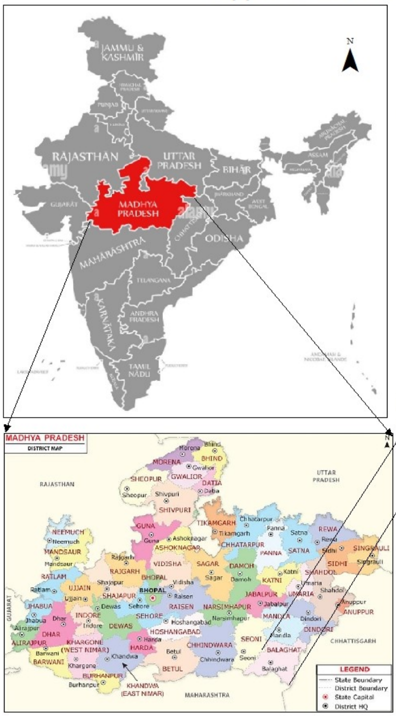
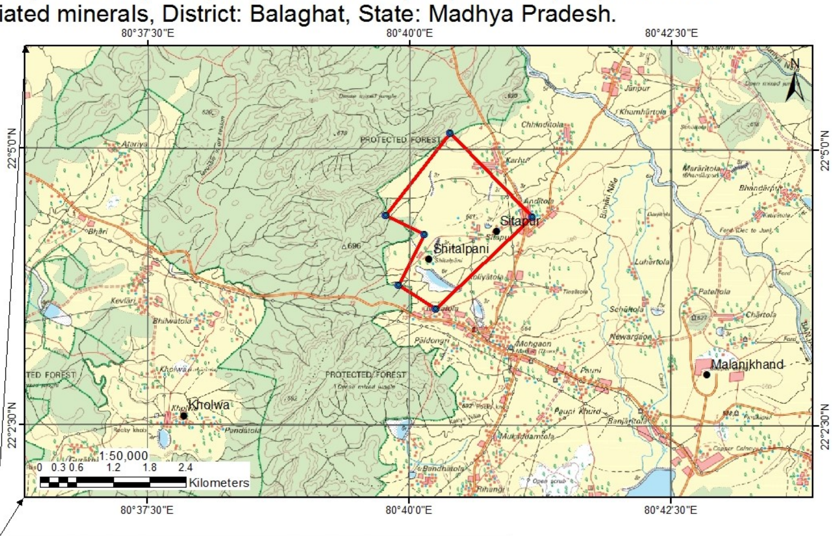
REPORT ON INDUCED POLARIZATION (IP), SELF-POTENTIAL(SP) AND MAGNETIC SURVEY IN

SITAPUR BLOCK

FOR COPPER PROSPECTING BALAGHAT, MADHYA PRADESH

Location Map of Proposed Sitapur Block (3.5 sq km) at Preliminary Exploration (G-3) Level for Copper and associated minerals, District: Balaghat, State: Madhya Pradesh.





Coordinates of Corner Points od Proposed Sitapur Block					
Sl. No.	Points	GCS WGS 1984 (DMS)		UTM (m)	
		Latitude	Longitude	Northing	Easting
1	A	22°05'09.04" N	80°40'23.04" E	2442365.06	466273.77
2	B	22°04'23.62" N	80°41'10.32" E	2440965.58	467625.73
3	C	22°03'33.15" N	80°40'14.99" E	2439417.01	466036.96
4	D	22°03'46.08" N	80°39'53.92"E	2439815.96	465433.96
5	E	22°04'13.90" N	80°40'08.73" E	2440670.37	465860.10
6	F	22°04'24.26" N	80°39'46.38" E	2440990.54	465220.34

Source: Survey of India; Toposheet No. 64B/12

Legend
- Places
- Proposed Sitapur Block Corner points
- Proposed Sitapur Block Boundary

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(Formerly Mineral Exploration Corporation Limited)

(Ministry of Mines, A Government of India Enterprise),

Nagpur- 440006, Maharashtra, India

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Report on Induced Polarization (IP), Self Petential and Magnetic Survey in Sitapur Block, Balaghat, Madhya Pradesh.

1.0 INTRODUCTION

Mineral Exploration & Consultancy Limited (MECL) formerly as Mineral Exploration Corporation limited having its corporate office at Nagpur, Maharashtra is functioning under Ministry of Mines, Government of India with 100% holding for systematic exploration of minerals.

In view of the MMDR amendments act -2015, Minerals (Evidence of Mineral Contents) Rule 2015 and Mineral Auction Rule-2015, Ministry of Mines, MECL prepared proposal for G-3 level exploration of Sitapur Block and submitted in the 43rd meeting of Technical-cum-Cost Committee (TCC) of NMET held on 28.07.2022 for approval. After detailed discussion TCC recommended it for approval of Executive Committee (EC) of NMET. The proposal was approved by EC in its 32nd meeting held on 06.12.2023 and approval received from NMET on 12.12.2023.

1.1 Scope of Work:

Based on the evaluation of previous available geological data such as Geological Report on Integrated Exploration for Copper in Shitalpani Block, Malanjkhand Granitoid (2001-2003), by MECL and report on synthesis of Geology of Malanjkhand Grainitoids in Balaghat and Rajnandgaon Districts of Madhya Pradesh, (F.S. 1991- 1994), by GSI and reported known occurrence of base metal mineralization in and around Sitapur Block , the present exploration program has been formulated to fulfill the following objectives as follows:

Phase-I

I. To carry out Geological mapping on 1:5,000 scale.

II. To carry out Geochemical samplings in a grid of 200m X 200m to delineate the potential zone of mineralization.

III. To demarcate concealed potential mineralisation zones by carrying out surface geophysical survey i.e. IP cum Resistivity, Self-Potential (S.P) and Magnetic at 100 m traverse interval and 20 m station interval.

IV. To establish strike and depth continuity of mineralized body.

V. To carry out trenching/pitting work in the anomalous zones identified with the help of geochemical survey and geophysical survey.

Phase-II

Based on the positive outcome of ground geophysical survey, geological mapping supported with geochemical sampling and 2 trench sample results, scout boreholes would be proposed to validate the geophysical and geochemical anomalies.

1.2 Geology of the Area:

The Sitapur block is occupied by the Malanjkhand granitoid comprising granitic rocks. These litho units intruded by quartz veins and metadolerite dykes along sheared zones, joints and fractures. Presents of schists and gneisses has been found near Amgaon at the west of Sitapur block. The stratigraphic sequence in the block is given below Table.

Recent to Sub-recent	Laterite
Cretaceous to Eocene	Deccan Trap
Unconformity	
JAMTOLA GROUP (Mid-proterozoic)	Quartz Vein, Graphite, Phyllite, occasional mica schists, Limestone lenses, quartzite, at places sandstone
Unconformity	
CHILPI GROUP (Mid-proterozoic)	Quartz veins, Dark grey finely laminated shale, Phyllite with banded chert and massive chert, Finely banded dark red to brown shales with thin lithic wacke and chart layers, Thin quartzites
Unconformity	
DARBARITOLA GRANITOIDS	Basaltic/Doleriticdykes , quartz veins, carbonate veins, aplite veins, gabbro. Fine to medium grained grey and pink biotite bearing granites
MALANJKHAND GRANITOIDS	Grey coarse grained, occasionally porphyritic, hornblend bearing, pink spotted, granodiorites and quartz diorites. Minor, dark grey, porphyritic diorites as small stocks. At places the granodiorites are epidote rich. Greenish-grey granite gneisses
Intrusive contact	
NANDGAON GROUP	Dark grey and pale brownish rock with characteristic altered (white) phenocrysts set in a fine graine matrix PORPHYROIDS of dacite and andesitic composition, associated with thick red, yellow, violet, grey and white colored tuffs and pyroclastics, with thin bands of chert and carbonate. Predominantly dark greenish and dark greenish-grey, altered metabasaltic and dacitic/ andesitic rocks with minor amygdular met basalt, associated with rhyo-dacitic to rhyolitic (porphyritic and nonporphyritic) rocks. Narrow zones of tuffaceous conglomerates, shaly tuffaites and quartzites.
Intrusive	
AMGAON GROUP	Pink aplite, Grey aplite veins Streaky, augen, layered, banded gneisses (Migmatites) with amphibolites enclaves.
BASE NOT SEEN	

Table 1: Stratigraphic Succession of the Study area

In adjoining Shitalpani block, copper mineralization mainly hosted in vein quartz and to some extent in granites. Vein quartz present in the block are confined to the sheared zones and fractures which form the main channels for the entry of mineralising solution and the intensity of mineralisation is controlled by the degree of fracturing. Encrustations with pyrite, chalcopyrite, bornite, and stains of limonite are the major surface indication of mineralization mainly manifested in the vein quartz. Gold occurs as very fine disseminations in negligible quantity with erratic distribution.

The integrated geophysical survey carried out by MECL in the year 2001-03 in the adjoining Shitalpani block helped to interpret the presence of a lineament or shear zone, tending ENE-WSW of 800 m strike length, which continued beyond the Shitalpani block boundary and extending in the proposed Sitapur block. Structural manifestations such as shears and their intersections are possible loci for mineralization, thus exploration through integrated approach including geophysical, geochemical surveys etc. around Sitapur village was recommended.

The proposed Sitapur block area is adjoining to Shitalpani block but the area is mostly under soil cover except few scanty outcrops at places. Based on recommendations of previous workers, and favourable geological setup and geophysical signatures it is expected that similar set up of copper mineralisation might be concealed under soil cover in the proposed Sitapur block. In the demarcated areas Fig. 5.1, the Geophysical Survey was carried out for delineating mineralised zone along with depth, strike and extent of occurrences and depositions of Pb, Zn, Cu ore & its host rocks with other associated mineralized zone.

The contrast in the physical properties of the mineralised zones and the host rocks forms the basis of Geophysical Survey. The physical properties of different expected ores of Cu, Pb, Zn, etc and host rock are shown in table below.

Ore/ rock	Chemical composition	Density (g/cc)	Magnetic Intensity
Chalcopyrite	$CuFeS_2$	4.1-4.3	Paramagnetic
Bornite	Cu_5FeS_4	5.06-5.09	Paramagnetic
Chalcocite	Cu_2S	5.5	Diamagnetic
Covellite	CuS	4.68	Diamagnetic
Pyrite	FeS_2	5.02	Paramagnetic
Biotite		2.92	Medium to low magnetic
Quartz/Quartzite		2.6-2.8	Diamagnetic
Galena	PbS	7.6	Diamagnetic
Sphalerite	ZnS	3.9-4.1	Paramagnetic

Table -2: Physical Properties of different expected Ores & host rocks

2.0 BRIEF INTRODUCTION TO GEOPHYSICAL METHOD

2.1 Induced Polarisation:

Induce Polarisation is the phenomena referred to build up of ionic charges in subsurface materials under the influence of electric field. There are two types survey method in IP

i) Time Domain.
ii) Frequency Domain.

I) **Time Domain:** The normalised area under the decay curve is the most often measured in time domain IP. Using the parameters listed in the adjacent graphic.
Essentially, chargeability (M) is the red region beneath the decay curve that has been normalised by the source voltage., Following equation can be used to represent it.

$$M = 1/V_p \int V_s (t)\, dt$$

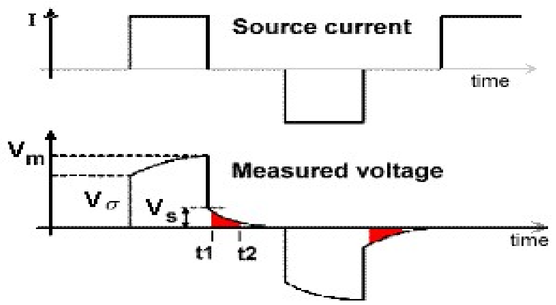

Fig. 2.1: Source current and voltage decay with respect to time in IP time domain method.

II) **Frequency Domain:** In frequency domain method the amplitude of potential is measured for two frequencies and it can be expressed as frequency effect. In this method the resulting data include i) DC resistivity ρ_{dc} and ii) ρ_{ac} for non-zero low frequency.
Frequency Effect can be expressed as following equation.

$$FE = (\rho_{ac} - \rho_{dc})/\rho_{ac}$$

Similar to resistivity method depth of investigation can be increased by increasing spread of the array.
All the different type of array in IP method has their advantages and disadvantages, so it is very crucial to select optimum array method considering our objective.

2.2 Self-Potential Method:

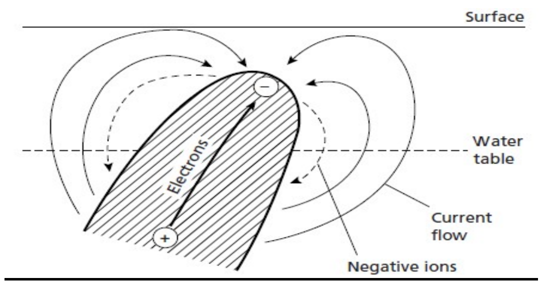

Fig.2.2: The mechanism of self-potential anomalies

The Self Potential method is based on the surface measurement of natural potential differences resulting from electrochemical reactions in the subsurface. Typical SP anomalies may have amplitude of several hundred millivolts(mV) with respect to barren ground. They invariably exhibit a central -Ve anomaly and are stable over long periods of time. Field studies indicate that for a SP

Anomaly to occur its causative body must lie partially in a zone of oxidation. They are usually associated with deposits of metallic sulphides, magnetite or graphite. A widely-accepted mechanism of self-potential requires the causative body to straddle the water table. Below the water table electrolytes in the pore fluids undergo oxidation and release electrons which are conducted upwards through the ore body. At the top of the body the released electrons cause reduction of the electrolytes. A circuit thus exists in which current is carried electrolytically in the pore fluids and electronically in the body so that the top of the body acts as a negative terminal. This explains the negative SP anomalies that are invariably observed and their stability as the ore body itself undergoes no chemical reactions and merely serves to transport electrons from depth. As a result of the subsurface currents, potential differences are produced at the surface.

2.3. <u>Magnetic Method:</u>

Generally, the aim of a magnetic survey is to investigate subsurface geology on the basis of the anomalies in the earth's magnetic field resulting from the magnetic properties of the underlying rocks. In general, the magnetic content (susceptibility) of rocks is variable depending on the rock type. Commonly causes of magnetic anomalies include dykes, faults and lava flows. In case of geothermal environment, due to high temperatures, the susceptibility decreases. It is not usually possible to identify with certainty the causative bodies of any anomaly from magnetic information alone.

