or respective State Govt. whichever is higher
3a	Core Sampling -1 Samplers Labour charge not included	day	1.5.2	5,100	-	-	60	306,000	60	306,000	
3b	4 labours/ party (Rs 350/day/labour) (As per rates of Central Labour Commissioner)	day	5.7	1,400	-	-	60	84,000	60	84,000	Amount will be reimburse as per the notified rates by the Central Labour Commissioner or respective State Govt. whichever is higher
	Sub-Total A				-	-	-	2,458,000	-	2,458,000	
B	GEOPHYSICAL SURVEY										
1	Gravity and Magnetic Survey	Nos	3.1b	4,500	500	2,250,000	-	-	500	2,250,000	
2	Survayor Work	days	1.6.1a	8,300	30	249,000	-	-	30	249,000	
3	4 labours/ party (Rs 350/day/labour) (As per rates of Central Labour Commissioner)	day	5.7	1,400	30	42,000	-	-	30	42,000	
	Sub-Total B				-	2,541,000	-	-	-	2,541,000	
C	PITTING AND TRENCHING										
1	Trenching (1m x 2mx 100 m)	Cu m	2.1.1	3300	-	-	200	660,000	200	660,000	
	Sub-Total C					-		660,000		660,000	
D	DRILLING										
1	Drilling (1 rigs)	m	2.2.1.4a	11,500	-	-	400	4,600,000	400	4,600,000	
2	Borehole deviation Survey	m	2.2.6	330	-	-	400	132,000	400	132,000	
3	Land / Crop Compansation	per BH	5.6	20,000	-	-	5	100,000	5	100,000	Amount will be reimburse as per actuals or max. Rs. 20000 per BH with certification from local authorities
4	Construction of concrete Pillar (12"x12"x30")	per borehole	2.2.7a	2,000	-	-	5	10,000	5	10,000	
5	Transportation of Drill Rig & Truck associated per drill	Km	2.2.8	36	650	23,400	650	23,400	1,300	46,800	
6	Monthly Accomodation Charges for drilling Camp (up to 2 Rigs)	month	2.2.9	50,000	-	-	5	250,000	5	250,000	
7	Drilling Camp Setting Cost	Nos	2.2.9a	250,000	1	250,000	-	-	1	250,000	
8	Drilling Camp Winding up Cost	Nos	2.2.9b	250,000	1	250,000	-	-	1	250,000	
9	Road Making (Flat Terrain)	Km	2.2.10a	22,020	-	-	5	110,100	5	110,100	Road Making will be considered as per the requirement and Road Making Charges will be reimbursed accordingly.
	Sub Total D					523,400		5,225,500		5,748,900	
E	LABORATORY STUDIES										
1	Chemical Analysis										
i)	Primary & Check samples										
	a. Primary Samples for 6 radical (Mn, SiO2, P2O5, Fe2O3, MnO2 and Insolubles)	Nos	4.1.7a + 7b	2,841	-	-	200	568,200	200	568,200	
	b-Internal (5%) and External(10%) Check samples from NABL Lab for 6 radical (Mn, SiO2, P2O5, Fe2O3, MnO2 and Insolubles)	Nos	4.1.7a + 7b	2,841	-	-	30	85,230	30	85,230	
ii)	Composite Samples										
	6 radical (Mn, SiO2, P2O5, Fe2O3, MnO2 and Insolubles)	Nos	4.1.7a + 7b	2,841	-	-	30	85,230	30	85,230	
2	Physical & Petrological Studies										
i)	X-RD Studies on composite	Nos	4.5.1	4,000	-	-	10	40,000	10	40,000	
ii)	ICP-MS studies (34 Trace elements- Cd,Sn,W,Sb,Ce,Nb,Ba,La,Bi,Co, Ni, Sr, Mo, V** etc.,	Nos	4.1.14	7,731	-	-	10	77,310	10	77,310	
iii)	Preparation of thin section	Nos	4.3.1	2,353	-	-	10	23,530	10	23,530	
iv)	Complete petrographic study report	Nos	4.3.4	4,232	-	-	10	42,320	10	42,320	
v)	Preparation of polished section	Nos	4.3.2	1,549	-	-	10	15,490	10	15,490	
vi)	Complete mineragrapic study report	Nos	4.3.4	4,232	-	-	10	42,320	10	42,320	
vii)	Specific Gravity determination	Nos	4.8.1	1,605	-	-	10	16,050	10	16,050	
	Sub-Total -E					-		995,680		995,680	
F	Drill Core Preservation										
	One complete borehole plus mineralised cores of remaining BHs of the Block, all cost included (80m for one borehole, 30m mineralised zone for remaining 5 Bhs, (80+(30x5)=230)	m	5.3	1,590	-	-	100	159,000	100	159,000	
	Sub-Total - F					-		159,000		159,000	

S.N	Item of Work	Unit	Rates as per NMET SoC 2020-21		Estimated Cost of the Proposal						Remarks
			SoC-Item Sl No.	Rates as per SoC	Year 2020-2021		Year 2021-2022		Total		
					Qty.	Amount (Rs)	Qty.	Amount (Rs)	Qty.	Amount (Rs)	
G	Total - A to F					3,064,400		9,498,180		12,562,580	
H	Geological Report Preparation		5.2	For the projects having cost more than Rs. 50 lakhs but less than Rs. 150 lakhs -		-		628,129.00		628,129.00	
I	Peer review Charges		As per EC decision			-		10,000		10,000	
J	Total Estimated Cost without GST					3,064,400		10,136,309		13,200,709	
K	Provision for GST (18% of J)	%				551,592		1,824,536		2,376,128	GST will be reimburse as per actual and as per notified prescribed rate
L	Total Estimated Cost with GST					3,615,992		11,960,845		15,576,837	
								or Say Rs. 155.77 Lakhs			

Note -

1. If any part of the project is outsourced, the amount will be reimbursed as per the Paragraph 3 of NMET SoC and Item no. 6 of NMET SoC. In case of execution of the project by NEA on its own, a Certificate regarding non outsourcing of any component/project is required.
2. Rates are calculated as per NMET SOC issued on 31st March 2020 without escalation. Although billing for subsequent financial years will be done as per the actual escalations as per RBI Indices.

**TABLE-6.1 TIME SCHEDULE / ACTION PLAN FOR EXPLORATION PROPOSAL FOR MANGANESE ORE IN
ANTAPALI (G-4) BLOCK, DISTRICT - BALANGIR, ODISHA**

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