Magnetism is, just like gravity, a potential field. So, it is also possible to transform one potential field to others. Anomalies in the earth's magnetic field are caused by induced or remnant magnetism. Induced magnetic anomalies are the result of secondary magnetization induced in a ferruginous body by the earth’s magnetic field. The shape dimensions, and amplitude of an induced magnetic anomaly is a function of the orientation, geometry, size, depth, and magnetic susceptibility of the body as well as the intensity and inclination of the earth's magnetic field in the survey area.

The magnetic method involves the measurement of the earth's magnetic field intensity. At any point on the Earth’s surface a freely suspended magnetic needle will assume a position in space in the direction of the ambient geomagnetic field. This will generally be at an angle to both the vertical and geographic north. A Schematic diagram given below in order to describe the magnetic field vector. The total field vector B has a vertical component Z and a horizontal component H in the direction of magnetic north. The dip of B is the inclination I of the field and the horizontal angle between geographic and magnetic north is the declination D. In the present study total magnetic field has been measured. Measurements of the horizontal or vertical component or horizontal gradient of the magnetic field may also be made.

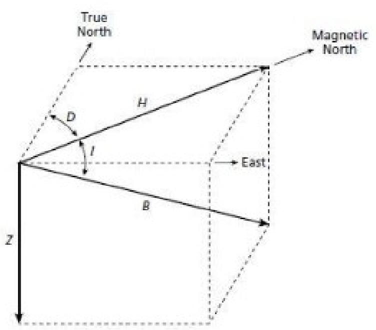

Fig.2.3: Schematic diagram magnetic field vector

3.0 GEOPHYSICAL QUANTUM OF WORK

The scope of work consists of Acquisition, Processing and Interpretation of ground Geophysical survey data in the potential area. The Profile lines were designed and aligned in such a way that it lays across the regional geological strike direction of the targeted potential zones and to be covered with 30 lines Km (3 Unit) of IP, SP and magnetic Survey Profile as approved by NMET. The Geophysical survey was carried out by using IP, SP and magnetic methods with 22 profile lines in grid pattern comprising 30-line Km. The lines were kept at 100 meters spacing with 20 meter as station spacing for recording data. The objective of the Geophysical survey was to delineate Cu ore and its host rock with other associated mineralized zone.

4.0 FIELD ACTIVITIES

A base camp was established near the Sitapur Block to facilitate the geophysical survey. The survey team consisted of three members (Table 4.) equipped with specialized instruments including the ENVI Pro Magnetometer for magnetic measurements, the IRIS Syscal R2 Resistivity Meter for SP data recording, the Syscal-Elrec Pro 10 Channels for IP-cum-Resistivity measurements and Trimble Juno Handheld GPS unit for precise location tracking/marking. Detailed specifications of this equipment are provided in Table 5. The block boundary map, along with its coordinates, is presented in Figure 4. and Table 3. respectively. To ensure accuracy and minimize disturbances the magnetic base was established Outside of the Sitapur block boundary area, as specified in Table 6.

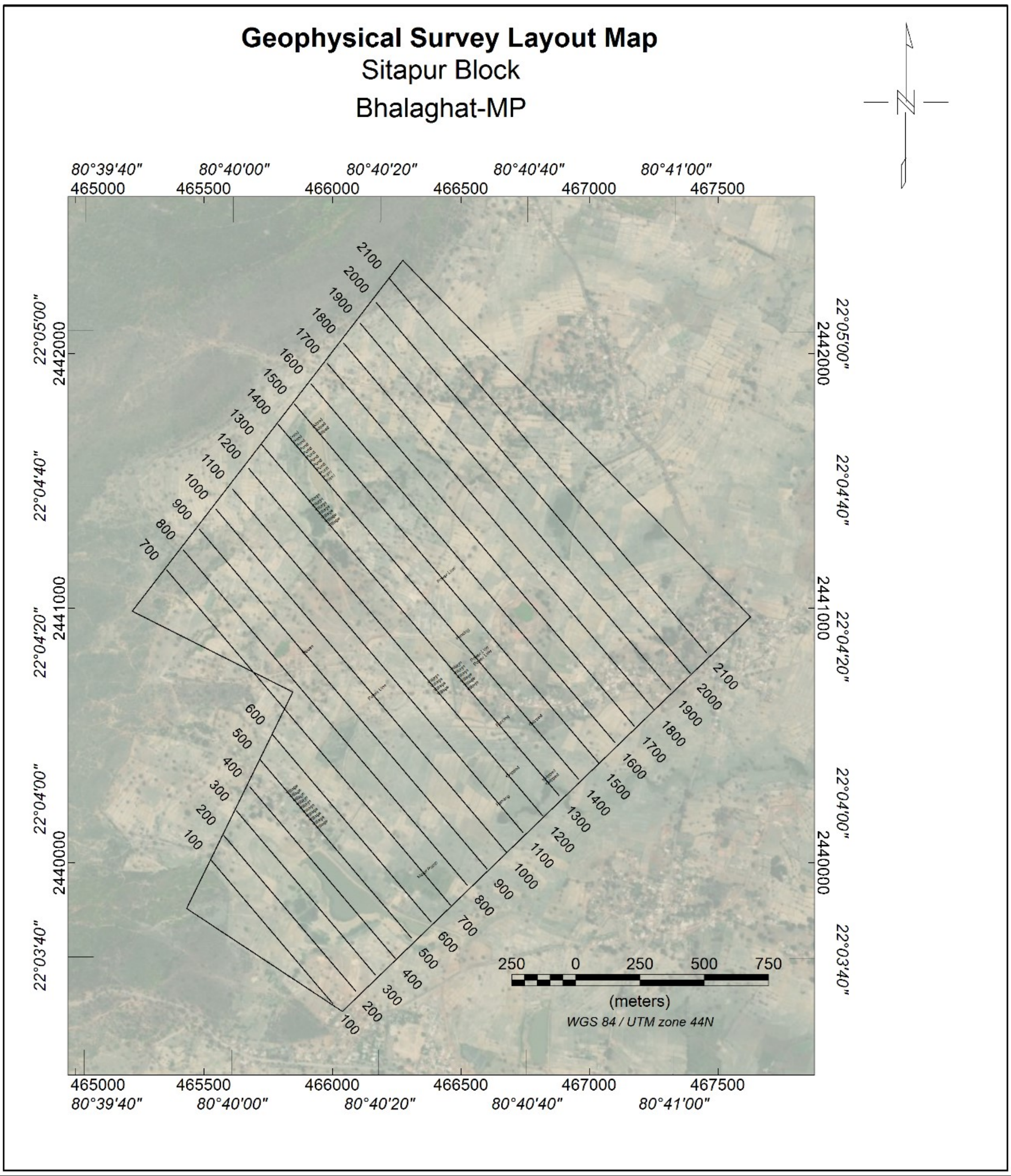

Figure 4: Block Boundary of Sitapur Block

The field activities consisted of the following:

- Demarcations of block boundaries were carried by DGPS system.
- Fixation of survey points in 20m X 1000m grid with GPS system.
- Magnetic data has been acquired with EnviPro Magnetometer and SP data with IRIS Syscal R2 and the Syscal-Elrec Pro 10 Channels for IP-cum-Resistivity measurements
- Field QC of acquired data on daily basis.

Total area surveyed and Line Km recorded in the blocks are given below.

Cardinal Points	Easting	Northing	Parameter	Grid	Line No	Line Km	Covered area (Km^2)
A	466273	2442365	MAGNETIC SP IP	20 x 100	L1 - L22	30	2.004
B	467625	2440966					
C	466037	2439417					
D	465434	2439816					
E	465860	2440670					
F	465220	2440991					
Magnetic Base	462365	2439989					

Table 3: Block boundary Coordinates

4.1. Duration of Work:

The Geophysical survey was completed within 60 days i.e. from 13-04-2024 to 11-06-2024.

4.2. Back-Office Work:

- QA/QC of acquired data on day-to-day basis.
- Preliminary processing of data to check for errors/jumps and any repetition if needed.
- Monitoring of covered Line Km and area.

4.3. List of Personnel:

The following personnel were involved in the project as given below:

Sr. No.	Name & Designation	Responsibility
1.	G.S. Dhami GM (GS)	Heading the Project, Planning Monitoring, Liasoning, Data processing, interpretation and report writing.
2.	Bimalendu Roy Manager (Geophysics)	Data processing, interpretation and report writing.
3.	Rajat Kumar (Geophysicist)	Data acquisition, Data QA/QC analysis, Data processing, interpretation & report writing work.
4.	Ramesh Kumar (Geophysicist)	Data acquisition.
6.	Rattan Malo (S&D)	Surveying.

Table 4: List of Personnel

5.0 EXPLORATION PARAMETER

5.1 Project Area And Location:

The proposed Sitapur Block is the adjoining to Shitalpani Copper block and covers an area of 2 sq. km. and is located at about 10 km north-west of Malanjkhand mine. The proposed Sitapur block comes under Survey of India toposheet number 64 B/12. The block is bounded between latitudes 22^{0}03’7” to 22^{0}5’ 3” N and longitudes 80^{0}39’15” and 80^{0}41’4” E. Newargaon, the nearest town is located about 5 km north west from Malanjkhand on MalanjkhandBaihar-Balaghat road. The Sitapur village can be approached from Newargaon by 5km semimetalled/ fair weather kutcha road. Newargaon is well connected with district HQ of Balaghat (86km) to the south-west and with Durg (130km) on the south-east by metalled road.

The nearest railhead is Lamta, situated on Gondia-Jabalpur narrow gauge line is 70km from Newargaon. Durg (130km) and Gondia (147 km) are the nearest broad gauge railway stations located on Mumbai-Howrah main line of South-Eastern railway.

The nearest airport Raipur is about 170 km from the proposed block.

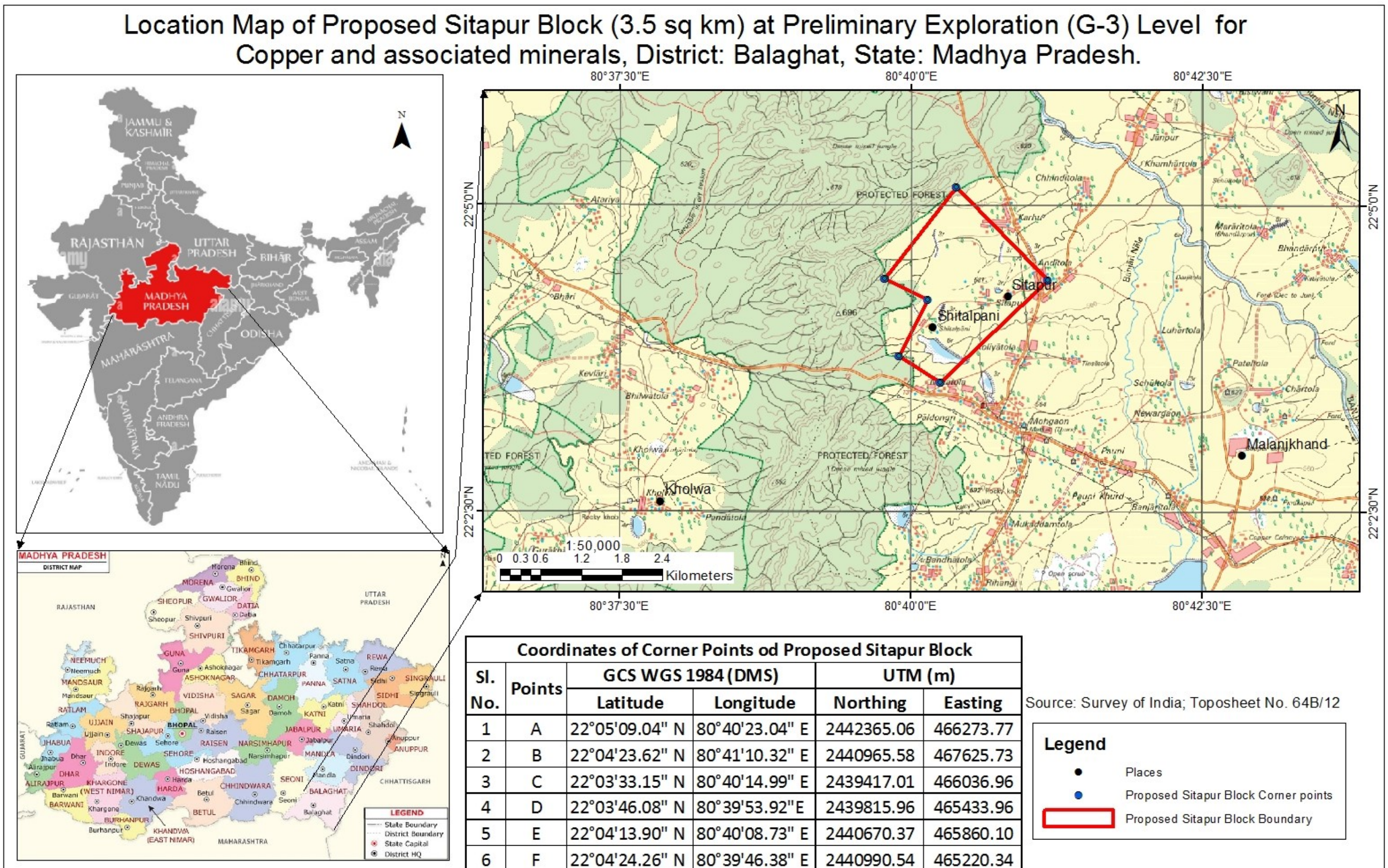

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Figure 5.1: Location map of the Sitapur Block

5.2. <u>Instrument Details:</u>

INDUCED POLARIZATION DATA ACQUISITION UNIT	
Type	Syscal Elrec Pro Resistivity meter with IP & SP measurements-10 Channels
Make	IRIS Instrument
Input impedance	100 M0hm
Voltage resolution	1 µV/0.2%
Voltage accuracy	0.2%
Automatic compensation of SP	-5V to +5V
RESISTIVITY METER (SP Measuring Unit)	
Type	SYSCAL R2 Resistivity meter with IP & SP measurements
Make	IRIS Instrument
Input impedance	100 MOhm
Voltage resolution	1 µV/0.2%
Voltage accuracy	0.2%
Automatic compensation of SP	-5V to +5V
MAGNETOMETER	
Type	Proton Precision Magnetometer (PPM)
Make	Scintrex (ENVI Pro MAG)
Sensitivity	0.1 nT
Accuracy	+1nT
Range	23000 to 100000 nT
SURVEYING	
Type	Hand-Held-DGPS
Model	Trimble-Juno

Table 5: Instruments Details

5.3. Field Data Acquisition:

<u>Magnetic Data Acquisition:</u>

The survey was designed in a grid pattern with a line interval of 100 meters and a station spacing of 20 meters, with positions marked using Hand held DGPS. Survey locations were meticulously demarcated by placing pegs, each indicating the corresponding line and station number. The layout map of the traverse lines and observation stations is shown in Fig. 4. As one line no 4 (400) was not accessible due to pond, it was skipped and offset- line in between line number 3 and 5 as infilling was taken into consideration to infill the data gap. The Magnetic data was recorded at every station with starting and ending at the base station on routine basis. The survey was meticulously designed to detect subtle changes in the magnetic field, which could indicate the presence of geological features such as shear zones, faults, and mineralized bodies.

IP Data Acquisition:

IP & Resistivity profile data was recorded by 20 m dipole-dipole array configuration with max 10 channels and min 4 channels of 20 m dipole interval. A sum of 30 L Km profile data was recorded in the surveyed block.

IP Survey Design:

ERT and IP survey is usually conducted following the various arrangements of four electrodes, two current electrode (C1 and C2) and two potential electrode (P1 and P2) depending upon the specific purposes. There are many electrode arrangements, which can be used in the ERT and IP field survey. In some geological situations one is particularly better than the other to give better response. To map lateral changes in structures Dipole –Dipole and Werner are considered as better compare to other arrays. So the Dipole-Dipole Survey (Fig. 5.3.1) has been used for the Block.

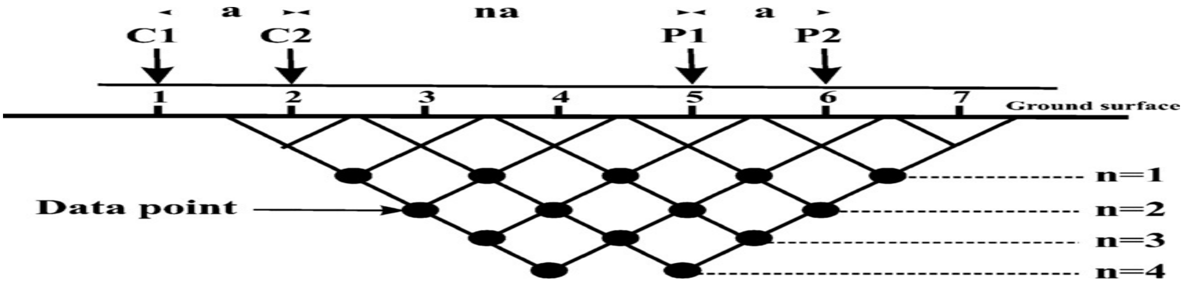
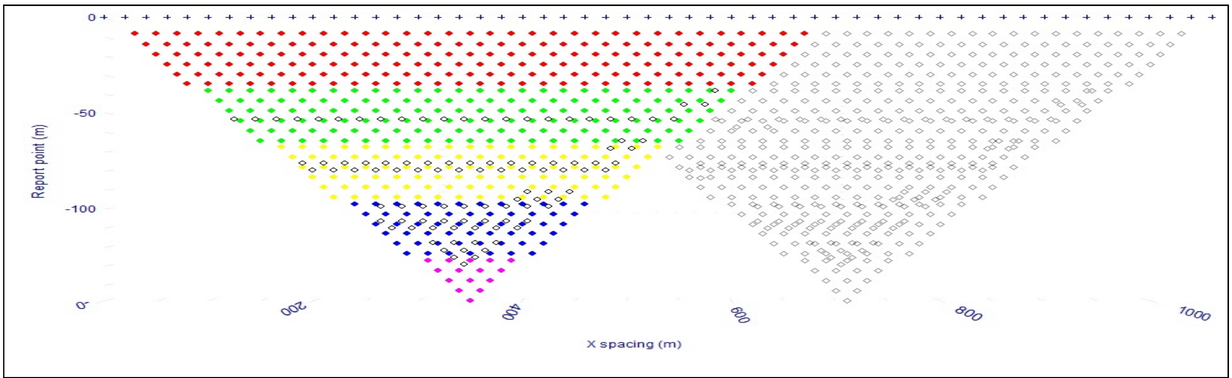


Figure 5.3.1: Dipole – Dipole Configuration

In present field 10 channels has been used for Imaging of subsurface. The electrode spacing is 20 m, and maximum array length is 180 m. In multi electrode channel system, the system automatically selects different combinations of C1, C2, P1 and P2 out of 10 electrodes. This helps us to image the subsurface effectively in optimum time period. For profile length more than 180 m, roll along method is applied to avoid data gaps in successive arrays. For better illustration of Multi electrode system a graphical representation is presented here



+ electrode location

Figure 5.3.2: Data acquisition pattern in subsurface for roll along profiles

SP Data Acquisition:

The SP survey was carried out using non-polarizing electrodes and a high-impedance voltmeter, along with an SYSCAL R2 system. The recording was done in a grid pattern, with a station spacing of 20 meters and line spacing of 100 meters. A total of 30 LKM was covered.

5.4 Data Reduction and Processing.

Magnetic Survey:

Recorded magnetic data was corrected for diurnal variation of the geomagnetic field with respect to the base station where data was recorded at the start and end of every day field work. IGRF correction of model 2020 was applied on the data set to overcome the large-scale structure of the Earth's main magnetic field and its secular variation. The data was processed using Geosoft Oasis Montaj software and the below listed magnetic anomaly maps have been generated.

- Total Magnetic Intensity (TMI) Map (Fig. 5.4.1.1)
- Magnetic Anomaly (MA) Map (Fig. 5.4.1.2)
- Reduced to Pole (RTP) Map of (TMI) (Fig. 5.4.1.3).
- Upward Continuation Map of Magnetic Anomaly at 100 m (Fig. 5.4.1.4)
- Residual Anomaly Map of Magnetic Anomaly at 100 m (Fig. 5.4.1.5)
- Total Horizontal Derivative (Dxy) Map (Fig. 5.4.1.6)
- Analytical Signal Analysis (ASA) Map (Fig. 5.4.1.7)
- Radially Average Power Spectrum (Fig. 5.4.1.8)
- Profile Plots of TMI (Fig. 5.4.1.9)

After applying diurnal corrections, the recorded magnetic data showed variation of 951.6 nT with the highest total magnetic intensity value of 45670.3 nT and minimum of 44718.7 nT was observed in TMI map (Fig. 5.4.1.1). While the magnetic anomaly with respect to IGRF shows a minimum of -1159.9 nT and maximum of 511.5 nT in Magnetic Anomaly Map (Fig. 5.4.1.2).

Induced Polarization (IP) and Resistivity Profiles:

The resistivity data were checked station-wise to remove any near surface effect prevailing in the data. The pseudo-depth data were inverted using the RES2DINV software to bring out the subsurface resistivity and chargeability distribution. The inverted sections for recorded IP and Resistivity data are processed in following order to obtain subsurface 2D models: -

1) Geo-referencing.
2) Edit/Mute (Noises).
3) Generate 2 D models of subsurface with the help of IP and Resistivity data (Fig.5.4.1.10).

Self-Potential (SP) Profiles:

The SP data was processed using Geosoft Oasis Montaj software. Total SP anomaly Map (Fig.5.4.1.11) and the SP Profile (Fig. 5.4.1.12) along each traverse have been generated from the SP data. Total variation in SP value was observed with the highest value of 0.72 mV and mV– 86.1 mV as lowest.

6.0. RESULTS OF GEOPHYSICAL SURVEY

6.1.1 Magnetic Anomaly:

The aim of a magnetic survey is to investigate subsurface geology on the basis of the anomalies in the earth's magnetic field resulting from the magnetic properties of the underlying rocks. In general, the magnetic content (susceptibility) of rocks is variable depending on the rock type. Commonly causes of magnetic anomalies include dykes, faults and lava flows. In case of geothermal environment, due to high temperatures, the susceptibility decreases. It is not usually possible to identify with certainty the causative bodies of any anomaly from magnetic information alone. The magnetic method involves the measurement of the earth's magnetic field intensity. Magnetism is, just like gravity, a potential field. So, it is also possible to transform one potential field to others. Anomalies in the earth's magnetic field are caused by induced or remnant magnetism. Induced magnetic anomalies are the result of secondary magnetization induced in a ferruginous body by the earth’s magnetic field. The shape dimensions, and amplitude of an induced magnetic anomaly is a function of the orientation, geometry, size, depth, and magnetic susceptibility of the body as well as the intensity and inclination of the earth's magnetic field in the survey area. The total magnetic intensity (TMI) (Fig. 5.4.1.1) has indicated characteristic variations of magnetic response over different litho-units. After applying diurnal corrections, the recorded magnetic data showed a total variation of 951.6 nT with the highest total magnetic intensity value of 45670.3 nT and minimum value of 44718.7 nT was observed in TMI map.

The magnetic anomaly map is characteristics in revealing changes in the magnitude of anomaly, trend and alignments attributable to known and unknown surface and subsurface geological situations. The magnetic anomaly map indicates the presence of ferromagnetic, paramagnetic as well as diamagnetic body aligned in the study area. Magnetic intensity decreasing (paramagnetic to diamagnetic) in the south- eastern portion of the block with an alignment in north-east to south-west direction, indicates the possible shear zone (Fig. 5.4.1.2). The high anomaly values in the magnetic maps show the presence of some magnetic ore body with feeble iron content. The magnetic anomaly value with respect to IGRF of model 2020 shows a minimum value of -1159.9 nT and maximum value of 511.5 nT in the magnetic anomaly map (Fig.5.4.1.2).

The low magnetic anomalies observed along the geological strike direction trending from northeast to southwest direction at the eastern part of the study area, suggest the possible presence of a shear zone, which may be further continued of the Shitalpani block. This zone may be associated with mineralization due shearing facies. This potential shear zone trending NE-SW has cumulative strike length of approximately 1.6 km.

6.1.2 Reduced To Pole (RTP):

Because of the dipolar nature of geomagnetic field, the magnetic sources observed anywhere except magnetic poles are asymmetric; this feature makes the interpretation of magnetic data difficult. The reduced to pole (RTP) technique is implemented over the Magnetic anomaly grid in order to convert magnetic anomaly to symmetrical shape so that the angle of inclination is 90 degree and declination is zero and hence, the effect of dipoles were eliminated. In the present study reduced to pole is applied on the diurnally corrected Magnetic Anomaly data.

RTP Map was generated from magnetic anomaly map with the amplitude correction inclination was at 90˚. The RTP Maps is showing the variation of 783 nT with the highest value of 225 nT and minimum of -558 nT was observed in RTP (Fig.5.4.1.3)

By applying the RTP technique, the low anomalous zone in the north-eastern part of the survey area becomes more prominent and aligned more closely in NW-SE direction, which was less visible in the original Magnetic anomaly map. The expected shear zone has also been well collaborated and sharper in the image at the south-eastern part of the surveyed block.

6.1.3 Residual Magnetic Anomaly:

The residual magnetic anomaly map (Fig.5.4.1.5) has been derived by deducting 100m upward continuation map (Fig.5.4.1.4) from magnetic anomaly map (Fig.5.4.1.2) applying "grid math" in Geosoft oasis montaj software, The residual magnetic anomaly map strongly reflects local the geological features / structures. The magnetic anomaly presents at the north-western part of the study area has been disappear in the residual anomaly map, it can be interpreted that the anomaly at the north-western part of the block is mainly due to the regional geology. Whereas anomaly at the south eastern part of the block trending in NE-SW direction is due to the shear facies at the study area and prominent as residual features. Thus, the smaller anomalies in the Magnetic anomaly map in areas of strong regional disturbances are more readily apparent on the residual Magnetic anomaly map.

6.1.4 Total Horizontal Derivative Map:

The total horizontal derivative maps of TMI (Fig.5.4.1.6) have been generated for enhancing local anomalies. Derivative tends to sharpen the edges of anomalies and to enhance shallow features. The total horizontal derivative of magnetic anomaly map has clearly demarcated the anomalous zone in the study area.

6.1.5 Analytic Signal Analysis Map:

The Analytical signal analysis known as total gradient method is useful in demarcating the edges/lithological boundaries of source of magnetic bodies. The shape of the analytical signal of the magnetic field is nearly independent of field orientation and remanence. The analytical signal analysis map (Fig.5.4.1.7) of the study area helped in inferring lithological boundaries in the form of high intensity analytical signal amplitude along the contacts and shallow anomalous bodies. Demarcated Contour lines by White-Lines highlight boundaries of the causative bodies. The analytical signal and RTP map, both the map showing the same location of shear zones and target zones in with trending NE-SW. Also, analytical map highlighted the different boundaries of anomalous bodies.

6.1.6 Radially Average Power Spectrum:

From the Radially average power spectrum (Fig.5.4.1.8) it can be observed that most the anomaly features and causative bodies are within the depth range of 100 to 500 mt.

6.2.1. Induced Polarization (IP) Profiles:

The resistivity data were checked station wise to remove any near surface effect prevailing in the data. The pseudo-depth data were inverted using the RES2DINV software to bring out the subsurface resistivity and chargeability distribution. The inverted sections for Line-1 to Line 21 are shown in Fig.5.4.1.10. These figures provide a detailed view of the subsurface characteristics, helping to interpret the underlying geological structures.

IP Response:

The IP (Induced Polarization) response in the survey area is characterized by high chargeability and moderate to high resistivity values, which are typically associated with alteration and shear zones. The combination of high chargeability with varying resistivity suggests the presence of mineralized zones, likely containing sulfides or other conductive minerals, within these altered geological formations.

Chargeability in the study area is ranging from 10 mV/V to 80 mV/V. The values above 40mV/V may interpreted as the presence of sulfide mineralization in the study area. A consistent trend is observed across all lines, showing a clear alignment in NE-SW direction at the shear zone derived from magnetic anomaly data in the survey area, indicates sulfide mineralization. Notably, the chargeability anomaly values in some profiles suggest that mineralization extends beyond 100 meters (up to depth of investigation).

6.3.1 Self-Potential (SP) Profiles:

The total SP anomalies along each traverse have been generated from the SP data. The total variation of SP anomaly of value 158 mV was observed with the highest value of 72 mV and – 86.1 mV as lowest.

The SP data did not provide conclusive results due to structural disturbances in the area. Although it is also well correlate with the IP, Resistivity, and Magnetic data, indicating that the electro-kinetic potential developed at shear zone due to sulphide mineralization.

7.0. CONCLUSION AND RECOMMENDATIONS

The integrated geophysical survey as approved by NMET has been conducted in the Sitapur Block by adopting IP, SP and Magnetic methods. The objective of the survey was to find out the potential zones for base metals comprising copper and other associated mineralisation. The effectiveness of these methods along with its limitation depends upon the physical properties contrast of the target and surroundings. The possible mineralized zones along with structural features like faults/shear zone, has been successfully demarcated with lithological contacts by adopting integrated geophysical survey. To demarcating the zones of interest and their contacts spatial filtering technique like Upward continuation, Horizontal derivatives and analytical signal analysis etc. were applied on magnetic data to enhance the outcomes. The area of Mineralization has also been marked in IP and apparent Resistivity sections and has plotted over profile (Fig.5.4.1.10). In order to obtain source depth information, radially averaged power spectrum and analytical signal analysis maps of Magnetic anomaly etc. has been generated and depth of the anomalous zones were found ranging from 80m to 140m in different segments of the block.

The results from both Resistivity and IP method surveys have a lot of similarities. The extents of potential mineralisation zone have been plotted over the AS map. The potential zones with high probability of mineralisation are also identified with continuous trend of possible mineralization within these low-intensity magnetic.

The magnetic intensity and Reduced-to-Pole (RTP) anomaly maps show the distribution of magnetic anomalies across the study area. The areas of low magnetic intensity, particularly in a NE-SW direction, are indicative of alteration zones, shear zones, or possibly zones of disseminated mineralization marked by white dotted lines in AS Map.

Based on these integrated geophysical results, four boreholes have been proposed to further investigate the subsurface. The locations of these boreholes are strategically placed over the Analytical Signal (Magnetic) maps (Fig. Fig.5.4.1.13), targeting the identified alteration and shear zones. Detailed information regarding the proposed borehole locations, including specific coordinates and depth recommendations, is provided in Table 6.

Detailed of Proposed Boreholes Sitapur Block					
PB ID	**Easting**	**Northing**	**Angle**	**Azimuth**	**Depth**
PB-1	**465768.8**	**2439879**	**50**	**N40W**	**100**
PB-2	**465959.5**	**244024**	**50**	**N40W**	**130**
PB-3	**466585.7**	**2440616**	**50**	**N40W**	**100**
PB-4	**466265.4**	**2440687**	**50**	**N40W**	**100**

Table 6: Detailed of Proposed Boreholes Sitapur block

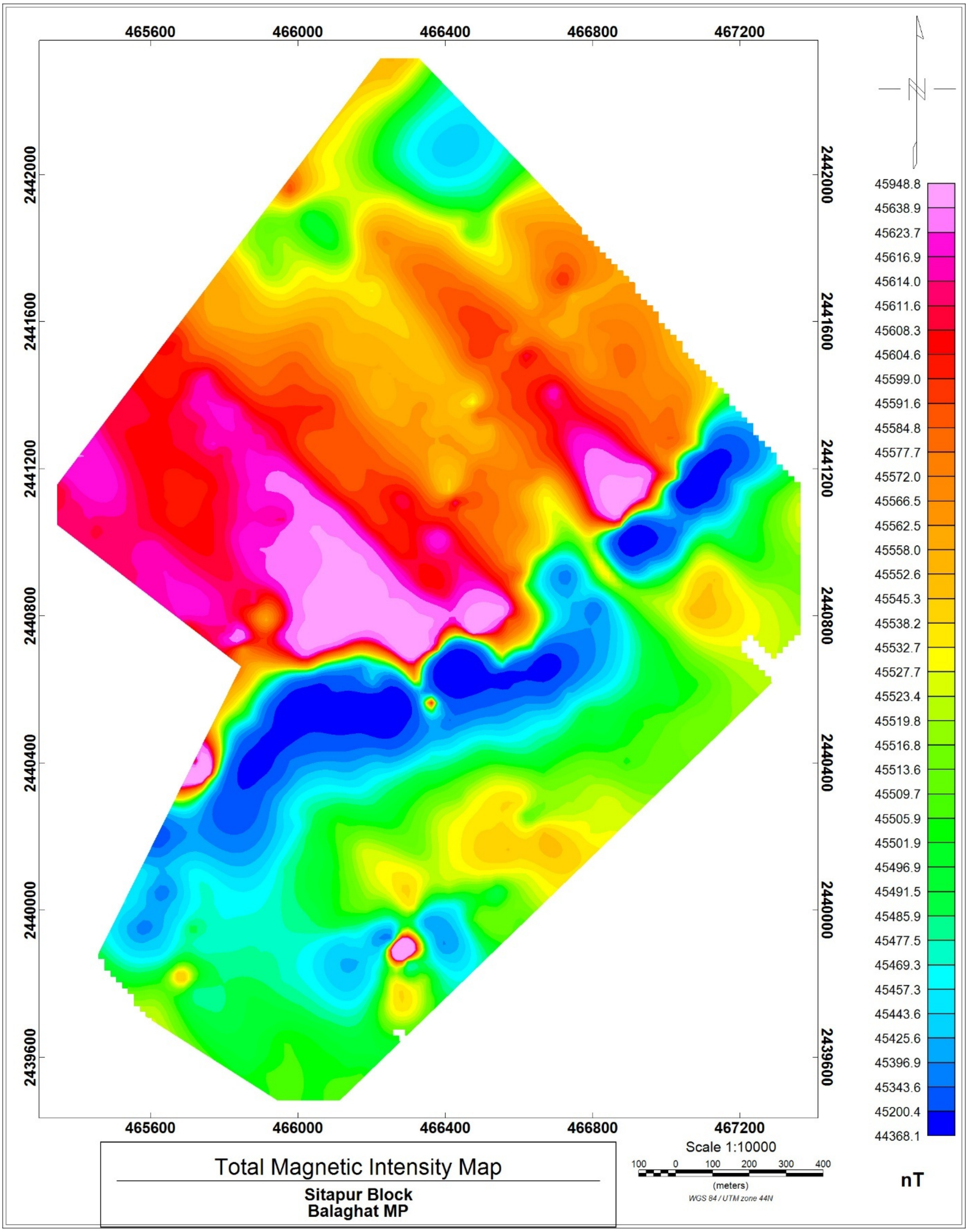


Fig. 5.4.1.1: Total Magnetic Intensity (TMI) Map

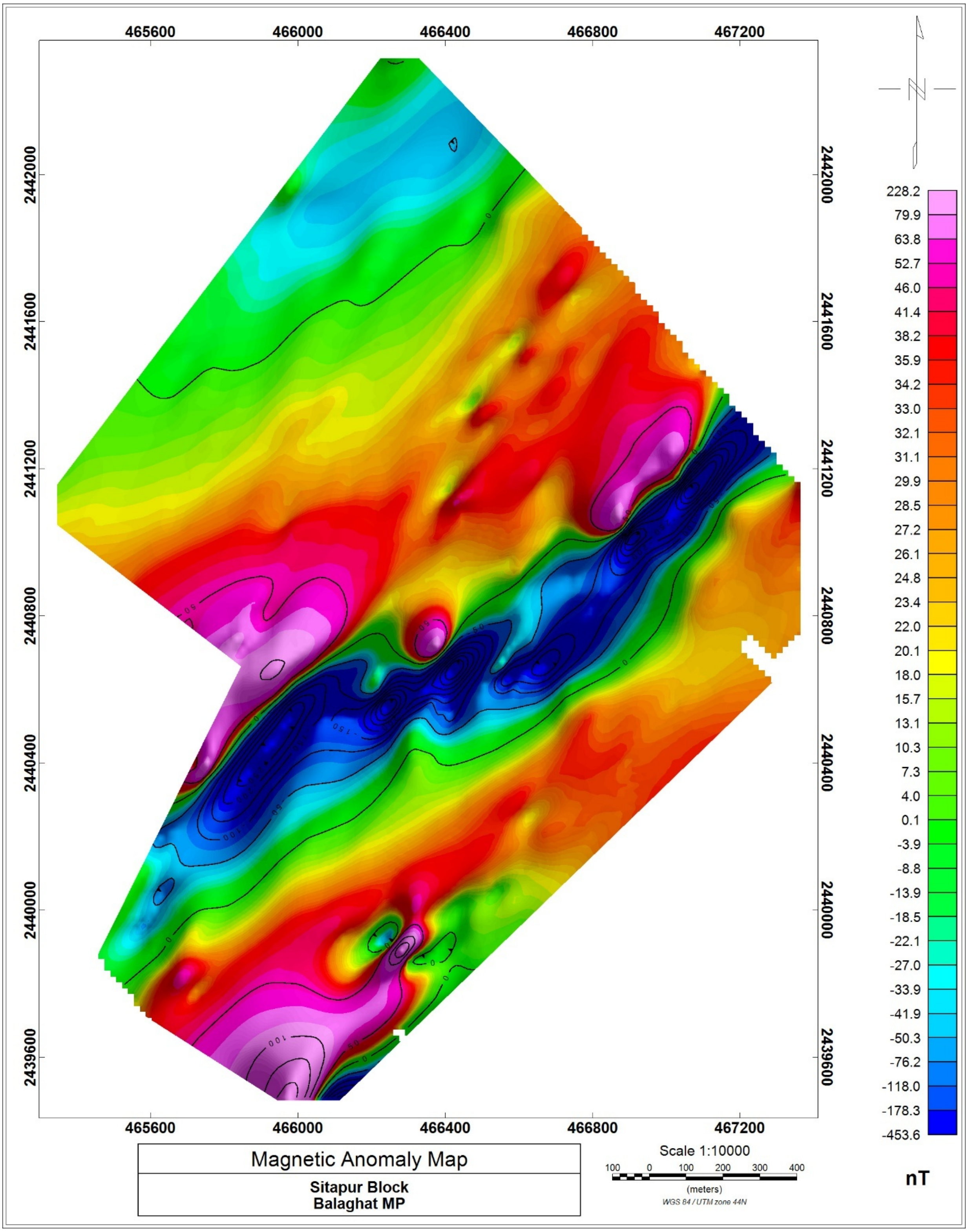


Fig. 5.4.1.2: Magnetic Anomaly (MA) Map

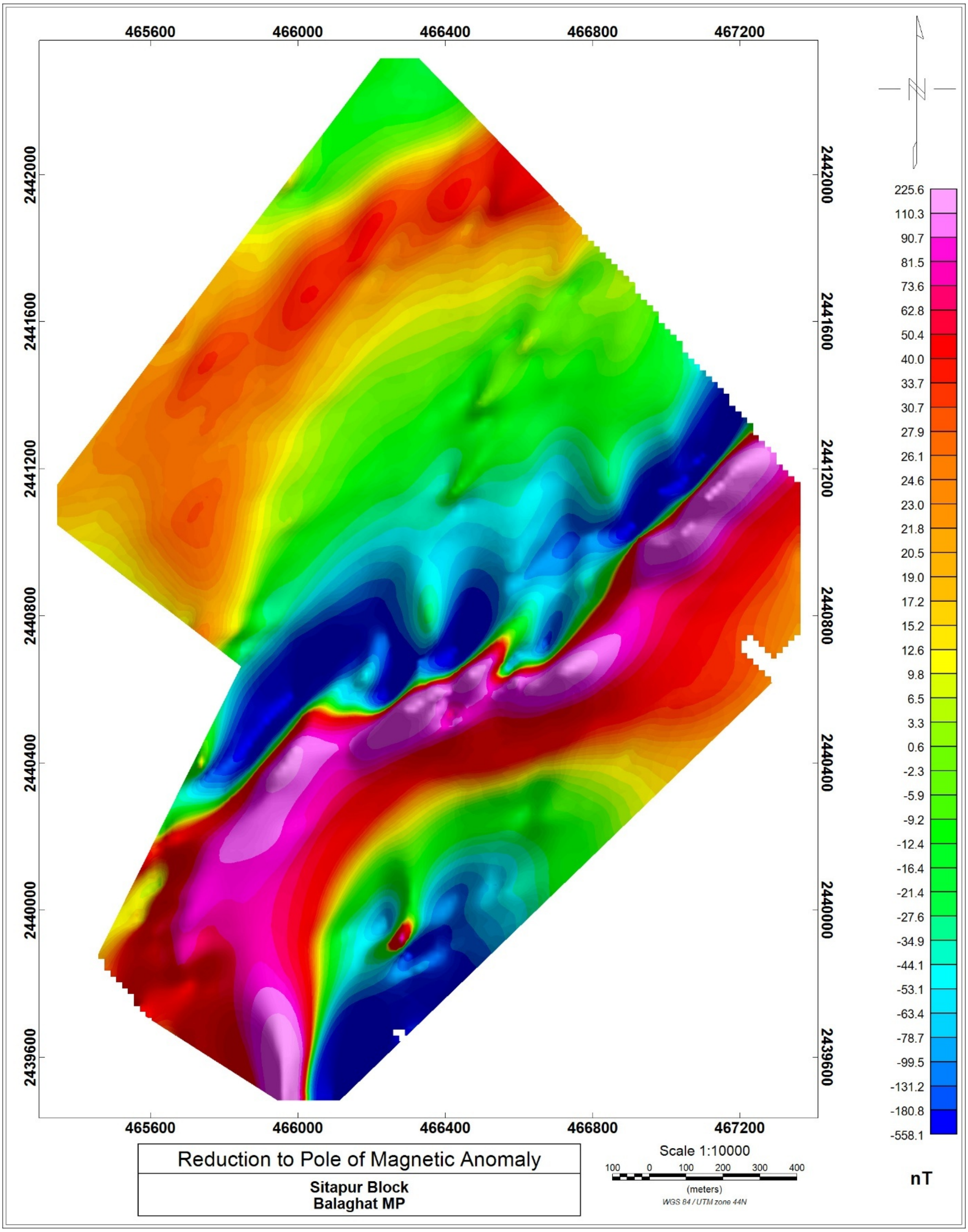


Fig. 5.4.1.3: Reduced to Pole (RTP) Map of (TMI)

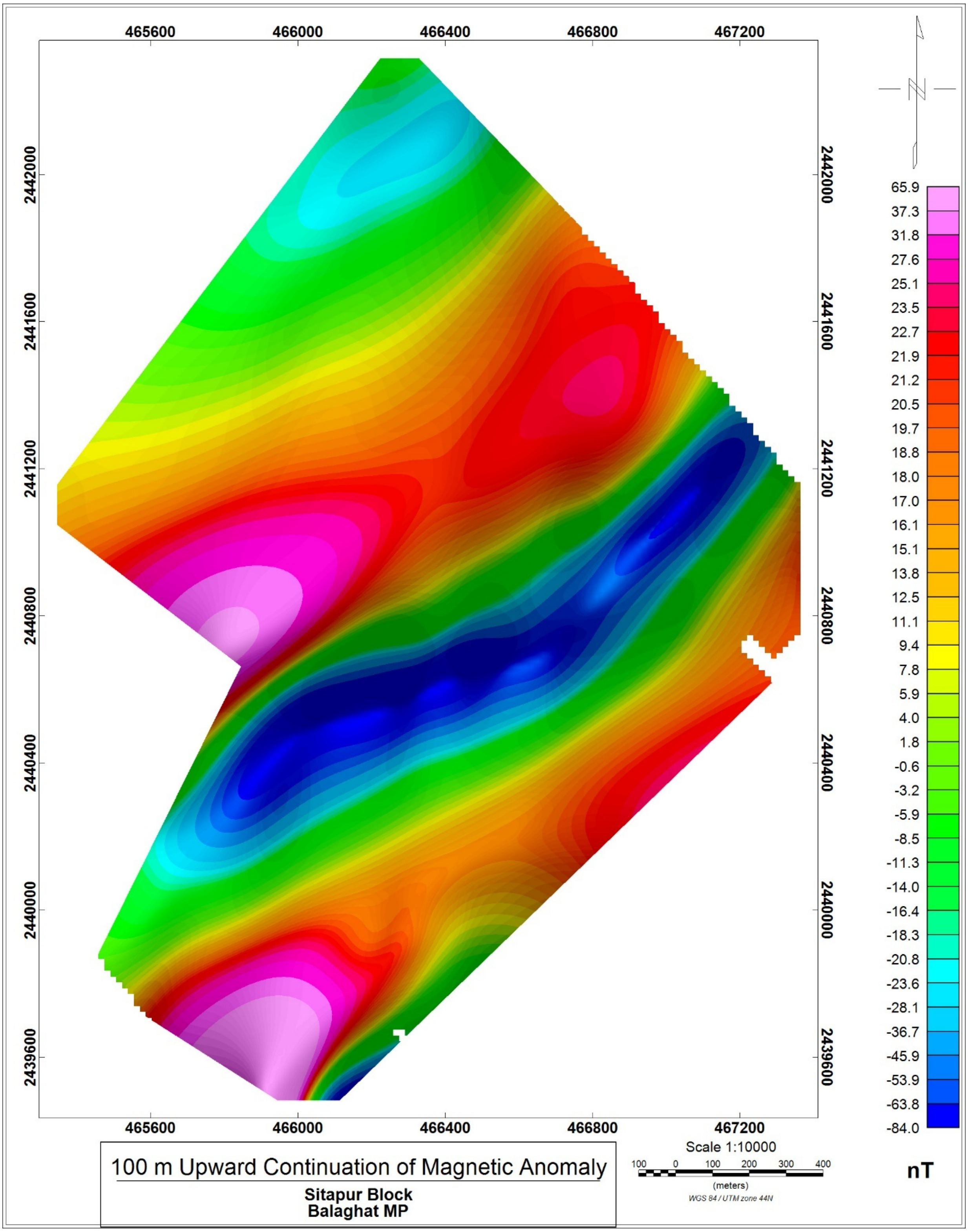


Fig. 5.4.1.4: Upward Continuation Map of Magnetic Anomaly at 100 m

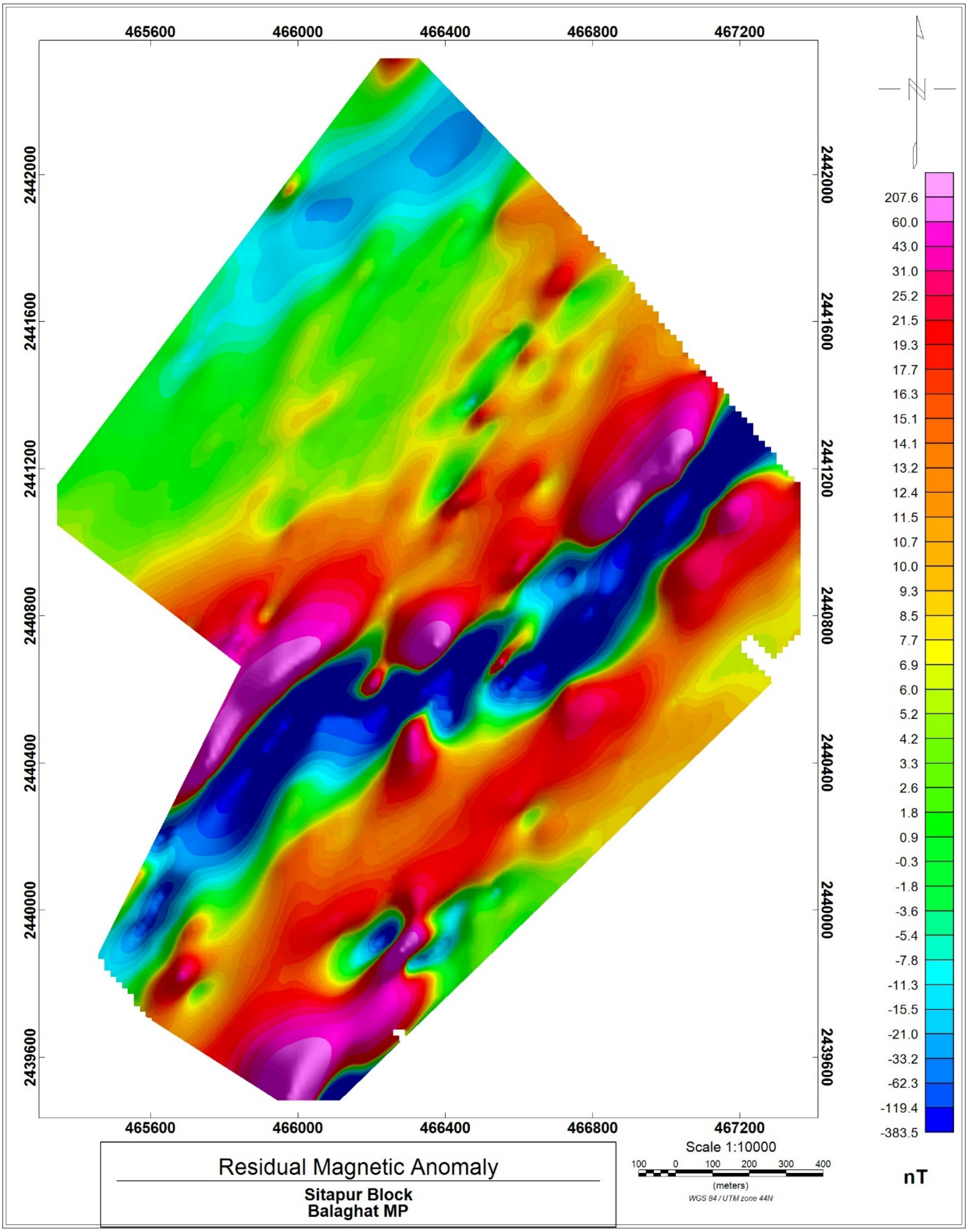


Fig. 5.4.1.5: Residual Anomaly Map of Magnetic Anomaly at 100 m

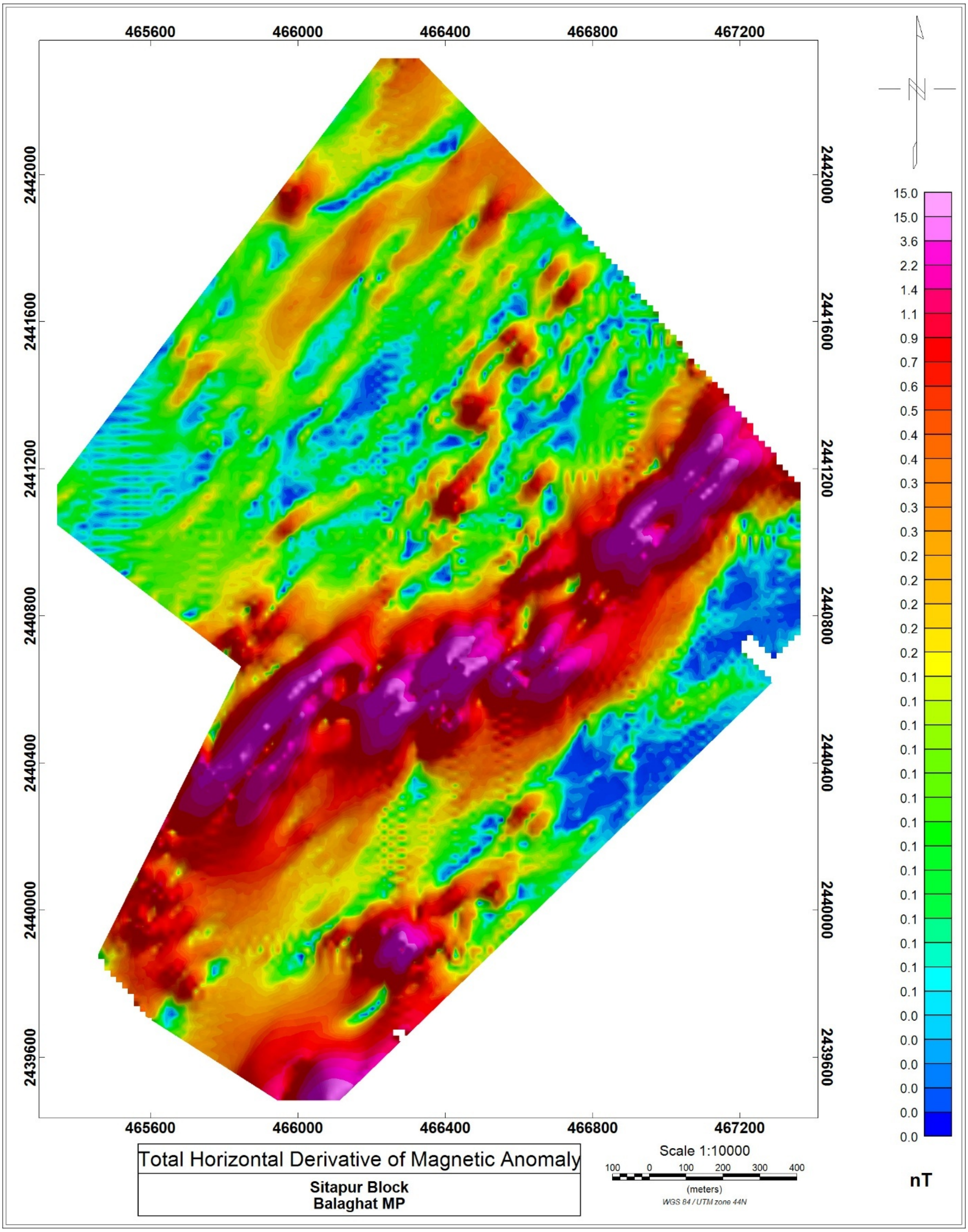


Fig. 5.4.1.6: Total Horizontal Derivative (Dxy) Map

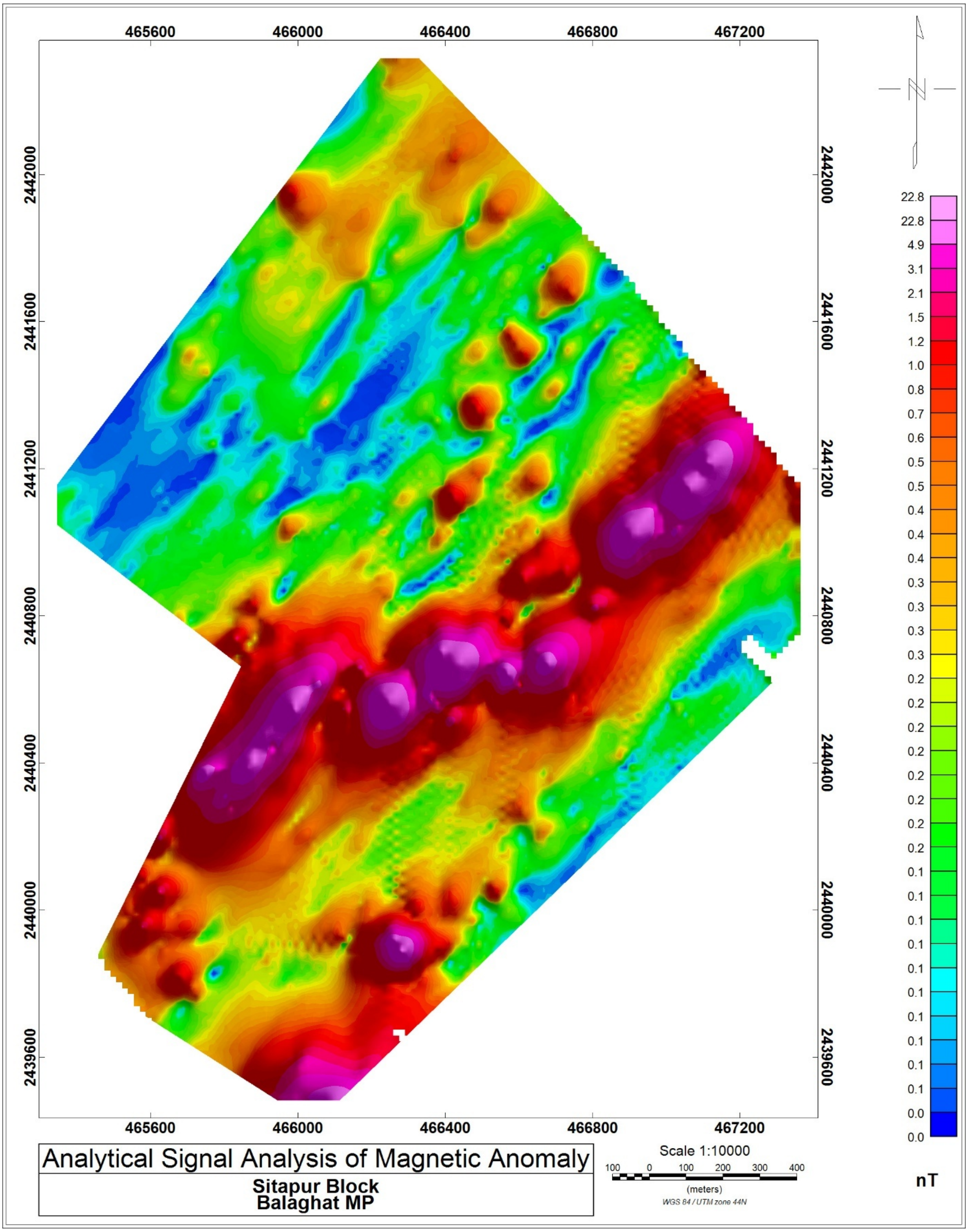


Fig. 5.4.1.7: Analytical Signal Analysis (ASA) Map

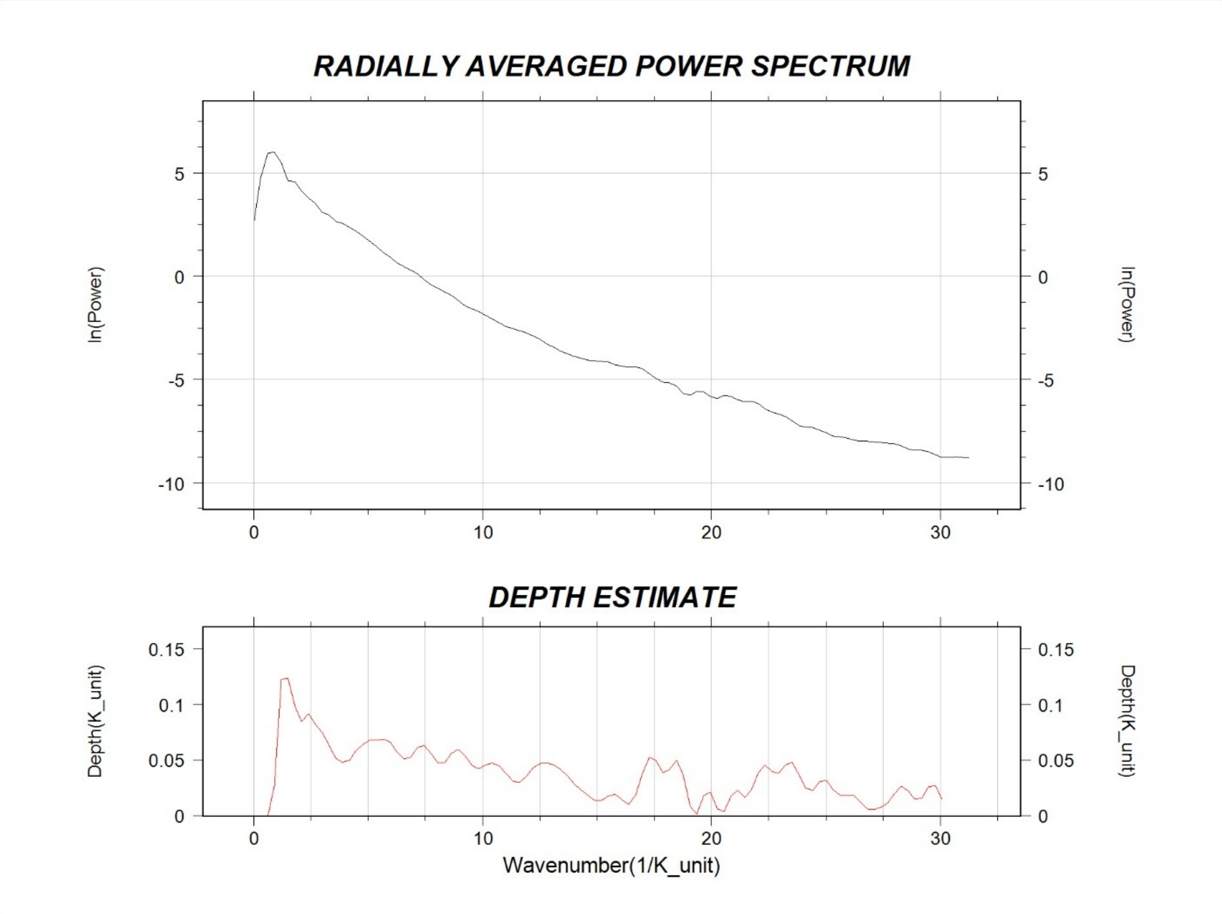


Fig. 5.4.1.8: Radially Average Power Spectrum

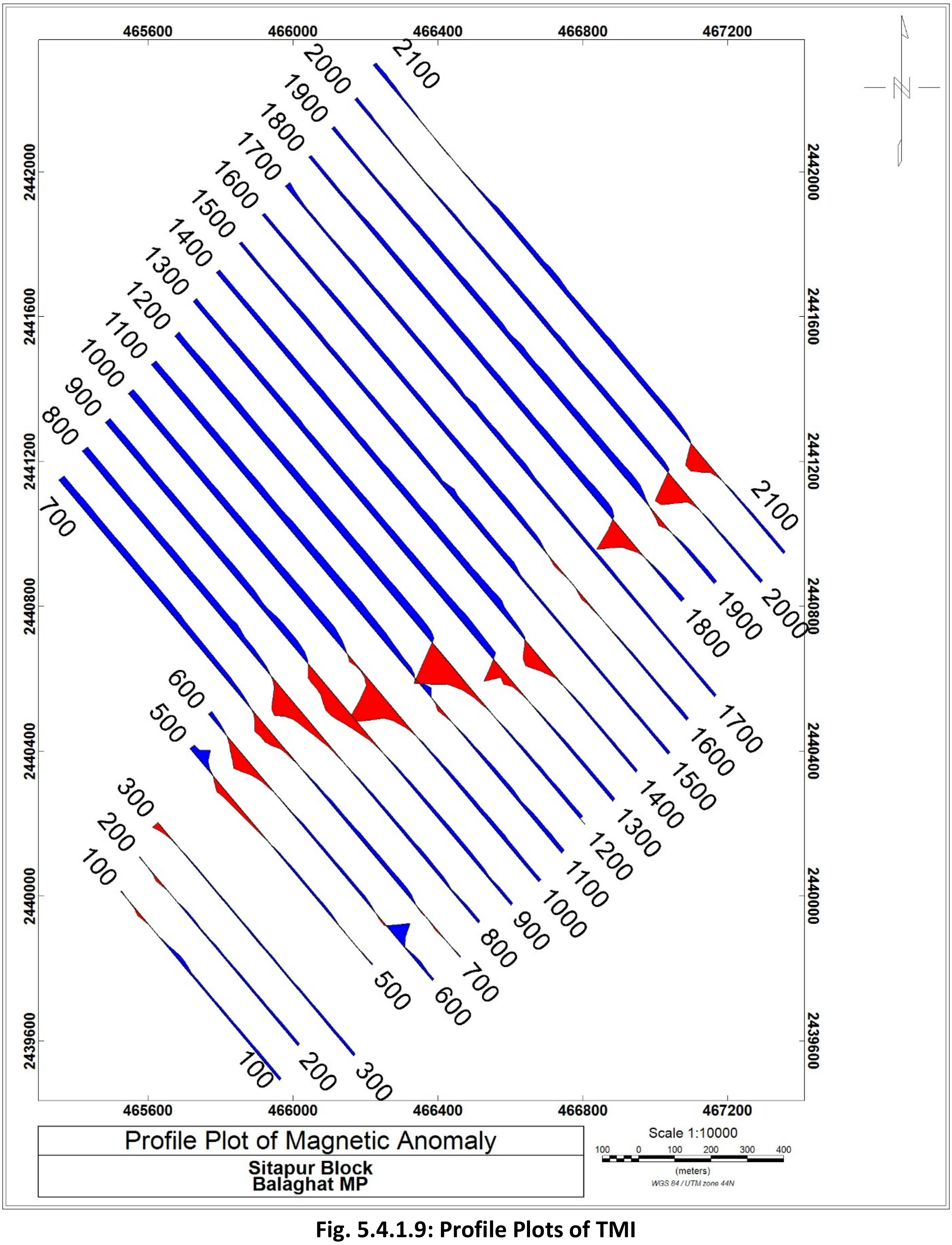


Fig. 5.4.1.9: Profile Plots of TMI

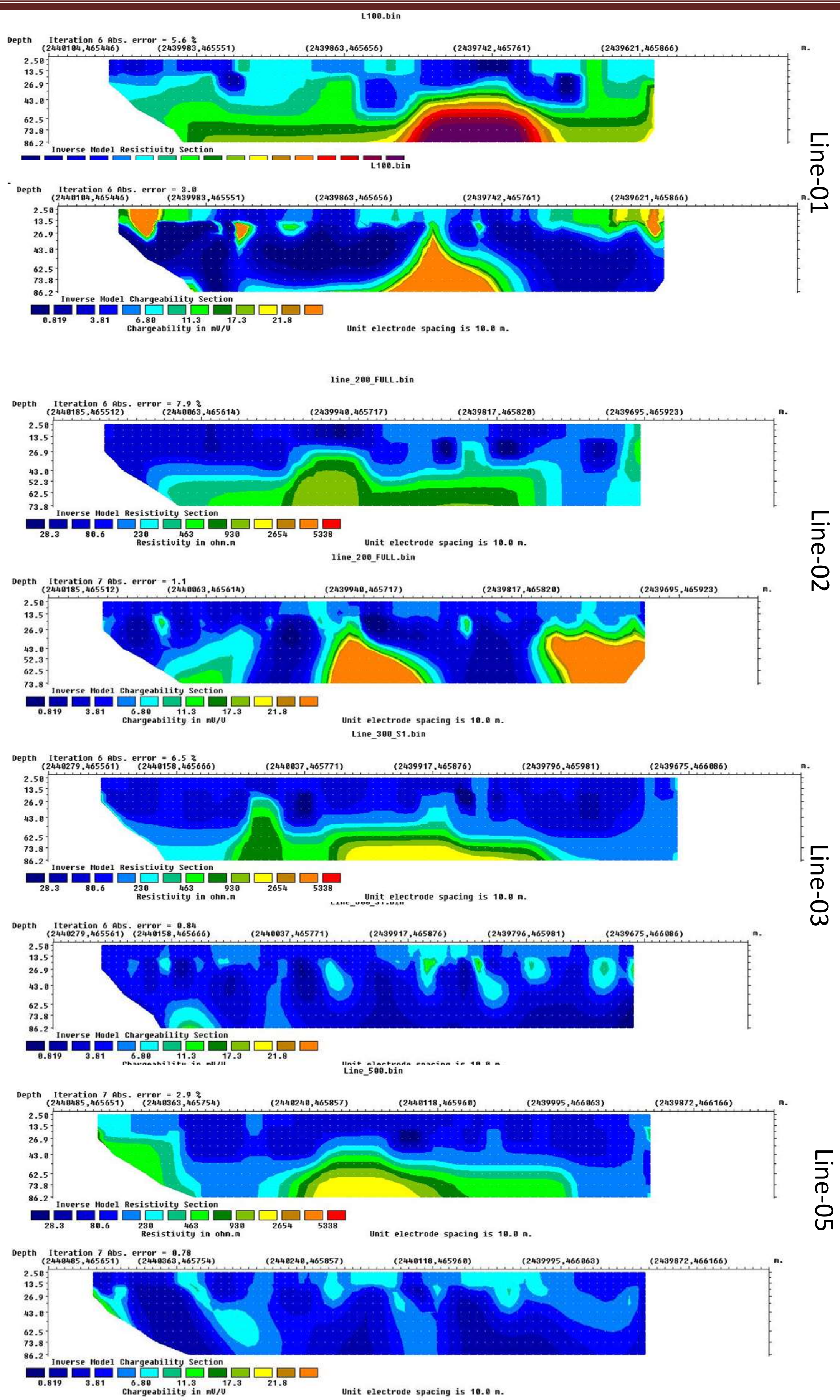


Fig.5.4.1.10.a: 2D Section of Resistivity and Chargeability (Line 1 to 5)

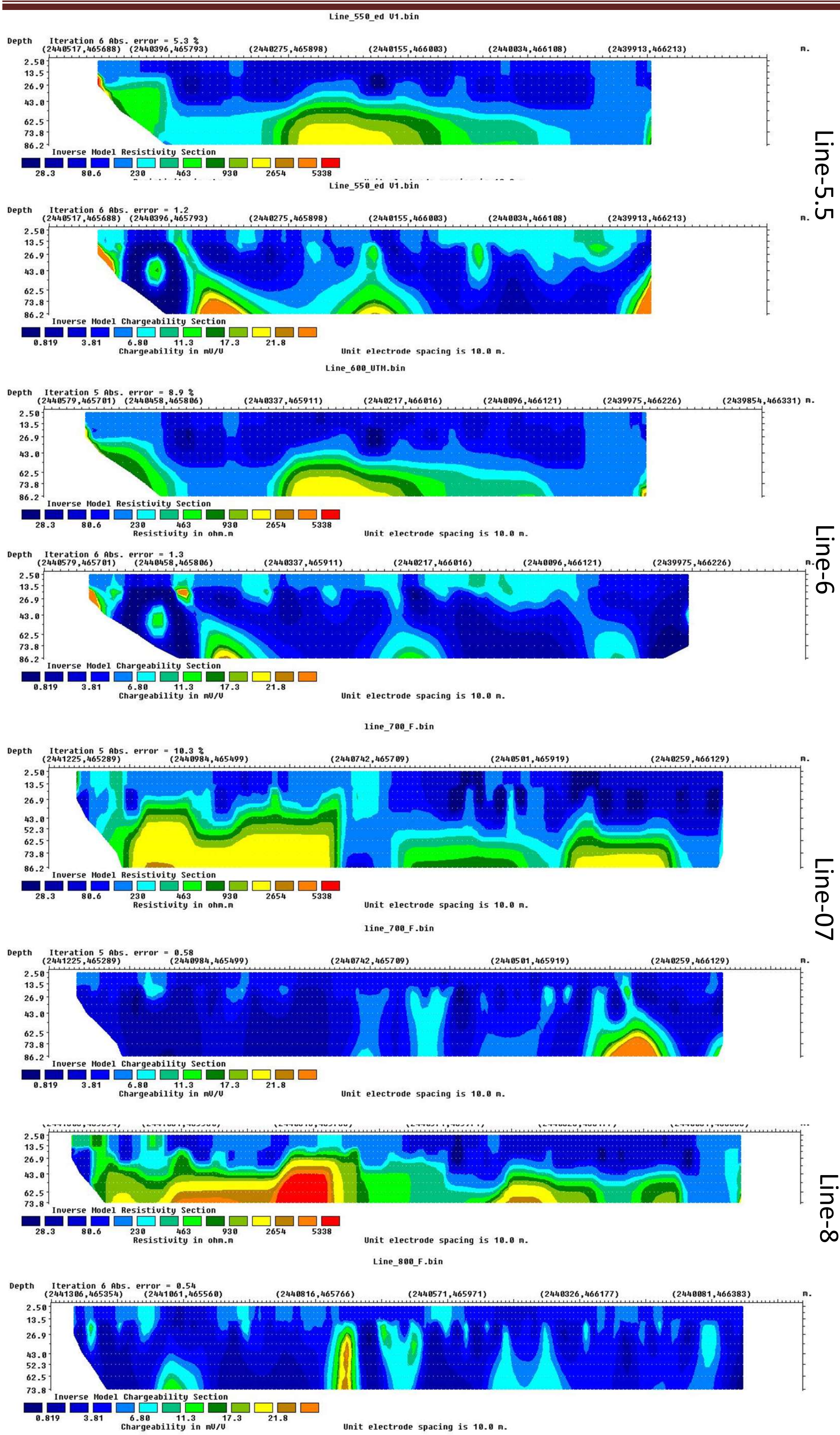


Fig.5.4.1.10.b: 2D Section of Resistivity and Chargeability (Line 6 to 8)

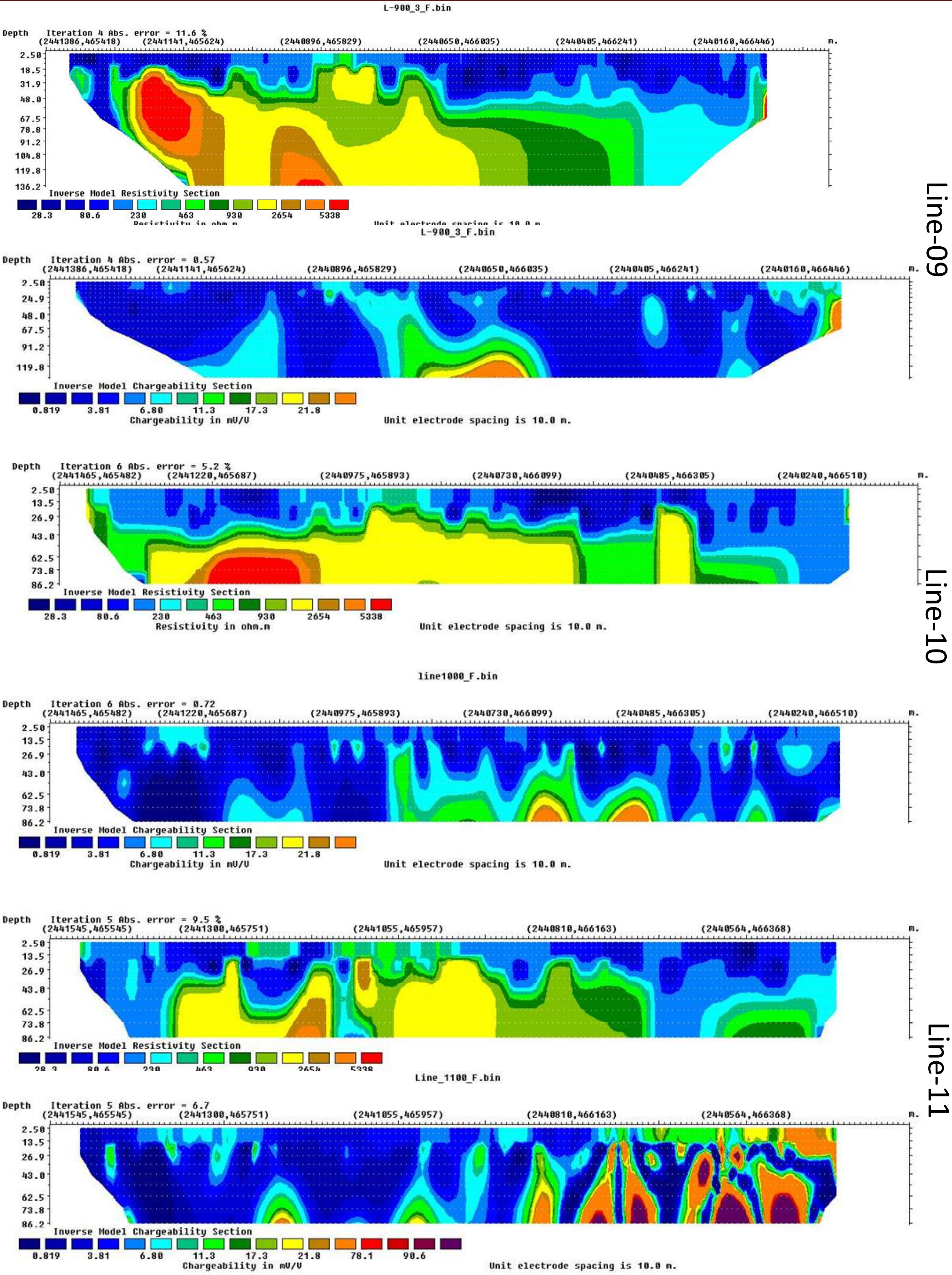


Fig.5.4.1.10.c: 2D Section of Resistivity and Chargeability (Line 9 to 11)

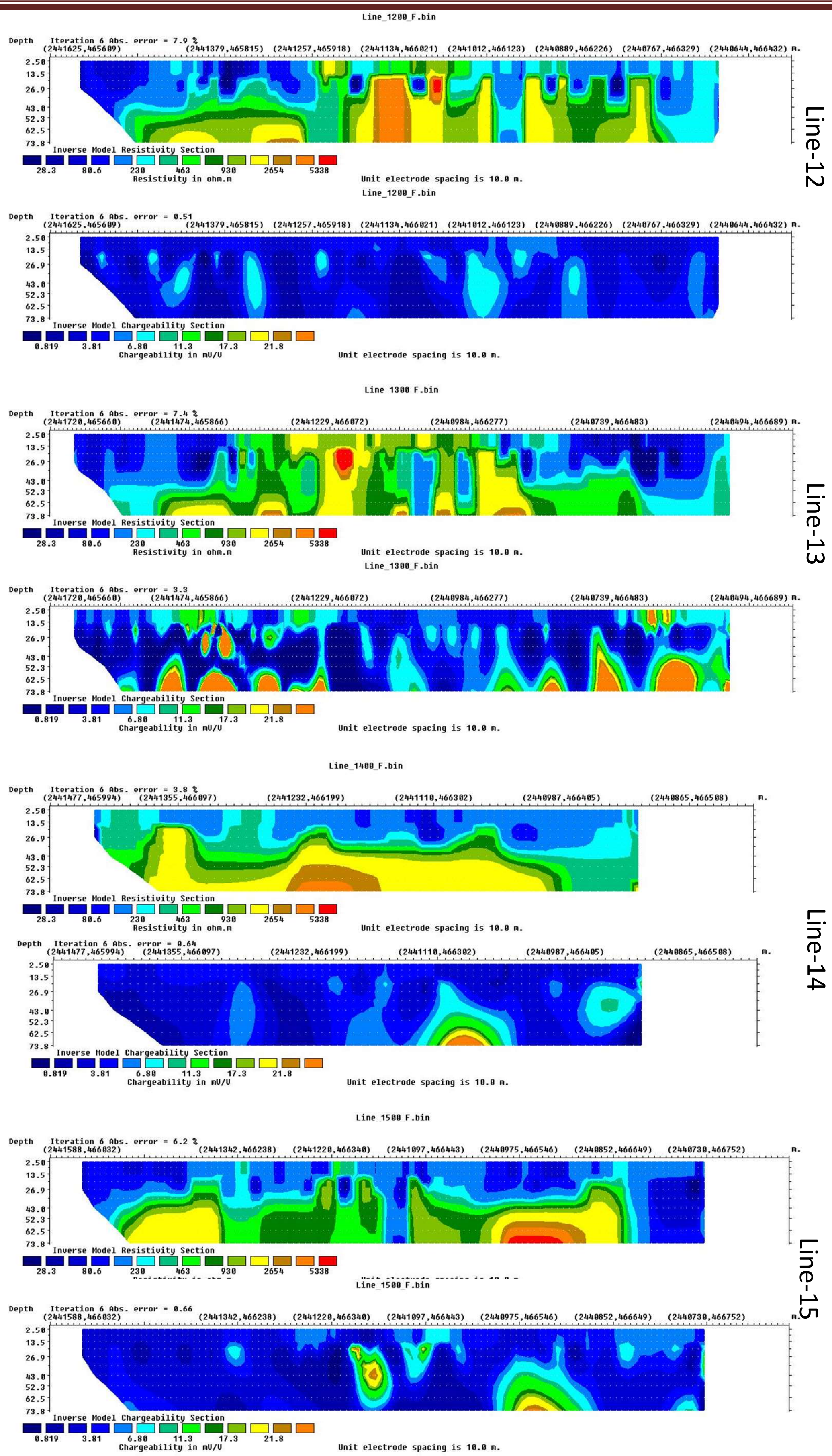


Fig.5.4.1.10.d: 2D Section of Resistivity and Chargeability (Line 12 to 15)

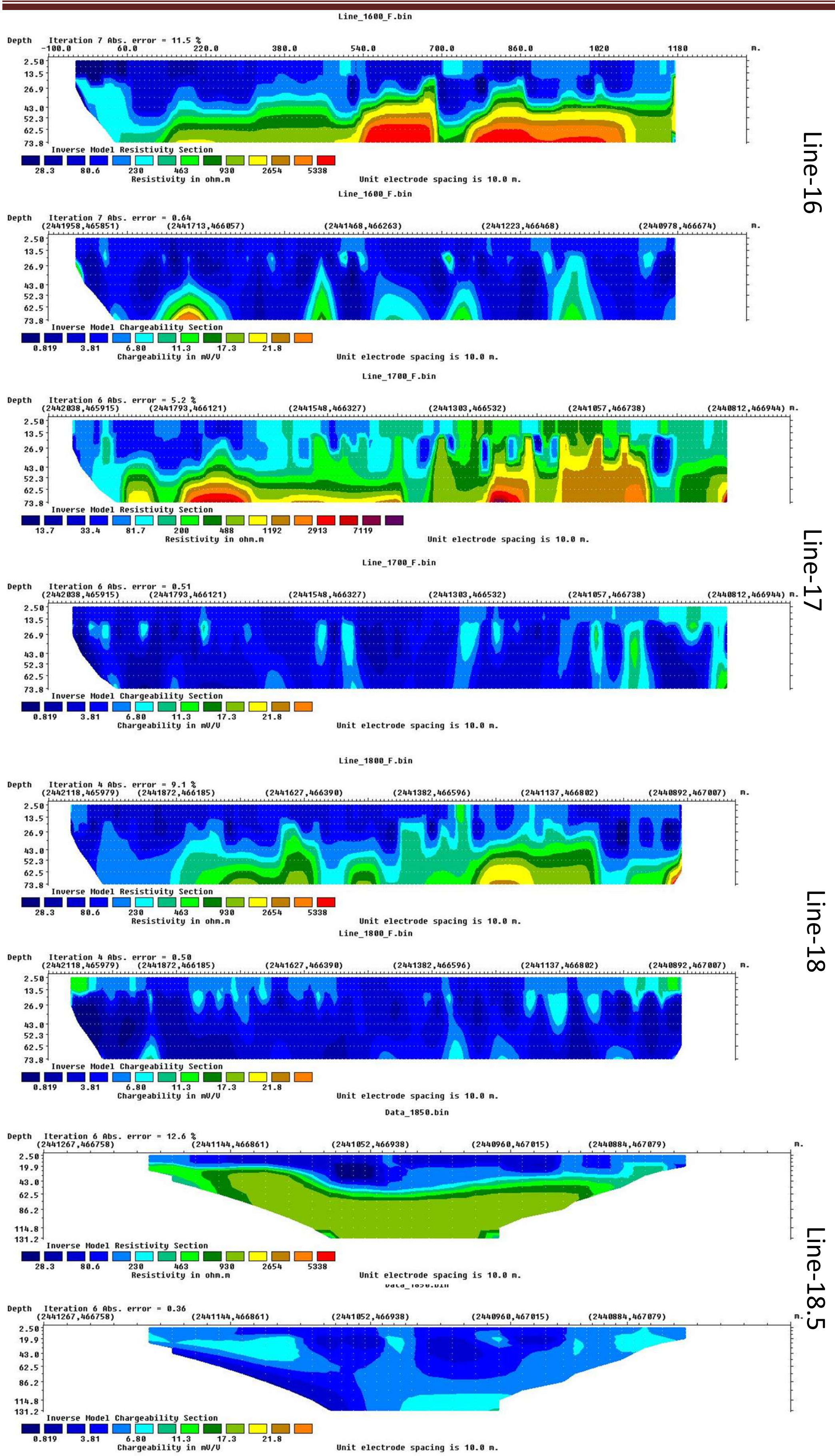


Fig.5.4.1.10.e: 2D Section of Resistivity and Chargeability (Line 16 to 18)

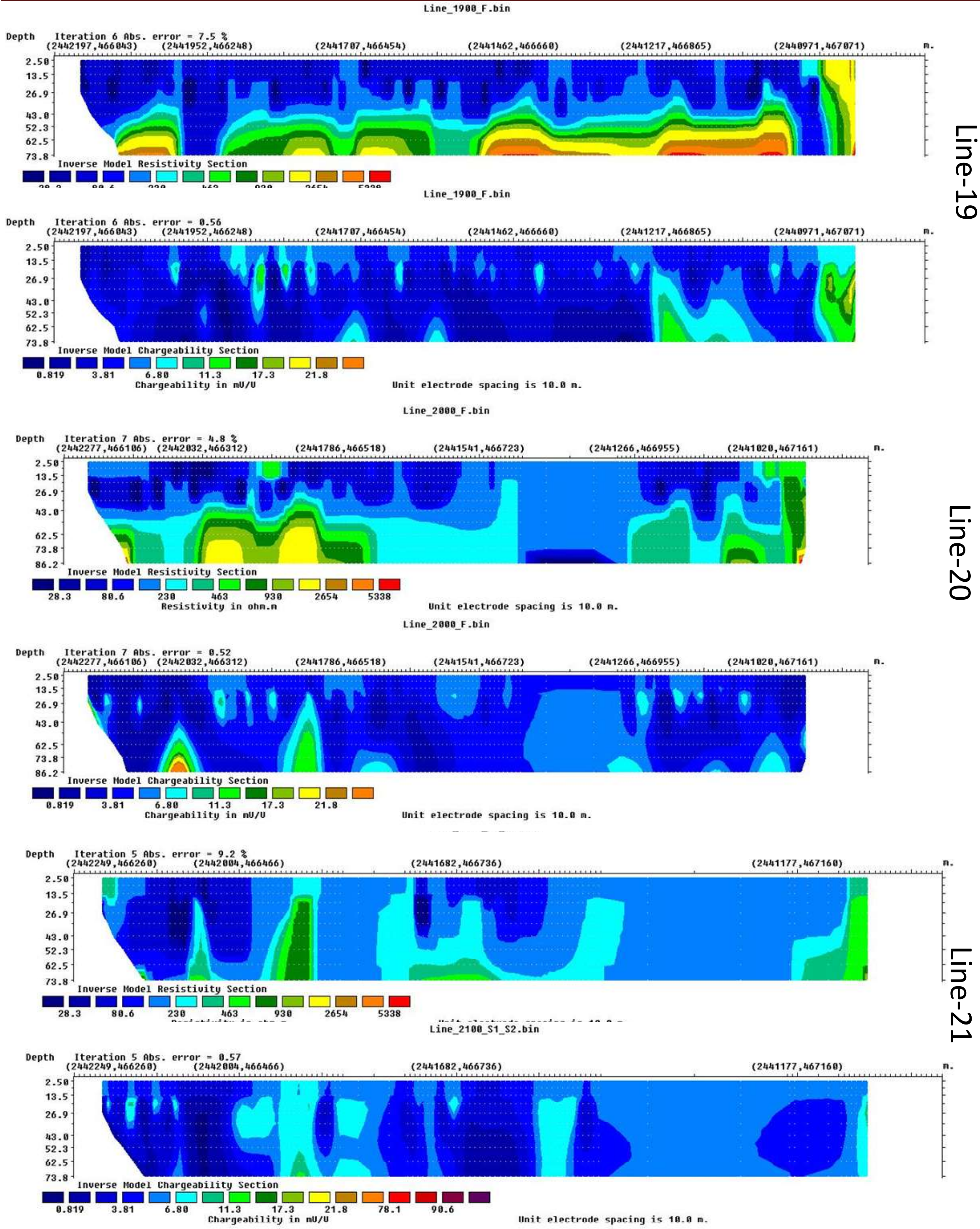


Fig.5.4.1.10.f: 2D Section of Resistivity and Chargeability (Line 19 to 21)

All the line started from North-West to South-East direction as proposed in line-layout Block Diagram in Fig. 4

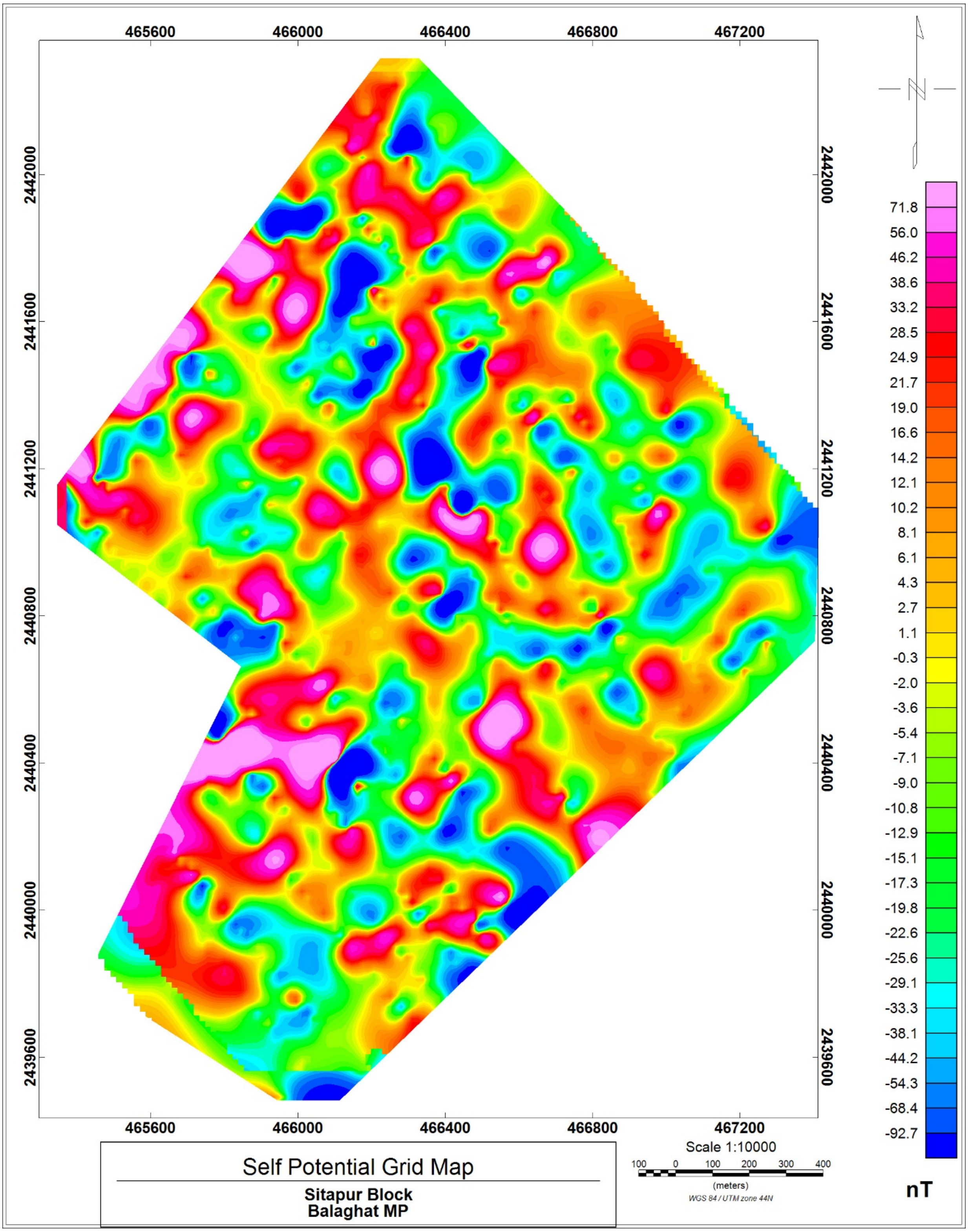


Fig.5.4.1.11: Total SP anomaly Map

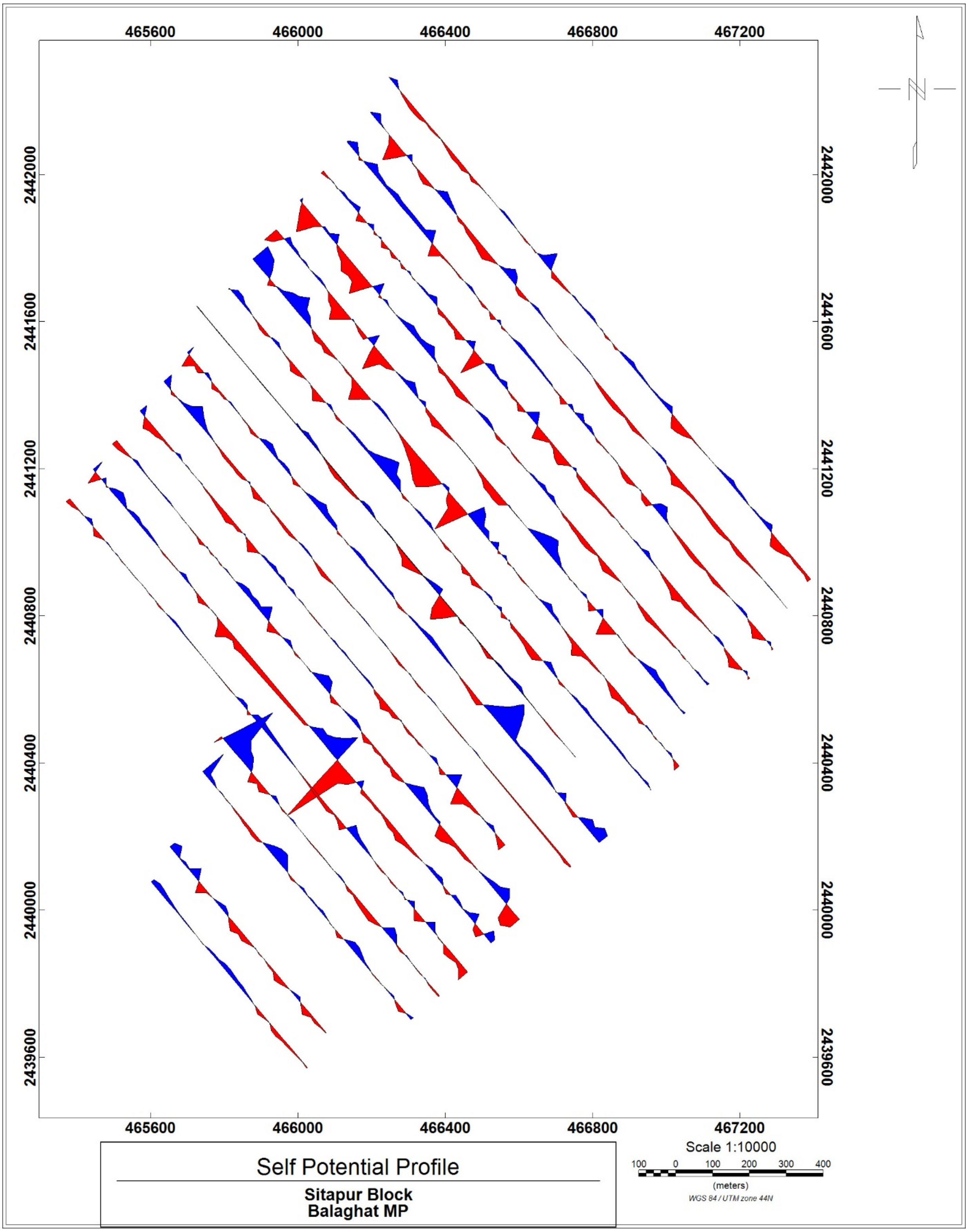


Fig.5.4.1.12: SP Profile Map

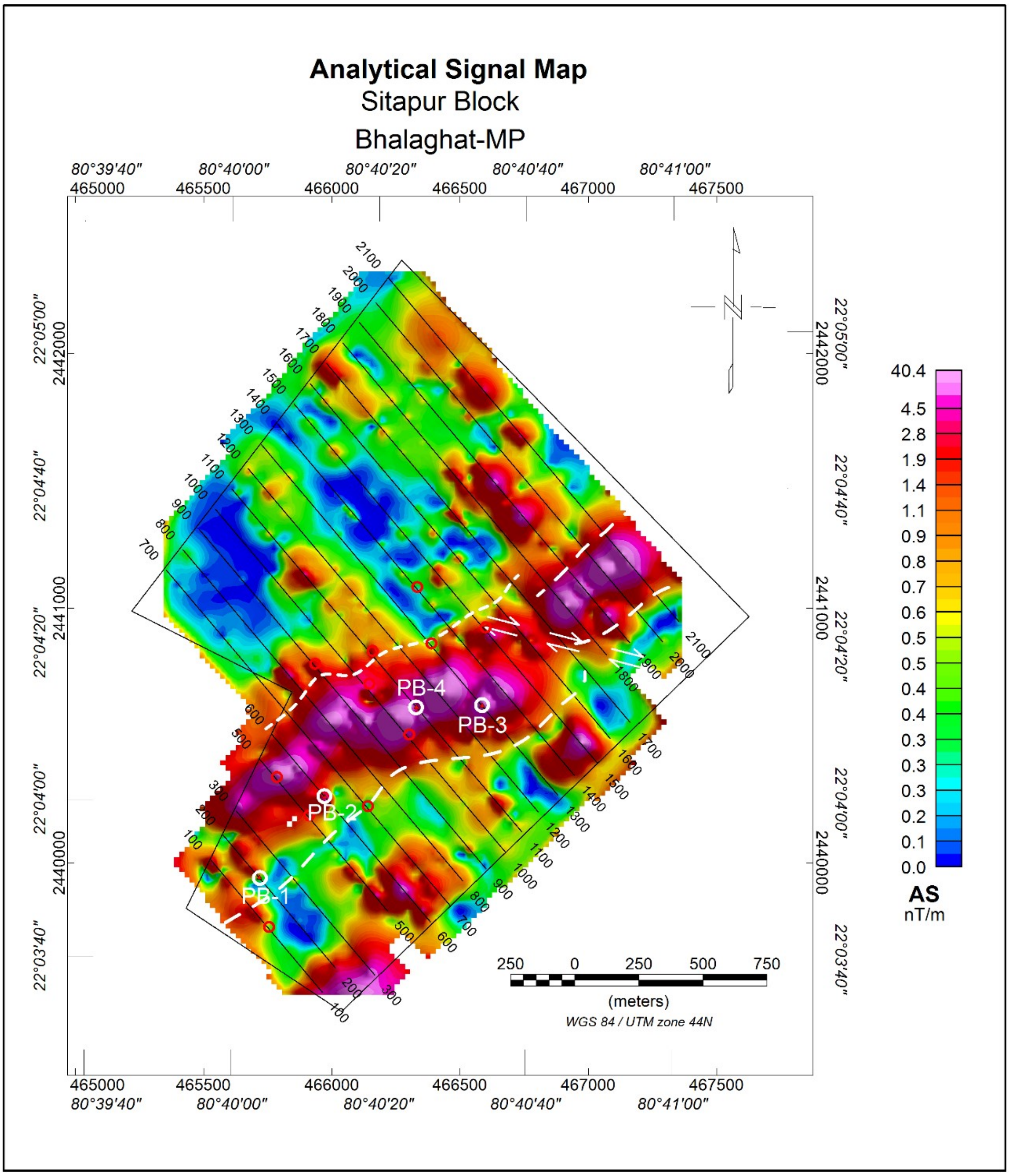


Fig.5.4.1.13: Proposed Borehole locations with Marked Shear Zone overlaid on Analytical Signal Analysis (Magnetic) Map

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